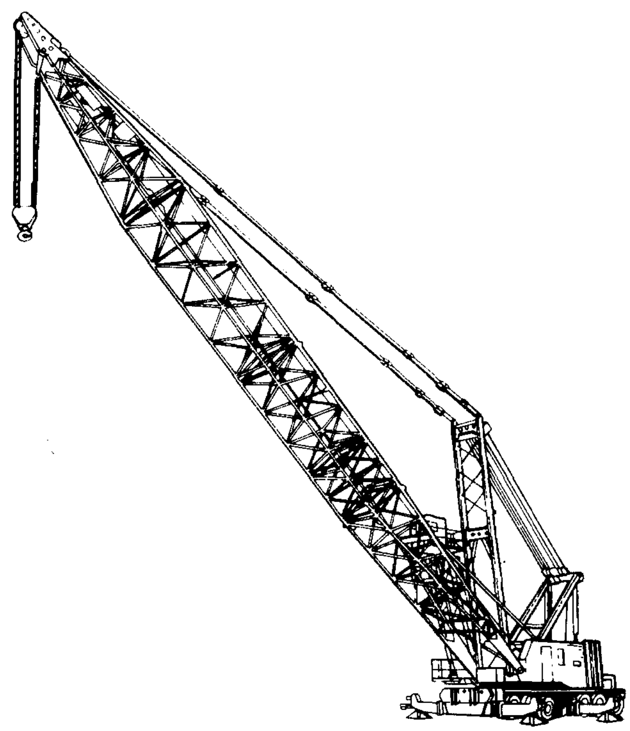
TECHNICAL MANUAL

OPERATOR'S ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS AND SPECIAL TOOLS LISTS, AND SUPPLEMENTAL OPERATING, MAINTENANCE AND REPAIR PARTS INSTRUCTIONS)



CRANE, MOBILE, CONTAINER HANDLING, TRUCK MOUNTED, 250-TON CAPACITY, DED, PT
NSN 3950-01-027-9253
(HARNISCHFEGER MODEL 6250TC)

HEADQUARTERS DEPARTMENT OF THE ARMY
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DEPARTMENT OF THE ARMY
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TM 10-3950-264-14&P-2, 1 June 1983, is changed as a result of an equipment alteration. Remove old pages and insert new pages as indicated below.

SHOP MANUAL

REMOVE	ADD
Title Page	Title Page
Last Page "Warnings etc"	Last Page "Warnings etc"
List of Charts and Tables	List of Charts and Tables
List of Illustrations Fig 1-1-9B-1	List of Illustrations 1-1,9B-1
List of Illustrations Fig 11D-3-13D-6	List of Illustrations Fig 11D-3,13D-6
Table of Contents Sec. 1	Table of Contents Sec. I
Page 1-13 & 1-14	Page 1-13 & 1-14
Page 1-15 & 1-16	page 1-15 & 1-16
Page 2-9 & 2-10	Page 2-9 & 2-10
Page 2-11	Page 2-11
Page 3-1 thru 3-8	Page 3-1 thru 3-8
Table of Contents Sec. IV	Table of Contents Sec. IV
Page 4E-9 & 4E-10	Page 4E-9 & 4E-10
	Page 4E-19 & 4E-20
Page 4F-1 thru 4F-7/8	Page 4E-21
Table of Contents Sec. IX	Page 4F-1 thru 4F-7/8
	Table of Contents Sec. IX
Page 13C-5	Page 13A-11
	Page 13C-5 thru 13C-9

File this transmittal sheet in front of the publication.

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

ROBERT M. JOYCE
Major General, United States Army
The Adjutant General

Distribution:

Change 1

Model 6250TC

Serial No's. E-50370, E-50371,
E-50941 and E-50942
Serial No's. E-52941 and 52942
DAAE07-80-C-6070
DAAE07-82-C-H330
NSN3950-01-027-9253

**shop
manual**

**CRANE, TRUCK MOUNTED
CONTAINER HANDLING
250 TON CAPACITY**

WARNINGS, CAUTIONS and NOTES are used throughout this manual to emphasize important and critical instructions. For the purpose of this manual, WARNINGS, CAUTIONS and NOTES are defined as follows:

WARNING An operating procedure, practice, etc., which, if not correctly followed, could result in personal injury, or loss of life.

CAUTION An operating procedure, practice, etc., which, if not strictly observed, could result in damage to, or destruction of, equipment.

NOTE An operating procedure, condition, etc., which is essential to highlight.

WARNINGS AND CAUTIONS

WARNING

Careful planning and supervision offer better protection than any known device. Insulated boom cages, proximity warning devices and insulating links have limitations and can fail without warning. Insulated boom cages and links only protect part of the crane and can break down electrically when contaminated with dust and water. Proximity warning devices can be confused by different arrangements of power lines, the movement of trucks, materials and the crane itself and other influences. Relying on any of these devices could be dangerous because operators may think they are providing protection when in fact they are not.

WARNING

Do not use your hands to guide wire rope onto drums.

WARNING

Do not attempt to drive the carrier when the power steering/ outrigger lamp is lit.

CAUTION

The carrier will not have brakes, except the Maxibrakes which are controlled by the Maxibrake control valve. Never move the carrier further than is absolutely necessary under these conditions, and avoid steep grades. Make certain that this knob is pulled out at all times during normal operation.

CAUTION

Stop the carrier before shifting the auxiliary transmission.

CAUTION

A 5 to 7 second delay is normal, after the retarder pedal is depressed, before the braking force is effective. During prolonged use of the retarder, the con-verter oil temperature should not exceed 250 degrees F (121 degrees C).

CAUTION

Make sure the power steering/outrigger light is out before driving the carrier. If the light is not out it will be necessary to go to the outrigger control boxes and turn the master switches to the "off" position.

CAUTION

Driver should always use the lowest reductions available in the auxiliary unit, for the conditions, and keep the main transmission in the higher gear ratios. Also select a gear for the speed you will attain because the auxiliary transmission should not be shifted while the vehicle is in motion.

CAUTION

The combination of low gear in the auxiliary transmission and low gear in the main transmission is intended for "off" highway conditions when maximum tractive effort is required. This combination develops sufficient torque to possibly damage the propeller shafts and/or other drive line components if used improperly.

CAUTION

Make sure that the swing brake is locked in the applied position before extend-ing the outriggers.

WARNING

Do not set the outriggers near holes, or on rocky, or extremely soft ground. This may cause the machine to tip, resulting in injury to personnel.

WARNING

All jackfloats must be removed from the carrier before swinging upper.

WARNING

Do not swing the upper when the jackfloats are stored on the carrier as shown in Figure 2-5.

WARNING

Do not use this switch to override the boom hoist limit to allow the boom to be raised to a working angle beyond the normal operating limits. This is extremely dangerous, since the boom may topple over the back of the machine.

CAUTION

Be sure the engine oil pressure reaches the normal operating range within 15 seconds after starting the engine. If it does not, stop the engine and correct the cause of the pressure failure before restarting the engine.

WARNING

Under no circumstances should the circuit breaker be prevented from tripping by any means. Overloaded electrical circuits can cause extensive damage to the machine and/or injury to personnel.

WARNING

This unit is an operating aid and cannot be used as a substitute for the rating plate. To maintain system accuracy the unit must be tested at least once each day and before each major lift. The unit should be inspected on a weekly basis for pinched or cracked cable. Also check that all connections are tight.

WARNING

The left and right transmissions should not be shifted while under load or with the engine running faster than low idle speed (600 rpm). The left hand transmission control is interlocked with the engine throttle to prohibit a shift except at low idle speed. If the control switch is moved from high to low, or vice-versa, while the engine speed is above low idle, the shift will not occur. It is possible to shift the left hand transmission into neutral at any time; however, this must never be attempted at higher engine speeds, because the transmission cannot be re-engaged in either gear until the engine has been throttled back to low idle speed. This interlock is designed to protect the boom while raising or lowering, but also affects the swing motion because of the common drive train.

CAUTION

When no lifting work is being done , rotate the modulated clutch control fully counterclockwise and lower the engine speed. This will prevent overheating of the converter.

WARNING

If the heater fails to produce heat within 30 seconds, turn it OFF immediately to prevent propane buildup in the burner head. Refer to the troubleshooting chart in Section XII of the Shop Manual.

WARNING

Do not switch the ignition, on the dash, to the off position before the heater stops running. If this is done, the purge cycle will be interrupted which may lead to a propane build-up in the burner head. Faulty heater operation may result.

WARNING

Personnel should use care to keep from spilling liquids upon themselves. Ex-posed parts of the body should not come into contact with metal during cold weather, as serious injury may result.

CAUTION

Cold weather operation can produce brittle fractures of structures normally considered to be ductile. Brittle fractures start as cracks in the structure. Per-form weekly inspection of the entire machine to locate and repair cracks in the structure. Consult a separate rating plate for operation below -20 degrees F (-28.9 degrees C). Cease all operation below -45 degrees F (-42.8 degrees C).

WARNING

When a machine of this size is being towed, extra precautions must be taken to ensure the safety of personnel and equipment.

CAUTION

Initial factor fill of Multi-Purpose Grease is of the soap base 12-Hydroxy Lithium Stearate type. Other soap base greases are not always compatible with initial fill lubricant, and Barium base grease is definitely not compatible. Various other soap base greases may be used if experience by the purchaser has shown these greases to be acceptible for the application. The grease systems must be thoroughly purged and the affected parts removed and cleaned before switching from a grease having one type of base to a grease having a different soap base.

CAUTION

Do not heat the rings or put them in oil as these two conditions cause the rings to expand excessively. Install the rings dry and at room temperature making this the last procedure during transmission assembly. Use hose clamp 44Z1673-13 on the right hand transmission and hose clamp 44Z1673-12 on the left hand transmission as they have a protective shoe in their inner diameter. This shoe will shield the ring from possible damage due to the slots in the hose clamp.

CAUTION

Use care when applying air pressure in the event the piston removed abruptly.

CAUTION

The high pressure regulator setting of 220 psi must be adhered to. Any at-tempt to change the setting without specific approval will void all warranties.

CAUTION

If both pumps were removed from the tower you must verify shaft rotation be-fore mounting them to the torque converter tower. Pump 37Q27 is left hand rotation and is mounted on the engine side of the tower. Pump 37Q28 is right hand rotation and is mounted on the converter side of the tower (see Figure 4E-4).

CAUTION

The pressure setting of 2140 psi (140.7 bars) must be adhered to. Any attempt to change the setting without specific approval will void any and all guarantees expressed or implied.

CAUTION

The pressure setting of 270 psi (1861 kPa) must be adhered to. Any attempt to change the setting without specific approval will void any and all guarantees, expressed or implied.

WARNING

Hydraulic oil must not come in contact with any brake or clutch lining during this bleeding operation. Hydraulic oil on the linings will cause the clutches or brakes to slip.

WARNING

Do not disassemble the rotating group. The sudden release of the cylinder block spring can cause bodily injury.

CAUTION

Before breaking an electrical circuit, be sure the power is OFF. To do this, disconnect the battery ground cable.

CAUTION

Before breaking any circuit, be sure all pawl locks are engaged and block or lower any load whose movement could generate pressure.

CAUTION

Do not stone the edges of the sealing lands on the valve spool. Rather, use a 500 grit abrasive paper to remove any burrs found on the spool. Use the paper very lightly on the outer diameter of the spool only.

CAUTION

Place adequate blocking beneath shaft (05) to prevent it from falling out the bottom of the revolving frame when retainer (04) is removed. It is advisable to thread an eyebolt into the top of shaft (01) and secure the shaft from above.

WARNING

Extreme caution must be exercised when removing the vertical swing shaft as it is necessary to remove the upper from the carrier. Every precaution must be taken to prevent the upper from falling or shifting while lifting the upper and when the upper is off the carrier.

WARNING

Extreme caution must be exercised when removing the slewing ring, as it is necessary to completely remove the upper from the carrier. Every precaution must be taken to prevent the upper from falling or shifting while lifting the up-per and when the upper is off the carrier.

WARNING

"This unit weighs approximately 6,500 pounds (2 948 kg). Use an adequate sling and lifting device when removing the drumshaft assembly.

CAUTION

Reapply the foot brake pedal before moving the brake lock switch away from the operator and lower the load under the control of the foot brake.

WARNING

At no time should the 3.500 inch dimension given for adjusting bolts (18) be greater than 3.500 inches when the machine is in operation. This could cause brake application interference if the dimension is allowed to become greater than 3.500 inches. The 3.500 inch or less, dimension must be held at all times.

WARNING

The upper must be placed over the side of the carrier to gain access to the cover plates over the engine and transmission.. The outriggers should be fully ex-tended, with the locking cams engaged. The boom should be lowered onto blocking. It may be necessary to shorten the boom to avoid exceeding over the side stability.

CAUTION

Before engine start-up, recheck all wiring, fuel, water and mechanical connections. Be prepared to shut down the engine if there should be some malfunction.

CAUTION

Care should be exercised to avoid skin rashes, fire hazards and inhalation of vapors when using solvent type cleaners.

CAUTION

Care should be exercised to avoid skin rashes and inhalation of vapors when us-ing alkali cleaners.

CAUTION

Do not strike these hardened steel pieces directly with a steel hammer.

CAUTION

Utilization of burnishing ball for this operation must be avoided, as it does not insure a true alignment between the two bushings.

CAUTION

Gasoline should be avoided.

CAUTION

It is not recommended to salvage damaged cross tube ends by repacking and re-placing the boot seal on nongreasable ends.

WARNING

Any indication of looseness in the total steering linkage arrangement under normal steering loads is sufficient cause to immediately check all pivot points for wear, regardless of accumulated mileage. Steering linkage pivot points should be checked each time the axle assembly is lubricated. If any indication of lateral movement is found, cross tube ends should be removed for inspection. Looseness at the steering linkage pivot points can be visually detected during movement of the vehicle steering wheel.

CAUTION

It is not recommended to salvage damaged ends by repacking and replacing the boot seal on nongreasable ends.

CAUTION

The bottom side of the thrust bearing must be seated on the face of the lower knuckle yoke. The lower seal must be positioned beneath the bottom face of the axle center.

CAUTION

Do not strike these hardened steel pieces directly with a steel hammer.

CAUTION

After measuring knuckle clearance (end play), add shims between upper knuckle pin boss and axle center end, as required, to obtain an end play of .005 to .025 inch (.12 to .64 mm) through full range of turn.

WARNING

The lock valve is holding the piston rod stationary in whatever position the piston may be in. When the hydraulic pressure in the cylinder is relieved, the piston rod may either extend or retract. Block under the outrigger box to prevent cylinder extension.

CAUTION

Prior to disconnecting the rod end of the cylinder from the outrigger beam, the cylinder should be blocked to prevent it from falling inside the outrigger beam.

WARNING

The lock valve, on the vertical lift cylinder, is holding the cylinder rod and outrigger box in a stationary position. The outrigger box must be sufficiently blocked to prevent it from falling to the ground when the hydraulic lines are removed.

CAUTION

Under no circumstance should the axle stop bolt come into contact with the axle stop when the road wheels are turned fully in either direction.

CAUTION

Since the transmission and PTO may not have lubrication at this time, running the PTO should be for as short a time as possible.

CAUTION

This steering gear is available in two gear ratios. The manufacturer states in his service bulletin that the guarantee will be void if any steering unit is serviced with noncompatible components due to different gear ratios, or if non-genuine factor replacement parts are used.

CAUTION

All 28.4 worms must be mated with a 50035 roler shaft and a 28.4 housing. All 32.5 worms must be mated with a 7DF236 roller shaft and a 32.5 housing. The housings are marked on the inside face of the casing, the worms are stamped on the finished end, and the rollers are stamped on the top on one of the roller shaft teeth.

CAUTION

Do not fully tighten cover screws (22) at this time. Rotate input shaft assembly (06) with one hand while slowly tightening the cover screws with the other hand to prevent damaging the bearing surfaces if the initial amount of shims is inadequate. Once a light preload is obtained by using a torque gauge on the input shaft, torque the cover screws to 45 to 55 ft-lbs (6.22 to 7.61 kg-m). See adjustments following for preload values.

CAUTION

When installing O-rings (15) on piston (16), do not move the piston in the body any further than is required to assemble the O-ring. If the O-ring on the gland end of the piston drops into the cavity in the body, it is likely to be cut or damaged. Apply light lubricating oil to the piston and seals when assembling.

CAUTION

Clamp only in the center of the valve, as this is the heaviest section.

WARNING

Do not use brake system to hold the machine while performing the following test. Hold the machine by blocking the wheels with wheel chocks.

CAUTION

If the pin cannot be removed by hand pressure, do not drive the pin out. This may damage the piston. Place the piston in hot water to expand the pin bore.
This will allow the pin to be removed by hand pressure

CAUTION

Do not use a screwdriver or scraper to remove carbon and scale. This may damage sealing surfaces.

CAUTION

Support the front support flange while removing or installing bushings.

CAUTION

Do not drive the piston pin in to the bore. This may damage the piston. It may be necessary to heat the piston in hot water. This will expand the pin bore and allow the pin to be installed.

CAUTION

A change in vehicle braking characteristics or a low pressure warning may indicate a malfunction in one of the brake circuits. Although the vehicle air brake system may continue to function, the vehicle should not be operated until the necessary repairs are made and both braking circuits are operating normally.

CAUTION

Care must be exercised to be sure capscrews (21 and 08) do not penetrate to the windings of alternator (11). Never use a capscrew longer than that originally used for attaching the bracket to the alternator.

CAUTION

Never, under any circumstance, use a megger, bell, buzzer, or other ringing device to check rectifiers. The surge voltages developed by these devices when interrupted will destory the rectifier cells.

CAUTION

Care should be used in lifting out the controller shaft assembly to insure no damage is done to the graphite brush. Do not attempt to remove the brush from the front of the brush holder.

CAUTION

Do not use solvents to clean the slip rings, as they leave a residue and contaminate the brushes. Only clean rings by mechanical methods as explained above.

WARNING

This unit is an operating aid and cannot be used as a substitute for the rating plate. The system should be inspected on a weekly basis for pinched, loose or cracked cables. Also check for proper sealing of the central unit and meters to keep out water and dust and to insure proper operation of the unit.

WARNING

The central unit shall not be opened or adjusted by non-authorized personnel. Opening and adjustment by other than authorized personnel voids the warranty and may result in failure of the warning device.

WARNING

Disconnect electrical power from the heater before removing the covers. Do not run the heater with covers removed except for troubleshooting or adjustment. The ignition pack generates a voltage that is high enough to cause severe injury.

WARNING

The heat exchanger must be inspected annually, or more frequently if heater usage is heavy. A damaged heat exchanger can allow poisonous gases to seep into the heated enclosure causing illness or death to occupants.

CAUTION

Heat exchanger must be install as shown to prevent exhaust gases from leaking around the burner head.

CAUTION

After the first 50 hours of operation, retighten the generator cylinder head bolts and check valve clearance.

CAUTION

Some engines are fitted with a 0.005 inch oversize piston and rings at the factory. These engines are marked with an E following the engine serial number.

CAUTION

The air housing, including the door, must be on when operating the engine. Overheating and permanent damage can result from as little as one minute of op-erating without it.

CAUTION

A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any parts of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly and install while still wet.

WARNING

Do not let the nozzle spray against your skin. The fuel can penetrate flesh and cause a serious infection.

CAUTION

If the engine starts, check immediately for oil pressure and shut the engine down if oil pressure doesn't build up within a few seconds. In this case, it is lack of oil pressure that is causing faulty operation, not the switch.

CAUTION

Be careful not to lose the spacer mounted on the gear shaft behind the gear.

CAUTION

Containers or filters that have been used for antifreeze or engine coolant must not be used for transmission oil.

WARNING

When conducting a stall test, the vehicle must be positively prevented from moving. Both the parking and service brakes must be applied, and the vehicle should be blocked to prevent movement forward or reverse. Keep people safely away from the vehicle path.

CAUTION

Do not maintain the stalled condition longer that thirty seconds due to rapid heating of the transmission oil. With the transmission in neutral, run the engine at 1200 to 1500 rpm for two minutes to cool the oil between tests. Do not allow the converter-out temperature to exceed 275 F (135 C). Keep a close check to prevent overheating of the engine cooling system.

CAUTION

Do not allow the temperature to exceed 225 F (107 C). If the vehicle does not have a temperature guage, do not stall the transmission for more than 10 seconds.

WARNING

Be sure to shut off the engine, set the vehicle brakes and lock the wheels be-fore any troubleshooting of the electric-shift solenoids. It is important that electricity never, under an circumstances, be applied to any electrical valve body component while the vehicle engine is running and while the mechanic is under the vehicle. Failure to shut off the engine and set the brakes could cause the vehicle to run away when the solenoids were activited by an external power supply. Removal of the power supply would not stop the run away vehicle because of the fail protection system. The vehicle could only be stopped by applying the vehicle brakes or shutting down the engine.

WARNING

Be sure that the power supply from the vehicle electrical system is switched off. This will prevent any unexpected shift during removal of the wiring harnesses.

CAUTION

Caustic cleaning compounds will damage some transmission parts. Use only mineral spirits or cleaning solvents such as PD-680-2 (or equivalent).

WARNING

Do not burn discarded teflon seals; toxic gases are produced by burning.

WARNING

Never dry bearings by spinning then with compressed air. A spinning bearing can disintegrate, allowing balls or rollers to become lethal flying projectiles. Also, spinning while they are not lubricated can damage the bearing.

CAUTION

Any bearing that has been subjected to metal contamination must be closely inspected for matal particles. Metal particles will cause failure of the bearing.

CAUTION

Do not use teflon tape on threaded parts. Slivers can cause the transmission to malfunction.

CAUTION

Do not use petrolatum to retain cork gaskets.

CAUTION

A puller placed on the outside diameter of the flange may deform the pilot diameter and mounting flange.

CAUTION

Do not use a pry bar or hammer to force the flange at disassembly.

CAUTION

Do not let the flange cool prior to installation. If the flange cools and seizes to the shaft prior to its final assembly, it will be necessary to remove the flange and repeat the assembly procedure. Do not attempt to force the flange with a hammer.

WARNING

Do not burn discared telfon seals; toxic gases are produced by burning.

CAUTION

If lip-type seal rings are installed incorrectly', the clutches will not operate properly.

CAUTION

The backlash in power take off (PTO) installations should be carefully checked. Excessive or insufficient backlash can result in damage to the transmission and the PTO assembly.

WARNING

When removing the flywheel assembly, lockup parts may drop from the flywheel cavity.

CAUTION

The stator rollers may drop when the stator assemblies are removed if the roller race does not lift with the stators.

CAUTION

The valve body assembly contains springs and other parts, some of which are similar and can be mistakenly interchanged. If parts are not reinstalled in the same locations from which they were removed, the calibration of valve body functions will be lost. Tag each part, at removal with its item number in B, Foldout 9, to simplify correct reassembly of valve body components.

CAUTION

Do not damage the threads and contact pins of the electrical connector.

WARNING

Do not attempt to weld repair the brazed joints of the hose fitting (Figure 15-92). Welding the cadmium plated materials produce toxic yellow-brown fumes which are extreme hazardous and can be fatal.

CAUTION

Do not use liquid or vapor cleaning methods on any electric connections.

CAUTION

Do not use acid, or acid core solder. Use only rosin core solder.

CAUTION

Hand tighten all mating connectors. Use of tools will damage components.

CAUTION

Center the clutch and drum assembly with extreme care during installation to avoid damaging the seal rings on the fifth and sixth gear clutch drum hub.

CAUTION

Rotate each pinion so the snap ring is cleared as the output shaft is installed in step 11. The snap ring must seat against the carrier.

CAUTION

Keep the transmission rear higher than the transmission front. If the transmission should be lowered to a horizontal position, or the transmission rear be lowered below the transmission front, some parts within the housing could shift, preventing the snap ring from being installed on the splitter output shaft.

CAUTION

When lowering the converter housing, lower it slowly and carefully, keeping it centered over the turbine shaft, so the hook-type seal rings on the shaft will not be damaged during the installation.

WARNING

Hose pressure and temperature can exceed 350 psi (2413 kPa) and 275 F (135 C). Protect them from vehicle physical contact. Abrasions will weaken the hose, and failure with possible personnel injury may occur.

CAUTION

The ST-548 Engine Rebuild Stand is not recommended for use with this engine.

CAUTION

Do not pry or pound on the viscous damper. Denting the outer shell will make the damper ineffective.

CAUTION

Due to the length of the camshaft, two men may be required, when removing the camshaft to avoid damage to the camshaft and bushings.

CAUTION

Care must be taken when removing and/or installing the piston/ connecting rod assemblies that damage to the piston cooling nozzle does not occur. Inspect the piston cooling nozzles to insure no damage has occured.

CAUTION

Care must be taken when removing No. 6 main bearing cap to avoid damage to the dowels.

CAUTION

Do not damage gasket surfaces.

WARNING

The use of acid may be extremely dangerous to workmen and injurious to machinery. Always provide a tank of strong soda water as a neutralizing agent.

CAUTION

The maximum torque is not to exceed 350 ft-lbs (475 N-m). Apply heat as necessary to loosen the press fit of the gear if the torque execeeds 350 ft-lbs (475 N-m). When heat is necessary to remove gear, discard the gear.

CAUTION

The expanding arbor must be installed with locking pin down and on center line of rod.

CAUTION

Never drive a piston pin into the pistons. Driving will cause distortion of the piston, causing piston seizure in the cylinder liner.

CAUTION

Do not use a drill of less than ten amperes or 450 rpm

WARNING

The use of acid is dangerous to you personally and damaging to machinery. Al-ways make available a tank of strong soda water as a neutralizing agent.

CAUTION

Over swaging around the insert may crack the cylinder head.

CAUTION

Never vacuum test a cylinder head with the injectors installed. Installation of injectors while the head is removed from block will cause out of alignment of the valves in the valve seat area and result in leakage during testing which will not normally occur during engine operation.

CAUTION

Place plunger where it will not be damaged, a slight nick can cause extensive damage.

CAUTION

Engine with integral cooling gear pumps, Figure 16G-24, must not be run with the fuel bleed hole plugged.

CAUTION

Under no circumstance should the pump be operated with cooling return flow plugged. This fuel flow is necessary to lubricate the bearing surfaces within the gear pump.

CAUTION

Be sure starting switch is in off position when checking coil.

CAUTION

Do not overpress spacer. It can be flattened, eliminating its effectiveness.

CAUTION

Cummins Engine Company Inc. assumes no responsibility of damage if fuel pump ,is calibrated to a different specification than listed for a specific engine model and pump code.

CAUTION

Never operate gear pump having cooling drain with the check valve hole plugged.

CAUTION

This setting must always be reached while increasing air pressure on the AFC bellows. If specified pressure is overshot, reduce pressure to 0 in. Hg., and wait until flow stabilizes at or near zero before increasing to correct setting.

CAUTION

The AFC plunger is easily broken when tightening the jam nut, use extreme care in tightening to 25 to 35 in-lb (2.8 to 4.0 N.m.) torque. Large and small hex sockets of Service Toll 3375137 must be fully retracted after loosening plunger jam nut to avoid interfering with AFC piston travel. If AFC piston position is disturbed while adjusting plunger, repeat sequence beginning with Step 4.

CAUTION

Weight assist plunger must be installed with the smallest end to governor plunger

CAUTION

Step 11 is to be used only if gear pump is worn preventing it from delivering enough pressure for proper calibration. Never change idle plungers to exceed the 10 to 15% unrestricted manifold pressure.

CAUTION

Do not alter pump settings to satisfy gauges and tachometers of unknown accuracy.

CAUTION

Do not screw the screw out beyond maximum throttle opening point otherwise a dead throttle travel may occur.

CAUTION

Under no circumstances should engine manifold pressure be set above minimum specifications. Doing so will void engine warranty.

CAUTION

Never check engine deceleration or adjust throttle leakage on a cold engine. Engine will decelerate faster when cold due to greater friction drag.

CAUTION

Do not use drills or other instruments to clean the cup holes. This will alter the size of the holes. Wires may be used if a smaller size wire is used than the spray hole. Do not use a wire brush or crocus cloth to clean the cups that have the part number printed on the side.

CAUTION

Handle the injector plunger with care to prevent damage which could render it useless.

CAUTION

Never alter the size of the injector cup spray holes.

CAUTION

Be certain all mating surface parts are clean and free of burrs or other imperfections which could result in incorrect flow or torque. Lap to repair.

WARNING

At any time fuel is forced from the cup spray holes, be sure to keep hands or body out of the spray stream to prevent injury.

CAUTION

After lapping, both the cup and the plunger must be cleaned thoroughly. Lap-ping compound will damage the fuel system parts unless removed. The most effective cleaning process is the use of an "ultrasonic cleaner" and an after rinse in fuel oil.

CAUTION

Never "peg" the load cell gauge; accuracy may be lost.

CAUTION

The ST-708-1 must be used with extreme caution when sizing the hi-flow injectors. Do not damage the injector body under the orifice plug.

CAUTION

Use only oil to SAE Specifications J967D, Cummins Part No. 3375364, in 55 gal. drums and 3375365 in 30 gal. drums. Calibration errors will occur if other test oil is used.

CAUTION

Do not proceed further until the correct combination is installed in the machine as indicated by the cylinder flange line.

CAUTION

Do not unclamp the injector until the main drive has stopped. However, do not leave the injector clamped more than one minute after stopping the main drive. Damage to the injector test stand could result.

CAUTION

If you use ST-708-1 Burnishing Tool Point on the large hole orifice plugs, you must grind off the end. If the end is not ground off, you will punch a hole through the adapter into the plunger area. This will cause lubricating oil dilution

CAUTION

Wait until the main drive has stopped turning before unclamping the injector.

CAUTION

1. Only lower the fuel arm when the injector is correctly clamped.

CAUTION

If the injector is not completely seated, the O-rings may be damaged if they are pulled down by the mounting capscrews.

CAUTION

The locknut (31) has left hand threads.

CAUTION

Never use a cleaner or solution that will damage the aluminum. Never use a wire brush, scraper or abrasives to clean the compressor housing.

CAUTION

Do not damage the compressor turbine wheel when separating the housings.

CAUTION

All parts and the work area must be free of grease, oil and dirt to keep the abrasives out of the turbocharger during assembly.

CAUTION

Avoid cocking the crankshaft during installation. Damage to bearing shells may result. If the crankshaft cocks, remove and inspect the condition and position of the bearing shells.

CAUTION

The following procedure is necessary due to the width between the crankshaft counterweights and the thickness of the connecting rod cap. Two men may be required when rotating crankshaft as described in Step 9.

CAUTION

Ring damage can result from improper use of a ring compressor. Ring should pass in to the liner smoothly. If a band type compressor is used, make sure that the inner band does not slip and bind the piston.

CAUTION

Do not bar engine until camshaft and accessory drive has been installed as misalignment of timing marks will result.

CAUTION

Mechanical tightening will distort or crack filter head.

CAUTION

Do not prime the engine lubricating system from the bypass filter.

WARNING

Clean the area of any lubricating oil spilled while priming or filling the crankcase.

CAUTION

Do not crank the engine continously for more than 30 seconds. If the engine does not fire, wait two to five minutes before repeating to avoid cranking motor dam-age.

CAUTION

Before breaking an electrical circuit, be usre the power is OFF. To do this, disconnect the battery ground cable.

CAUTION

After the first 50 hours of operation, retighten the generator cylinder head bolts and check valve clearance.

CAUTION

Any bearing that has been subjected to metal contamination must be closely inspected for matal particles. Metal particles will cause failure of the bearing.

CAUTION

Do not use acid, or acid core solder. Use only rosin core solder.

CAUTION

The maximum torque is not to exceed 350 ft-lbs (475 N-m). Apply heat as necessary to loosen the press fit of the gear if the torque execeeds 350 ft-lbs (475 N-m). When heat is necessary to remove gear, discard the gear.

CAUTION

Place plunger where it will not be damaged, a slight nick can cause extensive damage.

CAUTION

The ST-708-1 must be used with extreme caution when sizing the hi-flow injectors. Do not damage the injector body under the orifice plug.

CAUTION

Wait until the main drive has stopped turning before unclamping the injector.

CAUTION

Do not use an inpact wrench on the barring device to rotate the engine. Also, do not rotate the engine in a counterclockwise direction when the barring device is engaged.

CAUTION

For additional heat sink the POWER SUPPLY board is secured to the central unit frame with eight screws. Remove the screws, then remove the POWER SUPPLY board (see Figure 13C-4).

TECHNICAL MANUAL
No. 10-3950-264-14&P-2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *1 June 1983*

OPERATOR'S ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS AND SPECIAL TOOLS LISTS, AND SUPPLEMENTAL OPERATING MAINTENANCE AND REPAIR PARTS INSTRUCTIONS
For

CRANE, MOBILE, CONTAINER HANDLING, TRUCK MOUNTED, 250-TON CAPACITY, DED, PT HARNISCHFEGER MODEL 6250TC
NSN 3950-01-027-9253

REPORTING OF ERRORS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Tank-Automotive Command, ATTN: DRSTA-MBS, Warren, MI 48090. A reply will be furnished direct to you.

TM 10-3950-264-14&P-1 contains Operator's Manual with SOMARPI

TM 10-3950-264-14&P-3 contains Parts Manual

NOTE

This manual is published to provide an authorized commercial manual for the use of the personnel to whom this Crane is issued.

Crane Manufacturer:
Harnischfeger Corporation
PO Box 554
Milwaukee, WI 53101
Procured Under Contract No. DAAE07-80-C-6070

This technical manual is an authentication of the manufacturers commercial literature and does not conform with the format and content specified in AR 310-3, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

SAFE OPERATING PRACTICES FOR MOBILE CRANE AND EXCAVATOR USERS

INTRODUCTION

NOTE: This material replaces Catalogs 211 and 221.

Harnischfeger cranes and excavators are carefully de-signed, tested, and manufactured. When used properly by qualified operators, they will give safe, reliable service. Harnischfeger has offices world-wide to answer any questions about its products or their safe use.

Because cranes have the ability to lift heavy loads to great heights, they also have a potential for accidents if safe operating practices are not followed. This booklet will help you prevent accidents which could result in injury, death, or property damage.

General safe practices for working on machinery must be followed as well as the safe operating practices recommended here.

OPERATOR'S RESPONSIBILITY

Safety must always be the operator's most important concern. He must refuse to operate when he knows it is unsafe and consult his supervisor when safety is in doubt. He must read and understand the Operator's Manual and see that the machine is in proper order before operating. He must understand how to read the rating plate and know that his machine can safely lift each load before attempting to lift it.

He must be alert, physically fit, and free from the influences of alcohol, drugs, or medications that might affect his eyesight, hearing, or reactions.

He must see that people, equipment, and material are kept out of the work area. The area around the machine should be properly barricaded (see Operating Precautions #4 and 5).

When an operator's vision is blocked or when operating in hazardous areas such as near power lines or around people, a signalman must be used. Because the operator is not in the best position to judge distances and can not see all parts of the jobsite, a signalman may also be necessary at other times. Operators must understand standard crane signals and take signals only from designated signalmen.

SIGNALMAN'S RESPONSIBILITY

The primary duty of a signalman is to assist the operator in safe and efficient operation. Operators depend on designated signalmen to assist them in making movements without endangering people or property.

Signalmen must have a clear understanding of the work to be done so that they can safely coordinate each job with operators and other crew members.

Signalmen must place themselves where they can be clearly seen and where they can safely observe the entire operation.

Standard crane signals must be used unless other methods of signaling such as two way radios or flags have been agreed upon.

RESPONSIBILITIES OF ALL CREW MEMBERS

Any unsafe condition or practice must be corrected or reported to the job supervisor.

Everyone who works around cranes and excavators, including riggers and oilers, must obey all warning signs and watch out for his own safety and the safety of others. Crew members setting up machines or handling loads are expected to know proper machine erection and rigging procedures.

Watch for hazards during operations and alert the operator and signalmen of dangers such as power lines, the unexpected presence of people, other equipment or unstable ground conditions.

MANAGEMENT RESPONSIBILITY

See that operators are trained, competent, physically fit and, if required, licensed. Good vision is required, as are good judgment, coordination and mental ability. Any per-son who lacks any of these qualities must not be allowed to operate a crane or excavator.

Signalmen must have good vision and sound judgment, know standard crane signals and be able to give signals clearly. They must have enough experience to be able to recognize hazards and signal the operator to avoid them.

Riggers must be trained to determine weights and distances and to select and properly use lifting tackle. Rigging is a complex subject far beyond the scope of this booklet. It is management's responsibility to see that riggers are properly trained.

Crew members must be given specific safety responsibilities and instructed to report any unsafe conditions to their supervisors.

PLANNING THE JOB

Most accidents can be avoided by careful job planning. The person in charge must have a clear understanding of the work to be done, consider all dangers at the jobsite, develop a plan to do the job safely, and then explain the plan to all concerned. Factors such as these should be considered:

- What crew members are needed and what responsibilities will they be given?
- What is the weight of the load to be lifted, the lift radius, boom angle, and the rated capacity of the crane?
- How will the signalmen communicate with the operator?
- What equipment is required to do the job safely? Is a crane or excavator the best equipment for the job?
- How can the equipment be safely transported to the jobsite?
- Are there gas lines, power lines or structures which must be moved or avoided?
- Is the surface strong enough to support the machine and load?
- How will loads be rigged?
- What special safety precautions will be taken if a crane must travel with a suspended load or if more than one crane is needed to lift a load? (See Operating Precautions #26, 27 and 28).
- Are unusual weather conditions such as winds or extreme cold expected?
- What steps will be taken to keep unnecessary people and equipment safely away from the work area?
- How can cranes be positioned to use the shortest boom and radius possible?

OPERATOR'S SAFETY CHECK

The operator must make a safety check before starting to work each day to see that the machine is in proper order. Some things to check are:

- Check the machine log book to see that periodic maintenance and inspections have been performed and all necessary repairs made.
- Check the operation of boom hoist kickout, boom angle indicator, backup alarms, and other safety devices.
- Carefully inspect load bearing parts such as wire rope, (load lines, boom hoist cable, suspension lines), boom, outriggers, and hooks.
- Be sure no unauthorized field modifications have been made. Such as added counterweights and booms that have been improperly repaired.
- Check for air and hydraulic oil leaks.
- After starting the engine, check all gauges for proper readings.
- Test all controls for proper operation.
- Check brakes and clutches. Test load brakes by lifting a load a few inches off the ground and holding it.

OPERATING PRECAUTIONS

1. Mistakes in calculating lifting capacity can cause accidents.

Several factors must be considered, including:

A. Load radius (the distance 'between the center of the crane rotation to the center of the load). Note that the radius will increase when the load is lifted.

B. Weight of the load, hook, and rigging.

C. Boom length, jib, parts of line, and operating area (side, rear).

Use the next lower rated capacity when working at boom lengths or radii between the figures on the rating chart. It is dangerous to guess the capacity for boom lengths or radii between those listed on the rating plate.

Trying to lift a load without knowing whether it is within the rated capacity while expecting the crane to start to tip to warn of an overload is very dangerous. Cranes may suddenly tip over or collapse if the load is too heavy.

Always stay within rated capacity. The operator must reduce the load under adverse field conditions until, in his judgment, the machine can safely handle the lift.

(See Operating Precautions #3, 10, 12, 16, 19, 27 and 28.)

2. Cranes and excavators may tip over or collapse if the operating surface cannot support their weight. Timber mats, steel plates or concrete rafts may be needed under outrigger pads or crawlers to distribute the load under the crane so that the bearing strength of the ground is not exceeded.

Determine the load bearing capacity of the ground or other surface on which machines will be operating. Be sure cranes and excavators are adequately supported. Avoid soft or unstable ground, sand, areas with high water tables, and partially frozen ground. When machines are working near trenches the trenches should be shored or sloped to prevent cave-ins or slides.

3. The rated capacity of a crane is determined with the crane leveled within 1% of grade (1 foot drop or rise in 1 00 foot distance). Out of level more than 1% will drastically reduce the lifting capacity.

Be sure cranes are level. All tires must be off the ground for "On Outrigger" ratings.

4. People can be crushed by the scissors-like action of the upper rotating on the lower.

Stay away from rotating cranes and excavators. Erect barricades to keep people away. Take the time to determine that these areas are clear before swinging.

5. People can be crushed by the rear(counterweight) of the machine if there is not enough room for it to swing.

Position machines so that people cannot be trapped between the counterweight and other obstructions.

6. Many people have been injured when riding crane hooks or loads or while being lifted in manbaskets. They have no control over how they are handled and no protection from impacts or falls. Small mistakes can be fatal.

Do not lift people with cranes. Use ladders, scaffolds, elevating work platforms or other equipment designed to lift people, but do not use cranes.

7. Power lines have killed or seriously injured people working around cranes and excavators. These accidents can be avoided by following a few simple rules.

Always determine whether there are power lines in the area before starting any job. OSHA regulations require at least ten (10) feet of clearance from lines carrying 50,000 volts or less. Greater clearances are required for lines with higher voltages. Some states require greater clearances than OSHA. Safety requires that you stay as far as possible from power lines and never violate minimum clearances.

Always take these precautions if power lines are present.

A. Notify the Power Company before beginning work.

B. You and the Power Company must take specific precautions. These may include locating cranes and materials away from power lines, de-energizing and grounding lines, rerouting lines, removing or barricading lines, and insulating lines with rubber sleeves.

C. Use a signalman to maintain a safe distance between any part of the machine or load and power lines. The operator is not in the best position to judge distances.

D. Warn people to stay away from the machine and load at all times. If the load must be guided into place, ask the Power Company about special precautions such as insulated poles or hot sticks.

E. Slow down. Give yourself time to react to problems and to double check the distance between power lines and any part of the machine or load.

WARNING

Careful planning and supervision offer better protection than any known device. Insulated boom cages, proximity warning devices and insulating links have limitations and can fail without warning. Insulated boom cages and links only protect part of the crane and can break down electrically when contaminated with dust and water. Proximity warning devices can be confused by different arrange-ments of power lines, the movement of trucks, materials and the crane itself and other influences. Relying on any of these devices could be dangerous because operators may think they are providing protection when in fact they are not.

8. The load line can break if the hook block contacts the end of the boom. This is called "two blocking"' Two blocking can be caused by hoisting the hook into the end of the boom, lowering the boom or extending telescopic booms without paying out load line. Two blocking can pull jibs and lattice crane booms over backwards.

Always keep space between the hook block and boom point. Lower the hook when extending telescopic booms to avoid two blocking.

9. People can be injured if the hook, boom, load or outriggers are moved before everyone is clear.

Make sure everyone is in a safe place before moving the hook, boom, load or outriggers. Do not move loads over people. Do not allow the load to bump or catch on anything.

10. Rapid swings or sudden starts and stops can cause the hook and attached load to swing out of control.

Always start and stop movements smoothly and swing at speeds that will keep the load under control.

11. Dirty windows, darkness, bright sunlight, fog, rain, and other conditions can make it difficult for the operator to see.

Keep windows clean. Do not operate if you cannot see clearly enough to operate safely.

12. Even light winds can blow loads out of control, collapse booms, or tip machines. Winds aloft can be much stronger than at ground level.

Do not lift loads if winds create a hazard. Lower the boom if necessary. See the rating plate for possible restrictions.

13. Carelessness in getting on and off equipment can result in serious injuries.

Always wait until the machine has stopped. Do not jump on or off. Always use both hands and make sure you have good footing.

14. Slippery floors and steps, tools, trash, or other loose items can cause falls.

Keep the machine clean and dry.

15. Damaged crane booms may collapse. Lattice type booms will be weakened by damaged chords, bent or missing lacings, or cracked welds. Telescopic booms will be weakened by distorted bottom or side plates. In either case, the loss of strength is difficult to estimate.

Inspect the crane boom daily for damage. Do not use damaged booms.

NOTE

Due to the high strength steels used in booms, special repair procedures are required. Repair procedures for lattice booms are described in Harnischfeger Catalog 238. Consult Harnischfeger for further information.

16. Crane booms can buckle if side loaded (pulled side-ways). Typical causes of side loading are rapid starts and stops while swinging, dragging a load sideways, winds, or lifting when the crane is not level.

Take care to avoid side loading.

17. If the load strikes the boom or the boom hits a building or other object, the boom may collapse.

Never let the load or any other object strike the boom.

18. Boom suspension lines will stretch when the load is lifted and contract when the load is released. At high boom angles this may be enough to pull the boom backward over the crane.

When releasing loads be sure the boom never tightens against the backstops. Release loads slowly.

19. The load will swing out of control if it is not directly beneath the boom point when lifted. This can side load the boom and may cause the crane to tip or collapse.

Always place the boom point directly above the load when lifting.

20. Trying to lift a load which is stuck, frozen or attached to something else may result in tipping, boom collapse or other damage.

Be sure that loads are free before lifting.

21. If there is not enough wire rope on the drum the rope can be pulled off.

Keep at least two full wraps of wire rope on drums when operating.

22. Foot pedal brake locks are furnished on some cranes to allow the operator to rest his legs when suspending the load for short periods of time.

Keep your feet on the pedals while foot pedal brake locks are in use. Brakes may cool allowing the load to fall.

23. Trying to repair or adjust equipment with a suspended hook or load or with the boom raised could release ma-chinery and let it move unexpectedly.

Always lower the load to the ground and the boom onto proper cribbing before doing maintenance or repair work.

24. Pressure in hydraulic systems can be retained for long periods of time. If not properly released before mainte-nance people attempt to work on the hydraulic systems this pressure can let machinery move or cause hot oil and hose ends to shoot out at high speed.

Release system pressure before attempting to make adjustments or repairs.

25. Pin-connected booms and jibs may fall if not properly supported when removing pins.

Make sure both ends of each boom and jib section are supported and the boom suspension lines completely slacked off before removing pins. Never stand on, inside, or under booms or jibs during assembly or disassembly.

26. As with all heavy equipment, care must be taken when cranes or excavators are driven (traveled) whether on or off the jobsite.

Watch for people, power lines, low or narrow clearances, bridge or road load limits, and steep hills or uneven terrain. Use a signalman in close quarters. Know the height, width, and weight of your machine. Retract and lock outriggers, place the boom in the cradle, and set swing brake or lock before travelling.

27. Load ratings for cranes are based on the machine being stationary and level. Traveling a crane with a suspended load or with the boom erected involves special hazards, including the possibility of side loading or tipping over.

Because of the many variables involved in pick and carry operations, the user must evaluate conditions and take precautions such as these:

- Follow the travel precautions listed in rule 26.
- Check the rating plate for limitations.
- Position the boom in line with the direction of travel.
- Reduce the maximum load while traveling to reflect operating conditions. The safe load will vary depending on speed, crane, terrain, and other conditions.
- Inflate tires to specified pressure.
- Travel slowly and avoid sudden stops and starts.
- Avoid backing away from the load. This could increase the radius and cause the machine to tip over.
- Use tag lines to keep loads under control.
- Keep the load close to the ground.
- Use the shortest boom possible.

28. Using two or more cranes to lift a load involves many hazards not normally encountered in single crane lifts.

Multi-crate units must be carefully engineered, keeping the following points in mind.

- Since the load is not freely suspended, careful engineer-ing studies must be made to ensure that the load carried by each machine is less than its rated capacity.
- Make sure slings are arranged to divide the load as planned.
- Review the lifting plan with operators, signalmen and other crew members before beginning the lift.
- Carefully coordinate crane movements through every stage of the lift.
- Avoid boom side loading (see #16).

29. Leaving a machine unattended can be very dangerous.

Before leaving his seat, the operator must take the following steps to prevent his machine from moving:

- Lower the load or bucket to the ground. Lower the boom when necessary.
- Set the swing brake or lock.
- Set all drum pawls.
- Set parking brakes.
- Set propel brakes or locks on crawler machines.
- Disengage the engine clutch or shut off the engine.

30. All wire rope must be inspected daily to determine whether it should be replaced. See the inspection form in the Operator's Manual and contact wire rope manufacturers and their distributors for more information.

Wire rope should be replaced when any of the following conditions exist:

- In running ropes, six broken wires in one lay or three broken wires in one strand in one lay.
- Wear of one-third the original diameter of the outside individual wires.
- Evidence of heat damage from any cause.
- Reductions from nominal diameter of more than -
  1/32 inch for diameters 3/8 to 1/2 inch.
  3/64 inch for diameters 9/16 to 3/4 inch.
  1/16 inch for diameters 7/8 to 1-1/8 inches.
  3/32 inch for diameters 1-1/4 to 1-1/2 inches.
- In standing ropes, more than two broken wires in one lay in sections between end connections or more than one broken wire at an end connection.
- Evidence of kinking, bird caging, crushing, cuts, abrasions, sharp bends or any other damage that results in distortion of the rope structure.
- Rust or corrosion.

WARNING

Do not use your hands to guide wire rope onto drums.

31. Improper wire rope connections may fail under load.

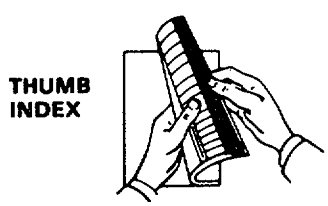
Wire rope end connections must be installed properly and inspected daily.

- Wedge sockets should be installed so that the loaded side of the rope is in a straight line with the edge of the socket and not bent by the wedge. Prevent the rope end from slipping out of the wedge socket by attaching a short piece of rope to the rope end with two U-bolt clamps.
- U-bolt clamps (clips) should be installed so that the U-bit is on the unloaded side and the saddle is on the loaded side.

TABLE OF CONTENTS

HOW TO USE THIS SHOP MANUAL

This Shop Manual is divided into the major sections shown above. Each major section can be located using the margin tab marks on the right edge of this page as shown in sketch. At the beginning of each major section is a Table of Contents which identifies the topics covered in that section.



LIST OF FOLDOUTS

SHOP MANUAL
LIST OF CHARTS AND TABLES

DESCRIPTION PAGE NO.

SHOP MANUAL
LIST OF CHARTS AND TABLES

DESCRIPTION PAGE NO.

SHOP MANUAL
LIST OF ILLUSTRATIONS

SHOP MANUAL
LIST OF ILLUSTRATIONS

SHOP MANUAL
LIST OF ILLUSTRATIONS

SHOP MANUAL
LIST OF ILLUSTRATIONS

SHOP MANUAL
LIST OF ILLUSTRATIONS

SHOP MANUAL
LIST OF ILLUSTRATIONS

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SHOP MANUAL
LIST OF ILLUSTRATIONS

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LIST OF ILLUSTRATIONS

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LIST OF ILLUSTRATIONS

SHOP MANUAL
LIST OF ILLUSTRATIONS

SHOP MANUAL
LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS

SECTION I
INTRODUCTION

List of Items Furnished 1-14
List of Items Required 1-15
Replacement Parts 1-16

SECTION I

INTRODUCTION

SCOPE

This manual provides maintenance personnel with information and instructions for servicing and repairing this machine. In order to become familiar with the various parts of the machine, it is urged that maintenance personnel study the instructions and illustrations in this manual and use it as a reference when performing repair or maintenance operations. An Operators Manual is provided with each machine to provide the essential information regarding day-to-day maintenance, adjustment, and lubrication of the machine.

NOTE

Sections I, II and III of the Operators Manual have been duplicated as the first three sections of this manual to provide maintenance personnel with the tabulated data, controls and operation, and lubrication information that may be necessary in the performance of repair or maintenance operations.

GENERAL INFORMATION

The information, specifications and illustrations in this publication are based on the information for U.S. built machines in effect at the time this manual was printed. Continuing improvement and advancement of product design may cause changes to your machine which may not be included in this publication. Each publication is reviewed and revised, as required, to update and include these changes in later editions.

Whenever a question arises regarding your machine, orthis publication, please consult your Harnischfeger representative for the latest available information. Part numbers are used occasionally in this manual to identify various parts and assemblies. The part numbers shown must not be used when ordering repair parts. Al- ways obtain part numbers from the Repair Parts Manual for your machine serial number.

SERIAL NUMBER LOCATION

Figure 1-1 illustrates the machine serial number which is located on the front right side of the revolving frame between the boom foot and mast lugs. Always indicate the machine serial number in all correspondence to properly identify the machine, and to ensure that the correct parts are obtained, when ordered.

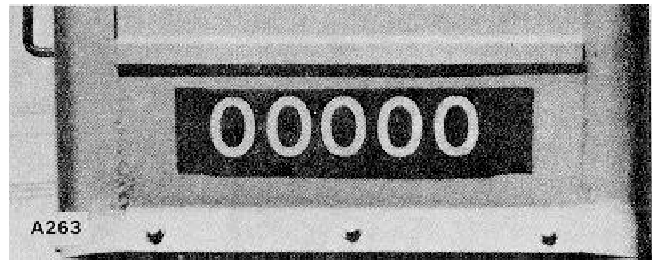


Figure 1-1. Machine Serial Number

WARRANTY

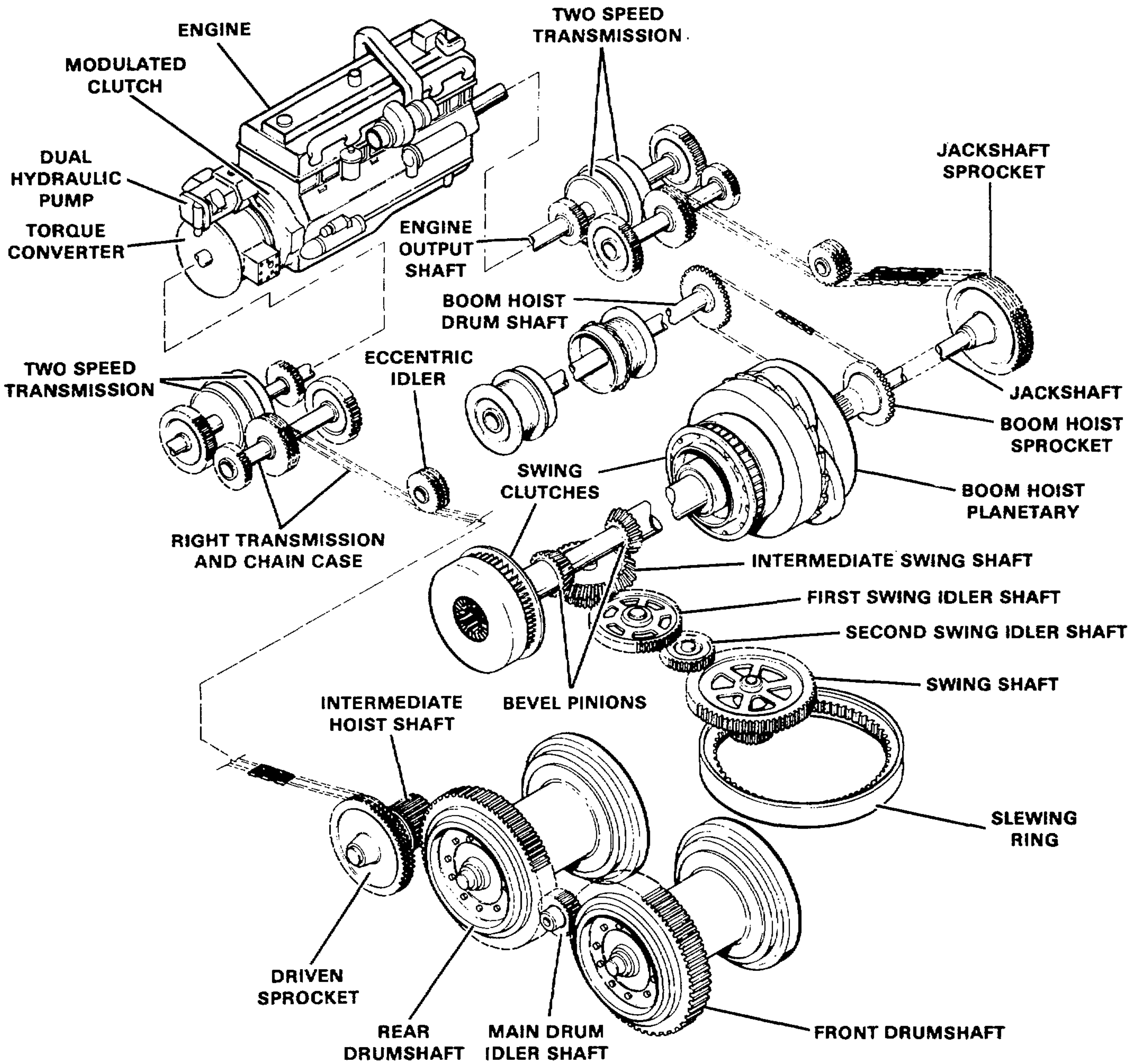
The terms under which this machine is guaranteed are clearly defined under the warranty which accompanies every Harnischfeger product.

This warranty will be voided if the machine is operated with loads in excess of the rating plate maximum, under unsafe operating conditions, or with accessories or attachments not designed and furnished, or approved by the Harnischfeger Corporation. Modifications made upon the machine which will affect its operation will void the warranty.

DESCRIPTION

This truck crane is a friction machine. All upper work functions, except the swing motion, are performed by friction clutches and brakes. Hydraulic cylinders are used to apply the clutches, brakes, and pawls to raise, lower, or hold the boom (or mast), main hoist lines, and jib lines. Hydraulic cylinders are also used to raise or lower the gantry and to apply the swing brake.

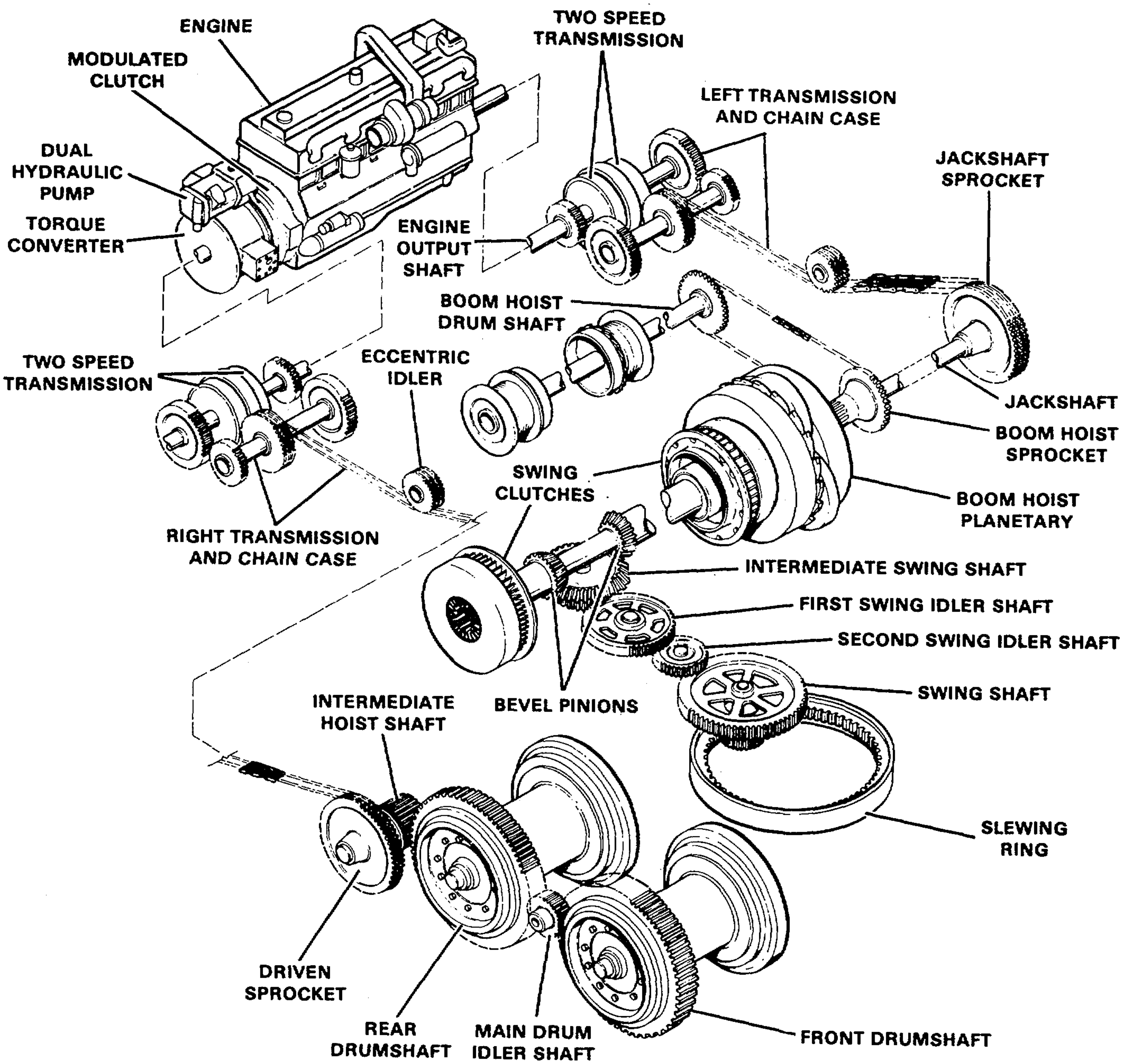
Direct current flow to two Magnetorque® swing clutches, swing (revolve) the upper of the machine on the carrier. The swing clutches are eddy current clutches which allow the operator to control the amount of swing power by varying the current through the clutches. When the operator applies excitation to the swing clutches, magnetic attraction between the inner and outer members cause the inner member to rotate with the outer member. (See Figure 1-2.)



NOTE 1: END OF SWING CLUTCH SHAFT EXTENDS THROUGH BOOM HOIST SPROCKET.

NOTE 2: MANY ITEMS HAVE BEEN MOVED IN ORDER TO SHOW THE OPERATION OF THE MACHINE MORE CLEARLY.

Figure 1-2. Power Train Schematic



NOTE 1: END OF SWING CLUTCH SHAFT EXTENDS THROUGH BOOM HOIST SPROCKET.

NOTE 2: MANY ITEMS HAVE BEEN MOVED IN ORDER TO SHOW THE OPERATION OF THE MACHINE MORE CLEARLY.

Figure 1-2. Upper Power Train Schematic

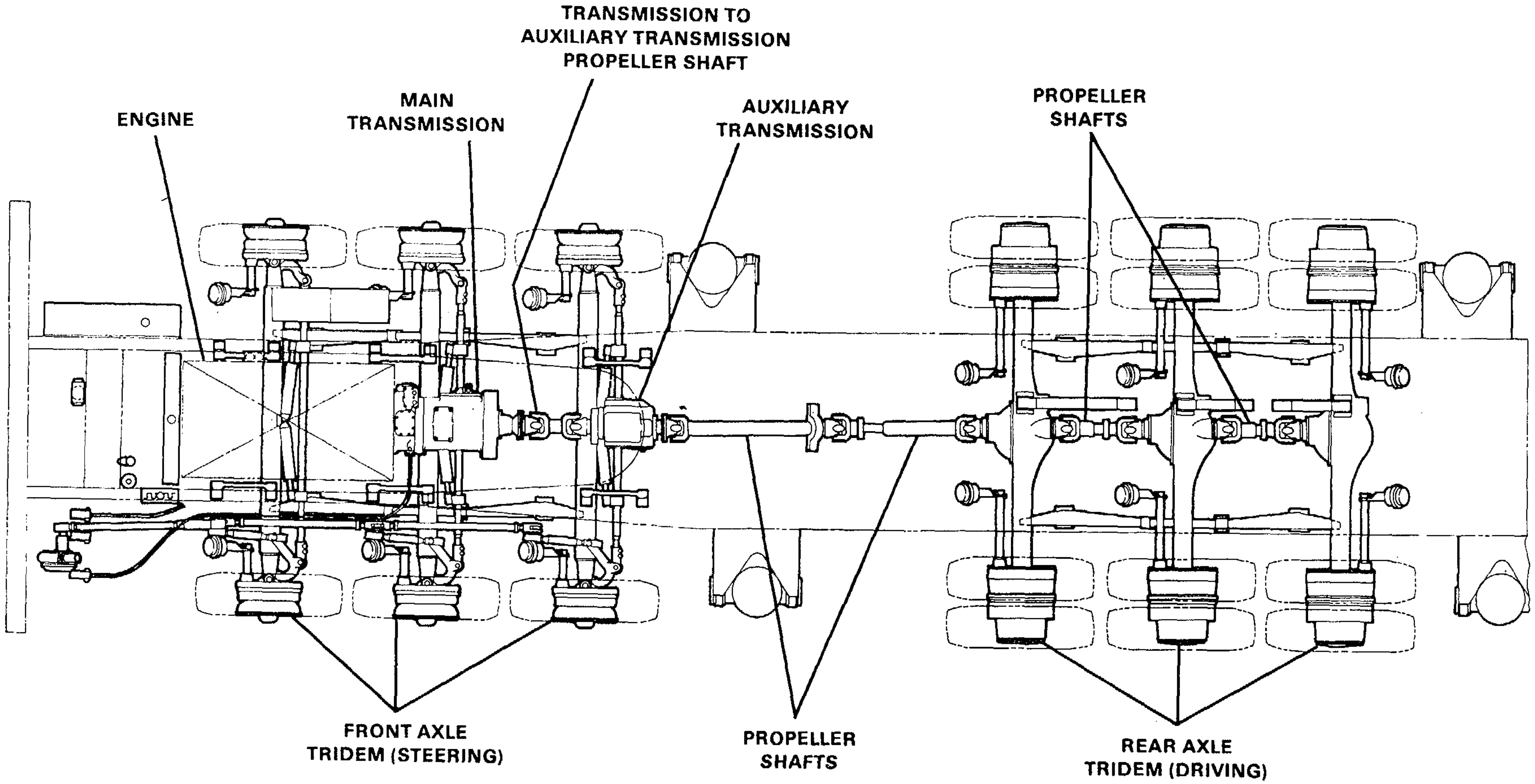


Figure 1-3. Carrier Power Train

The generator engine serves as the power supply for the generator which in turn supplies (generator) electricity for the machine and boom lights.

TERMINOLOGY

Certain terms are frequently used in this manual. For better understanding, several are defined below and illustrated in Figure 1-4.

CARRIER (LOWER): The carrier is the supporting base on which the upper machinery is mounted.

UPPER (SUPERSTRUCTURE): The upper is defined as the revolving portion of the mobile crane.

REVOLVING FRAME: The revolving frame is the deck of the upper on which all upper machinery is mounted.

CARRIER MACHINE FRONT: This is the end of the carrier where the operators cab and engine are located.

CARRIER MACHINE REAR: This is the end of the carrier opposite the operators cab and engine.

UPPER MACHINE REAR: The rear of the upper is the counterweight end:

UPPER MACHINE FRONT: The front of the upper is the end having the boom.

RIGHT SIDE: The right side of the machine is to the operator's right when he is seated at the controls and is facing forward.

LEFT SIDE: The left side of the machine is to the operator's left when he is seated at his controls and is facing forward.

ATTACHMENT: An alternate designation for front end equipment. In the case of the mobile crane, it includes the gantry, boom, mast if equipped, backstops, and jib.

HOIST: The process of lifting the load.

SWING: Swing is defined as the function of revolving the upper of the machine.

BOOM HOIST: The process of raising and lowering the boom.

CHARTS AND DIAGRAMS

AXLE LOADING CHART (8105N67). This chart includes information on total weight of machine and attachments. The columns across the top of the chart give the total weight or adjustment and then breaks the information down to whether the boom is over the front of carrier or over rear of carrier and what the weight is over the front tridem and rear tridem for each of the two categories (boom over front of carrier). Information is also given as to what effect removing items would have on the weight distribution. Example: Effect of removing counterweight #3. The total weight adjustment (from chart) is a negative 30,520 pounds (13843.9 Kg). If the boom were over the front of the carrier the removing of counterweight #3 would add 22703 lbs. (10298.1 Kg) to the front tridem axle and would remove 53,223 lbs. (24140.0 Kg) from the rear tridem axle. Using the same effect of removing counterweight #3 and the boom were over the rear of the carrier, removing the counterweight would remove 29,117 lbs. (13207.5 Kg) from the front tridem and remove 1403 lbs. (636.4 Kg) from the rear tridem axle. The information provided is useful for meeting road requirements when traveling and for consideration of ground load bearing requirements when working the machine.

RANGE DIAGRAM. This diagram is used in conjunction with the capacity chart to calculate the radius from center of rotation. Example: 210 feet of boom at a 60P boom angle. Start at 210 feet boom arc and follow it to 600 boom angle and drop down to read a 110 foot radius from center of load to center of machine rotation.

GENERAL DIMENSIONS. Use this drawing to calculate such things as TAIL SWING, GROUND CLEARANCE, OVER-HEAD CLEARANCE, OVERALL LENGTH, OVERALL WIDTH, etc.

TORQUE VALUES. This chart gives information on torque values for several grades of capscrews (across top of chart, Grade 1 or 2 and Grade 5) and for various sizes of bolts.

ENGLISH TO METRIC CONVERSIONS. This is for reference only. Most English units in the manual are converted to common metric usage. The metric conversion follows the English unit and is in parenthesis behind the English unit. Use this chart to convert English to metric units. Example: Convert 120 lbs per square inch (psi) to kilopareals (kPa). 120 psi x 6.895 = 827 kPa.

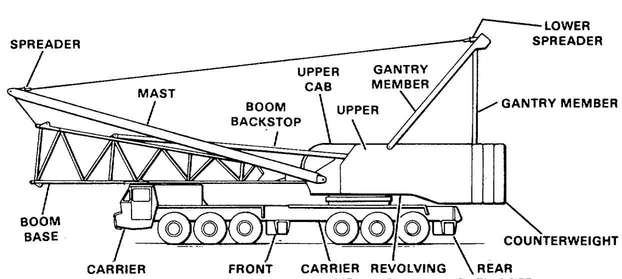


Figure 1-4. Truck Crane Terminology

TABLE 1-1. AXLE LOADING CCHART (8105N67)

Description of Item(s)	Total Weight or Adjustment		Boom Over Front of Carrier				Boom Over Rear of Carrier			
			Front Tridem Weight		Rear Tridem Weight		Front Tridem Weight		Rear Tridem Weight	
	Lbs	Kg	Lbs	Kg	Lbs	Kg	Lbs	Kg	Lbs	Kg
Basic Machine Including:										
Carrier										
Upper										
Module										
Mast										
Gantry (Horizontal Position)										
Aux. Platforms (4)										
1.000 In. Dia. x 1010 Ft. Cable (Boom Hoist)										
Fuel In Carrier (65 Gal.)										
Fuel In Upper (80 Gal.)										
Upper Spreader										
Lower Spreader*	244080	110714.7	40360	18307.3	203720	92407.4	72480	32876.9	171600	77837.8
Basic Machine Plus:										
40 Ft. Boom Base Section										
Backstop Assembly*	253220	114860.6	48640	22063.1	204580	92797.5	65740	29819.7	187480	85040.9
Complete Basic Machine Including:										
Carrier										
Upper										
70 Ft. Basic Boom (LDT)										
Backstop Assembly										
Counterweights (3)										
Module										
Mast										
Gantry (Intermediate Position)										
Auxiliary Platforms (4)										
1.000 In. Dia. x 1010 Ft. Cable (Boom Hoist)										
1.250 In. Dia. x 700 Ft. Cable (Load Hoist)										
Fuel In Carrier (65 Gal.)										
Fuel In Upper (80 Gal.)										
Upper Spreader										
Lower Spreader										
3 Sheave Bottom Block*	358539	162633.3	12880	5842.4	345659	156790.9	129540	58759.3	228999	103873.9
Effect of Removing:										
Counterweight #3	-30520	-13843.9	22703	10298.1	-53223	-24140.0	-29117	-13207.5	-1403	-636.4
Counterweight #2	-31020	-14070.7	21172	9603.6	-52192	-23674.3	-27690	-12560.2	-3330	-1510.5
Counterweight #2 & #3	-61540	-27914.5	43875	19901.7	-105415	-47816.2	-56807	-25767.7	-4733	-2146.9
Counterweight #1	-31020	-14070.7	19092	8660.1	-50112	-22730.8	-25611	-11617.1	-5409	-2453.5
Counterweight #1, #2 & #3	-92560	-42026.0	62967	28561.8	-155527	-70547.0	-82418	-37384.8	-10142	-4600.4
O/R Beams (Std.) - Frt. (2)	-6680	-3030.0	-3984	-1807.1	-2696	-1222.9	-3984	-1807.1	-2696	-1222.9
O/R Beams & Horizontal Cyl. - Frt. (2)	-6920	-3138.9	-4128	-1872.5	-2792	-1266.5	-4128	-1872.5	-2792	-1266.5
O/R Boxes, Beams & Horiz. Cyl. - Frt. (2)*	-12675	-5749.4	-7960	-3610.7	-4735	-2147.8	-7960	-3610.7	-4735	-2147.8
O/R Boxes, Beams, Horiz. & Vert. Cyl. - Frt. (2)	-14715	-6674.7	-8777	-3981.2	-5938	-2693.5	-8777	-3981.2	-5938	-2693.5
O/R Beams (Std.) - Rear (2)	-6680	-3030.0	2665	1208.8	-9345	-4238.9	2665	1208.8	-9345	-4238.9
O/R Beams & Horizontal Cyl. - Rear (2)	-6920	-3138.9	2761	1252.4	-9681	-4391.3	2761	1252.4	-9681	-4391.3
O/R Boxes, Beams & Horiz. Cyl. - Rear (2)*	-12750	-5783.4	5400	2449.4	-18150	-8232.8	5400	2449.4	-18150	-8232.8
O/R Boxes, Beams, Horiz. & Vert. Cyl. - Rear (2)*	-14790	-6708.7	5901	2676.7	-20691	-9385.4	5901	2676.7	-20691	-9385.4
70 Ft. Basic Boom Including:										
40 Ft. Boom Base										
30 Ft. Light Duty Tip										
Tip Guy Lines (2)										
Upper Spreader										
Boom Backstops	-1837	-833.3	-33965	-15406.5	15590	7071.6	30210	13703.3	-48585	-22038.2
30 Ft. Light Duty Tip Including:										
Tip Guy Lines (2)	-7415	-3363.4	-21032	-9540.1	13617	6176.7	19545	8865.6	-26960	-12229.1
40 Ft. Boom Base Including:										
Upper Spreader										
Boom Backstop	-10960	-4971.5	-12934	-5866.9	1974	895.4	10667	4838.6	-21627	-9810.0
Mast (Horizontal Position)	-5760	-2612.7	-8598	-3900.0	2838	1287.3	7387	3350.7	-13147	-5963.5
Basic Upper Including:										
Gantry (Horizontal Position)										
Module										
Aux. Platforms										
Fuel (80 Gal.)	-106685	-48392.3	17344	7867.2	-124029	-65259.6	-39763	-18036.5	-66922	-30355.8
Slewing Ring & Bolts	-7470	-3388.4	-785	-356.1	-6685	-3032.3	-785	-356.1	-6685	-3032.3
Module	-1520	-689.5	-424	-192.3	-1096	-497.1	-105	-47.6	-1625	-737.1
Aux. Platforms (4)	-825	-374.2	-229	-103.9	-596	-270.3	56	25.4	-881	-399.6

TABLE 1-1. AXLE LOADING CART (8105N67) - Continued

Description of Item(s)	Total Weight or Adjustment		Boom Over Front of Carrier				Boom Over Rear of Carrier			
			Front Tridem Weight		Rear Tridem Weight		Front Tridem Weight		Rear Tridem Weight	
	Lbs	Kg	Lbs	Kg	Lbs	Kg	Lbs	Kg	Lbs	Kg
Basic Carrier Including: 1400 x 24-24 PR Tires (18) Hydraulic O/R Assembly Slewing Ring Fuel (65 Gal.)*	127420	57797.7	44100	20003.8	83320	37793.9	44100	20003.8	83320	37793.9
Effect of Adding:										
Malkiel Float Assembly	58000	26308.8	9835	4461.2	48165	21847.6	9835	4461.2	48165	21847.6
Front Bumper Counterweight	30000	13608.0	44458	20166.1	14458	6558.1	44458	20166.1	14458	6558.1
Miscellaneous Weights:										
Cable - 1.000 In. Dia. (Lb./Ft.)	1.848	0.838								
Cable - 1.125 In. Dia. (Lb./Ft.)	2.340	1.061								
Cable - 1.375 In. Dia. (Lb./Ft.)	3.972	1.802								
Bottom Block (1 Sheave - 30 T.)	2300	1043.3								
Bottom Block (3 Sheave - 125 T.)	3190	1447.0								
Bottom Block (6 Sheave - 250 T.)	5600	2540.2								

ALLOWABLE LOAD/TIRE @ 100 PSI (6.89 BARS)**

Tire Size	0-1.5 MPH (0-2.4 kms/hr)	1.5-5 MPH (2.4-8.0 km/hr)	5-10 MPH (8.0-16.1 km/hr)
1400x24-L (20PR)	29170 lbs (13231.5 kg)	18670 lbs (8468.7 kg)	16040 lbs (7275.7 kg)
1400x24-N (24PR)	29170 lbs (13231.5 kg)	18670 lbs (8468.7 kg)	16040 lbs (7275.7 kg)

10-20 MPH (16.1-32.2 km/hr)	20-30 MPH (32.2-48.3 km/hr)	30-40 MPH (48.3-64.4 km/hr)	40-50 MPH (64.4-80.5 km/hr)
12980 lbs (5887.7 kg)	12120 lbs (5497.6 kg)	11480 lbs (5207.3 kg)	10730 lbs (4867.1 kg)
12980 lbs (5887.7 kg)	12120 lbs (5497.6 kg)	11480 lbs (5207.3 kg)	10730 lbs (4867.1 kg)

*Actual scaled weights from "Truck Crane Weights" Dates: 8-17-73, 10-3-73, 1-9-74.
**To obtain total allowable axle load, multiply the allowable single tire load by the number of tires per axle.

NOTE: The structural material used to fabricate this model has a nominal weight tolerance of ±3%. Therefore, the weight data provided should be used for reference only. To insure that any specific configuration meets local highway regulations, it is suggested that the calculated weight distribution be varied by actual scaled weights.

TABLE 1-2
LIQUID CAPACITIES (U.S. AND METRIC UNITS)

CARRIER
Fuel Tank (standard).................. 130 gallons (492 1)
Auxiliary Transmission ....15 pints (7.1 1)
Main Transmission .... 20 gallons (75.7 1)
Steering Gear....................................2.5 pints (1.2 l)
Steering/Outrigger Hydraulic Oil
  Initial Fill .... 75 gallons (283.9 1)
  Change .... 36 gallons (136.3 1)
Engine Cooling System
  Total Capacity.................. 26.5 gallons (100.3 1)
  Radiator Only..................... 16.5 gallons (62.5 1)
Engine Lube Oil, including filters
  Initial Fill .... 16.5 gallons (62.5 1)
  Change .... 15.5 gallons (58.7 1)
Axles
  Rear Axle Bowl (each) ....35 pints (16.6 1)
  Planetary Hubs, each end...........16 pints (7.6 1)

UPPER
Fuel Tanks (each) .... 78 gallons (295.2 1)
Engine Cooling System (engine, radiator and heat exchangers)
  Cummins KT 1150 (includes surge tank).......................... 27 gallons (102.2 1)
Engine Lube Oil, including filters and heat exchanger
  Cummins KT 1150 .... 15.5 gallons (58.7 1)
Torque Converter Reservoir...... 74 gallons (280.1 1)
Transmission Reservoir............. 50 gallons (189.3 1)
Drum Gear Case .... 12 gallons (45.4 1)
Boom Hoist Chain Case .... 2 gallons (7.6 1)
Hydraulic Control System Reservoir (includes lines and valves) .... 8 gallons (30.3 1)
Swing Deck Gear Case .... 40 gallons (151.4 1)
Bevel Gear (Swing) Case............. 14 gallons (53.0 l)
Generator Engine Oil ....6 pints (2.8 1)

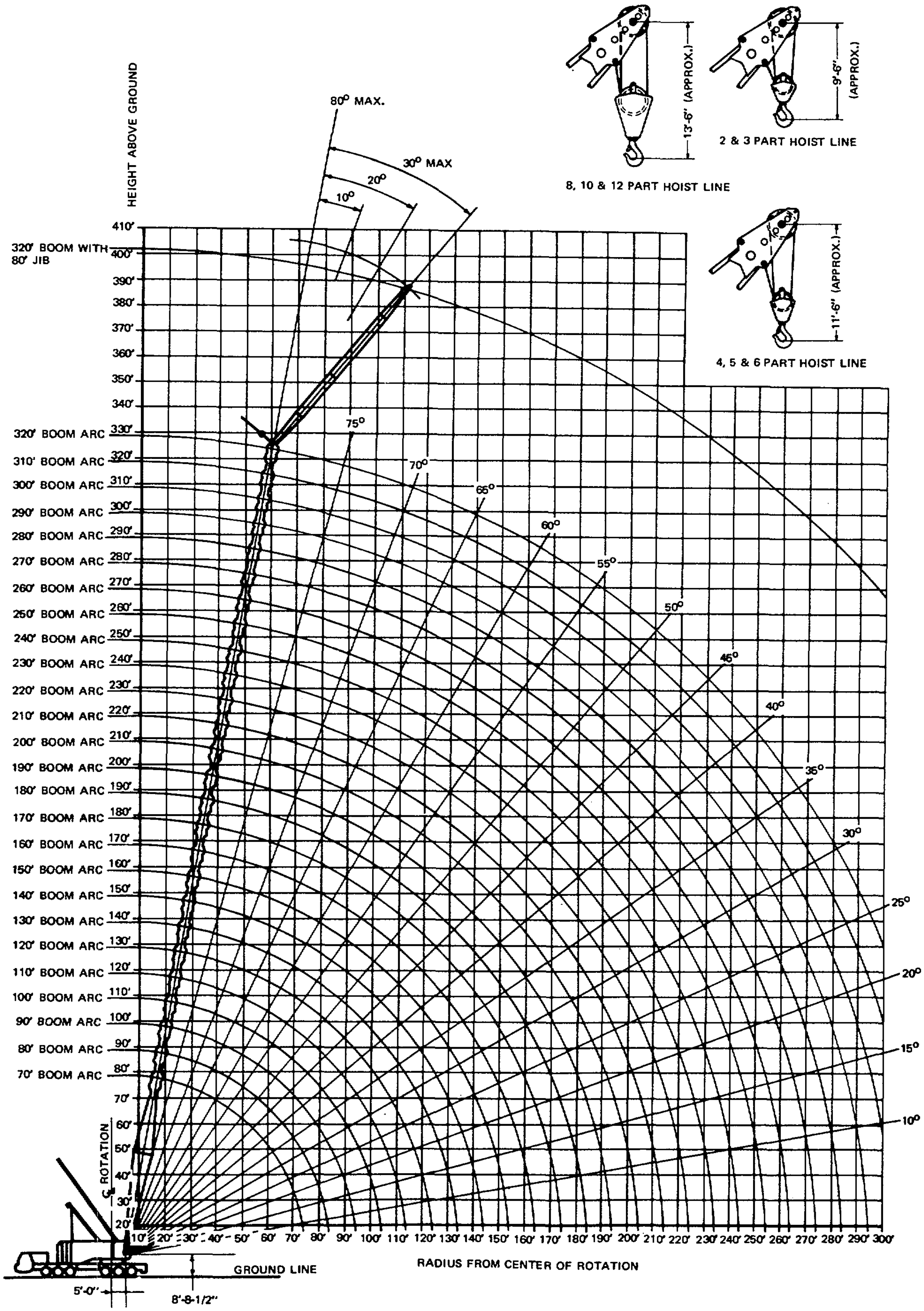


Figure 1-6. Range Diagram (105J641)

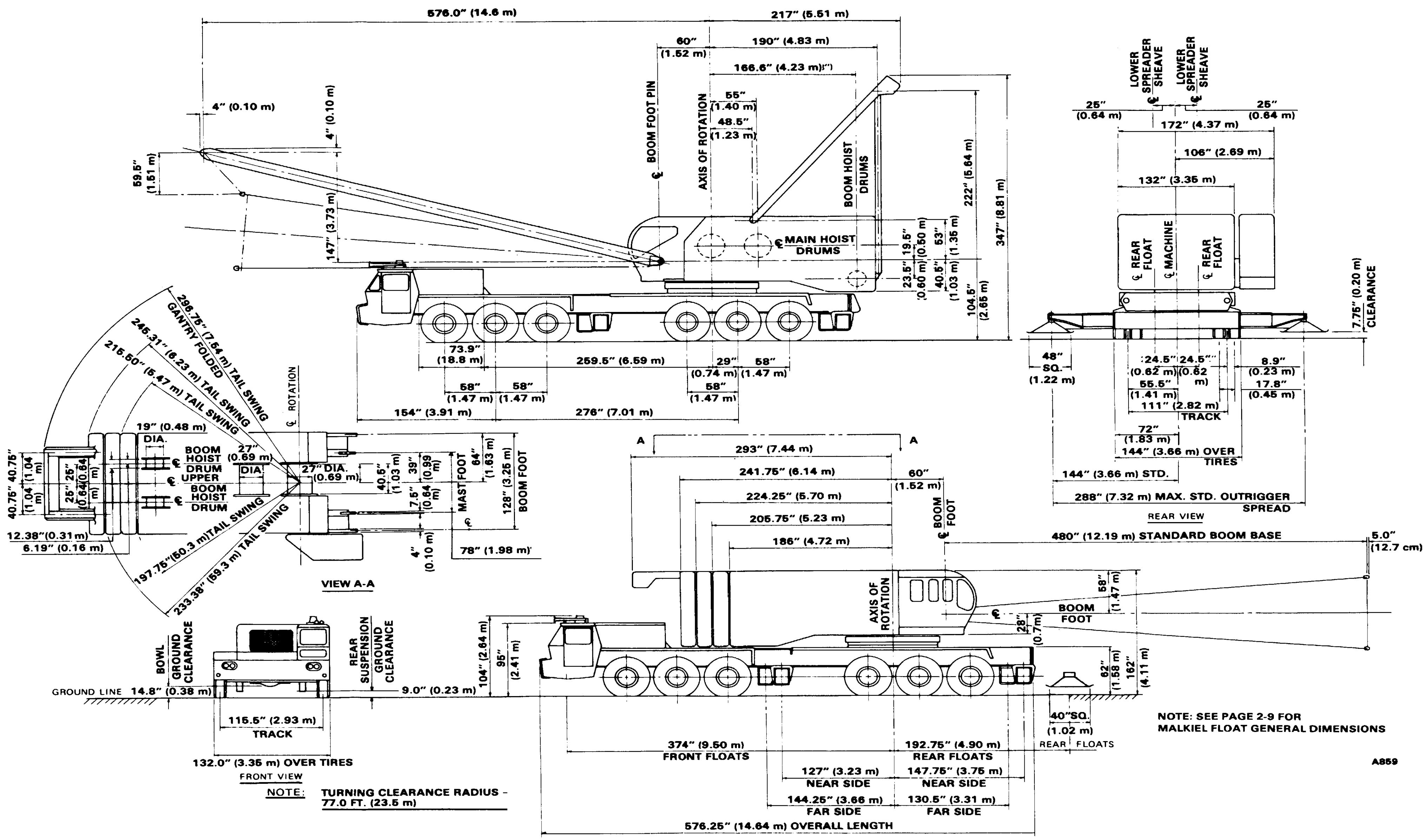


Figure 1-5. General Dimensions (8105J274)

TABLE 1-3

TORQUE VALUES
Unless otherwise specified, use the torque values listed below for tightening all common screws and bolts on this machine. Refer to the engine manufacturer's manual for engine torque values.

GRADE MARKING	 1 or 2		 5	
SAE Grade No. Bolt Body Size (inches) (thread)	* Torque		* Torque	
	Minimum Ft-lbs (kg-m)	Maximum Ft-lbs (kg-m)	Minimum Ft-lbs (kg-m)	Maximum Ft-lbs (kg-m)
1/4-20	4 (0.6)	6 (0.8)	7 (1.0)	9 (1.2)
1/4-28	5 (0.7)	7 (1.0)	9 (1.2)	11 (1.5)
5/16-18	10 (1.4)	12 (1.7)	16 (2.2)	18 (2.5)
5/16-24	12 (1.7)	14 (2.0)	18 (2.5)	20 (2.8)
3/8-16	17 (2.4)	19 (2.6)	30 (4.1)	32 (4.4)
3/8-24	19 (2.6)	21 (2.9)	34 (4.7)	36 (5.0)
7/16-14	27 (3.7)	29 (4.0)	48 (6.6)	50 (7.0)
7/16-20	29 (4.0)	31 (4.9)	54 (7.5)	56 (7.7)
1/2-13	38 (5.3)	40 (5.5)	73 (10.1)	77 (10.6)
1/2-20	40 (5.5)	42 (5.8)	83 (11.5)	87 (12.0)
9/16-12	50 (7.0)	52 (7.2)	105 (14.5)	115 (16.0)
9/16-18	54 (7.5)	56 (7.7)	115 (16.0)	125 (17.3)
5/8-11	81 (11.2)	85 (11.8)	145 (20.1)	155 (21.4)
5/8-18	93 (12.9)	97 (13.4)	165 (22.8)	175 (24.2)
3/4-10	100 (13.8)	110 (15.2)	265 (36.6)	275 (38.0)
3/4-10	110 (15.2)	120 (16.6)	290 (40.1)	300 (41.5)
7/8- 9	155 (21.4)	165 (22.8)	390 (54.0)	400 (55.3)
7/8-14	170 (23.5)	180 (24.9)	425 (58.8)	440 (60.9)
1- 8	230 (31.8)	240 (33.2)	580 (80.2)	600 (83.0)
1-14	240 (33.2)	250 (34.6)	650 (89.9)	670 (92.7)

*The above values are for threads lubricated with SAE 30 oil.

TABLE 1-4
ENGLISH TO METRIC CONVERSIONS

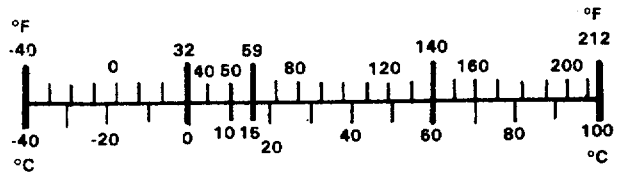
Multiply	by	to get equivalent number of:
LENGTH		
Inch	25.4	millimeters (mm)
Foot	0.304 8	metres (m)
Yard	0.914 4	metres
Mile (Statute)	1.609	kilometres (km)
AREA		
Inch^2	645.2	millimetres2 (mm2)
	6.45	centimetres2 (cm2)
Foot^2	0.092 9	metres2 (m2)
Yard^2	0.836 1	metres2
VOLUME		
Inch^3	16 387.	mm3
16.387	cm3	
	0.016 4	litres (l)
Quart	0.946 4	litres
Gallon	3.785 4	litres
Yard^3	0.764 6	metres3 (m3)
MASS		
Pound	0.453 6	kilograms (kg)
Ton (Short)	907.18	kilograms
Ton (Short)	0.907	tonne (t)
FORCE		
Kilogram	9.807	newtons (N)
Ounce	0.278 0	newtons
Pound	4.448	newtons

TEMPERATURE

OF = 9 (oC +32)

C= (OF -32)

Multiply	by	to get equivalent number of:
TORQUE		
in-lbs	0.112 98	newton-metres (N.m)
ft-lbs	1.355 8	newton-metres
ft-lbs	0.138 3	kg-m
POWER		
Horsepower	0.746	kilowatts (kW)
PRESSURE OR STRESS		
Inches of mercury	3.377	kilopascals (kPa)
Inches of water	0.249 1	kilopascals
Pounds/sq. in. (psi)	6.895	kilopascals
Pounds/sq. in. (psi)	0.069	bars
ENERGY OR WORK		
BTU	1 055.	joules (J)
Foot-pound	1.355 8	joules
Kilowatt-hour	3.6 x 106 or 3 600 000	joules (J = one W.s)
VELOCITY		
Miles/hour	1.609 3	kilometres/hr (km/h)



ENGINE TOOLS

Tool Number	Description
ST-1293	Belt Tension Gauge (Cummins Engine}
3375004	Injector Adjustment Kit (Cummins Engine)
ST-749	Mounting Plate
ST-302	Ball Joint Vise
ST-1249	Puller
ST-1143	Press
ST-1 105	Bushing Mandrel
ST-1 286 (2)	Engine Lifting Hook
ST-1258	Lifting Fixture
3375193	Engine Rebuild Stand
3375016	Camshaft Gear Puller
ST-1 307	Engine Stand Adapter
ST-1313	Camshaft Pilot
ST-1168	Liner Counterbore Tool
3375442	Counterbore Conversion Kit
3375444	Adapter Kit
3375115	Boring Machine
ST-1 177	Boring Tool (Main Boring Tool)
ST-1 228	Camshaft Bushing Drive Kit
ST-1252	Concentricity Gauge
ST-1309	Counterbore Tool
3375980	Counterbore Tool Holder
ST-257	Valve Seat Tool
ST-1 257-A or D	Valve Vacuum Tester
ST-1310	Valve Seat Insert Cutter Set
3375946	Valve Guide Arbor Set
3376256	Valve Facing Machine
ST-684	Valve Seat Grinding Machine
ST- 1012	Hydrostatic Tester
3375070	Hydrostatic Tester Base Plate
ST-1 134	Dowel Pin Extractor
ST-1265	Valve Guide Driver
ST-1280	Cup Plug Driver
ST-1282	Cup Plug Driver
ST-1315	Valve Guide Driver
3375182	Valve Spring Tester
ST-1284	Bushing Driver
ST-0000	Expansion Plug Driver
ST-1283	Cam Follower Roller Pin Block
ST-435	Fuel Pressure Gauge
ST-709	Puller
ST-848	Fuel Pump Test Stand
ST-853	Governor Barrel Lock Clip Driver
ST-884	Gear Pump Lock Plate
ST-984	Idle Adjusting Tool
ST-1032	Tachometer Drive Seal Driver
ST-1 190	Fuel Rate Checking Tool
3375206	Lube Oil Pump Boring Tool
ST-1231	Weight Carrier Gear Block
ST-1241	Plunger Protrusion Checking Tool
3375014	Fuel Filter Replacement Adapter
3375015	Fuel Filter Replacement Adapter Gasket
3375133	Front Cover Mounting Plate
3375137	AFC Plunger Adjusting Tool
3375140	AFC No-Air Needle Valve Adjusting Tool
3375146	AFC Plunger O-Ring Installation Tool
3375148	AFC Needle Valve O-Ring Installation Tool
3375204	Throttle Shaft Ball Installation Block
3375355	Throttle Lever Travel Template
3375364	Test Stand Test Oil - 55 Gallon Drum
3375372	Air Cylinder Assembly Tool
ST-995	Injector Cup Retainer Wrench
ST-1072	Crowfoot Wrench
ST-1089	Injector Plunger Extension
ST-1 298	Injector Holding Fixture (Air Operated)
3375000	Ultrasonic Cleaner
3375084	Injector Holding Fixture (Manual)
3375182	Spring Tester
3375209	Injector Plunger Sticking Checking Tool
ST-668-14	Fuel Hole Plug
ST-990	Injector Leakage Tester
3375089	Injector Adapter Spacer Ring
3375375	Injector Leakage Tester
3375398	Injector Link
3375440	Injector Adapter
3375459	Fuel Fittings
3376010	Ball Checking Kit
ST-668	Injector Spray Tester
ST-1 254	Injector Adapter Pot
ST-708	Burnishing Tool
STU-790	Injector Test Stand
ST-1 129	Injector Flow Comparator
ST-1 262	Master Injector
ST-1332	Orifice Sizing Tool
3375317	Injector Test Stand
3375364	Injector Test Oil
3375365	Injector Test Oil
3375366	Test Stand Audit Kit
3375367	Installation and Training Kit
3375408	Burnishing Tool
3375410	Injector Calibration Kit
3375421	Injector Calibration Kit
3375317	Injector Test Stand
ST-1217	Injector Removal Tool
3375161	Injector Removal Tool
3375181	Injector Removal Tool Torque Wrench
ST-788	Burnishing Tool
ST-790	Injector Test Stand
ST-1 261	"K" Injector Conversion Kit
3375187	Test Stand Audit Kit
ST-647	Puller
ST-657	Bearing Mandrel
3375265	Pulley Impeller Puller
3375320	Seal Driver
3375326	Bearing Separator

ENGINE TOOLS (Continued)

Tool Number	Description
3375448	Seal and Seat Mandrel
3375705	Spring Compressor Plate
ST-1314	Drive Bushing Mandrel
3375411	Thermostat Seal Driver
3375692	Oil Seal Driver Mandrel
3375707	Seal and Pulley Assembly Tool
3375693	Bearing Race Driver
3375694	Bearing Race Driver
3375695	Bearing Driver
3375704	Bearing Race Driver
3375697	Wear Sleeve Driver
3376030	Dial Indicator and Sleeve Assembly

Tool Number	Description
3375155	Injector Tip Protrusion Comparator
3376085	Pulley Assembly Tool
ST-1313	Camshaft Pilot
ST-1325	Dial Gauge Attachment
3375932	Pressure Gauge
3375150	Blow-By Checking Tool
ST-547	Gauge Block
3375522	Timing Fixture
3375422	Liner Driver
3375342	Piston Ring Compressor Sleeve
3375004	Injector Indicator Kit

ONAN (LIGHT PLANT) TOOLS

Tool Number	Description
420A248	Crankshaft Gear Pulling Ring
420P184	Nozzle Tester
420P208	Nozzle Cleaning Tool Set
420A252	Driver
420B250	Driver
420B264	Driver
420B269	Driver
420B270	Driver
420B250	Oil Seal Guide and Driver
420B272	Valve Seat Remover
420B274	Replacement Blades for 420B272
420B268	Oil Filter Wrench

MAIN TRANSMISSION TOOLS

Tool Number	Description
J-6534-02	Torque Converter Spanner Wrench
J-7441	Spring Compressor
J-23552	Stator Assembly Installing Tool
J-23556	Support Legs
J-24710	Switch Sequence Gauge
J-24711	Shift Inhibitor Clutch Drilling Fixture
J-24712	Harness Adapter

MARKLOAD TOOLS (for Load Weighing System)

Tool Number	Description
7774	Load-angle Simulator
1329	Load Cell Simulator
1840	Load Weighing Test Unit

TOOLS SUPPLIED WITH MACHINE

Upper Tools (In Box of Machine Parts)
- Padlock
- Extension Bar
- Grease Gun w/Hose
- Socket 1-5/16"
- Socket 1-7/16"

TOOLS SUPPLIED WITH MACHINE (Continued)

- Spanner Wrench (2)
- Grease
- Torque Limiting Wrench
- Torque Multiplier
- Adapter
- Bleeder Hose
- 1/8" Fitting (4)
- 1/4" Fitting (4)

Carrier Tools (In Box of Machine Parts)
- Jackscrew Handle
- Rim Nut Wrench and Handle
- Tire Hose
- Pin Puller
- Crane Connection Wire
- ToolBox
- Wrench - Cap Nut Wrench Handle 3/4" Dia.

LIST OF ITEMS FURNISHED

Basic Upper
Carrier
3 Counterweights
12 Tires and Rims
Generator Power Plant
3 Boom Inserts
- 2 Backstop Pipes
- 2 Reels of Cable
- Boom Base
- Boom Tip
- Boom Mast
- Elevated Cab Insert
- Gantry
- 8 Malkiel Floats
- 5 Jackfloats
- 4 Outrigger Beams
- 2 Transfer Beams
- 4 Equalizer Beams
- 2 Bottom Blocks
- 1 Spreader Bar
- Catwalks

LIST OF ITEMS FURNISHED (Continued)

Module Box
- 60K Load Cell (2 Pieces)
- Preamplifier (2 Pieces)
- Preamplifier Bracket
- Boom Angle Sender
- Boom Angle Sender Bracket (Mounting Kit)
- Load Cell Cable (2 Pieces)
- Boom Cable (2 Pieces)
- Boom Angle Cable
- Load Links (2-1/2 x 2-1/2) (8 Pieces)
- Safety Pin w/Nut and Key (8 Pieces)
- Spacer Washer (48 Pieces)
- Tyraps (100 Pieces)

Box of Machine Parts
- Boom Hoist Cable
- 25' Guy Cable (4)
- 10' Guy Cable (4)
- 20' Guy Cable (4)
- 30' Guy Cable (4)
- 7' Guy Cable (4)
- Carrier Tools (Listed Earlier)
- Upper Tools
- 1" Rope Wedge (2)
- 1-1/4" Rope Wedge (2)
- 1" Rope Clamp (2)
- 1-1/4" Rope Clamp (2)
- Boom Pins with Keys (16)
- Pipe Coupling (8)
- Pipe Nipple (8)
- 1/2" Fitting (8)
- 1 Sheave Bottom Block
- Cable Roller (5)
- Propane Heater Hose

LIST OF ITEMS FURNISHED (Continued)

Boom Travel Kit - Includes the
- Following:
- 7/8" Rope Assembly (2)
- Links (2)
- Pins (2)
- 2-1/2" Plain Washer (4)
- Cotter Pins (4)
- 1 Print
- Links (2)
- Counterweight Mounting Material
- Carrier Horns
- Windshield Wiper Arm and Blade (4)
- Wiper Motors (3)
- Boom Angle Indicator
- Mark Load Computer
- Trouble Lamp (2)
- Trouble Lamp (1)
- Flood Lamp (5)
- Flood Light (4)
- Slewing Ring Bolts (48)
- Rope Support
- Rear View Mirrors
- Spotter Mirror
- Gantry Plates (4)
- Pins for Gantry (2)
- Elevated Cab Cable
- 1 Gallon Green Paint
- Rope Sling Assembly (2)
- Rope Assembly (2)
- Shackle (2)
- Pins (2)
- Cotter Pins (4) 3/8" x 3"
- Gantry Tiedown Bracket
- Links (2)
- Links (2)
- Pins (8)
- Cotter Pins (8) 1/4" x 1-1/2" Shackle (2)

REPLACEMENT PARTS

USE ONLY PARTS DESCRIBED IN PARTS BOOK WHICH ACCOMPANIES this operator's and shop manuals. The replacement parts are designed and manufactured to maintain the safety and life of the crane. DO NOT SUBSTITUTE ANY PARTS under any conditions.

SECTION II.

CONTROLS AND OPERATION

SECTION II.

CONTROLS AND OPERATION

CARRIER CONTROL IDENTIFICATION

The instruments and controls in the cab of the carrier are shown in Figure 2-1. The numbers on this figure correspond to the numbers on the following list, which identifies the controls and describes their function.

Before attempting to operate this machine, the operator should study all of the information in this section. The operator should become familiar with the location and purpose of each control on the machine.

01. LIGHT SWITCH. Pull this switch out halfway, to the first detent, to use the tail lights, clearance lights, and the dash panel lights. Pull this switch out fully to use the headlights in addition to the other lights. Push this switch in completely to turn off all the lights.
02. STARTING AID PUSHBUTTON. This button controls the ether starting aid. Refer to Carrier Operation.
03. VOLTMETER. The voltmeter measures the voltage produced by the alternator and indicates the condition of the battery. See Figure 2-2 for an explanation of the voltmeter readings.
04. ENGINE OIL PRESSURE GAUGE. This gauge should read between 45 and 70 psi (310-483 kPa) during normal operation.
05. CLUTCH PRESSURE GAUGE. This gauge indicates the pressure in the main pressure circuit and the applied clutches of the transmission. This gauge should read between 170 and 210 psi (1172-1448 kPa) during normal operation.

NOTE

On some gauges a color range is given on the gauge face. The far left red area (low) indicates a range of 0 to 160 psi (0-1 103 kPa), the green area (normal) indicates a range of 160 to 200 psi (1103-1379 kPa) and the opposite red area (high) a range of 200 to 300 psi (1379-2069 kPa).

06. SPEEDOMETER-ODOMETER. The speedometer shows carrier speed in miles per hour, while the odometer indicates the total number of miles the carrier has traveled.
07. HIGHBEAM INDICATOR. This lamp, when illuminated, indicates that the high headlight beams are on.
08. HOURMETER-TACHOMETER. The hourmeter indicates accumulated hours of engine operation. The tachometer indicates the engine speed in revolutions per minute (RPM).
09. AIR PRESSURE GAUGE. This gauge shows air system pressure. In normal operation the pressure reading on this gauge should range between 105 and 120 psi (724-827 kPa).
10. LOW AIR PRESSURE INDICATOR. When illuminated, this lamp indicates that the pressure in the air system is below the normal safe operating level. Do not operate the machine when this light is lit.
11. TRANSMISSION FILTER INDICATOR. This lamp, when illuminated, indicates that the transmission oil filter elements must be changed promptly.
12. TORQUE CONVERTER OIL TEMPERATURE GAUGE. This gauge indicates the torque converter oil temperature, which should not exceed a maximum of 2500F (121 °C).
13. POWER STEERING/OUTRIGGER INDICATOR. This lamp, when illuminated, indicates that the steering/outrigger selector valve is in the outrigger position.

WARNING

Do not attempt to drive the carrier when the power steering/outrigger lamp is lit.

14. MAXIBRAKE INDICATOR. This lamp, when illuminated, indicates that the Maxibrakes are set.
15. EMERGENCY RELEASE VALVE. The emergency release valve provides a means of transferring the emergency reserve air to the Maxibrake control valve (item 16) when pressure in the service tanks is lost. Push this knob in and pull out the Maxibrake control knob (item 16) if it becomes necessary to use the air in the emergency air tank to release the Maxibrakes.

01. LIGHT SWITCH
02. STARTING AIR PUSHBUTTON
03. VOLTMETER
04. ENGINE OIL PRESSURE GAUGE
05. CLUTCH PRESSURE GAUGE
06. SPEEDOMETER-ODOMETER
07. HIGHBEAM INDICATOR
08. HOURMETER-TACHOMETER
09. AIR PRESSURE GAUGE
10. LOW AIR PRESSURE INDICATOR
11. TRANSMISSION FILTER INDICATOR
12. TORQUE CONVERTER OIL TEMPERATURE GAUGE
13. POWER STEERING/OUTRIGGER INDICATOR
14. MAXIBRAKE INDICATOR VALVE
15. EMERGENCY RELEASE
16. MAXI-BRAKE CONTROL VALVE
17. SPEED CHART
18. SHIFT CHART (AUX. TRANS.)
19. ENGINE WATER TEMPERATURE GAUGE
20. WINDSHIELD WIPER SWITCH
21. FUEL GAUGE
22. HAZARD WARNING INDICATOR
23. MASTER (IGN.) SWITCH
24. DEFROSTER FAN SWITCH
25. HEATER FAN SWITCH
26. HEADLIGHT DIMMER SWITCH
27. TURN SIGNAL LEVER
28. HAZARD WARNING LIGHT SWITCH
29. STEERING WHEEL
30. HORN BUTTON
31. MAIN TRANSMISSION SHIFT LEVER
32. AUXILIARY TRANSMISSION SHIFT SELECTOR
33. ACCELERATOR PEDAL
34. BRAKE PEDAL
35. RETARDER PEDAL
36. OPERATORS SEAT
37. ENGINE ALARM

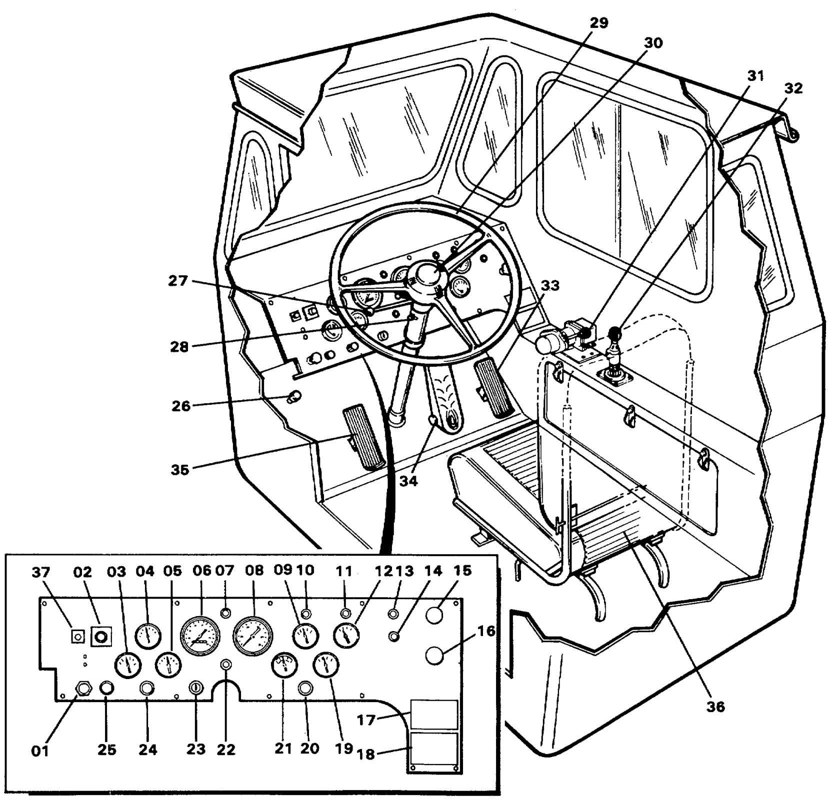


Figure 2-1. Carrier Controls

Engine not running or running at slow idle.

(1)

Dead or disconnected battery. Disconnected or badly connected meter.

(2)
Very low battery charge. Engine might not start.

(3)

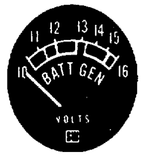
Low battery charge. Constant reading in this area would indicate need for check on generator and voltage regulator.

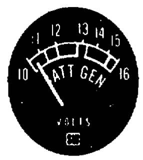
(4)
Well-charged battery. This indicates a good battery and also that generator and voltage regulator are operating properly.

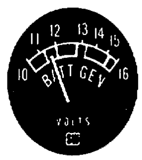
(5)
The pointer might remain in this position temporarily when the engine has been stopped after considerable use, due to a "surface charge" in the battery. To get a correct reading, turn on headlights for a few minutes.

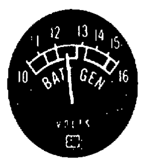
(6) (7)
Under normal conditions, a 12V battery is fully charged at 12.8V; a 24V battery at 25.6. A slightly higher reading may occur under the conditions outlined in No. 5 but, generally speaking, any reading above 12.8 or 25.6 when the engine is stopped is not a true reading.

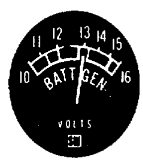
*NOTE: The word "generator" refers to both generator and alternator since both require the same instrumentation.
While a 1 2V gauge is shown, the principle voltmeter is the same for a 24V electrical system only difference are the values on the gauge face.











Engine running fast enough to make generator' produce.

(1)

Disconnected meter. Engine could not run with dead or disconnected battery unless circuit was completed around battery.

(2) (3)

When meter pointer stays below 13.3 or 26.6 with the engine running fast enough to operate generator, it shows that generator is not operating or voltage regulator is out of adjustment, or that current being drawn from battery by lights, heater fan, or other load, exceeds generator output.

(4) (5)
When engine is started, pointer may stay in this area temporarily but should gradually rise above 13.3 or 26.6 as generator reaches normal output.

(6)
This is the area in which the pointer should be when
generator, voltage regulator and battery are all in good condition and working properly.

(7)
When the pointer goes above 15.2 or 30.4, the volt- age regulator is set too high or is jammed and continued operation of the engine will burn out the battery.

Figure 2-2. Voltmeter Operation

CAUTION

The carrier will have no brakes, except the Maxibrakes which are controlled by the Maxibrake control valve. Never move the carrier farther than is absolutely necessary under these conditions, and avoid steep grades. MAKE CERTAIN THAT THIS KNOB IS PULLED OUT AT ALL TIMES DURING NORMAL OPERATION.

16. MAXIBRAKE CONTROL VALVE. Pull this knob out to release the Maxibrakes. Push this knob in to vent air from the Maxibrake chambers and apply the Maxibrakes. This control will shift to the applied position automatically if pressure in the air system drops below 28 psi (193 kPa).

17. SPEED CHART. This chart indicates "on-highway" and "off-highway" speed to gear combinations.

18. SHIFT CHART. This chart shows the shifting pattern of the auxiliary transmission.

19. ENGINE WATER TEMPERATURE GAUGE. This gauge shows the temperature of the engine coolant. The gauge should read between 165 to 1950F (74 to 91 0C). The engine coolant temperature must not exceed 2000F (930C).

20. WINDSHIELD WIPER SWITCH. Turn this switch clockwise to energize the windshield wiper; control the speed of the wiper by turning the switch clockwise or counterclockwise as desired.

NOTE

On some switches clockwise rotation to the first detent moves the wiper at low speed and rotation to the second detent moves the wiper at high speed.

21. FUEL GAUGE. This gauge shows the amount of fuel remaining in the fuel tank(s).'

22. HAZARD WARNING INDICATOR. This lamp, when illuminated, indicates that all directional lights are energized for use as hazard warning lights.

23. MASTER (IGN.) SWITCH. This switch is used to energize the electrical circuits of the carrier and to start the carrier engine.

24. DEFROSTER FAN SWITCH. Turn the switch clockwise to energize the defroster fan; control the speed of the fan by turning the switch clockwise or counterclockwise as desired.

NOTE

Some switches have an "off" position in the middle of the switch movement with a "low" or "high" position on either side of "off"

25. HEATER FAN SWITCH. This switch controls the heater fan. Turn the switch clockwise to energize the heater fan. Control the speed of the fan by turning the switch clockwise or counterclockwise as desired.

NOTE

Some switches have an "off" position and a two position detent. The first detent is for "low" speed and the second is for "high" speed.

A heater shut-off valve is located on the right hand side of the engine to stop the flow of water to the heater. Turn the valve clockwise when heat is not required. Turn the valve counterclockwise when heat is desired.

26. HEADLIGHT DIMMER SWITCH. The headlight dimmer switch allows the driver to raise or lower the headlight beams. The high beam indicator (item 7) will be lit when the high beams are on.

27. TURN SIGNAL LEVER.

28. HAZARD WARNING LIGHT SWITCH.

29. STEERING WHEEL.

30. HORN BUTTON. Depress this button to sound the carrier air horns.

31. MAIN TRANSMISSION SHIFT LEVER. This lever controls the main transmission. The six forward speeds, neutral, and reverse are plainly marked on the plate along the side of the lever.

32. AUXILIARY TRANSMISSION SHIFT SELFCTOR. This selector is used to change gears in the auxiliary transmission.

CAUTION

Stop the carrier before shifting the auxiliary transmission.

33. ACCELERATOR PEDAL. Depress this pedal to increase carrier engine speed.

34. BRAKE PEDAL. Depress this pedal to apply the carrier service brakes.

35. RETARDER PEDAL. Depress this pedal to use the speed retarder of the main transmission as a vehicle braking force. The retarder may be applied, and will operate, in any speed range.

CAUTION

A 5 to 7 second delay is normal, after the retarder pedal is depressed, before the braking force is effective. During prolonged use of the retarder, the converter oil temperature should not exceed 2500F (121°C).

36. OPERATORS SEAT. The operators seat has several comfort adjustments including:

A. Forward and back movement is adjusted by means of a lever located to the lower left of the operator.
B. Back angle adjustment to three different positions.
C. Preload adjustment is controlled by a ratchet mechanism. With the operator in the seat, move the lever located to the operator's right until the pointer on the left inside of the seat is just to the edge of the metal side panel.

37. ENGINE ALARM. When this light is lit and the buzzer sounds, it indicates that the engine is overheated or the engine oil pressure is below normal. Shut down the engine IMMEDIATELY when this light comes on and the buzzer sounds. Locate cause of alarm being activated.

CARRIER OPERATION

GENERAL. The following paragraphs are not intended to describe the method of operating the carrier, but to describe the sequence of starting the engine, releasing the parking brakes, running the carrier, transmission shifting, and shutting down the engine.

PREOPERATION INSPECTION. Before actually operating the machine each day, perform the 'A' Maintenance Checks outlined in Section V of this manual.

STARTING THE ENGINE. To start the engine, proceed as follows:

1. Place the main transmission shift lever in the neutral position.
2. Turn the master switch to the "on" position. Depress the accelerator pedal slightly and turn the key to the "start" position. As soon as the engine starts, release the key. Do not hold the starting motor "on " for more than 30 seconds at one time. if the engine does not start in this period of time, release the key and wait for two minutes before trying to start the engine again.

NOTE

The use of a cold weather starting aid may be required in extremely cold weather.

Use the ether starting aid, as follows:

A. Press the starting aid pushbutton for 2 to 3 seconds to fill valve chamber.

B. Release pushbutton and allow 2 to 3 seconds to empty the valve chamber.

C. Wait 2 seconds and engage the starter.

D. Repeat the above steps for temperatures below OO°F (-1 70C).

2. Check all gauges (Items 03, 04, 05, 09, 12 page 2-1 and Items 19 and 21 page 2-4) immediately after the engine starts, to be sure they are reading properly. If the readings are improper, stop the engine immediately and determine the cause of improper reading before continuing operation.
3. Allow the engine to run at 800 to 1,000 rpm for 4 to 5 minutes or preferably until the water temperature reaches normal operating temperature, 1650-1950F (740-910C), before beginning operation.

DRIVING THE CARRIER. Driving the carrier is similar to driving any comparable heavy duty vehicle, therefore a step-by-step operating procedure is not necessary. The following, then, are a series of precautions and special instructions to insure safe and proper operation of the carrier.

CAUTION

Make sure the power steering/outrigger light is out before driving the carrier. If the light is not out it will be necessary to go to the outrigger control boxes and turn the master switches to the "off" position.

1. With the engine warmed up and the brake air pressure built up to at least 75 psi (5.17 kPa), depress the brake pedal to set all wheel brakes. Then, pull out the Maxibrake control valve to release the Maxibrake.
2. Shift the auxiliary transmission to the appropriate conditions.

CAUTION

Drivers should always use the lowest reductions available in the auxiliary unit, for the conditions, and keep the main transmission in the higher gear ratios. Also select a gear for the speed you will attain because the auxiliary transmission should not be shifted while the vehicle is in motion.

3. Place the main transmission shift lever in position 1. The carrier is now ready to be moved.

CAUTION

The combination of low gear in the auxiliary transmission and low gear in the main transmission is intended for "off" highway conditions when maximum tractive effort is required. This combination develops sufficient torque to possibly damage the propeller shafts and/or other drive line components if used improperly.

4. Depress the accelerator pedal to accelerate the carrier. Up shift the main transmission when the speed reaches the value shown on the speed chart for the particular gear combination used.

NOTE

A main transmission shift, to a higher speed range in the same direction can be made at full throttle under load. Down shifts to the next lower range may be made at full throttle under load, provided the carrier speed is not exceeding the maximum speed attainable in the lower range. The electric shift control contains components that protect the transmission against downshifts occurring at excessively high speeds.

For maximum retarding, it is necessary to keep the retarder speed up by downshifting to the lowest gear possible in the main transmission, without over speeding the engine. The retarder pedal can be depressed in any gear range, and should be applied for short intervals or supplemented with the carrier brakes to maintain the converter oil temperature below the maximum limits, A downshift should not be made during converter lockup with the retarder applied.

5. If brake air pressure is lost for any reason, the Maxi brakes will set. To move the carrier in this event, refer to the descriptions of the Maxibrake control valve (item 16, Figure 2-1) and the emergency release valve (15). Observe the "Caution" following the release valve description.

6. Release the accelerator pedal and depress the brake pedal to stop the carrier. Then downshift the main transmission to low gear in preparation for accelerating the carrier, or in neutral if the crane is to be used.

SHUTTING DOWN THE CARRIER. To shut down the carrier, proceed as follows:

1. Place the main transmission in neutral.
2. Whenever possible, allow the engine to idle for a period of 3 to 5 minutes before shutting it down. The engine will then cool evenly and overheating, due to localized residual heat, will be prevented.
3. Turn the master switch to "off" to shut down the engine.

OUTRIGGER OPERATION

GENERAL. The hydraulic outriggers on this machine are controlled electrically from each side of the carrier. The control panel on each side of the carrier controls only the outriggers on that side of the carrier.

EXTENDING THE OUTRIGGERS. To extend the outriggers, proceed as follows (see Figure 2-3):

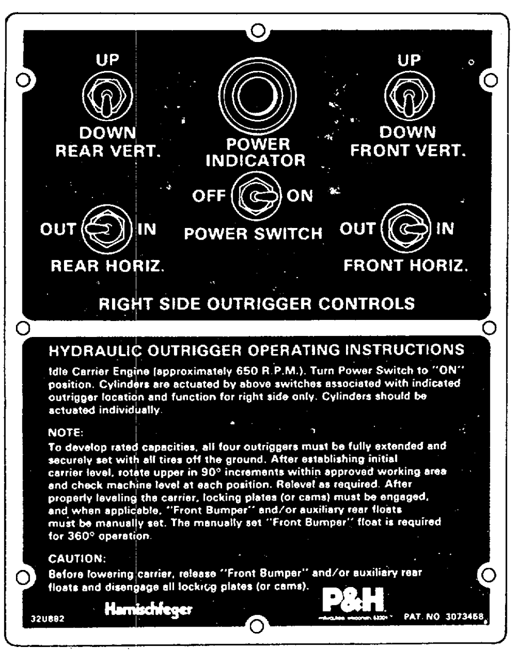


Figure 2-3. Outrigger Controls

NOTE

One front and one rear ouirigger cylinder can be operated simultaneously. Each bank is supplied by a separate section of the outrigger pump.

1. Start the carrier engine as described under the topic Carrier Operation. Run the engine at idle speed.
2. Place the power switch in the "on" position. The light above the switch will be lit, indicating that power is available at the control box.
3. Release the locking cams.

CAUTION

Make sure that the swing brake is locked in the applied position before extending the outriggers.

4. Fully extend the outrigger beam by placing the desired HORIZONTAL switch in the OUT position. Repeat the procedure for the other outrigger beams.
5. Attach and pin the jackfloats to the adapter at the end of each outrigger beam. See Figure 2-5 for jackfloat storage.

WARNING

All jackfloats must be removed from carrier before swinging upper.

6. If soil conditions warrant, lay down timbers for the jackfloat to bear against. Then lower all the jackfloats to the ground by lowering the outrigger beams.

WARNING

Do not set the outriggers near holes, or on rocky, or extremely soft ground. This may cause the machine to tip, resulting in injury to personnel.

7. Lift the machine off the ground by placing the desired VERTICAL switch in the DOWN position. After the machine is off the ground, level it by operating each VERTICAL switch individually, as required. Check the level of the machine using the level adjacent to each control panel.
8. After the outriggers are properly positioned, with the machine level, and with the wheels lifted off the ground, release the safety cams on the outrigger housings to mechanically lock the outriggers in the extended position (see Figure 2-4):
9. Return the power switch to the "off" position.
10. Shut off the carrier engine to avoid unnecessary circulation of hydraulic oil through the outrigger system.

RETRACTING THE OUTRIGGERS. To retract the outriggers, proceed as follows:

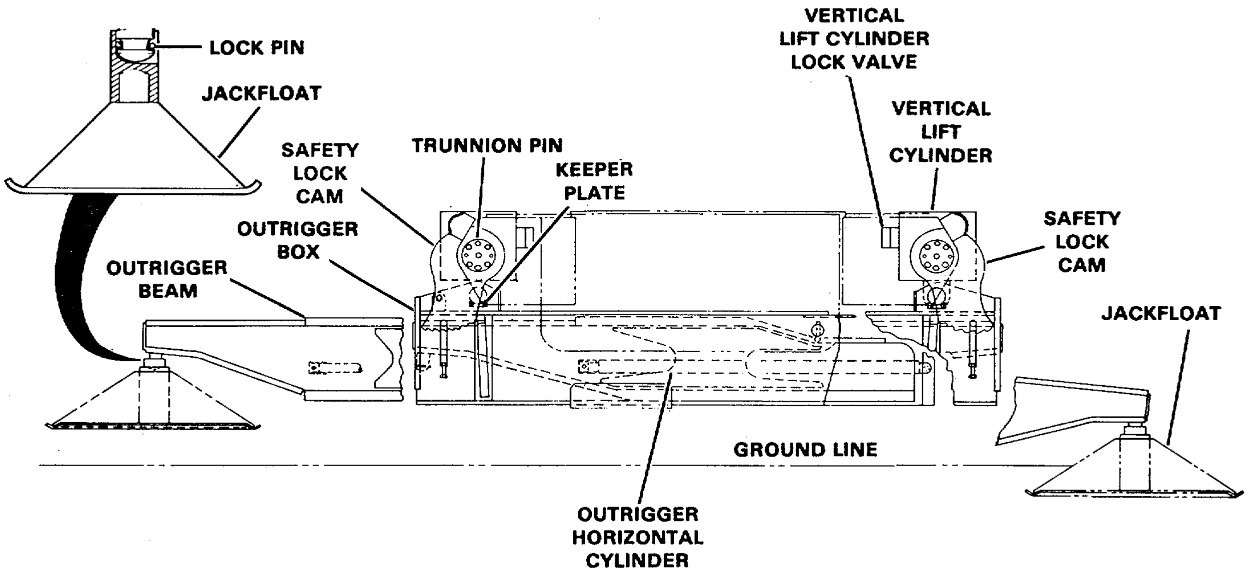


Figure 2-4. Hydraulic Outrigger Assembly (8100J3952-8)

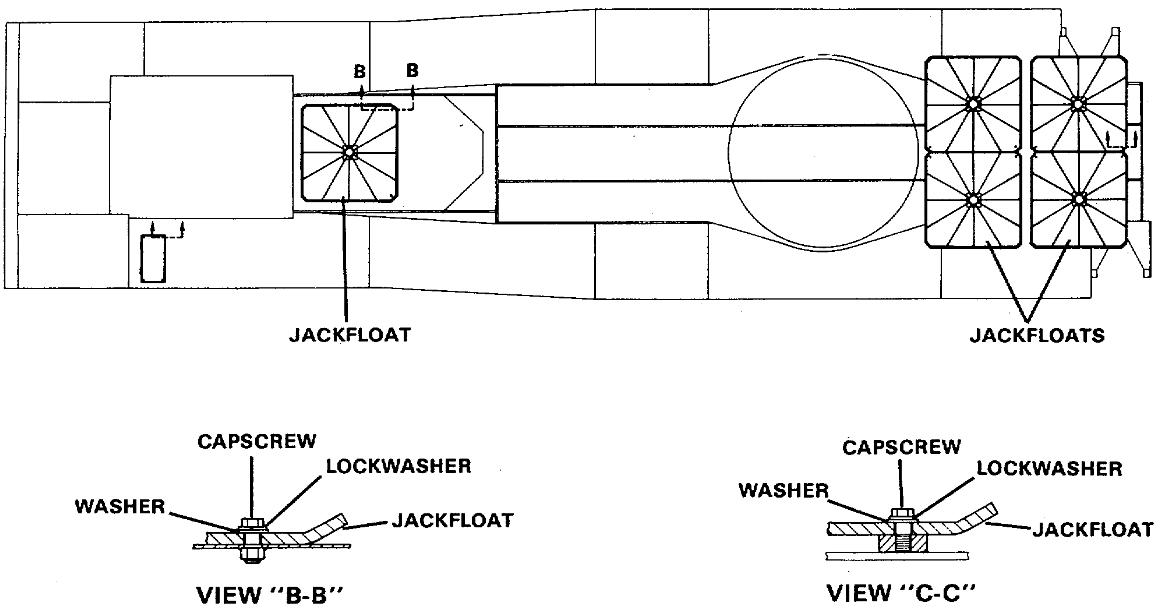


Figure 2-5. Jackfloat Storage

1. Remove the rear outriggers before retracting the outriggers.
2. Start the engine as described under the topic Carrier Operation. Allow the engihe to run at idle speed.
3. Place the power switch in the "on" position. The light above the switch will be lit, indicating power is available at the control box.
4. Disengage the safety cams of each outrigger.

NOTE

If the weight of the machine is resting on the safety cam it may be necessary to raise the machine slightly by placing the desired VERTICAL switch in the "down" position, before moving the safety cam to the unlocked position.

5. Raise the outrigger by placing the desired VERTICAL switch in the "up" position. Repeat the procedure for the other three outriggers.
6. Remove the jackfloat from the end of each outrigger beam, and store them on the carrier, see Figure 2-5.

'WARNING

Do not swing the upper when the jackfloats are stored on the carrier as shown in Figure 2-5.

7. Retract each outrigger by placing the appropriate HORIZONTAL switch in the "in" position.
8. Place the power switches in the "off" position.

AUXILIARY AND OPTIONAL OUTRIGGERS

REAR OUTRIGGER

GENERAL. The rear outrigger assembly is attached to the rear of the carrier frame and must be used for certain boom lengths (see the rating plate attached to the machine for boom lengths that require rear auxiliary outriggers).

INSTALLATION. To install the rear auxiliary outrigger, proceed as follows (see Figure 2-6).

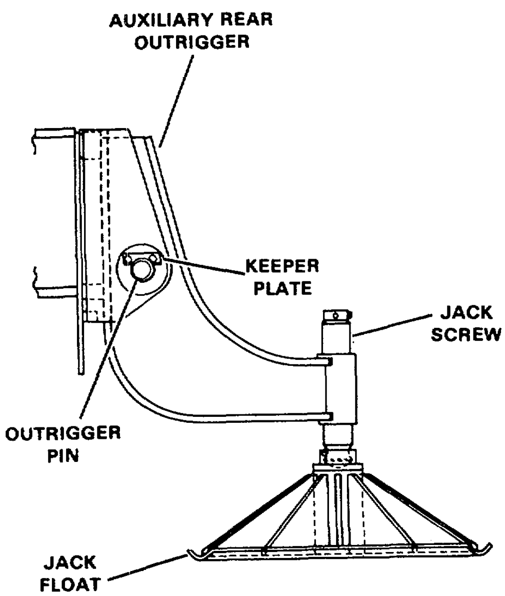


Figure 2-6. Rear Outrigger Assembly

1. Be sure the machine is level,' using the four standard outriggers.
2. Position the rear outrigger assembly on the rear of the carrier and install the outrigger pins. Lock the pins in position with the keeper plate, lockwashers, and capscrews.
3. If necessary, lay down timbers for the jackfloats to bear against. Attach and lock the jackfloats to the jackscrews. Lower the jackfloats to the ground by turning the jackscrews.

REMOVAL. Removal of the rear outrigger is the reverse of installation. Be sure the rear outrigger floats are raised or removed before the machine is lowered to the ground.

MALKIEL FLOAT ASSEMBLY

GENERAL. The malkiel float assembly is used to equalize loading over a broad area to reduce ground loading pressures. The assembly uses eight large floats, four per side, connected by equalizer and transfer beams. The transfer beam is attached to the machine outrigger beams allowing the malkiel floats to be lifted for traveling.

INSTALLATION. To attach the malkiel float assembly to the machine, proceed as follows (see Figure 2-7):

NOTE

When using Malkiel floats it will be necessary to remove the standard outrigger beam and install the special beam (see Figure 2-7).

1. Extend the outrigger beams on one side of the machine about half way out. Lay a level on each outrigger beam and level each beam to a horizontal position. If a true horizontal cannot be obtained, be sure that both outrigger beams are the same degree from horizontal.
2. Using a lift truck move the transfer beam up to the outrigger beams. Align the holes in the transfer beam with the shafts on the end of the outrigger beam shafts.
3. Secure the outrigger beams to the transfer beam using the keeper plate, lockwashers and capscrews. See Figure 2- 7, Assembly "E". Be sure a grease fitting is installed into each outrigger beam shaft.
4. Lay the floats on the ground using the dimensions given in Figure 2-7. Install the bearing assemblies to the floats and attach the equalizer beams to the bearing assemblies as shown in Assemblies "B" and "C".
5. Install the bearing assemblies to the equalizer beams as shown in Assembly "A".
6. Move the transfer beam over the bearing assemblies mounted on the equalizer beams. Lower the transfer beam and secure the beam to the bearing assemblies as shown in Assembly "A".
7. Attach the shim and capscrew to each outrigger box as shown in View "A-A"
8. Secure the outrigger beam to the outrigger box as shown in Figure 2-8. Torque dry to 400 ft-lbs (542 N.m) +25 ft-lbs ·(34 N.m).
9. Install the malkiel float assembly on the other side of the machine in the same manner as above.
10. When the malkiel float assemblies are installed, do not retract the outrigger beams. To travel, raise the outrigger

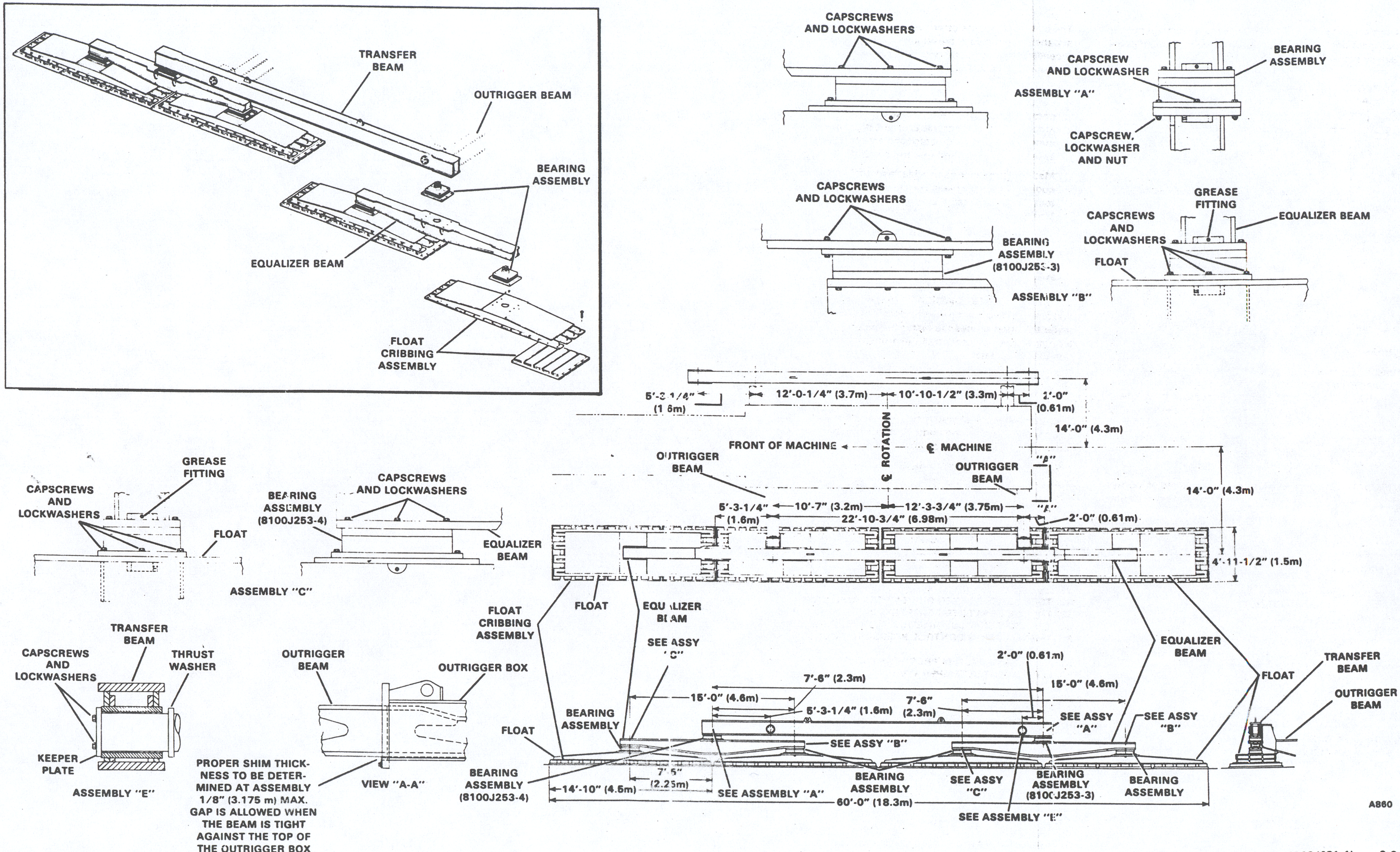


Figure 2-7. Malkiel Float Assembly (8100J631-1)

beams on one side of the machine together, then raise the outrigger beams on the other side of the machine together. Slowly proceed to travel the machine.

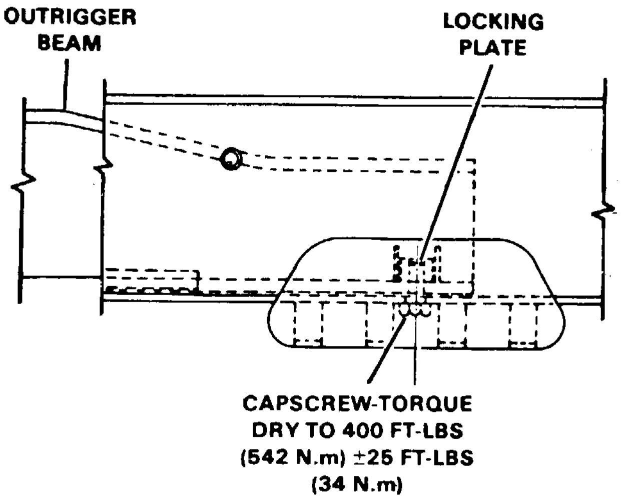


Figure 2-8. Outrigger Box and Beam Connection

UPPER CONTROL IDENTIFICATION

Unless otherwise stated, the instruments and controls in the upper cab are shown in Figure 2-9. The numbers on this illustration correspond to the numbers in the following list, which identifies the controls and describes their function. Although the functions of the controls do not change, the front, rear, and boom hoist drums may be utilized for different applications. See the topics Lift Crane Operating Cycle for a tabulation of these applications.

01. LOAD WEIGHING SYSTEM. The Load Weighing System continuously monitors load weight and boom radius. The computer calculates and displays the load being lifted and the boom radius. If preset load limits are approached or exceeded, the computer visually and audibly alerts the operator. The items below are furnished with the load system.

A. Central Unit. The central unit monitors the variable boom and load operating conditions. These signals are processed by the central unit and transmitted to the meters. The central unit also contains the controls necessary to calibrate and test the computer system.

B. Meters. Three meters provide readouts, and visual and audible warning signals. The meters are, from top to bottom, Hook Load Meter, Load Capacity Meter and Radius Meter.

C. JUNCTION BOX, This unit allows monitoring of loads on one of two hook blocks or the sum of the two loads. The junction box contains a LEFT-SUM-RIGHT selector switch.

02. DRUM ROTATION INDICATORS. The operator can see and feel the indicator move as he operates a drum lever. The faster the drum rotates the faster the motion of the indicator, the slower the rotation of the drum the slower the motion of the indicator.

03. MODULATED CLUTCH CONTROL This control is used to vary the amount of slip in the torque converter clutch. As viewed from above, turning the control clockwise will decrease the amount of clutch slippage and increase drumshaft speed. Turning the control counterclockwise will increase clutch slippage and decrease drumshaft speed.

04. SWING BRAKE SWITCH. In the "on" position the swing brake is released. In the "off" position the swing brake Is applied.

LEGEND FOR FIGURE 2-9

01. I,OAD WEIGHING SYSTEM
02. DRUM ROTATION INDICATORS
03. MODULATED CLUTCH CONTROL
04. SWING BRAKE SWITCH
05. SWING LEVER
06. FRONT DRUM CONTROL LEVER
07. FRONT DRUM LOCK SWITCH
08. REAR DRUM CONTROL LEVER
09. REAR DRUM LOCK SWITCH
10. ENGINE THROTTLE CONTROL
11. BOOM HOIST LEVER
12. REAR DRUM BRAKE PEDAL
13. FRONT DRUM BRAKE PEDAL
14. OPERATORS SEAT
15. HORN BUTTON
16. FUSES
17. HEATER CONTROLS
18. LOAU COMPUTER RESET
19. UPPER WINDSHIELD WIPER SWITCH
20. FRONT WINDSHIELD WIPER SWITCH
21. LOWER WINDSHIELD WIPER SWITCH
22. PANEL LIGHT SWITCH
23. CAB LIGHT SWITCH
24. REAR DRUM PAWL SWITCH
25. FRONT DRUM PAWL SWITCH
26. BOOM HOIST LIMIT OVERRIDE SWITCH
27. LEFT TRANSMISSION CONTROL
28. RIGHT TRANSMISSION CONTROL
29. ENGINE STARTING AID
30. MASTER SWITCH
31. ENGINE START BUTTON
32. TORQUE CONVERTER OIL TEMPERATURE GAUGE
33. TOPRQUE CONVERTER OIL PRESSURE GAUGE
34. TRANSMISSION LUBRICATION OIL PRESSURE GAUGE
35. TFANSMISSION CONTROL PRESSURE GAUGE
36. FUEL GAUGE
37. HYDRAULIC SYSTEM PRESSURE GAUGE
38. ENGINE WATER TEMPERATURE GAUGE
39. ENGINE OIL PRESSURE GAUGE
40. VOLTMETER
41. FUSE FAILURE UGHT
42. TRANSMISSION PRESSURE MALFUNCTION UGHT
43. TACHOMETER
44. HOURMETER
45. ELECTRICAL SYSTEM CIRCUIT BREAKER (NOT SHOWN
46. CLUTCH PRESSURE MALFUNCTION LIGHT
47. MODULATED CLUTCH PRESSURE GAUGE
48. ENGINE ALARM
49. OVERRIDE SWITCH
50. GENERATOR CONTROLS
51. LIGHT SWITCHES - 24 VOLT SYSTEM
52. CIRCUIT BREAKERS - 110 VOLT SYSTEM

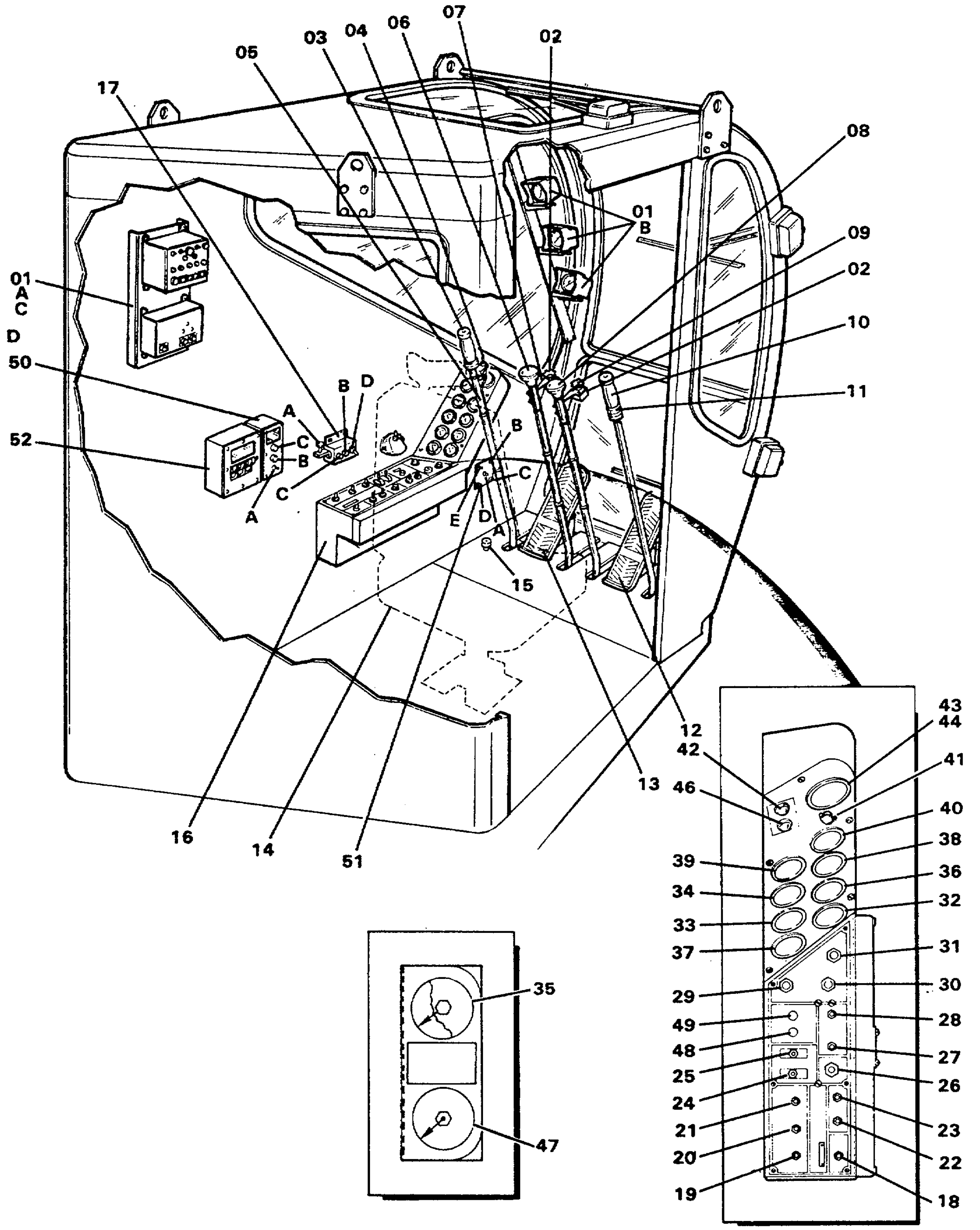


Figure 2-9. Upper Cab Controls

05. SWING LEVER. Push this lever forward to swing the upper to the left (toward the boom). Pull this lever back to swing the upper to the right (away from the boom).

06. FRONT DRUM CONTROL LEVER. Pull this lever back, toward the operator, to raise the load on the front drum. Push this lever forward to power lower the load.

07. FRONT DRUM LOCK SWITCH. Place this switch in the "on" position to lock the front drum brake in the applied position, thus preventing the front drum from turning. Place the switch in the "off" position to release the front drum brake.

08. REAR DRUM CONTROL LEVER. Pull this lever back, toward the operator, to raise the load on the rear drum. Push this lever forward to power lower the load.

09. REAR DRUM LOCK SWITCH. Place this switch in the "on" position to lock the rear drum brake in the applied position, thus preventing the rear drum from turning. Place the switch in the "off" position to release the rear drum brake.

10. ENGINE THROTTLE CONTROL. This control is used to control engine speed. Turn the control clockwise, while looking at the control from above, to increase engine speed. Turn the control counterclockwise to decrease engine speed.

11. BOOM HOIST LEVER. Pull this lever back, toward the operator, to raise the boom. Push this lever forward, away from the operator, to lower the boom.

12. REAR DRUM BRAKE PEDAL. Depress this pedal to apply the rear drum brake. Release the pedal to release the rear drum brake.

13. FRONT DRUM BRAKE PEDAL. Depress this pedal to apply the front drum brake. Release this pedal to release the front drum brake.

14. OPERATORS SEAT. The operators seat has several comfort adjustments including, seat back tilt, height, forward or back movement and head rest height.

15. HORN BUTTON. Depress this button to sound the signal horn.

16. FUSES. The electrical fuses are located behind the side console cover plate.

17. HEATER CONTROLS. Several switches are used to control the heater including the following:

A. Thermostat Control. Position this knob, as needed, to control the temperature.

B. Fuse Holder.

C. Run Light. This green light is lit when the heater is running. If the light goes out while the heater is operating, a malfunction has occurred in the heater.

D. Start Switch. This toggle switch is used to start and stop the heater. To start the heater, move the toggle switch to the start position. Hold the switch in this position approximately 30 to 45 seconds. When the switch is released, the green pilot light (item C) should remain on. If the light goes out, repeat the start cycle. If the light still goes out, move the thermostat control (item A) to a slightly higher setting and repeat the start cycle.

18. LOAD COMPUTER RESET. This switch must be depressed to activate the computer system. It is also used to override the hoist limit switch so that a load can be lowered after it has reached the limits of the limit switch. Depress and hold this button, then lower the load in the normal manner.

NOTE

The reset button must be used in order to come out of a load hoist limit condition. Extreme care must be exercised to ensure that the load is lowered only. The reset button is not intended to permit a load to be raised beyond the limits set by the respective hoist limit switches.

19. UPPER WINDSHIELD WIPER SWITCH. Turn this switch clockwise, to the detent, to operate the windshield wiper at slow speed. Turn the switch past the detent to operate the wiper at high speed.

20. FRONT WINDSHIELD WIPER SWITCH. The operation of this switch is the same as item 19.

21. LOWER WINDSHIELD WIPER SWITCH. The operation of this switch is the same as item 19.

22. PANEL LIGHT SWITCH.

23. CAB LIGHT SWITCH.

24. REAR DRUM PAWL SWITCH. Pull this switch down to engage the pawl in the ratchet of the rear drum. To release the pawl from the ratchet, push the switch up and pull the rear drum lever toward the operator to wrap a small amount of line on the drum. Use this control whenever a load is suspended on the rear drum load line.

25. FRONT DRUM PAWL SWITCH. This switch is used to control the pawl which engages the ratchet of the front drum. Its operation is identical to the rear drum pawl switch (item 24).

26. BOOM HOIST LIMIT OVERRIDE SWITCH. This switch is used to override the boom hoist limit switch, if the boom is lifted beyond the normal operating limits. Depress and hold this switch, to override the boom hoist limit switch, and lower the boom.

WARNING

Do not use this switch to override the boom hoist limit to allow the boom to be raised to a working angle beyond the normal operating limits. This is extremely dangerous, since the boom could be raised to the point that the boom may topple over the back of the machine.

27. LEFT TRANSMISSON CONTROL. This switch is used to select the speed range of the left transmission. Place the switch in the up position to engage the high speed ratio. Place the switch in the center position to engage the low speed ratio. Place the switch in the bottom position to disengage

(neutral) the transmission. Lift the toggle switch to change positions.
28. RIGHT TRANSMISSION CONTROL. This switch is used to select the speed range of the right transmission. Its operation is identical to item 27.
29. ENGINE STARTING AID. The engine starting aid is used to assist in cold weather starting. See page 2-14 for starting the engine.
30. MASTER SWITCH. This switch controls the electrical power of the machine. Turn the key clockwise to the "on" position to supply power to the start button and other electrical components of the machine. Turn the key counterclockwise to de-energize the electrical components and shut down the engine.
31. ENGINE START BUTTON. Depress this button to engage the engine starter.
32 TORQUE CONVERTER OIL TEMPERATURE GAUGE. During operation of the machine, the torque converter oil temperature should range between 180 and 2200F (82.2 and 104.40C). If the temperature does not remain within this range, find and correct the difficulty. The temperature must never exceed 2500F (121.10C).
33. TORQUE CONVERTER OIL PRESSURE GAUGE. During operation of the machine, with the modulated clutch fully engaged, this gauge should indicate pressure of approximately 40 psi (276 kPa). If the pressure is not approximately 40 psi (276 kPa) during normal operation, find and correct the difficulty.
34. TRANSMISSION LUBRICATION OIL PRESSURE GAUGE. During normal operation this gauge should read from 10 to 40 psi (69 to 276 kPa).
35. TRANSMISSION CONTROL PRESSURE GAUGE. During normal operation this gauge should read from 250 to 300 psi (1724 to 2069 kPa).

NOTE

This gauge is mounted on the front of the right hand chain case.

36. FUEL GAUGE. This gauge shows the amount of fuel remaining in the fuel tank.
37. HYDRAULIC SYSTEM PRESSURE GAUGE. This gauge indicates the high and low range of hydraulic system pressure. The green area of the dial face indicates the normal range, 1 200 to 2000 psi (8274-13790 kPa). Normal "operating" pressure on some machines is 1400 to 1550 psi (9653 to 10687 kPa) while on other machines it is 1550 to 1650 psi (10687 to 1 1377 kPa). The amber area of the dial face indicates the low range, 0 to 1200 psi (O to 8274 kPa).
38. ENGINE WATER TEMPERATURE GAUGE. This gauge shows the temperature of the engine coolant. The gauge should read between 165 to 1850F (73.8 to 90.50C) during normal operation.
39. ENGINE OIL PRESSURE GAUGE. This gauge indicates engine oil pressure. Thegauge should read between 30 and 70 psi (207 and 483 kPa), during normal operation.

CAUTION

Be sure the engine oil pressure reaches the normal operating range within 15 seconds after starting the engine. If it does not, stop the engine and correct the cause of the pressure failure before restarting the engine.

40. VOLTMETER. The voltmeter measures the voltage produced by the alternator and indicates the condition of the battery. See Figure 2-2 for an explanation of the voltmeter readings.
41. FUSE FAILURE LIGHT. This light will be lit when there has been a fuse failure in any one of the electrical circuits.
42. TRANSMISSION PRESSURE MALFUNCTION LIGHT. This light will be lit in the event that transmission control pressure drops below 70 psi (483 kPa). During engine starting this light will stay on until pressure reaches approximately 200 psi (1379 kPa). If the light should come on during operation, discontinue operation and locate the malfunction.
43. TACHOMETER. This gauge indicates the engine speed in revolutions per minute (RPM).
44. HOURMETER. The hour meter indicates the total number of hours the engine has been run.
45. ELECTRICAL SYSTEM CIRCUIT BREAKER (NOT SHOWN). The function of the circuit breaker is to protect the various upper electrical circuits. It is located at the rear of the engine near the engine starter. An overload will cause the circuit breaker to trip. Reset the circuit breaker and continue operation. If the circuit breaker should trip shortly after it is reset, check the circuit protected by the circuit breaker for the cause of the overload.

WARNING

Under no circumstances should the circuit breaker be prevented from tripping by any means. Overloaded electrical circuits can cause extensive damage to the machine and/or injury to personnel.

46. CLUTCH PRESSURE MALFUNCTION LIGHT. This light will be lit in the event that clutch control pressure falls below approximately 230 psi (1586 kPa). During engine starting this light will stay on until pressure reaches approximately 250 psi (1724 kPa). If the light should come on during operation, discontinue operation and locate the malfunction.
47. MODULATED CLUTCH PRESSURE GAUGE. During normal operation this gauge should read from 230 to 250 psi (1586 to 1724 kPa).

NOTE

This gauge is mounted on the front of the right hand chain case.

48. ENGINE ALARM. When this light and bell comes on it indicates that the engine is overheated or the engine oil pressure is below normal. Shut down the engine IMMEDIATELY -

when this light comes on. Locate the cause of alarm being activated.

49. OVERRIDE SWITCH. Press this switch during start up to prevent the system from activating during low oil pressure start up.

50. GENERATOR CONTROLS. The following controls are provided to start and stop the lighting generator.

A. ON-OFF SWITCH. Used to supply or cut off electrical circuit to generator.

B. START BUTTON. Pushbutton used to start generator.

C. PREHEAT BUTTON. Pushbutton used to assist generator starting in cold weather. See STARTING GENERATOR later in this section for use of preheat button.

51. LIGHT SWITCHES - 24 VOLT SYSTEM. Four light switches and a circuit breaker control the lights on the machine.

A. CIRCUIT BREAKER.

B. BOOM LIGHT SWITCH. Move switch up to turn ON boom lights. Move switch down to turn OFF boom lights.

C. MACHINERY HOUSE LIGHT SWITCH. Move switch upto turn ON inside machinery lights. Move switch down to turn OFF machinery lights.

D. REAR LIGHT SWITCH. Move switch up to turn ON rear cab lights. Move switch down to turn OFF rear cab lights.

E. FRONT LIGHT SWITCH. Move switch up to turn ON front cab lights. Move switch down to turn OFF front cab lights.

52. CIRCUIT BREAKERS - 110 VOLT SYSTEM. Three circuit breakers are provided to protect the 110 volt system cab lights and boom lights. The circuit breakers are (from left to right): Machine Cab Interior, Machine Cab Exterior and Boom.

53. GANTRY CONTROLVALVE. The gantry control valve is provided to assist in raising and lowering the gantry (see Figure 2-10). This valve is located on the right side of the

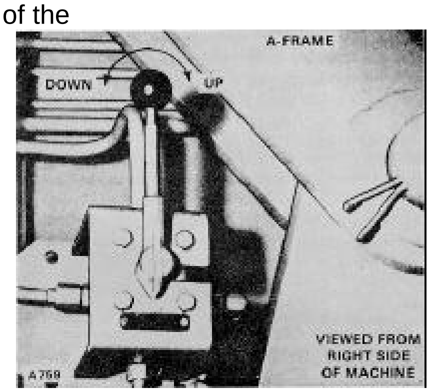


Figure 2-10. Gantry Control Valve

main machine, below the A-frame. See Gantry in Section IV for the use of this valve.

MACHINE OPERATION

GENERAL

The following operating suggestions are offered as a reminder rather than as an attempt to instruct, since the Harnischfeger Corporation is well aware of the fact that a machine of this size is not entrusted to anyone except a fully qualified operator.

1. Always consult the rating plate on the upper cab for the maximum load which may be lifted with the various combinations of boom length, boom angle, and other variable factors which may be involved with lifting the load.

2. When the load is being swung, it should be kept as near the machine and as close to the ground as possible. Also check tail swing clearance when swinging the machine.

3. Always pay out cable from the drum when the boom is being lowered to prevent "two blocking" the hook block.

4. Always set the outriggers before operating the machine.

5. If the operator must leave the machine, the extent of precautions which should be taken depend primarily on the hook block resting on the ground so as to prevent the upper from turning freely. The swing brake should be applied so as to prevent the upper from turning. Also check that the right and left transmissions are in "neutral". Do not leave the machine with the machinery turning over.

STARTING THE ENGINE

To start the upper engine, proceed as follows:

1. Perform the following functions before leaving the carrier cab:

A. Shift the main transmission to neutral.

B. Apply the Maxibrakes by pushing the Maxibrake button "in".

2. Make certain that all controls are in the neutral position, and that the swing and drum brakes are locked in the applied position. Place the left and right transmission switches in the neutral position. Also place the modulated clutch control in the extreme counterclockwise position.

3. Set the throttle control at idle speed. Push and hold override switch (49) until engine starts. To start the engine, turn the upper master switch clockwise, to the "on" position. Press the engine start button to start the engine. Do not hold the start button down for more than 30 seconds at one time. If the engine does not start in this period of time, release the start button, and wait two minutes before attempting to start the engine again.

NOTE

The use of a cold weather starting aid may be required in extremely cold weather. Press the starting aid button, wait two seconds and engage the starter. Repeat the procedure for temperature below O°F (-170C).

4. Check all gauges, immediately after the engine start, to be sure they are reading properly. If the readings are improper, stop the engine immediately and determine the cause of the improper gauge reading before continuing operation.

5. Allow the engine to run at 800 to 1000 rpm for 4 to 5 minutes or preferably until the water temperature reaches normal operating temperature before working the machine.

LOAD WEIGHING SYSTEM

The load weighing system is tested and adjusted at the central unit (Item 01, A, Figure 2-9). The unit must always be tested, before use as follows:

1. Set the PARTS OF LINE control for the total lines supporting the hook block (5), including the dead end line.

2. Set the CONFIGURATION and BOOM LENGTH switches for the crane operating conditions. Set the JIB-MAIN switch in the MAIN position.

3. Test the system by depressing the TEST switch. The HOOK LOAD meter should read slightly in excess of half scale. All lamps should be illuminated and the sonalerts should sound. The CAPACITY meter should read full scale. The RADIUS meter should read zero.

4. The Load meter will display left hook load, right hook load or the sum of left and right hook load as selected by the Left-Sum-Right selector switch on the Junction Box. The Capacity meter will display the single hook or sum capacity as selected with the Left-Sum-Right switch.

5. There are five conditions under which the system will sound an alarm and light warning lamps, as follows:

A. INPUT ERROR — The operating condition selected by the operator is not acceptable to the unit. The amber INPUT ERROR lamp on the central unit will light and a medium level audible warning will sound. Consult the operating instructions above and check the capacity charts.

B. NO LIFT ZONE — The boom angle is outside the limits specified by the capacity chart for lifting. The amber NO LIFT ZONE lamp on the central unit will light and a medium level audible warning will sound. Both amber and red lamps on the hook load meter will light. See the capacity chart.

C. 85 PERCENT WARNING — The load being lifted is between 85 and 100 percent of the crane capacity. The amber warning lamp on the hook load meter will light and a medium level audible warning will sound.

D. 100 PERCENT WARNING — The load being lifted is equal to, or greater than, the crane capacity. The red warning lamp on the hook load meter will light and a high level audible warning will sound.

E. TEST MODE — All lamps will light and the high level audible alarm will sound when the TEST switch on the central unit is depressed. The LOAD meter will read half scale, the CAPACITY meter will read maximum capacity and the RADIUS meter will read zero.

WARNING

This unit is an operating aid and cannot be used as a substitute for the rating plate. To maintain system accuracy the unit must be properly tested at least once each day and before each major lift. The unit should be inspected on a weekly basis for pinched or cracked cables. Also check that all connections are tight.

See Shop Manual (Subsection 13C) for calibration and troubleshooting instructions.

CRANE OPERATING CYCLE

This machine is equipped as a liftcrane. The functions of the drums during crane operation are tabulated below:

DRUM	FUNCTION LIFTCRANE
Front Drum	Main Load Line
Rear Drum	Jib Load Line
Boom Hoist Drum	Boom Hoist Line

WARNING

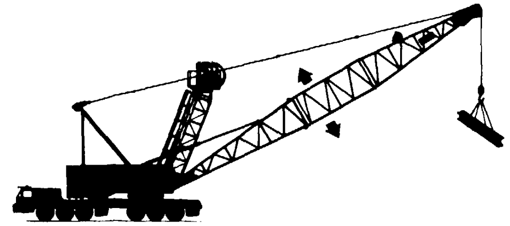
The left and right transmission should not be shifted while under load or with the engine running faster than low idle speed (600 rpm). The left hand transmission control is interlocked with the engine throttle to prohibit a shift except at low idle speed. If the control switch is moved from high to low, or vice-versa, while the engine speed is above low idle, the shift will not occur. It is possible to shift the left hand transmission into neutral at any time; however, this must never be attempted at higher engine speeds, because the transmission cannot be re-engaged in either gear until the engine has been throttled back to low idle speed. This interlock is designed to protect the boom while raising or lowering, but also affects the swing motion because of the common drive train.

The operating cycle consists of four steps: setting the boom angle (boom hoist operation), lifting the load (hoisting operation), swinging and spotting the load, and lowering the load (see Figure 2-11).

STOPPING THE ENGINE

To stop the engine, proceed as follows:

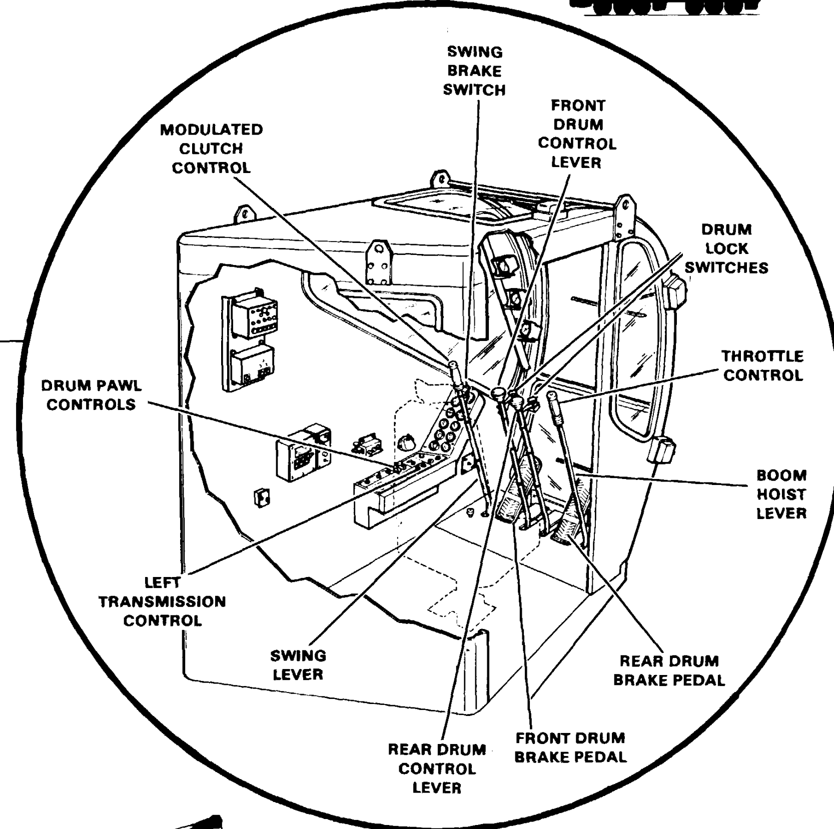
1. Make certain that all controls are in neutral position, and the swing brake is applied. Engage the drum pawls and the drum brake locks.

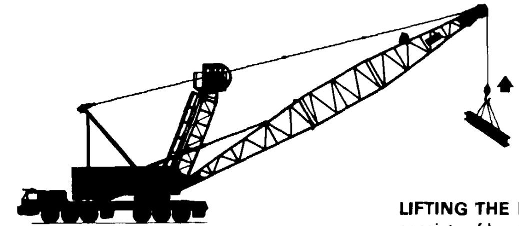


SETTING THE BOOM ANGLE. Position the boom at the proper angle for the load and working conditions. Refer to the rating plate. Place the left transmission control in the high or low speed position (see the Warning under Crane Operating Cycle). The low speed setting should be used if the boom is being raised or lowered from the ground. Pull the boom lever back to raise the boom. Push the boom hoist lever forward to lower the boom. Be sure to pay out line from the front and rear drums, as required to prevent the hook block(s) from coming in contact with the boom point. Use the engine throttle control to vary boom hoist speed.

SWINGING. Move the swing brake switch to the "on" position to release the swing brake. Place the left transmission control in the desired position, high or low speed. (See the Warning under Crane Operating Cycle.) Push the swing lever forward to swing to the right. To stop, or reverse, the swing motion slowly move the swing lever in the opposite direction (plugging the swing motion). If you wish to hold the upper from turning, move the swing brake switch to the "off" position.

Spotting the load requires accurate control of the boom hoist and swing movements. It takes practice to locate the load at the exact spot without hunting or overshooting. Raise or lower the boom with the boom hoist lever as necessary to accurately locate the load. Never extend the boom out so far that the rated load is exceeded. See the rating plate.





LIFTING THE LOAD (HOISTING). The operation of lifting the load consists of lowering the hook block, hooking on the load and then lifting the load. Place the right transmission control in the desired position, high or low speed (see the Warning under Crane Operating Cycle). Within the selected speed range the operator can control the converter output torque, thus providing infinite torque and speed control.

To lower the hook block and lift the load, proceed as follows: Depress the brake pedal and disengage the drum pawls and drum locks. Set the engine throttle at maximum governed speed, move the drum control forward, release the drum brake and turn the modulated clutch control clockwise to power down the hook block. Control the lowering speed with the modulated clutch control or pull the drum lever back to neutral and depress the brake pedal. Attach the load to the hook block, then pull the drum lever back to raise the load. Control the lifting speed by turning the modulated clutch control clockwise or counterclockwise.

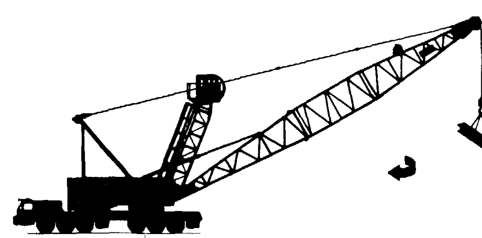
LOWERING THE LOAD. With the drum lever pulled back, turn the modulated clutch control counterclockwise until the load stops raising. Momentarily hold the load in position then turn the modulated clutch control further counterclockwise and lower the load against the machinery (slipping the modulated clutch).

The load may also be lowered by depressing the brake pedal, moving the drum lever forward and slowly release the brake pedal. This will power down the load. Control the lowering speed with the modulated clutch control or depress the brake pedal and pull the drum lever back to neutral.

CAUTION

When no lifting work is being done, rotate the modulated clutch control fully counterclockwise and lower the engine speed. This will prevent overheating of the converter.

The load may also be lowered by depressing the brake pedal and move the drum lever to neutral. Then slowly release the brake pedal and allow gravity to lower the load. Control the lowering speed with the brake pedal or pull the drum lever back.



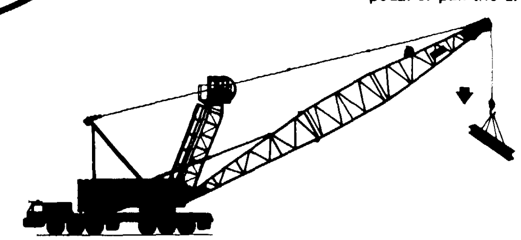


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Figure 2-11. Liftcrane Operating Cycle

2. If possible, allow the engine to run at half speed or less for several minutes before stopping the engine. This will allow the engine to cool down.
3. Place the master switch in the OFF position to stop the engine.

HEATER OPERATION

DESCRIPTION

The heater is located to the left of the operator's seat. The heater is thermostatically controlled and is of the propane type.

STARTING

To start the propane heater, proceed as follows:
1. Turn the heater control (Item 17A) to the HI position.
2. Hold the START-RUN-OFF switch (17D) in the START position. The green HEATING indicator (1 7C) must light immediately.

WARNING

If the heater fails to produce heat within 30 seconds, turn it OFF immediately to prevent propane buildup in the burner head. Refer to the Troubleshooting Chart in Section XII of the Shop Manual.

HEATING

To run the propane heater, proceed as follows:
1. The heater will continue to run as long as fuel and power are provided to it.
2. The internal microswitch, controlled by the position of the HEATER control, will cause the heater to cycle and maintain the desired temperature. Turn the HEATER control to the desired position.

STOPPING

To stop the propane heater, proceed as follows:

WARNING

Do not switch the ignition, on the dash, to the off position before the heater stops running. If this is done, the purge cycle will be interrupted which may lead to a propane build-up in the burner head. Faulty heater operation may result.

1. Move the START-RUN-OFF switch to the OFF position. The green HEATING indicator should go out immediately.
2. The heater may not shut off immediately, since the heater incorporates circuits for a purge cycle. The blower will run until all fuel in the burner is consumed and the heat exchanger cools sufficiently to open the flame switch. When this occurs, the blower motor will stop and the amber FLAME SWITCH will immediately go out.

GENERATOR

DESCRIPTION

The electric generating set consists of a one-cylinderdiesel engine and a 3.0 KW alternating current generator to power the boom lights.

STARTING

NOTE

Check fuel supply and check that shutoff valves are open. It may be necessary to prime fuel system if fuel filters were drained or changed or the fuel tank ran dry. To prime pump, move priming pump lever on generator engine up and down until fuel flows steadily from return line (disconnected).

1. Move ON-OFF switch to ON position (Item 50A).
2. Push and hold preheat button for: 30 seconds if air temperature is above 550F (13°C) 60 seconds if air temperature is below 550F (130C)
3. Release preheat button. Push in start button to start engine. Do not hold the start button down for more than 20 seconds at one time. If engine does not start in this period of time, release start button, and wait one minute before attempting to start engine again.

STOPPING
1. Move ON-OFF switch to the off position.
2. If the stop circuit fails to stop the generator engine, close the fuel valve.

HAND SIGNALS

It is frequently necessary during crane operation for the operator to depend on a signalman for instructions. When moving the machine into a position where there is very limited clearance, or when handling loads that are out of sight of the operator, the use of a signalman is essential.

The hand signals illustrated in Figure 2-12 are those generally accepted throughout the industry. Both the operator and the signalman should be thoroughly familiar with the standard hand signals illustrated to ensure cooperation and teamwork.

OPERATION UNDER UNUSUAL CONDITIONS

GENERAL. Unusual conditions refer to environment; specifically, extreme cold, extreme heat, dust or sandy conditions, areas with high humidity or salt air, and high altitudes. Separate paragraphs are devoted to each of these conditions.

OPERATION IN EXTREME COLD. Operation in extreme cold presents special problems due to the increased brittleness of metallic and rubber parts, the danger of freezing and the increased difficulty of keeping parts lubricated adequately.

ALWAYS STAND IN CLEAR VIEW OF CRANE OPERATOR, BE SURE TO STAY A SAFE DISTANCE FROM HOOK BOLCK OR BOOM

Figure 2-12. Hand Signals for Crane Operation

WARNING

Personnel should use care to keep from spilling liquids upon themselves. Exposed parts of the body should not come into contact with metal during cold weather, as serious injury may result.

1. Refer to Section III, Lubrication, for lubricant recommendations for cold weather operation. Change the lubricant if necessary.

2. Drain and flush the cooling system, to ensure proper circulation of coolant throughout the radiator core. Clean the radiator cooling fins, particularly the air passages through the core.

Check the condition of the radiator hoses, clamps, thermostat and radiator core.

When freeze protection is required, an ethylene glycol base permanent antifreeze should be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill, if a minimum antifreeze concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection and additional inhibitors may have to be added. Concentrations over 67% adversely affect freeze protection as shown in Figure 2-13.

Inhibitor depletion will occur in ethylene glycol base antifreeze through normal service. The inhibitors should be replenished at approximately 500 hour or 20,000 mile intervals with a non-chromate inhibitor system.

NOTE

The combination of a Chromate base inhibitor with an ethylene glycol antifreeze can produce Chromium Hydroxide, commonly known as "green slime".

3. Keep the battery fully charged at all times. The electrolyte in a discharged battery will freeze at a higher temperature than that in a fully charged battery.

NOTE

If it is necessary to add water to the battery, do so only immediately before or during operation, or with an external charger connected to the battery. Charging the battery, by any means, mixes the water and electrolyte, and thereby prevents the water from freezing.

Keep the battery terminal connections clean and free from snow or ice which could short circuit the terminals. Clean the cable connectors and battery posts Thoroughly, using a soda and water solution to remove corrosion. In extremely cold weather, it is advisable to remove the battery and store it in a heated area if the machine is to be idle overnight or for any extended period.

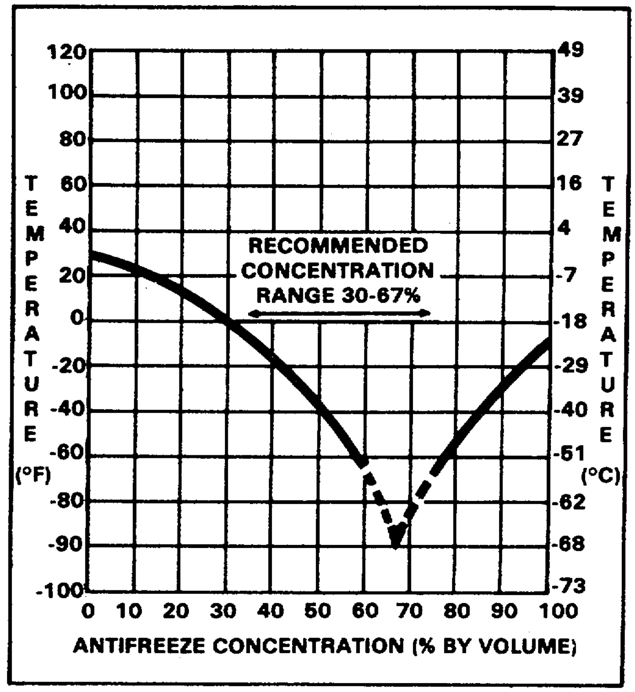


Figure 2-13. Antifreeze Concentration

4. Keep the fuel tanks as full as possible, with the proper grade of fuel, at all times to minimize condensation. If water is detected in the fuel supply, drain the tank and refill it with clean fuel.

5. Start the engine in accordance with the engine manufacturer's recommendations for cold weather starting, and run it at approximately 1200 RPM until the engine has warmed up.

NOTE

Cover part of the radiator to aid warmup and to maintain engine running temperature. During warmup only, the entire radiator may be covered. A shutter arrangement may have to be used.

To aid warmup of the carrier main transmission, place the auxiliary transmission in neutral, select a gear on the main transmission, and release the clutch pedal to turn over and warmup the main transmission.

6. Before shutting down the machine, raise the outriggers to the stored position, and drive the machine onto wooden planks or mats to prevent the machine from being frozen to the ground.

CAUTION

Cold weather can produce brittle fractures of structures normally considered to be ductile. Brittle fractures start at cracks in the structure. Perform weekly inspection of the entire machine to locate and repair cracks in the structure. Consult a separate rating plate for operation below -200F (-28.90C). Cease all operation below -450F (-42.8°C).

OPERATION IN EXTREME HEAT. Operation in extreme heat presents special problems due to the difficulty in preventing the engine from overheating.

1. Refer to Section III for lubricant recommendations in hot weather operation. Change the lubricant if necessary.
2. Make certain that the engine crankcase oil is at the proper level. An inadequate supply of crankcase oil will prevent proper dissipation of heat from the engine.
3. Drain and flush the cooling system, to insure proper circulation of coolant throughout the radiator core. Clean the radiator cooling fins, particularly the air passages through the core, of insects, leaves, dirt and other foreign material that will restrict air flow.
4. Inspect the cooling system for leaks. Replace worn or damaged hoses. Tighten the hose clamps.
5. Keep the water pump fan belt adjusted properly.
6. If the engine becomes overheated from lack of coolant, let the engine run at fast idle and add coolant slowly.
7. If the engine overheats after refilling the cooling system, shut down the engine and allow it to cool. Drain the cooling system by opening the drain cocks on the radiator and the engine block, and flush out the system. Refill the cooling system, with clean water; do not use salt or mine rat water solutions in the cooling system.
8. Keep as much air as possible circulating around the battery. Check the electrolyte level frequently; add distilled water as necessary to keep the electrolyte lever 3/8 inch (0.95 cm) above the plates.
9. Keep the air intake and exhaust opening clear. Keep the engine clean, and allow air to circulate freely around the engine.
10. Avoid racing the engine, and avoid operation at full throttle when part throttle will handle the load.
11. Avoid lugging the engine, keep the engine speed high enough to maintain fan speed.
12. Avoid idling the engine unnecessarily, shut the engine down during a lull in the operation.

OPERATION IN DUSTY AND SANDY AREAS. Operation in dusty or sandy areas presents special problems due to the abrasive action of dust which shortens the life of parts. Make every effort to keep dust and sand out of the moving parts of the crane machinery and engine.

1. All lubricants and lubricating equipment must be kept clean. Service breathers and air cleaners frequently to remove accumulated sand and dust. Lubricate more fre-quently to keep a supply of clean lubricant in the moving parts. Clean all lubrication fittings thoroughly before at-taching the grease gun.
2. Inspect the clutch and brake I linings frequently. After operation in dust or sand, blow loose grit out of linings. Failure to keep the linings clean will result in worn bands, scored drums, and unsatisfactory operation.
3. Keep unused cables in boxes. Clean and lubricate operating cables frequently.
4. Keep the fuel tank filler cap tight to prevent sand or dust from entering the fuel tank. Service fuel filters frequently to keep them free from sand and dust.
5. Use wood blocking or mats under the outrigger jack-floats when operating in sand. See that the carrier does not shift during operation.

OPERATING IN HUMID OR SALT WATER AREAS. Moisture and salt will cause deterioration of paint, cables, wiring, and all exposed metallic parts. Keep parts dry and well lubricated in high humidity or salt water conditions.

1. Completely remove rust and corrosion at the first appearance on any part of the machine. Wash off salt water and dry all parts thoroughly; paint the exposed surfaces immediately. Place a film of lubricant or grease on all polished or machined metal surfaces and other surfaces which cannot be painted.
2. Keep parts lubricated thoroughly to repel water from polished metal surfaces and to prevent the entry of water into bearings. Keep lifting cables lubricated.

OPERATION AT HIGH ALTITUDES. Operation at high altitudes presents special problems due to lower atmospheric pressure and wide temperature ranges. At altitudes above 7000 feet (2134 m) it may be necessary to adjust the engine fuel injectors. Make certain that the air cleaners are clean and free from obstructions. Check the engine frequently for overheating. Operate the engine using a lower power requirement to prevent smoke and over-fueling.

TOWING

If it becomes necessary to tow the machine, proceed as follows:

NOTE

Each towing situation presents special problems which cannot be anticipated in advance. Therefore, the following procedures are general in nature and additional steps may be necessary.

1. Disconnect and remove the propeller shaft that runs from the auxiliary transmission to the forward rear drive axle.
2. Attach a tow bar from the towing vehicle to the carrier frame.
3. Run the carrier engine until the air pressure is up to the normal operating range. If the carrier engine is inoperative, an outside air supply can be used to bring the air pressure up to normal.
4. When air pressure has reached the normal level, release the Maxibrakes and begin towing the machine.

WARNING

When a machine of this size is being towed, extra precautions must be taken to ensure the safety of personnel and equipment.

SECTION III.

LUBRICATION

SECTION III.
LUBRICATION

GENERAL

To insure proper operation of this machine, all points re quiring lubrication must be serviced with the correct lubri cant, at the proper time interval. All normal wear point which require lubrication are shown in the lubricatio chart. Note that the original manufacturer's recommenda tions take precedence over lubrication recommendation contained in this manual if any conflict exists.

Points not considered to be normal wear points(levers, link ages, pins and so forth) should be lubricated with an oil car once a week. Use a few drops of engine oil on each exposed pin or lever not equipped with grease fittings to prevent rust and to provide the limited lubrication required.

NOTE

The lubrication recommended in this manual is based on operation of the machine for a period not to exceed eight hours per day, five days per week. If a machine is operated in excess of the above time per day or week, lubrication schedules must be adjusted accordingly.

CAUTION

Initial factory fill of Multi Purpose Grease is of the soap base 12-Hydroxy Lithium Stearate type. Other soap base greases are not always compatible with initial fill lubricant, and Barium base grease is definitely not compatible. Various other soap base greases may be used if experience by the purchaser has shown these greases to be acceptable for the application. The grease systems must be thoroughly purged and the affected parts removed and cleaned before switching from a grease having one type of base to a grease having a different soap base.

All attachment fittings, whether illustrated on the lubrication chart or not, must be lubricated with multipurpose grease every 8 hours.

LUBRICANT SPECIFICATIONS

The following list will identify suitable lubricants for points shown in the lubrication charts by three methods. They are:

1. BY P&H SPECIFICATION NUMBER. This lubricant specification identifies the initial fill lubricant as classified by internal Harnischfeger Corporation Standards.
2. BY MILITARY SPECIFICATION NUMBER. If the lubricant classified by P&H Specification Number has a known military specification equivalent number, this equivalent number is also in the individual lubricant description.

NOTE

The absence of an entry In the Military Specification Column in a lubricant description does not mean that the lubricant recommended does not meet any equivalent military specification. It may mean, for instance, that the lubricant has not been tested and qualified by the military because it is relatively new. For that reason, it is not certified as meeting the standards of a particular military specification, even though it may be perfectly capable of so doing.

3. BY EQUIVALENT LUBRICANT. Equivalent lubricants presently confirmed as meeting the requirements of the P&H specification are listed by trade names. The absence of a lubricant from this list does not mean this is unsuitable. It means only that, as of the date of the writing, the lubricant has not been tested by P&H. The order in which the lubricants appear on any list is of no significance. No superiority of any brand listed should be read into the order of appearance on a list. The listing is purely random and all products on the list are equally acceptable.

NOTE

The lubricant specifications that follow were in effect at the time this manual was printed. The specification sheets are periodically updated to include the most recent vendor lubricants.

MULTIPURPOSE GREASE

P&H SPEC. NO.	AMBIENT RANGE	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	MANUFACTURERS
472A (NLGI #0 EP)	*Below -10°F (-12°C)	MIL-G-10924	Litholine Industrial 0 EP "Sinclair"	Atlantic Richfield Oil Co.
			Litholine H EP 0	
			Conolith EP #0	Continental Oil Company
			Rolubricant 0 or Lidok EP #0	Exxon Company
			Amolith Grease No. 0 EP	Amoco Oil Company
			Mobilux EP #0	Mobil Oil Corporation
			Alvania EPRO	Shell Oil Company
			Prestige 740 EP	Sun Oil Co. – DX Div.
			Multifak EP #0	Texaco, Incorporated
			Unoba EP NLGI #0	Union Oil Company of Calif.
			Dura-Lith Grease EP #0	Chevron Oil Company
472B (NLGI #1 EP)	*-20 to +40°F (-29 to 4°C)	MIL-G-10924	Litholine H EP 1	Atlantic Richfield Company
			Conolith EP #1	Continental Oil Company
			Rolubricant 1 or Lidok EP #1	Exxon Company (A)
			Mobilux EP #1	Mobil Oil Corporation
			Alvania EP #1	Shell Oil Company
			Prestige 741 EP	Sun Oil Co. – DX Div.
			Multifak EP #1	Texaco, Incorporated
			Amolith Grease #1 EP	Amoco Oil Company
			Unoba EP NLGI #1	Union Oil Company of Calif.
			Dura-Lith Grease EP #1	Chevron Oil Company
472 (NLGI #2 EP)	*+20 to 125°F (-6 to 52°C)	MIL-G-10924	Litholine H EP 2 or Arco EP Moly D	Atlantic Richfield Company
			Conolith EP #2	Continental Oil Company
			Rolubricant 2 or Lidok #2	Exxon Company (A)
			Mobilux EP #2	Mobil Oil Corporation
			Alvania EP #2	Shell Oil Company
			Prestige 742 EP	Sun Oil Company
			Multifak EP #2	Texaco, Incorporated
			Amolith Grease #2 EP	Amoco Oil Company
			Unoba EP NLGI #2	Union Oil Company of Calif.
			Dura-Lith Grease EP #2	Chevron Oil Company

*Pumpability tests also required when used in centralized lubrication systems. Consult manufacturer of system.

(A) Rolubricant for steel mill applications.
P115

PETROLEUM GEAR OIL

P&H SPEC. NO.	AMBIENT RANGE	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	SAE GRADE	MANUFACTURERS
497A	Below +10°F	MIL-L-2105C	Multipurpose Gear Lube	80	Amoco Oil Company
	-10° to +90°F		Citgo Premium Gear Oil (MP)	80W-90	Cities Service Oil Company
	-10° to +90°F		Conoco Universal Gear Lube	80W-90	Continental Oil Company
	Below +10°F		Gear Oil GX	80	Exxon Company
	-10° to +90°F		Mobilube HD	80W-90	Mobil Oil Corporation
	Below +10°F		Spirax Heavy Duty	80	Shell Oil Company
	Below +10°F		Sunfleet GL-5	80	Sun Oil Company
	Below +10°F		Multigear Lube	80	Texaco, Incorporated
	Below +10°F		Union MP Gear Lube	80	Union Oil Company of Calif.
497B	+10° to +90°F	MIL-L-2105C	Multipurpose Gear Lube	90	Amoco Oil Company
			Arco HD Gear Oil	90	Atlantic Richfield Company
			Citgo Premium Gear Oil (MP)	80W-90	Cities Service Oil Co.
			Conoco Universal Gear Lube	80W-90	Continental Oil Company
			Gear Oil GX	90	Exxon Company
			Mobilube HD	80W-90	Mobil Oil Company
			Spirax Heavy Duty	90	Shell Oil Company
			Sunfleet GL-5	90	Sun Oil Company
			Multigear Lube	90	Texaco, Incorporated
			Union MP Gear Lube	80W-90	Union Oil Company of Calif.
497C	Above +90°F	MIL-L-2105C	Multipurpose Gear Lube	140	Amoco Oil Company
			Arco HD Gear Oil	140	Atlantic Richfield Company
			Conoco Universal Gear Lube	85W-140	Continental Oil Company
			Gear Oil GX	140	Exxon Company
			Mobilube HD	85W-140	Mobil Corporation
			Sunfleet GL-5	140	Sun Oil Company
			Union MP Gear Lube	85W-140	Union Oil Company of Calif.
			Citgo Premium Gear Oil (MP)	85W-140	Cities Service Oil Co.

Issue No. 6, 6-80

P104

POWER TRANSMISSION FLUID AND GEAR OIL

P&H SPEC. NO.	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	MANUFACTURERS
494	Automatic Transmission Fluid, Type A, Dexron	American Dexron® ATF Fluid	American Oil Company
		ATF Dexron®	Atlantic Richfield Company
		Citgo AFT Dexron®	Cities Serive Oil Company
		Dexron® Fluid	Continental Oil Company
		Exxon ATF	Exxon Company USA
		Mobil ATF 220	Mobil Oil Corporation
		ATF Dexron® II	Phillips Petroleum
		Shell Donax T-6	Shell Oil Company
		DX ATF Dexron®	Sun Oil Company – DX Division
		Texamatic Fluid 8570 (GM Dexron®)	Texaco, Incorporated
		Union ATF Dexron®	Union Oil Company of Calif.

NOTE: This specification covers a petroleum power transmission fluid and lubricating oil properly described as Dexron® fluid.

HEAVY DUTY MOTOR OIL

P&H SPEC. NO.	AMBIENT RANGE	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	SAE GRADE	MANUFACTURERS
451A	Below +10°F	MIL-L-46152 (or latest issue in effect)	Conoco Fleet Motor Oils XD-3 Motor Oils Delvac 1200 Series Rotella T Oils Sunfleet HP Motor Oils Ursa Oils – Extra Duty Arco Fleet HD Motor Oils Amoco 200 Motor Oils Union Heavy Duty Motor Oils Citgo C-300 Motor Oils Delco 200 Motor Oils	10W 10W 10W 10W 10W 10W 10W 10W 10W 10W 10W	Continental Oil Company Exxon Company Mobil Oil Corporation Shell Oil Company Sun Oil Co. – DX Div. Texaco, Incorporated Atlantic Richfield Company American Oil Company Union Oil Company of Calif. Cities Service Oil Company Chevron Oil Company
451B	+10° to 32°F	MIL-L-46152 (or latest issue in effect)	**NOTE:** Equivalent lubricants and manufacturers are the same as for P&H Spec. 451A Motor Oil as described above. The only difference, insofar as this description is concerned, is that P&H Specification 451B is an SAE 20-20W grade oil.		
451C	+32° to 90°F	MIL-L-46152 (or latest issue in effect)	**NOTE:** Equivalent lubricants and manufacturers are the same as for P&H Spec. 451A Motor Oil as described above. The only difference, insofar as this description is concerned, is that P&H Specification 451C is an SAE 30 grade oil.		
451D	Above +90°F	MIL-L-46152 (or latest issue in effect)	**NOTE:** Equivalent lubricants and manufacturers are the same as for P&H Spec. 451A Motor Oil as described above. The only difference, insofar as this description is concerned, is that P&H Specification 451D is an SAE 40 grade oil.		
451E	Above +90°F	MIL-L-46152 (or latest issue in effect)	**NOTE:** Equivalent lubricants and manufacturers are the same as for P&H Spec. 451A Motor Oil as described above. The only difference, insofar as this description is concerned, is that P&H Specification 451E is an SAE 50 grade oil.		

P109

Issue No. 5, 2-75

HIGH TEMPERATURE GREASE

P&H SPEC. NO.	AMBIENT RANGE	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	MANUFACTURERS
476	(working temperature range) 0° to +450°F (-21 to 232°C)	Military Spec. not available at this time	Shell Darina #2 EP	Shell Oil Company

NOTE: The above lubricant is the only one currently approved as meeting P&H Specification No 476. It is Shell Oil Code Number 71522. This is a special grease which shows high thermal stability and resistance to shock loading and adverse chemical environment conditions. It is used as a replacement for P&H 472 MPG when reversing service, long life, or high temperature operation demands this premium lubricant.

LIQUID LUBRICANT-HYDRAULIC TORQUE CONVERTER FLUID

P&H SPEC. NO.	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	SAE GRADE	MANUFACTURERS
505A	MIL-L-2104C	Amoco C-3 Fluid	10W	Amoco Oil Company
		Arco C-3 Fluid	10W	Atlantic Richfield Company
		Chevron Torque Fluids Chevron Delo 400	10W	Chevron U.S.A. Inc.
		Hydraulic Transmission Fluid Type C-3. Polar Start DN-600 Fluid	10W	Continental Oil Company
		Torque Fluid #47 XD-3 Oil	10W	Exxon Company U.S.A.
		Delvac 1210 Delvac 1310 Power Fluid C2/C3 Mobilfluid 423	10W	Mobil Oil Corporation
		Hydraulic Fluid C-3 Donax T-5	10W	Shell Oil Company
		Sunfleet C2/C3	10W	Sun Oil Company
		Torque Fluid C-3 URSA Oil Super 3	10W	Texaco, Inc.
		Union C-3 Fluid	10W	Union Oil Company of Calif. Union 76 Division
505B	MIL-L-2104C	Chevron Delo 400	30W	Chevron U.S.A Inc.
		XD-3 Oil	30W	Exxon Company, U.S.A.
		Delvac 1230 Delvac 1330	30W	Mobil Oil Company
		Rimula U	30W	Shell Oil Company
		Sunfleet C2/C3	30W	Sun Oil Company
		URSA Oil Super 3	30W	Texaco, Inc.
		Union C-3 Fluid	30W	Union Oil Company of Calif. Union 76 Division

P153

HEAVY DUTY MOTOR OIL, MULTI-VISCOSITY

P&H SPEC. NO.	AMBIENT RANGE	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	SAE GRADE	MANUFACTURERS
452A	-10°F to 14°F	MIL-L-46167	Chevron Custom Motor Oil	10W-30	Chevron U.S.A. Inc.
			Exxon Extra Motor Oil	10W-30	Exxon Company, U.S.A.
			Gulflube Motor Oil X.H.D.	10W-30	Gulf Oil Company
			Mobil Delvac Special	10W-30	Mobil Oil Corporation
			Trop Artic	10W-30	Phillips Petroleum Co.
			Rotella Oil	10W-30	Shell Oil Company
			Ursatex	10W-30	Texaco Inc.
452B	14°F and Above	MIL-L-2104C	Chevron Delo 400 Motor Oil	15W-40	Chevron U.S.A. Inc.
			XD-3	15W-40	Exxon Company, U.S.A.
			XD-3 Extra	15W-40	Exxon Company, U.S.A.
			Gulflube Motor Oil X.H.D.	15W-40	Gulf Oil Company
			Mobil Delvac Super	15W-40	Mobil Oil Corporation
			Super HDII	15W-40	Phillips Petroleum Co.
			Rotella T Oil	15W-40	Shell Oil Company
			Ursa Oil Super Plus	15W-40	Texaco Inc.
452C	14°F and Above	MIL-L-2104C	Mobil Delvac Special	20W-40	Mobil Oil Corporation
			Sixty-Six Special	20W-40	Phillips Petroleum Co.
			Ursatex	20W-40	Texaco Inc.

P164

Issue No. 1, 2-81

OPEN GEAR AND WIRE ROPE LUBRICANT

P&H SPEC. NO.	AMBIENT RANGE (or application)	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	SAE GRADE	MANUFACTURERS
464	Open gears and racks under varying weather conditions. Peripheral speeds not to exceed 1200 feet per min. (365.8 m/min.)	V V-L-751 latest issue	Amovis Lubricant or Amoco Compounds	*	Amoco Oil Company
			Atlantic Lubricants, 36 thru 40	*	Atlantic Richfield Company
			Pinion Grease MS	*	Chevron Oil Company
			Coglube	*	Continental Oil Company
			Surett	*	Exxon Company
			Mobiltac	*	Mobil Oil Corporation
			Sunaplex or Sunep	*	Sun Oil Company
			Crater 2X	*	Texaco, Incorporated
			Union Gearshield	*	Union Oil Company of Calif.
			Liquid Gear Composition	*	Whitmore Mfg. Company

*Consult lubricant manufacturer for proper viscosity grade, which will depend on application and climate.

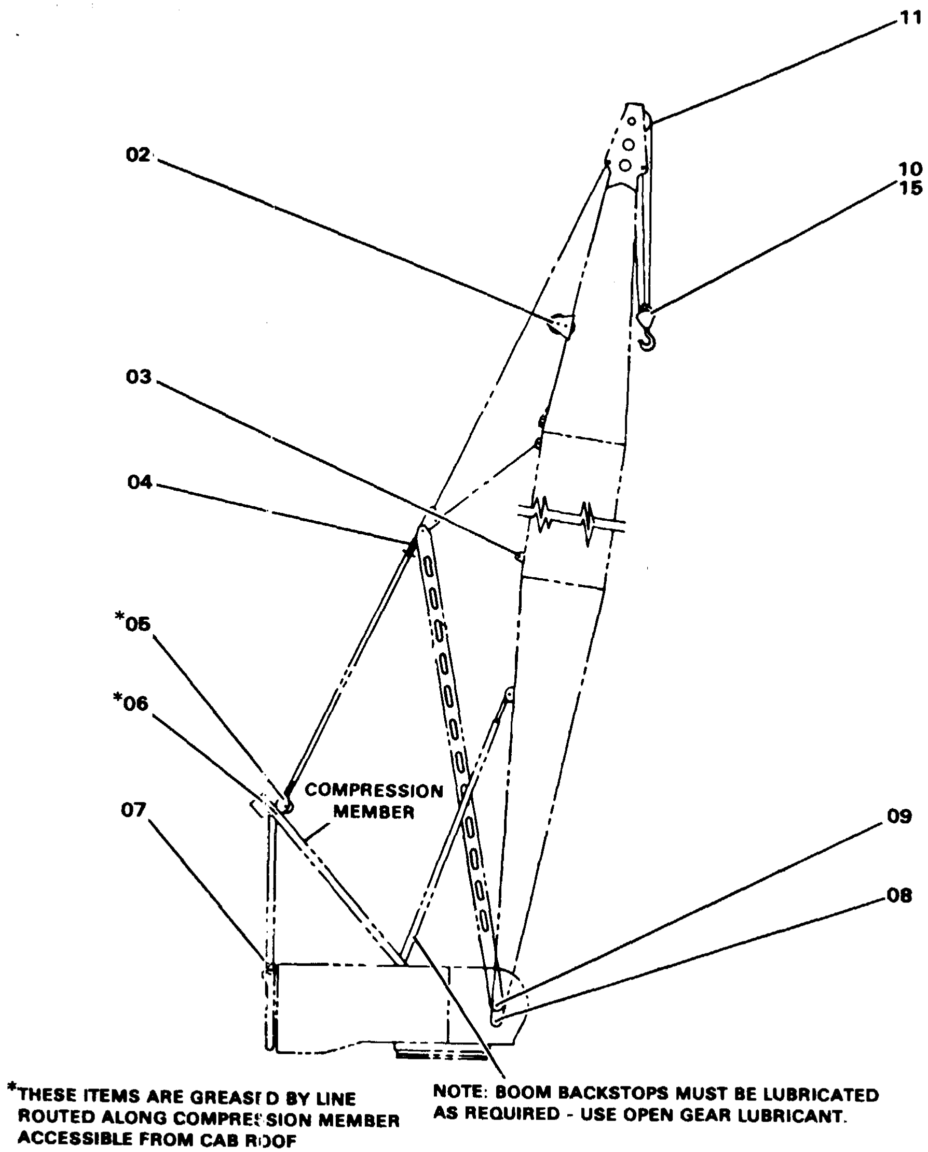
P108

Issue No. 6, 6-80

HYDRAULIC OIL

P&H SPEC. NO.	AMBIENT RANGE	MILITARY SPEC. NO.	EQUIVALENT LUBRICANTS	SAE GRADE	MANUFACTURERS
484A	Winter Service	MIL-L-2104C	UNAX AW 150 Chevron EP Hydraulic Oil EP-32 Amoco AW 32 Conoco Super Hydraulic Oil 15 Sunvis 816 WR Tellus 32 Rando Oil HD-32 Mobil D.T.E. 13 NUTO H32		Union Oil Company of Calif. Standard Oil of Calif. American Oil Company Continental Oil Company Sun Oil Company Shell Oil Company Texaco, Incorporated Mobil Oil Corp. Exxon Company
484B	Summer Service	MIL-L-46167	UNAX AW 315 Amoco AW 68 Mobil D.T.E. 26 Hydraulic Oil 68 Chevron EP Hydraulic Oil EP-68 Rando Oil HD-68 Conoco Super Hydraulic Oil 31 Sunvis 831 WR NUTO H68		Union Oil Company of Calif. American Oil Company Mobil Oil Corp. Shell Oil Company Standard Oil Comapny of California (Chevron) Texaco Continental Oil Company Sun Oil Company Exxon Company

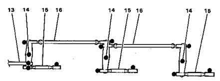
P140



HEAVY DUTY TIP (H.D.)					
Interval Hours	Ref. No.	Identification	Required Service	Lubricant Ref. Letter	No. of Serv. Pts.
10 Hours or Daily	6	Spreader Con. Pin	Lube	MPG	4
	8	Boom Foot Pin	Lube	MPG	2
	9	Mast Foot Pin	Lube	MPG	2
6 Months	10	Main and Jib Hook Blocks	Lube		
		1 Sheave Hook Thrust Brg.		MPG	2
		2 Sheave Hook Thrust Brg.		MPG	3
		3 Sheave Hook Thrust Brg.		MPG	4
		6 Sheave Hook Thrust Brg.		MPG	7
50 Hours or Weekly	2	Idler Sheave Assembly	Lube	MPG	2 H.D. 2 L.D. 4 C.T.
	3	Cable Roller Assembly	Lube	MPG	2 Ea. Assy.
	4	Upper Spreader Sheave Pin	Lube	MPG	7
	5	Lower Spreader Sheave Pin	Lube	MPG	8
	7	Boom Hoist Idler Sheaves	Lube	MPG	2
	11	Boom Point Sheave Assembly	Lube	MPG	6 H.D. 3 L.D. 6 C.T.

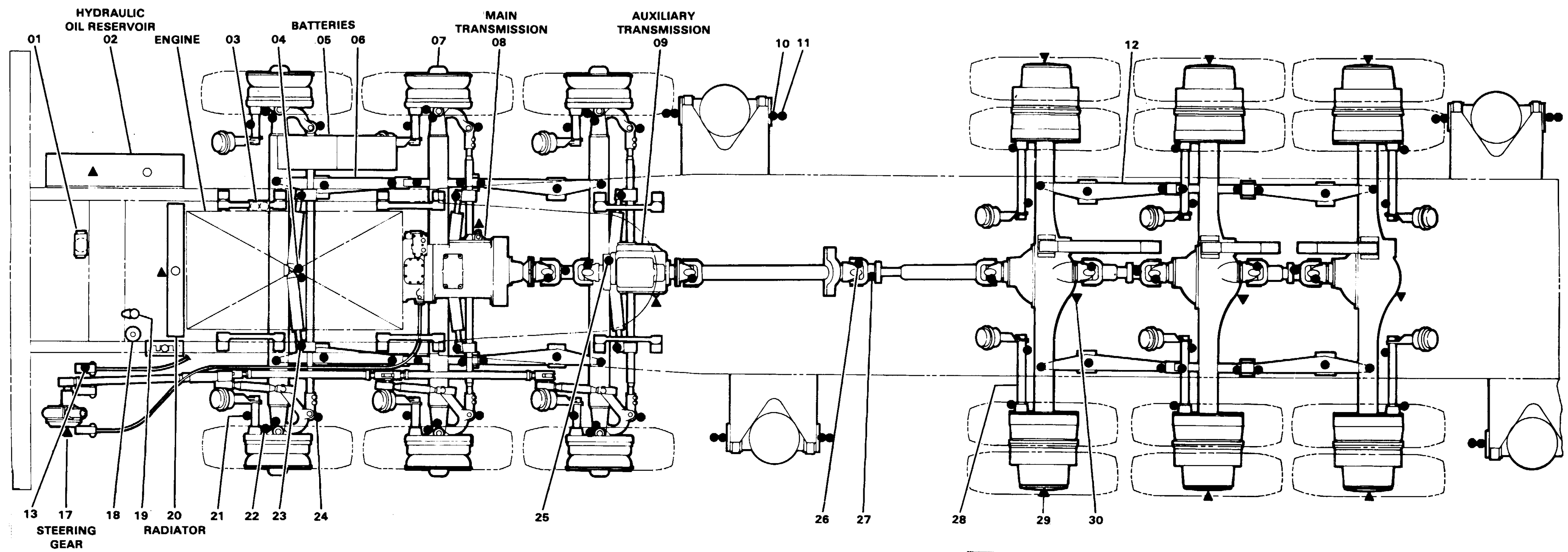
LUBRICATION RECOMMENDATIONS					
GENERAL					
		+40°F. to +110°F. (+4.4°C. to +43.3°C.)		-25°F. to +40°F. (-31.7°C. to +4.4°C.)	
Ref. Letter	Lubricant	P&H No.	Designation	P&H No.	Designation
MPG	Multipurpose Grease	472	NLGI #2 All Season		

Figure 3-1. Attachment Lubrication Chart (105N428-B)



STEERING LINKAGE

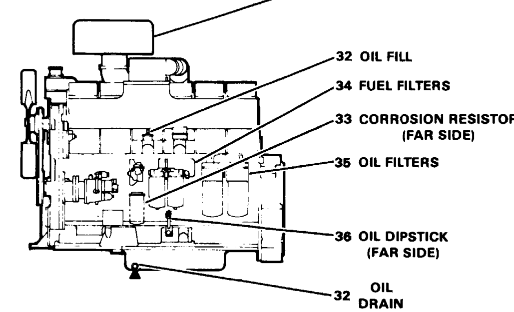
Time Interval	Ref. No.	Identification	Required Service	Lubricant	P&H No.	Number of Service Points
Daily 10 Hours	20	Radiator	Check	50/50 SOL	448	
	2	Hydraulic Oil Reservoir	Check	ATF	494	
	36	Engine Crankcase	Check	EO	452	See Vendors Manual
	31	Air Cleaner – Engine	–	–	–	
Weekly 250 Miles	27	Propeller Shafts Spline	Lube	MPG	472A	4 Fittings 1 Each Shaft
	26	Universal Joints	Lube	MPG	472A	9 Fittings 1 Each Joint
	5	Batteries	Check	Distilled Water	–	Each Cell
Monthly 1000 Miles 250 Hours	17	Steering Gear	Lube	MPG	472	1 Place
	13	Steering Drag Link	Lube	MPG	472	2 Fittings
	16	Steering Adjusting Rod	Lube	MPG	472	4 Fittings 2 Each Rod
	14	Steering Lever Bearing	Lube	MPG	472	3 Fittings 1 Each Lever
	15	Steering Link	Lube	MPG	472	6 Fittings 3 Each Link
	22	Front Steering Knuckle (King Pins)	Lube	MPG	472	12 Fittings 2 Each Wheel
	24	Steering Tie Rod	Lube	MPG	472	6 Fittings 3 Each Side
	23	Steering Cylinder Rod End	Lube	MPG	472	6 Fittings 1 Each Cylinder
	4	Steering Cylinder Anchor Pins	Lube	MPG	472	6 Fittings 1 Each Cylinder
	6	Front Suspension (Solid)	Lube	MPG	472	16 Fittings 8 Each Side
	12	Rear Suspension (Solid)	Lube	MPG	472	16 Fittings 8 Each Side
	10	Outrigger Box Pin	Lube	MPG	472	8 Fittings 4 Each Side
	11	Outrigger Cylinder Trunnion	Lube	MPG	472	8 Fittings 4 Each Trunnion
	21	Front Brake Camshaft Bearing	Lube	MPG	472	6 Fittings 1 Each Wheel
	28	Rear Brake Camshaft Bearing	Lube	MPG	472	12 Fittings 2 Each Wheel
	1	Hydraulic System Filter	Check	–	–	
	19	Air Supply Filter – Transmission Control	Check	–	–	
	25	Trunnion Mounting – Auxiliary Transmission	Lube	MPG	472	1 Fitting
3 Months 5000 Miles 500 Hours	30	Rear Axle	Check	MPL	497B	3 Places 1 Each Axle
	29	Rear Axle Planetary Wheel End	Check	MPL	497B	6 Places 1 Each Wheel End
	7	Front Wheel Bearing	Repack	MPG	472	6 Places 1 Each Wheel End
	33	Corrosion Resistor – Cummins	Replace	See	–	
	35	Engine Oil Filter	Change	Vendors	–	
	34	Engine Fuel Filter	Change	Manual	–	
	32	Engine Crankcase	Change	EO	452	
	18	Engine Bypass Filter – Cummins	Change	–	–	
Yearly 20,000 Miles 2000 Hrs.	2	Hydraulic System	Flush	HTF	505	
	1	Hydraulic System Filter	Change	–	–	
	20	Radiator	Flush	50/50 SOL	448	
6 Mos. 1000 Miles 1000 Hrs.	8	Main Transmission	Drain	HTF	505	
	9	Auxiliary Transmission	Drain	EO	451	
	30	Rear Axle	Drain	MPL	497B	3 Places 1 Each Axle
	29	Rear Axle Planetary Wheel End	Drain	MPL	497B	6 Places 1 Each Wheel End



LUBRICANT IDENTIFICATION CHART		
Abbreviation*	P&H No.	Lubricant Type & Temp. Range
EO		Engine Oil (For Diesel Engine)
	452A	−10°F to 14°F (−23° to −10°C) S.A.E. 10W30
	452B	Above 14°F (Above −10°C) S.A.E. 15W40 or
	452C	S.A.E. 20W40
EO		Engine Oil (For Main & Aux. Transmissions)
	451C	Below +10°F. S.A.E. 30 (Below -12°C.)
	451E	Above +10°F. S.A.E. 50 (Above -12°C.)
		(See Vendors Manual)
MPG		Multipurpose Type Grease
	472	N.L.G.I. – 2 EP
	472A	N.L.G.I. – 0 EP
MPL	497B	Multipurpose Type – Gear Lubricant S.A.E. 90
HTF	505A	Hydraulic Transmission Fluid Type C-3
		Below -10°F S.A.E. 10W (Below -23°C)
	505B	Above -10°F S.A.E. 30W (Above -23°C)
50/50 SOL	448	Ethylene Glycol (Mix With Water)

*Abbreviation Based on S.A.E. J754*a*

ENGINE



CAPACITY CHART						
Ref. No.	Identification		Lubricant	P&H No.	U.S.	Metric
2	Hydraulic System	– Initial Fill – Change	HTF	505	75 Gal. 36 Gal.	283,9 Liters 136,3 Liters
20	Cooling System	– System Total – Radiator Only	50/50 SOL	448	26.5 Gal. 16.5 Gal.	100,3 Liters 62,4 Liters
5	Battery – Each 3.5 Gallons		Electrolyte	–	7.0 Gal.	26,5 Liters
32	Cummins Engine KT-450 Crankcase With Filter	– Initial Fill – Change	EO	452	16.5 Gal. 15.5 Gal.	62,4 Liters 58,7 Liters
17	Steering Gear		MPL	497B	2.5 Pints	1,2 Liters
† 8	Main transmission Allison CLBT 5960		HTF	505	20 Gal.	75,7 Liters
† 9	Aux. Transmission Spicer 1241C		EO	451	15 Pints	7,1 Liters
†30 †29	Clark BD 91000	Rear Axle Bowl (Each) Axle / Wheel End (Each)	MPL	497B	35 Pints 16 Pints	16,6 Liters 7,6 Liters

†After the first 1000 miles or 50 hours of operation, whichever comes first, drain and flush or replace element.

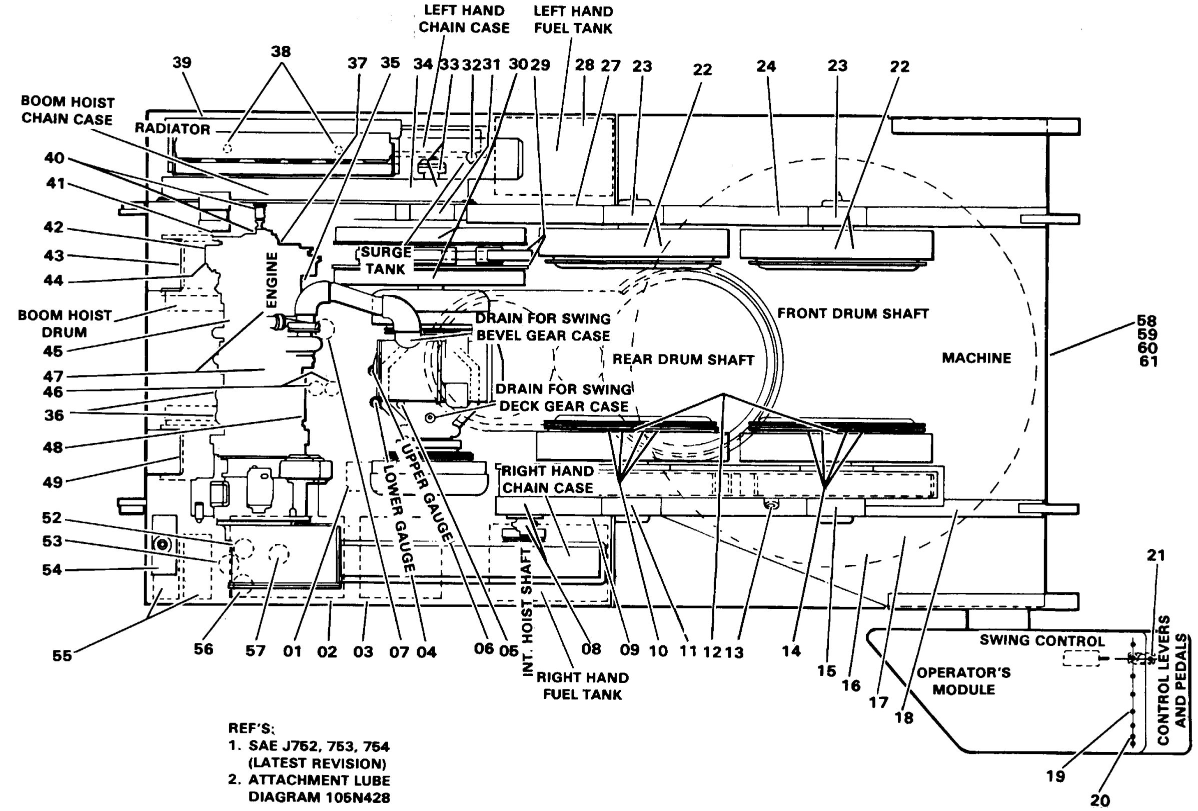
NOTE:

1. The lubrication intervals specified herein are a composite of several manufacturers recommendations. Consult manufacturers manual(s) on specific recommendations on individual components.

● STANDS FOR GREASE FITTING
▲ STANDS FOR OIL DRAIN

Figure 3-2. Carrier Lubrication Chart (810J229-B)

Interval Hours	Ref. No.	Identification	Required Service	Ref. Letter	No. of Service Points
10 or Daily	2	Hyd. Res. Mod. Clutch/Conv.	Check Level (Engine Shut Down)	HTCF	1
	3	Hyd. Res. Fans & Trans. Lube	Check Level (Engine Shut Down)	HO	1
	4	Swing Deck Gear Case	Check Level	RGL	1
	5	Air Cleaner	Check Service Indicator	—	1
	6	Bevel Gear Case	Check Level	RGL	1
	7	Fan & Trans. Lube Filter	Check Service Indicator	—	1
	10	Plan. (Lowering) Gear Pins (Rear)	Lube	MPG2	4
	13	Drum Gear Case	Check Level	RGL	1
	14	Plan. (Lowering) Gear Pins (Front)	Lube	MPG2	4
	28	Fuel Tanks (Left and Right)	Drain Sediment - Fill Tanks	—	2
	32	Radiator Coolant	Check Level	—	1
	34	Boom Hoist Chain Case	Check Level	EO (451)	1
	41	Eng. Alt., Magnetorque Alt.	Check Drive Belt Tension	—	3
	45	Dipstick - Engine Oil (Upper)	Check Level	EO (452)	1
	54	Main Hyd. Control Reservoir	Check Level	—	1
	58	Dipstick - Engine Oil (Generator)	Check Level	EO (451)	1
50 or Weekly	8	Hoist Shaft Universal	Lube	MPG1	2
	9	Plan. Brake Mech. Rear	Lube	EO (451)	1
	16	Slewing Rim	Grease liberally, grease should appear between upper rim of the entire circum. of slewing rim	MPG1	39
	17	Ring Gear	Lube	OGL	1
	18	Plan. Brake Mech. Front	Lube	EO (451)	1
	20	All Pins & Levers w/o Grs. Fits.	Lube	EO (451)	—
	24	Main Brake Mech. Front	Lube	EO (451)	1
	27	Main Brake Mech. Rear	Lube	EO (451)	1
	29	Boom Hoist Plan. Gear Brg.	Lube	MPG2	6
	33	Jackshaft Universal	Lube	MPG2	2
	40	Engine Drive Universal	Lube	—	1
	55	Battery (4)	Check Electrolyte Level	—	1
	59	Generator Engine Air Cleaner	Check	—	1
250 or Monthly	1	Engine Bypass Filter	Change Element	—	1
	5	Air Cleaner Piping	Check Hoses, Clamps, Etc.	—	—
	11	Rear Drum Sh. Brg. (Right)	Lube	MPG1	1
	12	Plan. Power Low. Front & Rear Drum	Lube	MPG1	2
	15	Front Drum Sh. Brg. (Right)	Lube	MPG1	1
	19	Control Levers & Pedals	Lube	MPG1	7
	21	Mod. Clutch Control Brg. & Gear	Lube (Sparingly)	HTG	1
	22	Front & Rear Drum Bearing	Lube	MPG1	4
	23	Front & Rear Drum Sh. Bearing	Lube	MPG1	2
	30	Boom Hoist Planetary	Lube	MPG1	2
	31	Jackshaft Bearing	Lube	MPG1	1
	35	Engine Corrosion Resistor	Change Element	—	1
	36	Engine Full Flow Filter	Change Element	—	1
	43	Boom Hoist Drum Shaft Brg.	Lube	MPG1	1
	44	Engine Throttle Linkage	Lube	EO (451)	1
	45	Engine Crankcase Oil	Change	EO (452)	1
	46	Engine Fuel Filters	Change Elements	—	2
	49	Boom Hoist Drum Sh. Brg.	Lube	MPG1	2
	53	Magnetic Separators	Clean Magnets	—	1
	58	Generator Engine Oil & Filter	Change	EO (451)	2
500 or 3 Months	37	Engine Water Pump	Lube (See Manual)	—	—
	47	Engine Crankcase Breathers	Clean Filters	—	2
	60	Generator Engine Primary Fuel Filter	Change Element	—	1
1000 or Six Months	34	Boom Hoist Chain Case	Drain and Refill	EO (451)	1
	39	Radiator Core (External)	Blow Out Dirt and Debris	—	1
	42	Engine Fuel Pump, Mag. & Screen	Clean	—	—
	48	Engine Cranking Motor	Check and Lube	—	—
2000 or Yearly	2	Hyd. Res. Mod. Clutch/Conv.	Drain, Clean, Refill	HTCF	1
	3	Hyd. Res. Fans & Trans. Lube	Drain, Clean, Refill	HO	1
	4	Swing Deck Gear Case	Drain, Refill	RGL	1
	6	Bevel Gear Case	Drain, Refill	RGL	1
	7	Fans & Trans. Lube Filter	Replace Element	—	1
	13	Drum Gear Case	Drain, Refill	RGL	1
	38	Hyd. Fan Motors	Check Shaft Seals for Leaks	—	—
	52	Torque Conv. Charge Filter	Replace Element	—	1
	54	Main Hyd. Control Rés.	Drain, Clean, Refill	ATF	1
	56	Mod. Clutch Filter	Replace Element	—	1
	57	Trans. Clutch Cont. Filter	Replace Element	—	1
	61	Generator Engine Secondary Fuel Filter	Change Element		



Capacities	Gal. (U.S.)
Drum Gear Case	12
Double Drum Boom Hoist Chain Case	2
Main Hydraulic Control Reservoir	8
Swing Deck Gear Case	40
Bevel Gear (Swing) Gear Case	14
Mod Clutch Converter Reservoir	74
Fans and Trans. Lube Reservoir	50
Engine and Radiator Coolant	27
Generator Engine Oil w/Filter	0.75
Engine	
Dipstick (low 8.5 gal., high 10 gal.)	
Bypass Lube Filter (3 gal.)	
Full Flow and Heat Exchanger (1 gal.)	

LUBRICATION RECOMMENDATIONS					
		40° to 110°F		-25°F to +40°F	
Ref. Letter Code	Lubricant	P&H Spec.	Desig-nation	P&H Spec.	Desig-nation
RGL	Regular Gear Lube	497B	SAE90	497B	SAE90
EO	Engine Oil (For Diesel Engine)	452	See Lubrication Spec. earlier in this section		
EO	Engine Oil (For All Other Parts)	451C	SAE30	451A	SAE10
HTCF	Hyd. Torque Conv. Fluid	505A	SAE10		
HO	Hydraulic Oil	484A	SAE10		
OGL	Open Gear Lube	464	—	464	—
ATF	Automatic Trans. Fluid	494		ATF Type "A"	
HTG	High Temp. Grease	476	—	476	—
MPG1	Multi-Purpose Grease	472		NLGI #2EP	
MPG2	Multi-Purpose Grease	472A		NLGI #0EP	

NOTE: For ambient temperatures beyond those stated consult the Service Department for lubricant recommendations.

A1265

Figure 3-3. Upper Lubrication Chart (2105J133)

SECTION IV.

UPPER POWER TRAIN

SUBSECTION PAGE

SUBSECTION 4A.

ENGINES

GENERAL

The information contained in this section is limited to troubleshooting, removal, and reinstallation of the engine. Information concerning the maintenance and repair of the engine can be obtained from the engine manufacturer.

TROUBLESHOOTING

A troubleshooting chart at the end of this subsection lists some of the difficulties which may be experienced with the engine and associated systems. No information is given as to the actual procedure for correcting the problem since this will vary, depending on the make of the engine. Refer to the engine manufacturer's manual for repair procedures.

ENGINE (51Q365)

REMOVAL. If it is determined that the engine must be removed from the machine, proceed as follows:

1. Lower the boom and mast, if so equipped, to a horizontal blocked position. Continue unspooling boom hoist cable until the weight of the spreaders and rope are in a complete sagged position.

2. Mark and remove the battery cables. Tape them to prevent shorting.

3. Remove the cab panel at the right rear of the upper.

4. Disconnect the universal joint at the intermediate hoist shaft, block up under the mod-clutch housing and remove the mod-clutch to engine capscrews. Remove the chain case mounting bolts and move the chain case, transmission, converter and mod-clutch assembly away from the engine about 2 inches (5.1 cm).

5. Disconnect the exhaust piping from the engine. Also disconnect the piping from the engine to the air cleaner.

6. Drain the cooling system and disconnect all cooling lines from the engine.

7. Disconnect the universal joint at the radiator end of the crankshaft.

8. Disconnect and tag all mechanical controls (engine throttle cable), fuel lines, hydraulic lines, and all electrical wiring to the engine and torque converter. Cap all fuel and hydraulic lines to prevent entry of contaminants. Make a thorough visual inspection of the engine and engine compartment to be sure that all necessary electrical, mechanical, and fuel lines have been disconnected and swung out of the way to allow removal of the engine.

9. Remove the capscrews which secure the engine base to the mounting pad.

10. Lower the engine lifting sling through the open cab roof door between the sagged boom hoist ropes held in a spread position by wood supports. Attach the lifting sling to the engine and lift the engine above the roof line. Rotate the engine 900 to clear the boom hoist ropes.

REPAIRS AND ADJUSTMENTS. Engine repairs and adjustments are covered in Section 16.

INSTALLATION. To install an engine in this machine, proceed as follows:

1. Make a thorough inspection of the engine compartment to be sure that all wiring, fuel, water, and mechanical linkage lines are clear of the engine mountings and frame.

2. Install the bonded mountings if they were removed. Lubricate the mounting and socket lightly with rubber lubricant or water.

3. Attach the lifting device to the engine and install it in the engine compartment in the same manner as it was removed.

4, Remove the wooden supports from between the boom hoist ropes.

5. Install the engine mounting hardware. The bolts through the bonded mountings should be tightened with sufficient pressure to seat the mounting in the socket and so that the snubbing washer is snug against the spine.

6. Install the front crankshaft material, if it has been removed, as follows (see Figure 4A-1):

A. With a clean soft dry cloth, wipe the nose of the crank-shaft, crank, adapter, sheave and damper.

B. Position the damper on the back of the crankshaft adapter. Align the crankshaft adapter mounting holes and position it on the crankshaft. Lubricate the flatwashers and capscrews. Tighten the capscrews, in sequence, to 160-180 ft-lbs. Repeat the tightening sequence this time tightening the capscrews to 320340 ft-lbs.

C. Lubricate the lockwashers and capscrews securing the damper to the crankshaft adapter. Tighten the capscrews alternately and evenly to 65-75 ft-lbs.

D. Mount a dial indicator on the front engine support. Rotate the crankshaft through 3600 and check that the damper does not exceed 0.030" in eccentricity or 0.030" in wobble.

E. Mount the sheave on the adpater. Tighten the capscrews (oiled) to 83-87 ft-lbs.

7. Install the universal joint at the radiator end of the en- gine. See Universal Joint in Subsection 4E.

8. Move the chain case, transmission, converter and mod-clutch up to the-engine and install the chain case mounting bolts. Install the clutch to engine capscrews and then install the universal joint at the intermediate hoist shaft.

9. Connect all electrical wiring that was disconnected when the engine was removed.

10. Connect all fuel and mechanical lines that were dis-connected when the engine was removed.

11. Reconnect the exhaust and air cleaner piping.

12. Reconnect all hydraulic and cooling lines. Fill the cooling system and crankcase with coolant and oil as necessary. See Section III.

13. Reconnect the chain case flanges and connect the chain. See Chain Cases in Subsection 4E.

14. Reconnect the battery cables.

NOTE

Before engine start-up recheck all wiring, fuel, water and mechanical connections. Be prepared to shut down the engine, preferably by blocking the intake air supply, if there should be some malfunction.

15. Start and run the engine. Check for oil, water and fuel leaks.

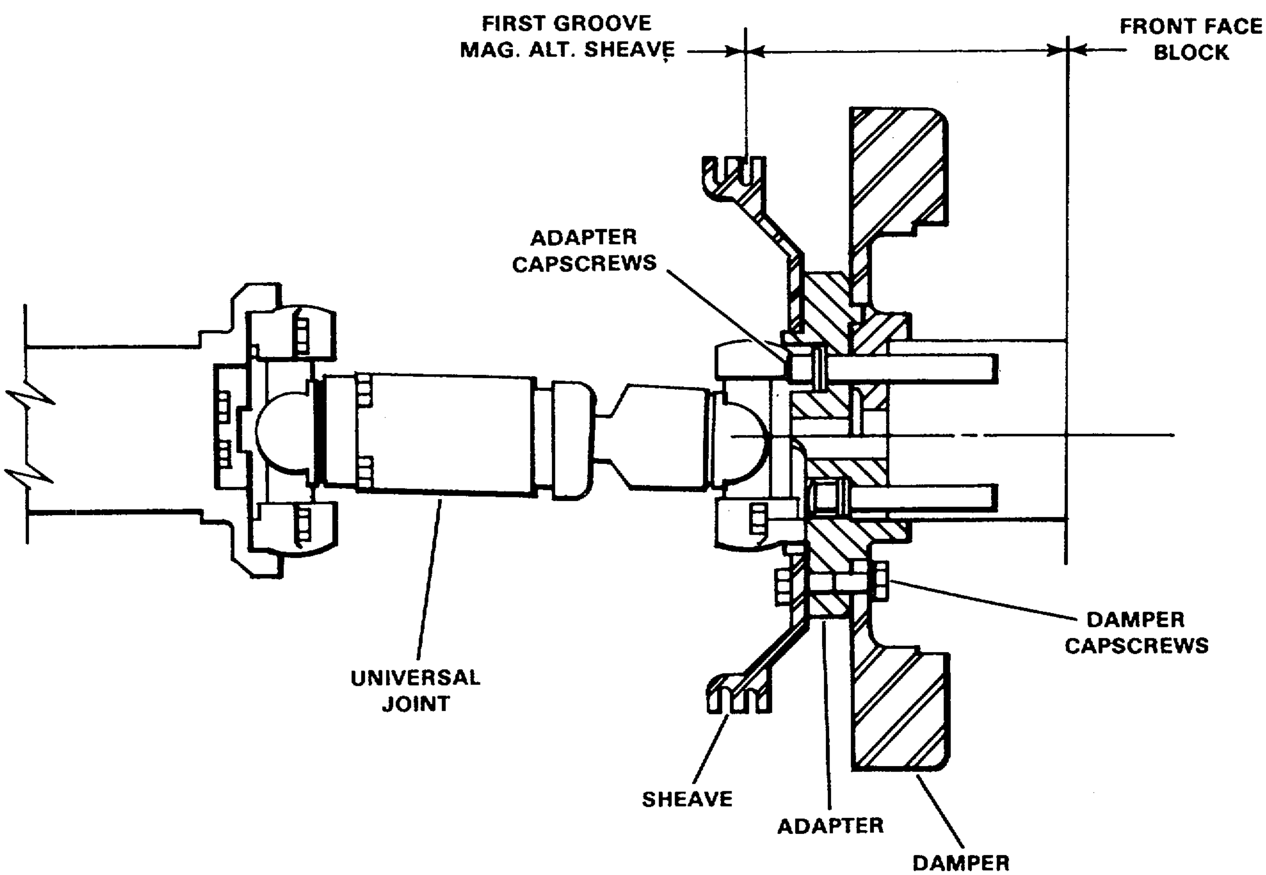


Figure 4A-1. Front Crankshaft Assembly

THROTTLE ADJUSTMENT. To adjust the throttle cable for proper idle, proceed as follows (see Figure 4A-2):

1. Rotate the engine throttle control (item 10, Figure 2-9 of Section II) to the low idle position.

2. Move the fuel pump throttle lever to the low position (toward the engine fan).

3. Adjust the throttle clevis as needed and attach it to the pump throttle lever. Tighten the locknut.

4. Start the engine and verify low engine speed of 625 rpm. Rotate the engine throttle control to the high speed position and verify engine speed of 2450 rpm.

5. Repeat steps 3 and 4 as needed until the proper rpm is attained.

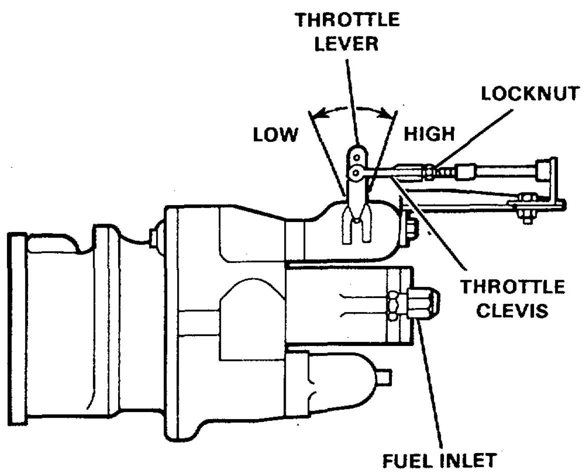


Figure 4A-2. Throttle Cable Adjustment

Troubleshooting Guide

	CAUSE	LOW POWER	POOR PERFORMANCE, OR ERRATIC ACTION	ROUGH IDLE, ENGINE VIBRATING	EXCESSIVE ENGINE SMOKE - BLACK	EXCESSIVE ENGINE SMOKE - WHITE OR BLUE	LOW OIL PRESSURE	ABNORMAL COOLANT TEMPERATURE	HARD OR NO STARTING	RECOMMENDED REMEDY
GENERAL	Excessive oil in or Restriction of Air Cleaner.	X	X	X	X	X			X	Service or Replace Filter as Required.
GENERAL	Faulty Injection Pump(s).	X	X	X	X	X			X	Have Pump Removed and Repaired.
GENERAL	Contaminated or Poor Quality Fuel.	X	X	X	X				X	Drain, Clean Tanks and Filter and Refill per Engine Mfg. Specs.
GENERAL	Cranking R.P.M. Too Low (Cold or Hot).								X	Check Battery and Starter. Replace if Necessary.
GENERAL	Low Compression.	X	X	X	X	X			X	Overhaul Engine.
GENERAL	Exhaust Blockage.	X	X	X				X		Remove Obstruction, Check for Bent or Crushed Pipes.
GENERAL	Incorrect Calibration.	X	X	X	X				X	Have Engine Re-calibrated.
TIMING	Injection Pump-to-Engine Timing Incorrect.	X	X	X	X				X	Re-Time to Engine Manufacturer's Specifications
TIMING	Injection Pump Drive (Train) Worn – Coupling Keyway.	X	X	X					X	Remove, Inspect and Replace Worn Parts.
TIMING	Injection Pump Internal Timing Incorrect.	X	X	X	X	X			X	Remove Injection Pump. Re-Time (Internally).
TIMING	Timing Advance Device Not Operating Properly.	X	X	X	X	X			X	Remove Injection Pump. Replace or Repair Advance Unit.
GOVERNOR	Throttle Linkage Mis-Adjusted.	X	X	X						Adjust to Engine Manufacturer's Specifications.
GOVERNOR	Throttle Linkage Sticking, Binding or Worn.	X	X							Check for Binding, Worn or Loose Parts, Foreign Particles. Repair or Replace Parts and Adjust to Specifications.
GOVERNOR	Improper Governor Operation.	X	X	X						Adjust or Repair to Permit Proper Governor Operation.
GOVERNOR	Control Rack(s) or Governor Linkage Sticking or Binding.	X	X	X						Remove Injection Pump. Repair
GOVERNOR	Worn or Loose Governor Linkage or Components or Weak or Broken Governor Torsion Spring.	X	X	X						Repair or Replace.

Troubleshooting Guide (cont'd)

	CAUSE	LOW POWER	POOR PERFORMANCE, OR ERRATIC ACTION	ROUGH IDLE, ENGINE VIBRATING	EXCESSIVE ENGINE SMOKE - BLACK	EXCESSIVE ENGINE SMOKE - WHITE OR BLUE	LOW OIL PRESSURE	ABNORMAL COOLANT TEMPERATURE	HARD OR NO STARTING	RECOMMENDED REMEDY
NOZZLES	Nozzle Defective – Leaking – Worn.	X	X	X	X				X	Remove, Repair or Replace, Reassemble, Test, Set Opening Pressure.
NOZZLES	Incorrect Nozzle Opening Pressure	X	X	X	X				X	Re-Set to Specifications.
NOZZLES	Nozzle Cap Nut Incorrectly Torqued.	X	X	X	X				X	Remove, Retighten Cap Nut Using Proper Nozzle Centering Sleeve, Replace Copper Gasket, Clean Engine Recess and Re-Install in Engine.
NOZZLES	Nozzle Incorrectly Installed or Torqued in Engine.	X	X	X	X				X	Remove, Replace Copper Gasket, Clean Recess, Reassemble to Engine (Tighten Evenly to Require Torque Value).
NOZZLES	Nozzle Valve Sticking.	X	X	X	X				X	Remove, Clean, Repair or Replace as Required.
NOZZLES	Nozzle Spray Holes Plugged or Partially Plugged.	X	X	X					X	Remove Nozzle. Clean Holes or Replace Nozzle as Required.
NOZZLES	Incorrect Nozzle in Engine.	X	X	X	X				X	Always Use The Correct Nozzle Recommended For The Engine. Do Not Mix Nozzles in The Same Engine Unless Permitted By Manufacturer.
OIL LEAKAGE	Oil Lines or Connections Leaking.						X			Repair or Replace.
OIL LEAKAGE	Lube Oil Diluted.					X	X	X		Check for Internal Oil or Water Leak. Drain and Replace Oil.
OIL LEAKAGE	Fuel Supply Pump Leaking					X	X			Replace.
OIL LEAKAGE	Faulty Gasket or Oil Seal.						X			Replace.
OIL LEAKAGE	Defective Oil Pressure Sending Unit.						X			Check Unit and Gauge. Replace if Necessary.
COOLING SYSTEM	Insufficient Coolant.		X					X		Add Necessary Coolant.
COOLING SYSTEM	Loose or Broken Fan Belt.							X		Check and Adjust or Replace.
COOLING SYSTEM	Faulty Thermostat.							X		Replace.
COOLING SYSTEM	Defective Water Pump.		X					X		Repair or Replace.
COOLING SYSTEM	Coolant Passages Clogged.		X					X		Drain and Flush Cooling System. Check Hoses.
COOLING SYSTEM	Defective Water Temperature Sending Unit.							X		Check Unit and Gauge. Replace if Necessary.

Troubleshooting Guide (cont'd)

	CAUSE	LOW POWER	POOR PERFORMANCE, OR ERRATIC ACTION	ROUGH IDLE, ENGINE VIBRATING	EXCESSIVE ENGINE SMOKE - BLACK	EXCESSIVE ENGINE SMOKE - WHITE OR BLUE	LOW OIL PRESSURE	ABNORMAL COOLANT TEMPERATURE	HARD OR NO STARTING	RECOMMENDED REMEDY
FUEL SUPPLY PRESSURE	Fuel Filters Clogged or Restricted.	X	X	X					X	Remove and Clean or Replace.
FUEL SUPPLY PRESSURE	External or Internal Fuel Leaks.	X	X						X	Inspect and Repair.
FUEL SUPPLY PRESSURE	Air Leaks In Fuel Suction System.	X	X	X					X	Inspect and Correct. Replace Parts where Required.
FUEL SUPPLY PRESSURE	Restriction in Fuel Suction Lines.	X	X	X						Clean and Repair or Replace Parts as Required.
FUEL SUPPLY PRESSURE	Little or No Fuel In Tank		X	X					X	Fill Tank With Proper Grade Fuel
FUEL SUPPLY PRESSURE	Supply Pump Worn or Damaged.	X	X	X					X	Remove Supply Pump, Replace or Repair.
FUEL SUPPLY PRESSURE	Supply Pump Relief Valve Worn or Stuck Open, or Spring Broken.	X	X	X					X	Remove Supply Pump. Replace or Repair.
FUEL SUPPLY PRESSURE	Overflow Valve Leaking or Stuck Open, or Spring Broken.	X	X	X					X	Clean and Repair or Replace.
FUEL SUPPLY PRESSURE	Supply Pump Check Valves Not Operating Properly or Damaged.								X	Remove Supply Pump. Repair.
FUEL SUPPLY PRESSURE	Air in Fuel System.	X	X	X					X	Prime System with Hand Priming Pump to Force Out Trapped Air.
FUEL SUPPLY PRESSURE	Fuel Return Line to Tank Restricted.		X	X						Clean and Flush. Replace if Necessary.
FUEL SUPPLY PRESSURE	Improper Grade Fuel for Temperature.	X	X	X	X				X	Drain Fuel. Fill With Correct Grade.
FUEL SUPPLY PRESSURE	Fuel Pump Inoperative.								X	Inspect and Correct. Replace Parts Where Required.
OIL SUPPLY	Improper Oil Viscosity					X	X	X	X	Drain and Replace Oil With Proper Viscosity for Conditions.
OIL SUPPLY	Oil Cooler or Filter Clogged.						X			Remove, Clean or Replace.
OIL SUPPLY	Clogged Pump Intake.						X			Remove and Clean, or Replace.
OIL SUPPLY	Faulty Cooler or Pump Relief Valve.						X			Remove, Clean, Repair or Replace
OIL SUPPLY	Oil Pump Damaged.						X			Remove and Replace.
OIL SUPPLY	Low Crankcase Oil Level.						X	X		Check and Add Oil.

SUBSECTION 4B.

CLUTCHES

GENERAL

This subsection will cover the removal, disassembly, assembly, and installation of the clutches used in the left and right hand transmissions. Since the clutch in the torque converter is an integral part of the torque converter the information required to repair this clutch is contained in Subsection 4C.

TEFLON RING INSTALLATION (2110T3)

GENERAL. A recommended procedure has been established for installing teflon rings on the ends of the transmission clutch shafts. Figure 4B-1 shows the grooves in the end of the clutch shaft where the teflon rings are to be installed. Several rings and hose clamps that compress to a 2 inch (5.1 cm) diameter are required.

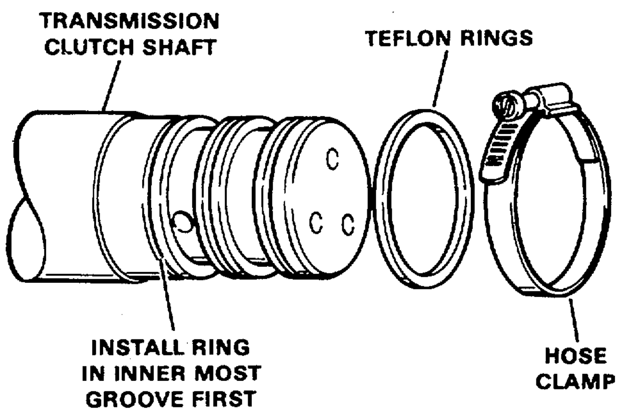


Figure 4B-1. Teflon Ring Installation

CAUTION

Do not heat the rings or put them in oil as these two conditions cause the rings to expand excessively. Install the rings dry and at room temperature making this the last procedure during transmission assembly. Use hose clamp44Zl673-13on the right hand transmission and hose clamp 44Z1673-12 on the left hand transmission as they have a protective shoe in their inner diameter. This shoe will shield the ring from possible damage due to the slots in the hose clamp.

To install the teflon rings, proceed as follows:

1. Loop the ring over the end of the shaft and progressively move the ring to the innermost groove as shown in Figure 4B-2.

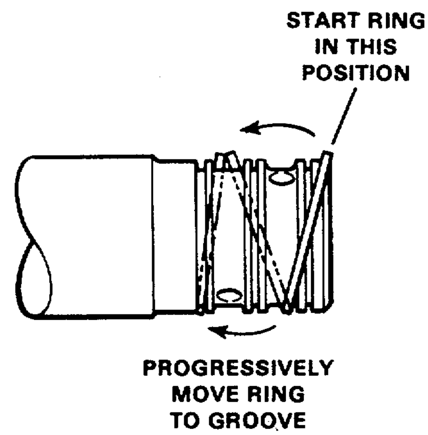


Figure 4B-2. Teflon Ring Installation

2. Place a hose clamp directly over the ring and groove. Tighten the clamp and check to be sure the ring is uniformly compressed into the groove, not twisted or rolled.

3. Repeat steps 1 and 2 to install the remaining rings.

NOTE

Have the bearing retainer ready to install over the end of the shaft.

4. Keep the hose clamps tightened in position for approximately 5 minutes.

5. Quickly remove the clamps after the five minute period, exercising care not to damage or disturb the rings and install the bearing retainer immediately (within one minute) over the rings and the end of the shaft. Do not force the retainer by driving it on as damage to the rings may result.

NOTE

The hose clamp method described above is best if only an occasional unit is assembled. For those locations where frequent assembly is done, the tool shown in Figure 4B-3 should be placed over the rings as soon as possible during assembly and left in place until just before the retainer is installed.

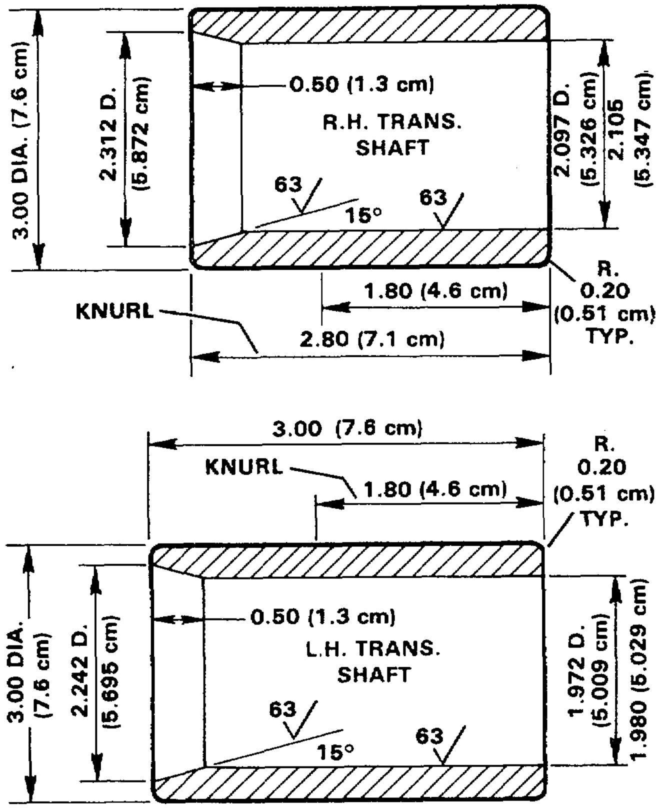


Figure 4B-3. Ring Retainers

CLUTCH (53U32)

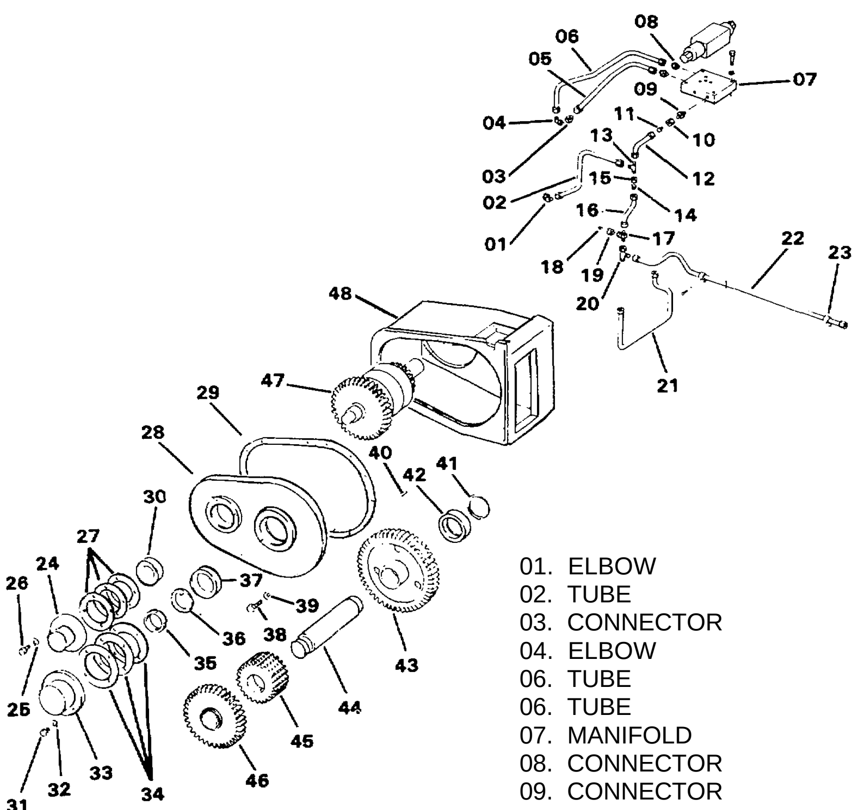
DESCRIPTION. This clutch is a duplex, hydraulically-actuated type, incorporating independent clutch-apply pistons for each clutch pack. Clutch control and overspeed protection is provided through the use of dump valves located 1800 apart to provide balance.

REMOVAL. To remove the clutch pack as a unit, proceed as follows (see Figure 4B-4):

1. Shut off the engine and tag the ignition switch to warn against starting the engine. Crack open the hydraulic lines to the manifold and bearing retainer to relieve any pressure in the lines. Tag and remove lines (02, 05, 06, 12, 16, 21 and 22).

2. See Chains in Subsection 4E and remove the chain tension from the chain.

3. Remove bearing retainers (24 and 33) by removing the attaching hardware and remove shims (27 and 34). Remove locknut (35) and lockwasher (36).



01. ELBOW
02. TUBE
03. CONNECTOR
04. ELBOW
06. TUBE
06. TUBE
07. MANIFOLD
08. CONNECTOR
09. CONNECTOR
10. NUT
11. REDUCER
12. TUBE
13. TEE
14. REDUCER
15. NUT
16. TUBE
17. TEE
18. PLUG
19. CONNECTOR
20. TEE
21. TUBE
22. TUBE
23. CLAMP
24. RETAINER
25. LOCKWASHER
26. CAPSCREW
27. SHIMS
28. COVER
29. GASKET
30. BEARING
31. CAPSCREW
32. LOCKWASHER
33. RETAINER
34. SHIMS
35. LOCKNUT
36. LOCKWASHER
37. BEARING
38. CAPSCREW
39. LOCKWASHER
40. DOWEL PINS
41. SNAP RING
42. BEARING
43. GEAR
44. SHAFT
45. SPROCKET
46. GEAR
47. CLUTCH UNIT
48. TRANSMISSION CASE

Figure 4B-4. Clutch Removal

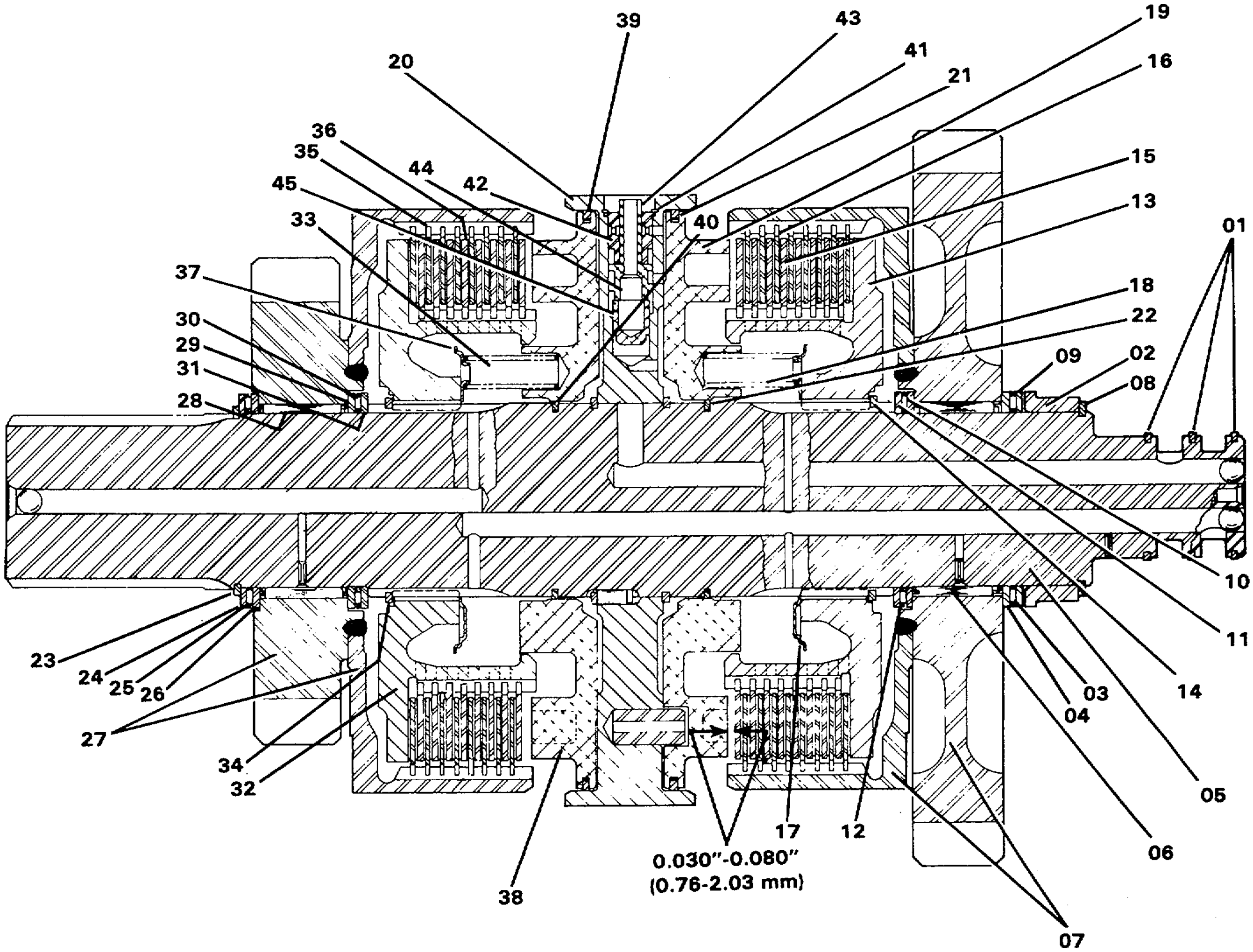
4. Remove capscrews (38) and lockwashers (39). Slowly pull cover (28) off of case while at the same time tapping the shaft of clutch (47) and shaft (44) with a soft hammer to work them out of bearings (30 and 37).

5. When cover (28) is off, support shaft (44) with blocking.

Using a support, sling and hoist arrangement pull clutch unit (47) out of case (48).

6. Remove gasket (29) and replace with a new one.

DISASSEMBLY. To disassemble the clutch unit, proceed as follows (see Figure 4B-5):



01. TEFLON PISTON RINGS
02. BEARING
03. NEEDLE BEARING
04. THRUST WASHER
05. SHAFT
06. BEARING
07. GEAR AND RING DRIVE ASSEMBLY
08. SNAP RING
09. WASHER
10. THRUST WASHER
11. WASHER
12. NEEDLE BEARING
13. CLUTCH HUB
14. SNAP RING
15. PLATE
16. PLATE
17. SPRING RETAINER
18. SPRING
19. CLUTCH PISTON
20. HOUSING
21. SEALING RING
22. RING
23. SNAP RING
24. WASHER
25. NEEDLE BEARING
26. THRUST WASHER
27. GEAR AND RING DRIVE ASSEMBLY
28. BEARING
29. THRUST WASHER
30. NEEDLE BEARING
31. WASHER
32. CLUTCH HUB
33. SPRINGS
34. SNAP RING
35. PLATES
36. PLATES
37. SPRING RETAINER
38. CLUTCH PISTON
39. RING
40. RING
41. SNAP RING
42. SLEEVE
43. DUMP VALVE
44. SPRING
45. VALVE

Figure 4B-5. Clutch (53U32)

1. Place the clutch pack on a suitable stand with piston rings (01) upward. Remove rings (01). Remove snap ring (08) and using a puller remove bearing (02) from the shaft.
2. Remove washer (09), needle bearing (03) and thrust washer (04).
3. Remove gear and ring assembly (07) and bearing (06) from shaft (05). Remove thrust washer (10), needle bearing (12) and washer (11).
4. Use an arbor press and apply pressure to clutch hub(13) to compress the piston release springs, and uncover snap ring (14). Remove snap ring (14), release the press and remove clutch hub (13). Remove plates (15 and 16) from clutch hub (13).
5. Remove spring retainer (17) and springs (18). Remove clutch piston (19) from housing (20). Air pressure through the clutch apply passage of the shaft will assist in removal of the clutch piston.

CAUTION

Use care when applying air pressure in the event the piston removed abruptly.

6. Remove sealing ring (21) from piston (19) and remove ring (22) from shaft (05).
7. Set the clutch assembly with the attached parts on the bench so the opposite end is up. Remove snap ring (23), washer (24), needle bearing (25) and thrust washer (26) from the shaft.
8. Remove gear and ring assembly (27) from shaft (05). Remove bearing (28), thrust washer (29), needle bearing (30) and washer (31).
9. Use an arbor press and apply pressure to clutch hub(32) to compress clutch spring (33) and expose snap ring (34).

Remove snap ring (34) from the shaft. Release the press and remove hub (32)with plates (35 and 36). Remove plates(35 and 36) from hub (32), if necessary.

10. Remove spring retainer (37) with springs (33). Remove the springs from the retainer only if replacement is necessary.
11. Remove clutch piston (38) from housing (20). Use air pressure through the clutch apply passage of the clutch shaft to separate the piston from the shaft and housing.

CAUTION

Use care when applying air pressure in the event the piston removes abruptly.

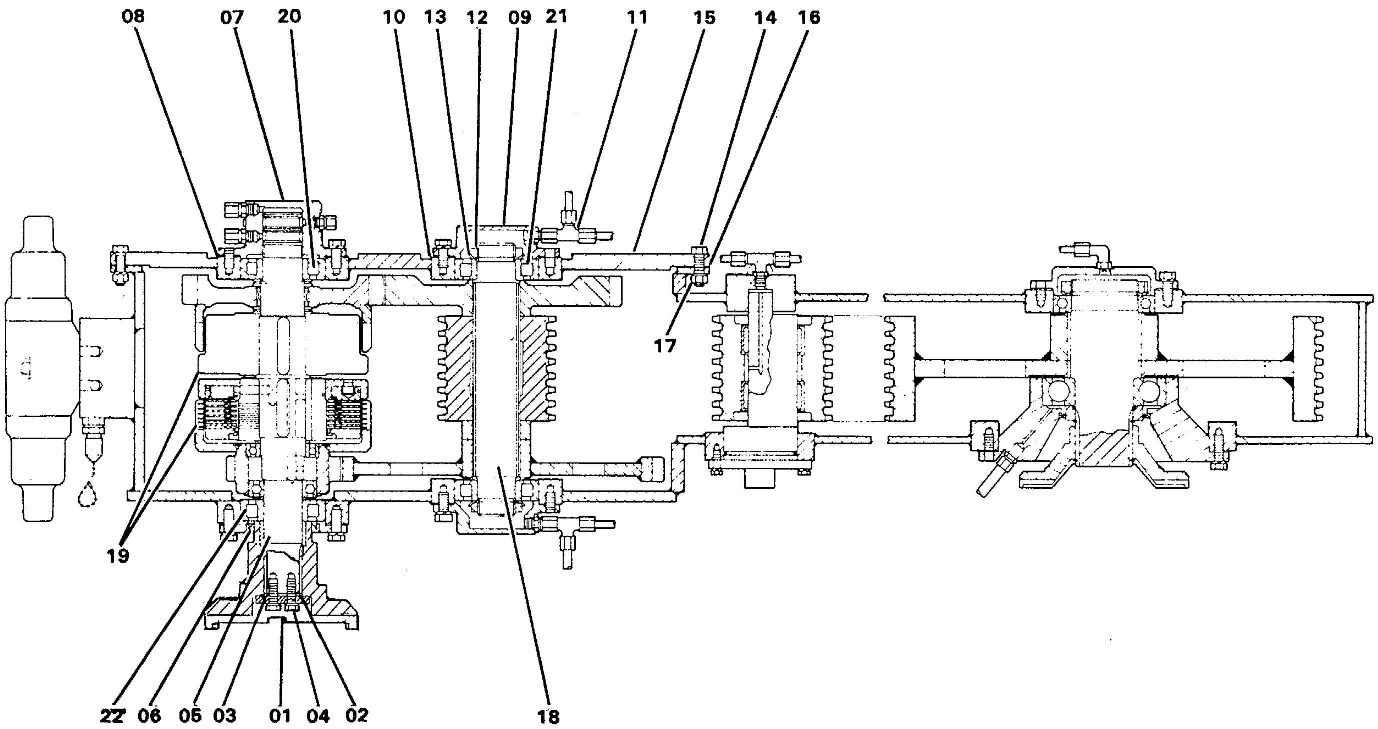
12. Remove ring (39) from piston (38) and remove ring (40) from shaft (05).
13. Remove snap ring (41) from the bore of one of the dump valve assemblies, and remove dump valve sleeve (42), dump valve (43), spring (44) and valve (45) from their bore. Remove the other dump valve assembly in the same manner.
14. No further disassembly of the shaft is required. If the remaining parts need replacement, they are supplied as one assembly.

INSPECTION AND REPAIR. Wash all parts of the clutch assembly, except the driving plates, in clean fuel oil or a good solvent, then blow dry and make the following inspections:

1. Examine the driving plates for scoring, burns, or cracks. Inspect the driving teeth for wear or damage. If necessary replace the plates.
2. Replace all piston rings, sealing rings and all other soft ware items.
3. Clean all oil passages by working a piece of wire back and forth through the passages and flushing with spirits. Dry the passages with compressed air.
4. Inspect all bearings and all other parts for wear or damage. Remove any scratches and burrs with crocus cloth. Replace any parts that are questionable.
5. Inspect springs for signs of overheating, permanent set, or wear due to rubbing adjacent parts. Replace the spring if any of these conditions are found.

ASSEMBLY. To assemble the clutch pack, proceed as follows (see Figure 4B-5):

1. Install valve (45) with its closed end first to the bottom of the valve bore in housing (20). Install spring (44) in valve (45).
2. Install valve (43) with the large end of the valve entering the bore first. Install sleeve (42) over the stem of valve (43). Secure the assembly with snap ring (41). Assemble the other dump valve assembly in the same manner.
3. Set shaft (05) on a work bench so the seal ring end of the shaft is down. Install seal ring (40) in the groove on shaft (05). Install ring (39) on piston (38). Lubricate the rings.
4. Install piston (38) over shaft (05). Use care when starting ring (39) into housing (20). The piston return spring bores should face up when the piston is installed.
5. Place spring (33) in retainer (37) if removed and place the retainer over the shaft onto piston (38).
6. Set clutch hub (32) on the bench with the splined hub section up. Install plates (35 and 36) beginning with a faced plate then a steel plate alternately, until the pack is complete. Hold the plates in place then invert the hub and place it on shaft (05) against retainer (37).
7. Using an arbor press apply pressure to hub (32), compressing the springs and exposing the groove for snap ring (34). Install snap ring (34) and release the arbor press.
8. Measure the clearance between the clutch plates and piston with feeler gauges. This should be 0.030-0.080 inches (0.76-2.03 mm) after assembly at this point. The steel plates are supplied in coned or flat shape, so adjustment of this clearance can be made. After proper adjustment, install thrust washer (31), needle bearing (30) and washer (29) on the shaft against the hub spline shoulder.



01. INPUT FLANGE
02. CAP
03. O-RING
04. CAPSCREW
05. SHAFT
06. OIL SEAL
07 RETAINFR
08. GASKET
09. RETAINER
10. GASKET
11. FITTING
12. LOCKNUT
13. LOCKWASHER
14. CAPSCREW
I5 . COVER
16. GASKET
17. NUT
18. SHAFT
19. CLUTCH ASSEMBLY
20. BEARING
21. BEARING
22. BEARING

Figure 4B-6. Clutch Removal and Installation

9. Install gear and ring assembly (27) engaging the spline of the drive ring with the teeth of plates (35).

10. Heat and install bearing (28) on shaft (05). Install thrust washer (26), needle bearing (25), washer (24)and snap ring (23).

11. Invert the clutch shaft so the seal ring end faces up. Install ring (22) on shaft'(05). Install ring (21) onto piston (19) and lubricate the rings. Install piston (1 9) over the shaft and into housing (20) using care when starting the ring into the housing. The piston spring bores must face out.

12. Install springs (18) onto retainer (17) if they were removed and install the retainer and springs onto the shaft and piston.

13. Set hub (13) on a bench with the splined section facing up. Install plates (15 and 16) onto hub (13) alternately beginning with a faced plate and then a steel plate until all the plates are installed.

14. Hold the plates in place and invert hub (38), placing it on the splines of the shaft against retainer (17).

15. Using an arbor press, apply pressure to hub (38) compressing the springs and exposing the groove for snap ring (14). Install snap ring (14) and release the press.

16. Measure the clutch plate clearance with a feeler gauge for 0.030-0.080 inches (0.76-2.03 mm) and correct as required by selecting the steel plates. Coned or flat plates are available.

17. Install thrust washer (11), needle bearing (12) and washer (10). Install gear and ring assembly (07) on shaft (05). Heat and install bearing (06).

18. Install washer (04), needle bearing (03) and washer (09). Heat and install the inner race of bearing (02) and install snap ring (08).

19. Install seal rings (01) in their grooves of shaft (05). See Teflon Ring Installation earlier in this subsection for instructions.

INSTALLATION. To install the clutch pack, proceed as follows (see Figure 4B-4): 1. Set clutch pack (47) into case (48) engaging the splines of the clutch shaft with the output shaft of the torque converter.

2. Install the outer race of bearing (30) into cover (28). If bearing (37) was removed, heat and reinstall it. Also install lockwasher (41) and locknut (42).

3. If dowel pins (40) were removed, install them at this time. Remove any blocking from inside case (48). Set cover (28), with gasket (29), on locating pins (40). Install lockwashers (39) and capscrews (38). Tighten securely.

4. Install bearing retainers (24 and 23). Install shims (27 and 34) to give 0.003-0.005 inch (0.076-0.127 mm) shaft end play when the retainers are installed.

5. Tighten the chain. See Subsection 4E for chain adjustment. Reinstall the case cover.

6. Reinstall all lubrication and clutch apply lines.

CLUTCH (53U50)

DESCRIPTION. This clutch is a duplex, hydraulically actuated type, incorporating independent clutch-apply pistons for each clutch pack. Clutch release is aided by wave springs when hydraulic pressure is released.

REMOVAL. To remove the clutch packs as a unit, proceed as follows (see Figure 4B-6): 1. Shut off the engine and tag the ignition switch to warn against starting the engine. Crack open the hydraulic lines on the manifold and bearing retainers to relieve any pressure in the lines. Tag and remove all lines that will interfere with the removal of cover (15).

2. See Chains in Subsection 4E and remove tension from the chain.

3. Disconnect the universal joint from input flange(01). Remove capscrews (04), cap (02) and pull flange (01) off of shaft (05). Remove and replace oil seal (06). Remove O-ring (03) from cap (02).

4. Remove retainers (07 and 09) along with gaskets (08 and 10). Remove locknut (12) and lockwasher (13).

5. Remove capscrews (14) and nuts (17). Slowly pull cover (15) off of the case while at the same time tapping the shaft (05) and shaft (18) with a soft hammer to work them out of bearings (20 and 21).

6. When cover (15) is off, support shaft (18) with blocking. Using a support, sling and hoist arrangement, pull the clutch shaft assembly out of the case.

7. Remove gasket (16) and replace with a new one.

DISASSEMBLY. To disassemble the clutch unit, proceed as follows (see Figure 4B-7):

1. Place the clutch pack on a suitable stand with piston rings (01) up. Remove rings (01). Using a puller, remove bearing (02).

2. Remove race (03) and needle bearing (04) from shaft (10). Pull clutch spider (05) off of the shaft and if necessary remove bearing (06) from the clutch spider.

3. Remove needle bearing (07) and race (08). Pull clutch assembly (69) off of the shaft. It will be necessary to press the shaft out of the clutch.

4. Set the clutch assembly, with the attached parts, on the bench so the opposite end is up. Remove bearing (19), spacer (18) and bearing (17) from shaft (10).

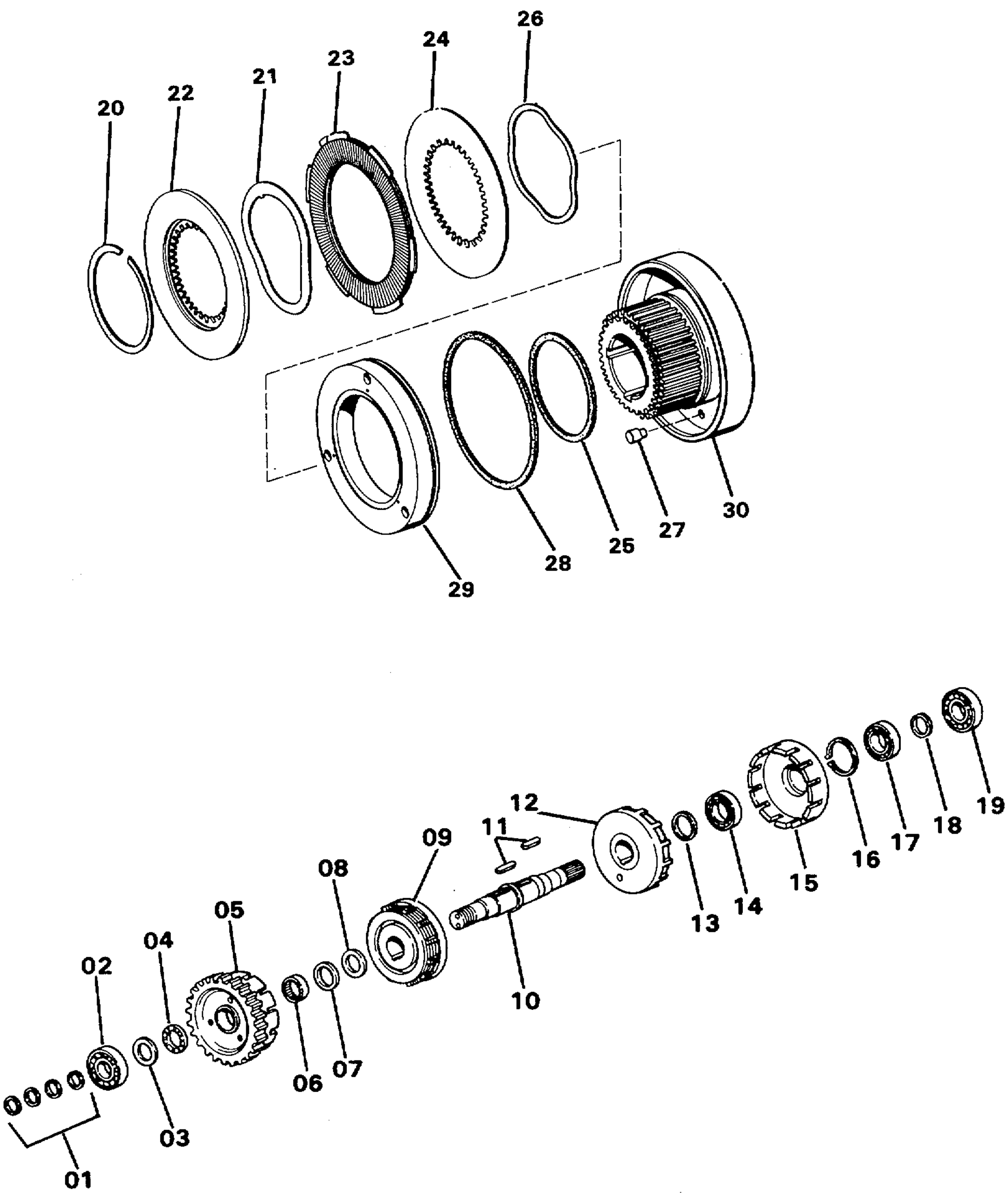
5. Pull clutch spider (15) off of the shaft and remove snap ring (16) from the clutch spider. Remove bearing (14) and spacer (13).

6. Pull clutch assembly (12) off of shaft (10).

7. To disassemble clutches (09 and 12), proceed as follows:

A. Press back plate (22) down and remove snap ring (20).

B. Remove back plate (22), plates (23 and 24) and wave springs (26).



01. RING
02. BEARING
03. RACE
04. NEEDLE BEARING
05. CLUTCH SPIDER
06. BEARING
07. NEEDLE BEARING
08. RACE
09. CLUTCH ASSEMBLY
10. SHAFT
11. KEY
12. CLUTCH ASSEMBLY
13. SPACER
14. BEARING
15. CLUTCH SPIDER
16. SNAP RING
17. BEARING
18. SPACER
19. BEARING
20. SNAP RING
21. WAVE SPRING
22. BACK PLATE
23. STEEL PLATE
24. SINTERED PLATE
25. RING
26. WAVE SPRING
27. PIN
28. RING
29. PISTON
30. HUB

Figure 4B-7. Clutch Assembly

C. Remove clutch piston (29) from hub (30). Use air pressure through the clutch apply passage of the hub to separate the piston from the hub.

CAUTION

Use care when applying air pressure in the event the piston removes abruptly.

D. Remove rings (25 and 28) from piston (29).

INSPECTION AND REPAIR. Wash all parts of the clutch assembly, except the plates, in clean fuel oil or a good solvent, then blow dry and make the following inspections:

1. Examine the clutch plates for scoring, burns, or cracks. Inspect the driving teeth for wear or damage. If necessary replace the plates.
2. Replace the piston rings and all other software items.
3. Clean all oil passages by working a piece of wire back and forth through the passages and flushing with spirits.
Dry the passages with compressed air.
4. Inspect all bearings and all other parts for wear or damage. Remove any scratches and burrs with crocus cloth. Replace any parts that are questionable.
5. Inspect the wave springs for signs of wear or overheating and replace if necessary.

ASSEMBLY. To assemble the clutch pack, proceed as follows (see Figure 4B-7): 1. To assemble clutch (09 and 12), proceed as follows:

A. Install ring (25) into hub (30) and install ring (28) into piston (29).
B. Install piston (29) into hub (30). Use care when starting rings (25 and 28) into the housing. The piston should engage pins (27).
C. Install wave spring (26). Wave springs (21) must be correctly installed or distortion of the steel clutch plates may result. This distortion can cause clutch drag, leading to burning and eventual failure. The tab on each wave spring should be located midway between wave peaks, within 0.030 inch (0.76 mm), see Figure 4B-8. Discard any wave spring whose tab is not so located.

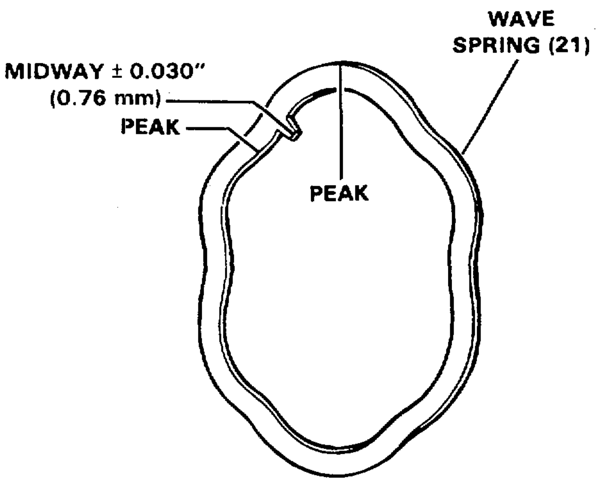


Figure 4B-8. Clutch Wave Spring Location

D. Look for two scribe marks on clutch hub (30). These scribe marks should be 9 pitches apart, as indicated on Figure 4B-9. If the scribe marks are not present, make them at this time.

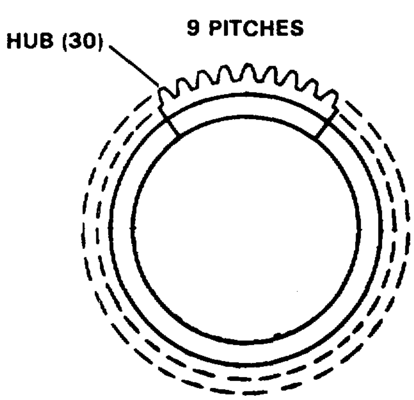


Figure 4B-9. Clutch Hub Scribe Marks

E. Install plates (23 and 24) and wave springs (21). As the wave springs are installed, alternate the tabs in the tooth spaces marked in step D. That is, align the tab of spring number 1 with the left hand scribe mark; the tab of spring number 2 with the right hand scribe mark; and so forth.
F. Install back plate (22), press the plate and install snap ring (20).

2. Set the clutch shaft (10) on the bench with the splined hub section up. Install clutch assembly (12) with the back plate facing the splined end of the shaft. Install spacer (1 3).
3. Heat and install bearing (14), then install clutch spider (15) engaging the splines of the spider with the teeth of plates (23). Install snap ring (16) into spider (15). Heat and install bearing (17).
4. Install spacer (18). Heat the inner race of bearing (19) and install on shaft (10). Install the outer race into the transmission case.
5. Invert the clutch shaft so the seal ring end faces up. Install clutch assembly (09). Set race (08) and needle bearing (07) against clutch (09).
6. Install clutch spider (15) engaging the splines of the spider with the teeth of the clutch plates. Heat and install bearing (06). Install bearing (06) so that spider (15) turns freely and allow o.bi 0 inch (0.254 mm) maximum running clearance.
7. Install needle bearing (04), race (03) and the inner race of bearing (02) on shaft (10).
8. Install seal rings (01) on shaft (10). See Teflon Ring Installation earlier in this subsection.

INSTALLATION. To install the clutch assembly, proceed as follows (see Figure 4B-6):

1. Set clutch pack (19) into the transmission case engaging the inner and outer races of bearing (22) and the gears. Support the clutch assembly from above.
2. Install the outer race of bearing (20) into cover (15). If the outer race bearing (21) was removed, reinstall it in cover (15).
3. If the locating pins were removed from the case, reinstall them at this time. Remove any blocking from inside the case. Set cover (15), with gasket (16), on the locating pins. Install capscrews (14) and nuts (17). Tighten securely.
4. Install lockwasher (13) and locknut (12). Also install bearing retainers (09 and 07) with gaskets (08 and 10).
5. Install oil seal (06), input flange(01), cap(02)with O-ring (03) and secure with capscrews (04).
6. Reconnect the universal joint to input flange (01).
7. Tighten the chain. See Subsection 4E for chain adjustments. Reinstall the chain case cover.
8. Reinstall all lubrication and clutch apply lines.

SUBSECTION 4C.

SYSTEM TROUBLESHOOTING

GENERAL

This subsection contains information necessary to trouble shoot the torque converter and lubrication system.

TROUBLESHOOTING GUIDE - TORQUE CONVERTER SYSTEM

GENERAL

The purpose of this troubleshooting material is to provide a method of solving problems on the modulated clutch control and transmission control systems. It is assumed that the system has been operating satisfactorily, but there has been some malfunction and adjustments or repairs are required. The procedure to be followed is outlined in the following paragraphs. The same procedure is recommended when a new machine is being erected and placed in service for the first time.

Probably the greatest aid to troubleshooting is knowing the system. Every component has a purpose in the system. Several systems have been used so it is important for you to study the descriptions at the end of this subsection to determine which one applies to your machine. Every component has a purpose in the system. The construction and operating characteristics of each one should be understood. Some additional practices which will increase your ability to troubleshoot the system, and also the useful life of the system are listed below:

1. Know the capabilities of the system. Each component in the system has a maximum rated speed, torque or pressure. Loading the system beyond the specifications simply increases the possibility of malfunction.

2. Know the correct operating pressures. Always check pressures with a gauge that is known to be accurate. How else can you know if the operating pressure is above the maximum rating of the components?

NOTE

The following safety procedure should be kept in mind at all times. If a load is suspended aloft, and the modulated clutch malfunctions so that it is not possible to lower the load in the usual manner, lower the load to the ground by placing the appropriate main drum clutch lever in the neutral position and lower the load under the control of the main drum brake or power lower the load. Do this before attempting any maintenance or adjustment procedures.

Three simple maintenance procedures have the greatest effect on hydraulic system performance, efficiency and life. Yet, the very simplicity of them may be the reasons they are so often overlooked.

1. Change filters.

2. Maintain a sufficient quantity of clean hydraulic fluid of the proper type and viscosity in the reservoir(s).

3. To exclude air from the system, keep all connections tight, but not to the point of distortion.

INDEPENDENT TORQUE CONVERTER AND TRANSMISSION RESERVOIRS (2105J120)

DESCRIPTION

This is a "modulating" wet clutch torque converter (see Figures 4C1 and 4F1) which transmits power from the engine to the hoist functions. This assembly uses two separate hydraulic systems each with its own dual pump which are driven by the clutch spider in the torque converter. One dual pump supplies oil to the radiator motors, the lubricators of the chain cases and to the chain case clutches. The other dual pump supplies oil for controlling and cooling the modulated clutch system.

Beginning at the right hand reservoir, oil is displaced by one-half of the dual pump to two radiator motors. Pressure at the motors is maintained at 2040 psi (140.7 bars)with excess fluid sent to the chain case lubricators. Return oil from the radiator motors is sent through a filter to the chain case and clutch lubricators. Pressure in the lubrication lines is maintained at 40 psi (2.8 bars) with the excess fluid sent to the reservoir. The radiator motors have an internal case drain and two check valves that insure motor case drain flows out the return line. In the event the radiator motors run away (inlet pressure becomes less than return oil pressure) the pressure on the back side of the anticavitation check will drop, while return oil pressure on the other side of the anticavitation check valve will increase. This will cause the check valve to unseat, and return oil will add to the pump oil to fill the void and prevent cavitation of the motor. As soon as system pressure is reestablished, the anticavitation check valve will close and return oil will again flow to the lubricators.

Oil displaced by the other half of the pump is sent through a filter to the chain case clutches for engaging and disengaging the clutches. Pressure is maintained at 270 psi (18.6 bars) with excess fluid sent to the reservoir.

Beginning at the left hand reservoir, oil is displaced by one half of the pump through a filter to a heat exchanger. There is a relief valve ahead of the heat exchanger, set at 125 psi (8.6 bars), to bypass the heat exchanger when the oil is cold and to prevent high pressure damage to the heat exchanger. Fluid not required for converter charge is sent back to the reservoir. The cool oil is then sent to the converter low pressure regulator.

Oil displaced by the other ha If of the pump passes through a filter to the high pressure regulator, the bias valve, the shutoff valve and through a magnetic separator to the modulator valve. The high pressure regulator is set at 220+10 psi (15.2+0.7 bars) with one port being a vent to sump to prevent oil pressure buildup behind the regulator valve piston. When pressure reaches the setting of the high pressure regulator, excess flow is sent through a heat exchanger to the low pressure regulator.

The modulator valve is controlled by the operator electrically. As the modulator valve control stem is moved in or out of the valve, oil (pilot pressure) is supplied to the shutoff valve and bias valve at any amount of variable or constant pressure the operator desires. When the shutoff valve is in the off position, oil is supplied to the modulated clutch plates for cooling. When modulated inlet pressure to the shutoff valve reaches 30 psi (2.1 bars)this valve trips to the open position allowing main pressure to the bottom of the Omega valve in addition to sending oil to the modulated clutch plates.

NOTE

There is a small orifice in the clutch carrier which restricts the flow of main pressure oil to the bottom of the Omega valve. This flow to the Omega valve is called "Z", clutch apply pressure. At this point, the Omega valve is open and apply pressure is being discharged into the flywheel housings.

Simultaneous to the "shutoff" valve action, the increasing pilot pressure signal is actuating the converter low pres sure regulator. With some low pilot pressure, the regulator, (Port MB) was null adjusted to read 3 to 5 psi (0.20.3 bars). The regulator charges the converter circuit and this pressure increases in proportion to pilot signal. Full converter charge pressure is regulated at 90 to 100 psi (6.26.9 bars). With 15 psi (1.03 bars) or more pressure, the converter circuit is ready to operate.

Increasing pilot pressure "P" to 40 psi (2.8 bars) starts the bias valve spool to displace. Main supply oil is metered through the valve passing on to the top of the Omega valve piston. Port V is used to monitor this "clutch control" pressure. Further increasing the pilot pressure puts more pressure on the piston. Movement of the piston is in, toward the center of rotation, metering off "clutch apply" (Port Z) oil being dumped into the flywheel housing. Pressure is progressively increased within the Modulated Clutch carrier housing. In turn, clutch plate engagement begins to take place. The amount of clutch plate slippage (% of engagement) provides for a variable input speed to converter impeller with a constant engine speed. The amount of slippage is determined by the pilot pressure which is controlled by the operator (twist grip position).

Converter cooling is accomplished by the converter impeller forcing a flow of oil from the outside diameter of the converter through the heat exchanger and back to the lower pressure inside diameter of the converter. Oil is also "orificed-off" the converter low pressure regulator and directed to the clutch plates for additional cooling any time the converter is being charged.

Retarding is available from the converter for the purpose of controlling a descending load. As the clutch control pressure (Port V) is reduced, clutch slippage increases until the load begins to descend. In the case of light loads the control pressure may be reduced until the clutch becomes completely released. Modulation of the converter basic pressure (Port W) determines the descending load speed (maximum converter back driven speed limited to 3200 rpm). At this point the operator maintains desired control pressure.

The modulating valve also contains a manual override should there be a malfunction in the modulating valve. When the valve is in the override position the clutch and torque converter are locked up and there is no modulating feature. Engine speed will then control the converter output shaft speed.

INITIAL INSPECTION

Before it is assumed that the modulated clutch control system is at fault, certain exterior causes of trouble should be eliminated, since they could give the appearance of control problems when, in fact, the control is working properly. Proceed as follows:

1. Check the adjustment of the main drum brakes. Be sure the brakes do not drag.

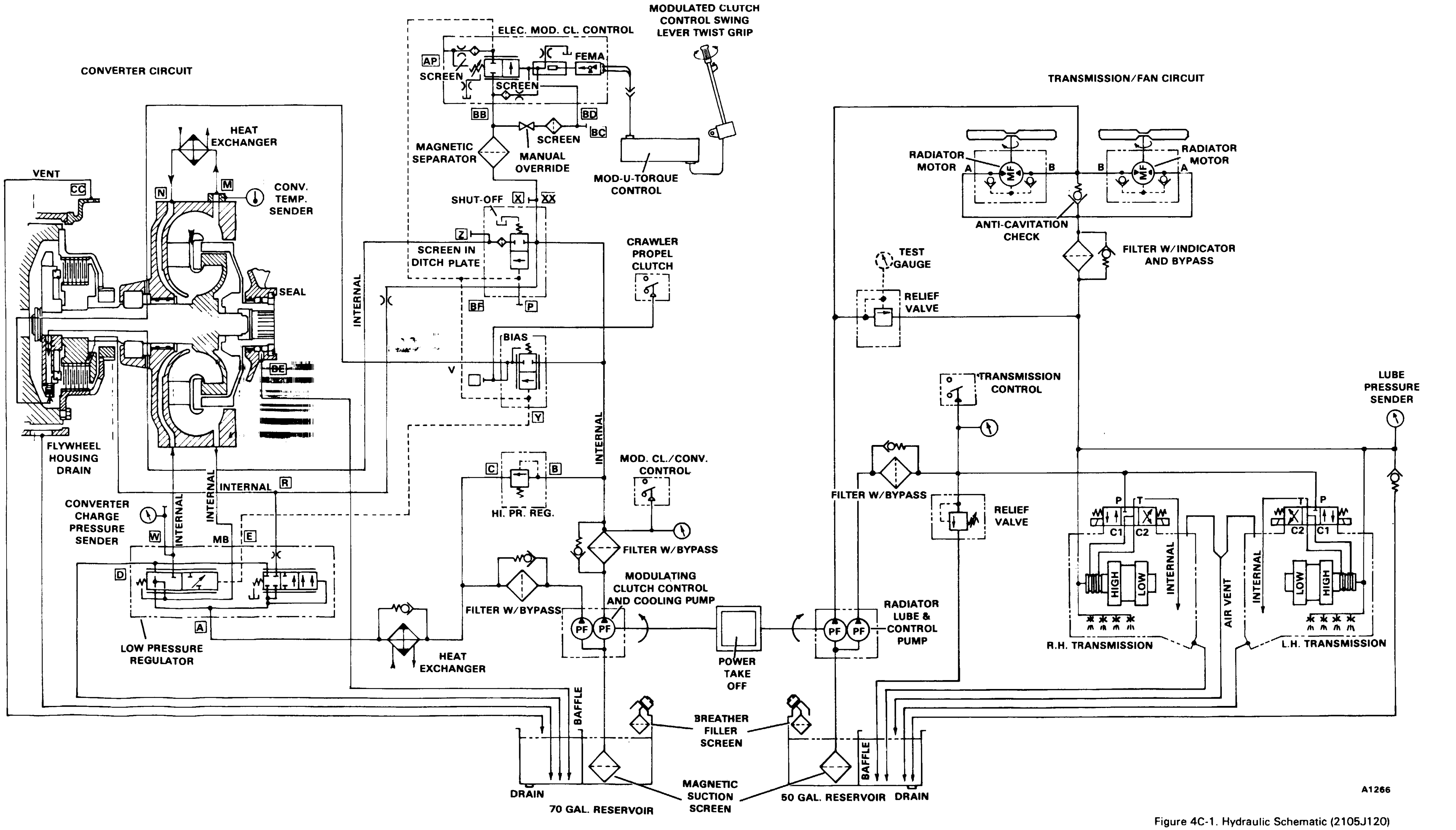
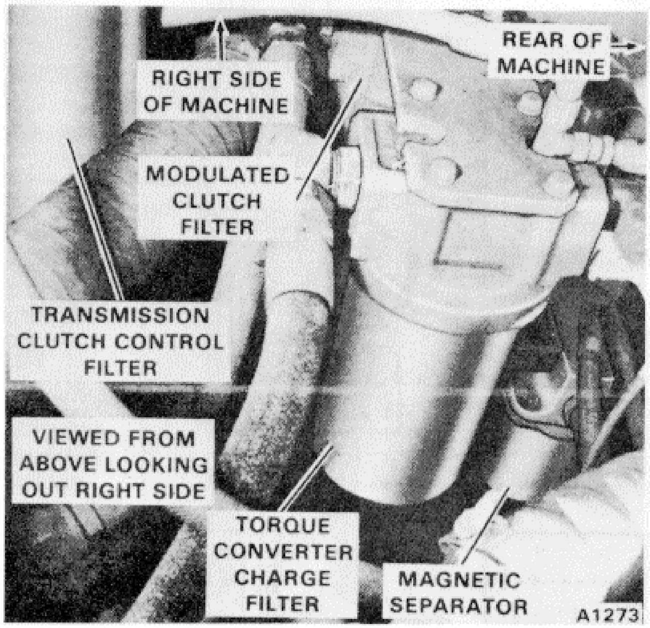


Figure 4C-1. Hydraulic Schematic (2105J120)

2. Check the adjustment of the main
3. Check the level of the oil in the hyd Add oil if necessary. See Section III.
4. Check the oil filter service indicat, and the elements on filters that do not indicator or element shows the need so.
5. Inspect the pump suction lines for Indicated by foam on the surface of the pump noise, and perhaps by oil leaks.
6. With the engine running, check to see that electrical and mechanical power is available to power the system. Before attempting to troubleshoot the system. Before attempting to troubleshoot the system, run the engine (preferably with the modulated clutch engaged) and allow the torque converter oil to warm up the normal 180-200°F (82.2-93.3°C).



7. Make a visual inspection of all electrical leads, connectors and so forth to be sure that something has not simply vibrated loose. Do the same for the complete hydraulic system.
8. Check that the manual override lever is in the normal position as shown in Figure 4C-3.
9. If you are unfamiliar with the overall operation of the system, refer to the hydraulic circuit and description earlier until yo thoroughly understand the operation of the system. There is no substitute for understanding this system if you want to find and correct problems which may occur. Normal system values, as measured in the operator's module with system temperature at 180-200°F (82.2-93.3°C) are tabulated in Table 4c-1.

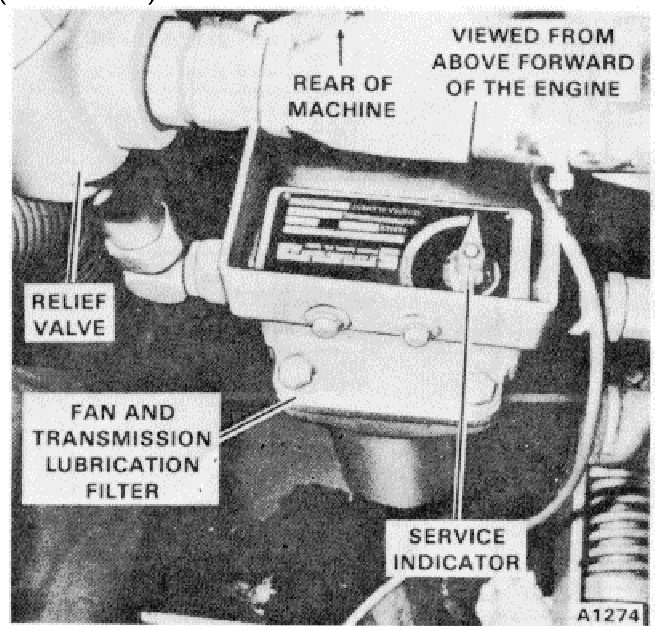


Figure 4C-2. Filter and Service Indicator

Table 4C-1. Pressure Values

Engine RPM (Approx.)	Transmission Control Pres. PSI	Modulated Clutch	Transmission Pressure Failure Light	Torque Converter Charge Pres. Port "W"	Torque Converter Pres. Port "MB"
Low Idle 575-625		Disengaged	OFF		
High Idle 2350-2500	230 PSI (15.9 Bars)	Disengaged	OFF	0 PSI (0 Bars)	3-5 PSI* (0.2-0.3 Bars)
Full Load 2100	210 to 230 PSI (14.5-15.9 Bars)	Engaged	OFF	75 to 85 PSI (5.2-5.9 Bars)	90-100 PSI (6.2-6.9 Bars)

*Note: As these values are small, an accurate low pressure mechanical gauge at Port "MB" must be employed to verify values.

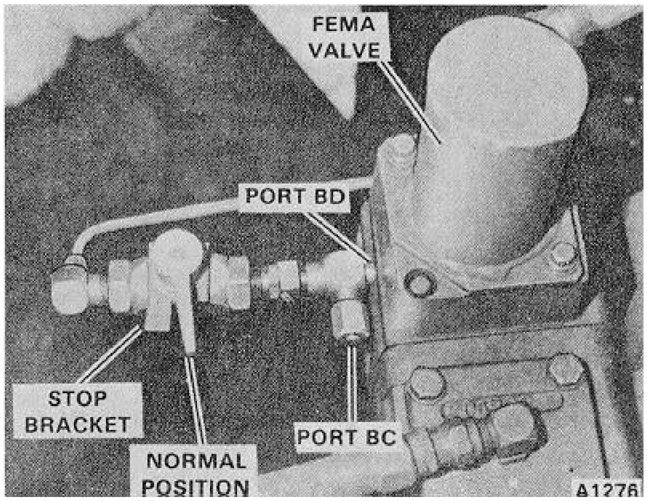


Figure 4C-3. Manual Override Valve.

TYPICAL PROBLEMS

Bearing in mind that normal operating procedure in lifting and lowering loads is to toggle in the appropriate drum clutch lever and then to control the load with the modulated clutch twist grip located on the swing lever, typical problems can usually be classified into one of the two following categories:

1. The modulated clutch control does not provide smooth engagement, varying from minimum engagement to full engagement in accordance with twist grip settings. In the case of partial engagement, typical symptoms will include loss of power and line speed. Obviously, total failure to engage will cause the machine to be inoperative insofar as modulated clutch driven functions are concerned.

2. The modulated clutch control does not provide smooth disengagement in accordance with twist grip settings. This may vary from a partial failure to disengage when handling relatively light loads to a total failure to disengage under any conditions. If a relatively light load cannot be lowered by increasing modulated clutch slip, and all drum brakes and clutches are properly adjused, the modulated clutch control system may require adjustment or repair.

NOTE

When handling "light" loads the operator should use the HIGH range of the transmission. When handling "heavy" loads the operator should use the LOW range. Heavy loads are defined, for the purpose of troubleshooting, as the maximum single line ratings, or for the front drum with 11/4 inch (3.18 cm) diameter cable, 41,700 pounds (18,915 kg). For the rear drum with 1 inch (2.54 cm) diameter cable, 26,700 pounds (12,111 kg). Light loads are defined as less than 20,000 pounds (9072 kg) on the front drum, and less than 13,000 pounds (5897 kg) on the rear drum single line.

There are three areas of potential trouble in regard to this system. The first, simple mechanical misadjustments, should have been eliminated by proper performance of the initial inspection. The remaining two (electrical and hydraulic) are equally likely to contain the cause of any remaining malfunction. See Figures 4C4 and 4C5 for faultlogic charts. The performance of the electrical analysis is given next because the electrical system is the start of the control sequence.

ELECTRICAL ANALYSIS

GENERAL. The electrical analysis is performed with the aid of the Transistorized Control Performance Analyzer illustrated in Figure 4C6. The procedure should be followed step-by-step, in the sequence described.

NOTE

If it is necessary to replace either the Transistor Control Module (Figure 4C7) or the Modulating Valve as a result of the following test procedure, the Null Adjustment Procedure given later must be performed.

1. Place the ignition switch, in the operator's module, in the OFF position.

2. Remove the cover panel from the bottom of the operator's module, exposing the control module enclosure. Remove the enclosure cover as shown in Figure 4C7. Check the fuses before proceeding further.

3. Disconnect wires 5 and 6 from the terminal strip in the control module. See Figure 4C7. Wire 5 is brown and wire 6 is grey with red stripping.

4. Using a standard volt/ohmmeter, take resistance readings as follows (see Figure 4C8):

NOTE

For clarity purposes Figures 4C8 and 4C9 do not show leads 5 and 6. When the cover panel is removed from the operator's module lead #'s 5 and 6 can be readily seen on the terminal block.

A. Wire 5 to wire 6 (should read 16 to 20 ohms).
B. Wire 5 to ground (should read infinity).
C. Wire 6 to ground (should read infinity).

NOTE

When taking the resistance reading the ohm scale should be on the highest one (1 OK, 1 OOK) in order to detect a high resistance ground leak. Also when taking any meter readings, especially high ohmic values, the meter must be zeroed in every time a scale change is made. Failure to do so will only result in incorrect findings.

A reading of less than 16 ohms between wires 5 and 6 indicates a circuit problem or a defective coil in the modulating
valve. Either the coil is partially shorted internally or leads to

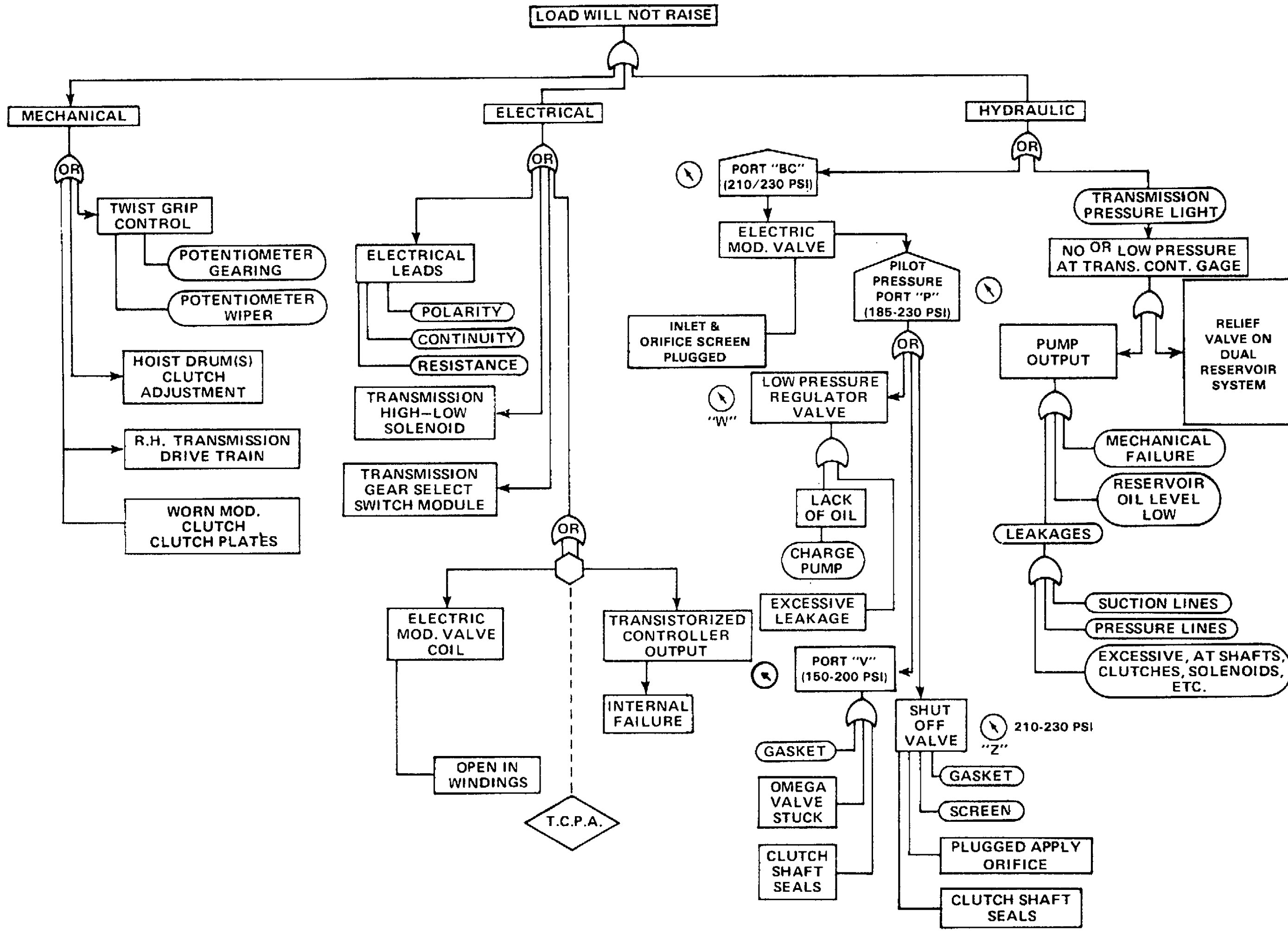


Figure 4C-4. Fault Tree-Load Will Not Raise

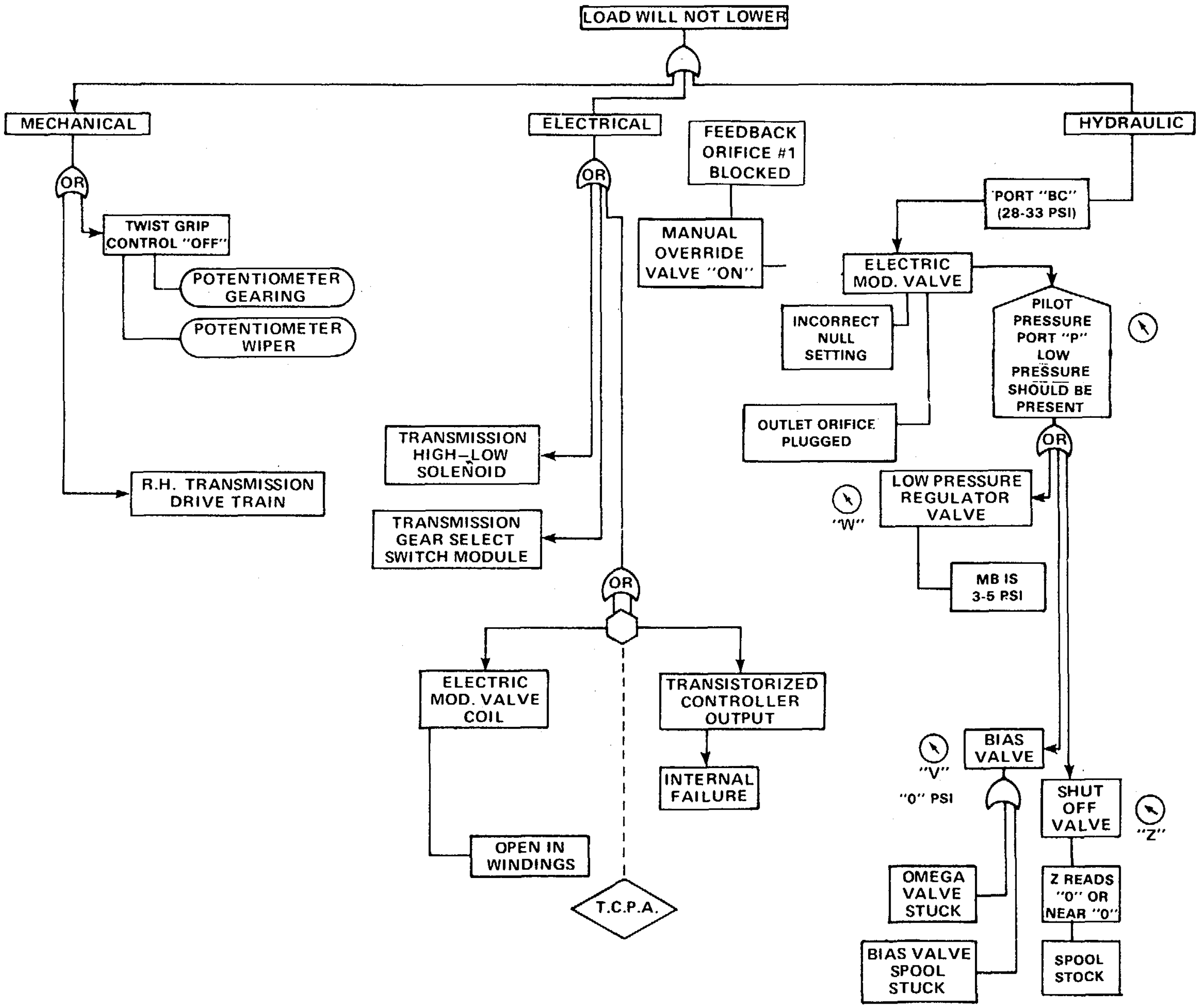


Figure 4C-5. Fault Tree-Load Will Not Lower

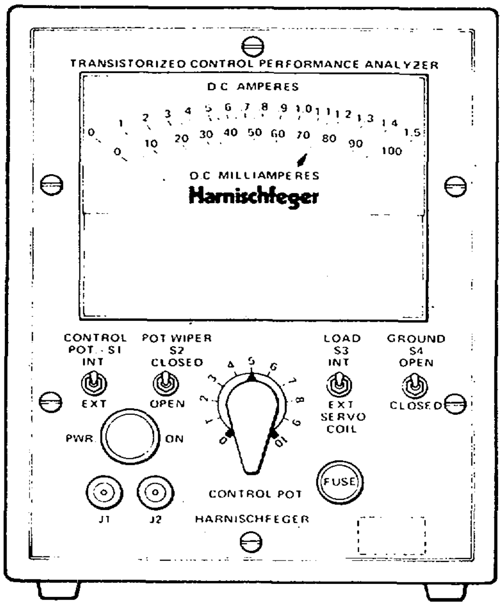


Figure 4C-6. Transistorized Control Performance Analyzer (100J4349)

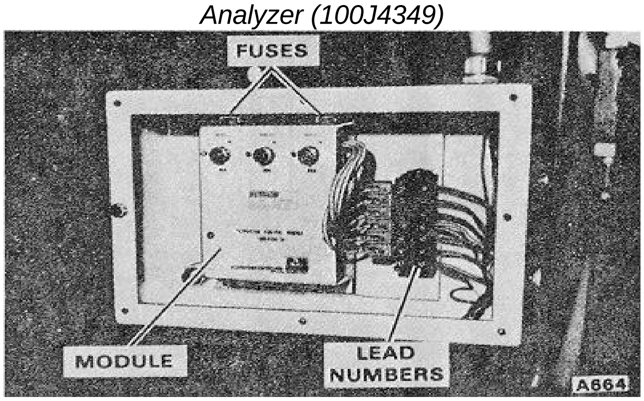


Figure 4C-7. Transistor Control Module

the coil are partially shorted. Isolate the trouble by measuring coil resistance at A and B of receptacle on coil housing. If more than 20 ohms, this indicates an open inside of the coil. If the coil is not open, then check for poor connection between the coil and controller. A reading of less than 20 ohms from either wire 5 or 6 to ground indicates a ground in that wire, or in the coil of the modulating valve. Check each connection back to the coil, removing the ground if it exists. If this check does not remove the ground, the coil must be defective and this can be confirmed by checking ;ins A and B of the coil to ground. Replace the defective valve.

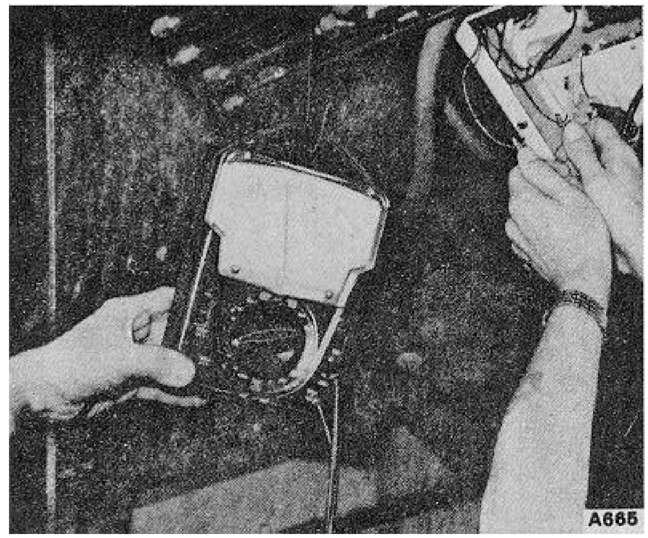


Figure 4C-8. Using Ohmmeter

5. Reconnect wires 5 and 6 to the terminal strip. Readjust the system if the modulating valve has been replaced. See Null adjustments later. Proceed with step 6 only if the system still fails to operate properly.

6. Connect the performance analyzer as shown in Figure 4C9. Set the switches on the analyzer as follows, being careful to see that wires 1 through 6 on the performance analyzer are connected to the corresponding leads in the control module.

A S1 - INT.
B. S2- CLOSED
C. S3 - INT.
D S4- CLOSED
E. CONTROL POT - Set to 0 position (fully CCW)

7. Remove the light bulb from the performance analyzer. Turn the ignition switch in the operator's module to ON.

8. Rotate the analyzer control pot pointer to insure that the meter needle moves. If no needle movement occurs, check the analyzer fuse, the input power circuitry or if there is still no movement the transistor control module is defective and must be replaced.

9. Turn the analyzer control pot pointer back to zero after determining that the meter needle will move.

10. Record the analyzer meter ampere readings (Upper Scale 01.5) obtained at each of the 10 points on the control pot pointer scale. Fill in the observed readings in the first column of Table 4C5. Compare these readings with the values listed in Table 4C2.

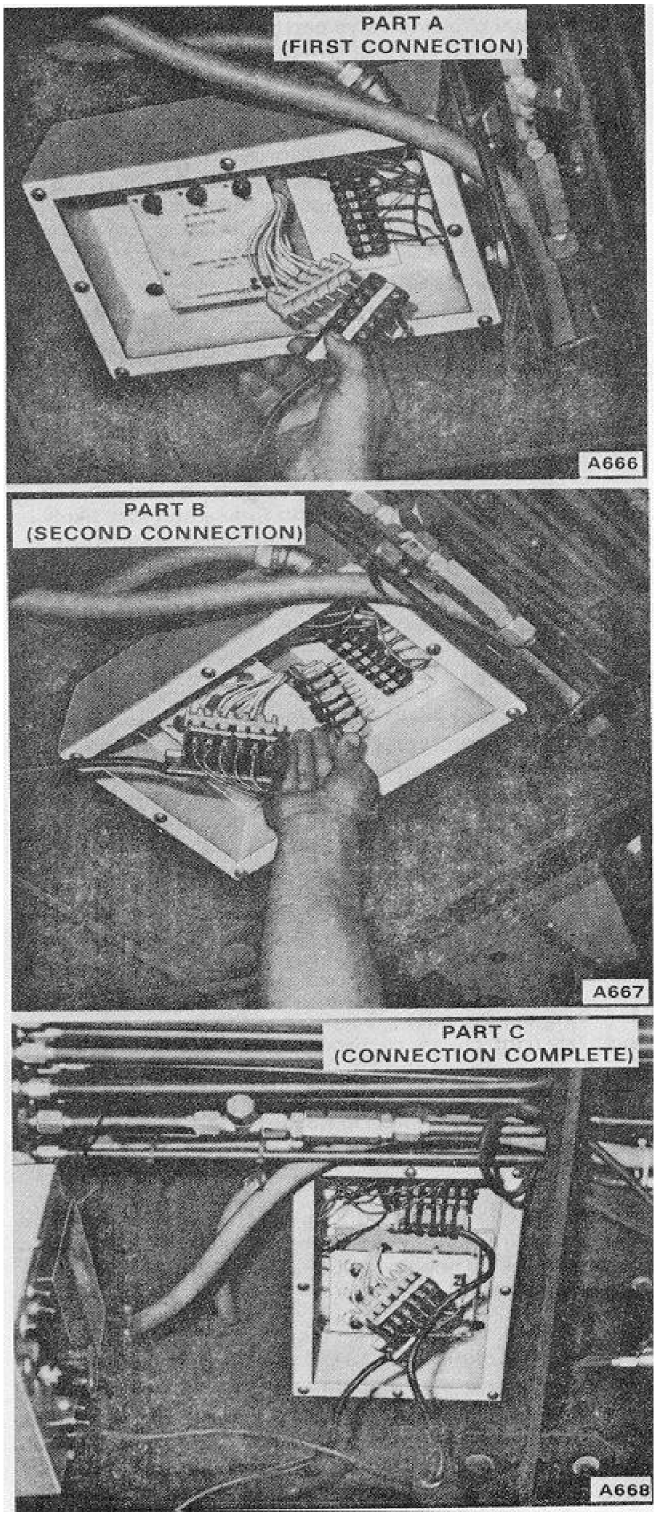


Figure 4C-9. Performance Analyzer Connections

SUBSECTION 4C

Table 4C-2. Performance Table

INTERNAL POT POSITION	TYPICAL VALVES D.C. AMPS ±10-15%
0	0
1	0.062
2	0.090
3	0.120
4	0.150
5	0.175
6	0.20
7	0.237
8	0.266
9	0.450
10	0.660
MID-S2	0.175

Check transistorized controller output amperage, engine speed at maximum RPM.

If the readings observed are not within the limits specified in the performance table, the MIN, MID, and MAX voltage potentiometers in the transistor control module (Figure 4C7) are out of adjustment. Refer to Adjustment procedures later in this subsection.

NOTE

The performance table shown in Table 4C2 indicates TYPICAL range D.C. Amps, not mandatory values. The important thing is that "O" is read at the 0 pot position, that 0.6500.670 is read at the 10 pot position, and that there be progressive changes between. If this is attained it indicates that the transistorized controller is functioning.

11. Hold performance analyzer switch S2 in the OPEN position. Observe the meter reading, which represents the midpoint current. Record the reading. This reading will be needed in the event that factory assistance is later required.

12. Place performance analyzer switch S1 in the EXT position. Rotate the modulated clutch twist grip to the full "on" position and note the meter reading. This reading should equal the reading obtained at point 10 in step 10 above. If it does not do so, check the potentiometer at the base of the swing lever to see that it measures 400 ohms, and check the potentiometer wiring and the potentiometer gear arrangement. The 400 ohm reading can only be checked after the lead wires to the transistor control are removed. Ob-

serve that the wiper travels the full distance of the windings. Rotate the twist grip handle to the "off" position. The wiper contact must cover part of the end terminal. Rotate the handle to the full "on" position. The wiper contact must cover part of the other end terminal. Check the terminals for tightness and the twist grip gear if there is a malfunction. Check this procedure if installing a replacement potentiometer.

13. Place the performance analyzer switch S3 in the EXT position. Then start the engine.

14. Rotate the twist grip control slowly, from the off position, and note whether or not the modulated clutch engages. Modulated clutch engagement will cause the engine to lug down slightly (tachometer rpm will drop). A distinct change in the sound of the engine will also occur. If the modulated clutch fails to engage, engine vibration may have created an open or ground in wires 5 or 6 which might not have shown up in previous checks which were made with the engine off. Aground in the wiring or coil may cause the modulated clutch to engage, and the operator will no longer be able to control the load by means of the modulated clutch twist grip. If this should occur, rotate the twist grip to the full off position. Minimum current reading on the performance analyzer meter should equal the minimum reading in step 10. If a substantial change is noted, this indicates a ground fault in the external system. If no substantial change in current reading is noted, place performance analyzer switch S4 in the OPEN position. Using a DC voltmeter on the 10 volt scale, measure the voltage across jacks J1 and J2 of the performance analyzer. If J2 is positive with respect to J1, the modulating valve coil is almost certainly grounded and the modulating valve should be replaced. However, if J2 is not positive with respect to J1, this does not absolutely establish that the modulating valve is working properly. The possibility remains that the modulating valve coil may be grounding out intermittently. Place switch S4 in the CLOSED position.

15. If the electrical system checks satisfactorily, another possibility for lack of control is that wires 5 and 6, which connect to the modulating valve coil, have somehow been reversed. To eliminate this possibility use the voltmeter to verify proper polarity. Wire 5 (Pin A) should be positive with respect to wire 6 (Pin B). If that is not the case, reverse the leads and the valve should function. Determine whether or not the system is operating properly, and continue with this procedure only if the trouble has not been eliminated.

Rotate the twist grip control from full off to full on. Note the performance analyzer meter readings at both the full off and full on positions. These readings should agree with the readings observed at positions 1 and 10 in step 10 above. If the readings obtained in this step agree with those obtained in step 10, the electrical circuitry is presumed to be functioning properly.

16. Leave the TCPA connected to the system to assist in making hydraulic tests. Check that the switches are left as follows:

S1 - EXT	S3 - EXT
S2 - CLOSED	S4 - CLOSED

NOTE

The manual override valve can be turned to the override position as a TEMPORARY FIX to permit machine operation until a replacement valve or controller are available. Under these conditions the modulated clutch/torque converter functions as a conventional torque converter (the modulated clutch is lockedup). The twist grip will not control the load and the engine throttle must be used to vary the torque converter output.

HYDRAULIC ANALYSIS

INTRODUCTION. If no problems were revealed during the electrical control system analysis, some form of hydraulic problem can be assumed.

NOTE

If it is necessary to remove the control valve banks from the torque converter housing for any reason, the valve and ditch plate mounting gaskets most likely will not be reusable. A full set of gaskets should therefore be on hand. See the Replacement Parts Manual for the gasket kit.

The cause of the problem can be determined by monitoring certain critical hydraulic pressures under simulated operating conditions.

To effectively troubleshoot the torque converter hydraulic system, the system must be thoroughly understood. A full description is given earlier in this subsection along with a complete hydraulic schematic. A summary of the functions of the various control valves in the system, and the sequence in which they operate, follows:

Metered flow through the electric modulating valve produces the pilot pressure that shifts the three pressure control valves (bias, shutoff and low pressure regulator). This pilot pressure can be observed at Port "P".

For reference, the pilot pressure and the three pressures it ultimately controls are represented in graph form in Figure 4C10. Although plotted against positions of the Performance Analyzer internal potentiometer, the same curves would plot against twist grip positions in a normally functioning system.

Pressure through the modulating valve increases as the twist grip on the swing lever is rotated from the off position toward the full on position (clockwise). This is the pilot pressure (Port "P").

From a normal minimum of 3 to 5 psi (0.20 to 0.30 bars), engine at high idle and modulated clutch disengaged, the torque converter charging pressure (at Port MB) increases to 90100 psi (6.26.9 bars).

When pilot pressure reaches 30 psi (2.1 bars), the shutoff valve shifts to the open position. Full clutch apply pressure should then appear at Port Z. The clutch plates will not

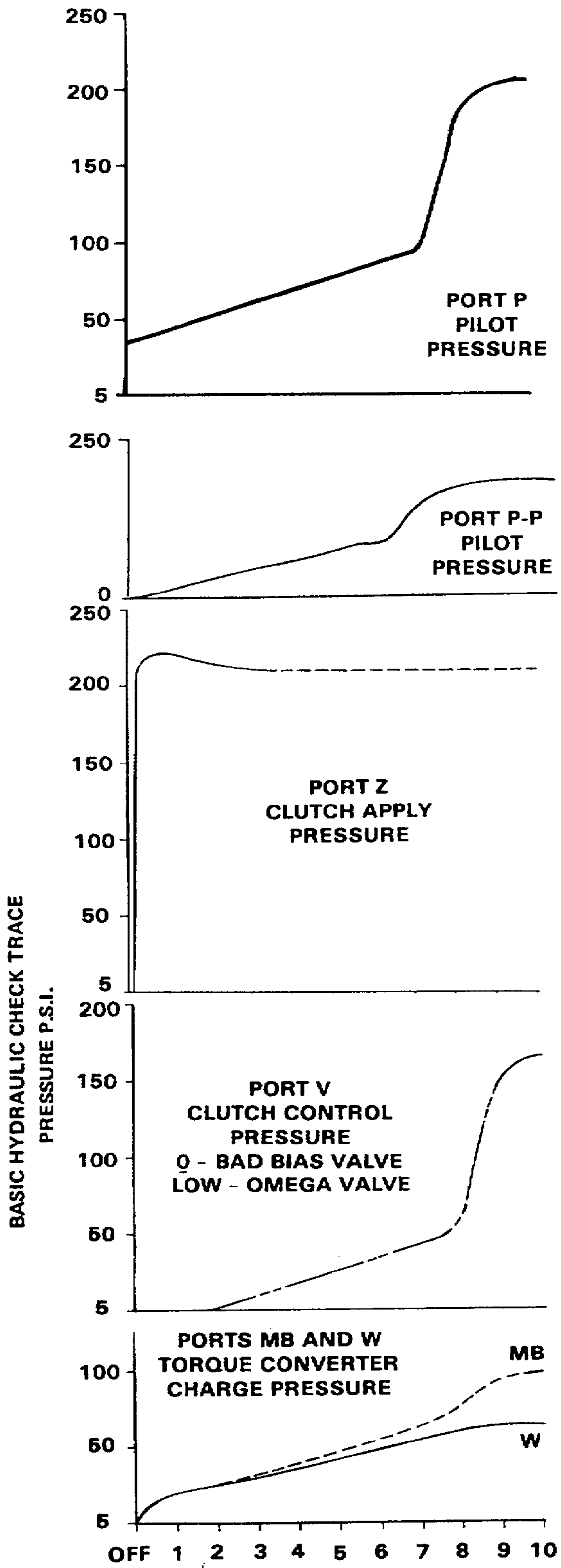


Figure 4C-10. Control Pressure Curves

"lock-up" at this stage, however, due to the action of the Omega valve in the clutch.

When pilot pressure reaches 40 psi (2.7 bars), the bias valve opens, and clutch control pressure should begin to build up at Port V. As shown in Figure 4C10, the pressure at Port V follows a curve similar to the pilot pressure (P) curve. As the name implies, it is the clutch control pressure which varies the slip in the modulated clutch. The clutch control pressure is applied to the outer end of the Omega valve, while the clutch apply pressure (Port Z) is applied against the inner end. As the clutch control pressure increases, the Omega valve is shifted inward, progressively closing off the bypass orifice and allowing a higher portion of the clutch apply pressure to build up behind the clutch piston. Clutch slip progressively decreases and finally "locks-up" when the clutch control pressure reaches its maximum level (twist grip fully clockwise).

Rotating the twist grip counterclosewise causes pressure through the modulating valve to decrease, following the curve shown in Figure 4C10. The clutch control pressure will decrease with the pilot pressure, causing a corresponding decrease in clutch apply pressure at the clutch piston. Clutch slip will increase as the apply pressure decreases.

When the pilot pressure decreases, the low pressure regulator valve begins to meter flow from Port A to Port D. The converter charging pressure (Ports MB and W) then begins to decrease. At a pilot pressure of 30 psi (2.1 bars)the shutoff valve closes off, removing clutch apply pressure (Port Z).

TROUBLESHOOTING PROCEDURE. It is assumed that the Initial Inspection and Electrical Analysis procedures outlined earlier in this subsection have been performed, and that the cause of abnormal operation has been narrowed down to the hydraulic control system.

NOTE

If the modulated clutch remains lockedup, a sticking modulating valve spool, a plugged outlet orifice, feedback orifice or the manual override valve in the wrong position are the likely causes. Also check the power supply.

Proceed with system troubleshooting as follows:

1. With the engine shut off, connect the Performance Analyzer as instructed in the topic Electrical Analysis, given earlier in this subsection. Set the switches as instructed in step 16.

2. Connect test gauges, equipped with manual shut-offs, as follows:

A. Connect a 0-600 psi gauge (#1) to Port X (Figure 4C- 11).

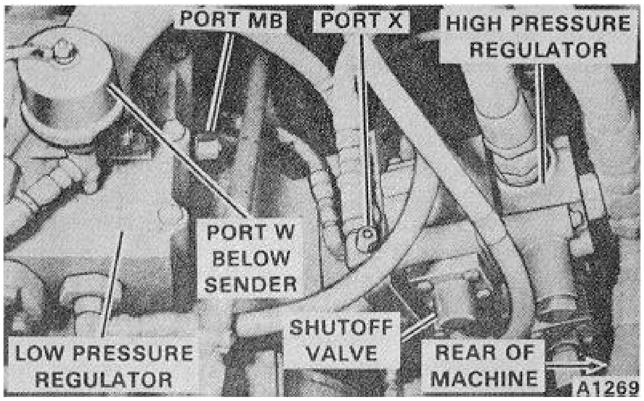


Figure 4C-11. Location of Ports X and MB

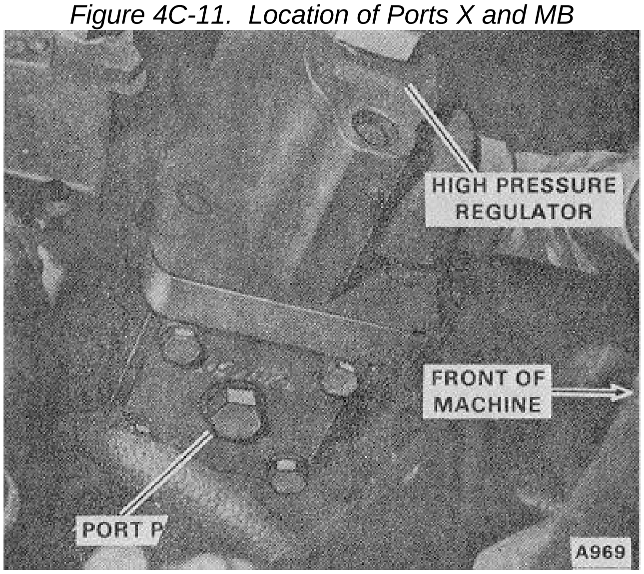


Figure 4C-12. Location of Port P

B. Connect a 0600 psi gauge (#2) to Port P (Figure 4C1 2).

C. Connect a 0100 psi gauge (#3) and a 015 psi gauge (#4) to Port MB (Figure 4C1 1), using a tee fitting.

D. Connect a 0300 psi gauge to the feedback pressure port (AP) of the modulating valve (Figure 4C1 3, also see Figure 4C1 6). It will be necessary to remove the pipe plug from the modulating valve.

NOTE

The 015 psi gauge (#4) is used when adjusting the null point of the electric modulating valve. The pressure at Port MB when the null point is properly set is in the range of 3 to 5 psi (at high idle engine speed), and is a critical pressure requiring the precision of the 015 psi gauge. Be sure to protect this gauge from excessive pressure by closing off the shutoff valve before pressure at Port MB reaches 15 psi. The maximum pressure at Port MB is 90100 psi, which could damage the gauge.

3. Check the oil level in the system reservoir, and add oil of the proper type if necessary. See Section III.

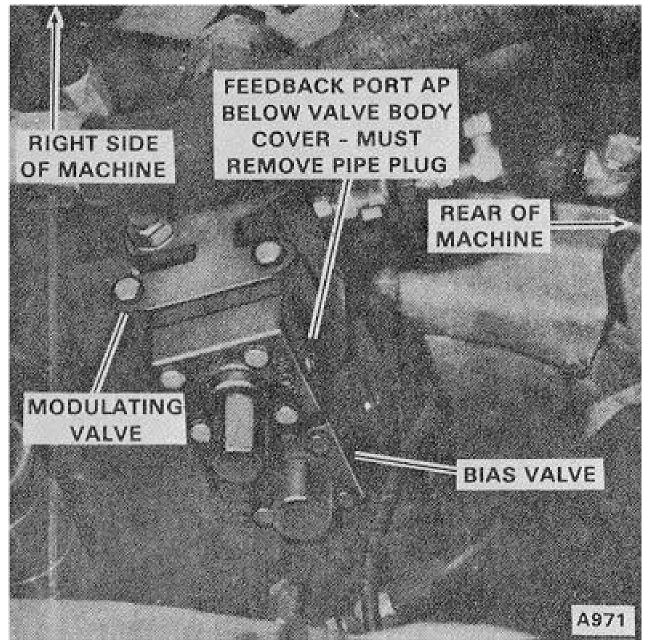


Figure 4C-13. Modulating Valve Feedback Pressure

4. Shut off the valves for each test gauge.

5. Start the upper engine and run it until the converter oil temperature reaches 1802000F (82.293.30C), using the gauge in the operator's module. If possible, engage the modulated clutch (with the transmission in neutral) to speed warmup of the system oil.

6. Open the shutoff valve for the gauge installed in step 2A, above, and note the pressure reading. This is the control pressure (Port X) and should range from 220230 psi (15.215.9 bars), with the modulated clutch disengaged and the engine running at high idle. The pressure gauge on the front of the right hand transmission should read the same as the test gauge in Port X. A comparison should be made to verify the accuracy of the gauges.

7. If pressure is normal at Port X, proceed to step 8. Low pressure at Port X indicates either a defective high pressure regulator valve or a malfunctioning pump. To locate the exact cause, proceed as follows:

A. A low pressure at X indicates a malfunctioning pump or a high pressure regulator problem. See Pump (37Q27 and 37Q28) in Subsection 4E if it is the pump.

B. If the pump proves to be satisfactory, the high pressure regulator valve (see Figure 4C12) is contaminated or defective. Remove the valve and clean it thoroughly in solvent. If this does not restore normal control pressure, replace the valve.

CAUTION

The high pressure regulator setting of 220 psi must be adhered to. Any attempt to change the setting without specific approval will void all warranties.

C. When the correct control pressure has been achieved, check to insure that a load can be controlled in the normal manner using the twist grip on the swing lever. If the load cannot be controlled the problem may exist in the transmission control circuit. Check relief valve (36Z1273) and pressure check the solenoid valves. Replace any leaky valve or valves.
D. If the load handling characteristics are still not satisfactory, proceed to step 8.

8. Disconnect the 0600 psi gauge (#1) from Port X and connect it to Port Z (see Figure 4C14). This with test gauges 2, 3, 4 and an extra gauge in the feedback port, connected as described in step 2 and the Performance Analyzer connected in the control circuit, make a check of control pressure as follows:

NOTE

On some torque converters, pressure Port Z may have a connector, elbow and cap nut provided to make gauge hook-up easier.

A. Set the potentiometer pointer on the Performance Analyzer to "0", and switch S1 to INT.

B. Place both transmissions in neutral.

C. Start the engine and run it at high idle speed. Record the readings on each gauge. Now close the shutoff valve in the line to gauge #4.

D. Slowly rotate the pointer on the Performance Analyzer clockwise while observing the pressure gauges. See

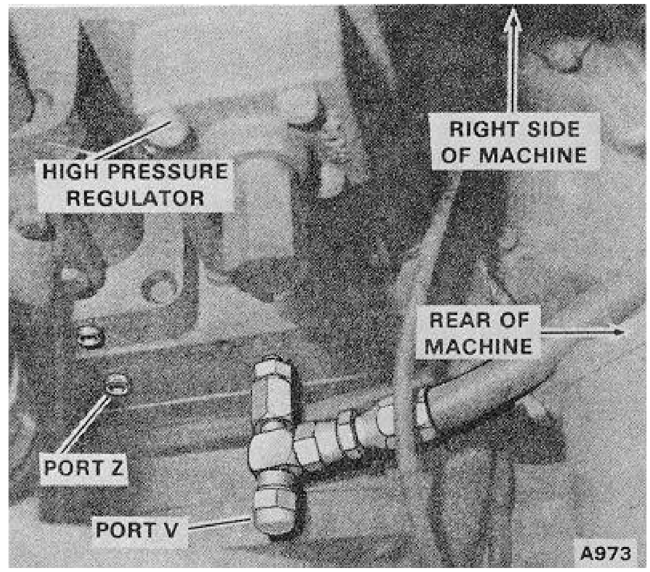


Figure 4C-14. Component Identification

E. The pilot pressure (Port P) should rise as shown by its curve in Figure 4C10. The feedback pressure should also rise like the pilot pressure. The feedback pressure (AP) should be 7080% of Port P.
F. The converter charging pressure (Port MB) will begin to increase as shown in Figure 4C10. Observe gauge #3.
G. At 30 psi (2.1 bars), full clutch apply pressure of 210220 psi (14.515.2 bars) should appear on test gauge #1 (Port Z).

Table 4C-3. Pressure Ratings

CIRCUIT NAME	TEST PORT LETTER CODE	NORMAL PRESSURE READING (PSI & BARS) (Engine @ Max. RPM Oil @ 180-200°F (82.2-93.3°C) Modulated Clutch Converter			
		DISENGAGED		ENGAGED	
		PSI	BARS	PSI	BARS
Omega Pilot Pressure	V	0	0	170 Min.	1.7 Min.
Control Pressure (Also Operator's Gauge)	X	210-230	14.5-15.9	210-220	14.5-15.2
Torque Converter Charge	MB	3-5	0.2-0.3	90-100	6.2-6.9
Modulated Pilot Pressure	P	5^{+2}_{-0}	$0.3^{+0.1}_{-0}$	$210^{\pm10}$	$14.5^{\pm0.7}$
Modulated Clutch Apply	Z	0	0	215	14.8
Lubrication		$25^{\pm5}$	$1.7^{\pm0.3}$	$25^{\pm5}$	$1.7^{\pm0.3}$
Transmission Clutches		Off 0	0	On $260^{\pm10}$	17.9
Fan Motors		225	15.5	2040	140.7

H. Disconnect gauge #1 from Porort Z and reconnect to Port V (see Figure 4C14).

I. At 40 psi (2.8 bars) pilot pressure, clutch control pressure should appear on gauge #1 (Port V). This pressure should increase as long as pilot pressure increases, and at nearly the same rate. See Figure 4C10.

J. At position 10 of the Performance Analyzer pointer, the four pressures being observed should be at the levels listed in Table 4C3 and the modulated clutch should be fully engaged.

9. If the pilot pressure (Port P) or the feedback pressure (Port AP) do not come up in the prescribed manner, the electric modulating valve should be suspected. Check the modulating valve as follows (see Figure 4C15):

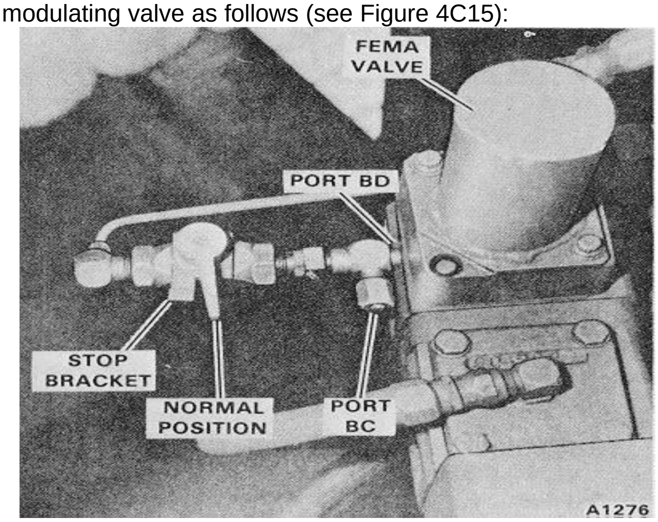


Figure 4C-15. Location of Port BC

A. Install a 0300 psi gauge at Port BC. Check that manual override valve is shut off (see Figure 4C15). Port BC should read 200 psi minimum, TCPA in full on position, #10. If gauge reading is less than specified, momentarily open override valve. Port BC should rise to 210 psi, Z to 210 psi and V to 170 psi minimum.

B. (From Step 9A) Turn the manual override to the open (on) position. If Port BC (Z and V also) is substantially less than 200 psi, this indicates the main supply is less than required (Port X). Recheck the supply and correct the shortage.

C. (From Step 9A) With the manual override in the open (on) position, Ports BC, Z and V read normal. Problem could have been dirt at one of many orifices, which has now been flushed away. Momentarily move the manual override valve to the off position and retest position #10, TCPA. Should Port P now respond, and Port Z or V not, then go on to specific port procedure checks which follow:

D. (From Step 9C, retest) Port P does not respond to electrical signal from TCPA. Shut the machine down. Supply a 12 VDC signal to Pin A (+) and Pin B (). Make and break the connection several times while listening for an audible "clicking" sound.
   1. No click sound. This indicates the possibility of debris between the plunger and seat. See Step9Hforcleaning procedure.
   2. Clicking sound heard. This indicates that the pressure control valve is functioning and that the problem may not have been identified properly.

If in step 8J (above) Port P is within the specification given in Table 4C3 but is not responsive enough, the possibility of a plugged orifice exists.

E. Port P reaches required pressure quickly but Port V is slow or does not reach its required pressure. Go to step 12.

F. Port P reaches required pressure, but is slow and gradual, Port V follows the same slow buildup. Pressure control valve final strainer may be clogged (rare). See cleaning procedure Step 9H.

G. Port P follows TCPA positioning along with Port V, but output pressures are less than specified. This indicates clogged feedback orifices. See cleaning instruction step 9H.

H. To clean the modulating valve (see insert of Figure 4C1 6), remove the capscrews securing the assembly to the valve body. Remove the inlet filter, thoroughly clean it in suitable solvent, air dry and reinstall it in the valve. Inspect the orifice hole in the stem of the valve to be sure it is open and not plugged. Clean the hole by blowing with dry compressed air. Remove the valve spool and spring from the valve body. Remove the valve cover body and then remove the orifice plug and clean it. Check all passages in the valve body to be sure they are clean. Reassemble the valve in the reverse order. The molded pressure control valve end is not repairable. Do not attempt to disassemble the pressure control valve.

J. If pressures are still abnormal a defective modulating valve is assumed. Replace the modulating valve and adjust the null setting as instructed under the topic, Adjustment Procedure.

10. If the clutch apply pressure (Port Z) does not develop, either the shutoff valve is defective or the strainer in the outlet port of the valve is blocked. An abnormally low pressure indicates either a partially clogged strainer or a leaking mounting gasket.

11. If the converter charging pressure (Port MB) does not increase at the normal rate, three things are suspect. First, there may be a defective converter charging pump. Second, the low pressure regulator valve may be binding or leaking excessively. In this case, replace the low pressure regulator. A third cause can be an internal converter housing leak.

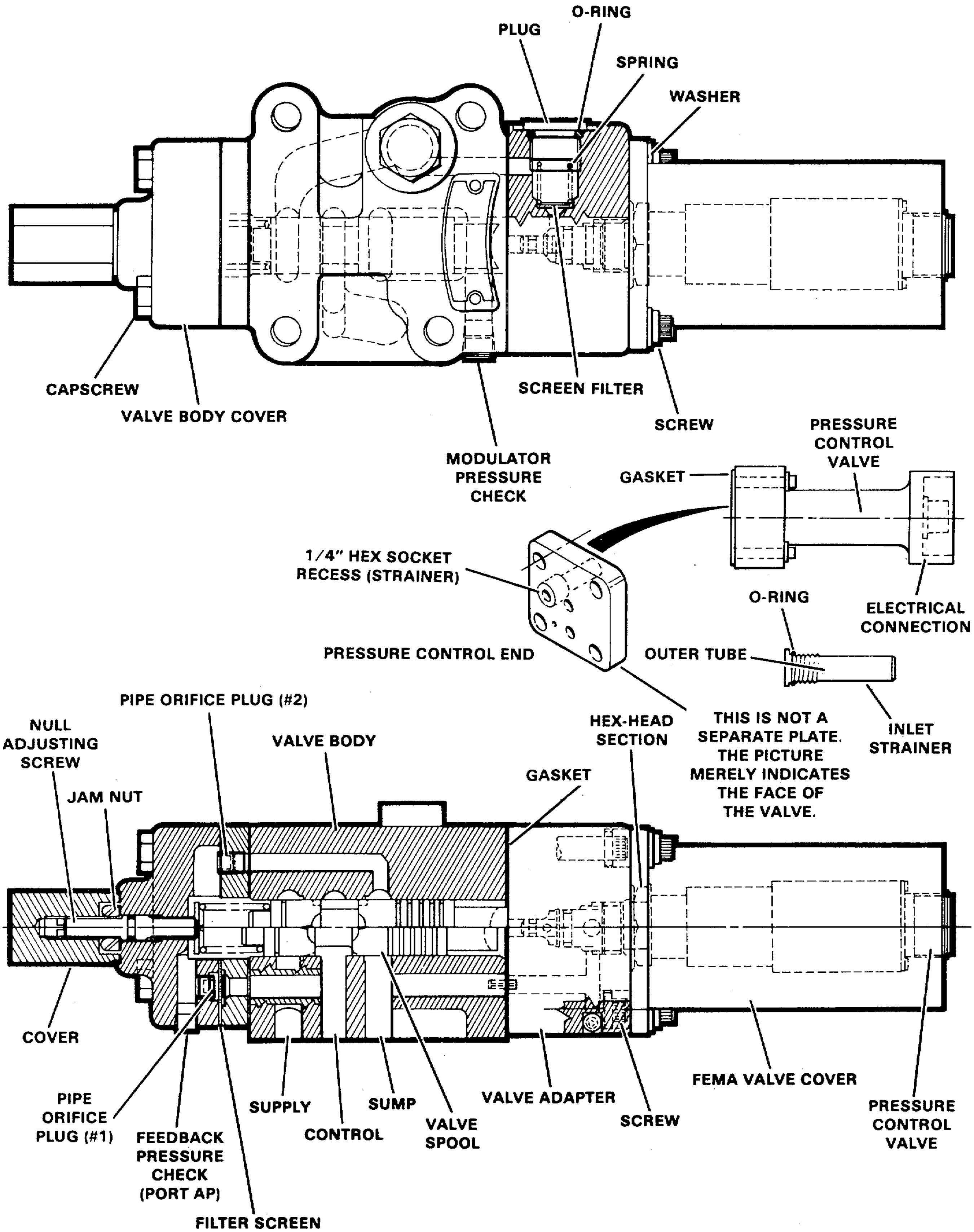


Figure 4C-16. Modulating Valve (Fema Type)

Take a set of pressure readings at Port MB and X and fill the data in the Field Column of Table 4C-4.

12. If the clutch control pressure (Port V) does not increase at the normal rate and/or does not reach a minimum of 170 psi (11.7 bars), with pilot pressure (Port P) at its specification maximum (Figure 4C10), possible faults can be:

A. Bias valve. Remove end cap, check spool movement and freedom. Clean the valve assembly in suitable solvent, inspect, reassemble and retest. If retest is negative see Step 12B or replace the bias valve.

B. Modulated clutch shaft seal rings or Omega valve. Possibility of internal leaks or sticking valve may exist. See following note and steps.

NOTE

Before pulling the torque converter, make the test described in step 13. It is even then recommended that the factory be consulted before proceeding to pull the torque converter. Internal problems are rare and pulling the torque converter is a time consuming job that should not be undertaken without being absolutely certain that it is necessary. Take a set of readings at Port MB and X and fill the data in the Field columns of Table 4C4, before calling the factory. Greater assistance can be rendered if the full set of pressures is available.

13. If the conditions described in step 13 exist, the condition of the Omega valve and the oil seals in the clutch control and clutch apply pressure passages in the modulated clutch can be determined by the following test:

A. Remove the complete valve bank, using extreme care to avoid damaging the gaskets.

B. The control, clutch apply and drain cavities are now exposed (see Figure 4C17).

C. In turn, pour a measured amount of SAE1 0 hydraulic oil (P&H Spec. 484A) into the control and clutch apply cavities. Record the times required to pour the measured amounts of oil into each cavity.

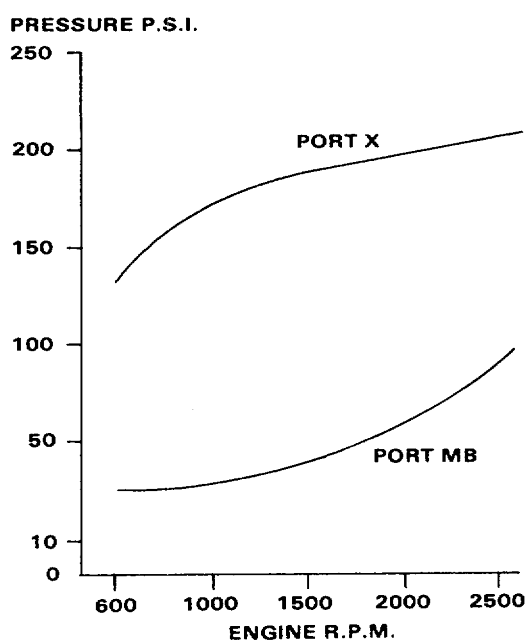
D. Oil should pour into the control cavity at a rate of 8 ounces (0.24 litres) nominal per minute, and into the clutch apply cavity at a rate of 16 ounces (0.47 litres) per minute. These rates are based on P&H Spec. 484A oil at a maximum temperature of 1 100F (43.30C).

NOTE

The above pour rates could be somewhat greater if the Omega valve cartridge happened to be located at the 6 o'clock position.

E. If the time required to pour the measured quantity of oil into either cavity is less than that specified, the torque converter assembly must be removed for repair. Refer to the Note following step 12.

Table 4C-4. Machine Characteristics Reference



ENGINE RPM	PORT "MB" PSI FACTORY FIELD	PORT "X" PSI FACTORY FIELD	PORT "P" PSI FACTORY FIELD
600			
700			
900			
1100			
1300			
1500			
1700			
1900			
2100			
2300			
2500			

TORQUE CONV. OIL TEMP. (MIN.) 180°F., MODULATED CLUTCH CONTROL FULL ON. INCREASE ENGINE THROTTLE FROM LOW IDLE TO VARIOUS RPM, RECORD PRESSURES AT EACH SPEED SETTING.

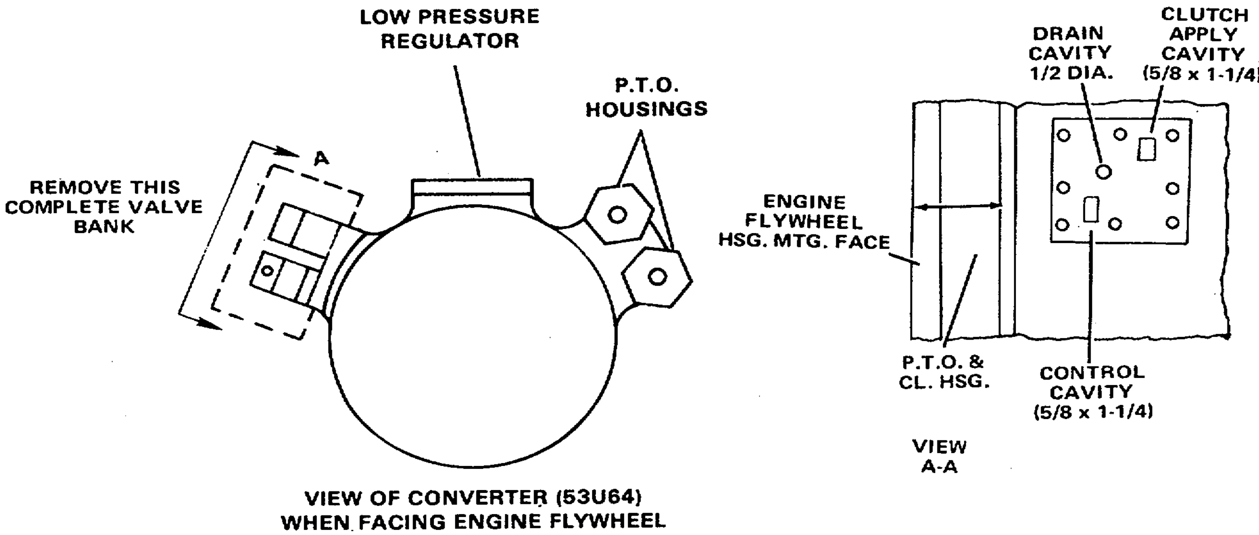


Figure 4C-17. Location of Control and Clutch Apply Cavities

GENERAL. The following adjustment procedure is to be used whenever an electrical component of the system has been replaced, or when required by different operating conditions. Install gauge #1 in Port V, gauge #2 in Port X, and gauges #3 and #4 in Port MB. Accurate results depend on proper preparation as described under the topic, Initial Inspection.

TORQUE CONVERTER NULL ADJUSTMENT AND TRANSISTORIZED CONTROL ADJUSTMENT. To adjust the null position of the modulating valve and to adjust the controller, proceed as follows:

1. Refer to Figure 4C18 and disconnect the electrical cable at the electric modulating valve.
2. Start the engine, with both the right and left hand transmissions in neutral. Warm the converter oil to 180200°F (82.293.30C). Turn the twist grip (modulated clutch control) to the "off" position and check that the manual override valve is in the normal position. After the engine oil pressure reaches 520 psi (0.31.4 bars), increase the engine speed to maximum. Open the needle valve to gauge 4 (Port MB). The pressure gauge should read 3 to 5 psi (0.20.3 bars). If the pressure is not as given, proceed as follows to adjust (see Figure 4C16):

   A. Remove the cover to gain access to the null adjusting screw. Loosen the jam nut.

   B. Turn the null adjusting screw "in" to lower MB pressure. Turn the null adjusting screw "out" to raise the MB pressure.

   C. Lock the jam nut when Port MB pressure is as given in step 2 above. Wait several seconds to verify that MB pressure did not drift when tightening the jam nut.

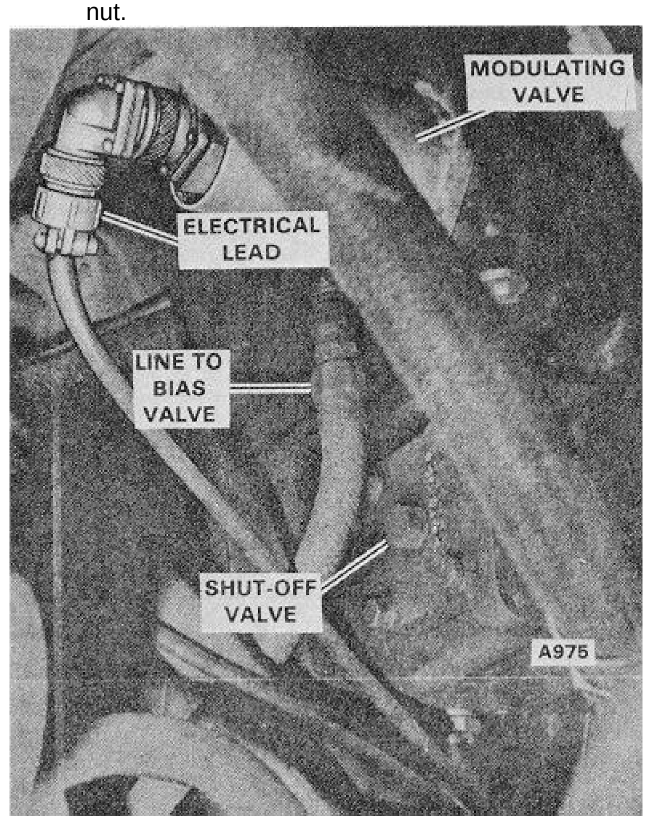


Figure 4C-18. Modulating Valve Electrical Lead

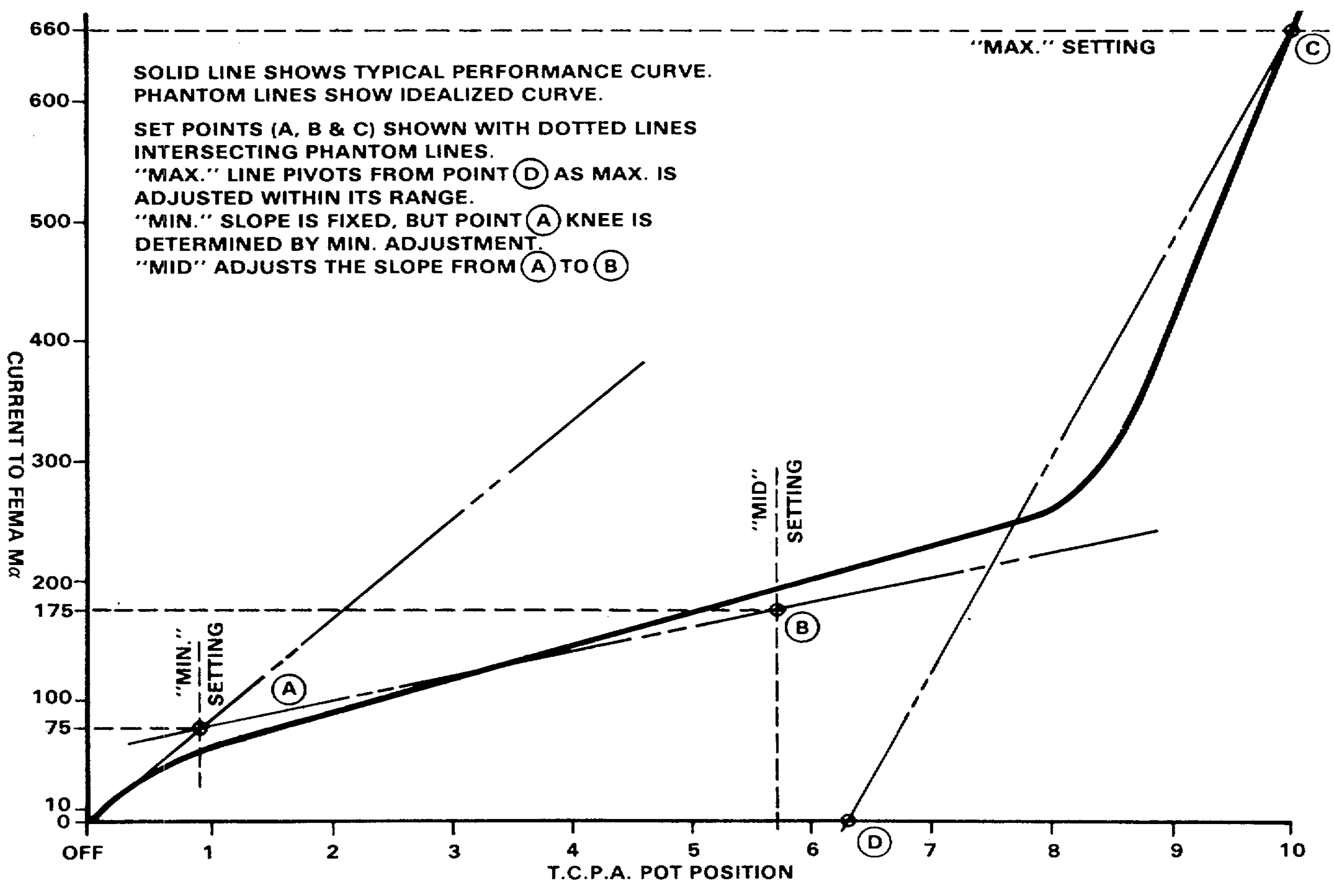
Table 4C-5. Test Data Record Sheet

MACHINE E ______________ MODEL ______________ HR. MTR. ______________

CUSTOMER ______________ CONVERTER S/N ______________ DATE ______________

AMBIENT AIR TEMP. ______________ °F RECORDED BY ______________

T.C.P.A. POT POSITION	T.C.P.A. I AMP.	PORT X PSI	PORT P PSI	PORT Z PSI	PORT V PSI	PORT MB PSI	FEEDBACK PRESSURE AP PSI	PORT BC PSI
OFF								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
MID S-2 OPEN								



NOTE

A check of Port MB should be made to verify zero (0) current flow to the modulating valve when the controller is full "off". Reconnect the electrical cable to the modulating valve and turn the twist grip handle to the "off" position. The pressure at Port MB should be 35 psi. The TCPA, set at the 0 pot position, should read zero (0) current. If there is current flowing to the modulating valve, check the modulator control wiper contact. It must cover part of the end terminal. Also check the terminals for tightness and check the twist grip gear. Disconnect the electrical cable from the modulating valve.

D. Reinstall the cover and hand tighten. Close the shutoff needle valve to gauge #4.
E. Reduce the engine RPM to low idle speed. After 2 minutes the engine may shut down. Turn the ignition switch to off and reconnect the electrical cable to the modulating valve.

3. Install the Performance Analyzer (see Figure 4C-9). Set the switches as follows:
S1 - INT S3- EXT
S2 - CLOSED S4 - CLOSED

4. Remove the Power On light bulb from the performance analyzer and turn the master (ignition) switch to the "on" position.
5. Adjust the controller Max., Min. and Mid. points as follows (see Figure 4C7):

A. Turn the control pot to the full on position (position 10).

B. Set the Max. adjustment pot from 0.6500.670 amps.

C. Turn BOTH the Min. and Mid. adjusting pots to the extreme counterclockwise position.

D. Hold S2 to OPEN and set the Min. adjusting pot to 0.075 amps.

E. Hold S2 to OPEN and set the Mid. adjusting potto0.1 75 amps.

F. Lock the adjusting pots and turn the control pot to the off position. Set switch S1 to EXT. Run a complete set of data and fill in Table 4C5 for future reference.

6. Turn the master (ignition) switch to off, remove the testers and return the machine to original condition.

SUBSECTION 4D

TORQUE CONVERTERS

GENERAL

This subsection will cover the torque converters used in the upper of this machine. The information will include the removal, disassembly, assembly, installation and any adjustments.

TORQUE CONVERTER (53U64)

TROUBLESHOOTING GUIDE

GENERAL. Subsection 4C contains a complete electrical and hydraulic troubleshooting guide. The troubleshooting charts and maintenance hints that follow are of a mechanical nature and are general.

KNOWING THE SYSTEM. Probably the greatest aid to troubleshooting is knowing the system. Every component has a purpose in the system. The construction and operating characteristics of each one should be understood. Know how the system works and what the valve settings and charge pump output should be (see Subsection 4C).

DEVELOPING SYSTEMATIC PROCEDURES. Analyze the system and develop a logical sequence of looking for trouble. Ask the operator how the torque converter performed when it started to malfunction or if there is anything unusual about it. Operate the unit to see if gauges are reading properly, that all controls operate smoothly, and check for unusual noises. Visually inspect the converter, looking for oil leaks. Examine filters and all lines, checking for heat, loose connections or collapsed hoses. Develop a cause and effect troubleshooting guide similar to the chart which follows and carefully study Subsection 4C. The initial time spent on such a project could save hours of downtime.

Table 4D-1. Troubleshooting

SYMPTOM	CAUSE	REMEDY
1. No output drive.	A. Low oil supply.	A. Check and fill oil sump.
	B. No oil pressure.	B. Check oil pump output. Check high pressure regulator valve for sticking open. Clean valve as required. Check suction strainer and filter for blocking of oil flow. Clean or replace as required.
	C. Modulating valve.	C. Check valve for free movement.
	D. Omega valve.	D. Clean or replace valve as required. Check operation.
	E. Clutch.	E. Disassemble and overhaul clutch.
	F. Converter input shaft and/or impeller.	F. Disassemble converter. Inspect and overhaul.
	G. Turbine and output flange.	G. Same as F.
2. Erratic drive.	A. Omega valve dirty or defective.	A. Clean or replace Omega valve. Install clean oil.
	B. Foamed oil.	B. Drain and refill oil supply with a reputable SAE No. 10 oil to MS service specifications. Check for an air leak on suction side of oil pump. Check all vents.

Table 4D-1. Troubleshooting (Continued)

SYMPTOM	CAUSE	REMEDY
	C. Modulating valve control.	C. Check control pressures, or volts and correct (see Subsection 4C).
	D. High pressure regulating valve sticking.	D. Clean or replace valve as required.
	E. Clutch.	E. Inspect and repair clutch. Check for proper clutch apply pressure range (see Subsection 4C).
	F. Intermittent oil pressure to Omega valve.	F. Clean, check, and/or replace the high pressure regulator valve (see Subsection 4C).
3. High oil pressure.	A. High pressure regulator valve piston sticking.	A. Clean or replace high pressure regulator valve.
	B. Low temperature operation. Cold oil relief valve stuck closed.	B. Clean or replace cold oil relief valve. Check sump line.
4. Low oil pressure to Omega valve.	A. Wrong spring in high pressure regulator valve.	A. Disassemble, inspect and correct high pressure regulator valve defect. Test pressure control (see Subsection 4C).
5. Noisy operation.	A. Bearing failures in converter.	A. Overhaul converter.
	B. Impeller, turbine, or stator failure.	B. Same as A.
	C. Oil cavitation.	C. Check oil for foaming and oil level. Replace oil and fill properly as required. Check suction side of pump for air leakage.
	D. Drive ring loose on flywheel.	D. Tighten drive ring.
6. System overheats.	A. Operating in high heat range.	A. Check performance o assure converter system is operating near maximum efficiency (see Subsection 4C).
	B. Heat exchanger.	B. Check heat exchanger for restrictions.
	C. Flywheel scavenging.	C. Check flywheel and return line for restrictions. Check for adequate venting.
	D. Low pump flow.	D. Check flow and pressure check for air in suction side.
7. Poor performance.	A. Engine.	A. See Subsection4Afortroubleshooting.
	B. Clutch.	B. Check for clutch slipping. Check apply flow and pressure and control flow and pressure (see Subsection 4C). If necessary, remove converter and check clutch apply orifice and Omega valve seat. Check seal ring and lathe cut rings for wear. Check clutch plates.
	C. Converter.	C. Check converter basic pressure (see Subsection 4C). Check assembly for wear or looseness.

MAINTENANCE. Three simple maintenance procedures have a great effect on converter performance, efficiency, and life. They are:

1. Change filters.
2. Maintain a sufficient quantity of clean hydraulic fluid of the proper type and viscosity in the reservoir.
3. Keep all connections tight, but not to the point of distortion, so that air is excluded from the system.

REMOVAL

Prior to any attempt to remove the converter it should be tested to determine the necessity of complete removal. Items such as filters, pumps, high pressure regulator, converter pressure regulator, and the modulating valve can be removed and serviced separately after a thorough cleaning of the area involved.

The best method of removing the torque converter is to remove the right hand chain case and torque converter as a unit. To remove the converter and chain case, proceed as follows:

1. Remove all sheet metal from around the chain case and transmission.

2. Remove all external electrical, hydraulic and case drain lines leading to the torque converter and chain case.

3. Disconnect the output universal joint from the case to the intermediate hoist shaft.

4. Remove the capscrews that secure the upper block support of the chain case to the lower block support at the front of the chain case.

5. Support the torque converter end of the case and remove the capscrews securing the torque converter to the engine. Also remove the capscrews securing the torque converter support to the engine base.

6. Using a suitable sling and lifting device, remove the chain case and torque converter as an assembly. Set the assembly on blocking.

7. Disconnect the torque converter from the chain case and remove the large O-ring from the converter. Set the torque converter on a bench for disassembly.

OVERHAUL GENERAL. The following overhaul instructions have been arranged to provide the best method of completely disassembling and reassembling the transmission. The instructions for disassembling and reassembling a subassembly, where applicable, are given in the numbered steps following the subassembly title. In the event it is not necessary to overhaul a subassembly, proceed to the next subassembly title.

NOTE

Unless specifically stated to the contrary, numbered callouts after an item in the disassembly and reassembly refer to the exploded view which appears at the end of this write-up.

Complete overhaul is not necessary if the known repair work is limited to such items as a charging pump, the converter, or the control valves. Complete overhaul will be necessary if the hydraulic fluid has become contaminated with metal particles.

It is suggested that before any work is done on this unit, all the steps for disassembly and reassembly be read carefully and understood.

NOTE

Be sure to match mark the cases whenever any cases will be pulled apart. If a new case is going to be installed, note the positioning of the cases.

Expendable parts such as oil seals and Orings should never be reused even though inspection may show these items as being serviceable for future use. The cost of these items is negligible compared to the costs involved in replacing such items if they do not function properly. Service kits are available for each subassembly, as presented by these overhaul instructions.

All replacement parts should be given your final inspection to ensure that no damage has resulted after the final factory inspection was made.

Cleanliness is of prime importance when any part of this unit is disassembled or reassembled. Before starting disassembly, be sure that a clean work area with a dust and grit free workbench is available.

TOOLS. In addition to normal hand tools, some special tools are required to overhaul the torque converter. Do not attempt to overhaul the converter without the special tools.
Where applicable, drawings are included to allow the fabrication of the tools required for overhaul.

CLEANING AND INSPECTION. The following steps are given as an aid to cleaning and inspecting parts when the transmission is overhauled.

1. All parts must be clean to permit effective inspection. At assembly, it is very important that no dirt or foreign material be allowed to enter the converter. Even minute particles can cause the malfunction of close fit parts, such as valves.
2. All metallic parts of the converter, except bearings, should be cleaned thoroughly with volatile mineral spirits or by the steam cleaning method. Do not use caustic soda solution for steam cleaning.
3. Parts should be dried with compressed air. Steam cleaned parts should be oiled immediately after drying.
4. Clean oil passages by working a piece of wire back and forth through the passages and flushing with spirits. Dry the passages with compressed air.
5. Examine parts, expecially oil passages, after cleaning, to make certain they are entirely clean. Reclean them, if necessary.
6. Bearings that have been in service should be thoroughly washed in volatile mineral spirits. If the bearings are particularly dirty or filled with hardened grease, soak them in the spirits before trying to clean them.

Before inspection, oil the bearing with the same type of oil that will be used in the torque converter.

NOTE

Never dry bearings with compressed air. Do not spin bearings while they are not lubricated.

7. Inspect bores for wear, scratches, grooves and dirt. Remove scratches and burrs with crocus cloth. Remove foreign matter. Replace parts that are deeply scratched or grooved.
8. Inspect mounting faces for nicks, burrs, scratches, and foreign matter. Remove such defects with crocus cloth or a soft stone. If scratches are deep, replace the damaged parts.
9. Inspect threaded openings for damaged threads. Chase damaged threads with the correct size used tap.
10. Replace housing or other cast parts that are cracked.
11. Inspect all machined surfaces for damage that could cause oil leakage or other malfunction of the part. Replace the faulty part.
12. Inspect bearings for roughness of rotation. Replace a bearing if its rotation is still rough after cleaning and oiling.
13. Inspect bearings for scored, pitted, scratched, cracked, or chipped races, and for indication of excessive wear of rollers or balls. If one of these defects is found, replace the bearing.
14. Inspect a defective bearing's housing and shaft for grooved, burred, or galled conditions that indicate that the bearing has been turning in its bore or on its shaft. If damage cannot be corrected with crocus cloth, replace the damaged part.
15. Inspect bushings for scores, burrs, roundness, sharp edges and evidence of overheating. Remove scores with crocus cloth. Remove burrs and sharp edges with a scraper or knifeblade. If the bushing is out-of-round, deeply scored, or excessively worn, replace it with the proper size bushing.

NOTE

Sometimes it is necessary to cut out a damaged bushing. Be careful not to damage the bore into which the bushing fits.

16. Inspect thrust washers for distortion, scores, burrs and wear. Replace the thrust washer if it is worn or damaged.
17. Inspect seal rings for cuts and hardness. Replace seal rings if these defects are found.
18. When replacing lip-type oil seals, the spring loaded side must be toward the oil to be sealed in (toward the inside of the unit). Use a non-hardening sealing compound on the outside diameter of the seal to prevent oil leaks. Coat the inside diameter of the seal with high temperature grease (MILG3534A or equivalent) to protect the seal during shaft installation and to provide lubrication during initial operation.
19. Replace all composition gaskets.
20. Inspect gears for scuffed, burred, nicked or broken teeth. If the damage cannot be removed with a soft stone, replace the gear.
21. Inspect gear teeth for wear that may have destroyed the original tooth shape. If this condition is found, replace the gear.
22. Inspect the thrust face of gears for scores, scratches and burrs. Remove such defects with a soft stone. If scratches and scores cannot be removed with a soft stone, replace the gear.
23. Inspect splined parts for stripped, twisted, chipped or burred splines. Remove burrs with a soft stone. Replace the part if other damage is found. Spline wear is not considered detrimental except where it affects tightness of fit of the splined parts.
24. Inspect snap rings for nicks, distortion, and excessive wear. Replace the snap ring if any of these defects are found. The snap ring must snap tight in its groove for proper functioning.
25. Inspect springs for signs of overheating, permanent set, or wear due to rubbing adjacent parts. Replace the spring if any of these conditions are found.
26. Inspect the clutch plates for burrs, imbedded metal particles, severely pitted faces, excessive wear, or core, cracks, distortion and damaged spline teeth. Remove burrs, using a soft honing stone. Replace plates which have other defects.
27. Inspect the impeller wheel, turbine wheel and stator for loose, bent or broken blades. Replace a damaged assembly.
28. Inspect the metal rings on the two carrier assemblies for excessive wear and replace any that are questionable.

EXTERNAL PARTS. If it is necessary to remove and reinstall the pumps mounted on the power take off unit see the appropriate subsection. (4E for the torque converter charge pump and the lubrication pump. 5B for the main machine pump). If it is necessary to remove and reinstall the control valves and/or ditch plates, proceed as follows (see Figure 4D14):

1. Tag and disconnect the appropriate hydraulic lines to the item (02, 06, 21, 25 or 36) being removed. Plug the lines to prevent the entry of contaminants.
2. Remove the attaching hardware and pull the item(s) off of the converter. Remove any gaskets and plug the ports to prevent the entry of contaminants.
3. If necessary remove ditch plates (04, 10, 23, 27 or 19) by removing the attaching hardware. Remove the gaskets and replace with new ones. Also remove and clean screen (12) from ditch plate (19).
4. All of the valves (02, 06, 21, 25 and 36) are non-repairable items. If the item is damaged it will be necessary to replace it. See Subsection 4E for the cleaning of the FEMA valve.

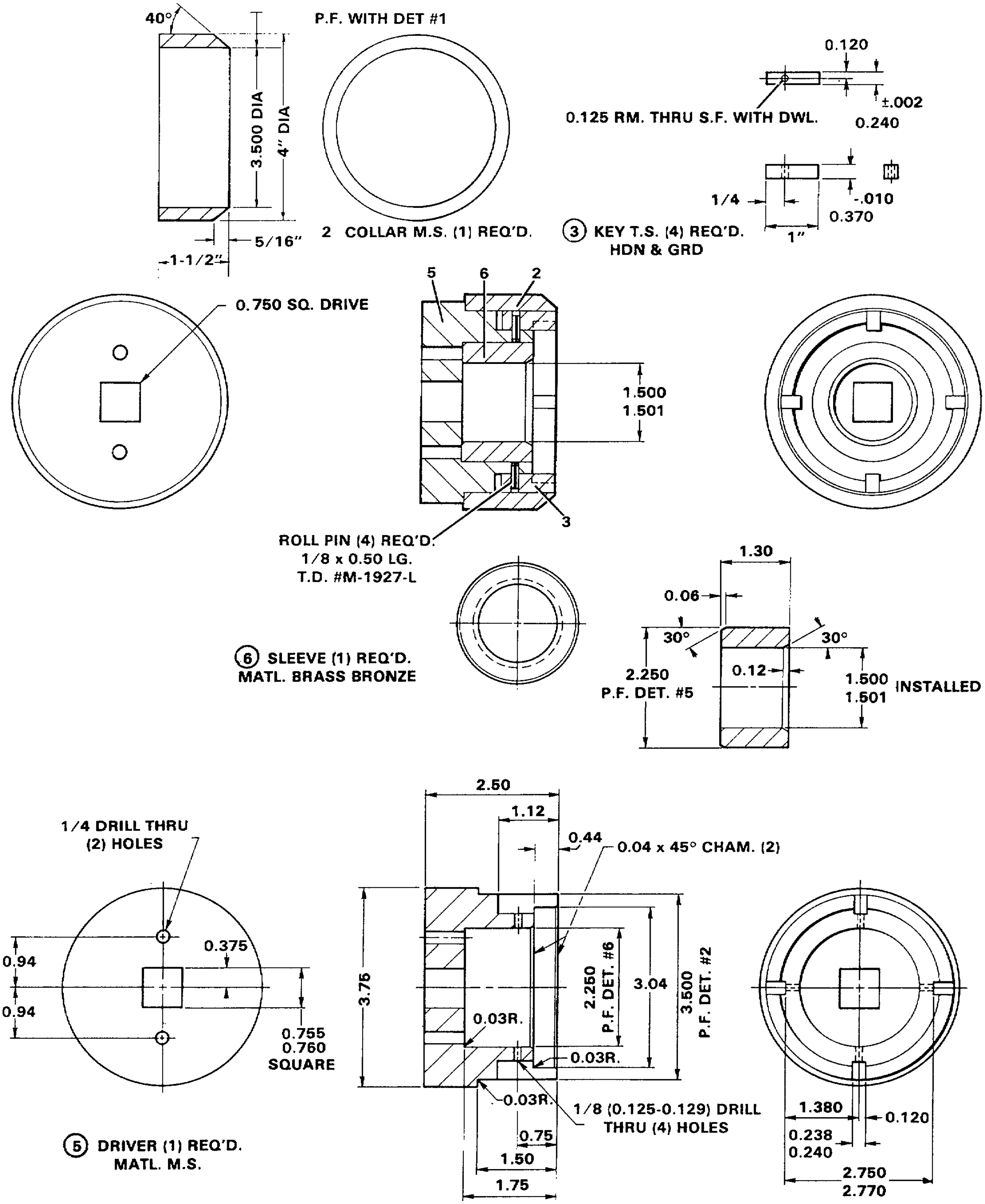


Figure 4D-1. Nut Tool

5. To reinstall the ditch plates, clean the area and reinstall the gasket. Set the ditch plate on the converter, or valve, and reinstall the mounting hardware.
6. To reinstall the valves, clean the area where the item will mount and install a new gasket. Set the item on the ditch plate and reinstall the mounting hardware. Tighten securely.
7. Remove the plugs and reinstall the appropriate hydraulic lines.

PUMP DRIVES. Before the pump drives can be removed from the takeoff case, the charge pump, lubrication pump and/or the hydraulic controls pump must be removed. See Subsection 4E to remove the charge pump and lubrication pump. See Subsection 5B to remove the hydraulic controls pump. When removing any of the pumps be sure to remove and replace any gaskets. To remove, repair and reinstall the pump drives, proceed as follows (see Figure 4D14):

1. Remove mounting plate (43) by removing the attaching hardware. Remove gasket (44). If necessary remove cover (139) from plate (43).
2. Pull drive gear (46) from takeoff case (53). Bearings (45 and 47) should come off with the gear. Remove bearings (45 and 47) from gear (46). Remove adapter (41) and snap ring (140) from gear (46).
3. Remove oil seal (42) from mounting plate (43). If necessary remove mounting plate (49) and gasket (48). Remove oil seal (50) from mounting plate (49).
4. After disassembly, thoroughly clean the takeoff case and the pump drive components in solvent or clean diesel fuel. Discard all gaskets and oil seals. Replace any worn bearings and parts that show considerable wear.
5. Install oil seal (50) into mounting plate (49). Install the mounting plate and gasket (48) on case (53). Secure with the attaching hardware.
6. Heat and install bearing (45 and 47) on gear (46).
7. Seat gear (46) into mounting plate (49). Install mounting plate (43), with gasket (44), over bearing (45). Secure in place with the attaching hardware. Install oil seal (42) into mounting plate (43).
8. Install snap ring (140) and adapter (41) into gear (46). If removed, install cover (139).
9. After assembly, reinstall the charge pump, lubrication pump and/or hydraulic controls pump. Reinstall any gaskets removed during disassembly.

CLUTCH GROUP. To disassemble, repair and reassemble the clutch group, proceed as follows (see Figure 4D14):

1. Remove setscrew (54). Using the tool shown in Figure 4D1, remove nut (55) along with lockwasher (56). Remove clutch carrier (57) as a unit.
2. Remove return plate (62) and pull piston (61) out of carrier (57). Remove O-ring (63) from piston (61). Remove 0ring (64) from carrier (57).
3. Remove compression springs (68) from hub and back plate (67). Remove the hub and back plate as an assembly and remove drive plates (66) and driven plates (65).
4. If necessary remove snap ring (70) and plate (69) from hub and back plate (67).
5. Remove capscrews (58). Clean and inspect the Omega valve piston to be sure that it is free in the bore and is not scored. Check the valve seat plate to see that the piston seats properly on the plate. Also check the orifice plug to be sure that it is not plugged. It may not be necessary to remove this plug from carrier (57).
6. After the clutch group is completely disassembled, thoroughly clean the parts with solvent or clean diesel fuel. Inspect all parts for wear and replace if necessary. Discard all O-rings and replace with new ones. Omega valve (59) is replaceable as a unit only.
7. If Omega valve (59) was removed, reinstall it on carrier (57) and secure in place with capscrews (58).
8. Set plate (69)on hub and back plate (67) and hold in place with snap ring (70). Set the hub and back plate on shaft (71).
9. Alternately install clutch plates (65 and 66) beginning with a drive plate (the plate with teeth on the outer diameter). Install compression springs (68) (see Figure 4D2).

NOTE

Torque converter 53U64 uses 6 clutch plates.

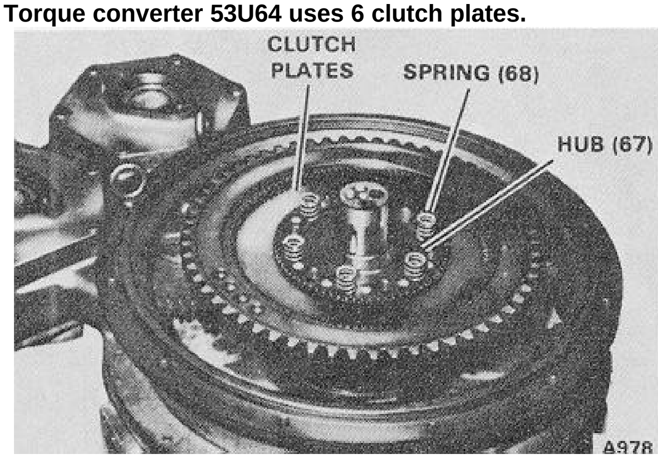


Figure 4D-2. Clutch Plate Installation

10. Lay carrier (57) on a clean workbench. Install O-ring (64) in carrier (57). Install O-ring (63) on piston (61) then install piston (61) into carrier (57). Put a coat of oil film on return plate (62) and set the plate over the roll pins (see Figure 4D-3.

11. Install the assembled carrier on shaft (71). Hold return plate (62) in place when setting the carrier on the shaft.

12. Install lockwasher (56), lubricated, to 290-320 ft-lbs (40.1-44.3 kg-m) using the tool shown in Figure 4D-1. Install and stake set-screw (54). See Figure 4D-4.

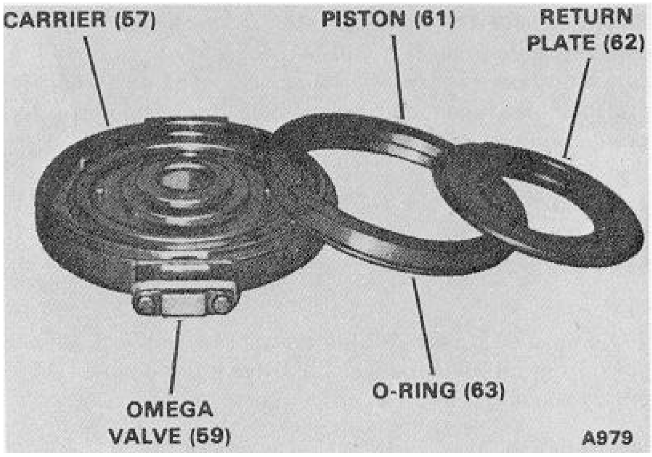


Figure 4D-3. Carrier and Piston Assembly

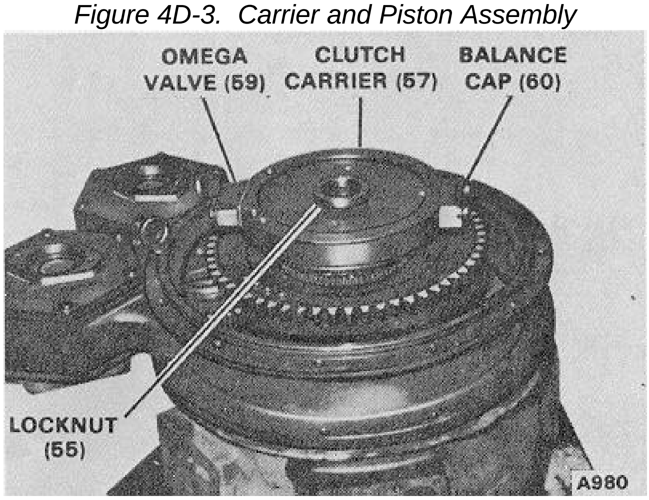


Figure 4D-4. Clutch Carrier Installation

1. Drive ring (72) will remain mounted on the engine flywheel and should only be removed if there is excessive wear on the teeth or runout on the flywheel is noted.
2. Remove drive spider (75) and drive gear (77), with bearing (76), from shaft (71). If bearing (76) needs replacing, remove snap rings (73)and push the bearing out from the bore of the drive gear.
3. Remove capscrews (95) and pull housing (53) off of housing (96). Set housing (53) on a workbench for further disassembly.
4. Remove capscrew (84), with washer (85), and using a puller arrangement pull idler shaft (86) out of housing (53).
Idler gear (79) and bearing (80) can then be removed by moving the assembly toward the center of housing (53).
5. Remove capscrews (82) and split washer (81). Push bearing (80) out of gear (79).
6. Remove and replace O-ring (78).
7. After disassembly, thoroughly clean the case and its components in solvent or clean diesel fuel. Discard all 0rings and gaskets. Replace any worn bearings and parts that show considerable wear.
8. Install O-ring (78) on housing (53). Press bearing (80) into gear (79) and secure in place with split washer(81) and capscrews (82).
9. Set the gear assembly into housing (53) and press in shaft (86). Set washer (85) on shaft (86) then install and fully tighten capscrew (84). See Figure 4D-5.

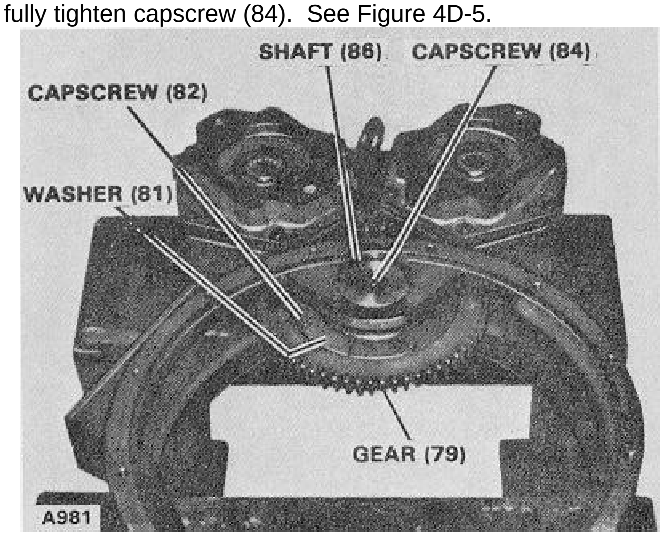


Figure 4D-5. Idler Gear Installation

10. Set housing (53) on housing (96) and install capscrews (95). See Table 4D2 for torque values.

11. Install one snap ring (73) on bearing (76) then install bearing (76) into gear (77) and secure in place with other snap ring (73). Set the assembly over shaft (71). See Figure 4D6.

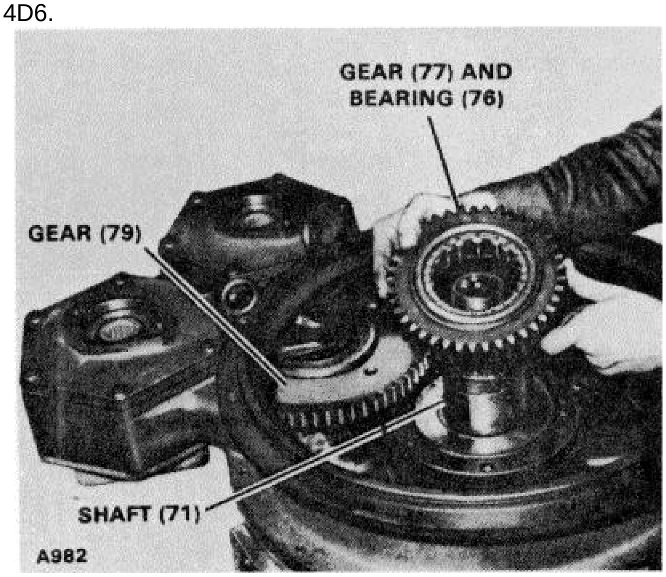


Figure 4D-6. Installing Gear and Bearing

12. If snap ring (74) was removed from drive spider (75) install it at this time. Set drive spider (75) on gear (77). See Figure 4D-7.

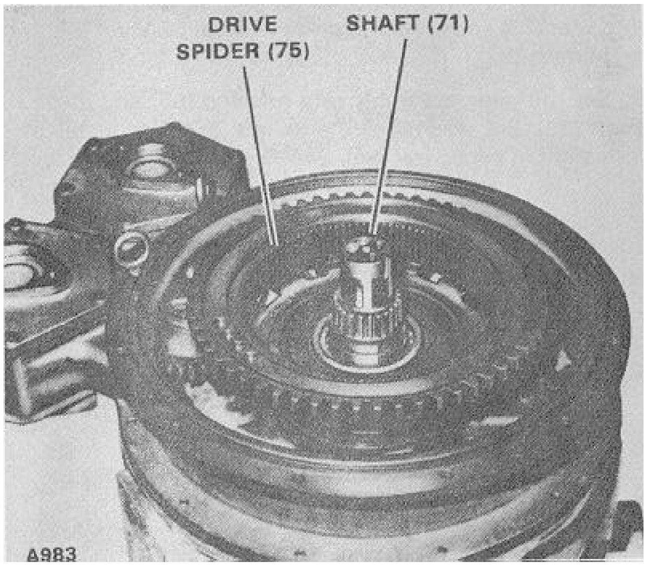


Figure 4D-7. Input Group

BASIC CONVERTER GROUP. Before the basic converter can be disassembled, it will be necessary to remove the clutch and power takeoff groups, as explained earlier. To disassemble, repair and reassemble the basic converter group, proceed as follows (see Figure 4D14):

1. Remove capscrews (135) and separate housing (134) from housing (96). Turbine wheel (129) will stay with housing (1 34).
2. Remove setscrew (145), locknut (144) and lockwasher (143) from turbine wheel (129). Drive turbine wheel (129) out of housing (134).
3. Remove capscrews (146), bearing retainer (138), gasket (141) and oil seal (142). Drive bearing (137) out of housing (134). Also remove wear sleeve (133)from housing (134).

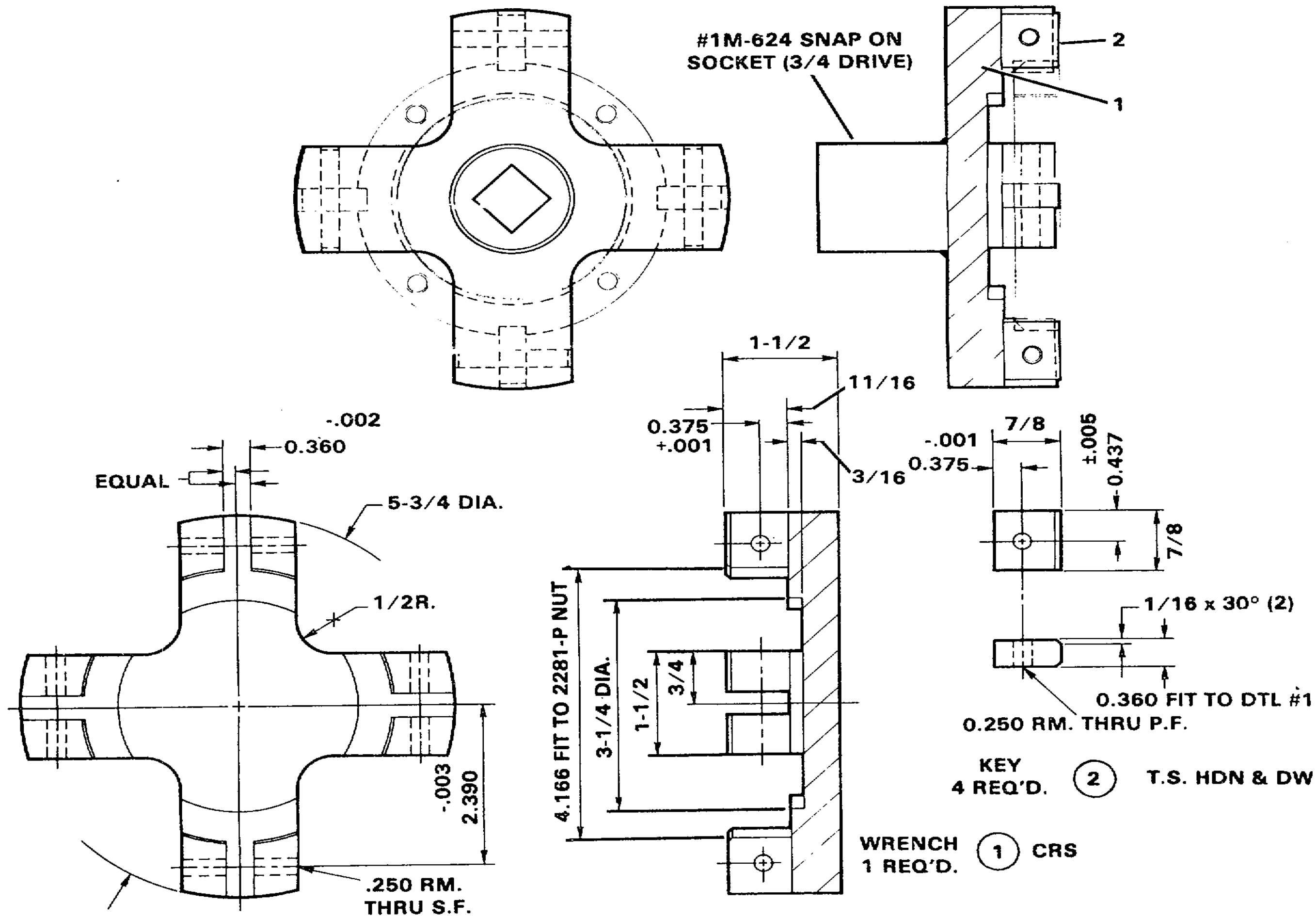


Figure 4D-8. Nut Tool

4. Remove snap ring (118) and pull freewheel cam (120) and related parts out from turbine wheel (129). Remove cage (122) and rollers (121) from cam (120). Also remove springs (123) and thrust washer (124).
5. Remove setscrew (117), bearing locknut (116) using the tool shown in Figure 4D-8 and lockwasher (115). Pull impeller (114) off of shaft (71).
6. Remove snap ring (126) and remove the outer race of bearing (87), spacer (127) and plug (128). Remove snap ring (88) and remove the inner race of bearing (87) from shaft (71).
7. Remove capscrews (97) and bearing retainer (98). Press shaft (71) out of housing (96). Press bearing (100) and piston carrier (102) off of shaft (71). Remove piston rings (101) from piston carrier (102).
8. Remove capscrews (104 and 103) and lift guide wheel (113) out of housing (96). Remove roll pin (110) and snap ring (106) then press wear sleeve (107) out of housing (96).
9. After disassembly, thoroughly clean the converter components in solvent or clean diesel fuel. Discard all O-rings and oil seals. Replace with new seals. Replace any worn bearings and parts that show considerable wear.

NOTE

If shaft (71) is being replaced, polish it to remove all burrs or nicks.

10. Press wear sleeve (107) into housing (96). Set guide wheel (113) into housing (96) and thread one or two of capscrews (103 or 104) to temporarily hold the guide wheel in place. Turn the housing over and install capscrews (103 and 104). See Table 4D-2 for torque values. Install snap ring (106). Install roll pin (110).

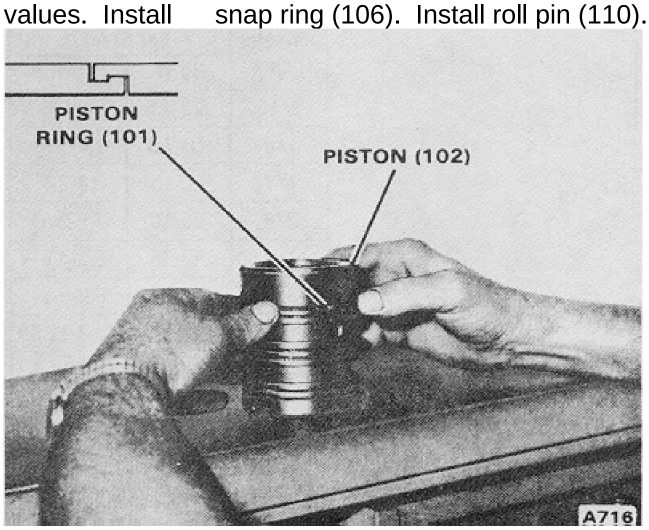


Figure 4D-9. Installing Piston Rings

NOTE

Check that spacers (112) are in three of the holes where capscrews (104) are used.

11. Press bearing (100) on shaft (71). Install and lock rings (101) on piston (102). See Figure 4D-9.
12. Lightly oil the outer race of bearing (100) and press the bearing and shaft into case (96). Turn the shaft while pressing the bearing into the case. See Figure 4D-10. Install bearing retainer (98) and secure in place with capscrews (97). See Table 4D-2 for torque values.

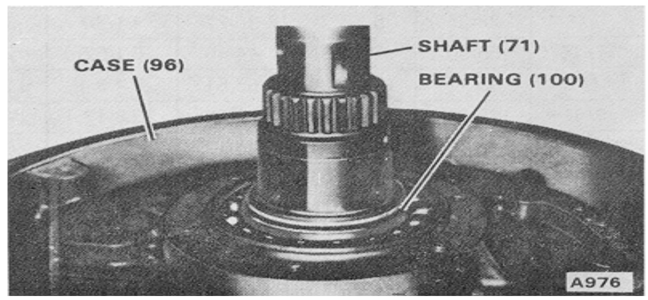


Figure 4D-10. Installing Shaft and Bearing

13. Turn case (96) over and set impeller (114) over shaft (71). Install lockwasher (115) and locknut (116). Using the tool shown in Figure 4D-8 tighten nut (116) to 620-680 ft-lbs (85.7-94.0). Install and stake setscrew (117).
14. Heat and install the inner race of bearing (87) on shaft (71). Install snap ring (88).
15. Set turbine wheel (129) on a bench with the shaft end up. Install piston rings (132) on piston carrier (131), then press the carrier on the shaft end of turbine wheel (129). Press wear sleeve (133) into case (134) and set the case over turbine wheel (129).
16. Install oil seal (142) in retainer (138). Install bearing (137), then set lockwasher (143) on the bearing and thread on locknut (144). Tighten llocknut (144)to 1070-1180 ft-lbs. Install retainer (138), with gasket (141) and secure in place with capscrews (146). Check turbine end plate which should be 0.002-0.010 inch. Install setscrew (145) and stake. Install O-ring (136) on case (134).
17. Turn case (134) over and install plug (128), spacer (127), the inner race of bearing (87) and snap ring (126) into turbine wheel (129).

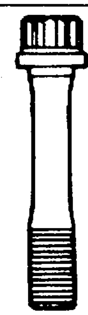
Table 4D-2. Torque Values
For Tightening Capscrews, Bolts & Pipe Plugs

CAPSCREWS, BOLTS & NUTS (1)										
Torque (lb-ft or kg-m) for Coarse and Fine Threads										
Nominal Thread Diameter (Inches)	SAE Grade 5				SAE Grade 8 (4)				Screws for Univ. Joint Bearing Caps	
	Dry (2)		Oiled (3)		Dry (2)		Oiled (3)		Oiled (3)	
	lb-ft	kg-m	lb-ft	kg-m	lb-ft	kg-m	lb-ft	kg-m	lb-ft	kg-m
1/4	11-10	1.5-1.4	9-8	1.2-1.1	16-14	2.2-1.9	13-11	1.8-1.5		
5/16	21-19	2.9-2.6	17-15	2.4-2.1	30-27	4.1-3.7	24-21	3.3-2.9		
3/8	38-34	5.3-4.7	30-27	4.1-3.7	53-48	7.3-6.6	42-38	5.8-6.3		
7/16	55-50	7.6-6.9	44-40	6.1-5.5	78-70	10.8-9.7	62-56	8.6-7.7	67-60	9.2-8.3
1/2	85-77	11.8-10.6	68-61	9.4-8.4	118-108	16.3-14.9	95-86	13.1-11.9	105-95	14.5-13.1
9/16	125-115	17.3-15.9	100-90	13.8-12.4	177-162	24.5-22.4	140-127	19.4-17.6		
5/8	175-160	24.2-22.1	140-125	19.4-17.3	245-225	33.9-31.1	195-177	27.0-24.5	200-180	27.7-24.9
3/4	300-270	41.5-37.3	240-215	33.2-29.7	420-380	58.1-52.6	335-305	46.3-42.2		
7/8	450-405	62.2-56.0	360-325	49.8-44.9	630-570	87.1-78.8	505-460	69.8-63.6	535-485	74.0-67.1
1	680-610	94.0-84.4	545-490	75.4-67.8	1100-1000	152.1-138.3	880-792	121.7-109.5		
1-1/8	860-770	118.9-106.5	690-620	95.4-85.7	1390-1250	192.2-172.9	1110-1010	153.5-139.7		
1-1/4	1150-1030	159.0-142.4	920-830	127.2-114.8	1860-1670	257.2-231.0	1490-1350	206.1-186.7		

3 DASHES
120° Apart

6 Dashes
60° Apart

SAE standard Hex Bolt Head Markings



12 Pt. Head
Undercut
Body

PIPE PLUGS		
Recommended Torque (lb-ft)*		
NPT Diameter (Inches)	Iron, Steel & Brass Plug or Fittings In Cast Iron or Steel	
	lb-ft	kg-m
1/16	6.2-4.5	0.9-0.6
1/8	10-7.5	1.4-1.0
1/4	20-15	2.8-2.1
3/8	25-19	3.5-2.6
1/2	47-35	6.5-4.8
3/4	59-44	8.2-6.1
1	100-80	13.8-11.6
1-1/4	130-105	18.0-14.5
1-1/2	150-120	20.7-16.6

1. Torque values for capscrews and bolts also apply to use in aluminum provided the thread engagement is twice the nominal thread diameter and a hardened flat steel washer is used under the head. This table covers tightening torques for the majority of Twin Disc's use of capscrews and bolts in threaded steel, cast iron, aluminum and brass parts. Individual assembly drawings will show special requirements.
2. Use for all capscrews, bolts and nuts when dry or coated with a rust preventative which is dry to the touch.
3. Use for all fasteners lubricated with moly-disulfide, when plated with zinc or cadmium, or when dipped in lubricating oil.
4. Socket head screws and 12 point head screws with full body are also Grade 8.

* Must be used with compound, John Crane insoluble plastic lead seal No. 2 or equivalent.

NOTE

If turbine wheel (129) is a new wheel, plug (128) will already be installed.

18. Set thrust washer (124) into turbine wheel (129). Set freewheel cam (120) on a bench with the tangs facing up. Set cage (122) over cam (120) and place bumper and engaging springs (123) on cage (122). See Figure 4D11.

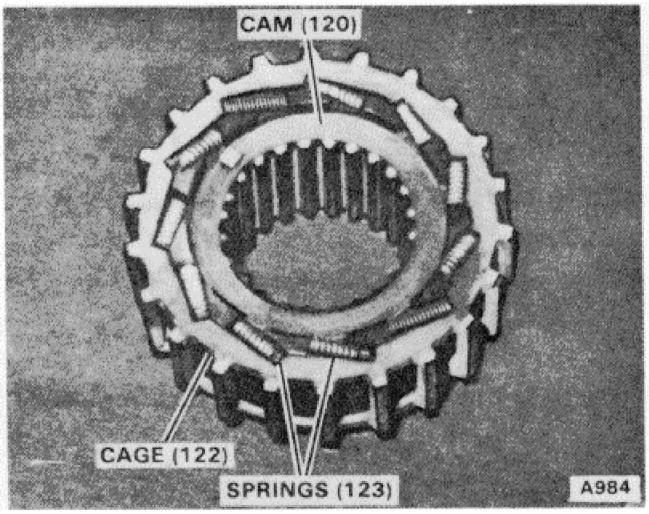


Figure 4D-11. Freewheel Assembly

19. Set an O-ring over cage (122) and place rollers (121) under the O-ring, see Figure 4D-12. Set the freewheel assembly into turbine wheel (129). As the assembly drops in the O-ring will come off.

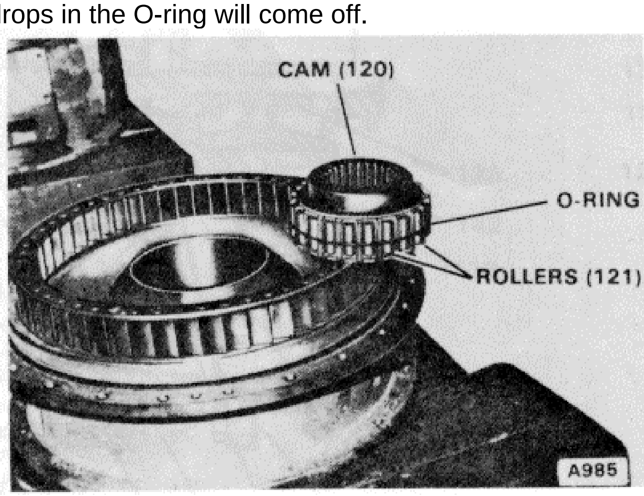


Figure 4D-12. Installing Rollers

20. Install bearing (119) and secure in place with snap ring (118). Install 0-ring (130) on case (134).
21. Attach a hoist to case (134) so the freewheel assembly faces downward. Case (96) and case (134) flange surfaces must be as square as possible. See Figure4D-13. Slowly lower case (134) indexing the inner and outer races of bearing (87). Lower the case completely and install capscrews (135). See Table 4D-2 for torque values.

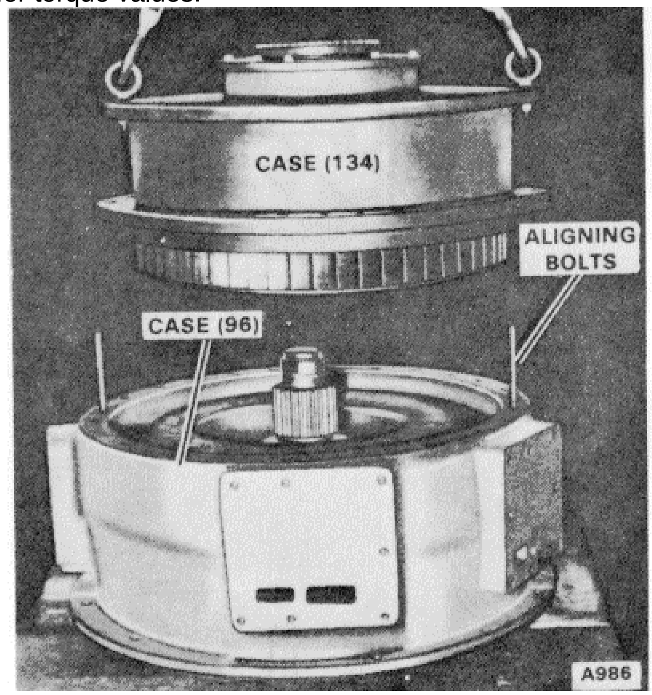


Figure 4D-13. Case Alignment and Installation

INSTALLATION

To install the torque converter on the machine, proceed as follows:

1. Set the torque converter up to the chain case and engage the turbine internal splines with the shaft of the chain case clutch pack.
2. Install and tighten the capscrews to secure the torque converter to the chain case. See Table 4D-2 for torque values.
3. Using a suitable sling and lifting device set the chain case, with the torque converter, up to the engine. Install the capscrews securing the torque converter to the engine. Also install the capscrews securing the converter support to the engine base.
4. At the front of the chain case install the capscrews securing the upper block support to the lower block support.
5. Reinstall the universal joint from the chain case to the intermediate hoist shaft (see Subsection 4E).
6. Reinstall all electrical, hydraulic and mechanical lines leading to the torque converter and chain case. Also reinstall any case drain lines.

7. Reinstall all sheet metal.

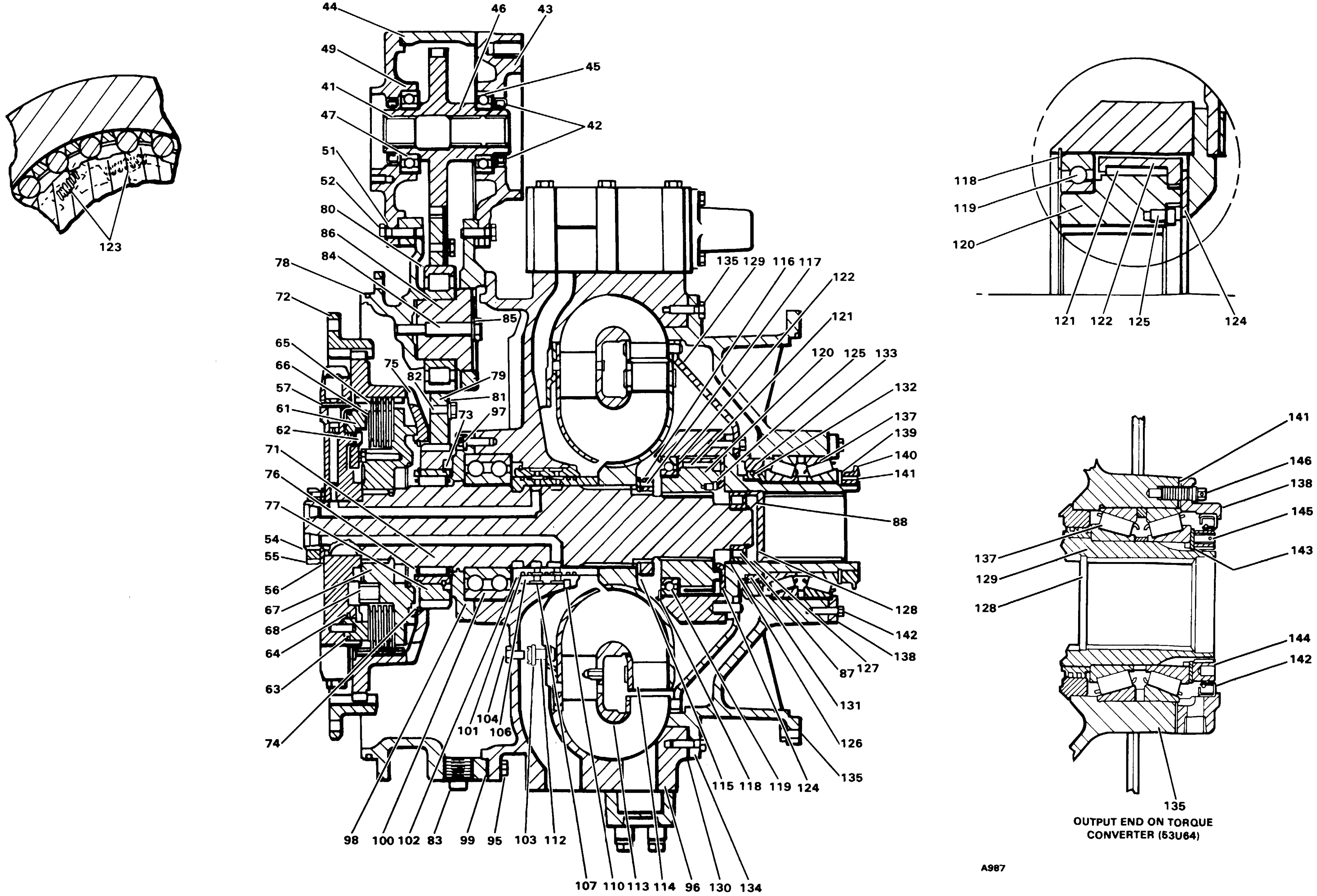


Figure 4D-14. Torque Converter (53U64)

SUBSECTION 4E
SYSTEM COMPONENTS

GENERAL

This subsection will cover the repair of components such as pumps, relief valves, motors and solenoid valves.

TROUBLESHOOTING GUIDE - RADIATOR AND TRANSMISSION SYSTEM

The troubleshooting charts and maintenance hints that follow provide an intuitive feeling for the radiator and transmission system. The pressure checks and adjustments indicated in the charts can be found under the specific item in this subsection. The following charts are arranged in five main categories. The heading of each is an effect which indicates a malfunction in the system. For example: if a pump is exceptionally noisy, refer to Table 4C-1, titled Excessive Noise. The noisy pump appears in Column A under main heading. In Column A there are four probable causes for a noisy pump. The causes are listed according to the likelihood of occurrence and of the ease of checking it. The first cause is cavitation and the remedy is "a". if the first cause does not exist, check for cause number 2, etc.

PUMP (41Z58)

GENERAL. This hydraulic pump supplies fluid to the converter charging system and is driven by the converter power take-off tower.

The major components of this unit consist of an inlet cover, outlet body, driveshaft and pumping cartridge. The principal components of the pumping cartridge are the wear plate, ring, rotor, pressure plate, several vanes and attaching parts.

OPERATION. Fluid enters the pumping cartridge through the inlet port in the body and is discharged through the pressure plate to the outlet port in the cover. The action of a pumping cartridge is shown in Figure 4E-1.

The rotor is driven within the ring by the driveshaft. As the rotor turns, centrifugal force on the vanes, aided by the under-vane pressure fed from the outlet port, causes them to follow the elliptical inner surface of the ring.

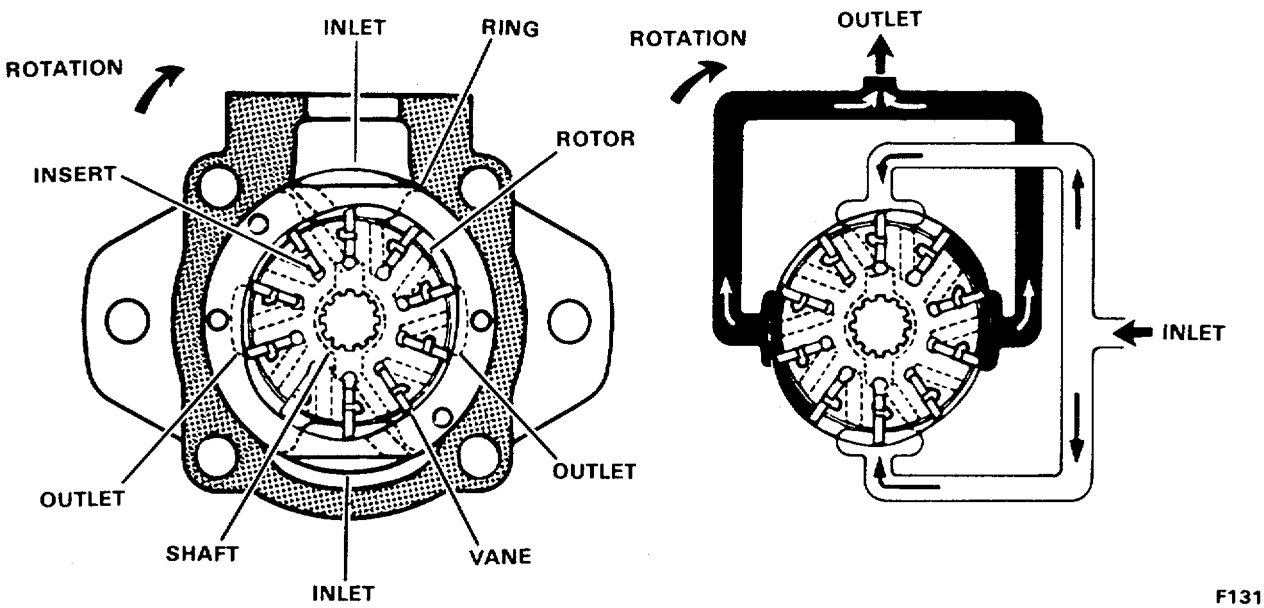
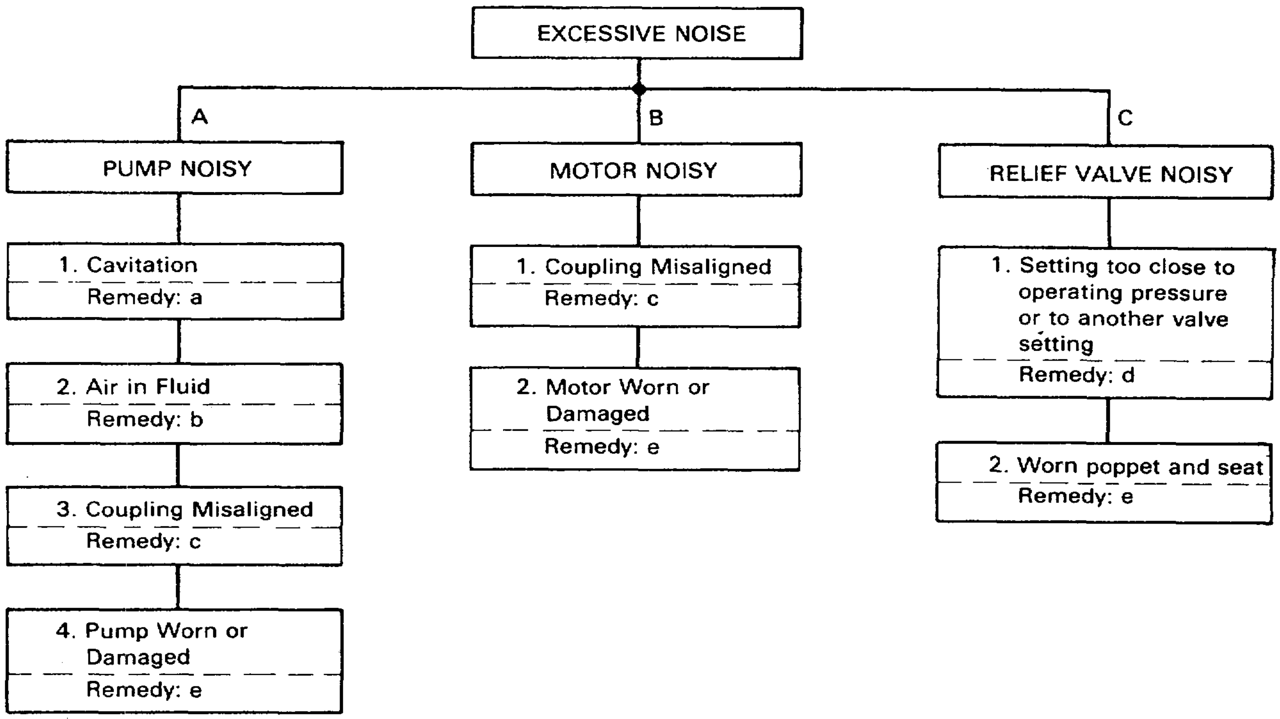


Figure 4E-1. Pump Operation

Table 4E-1. Excessive Noise



REMEDIES:

a. Any or all of the following: Replace dirty filters – Clean clogged inlet line or suction screen – Clean reservoir breather vent – Change system fluid

b. Any or all of the following: Tighten leaky inlet connections – Fill reservoir to proper level – Replace pump shaft seal

c. Align unit and check condition of seals and bearings

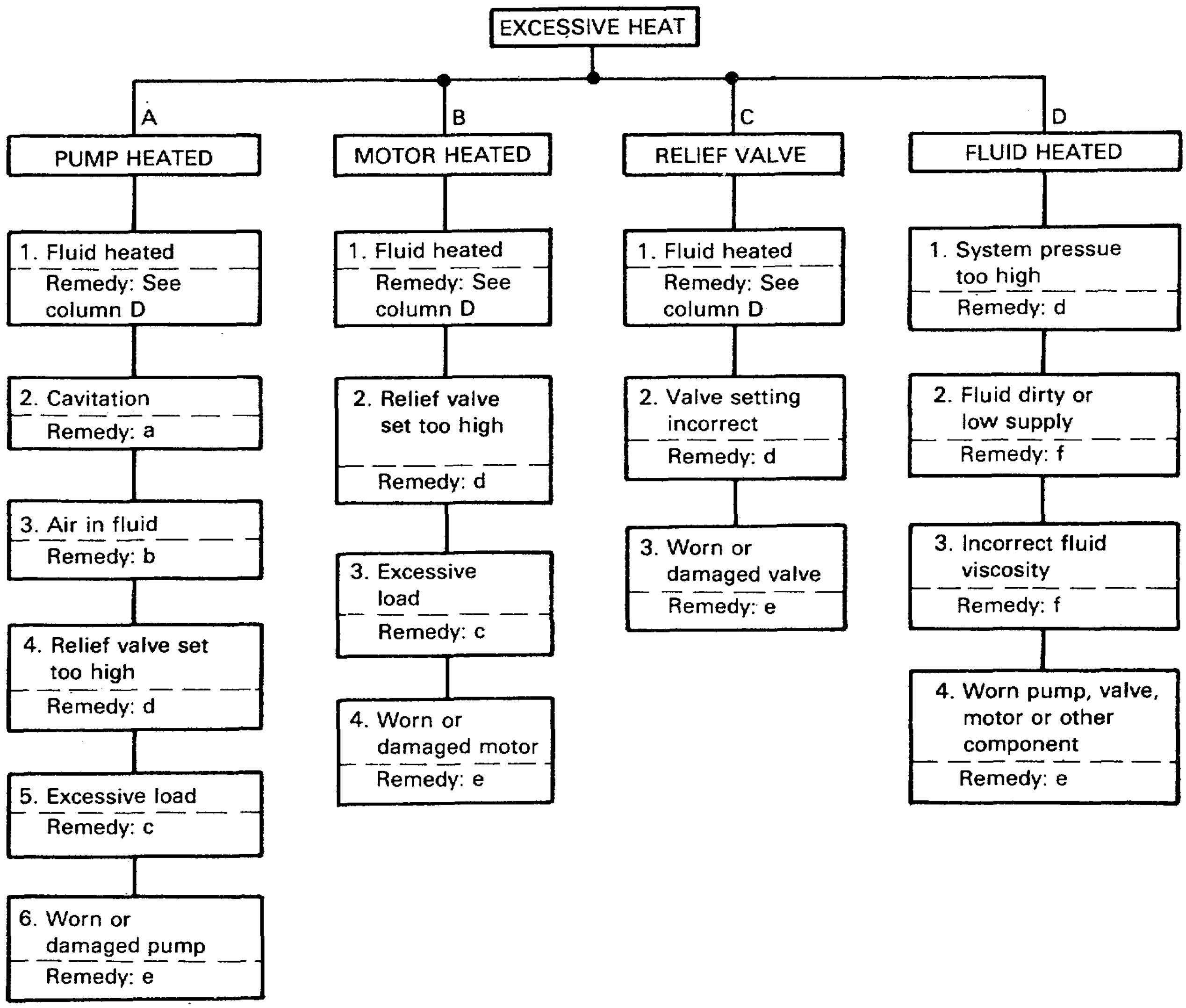
d. Install pressure gauge and adjust to correct pressure

e. Overhaul or replace

Radial movement of the vanes and turning of the rotor causes the chamber volume between the vanes to increase as the vanes pass the inlet sections of the ring. This results in a low pressure condition which allows atmospheric pressure to force fluid into the chambers. This fluid is trapped between the vanes and carried past a sealing land to the outlet section of the ring. As the outlet section is approached, the chamber volume decreases and the fluid is forced out into the system. System pressure is fed under the vanes, assuring their sealing contact against the ring during normal operation.

The pump ring is shaped so that the two pumping chambers are formed 180 degrees apart. Thus, opposing hydraulic forces which would impose side loads on the shaft cancel each other out.

Table 4E-2. Excessive Heat



REMEDIES:

a. Any or all of the following: Replace dirty filters – Clean clogged inlet line or suction screen – Clean reservoir breather vent – Change system fluid

b. Any or all of the following: Tighten leaky inlet connections – Fill reservoir to proper level – Replace pump shaft seal

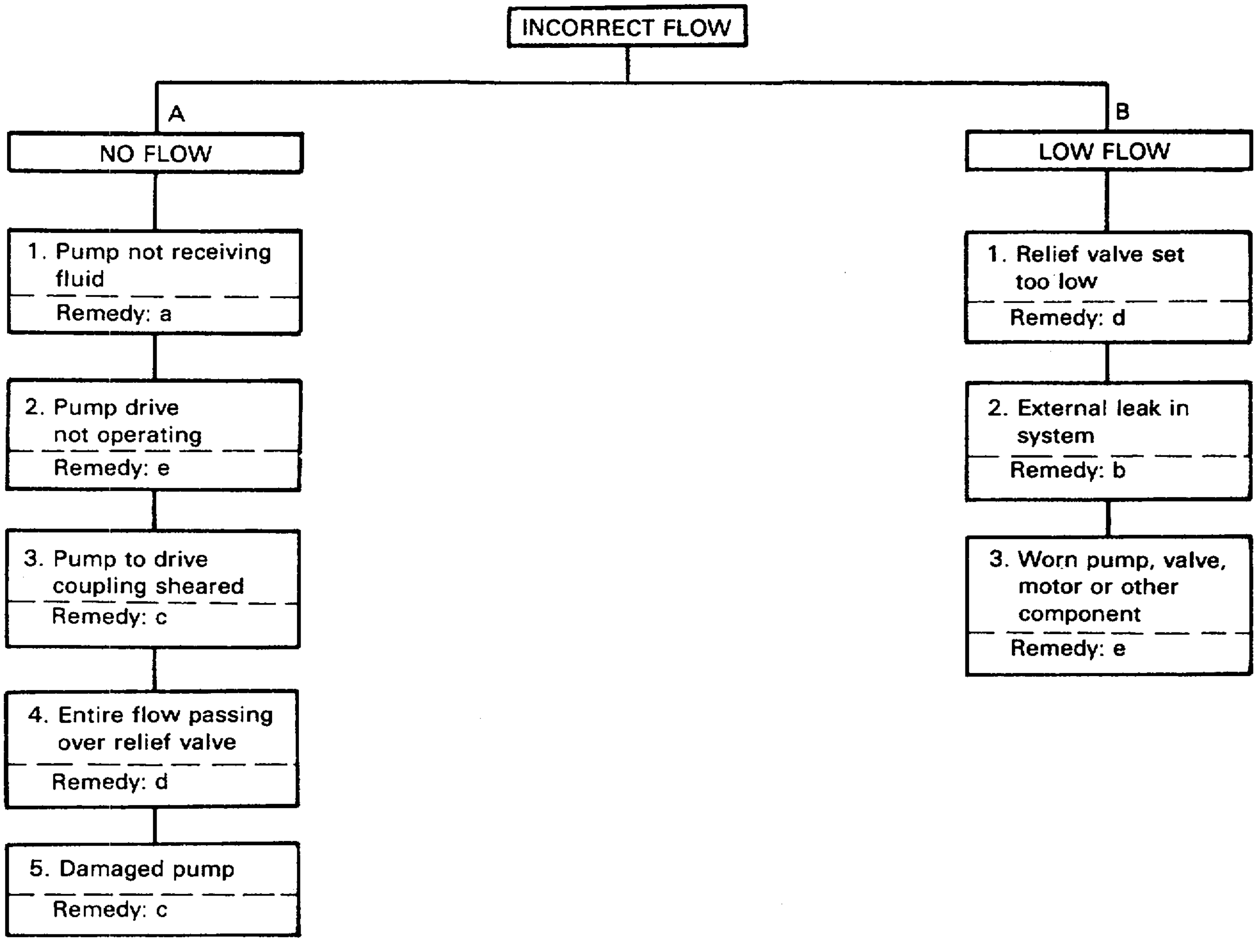
c. Align unit and check condition of seals and bearings – Locate and correct mechanical binding – Check for work load in excess of circuit design

d. Install pressure gauge and adjust to correct pressure

e. Overhaul or replace

f. Change filters and also system fluid if of improper viscosity – Fill reservoir to proper level

Table 4E-3. Incorrect Flow



REMEDIES:

a. Any or all of the following: Replace dirty filters – Clean clogged inlet line or suction screen – Clean reservoir breather vent – Fill reservoir to proper level

b. Tighten leaky connections.

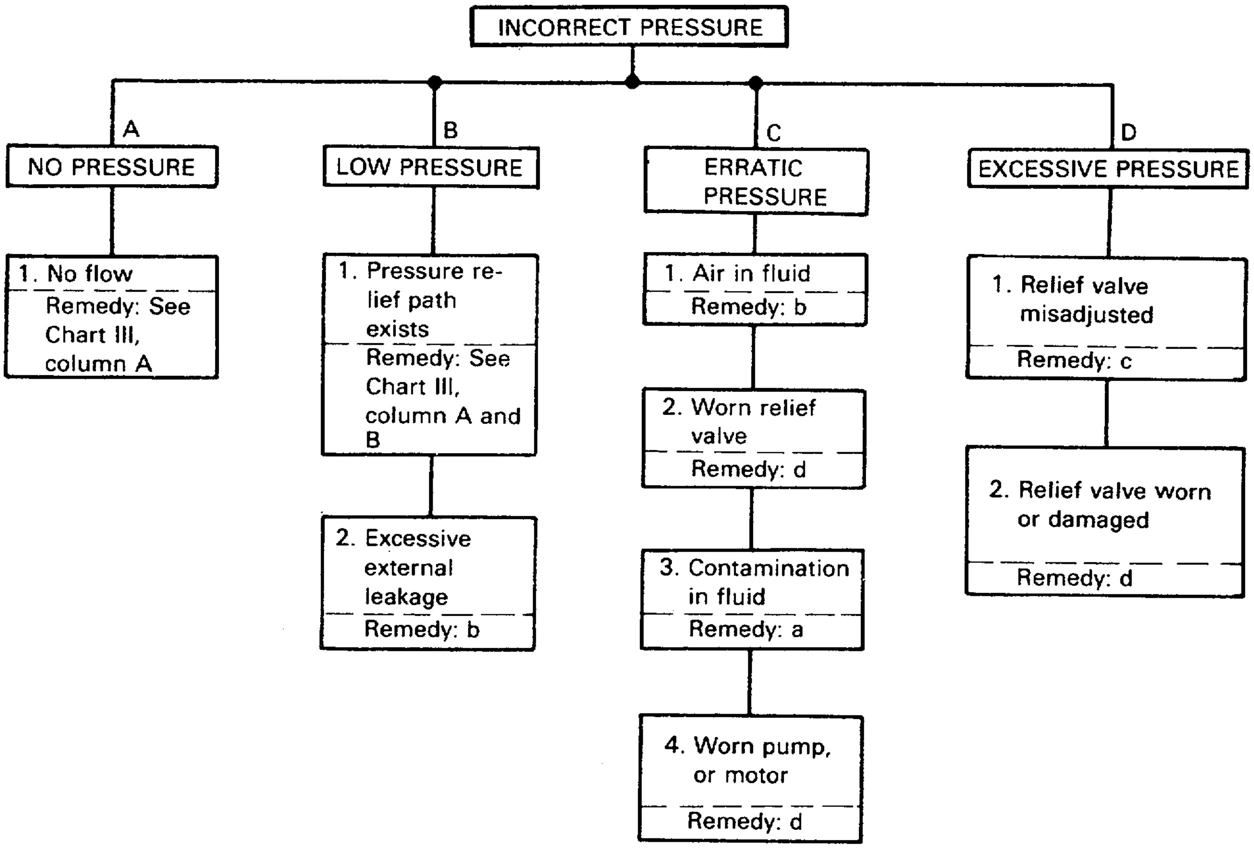
c. Check for damaged pump or pump drive – Replace and align coupling

d. Adjust

e. Overhaul or replace

f. Check position of manually operated controls

Table 4E-4. Incorrect Pressure



REMEDIES:

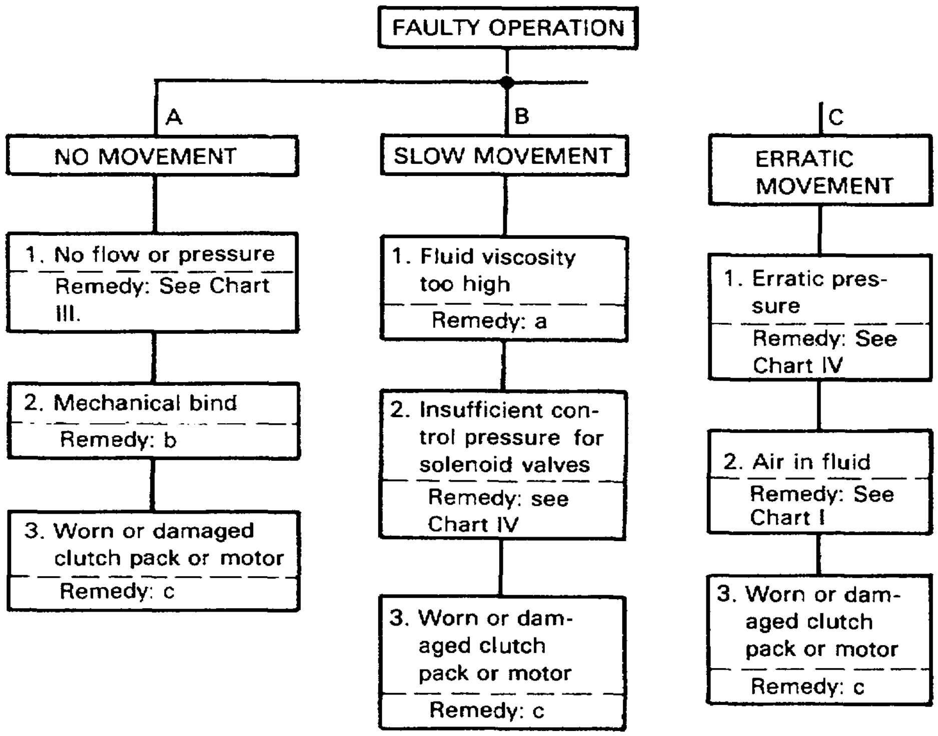
a. Replace dirty filters and system fluid

b. Tighten leaky connections – Fill reservoir to proper level

c. Adjust

d. Overhaul or replace

Table 4E-5. Faulty Operation



REMEDIES:

a. Fluid may be too cold or should be changed to clean fluid of correct viscosity
b. Locate bind and repair
c. Overhaul or replace
d. Lubricate

The pressure plate seals the pumping chamber. System pressure is effective against the area at the back of the plate, which is larger than the area exposed to the pumping cartridge. Thus, an unbalanced force holds the plate against the cartridge, sealing the cartridge and providing the proper running clearance for the rotor and vanes. The pressure plate also contains passages for feeding pressure to the space between the vanes and inserts.

TROUBLESHOOTING. If there are pressure and/or flow problems in the charging pump, consult the troubleshooting chart in Table 4E-6 before actually removing and disassembling the pump. The problem may originate in an area other than the pump so it is important that you study the troubleshooting chart.

Table 4E-6. Pump Troubleshooting Chart

TROUBLE	PROBABLE CAUSE	REMEDY
Pump not delivering fluid	Coupling or shaft sheared or disengaged	Disassemble the pump and check the shaft and cartridge for damage. Replace the necessary parts.
	Fluid intake pipe in reservoir restricted	Check suction strainer for dirt and sludge. Clean if necessary.
	Fluid viscosity too heavy to pick up prime	Completely drain the system. Add new filtered fluid of the proper viscosity.
	Air leaks at the intake. Pump not priming	Check the inlet connections to determine where air is being drawn in. Tighten any loose connections. See that the fluid in the reservoir is above the intake pipe opening.
	Vane(s) stuck in the rotor slot(s)	Disassemble the pump. Check for dirt or metal chips. Clean the parts thoroughly and replace any damaged pieces. If necessary flush the system - and refill it with clean fluid.
Insufficient pressure build-up	Worn parts causing internal	Replace pump cartridge.
Pump making noise	Pump intake partially blocked	leakage of pump delivery Service the intake strainers. Check the fluid condition and, if necessary, drain and flush the system. Refill with clean fluid.
(Oil in reservoir	Air leaks at the intake or to determine where air is being would probably be foamy)	Check the inlet connections and seal shaft seal. drawn in. Tighten any loose connections and replace the seal if necessary. See that the fluid in the reservoir is above the intake pipe opening.
	Pump drive speed too slow or too fast	Operate the pump at the recommended speed.
	Coupling misalignment	Check if the shaft seal bearing or other parts have been damaged. Replace any damaged parts. Realign the coupled shafts.

REMOVAL. To remove the pump, proceed as follows: 1. Tag and disconnect the appropriate hydraulic lines to the charge pump. Plug the lines to prevent the entry of contaminants.

2. Remove the pump mounting bolts and lockwashers. Pull the pump from the power take-off. DISASSEMBLY. During disassembly pay particular attention to the identification of the parts to assure correct reassembly. To disassemble the pump, proceed as follows (see Figure 4E-2):

1. Lightly clamp the pump body in a padded vise, cover end up, and remove the four cover screws. Note the position of the cover port with respect to the body port before lifting off the cover and O-ring.

2. Remove the pressure plate and spring. Note the position of the ring for correct reassemble. Lift off the ring and remove the locating pin. Separate the vanes from the rotor and remove the rotor from the shaft.

3. Turn the pump body over and remove the shaft key and the snap ring which retains the outer bearing. Tap with a soft hammer on the splined end of the shaft to force the shaft out of the body. Support the bearing inner race and press the shaft out of the bearing. Pull the shaft seal out of the body with a suitable hooked tool and press out the inner bearing.

INSPECTION AND REPAIR. To inspect and repair the pump, proceed as follows:

1. Discard the shaft seal and all O-rings. Wash the metal parts in mineral oil solvent, blow them dry with filtered air, and place them on a clean surface for inspection.
2. Check the wearing surfaces of the body, pressure plate, ring, and rotor for scoring and excessive wear. Remove light score marks by lapping. Replace any heavily scored or badly worn parts.
3. Inspect the vanes for burrs, wear, and excessive play in the rotor slots. Replace the rotor if the slots are worn.
4. Check the bearings for wear and looseness. Rotate the bearings while applying pressure to check for pitted or cracked races.
5. Inspect the oil seal mating surface on the shaft for scoring or wear. If mark son the shaft cannot be removed by light polishing, replace the shaft.

REASSEMBLY. To reassemble the pump, proceed as follows (see Figure 4E-2):

1. Coat all parts with hydraulic fluid to ease assembly and provide initial lubrication. Use small amounts of petroleum jelly to hold the O-rings in place during assembly.

NOTE

During handling and shipping of the precision machined parts it is possible to raise burrs on the sharp edges. All sharp edges on the parts of a new cartridge should be stoned prior to installation.

2. Press the shaft into the front -bearing while supporting the bearing inner race. Next, press the inner bearing into the body using a driver which contacts the outer race only. Be certain both bearings are firmly seated.

NOTE

Before assembling the shaft seal, determine the correct position of the sealing lip. Double lip seals are assembled with the spring toward the pumping cartridge. Single lip seals have two pressure holes, which are assembled toward the shaft end of the pump.

3. Press the shaft seal firmly in place and lubricate the with petroleum jelly or other grease compatible with the system fluid. Slide the drive shaft into the body until the bearing is seated. Tap lightly on the end of the shaft, i necessary. Install the snap ring.
4. Install new O-rings in the body and cover. Insert the ring locating pins in the body and assemble the ring so that the arrow on the perimeter points in the proper direction of rotation. Install the rotor on the shaft and insert the vanes in the rotor slots. Be certain the radius edges of the vanes are toward the cam ring.
5. Place the pressure plate on the locating pins and flat against the ring. Use a small amount of petroleum jelly or grease to stick the spring in the recess in the pressure plate. Carefully install the cover with the outlet port in the correct position. Tighten the cover screws to 75-85 ft-lbs (10.411.8 kg-m) of torque. Turn the shaft by hand to insure that there is no internal binding.

INSTALLATION. To install the pump, proceed as follows:

1. Engage the pump splines with the torque converter drive coupling. Push the pump all the way into the converter drive and install the mounting lockwashers and bolts. Tighten the bolts securely.
2. Remove the plugs from the lines and reconnect them to the pump.

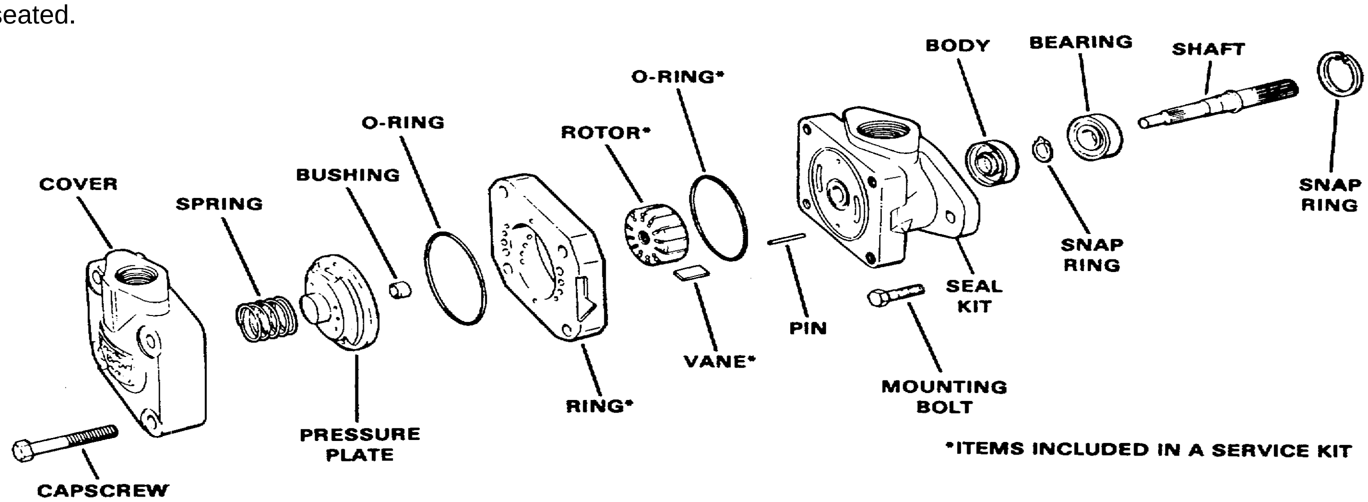


Figure 4E-2. Pump (41Z58)

3. Refill the hydraulic reservoir, If necessary, to the proper level with the recommended lubricant. Start the engine. Allow the engine to run at idle speed. with no load applied to the hydraulic system, to prime the system.
4. Run the engine at moderate speed and load for a short period of time. Check the reservoir oil level and add oil if required.

SOLENOID VALVE (36Z646)

NOTE

This valve is used on machine serial numbers 50370, 50371, 50941 and 50942.

GENERAL. This valve is a four-way, three-position, DC solenoid operated type. Two valves are used as a means of engaging and disengaging the two speed transmission clutches located in the right and left hand transmissions. The valves may be placed in either the high speed, neutral, or low speed positions, using the switches provided on the side console of the operator's module. Manual operators are provided so that the valves may be operated in emergency conditions and may be checked without the use of electrical power.

REMOVAL. To remove the valve, proceed as follows:

1. Shut off the engine and tag the ignition switch to warn against starting the engine, or remove the ignition key until the valve is reinstalled.
2. Tag and remove the electrical wire on the valve.
3. Loosen, but do not remove, the three mounting capscrews that attach the valve to the manifold. Allow any pressure to relieve, then remove the capscrews and valve. Note the mounting position of the valve to the manifold.
4. Plug the holes in the manifold to prevent the entry of contaminants.

REPAIRS. Repair of this valve is limited to the replacement of the coil and O-rings. If the valve sleeve, piston, body or any other parts are damaged or worn, the entire valve must be replaced. To replace the coil and seals, proceed as follows (see Figure 4E-3):

NOTE

Items 10 through 31 are used on both sides of body (02). The repairs of this valve are identical for both sides so the procedure below will disassemble only one side of the body.

1. Set valve body (02) in a vise and unthread shell (24) off of retainer (10). Remove O-ring (17) and spring (23).
2. Remove capscrews (07), pull plug (08) upward and remove the solenoid wires from the plug. Pull coil (11) out. If the remaining seals are to be replaced, continue with the remaining steps of this procedure.
3. Remove capscrews (1 2) and set the tube assembly aside. Remove spring (18), spring rest (16), wave spring (14) and spacer (13) from body (02).
4. Remove spool assembly (01) from body (02) and remove O-rings (03) from the spool.

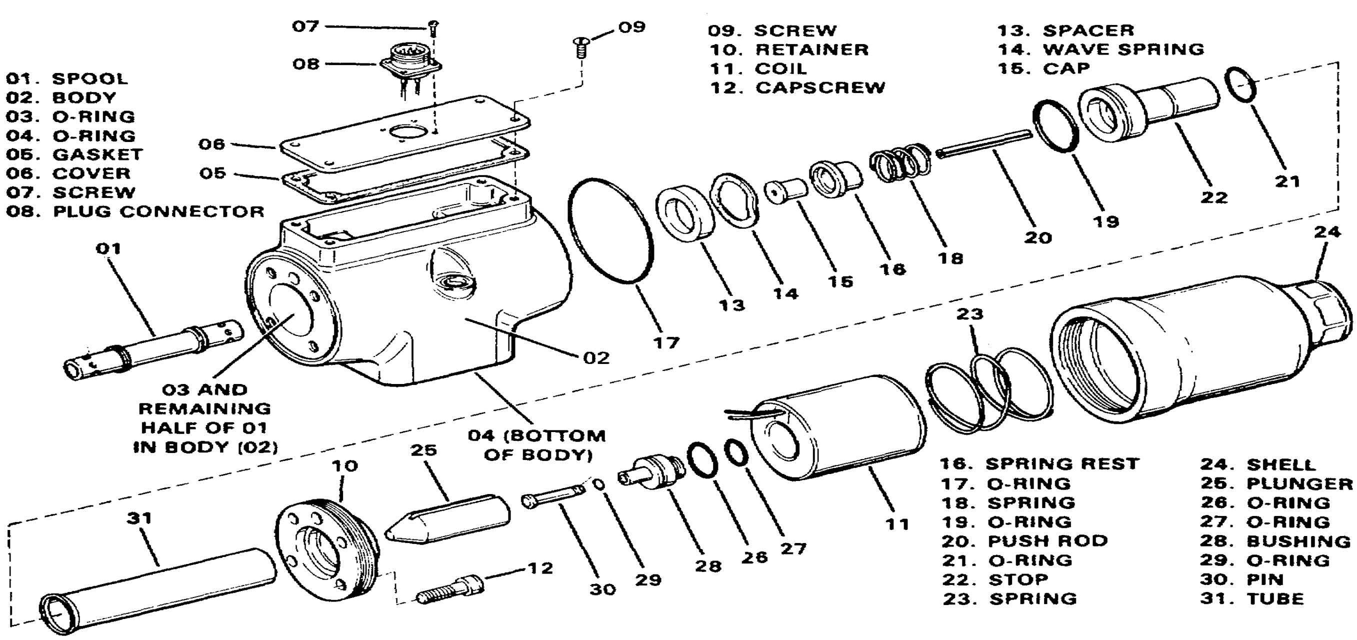


Figure 4E-3. Solenoid Valve (36Z646)

5. Pull stop (22) out of tube (31) and remove pin (20)and O-rings (19 and 21) off of the stop.
6. Remove plunger (25) and bushing (28) from tube (31). Remove O-rings (26 and 27) from bushing (28). Remove pin (30) from bushing (28) and remove O-ring (29).
7. Repeat the above steps to disassemble the other half of the valve.

INSPECTION AND REPAIR. Repair of this valve is limited to replacement of the coils and an O-ring kit. See the Replacement Parts Manual. If any other items are in any way damaged, replace the entire valve. Before reassembling the valve, wash all components in a clean solvent and blow dry.

ASSEMBLY. To reassemble the valve, proceed as follows (see Figure 4E-3):

1. Generously coat all parts to be assembled with clean hydraulic oil.
2. Install pin (30), with O-ring (29), into bushing (28). Place O-rings (26 and 27) on bushing (28) and set the bushing into tube (31). Also set plunger (25) into the tube. The point of plunger (25) should face the open end of tube (31).
3. Place O-rings (19 and 21) on stop (22). Set the stop in tube (31) and set pin (20) into stop (22).
4. Place O-rings (03) onto spool assembly (01) and set the spool assembly into body (02).
5. Place spacer (13), cap (15), spring rest (16), spring (18) and wave spring (14) into the valve body.
6. Set the assembled tube against wave spring (14) and install retainer (10). Install and fully tighten capscrews (12).
7. Set coil (11) on tube (31) and feed the wires up to plug connector (08). Solder the wires to the connector and install capscrews (07) only if the other half of the valve was not disassembled.
8. Install O-ring (17) in the valve body. Place spring (23) into shell (24) and thread the shell onto retainer (10).
9. Repeat the above steps to assemble the other half of the valve if it was disassembled.

INSTALLATION. To install the valve, proceed as follows:

NOTE

Check to be sure there are O-rings (item 04, Figure 4E-5) installed in the port holes.

1. Set the valve on the manifold in the same position as before it was removed.
2. Align the holes in the valve with the mounting holes in the manifold and install the mounting capscrews. Tighten the capscrews securely.
3. Attach the electrical lead to the valve.
4. Start the engine and observe the valve for leaks and proper operation. Check the oil level in the reservoir and fill with clean hydraulic oil. See Section III for recommended oil.

PUMP (37Q27 & 37Q28)

GENERAL. These are dual, vane type pumps. One pump (37Q27) supplies fluid to operate the dual radiator motors, the lubrication of the chain cases and operation of the chain case clutches. The other pump (37Q28) supplies fluid for the modulated clutch, the torque converter and cooling oil for the converter system.

Each pump consists basically of an outlet body, inlet housing, outlet cover, driveshaft and two pumping cartridges. The components of each cartridge are an elliptical ring, a slotted rotor which is splined to the driveshaft, a pressure plate, a wear plate and ten vanes which fit into the rotor slots.

OPERATION. As the rotor in each pumping cartridge is driven by the driveshaft, the vanes carry fluid around the elliptical ring contour. Fluid enters the cartridge through the inlet port in the center housing and is discharged through the pressure plates to the outlet ports. The action of the cartridge is illustrated in Figure 4E-1.

When the rotor turns, centrifugal force on the vanes causes them to follow the elliptical inner surface of the ring. Radial movement of the vanes and rotation of the rotor cause the chambers between the vanes to increase in size as the vanes pass the inlet sections of the ring. This results in a low pressure condition which allows atmospheric pressure to force fluid into the chambers. The fluid is then trapped between the vanes and carried past the large diameter of the ring. As the fluid approaches the outlet section, the diameter of the ring decreases and the fluid is forced out into the system. System pressure is also fed under the vanes to assure their sealing contact against the ring during normal operation.

TROUBLESHOOTING. Table 4E-6 lists the common difficulties experienced with vane pumps and hydraulic systems. It also, indicates the probable causes and remedies for each of the troubles listed.

It should always be remembered that many apparent pump failures are actually the malfunction of other parts of the system. The cause of improper operation is best diagnosed with adequate testing equipment and a thorough understanding of the system.

REMOVAL. These pumps are mounted on the face of the torque converter power-take-off tower. Disconnect the hydraulic lines at the pump, capping the lines and pump parts immediately. Remove the attaching bolts and pull the pump from the take-off tower. See Figure 4E-4.

DISASSEMBLY. During disassembly pay particular attention to the identification of the parts to assure correct reassembly. To disassemble the pump, proceeds follows (see Figure 4E-5):

1. Lightly clamp the pump body in a padded vise, cover end up, and remove the four cover bolts. Note the cover port position for correct reassembly, then lift the cover from the pump. Remove the cover O-ring. Pull out the cover end cartridge.

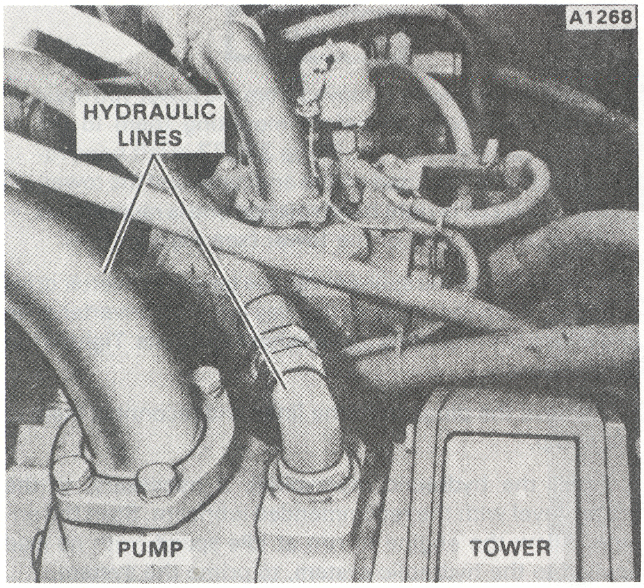


Figure 4E-4. Pump Mounting

2. Remove the four bolts which attach the inlet housing to the body and lift off the inlet housing and the body O-ring. Turn the shaft to free the large cartridge and pull the cartridge from the body.

3. Remove the large snap ring and pull the shaft and bearing. Drive the shaft seal and wiper out from the opposite end. If it is necessary to remove the shaft bearing, first remove the small snap ring, then press the shaft out of the bearing supporting the inner race.

INSPECTION AND REPAIR. Inspect the pump components and make repairs as follows:

1. Discard the shaft seal and all O-rings and back-up rings. Wash the metal parts in clean mineral solvent, blow them dry with filtered compressed air and place them on a clean surface for inspection.

NOTE

Replacement cartridge kits are available. See the Replacement Parts Manual.

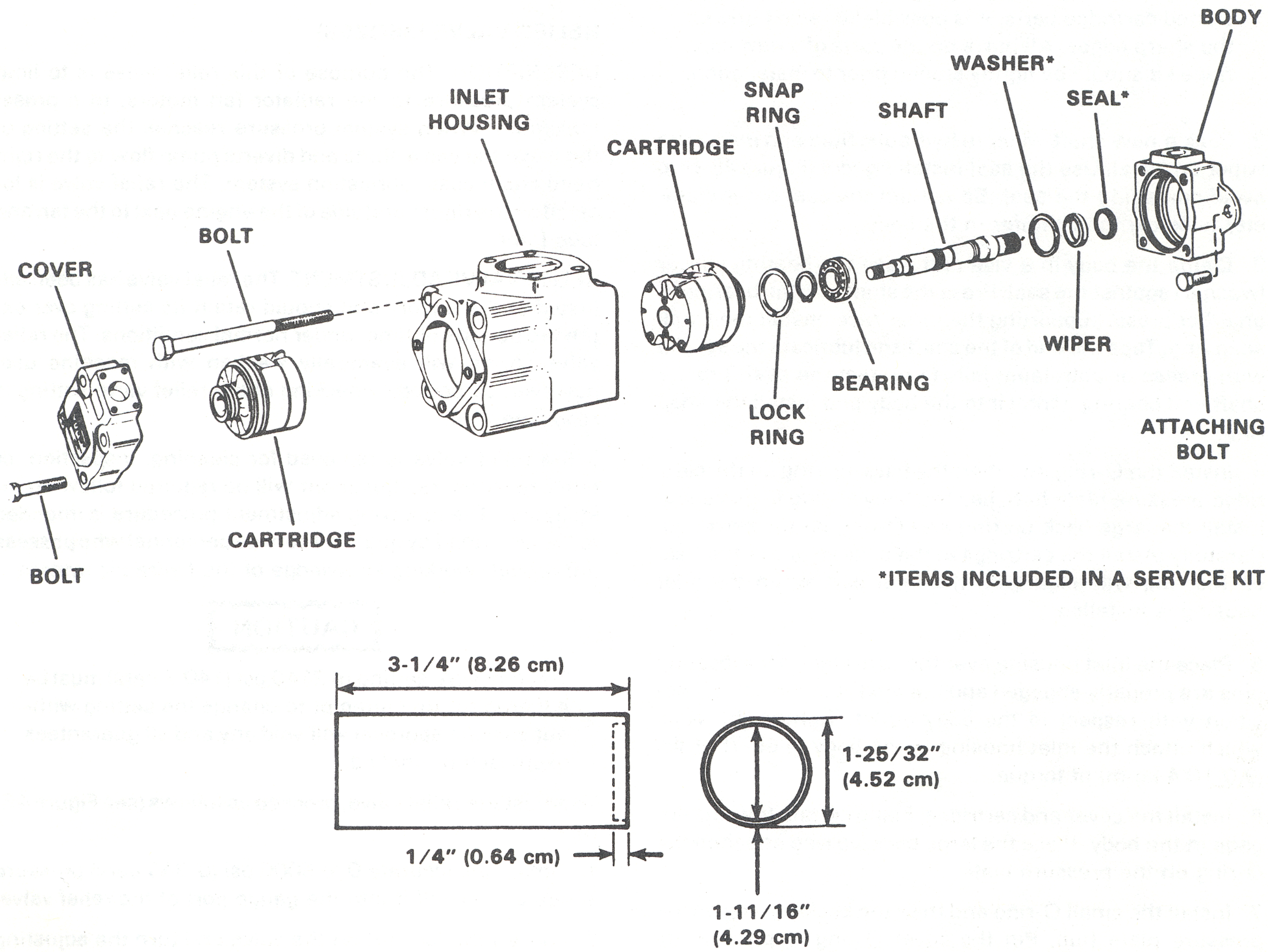


Figure 4E-5. Pump (37Q27 & 37Q28)

2. Check the wearing surface of the cartridge parts for scoring and excessive wear. Remove light score marks by lapping. An application of Lubrite or Moly-Kote (or their equivalent) is desirable after lapping to prevent seizure during start-up. The entire cartridge assembly will have to be replaced if any of the parts are heavily scored or badly worn. See the Replacement Parts Manual.

3. Rotate the bearing while applying pressure to check for wear, looseness and pitted or cracked races. Replace if necessary.

4. Inspect the seal and bushing mating surfaces on the shaft for scoring or wear. Replace the shaft if marks cannot be removed by light polishing.

REASSEMBLY. To reassemble the pump, proceed as follows (see Figure 4E-4):

1. Coat all parts with hydraulic fluid to facilitate assembly and provide initial lubrication. Use small amounts of petroleum jelly to hold O-rings in place during assembly.

NOTE

During handling and shipping of the precision machined cartridge parts, it is possible to raise burrs on the sharp edges. All burrs on the parts of a new cartridge kit should be lightly stoned prior to installation.

2. Soak a new shaft wiper in hydraulic fluid and install the wiper and seal. Use the seal installing tool (Figure 4E-5) to avoid damaging the seal. Be certain the seal outer diameter is below the chamfer in the body.

3. Clamp the body in a vise and place the bearing spacer (washer) against the seal. Press the shaft into the bearing in an arbor press, supporting the inner race. Install the small snap ring. Tape the end of the shaft and lubricate the seal lip with grease or petroleum jelly to protect the seal. Tap the shaft and bearing gently into the body and install the snap ring.

4. Install the O-ring and then the back-up ring on the cartridge pressure plate hub. Lay the body O-ring in place and install the large back-up ring and O-ring on the cartridge. Carefully install the cartridge in the body so one of the flats on the ring will align with the inlet port when the inlet housing is installed.

5. Place the inlet housing over the cartridge so the locating pins are properly engaged and the inlet is in the correct position with respect to the body outlet. Tighten the bolts which attach the inlet housing to the body to 65-75 ft-lbs (9.0-10.4 kg-m) of torque.

6. Install the cover end cartridge, being certain the pins engage in the body. Place the large back-up ring and then the O-ring on the pressure plate.

7. Install the small O-ring and then the back-up ring on the pressure plate hub. Put the cover O-ring in place in its groove. Install the cover and bolts. Tighten the bolts to 40-50 ft-lbs (5.5-6.9 kg-m) of torque.

INSTALLATION. To install the pump, proceed as follows:

CAUTION

If both pumps were removed from the tower you must verify shaft rotation before mounting them to the torque converter tower. Pump 37Q27 is left hand rotation and is mounted on the engine side of the tower. Pump 37Q28 is right hand rotation and is mounted on the converter side of the tower (see Figure 4E-4).

1. Engage the pump splines with the torque converter drive coupling. Push the pump all the way into the converter drive and install the mounting lockwashers and bolts. Tighten the bolts securely.

2. Remove the plugs from the lines and reconnect them to the pump.

3. Refill the hydraulic reservoir(s), if necessary, to the proper level with the recommended lubricant. Start the engine. Allow the engine to run at idle speed, with no load applied to the hydraulic system, to prime the system.

4. Run the engine at moderate speed and load for a short period of time. Check the reservoir oil level and add oil if required.

RELIEF VALVE (36Q258)

DESCRIPTION. The purpose of this relief valve is to limit system pressure to the radiator fan motors, to a preset maximum. When system pressure reaches the setting of the valve the valve shifts and diverts pump flow to the right hand chain case lubrication system. The relief valve is located on the right hand side of the engine next to the fan and lube filter.

RELIEF VALVE ADJUSTMENT. The relief valve has been adjusted at the factory and should retain its setting over extended periods of time, under normal conditions. The relief valve spring will eventually weaken with machine use, however, so periodic checking of the relief valve setting is recommended.

If the relief valve is removed for cleaning, inspection, or other reasons, readjustment will be required following installation. The following adjustment procedure is intended to be performed by qualified service personnel who possess a thorough working knowledge of the hydraulic system.

CAUTION

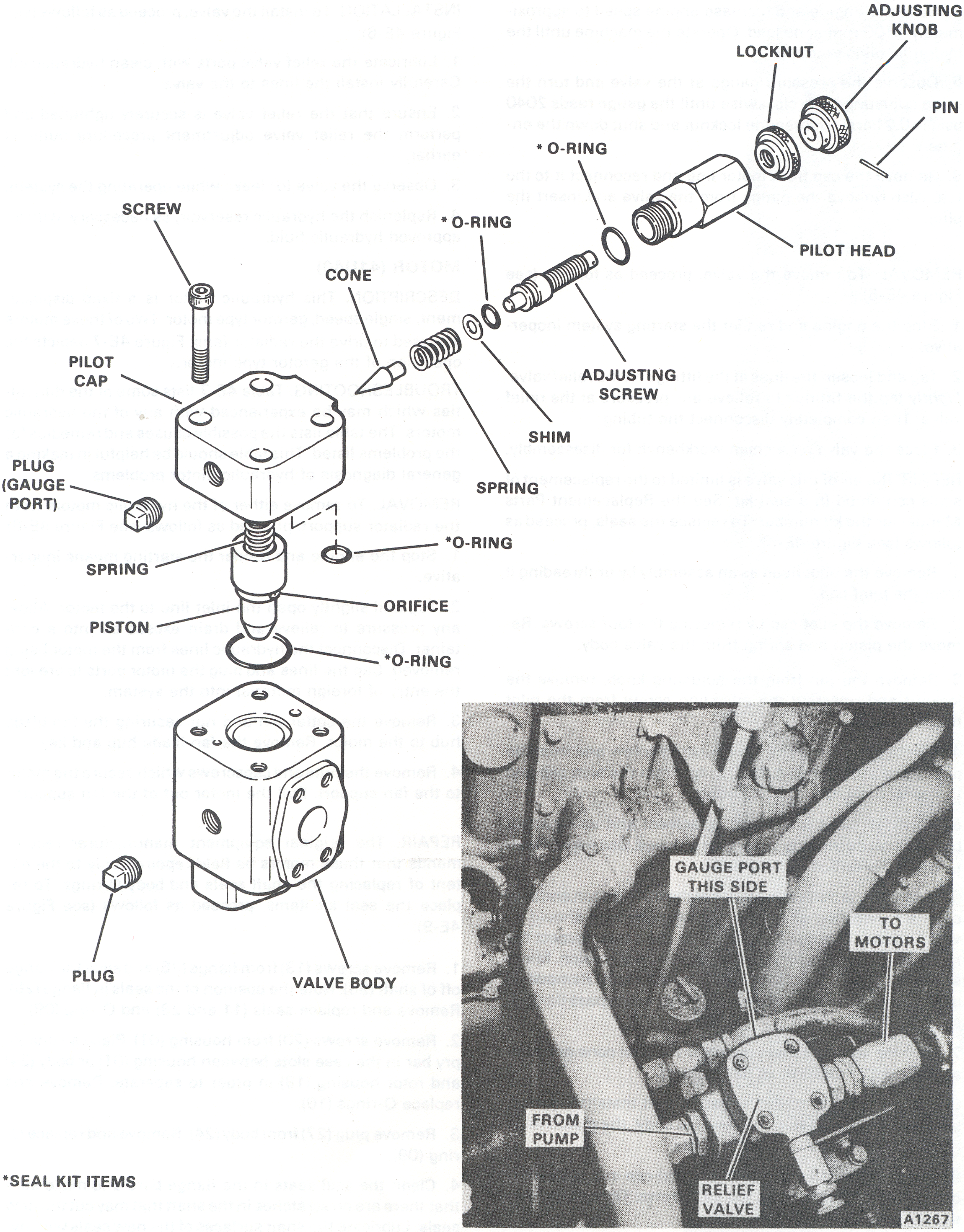
The pressure setting of 2140 psi (140.7 bars) must be adhered to. Any attempt to change the setting without specific approval will void any and all guarantees expressed or implied.

To adjust the relief valve, proceed as follows (see Figure 4E-6):

1. Obtain an accurate 0 to 5000 psi (0-345 bars) pressure gauge and install it into the gauge port of the relief valve.

2. Loosen the locknut on the valve and turn the adjusting knob completely counterclockwise.

3. Remove the line to the radiator motors at the tee just before the motors. Cap the line with a nut.



*SEAL KIT ITEMS

Figure 4E-6. Relief Valve (36Q258)

4. Start the engine and increase engine speed to approximately 1400 rpm at no load. Operate the machine until the hydraulic oil is warmed.

5. Observe the pressure gauge at the valve and turn the valve adjusting knob clockwise until the gauge reads 2040 psi (140.7 bars). Tighten the locknut and shut down the engine.

6. Remove the cap from motor line and reconnect it to the tee. Also remove the gauge from the valve and insert the plug.

REMOVAL. To remove the valve, proceed as follows (see Figure 4E-6):

1. Stop the engine and render the starting system inoperative.

2. Tag and loosen the lines at the fittings on the relief valve. *Lightly* tap the fittings to relieve any pressure at the relief valve. Then completely disconnect the tubing.

3. Place the valve on a clean workbench for disassembly.

REPAIR. Repair of this valve is limited to the replacement of seals contained in a seal kit. See the Replacement Parts Manual for the kit number. To replace the seals, proceed as follows (see Figure 4E-6):

1. Remove the pilot head as an assembly by unthreading it from the pilot cap.

2. Remove the pilot cap by removing the four screws. Remove the piston and spring from the valve body.

3. Remove the pin from the adjusting knob, remove the locknut and unscrew the adjusting screw from the pilot head.

4. Remove the O-rings from adjusting screw and from the pilot head. Also remove the O-rings from the pilot cap and the valve body. Discard all O-rings.

5. Wash all parts in a cleaning solvent and using a soft brush clean all threads and piston grooves. Use a small wire to clean the orifice in the piston.

6. Examine the conical surfaces of the main piston and pilot cone for evidence of erosion. A complete ring should be visible, indicating good contact with the seats. Inspect the main and pilot seats for cracks or evidence of erosion. Minor scratches may be polished with crocus cloth. Remove all burrs and sharp edges, especially those which pass through seals.

7. If either seat, the main piston or the pilot cone are damage the entire valve must be replaced.

8. Lubricate all parts with hydraulic fluid. Install the piston, spring and large O-ring in the valve body. the piston must rotate 360 degrees with out binding.

9. Install the small O-rings in the pilot cap and secure the cap to the valve body with the capscrews. Tighten the capscrews to 25 ft-lbs (3.5 kg-m).

10. Assemble the pilot head as shown and thread into the pilot cap. Tighten the head to 10 ft-lbs (1.4 kg-m).

INSTALLATION. To install the valve, proceed as follows (see Figure 4E-6):

1. Lubricate the relief valve ports with clean hydraulic oil. Carefully install the lines to the valve.

2. Ensure that the relief valve is securely tightened and perform the relief valve adjustment procedure outlined earlier.

3. Observe the valve for leaks while operating the system.

4. Replenish the hydraulic reservoir, as necessary, with an approved hydraulic fluid.

MOTOR (41U40)

DESCRIPTION. This hydraulic motor is a fixed displacement, single speed, gerotor type motor. Two of these motors are used to drive the radiator fans. Figure 4E-7 depicts the operation of the gerotor type motor.

TROUBLESHOOTING. Table 4E-7 lists some of the difficulties which may be experienced with any of the hydraulic motors. The table lists the possible causes and remedies for the problems listed. This table should be helpful in making a general diagnosis of hydraulic motor problems.

REMOVAL. To remove either of the hydraulic motors from the radiator support, proceed as follows (see Figure 4E-8):

1. Stop the engine and render the starting means inoperative.

2. Tag and slightly open the inlet line to the motor. Allow any pressure to relieve and drain excess oil into a container. Disconnect the hydraulic lines from the motor being removed. Cap the lines and plug the motor ports to prevent the entry of foreign material into the system.

3. Remove the cotter pin and nut securing the fan blade hub to the motor. Remove the fan blade hub and key.

4. Remove the nuts and capscrews which secure the motor to the fan support. Pull the motor out of the fan support.

REPAIR. The original equipment manufacturer recommends that these motors be field repaired only to the extent of replacing the shaft seals and body O-rings. To replace the seal kit items, proceed as follows (see Figure 4E-9):

1. Remove screws (13) from flange (26) and slide the flange off of shaft (23). Note the position of the seals in flange (26). Remove and replace seals (11 and 28) and O-ring (09).

2. Remove screws (20) from housing (01). Place a suitable pry bar in the case slots between housing (01) or body (24) and rotor housing (19) in order to separate. Remove and replace O-rings (10).

3. Remove plug (27) from body (24). Remove and replace O-ring (09).

4. Clean the seal seats in the flange bore and make sure that there are no scratches in the shaft that may cut the new seals. Lubricate the shaft surfaces of the new seals with hydraulic oil. Also inspect and clean the housings where O-rings (10) seat.

Table 4E-7. Motor Troubleshooting

TROUBLE	PROBABLE CAUSE	REMEDY
1. Motor does not deliver fluid.	A. Fluid level in reservoir too low.	A. Fill the reservoir with the proper grade and type of fluid. Check for possible external leaks.
	B. Motor inlet line plugged.	B. Remove and clean. Check filters and reservoir for other possible obstructions.
	C. Air leak in motor inlet line.	C. Repair leak.
	D. Pump or motor speed too slow.	D. Increase speed.
	E. Fluid viscosity too high.	E. Use only those fluids recommended in Section III.
	F. Broken or worn parts inside the motor.	F. Analyze the conditions that brought on the failure and correct them. Replace the motor, if required.
2. No pressure.	A. Motor not delivering fluid.	A. Follow the remedies in Part I.
3. Low or erratic pressure.	A. Cold fluid.	A. Warm up system. Operate only at recommended operating temperature range. See Operation Section.
	B. Fluid viscosity wrong.	B. See Section III. Use only those lubricants listed.
	C. Air leak or restriction at inlet line.	C. Repair or clean.
	D. Pump or motor speed too slow.	D. Increase speed.
	E. Internal parts of motor are worn excessively.	E. Repair or replace.
4. Motor making noise.	A. Restricted or clogged inlet line.	A. Clean or repair.
	B. Air leaks in intake line or air drawn through inlet line.	B. Repair. To check for leaks pour fluid around joints and listen for a change in sound of operation.
	C. Low fluid level.	C. Fill to proper level with proper grade and type of fluid.
	D. Air in the system.	D. Check for leaks. Bleed air from the system.
	E. Fluid viscosity too high.	E. Fill only with fluids recommended in Section III.
	F. Pump or motor speed too fast.	F. Check engine speed.
	G. Worn or broken parts.	G. Check and correct cause of parts failure. Replace motor.
5. Excessive wear.	A. Abrasive contaminants or sludge in the fluid.	A. Check for cause of contaminants. Replace filter elements. Replace motor. Replace fluid with recommended grade and quantity.
	B. Viscosity of fluid too low or too high.	B. Replace fluid with proper grade and type. (See Section III.)
	C. Sustained high pressure above maximum motor rating.	C. Check for possible relief valve malfunction or other parts failures. Adjust if necessary.
	D. Air leaks or restriction in system causing cavitation.	D. Eliminate from system. Replace motor if necessary.

Table 4E-7. Motor Troubleshooting (Continued)

TROUBLE	PROBABLE CAUSE	REMEDY
6. Excessive fluid leakage.	A. Damaged seal or packings around drive shaft.	A. Check and replace. Check to be sure that chemicals in fluid are not destroying packing or seals. Follow recommendations on grade and type of fluid in Section III.
7. Internal parts breakage.	A. Excessive pressure above maximum limits for motor.	A. Same as 5C above.
	B. Seizure due to lack of fluid.	B. Check motor inlet line.

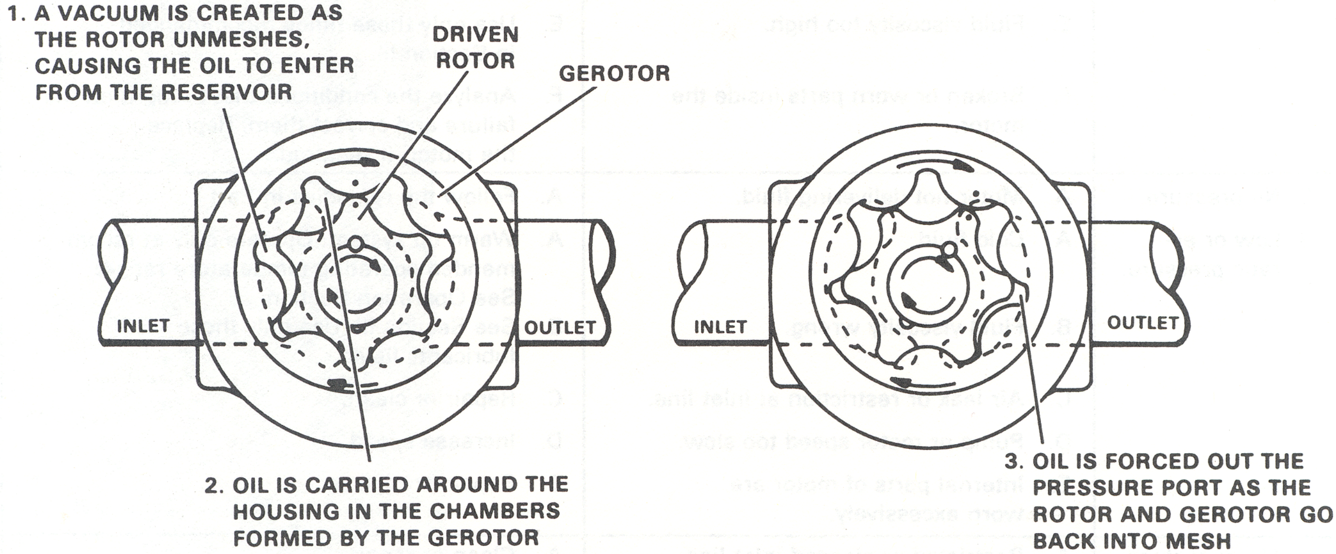


Figure 4E-7. Gerotor Motor Principles of Operation

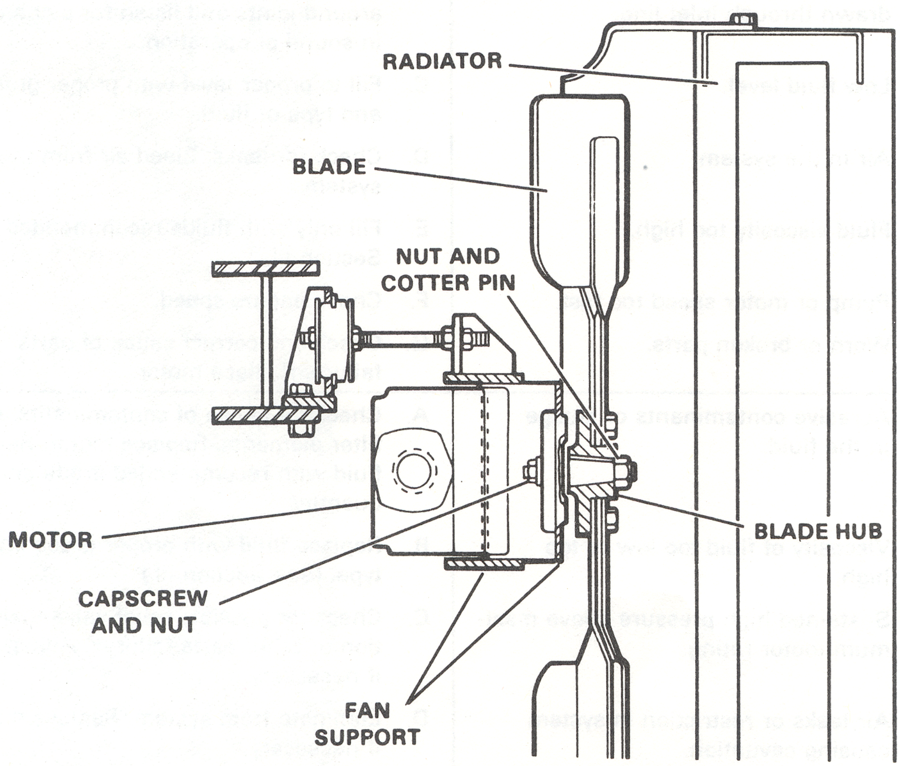
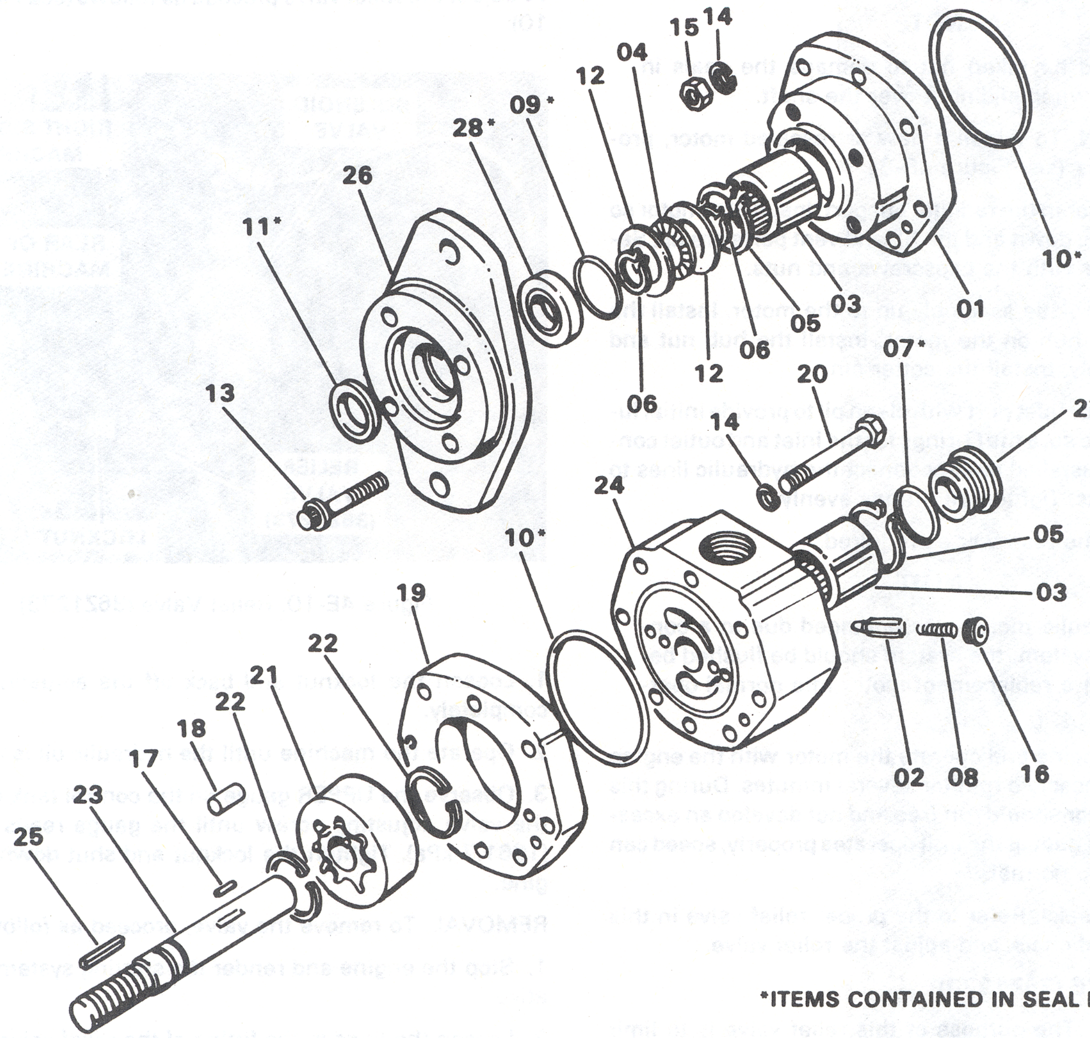


Figure 4E-8. Motor Mounting



*ITEMS CONTAINED IN SEAL KIT

01. HOUSING
02. POPPET
03. BEARING
04. BEARING
05. RETAINER RING
06. RETAINER RING
07. O-RING
08. SPRING
09. O-RING
10. O-RING
11. SEAL
12. WASHER
13. SCREW
14. LOCKWASHER
15. NUT
16. PLUG
17. KEY
18. DOWEL
19. HOUSING
20. SCREW
21. GEROTOR
22. RETAINER RING
23. SHAFT
24. BODY
25. KEY
26. FLANGE
27. PLUG
28. SEAL

Figure 4E-9. Motor (41U40)

5. Place gerotor housing (19) in place and locate in the dowel holes. Care should be taken that O-ring (10) is located properly and is not pinched when housing (19) is firmly seated. Precaution must be taken so the gerotor drive key (17) does not damage the front of housing face (01). This can be achieved by keeping the shaft assembly in its proper place.

Care should be taken so that O-ring (10) is located properly and not pinched when body (24) is seated.

7. Place screws (20) with lockwashers (14) in place through from body (24). Place lockwashers (14) and nuts (15) on screws (20) and torque to 600 inch pounds using a sequence of torquing opposite nuts. The shaft must be rotated while nuts (15) are being torqued.

8. Place flange (26) over the shaft and locate on housing (01). Place screws (13) in flange (26) and torque to 600 inch pounds.

NOTE

Care should be taken not to damage the seals in flange (26) when sliding it over the shaft.

INSTALLATION. To install a new or resealed motor, proceed as follows (see Figure 4E-8):

1. Set the motor in the radiator support. Install the motor so the drain port is down and the fill and vent ports are up. Secure the motor with the capscrews and nuts.

2. Set the fan blade assembly up to the motor. Install the key and blade hub on the motor. Install the hub nut and tighten securely. Install the cotter pin.

3. Fill the motor inlet port with clean oil to provide initial lubrication. Make sure the O-rings for the inlet and outlet connections are installed and reconnect the hydraulic lines to the motor ports. Tighten all fittings evenly.

4. Add oil to the reservoir as required.

NOTE

If the hydraulic motor was damaged due to a contaminated system, the system should be flushed before placing a replacement motor into normal operation.

5. Start the engine and operate the motor with the engine at the lowest possible rpm for several minutes. During this period the motor should run free and not develop an excessive amount of heat. If the unit operates properly, speed can be increased to normal.

6. Check for leaks. Refer to the proper relief valve in this subsection and check and adjust the relief valve.

RELIEF VALVE (36Z1273)

DESCRIPTION. The purpose of this relief valve is to limit system pressure in the transmission clutch control system to a preset maximum, by diverting pump flow to tank when the pressure setting is reached. The relief valve is located on the right hand chain case near the transmission clutch control filter.

RELIEF VALVE ADJUSTMENT. The relief valve has been adjusted at the factory and should retain its setting over extended periods of time, under normal conditions. The relief valve spring will eventually weaken with machine use, however, so periodic checking of the relief valve setting is recommended.

If the relief valve is removed for cleaning, inspection, or other reasons, readjustment will be required following installation. The following adjustment procedure is intended to be performed by qualified service personnel who possess a thorough working knowledge of the hydraulic system.

CAUTION

The pressure setting of 270 psi (1861.7 kPa) must be adhered to. Any attempt to change the setting without specific approval will void any and all guarantees, expressed or implied.

To adjust the relief valve proceed as follows (see Figure 4E-10):

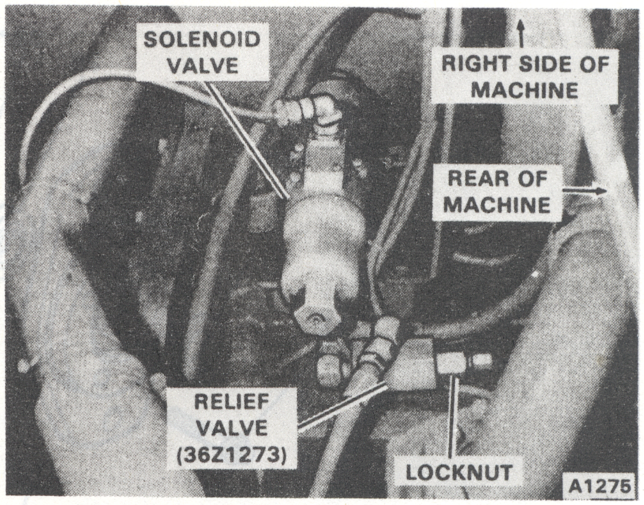


Figure 4E-10. Relief Valve (36Z1273)

1. Loosen the locknut and back off the adjusting screw completely.

2. Operate the machine until the hydraulic oil is warmed.

3. Observe the UPPER gauge on the control tank and turn the valve adjusting screw until the gauge reads 270 psi (1861.7 kPa). Tighten the locknut and shut down the engine.

REMOVAL. To remove the valve, proceed as follows:

1. Stop the engine and render the starting system inoperative.

2. Loosen the lines at the fitting of the relief valve. Lightly tap the fittings to relieve any pressure at the relief valve. Then completely disconnect the tubing.

3. Place the valve on a clean workbench for cleaning and disassembly.

REPAIR. Repair of this valve is limited to replacement of O-rings, a back-up ring and gaskets contained in a kit. The relief cartridge is also available as a complete assembly. See the Replacement Parts Manual for the kit and cartridge numbers. If the body of the relief valve is badly scored or damaged the entire valve must be removed and replaced with a new one.

INSTALLATION. To install a relief valve, proceed as follows:

1. Lubricate the relief valve ports with a clean, recommended hydraulic oil.

2. Fasten the tubing to the relief valve.

3. Adjust the relief valve as explained earlier.

4. Check for leaks at the relief valve, and add oil to the reservoir as necessary.

SOLENOID VALVE (36Z1470)

NOTE

This solenoid valve is used on machine serial numbers E-52941 and E-52942.

GENERAL. This valve is a four-way, three-position, DC solenoid operated type. Two valves are used as a means of engaging and disengaging the two speed transmission clutches located in the right and left hand transmissions.

The valves may be placed in either the high speed, neutral, or low speed positions, using the switches provided on the side console of the operator's module. Manual operators are provided so that the valves may be operated in emergency conditions and may be checked without the use of electrical power.

REMOVAL. To remove the valve, proceed as follows:

1. Shut off the engine and tag the ignition switch to warn against starting the engine, or remove the ignition key until the valve is reinstalled.
2. Tag and remove the electrical wire on the valve.
3. Loosen, but do not remove, the three mounting capscrews that attach the valve to the manifold. Allow any pressure to relieve, then remove the capscrews, lockwashers, and valve. Note the mounting position of the valve to the manifold.
4. Plug the holes in the manifold to prevent the entry of contaminants.
5. Remove the O-rings from between the valve and manifold.

TROUBLESHOOTING. The table and maintenance hints that follow are of a general nature, but should provide helpful information when combined with the schematic in Subsection 4C.

Table 4E-8 lists the common difficulties experienced with directional valves and systems. It also indicates the probable causes and remedies for each of the troubles listed.

It should always be remembered that many apparent valve failures are actually the failure of other parts of the system. The cause of improper operation is best diagnosed with adequate testing equipment and a thorough understanding of the complete hydraulic system.

SOLENOID REPLACEMENT. It is not necessary to remove the valve to replace the solenoid coil. After determining the solenoid coil is defective, proceed as follows (see Figure 4E-1 1):

CAUTION

Before breaking an electrical circuit, be sure the power is OFF. To do this, disconnect the battery ground cable.

1. Remove plate (01), gasket (02) and disconnect the wires from the coil to the terminal strip. Make tags to identify the wires for proper assembly.
2. Remove snap ring 129) and pull coil (30) from solenoid (27). Remove the manual plunger and install it in the new coil.

NOTE

Attach a piece of wire or cord to the wire ends of coil (30). This will make assembly easier.

3. Attach the wires of the new coil to the cord (wire) and pull the wires into body (05). Push the coil into the solenoid.
4. Install the snap ring and connect the coil wires to the terminal strip.
5. If removed on disassembly, connect wire on gasket (02) to ground and install plate (01).

DISASSEMBLY. To disassemble the valve, proceed as follow (see Figure 4E-1 1):

1. Loosen screws (28) and remove solenoids (5) (27) from the valve. Loosen guide (15) and washer (35).

Table 4E-8. Troubleshooting Chart

TROUBLE	PROBABLE CAUSE	REMEDY
Valve spool fails to move.	Dirt in system.	Disassemble, clean and flush.
	Solenoids inoperative.	Check electrical source and solenoids.
	Improper assembly after overhaul.	See Figure 5D-9 to check proper assembly of unit.
	Improper installation connection.-	Check installation.
Valve produces undesirable response in work unit.	improper assembly of valve or improper installation connections.-	Check Figure 5D-9 for assembly and the schematic diagram in Subsection 5A for installation.

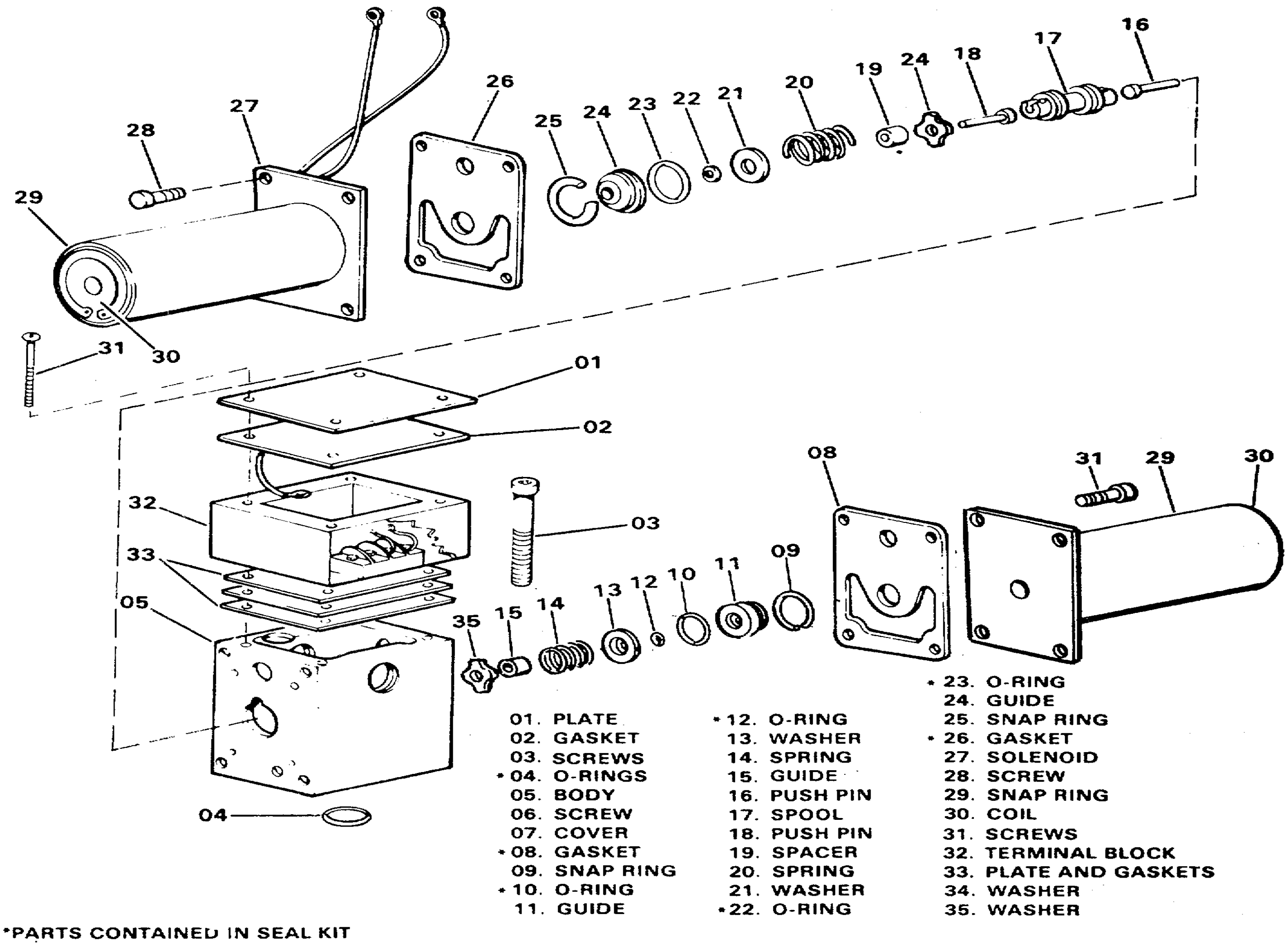


Figure 4E-11. Solenoid Valves (36Z1470)

2. Remove snap ring (09), then remove guide (1), O-rings (10 and 12), washer (1 3), spring (14). Apply force to push pin (16) as this will aid in removing guide (11) from the valve body.
3. Remove snap ring (25), now remove guide (24), O-rings (22 and 23) and washer (21).

NOTE

Discard and replace all O-rings and gaskets removed in disassembly except gasket (02) unless it is dam aged. Refer to the Parts Manual for the applicable seal kit number.

4. Remove spring (20) and spacer (19) and washer (34).
5. Slide spool (17) from the valve body with push pins (16 and 18). Remove the push pins from the spool, then mark the spool as noted below.

NOTE

Certain spool types are not symmetrical. To provide correct assembly, it is recommended that the spool and body be marked with a metal scribe. The spool should be marked on the minor diameter, not across the sealing lands.

CLEANING. The importance of cleaning the valve and all its parts cannot be overemphasized. All parts must be thoroughly cleaned and kept clean during inspection and assembly. The close tolerance of the valve body and spool makes this requirement more stringent than usual. Clean all removed parts, using commercial solvent that is compatible with the system fluid. Compressed air may be used in cleaning the valve, but it must be filtered to remove water and contamination. Clean compressed air is particularly useful in cleaning the spool orifices and body passages.

INSPECTION AND REPAIR. Inspect, repair, and replace the valve and all its parts as follows:

1. Visually inspect the internal bore of valve body (05) for scratches or erosion across the spool land sealing areas. If scratches or erosion are found, replace the complete valve.

CAUTION

Do not stone the edges of the sealing lands on the valve spool. Rather, use a 500 grit abrasive paper to remove any burrs found on the spool. Use the paper very lightly on the outer diameter of the spool only.

2. Inspect the spool for burrs or small scratches. If any are found, remove them with 500 grit abrasive paper. Then insert the spool into the bore, rotate it while moving it back and forth to check for binding. If any binding or side movement exists, the spool must be replaced.
3. If a new spool (1 7) is required, use a very fine grit stone to break the feathered edges of the balancing grooves. Use 500 grit paper to lightly polish the outside diameter of the spool.

4. Inspect all the other parts for wear or damage and replace as necessary.
5. Check the grooves where any seals are placed; grooves and detents should be free of any rough edges to prevent damage to the new seals on assembly.
6. Perform a continuity check on the solenoid coil. The coil should have a resistance value of 24 ohms.

ASSEMBLY. To assemble the valve, proceed as follows (see Figure 5D-9):

1. Lubricate all the parts and O-rings with clean hydraulic oil to aid in assembly and provide initial lubrication.

2. The assembly of the valve is basically the reverse of the disassembly procedure. The following items require special attention:

A. Check the special marks on the spool and valve bore to ensure correct assembly.
B. Insert the heads of push pins (16 and 18) into the spool before installing the spool into the valve body.
C. Install washer (34) with the sharp break edge toward the spring.
D. Install washer (35) with the sharp break edge toward spring (14).
E. Check for secure installation of snap rings (09 and 25).
F. Complete the wiring connection of the solenoid at installation.

INSTALLATION. To install the solenoid valve, proceed as follows:

1. Place O-rings (04) in the ports at the bottom of the valve body if not already done. Now set the valve on the subplate or manifold on its correct position and secure with the four socket head screws and lockwashers.
2. Complete the wiring of the solenoid and attach the ground wire of gasket (02). Install the plate and fasten with the screws.
3. Bleed the system of air as described in Subsection 5A.
4. Connect the battery cable, start the engine, and check for leaks. If none, test the valve for proper operation.

SUBSECTION 4F
CHAIN CASES AND UNIVERSAL JOINTS

GENERAL

This subsection will cover the removal and installation of the right and left hand chain cases. In addition it will cover the removal, repair, and installation of the chain, fan belts, U-joints, and drive, idler and driven assemblies which are part of each chain case. See Figure 4F-1 for the location of the items.

CHAIN CASE (914J174-4,5 & 6)

REMOVAL

To remove the left hand chain case, proceed as follows:

NOTE

It is not necessary to remove the chain case to perform repairs on the idler and drive assemblies. Chain case removal is only necessary if the whole unit is to be taken out.

1. Remove all sheet metal from around the chain case.
2. Remove the lubricating oil connections and control connections, including the quick disconnect connections to the solenoid valve, and case drain lines.
3. Disconnect both the input and output universal joints.
4. Remove the fan belts from the input flange.
5. Remove the mounting pins at the transmission case foot.
6. Using a suitable sling and lifting device remove the transmission case as an assembly. Set the chain case on blocking.

DRIVE SPROCKET

REMOVAL AND DISASSEMBLY. To remove and disassemble the drive sprocket from the case, proceed as follows (see Figure 4F-2):

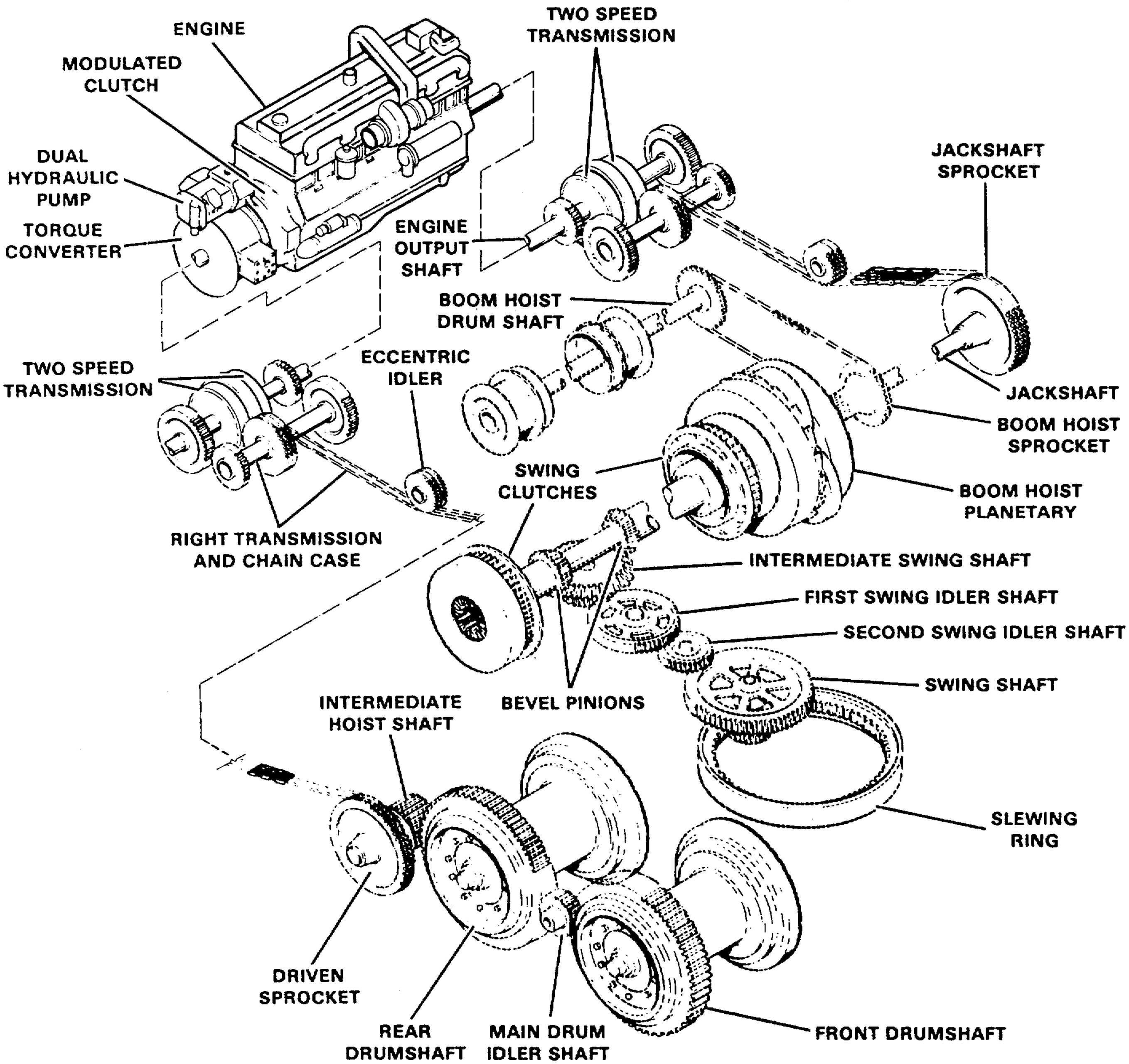
1. If the chain case is in the machine it will be necessary to remove the universal joint from input flange (152).
2. Remove capscrews (47) and lockwashers (46). Turn shaft (45) to slacken the chain. Remove tubes {120, 116 and 134) from tees (131 and 132).
3. Remove capscrews (57) and lift cover (58), with gasket (55) from the case.
4. See Chain later in this subsection and remove the chain from the case.
5. Remove cap (154) and pull input flange (152) off of the clutch shaft. Remove and replace oil seal (149). Remove 0ring (153) from cap (154).
6. Remove all the lubrication and clutch apply lines that will interfere with the removal of cover (69).
7. Remove retainers (66 and 03) along with gaskets (65 and 04). Remove locknut (05) and lockwasher (06).
8. Remove capscrews (70 and 62) and nuts (60). Slowly pull cover (69) off of the case while at the same. time hitting the shaft of the clutch and shaft (12)with a soft hammer to work them out of bearings (07 and 63).
9. When cover (69) is off, first remove the clutch assembly then remove the drive sprocket assembly. Remove gasket (71) and replace with a new one. Set the drive sprocket assembly on a bench for disassembly.
10. Using a puller, remove bearing (07) from shaft (12). Remove gear (08), sprocket (09), spacer (10) and gear (11) from the shaft.
11. Remove locknut (15) and lockwasher (14). Using a puller, remove bearing (13) from the shaft.

INSPECTION AND REPAIR. Prior to reassembly, inspect the drive parts as follows:

1. Replace any bearing which shows signs of wear or damage.
2. Replace all capscrews which have rounded corners and all other damaged or worn parts.
3. If inspection reveals nicks, mars, or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure to inspect the sprocket, sprocket teeth and gears for cracks, breaks or dirt.
4. See Chains later in this subsection and inspect the chain.

ASSEMBLY AND INSTALLATION. To assemble and install the drive sprocket, proceed as follows:

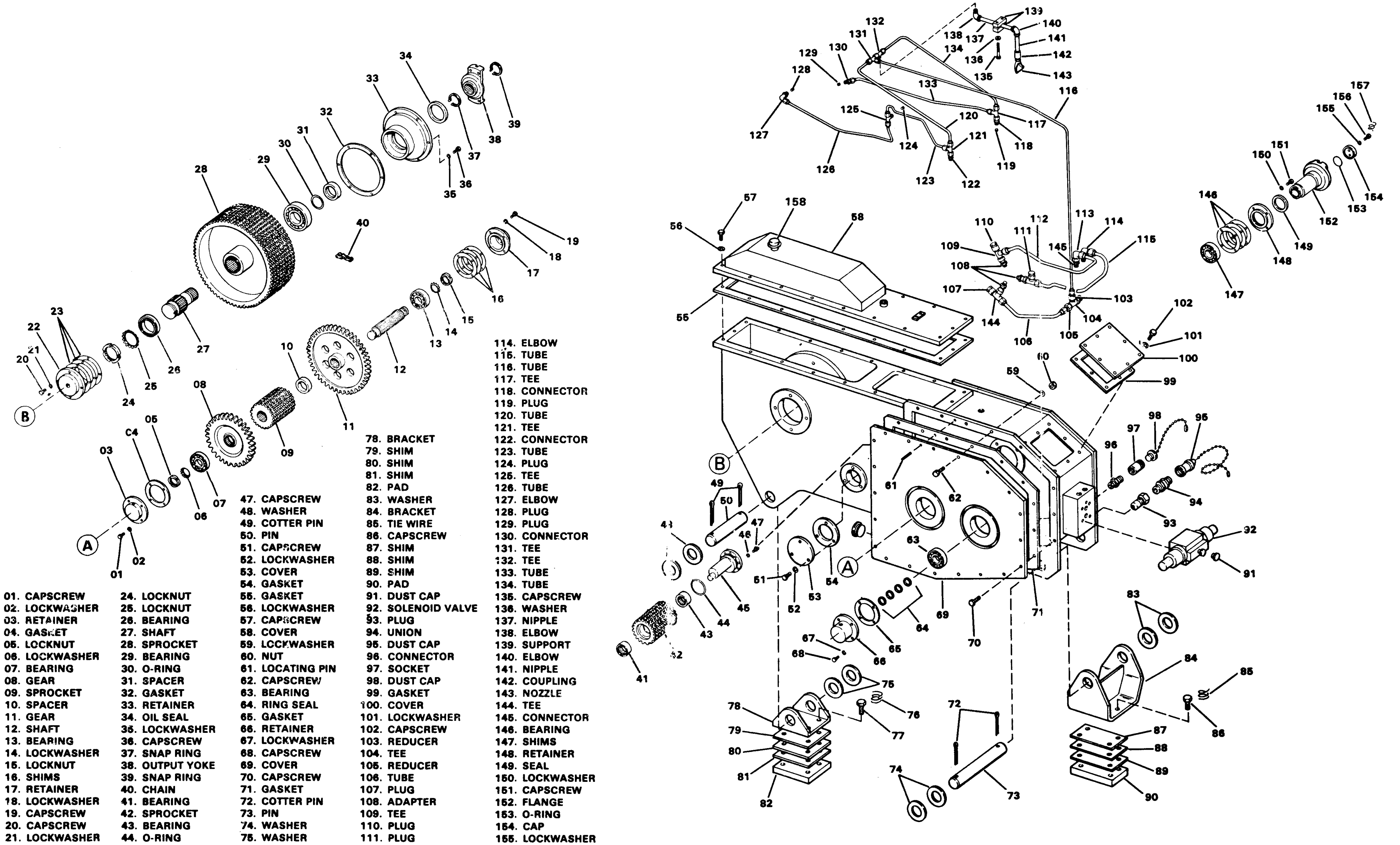
1. Heat and install bearing (13). Install, but do not tighten, lockwasher (14) and locknut (1 5).
2. Install gear(11), spacer (10), sprocket (09) and gear(08). Heat and install the inner race of bearing (07) on shaft (12).



NOTE 1: END OF SWING CLUTCH SHAFT EXTENDS THROUGH BOOM HOIST SPROCKET.

NOTE 2: MANY ITEMS HAVE BEEN MOVED IN ORDER TO SHOW THE OPERATION OF THE MACHINE MORE CLEARLY.

Figure 4F-1. Power Train



01. CAPSCREW
02. LOCKWASHER
03. RETAINER
04. GASKET
05. LOCKNUT
06. LOCKWASHER
07. BEARING
08. GEAR
09. SPROCKET
10. SPACER
11. GEAR
12. SHAFT
13. BEARING
14. LOCKWASHER
15. LOCKNUT
16. SHIMS
17. RETAINER
18. LOCKWASHER
19. CAPSCREW
20. CAPSCREW
21. LOCKWASHER
22. RETAINER
23. SHIMS
24. LOCKNUT
25. LOCKNUT
26. BEARING
27. SHAFT
28. SPROCKET
29. BEARING
30. O-RING
31. SPACER
32. GASKET
33. RETAINER
34. OIL SEAL
35. LOCKWASHER
36. CAPSCREW
37. SNAP RING
38. OUTPUT YOKE
39. SNAP RING
40. CHAIN
41. BEARING
42. SPROCKET
43. BEARING
44. O-RING
45. SHAFT
46. LOCKWASHER
47. CAPSCREW
48. WASHER
49. COTTER PIN
50. PIN
51. CAPSCREW
52. LOCKWASHER
53. COVER
54. GASKET
55. GASKET
56. LOCKWASHER
57. CAPSCREW
58. COVER
59. LOCKWASHER
60. NUT
61. LOCATING PIN
62. CAPSCREW
63. BEARING
64. RING SEAL
65. GASKET
66. RETAINER
67. LOCKWASHER
68. CAPSCREW
69. COVER
70. CAPSCREW
71. GASKET
72. COTTER PIN
73. PIN
74. WASHER
75. WASHER
76. TIE WIRE
77. CAPSCREW
78. BRACKET
79. SHIM
80. SHIM
81. SHIM
82. PAD
83. WASHER
84. BRACKET
85. TIE WIRE
86. CAPSCREW
87. SHIM
88. SHIM
89. SHIM
90. PAD
91. DUST CAP
92. SOLENOID VALVE
93. PLUG
94. UNION
95. DUST CAP
96. CONNECTOR
97. SOCKET
98. DUST CAP
99. GASKET
100. COVER
101. LOCKWASHER
102. CAPSCREW
103. REDUCER
104. TEE
105. REDUCER
106. TUBE
107. PLUG
108. ADAPTER
109. TEE
110. PLUG
111. PLUG
112. TUBE
113. ELBOW
114. ELBOW
115. TUBE
116. TUBE
117. TEE
118. CONNECTOR
119. PLUG
120. TUBE
121. TEE
122. CONNECTOR
123. TUBE
124. PLUG
125. TEE
126. TUBE
127. ELBOW
128. PLUG
129. PLUG
130. CONNECTOR
131. TEE
132. TEE
133. TUBE
134. TUBE
135. CAPSCREW
136. WASHER
137. NIPPLE
138. ELBOW
139. SUPPORT
140. ELBOW
141. NIPPLE
142. COUPLING
143. NOZZLE
144. TEE
145. CONNECTOR
146. BEARING
147. SHIMS
148. RETAINER
149. SEAL
150. LOCKWASHER
151. CAPSCREW
152. FLANGE
153. O-RING
154. CAP
155. LOCKWASHER
156. CAPSCREW
157. TIE WIRE
158. BREATHER

Figure 4F-2. Chain Case(914J174-4, 5 & 6)

3. Set the assembled drive shaft into the case. Also set the clutch pack into the case.
4. Install the outer race of bearings (63 and 07) into cover (69).
5. If locating pins (61) were removed from the case, reinstall them at this time. Set cover (69), with gasket (71)on the locating pins. Install capscrews (62 and 70) and nuts (60).
6. Install oil seal (149), input flange (152), cap (154)with O-ring (153) and secure to the clutch shaft with capscrews (156).
7. Install ring seals (64). See Teflon Ring Installation in Subsection 4B. Install retainer (66) with gasket (65).
8. Install lockwasher '(06) and locknut (05). Using locknuts (05 and 15) position gears (08 and 1 11) so they line up with the clutch shaft gears, then tighten one of the locknuts.
9. If new parts were added to the drive shaft, check shaft end play. Shaft end play should be 0.003-0.005 inch (0.076-0.127 mm) between mounting bearings (07 and 13). If adjustment is necessary, remove retainer (17) and add or subtract shims (16) as needed. Reinstall retainer (17).
10. Install retainer (03) with gasket (04).
11. Reinstall the chain in the case and tighten it. See Chains later in this subsection.
12. Reinstall cover (58) with gasket (55). Reinstall all lubrication and clutch apply lines.
13. If the chain case remained on the machine, reinstall the universal joint.

IDLER SPROCKET

REMOVAL AND DISASSEMBLY. To remove and disassemble the idler sprocket, proceed as follows (see Figure 4F-2):

NOTE

It may be necessary to remove radiator support members to gain access to the idler sprocket.

1. Remove the lubrication line from cover (58) then remove the cover and gasket (55).
2. Remove capscrews (47) and rotate shaft (45) to slacken the chain. Support sprocket (42) from above and pull shaft (45) out of the case.
3. Remove sprocket (42) from the case and remove bearings (41 and 43) from the sprocket. Also remove O-ring (44) from shaft (45).

INSPECTION AND REPAIR. Prior to reassembly inspect the idler parts as follows:

1. Replace any bearing which shows signs of wear or damage.
2. Replace any capscrews with rounded corners and all other damaged or worn parts. Replace the shaft O-ring.
3. If inspection reveals nicks, mars or burrs on machined or ground surfaces use a fine mill file or India Stone for removal. Be sure to inspect the sprocket and sprocket teeth for cracks, breaks or dirt.

SUBSECETION 4F

ASSEMBLY AND INSTALLATION. To assemble and install
the idler shaft, proceed as follows (see Figure 4F-2):

1. Install O-ring (44) on shaft (45). Also install bearing (41 and 43) into sprocket (42).
2. Place sprocket (42) into the case and start shaft (45) into the case and the sprocket. Push shaft (45) all the way into the case. Turn shaft (45) until chain (40) is tight, then rotate the shaft in the opposite direction one set of holes for capscrews (47). Install capscrews (47) and tighten.
3. Reinstall cover (58) with gasket (55). Reinstall the lubrication line.

DRIVEN SPROCKET

REMOVAL AND DISASSEMBLY. To remove and disassemble the driven sprocket, proceed as follows (see Figure 4F2):

1. If the case is in the machine, remove the universal joint from output yoke (38).
2. Remove tube (126) from elbow (127). Remove the lubrication line from cover (58) and remove the cover with gasket (55).
3. See Chains later in this subsection and remove the chain from the case.
4. Remove retainer (22) and shims (23). Remove locknut (24) and lockwasher (25). Disconnect tube (133) from connector (130).
5. Remove snap ring (39), yoke (38) and snap ring (37). Support sprocket (28) from above and drive shaft (27) out the left side of the case.
6. Remove capscrews (36) and pull retainer (33) off of the case. Remove bearing (29), O-ring (30), spacer (31) and oil seal (34) from retainer (33).
7. Remove bearing (26) from shaft (27).

INSPECTION AND REPAIR. Prior to reassembly, inspect the driven sprocket items as follows:

1. Replace the oil seal and O-ring.
2. Any bearing which shows signs of wear or damage should be replaced.
3. Replace all capscrews which have rounded corners and all other damaged or worn parts.
4. If inspection reveals nicks, mars, or burrs on machined or ground surfaces use a fine mill file or India Stone for removal. Be sure to inspect the sprocket and sprocket teeth for cracks, breaks or dirt.
5. See Chains later in this subsection and inspect the chain.

ASSEMBLY AND INSTALLATION. To assemble and install
the driven sprocket, proceed as follows (see Figure 4F-2):

1. Heat and install bearing (26) on shaft (27).
2. Set and suspend sprocket (28) in the chain case. Start shaft (27) through the case and sprocket (28). When the

shaft is through the sprocket, heat and install bearing (29) on the shaft.

3. Install retainer (33), with gasket (32), over bearing (29). Install capscrews (36). Install O-ring (30), spacer (31), oil seal (34) and snap ring (37) on shaft (27).

4. Install lockwasher (25) and locknut (24). Install yoke (38) and secure in place with snap ring (39).

5. If new parts were added to the driven shaft, check shaft end play. Shaft end play should be 0.003-0.005 inch (0.076-0.127 mm) betweenmounting bearings (26 and 29). If adjustment is necessary, add or subtract shims (23) as needed. Install the shims and retainer (22).

6. Reinstall the chain in the case and tighten it. See Chains later in this subsection.

7. Reinstall cover (58) with gasket (55). Reinstall all lubrication and clutch apply lines.

8. If the chain case remained on the machine, reinstall the universal joint.

INSTALLATION

To install the chain case on the machine, proceed as follows:

1. Using a suitable lifting device, set the chain case over the mounting brackets and install the pins, washers and cotter pins.

2. Reinstall the input and output universal joints. Also reinstall the radiator fan belts (see Fan Belts later in this subsection).

3. Connect the lubricating oil and control connections previously removed. Also reconnect the case drain lines.

4. Reinstall all sheet metal.

CHAIN CASE (100J4160-2 & 3)

REMOVAL

To remove the right hand chain case, proceed as follows:

NOTE

It is not necessary to remove the chain case to perform repairs on the idler and drive assemblies. Chain case removal is only necessary if the whole unit is to be taken out.

1. Remove all sheet metal from around the chain case.

2. Remove the lubricating oil connections and control connections, including the quick disconnect connections to the solenoid valve and chain case drain lines.

3. Disconnect the output universal joint.

4. See Clutch (53U32) in Subsection 48 and remove the clutch from the chain case.

5. Remove the six capscrews that secure the upper block support to the lower block support.

6. Support the torque converter end of the case and remove the capscrews securing the torque converter to the chain case.

7. Using a suitable sling and lifting device, remove the transmission case as an assembly. Set the chain case on blocking. Remove the large O-ring from the converter and replace.

DRIVE SPROCKET

REMOVAL AND DISASSEMBLY. To remove and disassemble the drive sprocket from the case, proceed as follows (see Figure 4F-3):

NOTE

If the chain case remained on the machine it will be necessary to remove the clutch assembly. See Clutch (53U32) in Subsection 48 to remove the clutch.

1. See Chains later in this subsection and remove the chain from the case.

2. Remove the drive sprocket as an assembly. Set the drive sprocket assembly on a bench for disassembly.

3. Using a puller, remove bearing (19) from shaft (26). Remove gear (28), sprocket (27) and gear (25) from the shaft.

4. Remove snap ring (23) from the shaft. Using a puller, remove bearing (24).

INSPECTION AND REPAIR. Prior to reassembly, inspect the drive parts as follows:

1. Replace any bearing which shows signs of wear or damage.
2. Replace all capscrews which have rounded corners and all other damaged or worn parts.
3. If inspection reveals nicks, mars, or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure to inspect the sprocket, sprocket teeth and gears for cracks, breaks or dirt.
4. See Chains later in this Subsection and inspect the chain.

ASSEMBLY AND INSTALLATION. To assemble and install the drive sprocket, proceed as follows:

1. Heat and install bearing (24). Install snap ring (23).

2. Install gear (25), sprocket (27)and gear(28) on shaft (26). Heat and install the inner race of bearing (19) on the shaft.

3. Set the assembled drive shaft into the case.

4. Reinstall the chain in the case. See Chains later in this subsection.

NOTE

If the chain case remained on the machine, reinstall the clutch pack at this time. See Clutch (53U32) in Subsection 4B for installation instructions.

IDLER SPROCKET

REMOVAL AND DISASSEMBLY. To remove and disassemble the idler sprocket, proceed as follows (see Figure 4F-3):

01. GASKET
02. COVER
03. LOCKWASHER
04. CAPSCREW
05. CLUTCH
06. GASKET
07. COVER
08. BEARING
09. SHIMS
10. RETAINER
11. CAPSCREW
12. LOCKWASHER
13. CAPSCREW
14. LOCKWASHER
15. RETAINER
16. SHIMS
17. LOCKNUT
18. LOCKWASHER
19. BEARING
20. CAPSCREW
21. LOCKWASHER
22. PIN
23. SNAP RING
24. BEARING
25. GEAR
26. SHAFT
27. SPROCKET
28. GEAR
29. O-RING
30. SHAFT
31. LOCKWASHER
32. CAPSCREW
33. GASKET
34. COVER
35. BEARING
36. LOCKWASHER
37. LOCKNUT
38. SHIMS
39. RETAINER
40. LOCKWASHER
41. CAPSCREW
42. CASE
43. GASKET
44. CONNECTOR
45. PLUG
46. RETAINER
47. LOCKWASHER
48. CAPSCREW
49. SPACER
50. TIE WIRE
51. YOKE
52. SNAP RING
53. SHAFT
54. BEARING
55. O-RING
56. OIL SEAL
57. SNAP RING
58. SPROCKET
59. CHAIN
60. BEARING
61. SPROCKET
62. BEARING
63. GASKET
64. GASKET
65. COVER
66. PLATE
67. FILLER CAP
68. GASKET
69. LOCKWASHER
70. CAPSCREW
71. CAPSCREW
72. PLATE
73. BONDED MOUNTING
74. CAPSCREW
75. BLOCK
76. SHIMS
77. BLOCK
78. HOSE
79. CAP
80. ELBOW
81. TUBE
82. PLUG
83. ELBOW
84. TUBE
85. PLUG
86. ELBOW
87. LOCKWASHER
88. SCREW
89. TUBE
90. TEE
91. CONNECTOR
92. PLUG
93. TEE
94. TUBE
95. NUT
96. REDUCER
97. ELBOW
98. TUBE
99. CONNECTOR
100. ELBOW
101. TUBE
102. TUBE
103. TEE
104. TUBE
105. REDUCER
106. NUT
107. CONNECTOR
108. CONNECTOR
109. DUST CAP
110. CAP
111. VALVE
112. CAPSCREW
113. LOCKWASHER
114. CONNECTOR
115. MANIFOLD
116. NOZZLE
117. TUBE
118. CLAMP
119. UNION
120. PLUG
121. CONNECTOR
122. TUBE

NOTE: If Manifold (115) is removed apply RTV sealant (21Z549) to both sides of gasket (64) and threads of capscrews (112).

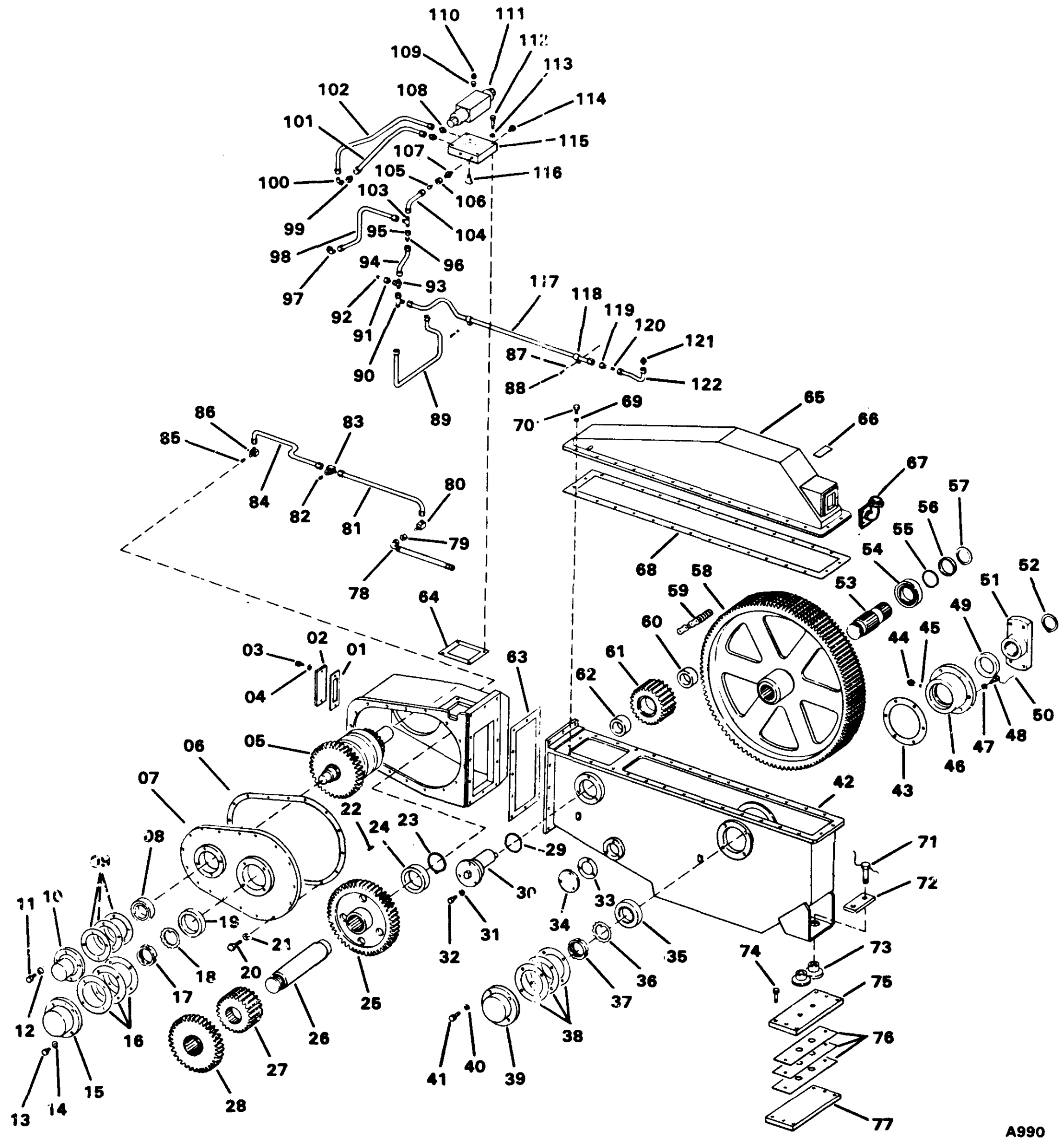


Figure 4F-3. Chain Case (100J4160-2 & 3)

1. Remove cover (65) and gasket (68).
2. Remove capscrews (32) and rotate shaft (30) to slacker the chain. Support sprocket (61) from above and pull shah (30) out of the case.
3. Remove sprocket (61) from the case and remove bearings (60 and 62) from the sprocket. Also remove O-ring (29) from shaft (30).

INSPECTION AND REPAIR. Prior to reassembly inspect the idler parts as follows:

1. Replace any bearing which shows signs of wear or damage.
2. Replace any capscrews which have rounded corners and all other damaged or worn parts. Replace the shaft O-ring.
3. If inspection reveals nicks, mars or burrs on machined or ground surfaces use a fine mill file or India Stone for removal. Be sure to inspect the sprocket and sprocket teeth for cracks, breaks or dirt.

ASSEMBLY AND INSTALLATION. To assemble and install the idler shaft, proceed as follows (see Figure 4F-3):

1. Install O-ring (29) on shaft (30). Also install bearings(60 and 62) into sprocket (61).
2. Place sprocket (61) into the case and start shaft (30) into the case and the sprocket. Push shaft (30) all the way into the case. See Chains later in this section to adjust the chain.
3. Reinstall cover (65) and gasket (68) when the chain has been adjusted.

DRIVEN SPROCKET

REMOVAL AND DISASSEMBLY. To remove and disassemble the driven sprocket, proceed as follows (see Figure 4F-3):

1. If the case is in the machine, remove the universal joint from output yoke (51).
2. Remove cover (65) and gasket (68) from case (42).
3. See Chains later in this subsection and remove the chain from the case.
4. Remove hose (78) from retainer (46). Also remove hose (122) from retainer (39).
5. Remove retainer (39) and shims (38). Remove locknut (37) and lockwasher (36). Remove snap ring (52) and pull yoke (51) off of shaft (53).
6. Remove snap ring (57) and support sprocket (58) from above. Shaft (53) will be driven out the right side of the case.
7. With the sprocket supported, drive shaft (53) out of the case. Lift sprocket (58) out of the case. Remove capscrews (48) and pull retainer (46) off of case (42).
8. Remove bearing (54), O-ring (55), spacer (49) and seal (56) from retainer (46).
9. Remove bearing (35) from shaft (53).

INSPECTION AND REPAIR. Prior to reassembly, inspect the driven sprocket items as follows:

1. Replace the oil seal and O-ring.
2. Any bearing which shows signs of wear or damage should be replaced.
3. Replace all capscrews which have rounded corners and all other damaged or worn parts.
4. If inspection reveals nicks, mars or burrs on machined or ground surfaces use a fine mill file or India Stone for removal. Be sure to inspect the sprocket and sprocket teeth for cracks, breaks or dirt.
5. See Chains later in this subsection and inspect the chain.

ASSEMBLY AND INSTALLATION. To assemble and install the driven sprocket, proceed as follows (see Figure 4F-3):

1. Heat and install bearing (35) on shaft (53).
2. Set and suspend sprocket (58) in the chain case. Start shaft (53) through the case and sprocket (58). When the shaft is through the sprocket, heat and install bearing (54) on the shaft.
3. Install retainer (46), with gasket (43), over bearing (54). Install capscrews (48). Install O-ring (55), spacer (49), oil seal (56) and snap ring (57) on shaft (53).
4. Install lockwasher (36) and locknut (37). Install yoke (51) and secure in place with snap ring (52).
5. If new parts were added to the driven shaft, check shaft end play. Shaft end play should be 0.003-0.005 inch (0.076-0.127 mm) between mounting bearings (35 and 54). If adjustment is necessary add or subtract shims (38) as needed. Install the shims and retainer (39).
6. Reinstall the chain in the case and tighten it. See Chains later in this subsection.
7. Reinstall hoses (122 and 78).
8. Reinstall cover (65) with gasket (68).
9. If the chain case remained on the machine, reinstall the universal joint.

INSTALLATION

To install the chain case on the machine, proceed as follows:

1. Install the bonded mountings to the case block if they were removed. Lubricate the mounting and socket lightly with rubber lubricant or water.
2. Using a suitable lifting device, set the chain case over the mounting bracket and against the torque converter. Be sure to install a new O-ring between the case and converter. Install all mounting bolts and capscrews.
3. Reinstall the output universal joint.
4. See Clutch (53U32) in Subsection 4B and reinstall the clutch.
5. Connect the lubricating oil and control connections previously removed. Also reconnect the case drain lines.
6. Reinstall all sheet metal.

REMOVAL

To remove the chain, remove the chain case cover and gasket. Turn the drive until the connecting link is fully engaged with one of the sprockets, so as to relieve the tension of the connecting link pins. Then remove the connecting link and lift the chain off the sprockets.

INSPECTION AND REPAIR

A chain, like any other operating equipment, requires inspection to obtain long life and satisfactory performance. Inspect the chain as follows:

1. Check for wear on the sides of the sprocket teeth and on the link plates. Such wear indicates misalignment.
2. Check for wear on the working faces of the sprocket teeth. As the drive runs in, these faces should develop a bright, polished appearance. Scratches, galls, grooves, or visible changes in tooth form are signs of trouble, probably caused by sluggish roller action due to lubrication problems.
3. An elongation of as much as three percent indicates that the chain is riding near its limit of allowable height on the sprocket teeth. Gradual increases in chain length are the result of normal wear.
4. Check the chain and the sprocket teeth for accumulations of dirt or foreign material and for evidence of corrosion. Foreign material packed into the chain or sprocket teeth may cause chain or sprocket breakage.
5. Check the lubricant level in the chain case. See the Operator's Manual for the method of checking the level.
6. To cut a roller chain, alternately strike the two pins of a link out of its link plate. Be sure to alternately strike the pins to avoid distortion of the roller link plates. If the pins are "headed", grind off the heads before driving them through the link plates.

INSTALLATION

To install a chain, wrap the chain around the sprockets, bringing the free ends together on one sprocket. Insert the pins of the connecting link in the two end links of the chain; then install the free plate of the connecting link, and fasten the plate using the cotters, spring lip or other fasteners supplied. After the fasteners have been inserted, it is important that the ends of the chain pins be tapped back so that the fasteners come up snugly against the outside of the connecting link plate.

CHAIN TENSION ADJUSTMENT

RIGHT HAND CHAIN CASE. To adjust the chain tension in the right hand chain case, proceed as follows (see Figure 4F-4):

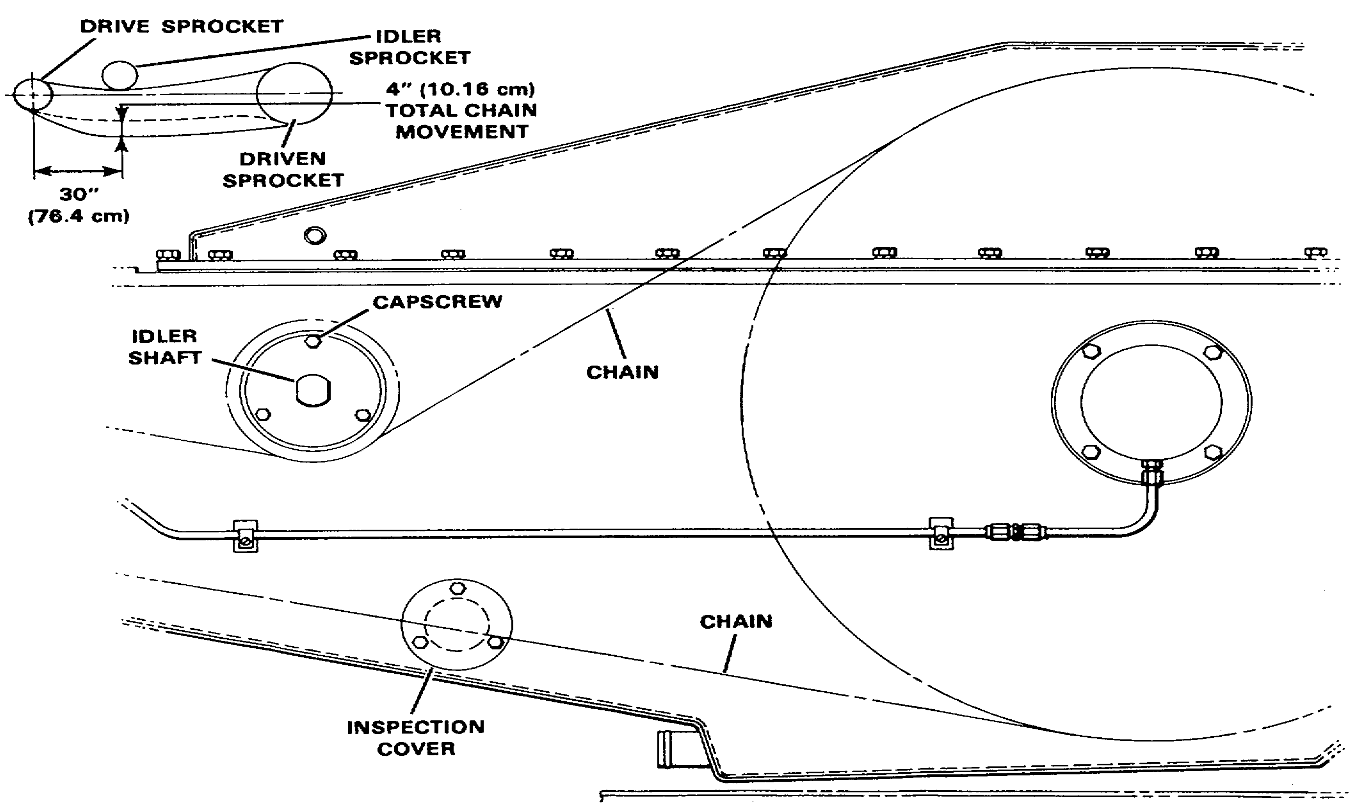


Figure 4F-4. Chain Tension Adjustment - R.H. Chain Case

1. Remove the inspection cover from the right side of the chain case.
2. At the center of chain span, 30 inches (76.4 cm)from the centerline of either sprocket, measure the chain movement. The total chain movement should be 4 inches (10.1 6 cm).
3. If the chain movement is correct, reinstall the inspection and top covers. if the chain movement is incorrect, proceed as follows to change it:

A. Remove the idler shaft capscrews.
B. Turn the idler shaft, as needed, to increase or decrease the chain tension. The idler shaft is eccentric.
C. Recheck the chain tension as explained in step 2 above. If the chain tension is correct, reinstall the idler shaft capscrews.
D. Reinstall the inspection and top covers.

LEFT HAND CHAIN CASE. To adjust the chain tension in the left hand chain case, proceed as follows (see Figure 4F-5):

1. Remove the idler shaft capscrews.
2. Rotate the idler shaft until the chain is tight. It may be necessary to remove the inspection cover on the left side of the case to check chain tightness.
3. Rotate the idler shaft in the opposite direction as done in step 2 one set of holes.
4. Reinstall the idler shaft capscrews.

UNIVERSAL JOINT (18U22 & 18U40)

GENERAL. These universal joints are used to connect the outputs of the left and right hand transmissions to their respective jackshaft or hoist shaft.

REMOVAL. To remove the universal joint, remove the capscrews securing the two ends together and pull the U-joint out.

DISASSEMBLY. Disassembly is accomplished by removing the capscrews (and tie wire is used) securing the bearing assemblies to the coupling and pull the items apart.

REPAIR. Repair of these universal joints is limited to the replacing of the bearing assemblies as a unit and replacement of the coupling.

ASSEMBLY. Assembly is accomplished by placing the coupling between the bearing assemblies and installing the capscrews. On U-joint 18U22 torque the capscrews, dry, to 235 + 5 ft-lbs (32.5 + 0.7 kg-m)and install the tie wire. On U-joint 18U40 torque the capscrews, oiled, to 95-105 ft-lbs (13.1-14.5 kg-m).

INSTALLATION. Set the complete assembly up to the flanges and install the capscrews. On U-joint 1 8U22 torque the capscrews, dry, to 235 f 5 ft-lbs (32.5 + 0.7 kg-m). On U-joint 18U40 torque the capscrews, oiled, to 95-105 ft-lbs (13.1-14.5 kg-m).

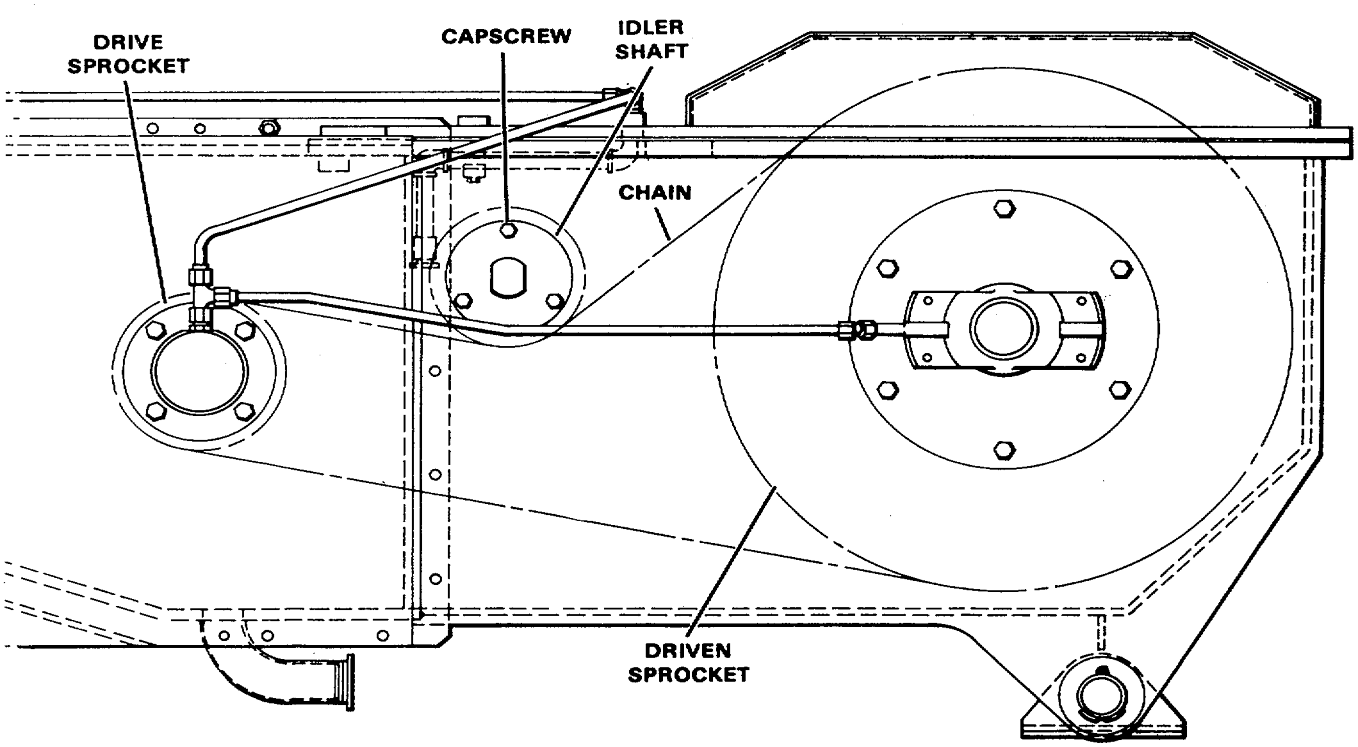


Figure 4F-5. Chain Tension Adjustment - L.H. Chain Case

UNIVERSAL JOINT (18U25)

GENERAL. This universal joint is used to connect the output flange on the front of the engine to the input of the left hand transmission.

REMOVAL. To remove the universal joint, remove the capscrews securing the two ends together and pull the U-joint out.

DISASSEMBLY. To disassemble the universal joint, proceed as follows (see Figure 4F-6):

1. Remove the capscrews securing the bearing assemblies to the yoke stub and the slip yoke.
2. Remove the stuffing cap and match mark the yoke stub in relation to the slip yoke so they are reassembled in the same manner as they are removed. Separate the slip yoke from the yoke stub.
3. Remove the stuffing cap from the yoke stub and remove

REPAIR. Repair of the universal joint is limited to replacement of the bearing assemblies, seal, stuffing cap, slip yoke and stub yoke.

ASSEMBLY. To assemble the universal joint, proceed as follows (see Figure 4F-6).

1. Install the seal in the stuffing cap and place the cap on the yoke stub.
2. Install the slip yoke over the yoke stub in the same manner as it was removed. Secure with the stuffing cap.
3. Install the bearing assemblies to the yoke stub and slip yoke with the capscrews. Tighten the capscrews, dry, to 7080 ft-lbs (9.7-11.1 kg-m).

INSTALLATION. Set the complete assembly up to the flanges and install the capscrews. Tighten the capscrews, dry, to 70-80 ft-lbs (9.7-11.1 kg-m).

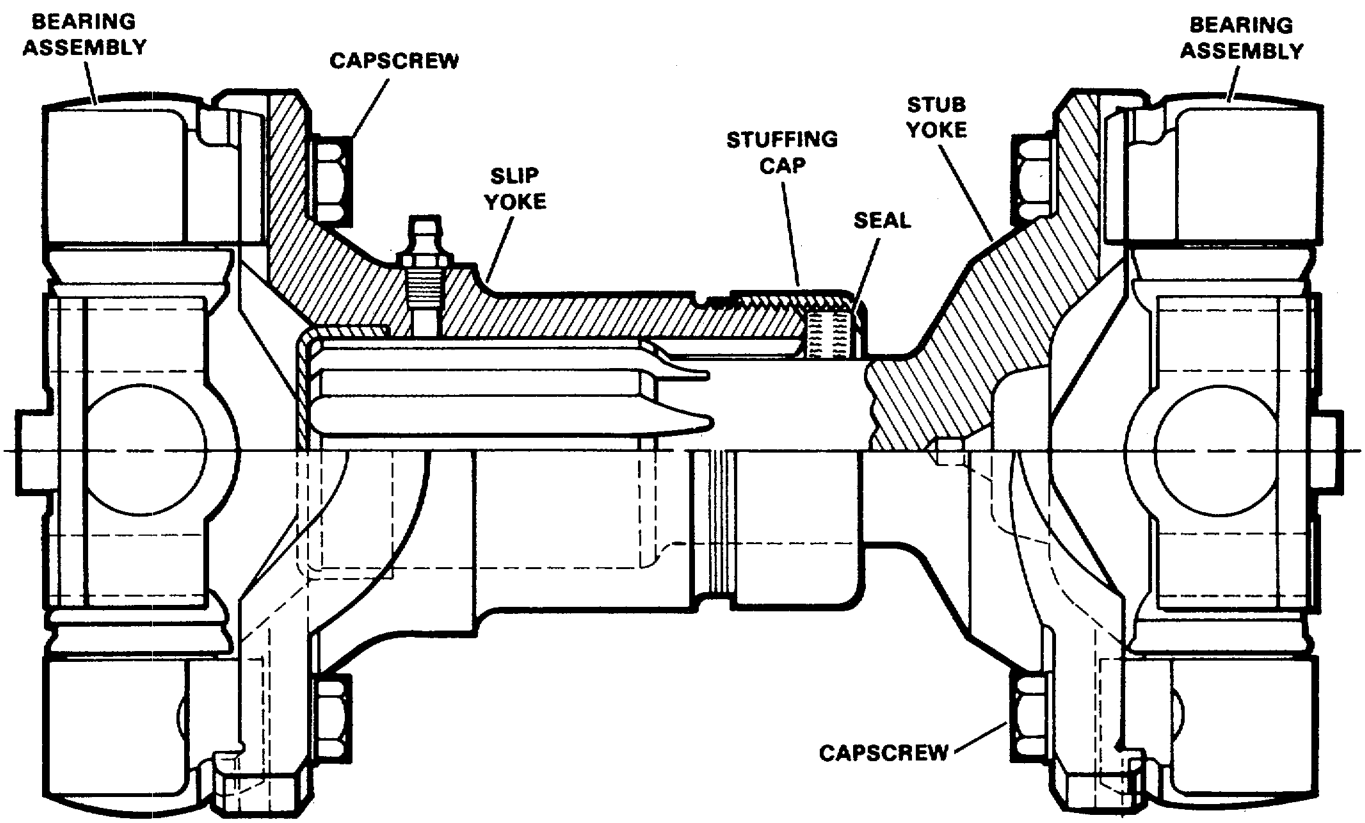


Figure 4F-6. Universal Joint (18U25)

SECTION V.
UPPER HYDRAULIC SYSTEM AND COMPONENTS

SUBSECTION **PAGE**

SUBSECTION 5A.
HYDRAULIC SYSTEM

GENERAL

The hydraulic system, as defined for this manual, includes all the hydraulic components on the upper of the machine. The items included in this system are the pump, control valves, actuating cylinders, and related components.

Hydraulic schematics of complete hydraulic systems, along with a description of system operation, are at the rear of this section.

GENERAL MAINTENANCE

The following points should be kept in mind when working on the hydraulic system or any hydraulic component:

1. Any structure has limits of strength and durability. To prevent the failure of structural parts of hydraulic components, an unloading valve which limits pressure to a safe operating value is included in the hydraulic circuit. The setting of this unloading valve must never be changed.
2. Tolerances of working parts in the hydraulic system are very close. Even small amounts of dirt or foreign material in the system can cause wear or damage to components, as well as generally faulty operation of the system. Every precaution must be taken to assure absolute cleanliness of the hydraulic oil.
3. Samples of hydraulic oil should be drawn from the reservoir every six months. These samples should be taken while the oil is warmed through normal operation. If possible, the sample should be analyzed by a qualified lubrication specialist to determine whether it is suitable for further use. The interval between oil changes depends on operating conditions and on the care used in keeping the oil clean.
4. Whenever there is a hydraulic component failure which gives reason to believe that there are metal particles or other foreign materials in the system, drain and flush the entire system and replace the filter cartridges. A complete change of hydraulic oil must be made under these circumstances.
5. Whenever the hydraulic system is drained, check the magnetic drain plug for metal particles. If metal particles are present, flush the system and add a new charge of oil. The presence of metal particles also may indicate the possibility of imminent component failure.
6. Do not use synthetic or fire resistant oils in this machine. The packing in this system are designed for a good grade mineral oil.
7. All containers and funnels used in handling hydraulic oil must be absolutely clean. Use a funnel with a 200 mesh screen for filling the hydraulic oil reservoir, and fill the reservoir only through the filler opening. The use of cloth to strain the oil should be avoided to prevent lint from getting into the system.
8. When removing any hydraulic component, be sure to cap and tag all hydraulic lines involved. Also plug the ports of the removed components.
9. All hydraulic components must be disassembled and assembled in spotlessly clean surroundings. During disassembly, pay particular attention to the identification of parts to assure proper reassembly. Clean all metal parts in a clean mineral oil solvent. Be sure to thoroughly clean all internal passages. After the parts have been dried thoroughly, lay them on a clean lint-free surface for inspection.
10. Replace all O-rings, back-up rings, and seals when overhauling any component. Lubricate all parts with clean hydraulic oil before reassembly. Use small amounts of petroleum jelly to hold O-rings in place during reassembly.
11. Be sure to replace any lost hydraulic oil when completing the installation of the repaired component, and bleed any air from the system when required.
12. All hydraulic connections must be kept tight. A loose connection in a line will permit the oil to leak out or air to be drawn into the system. Air in the system can cause damage to the components and noisy or erratic system operation.

FLUSHING THE HYDRAULIC SYSTEM

If any evidence of hydraulic system contamination, such as dirt, sludge, and/or metallic particles is discovered, flush and clean the system as follows. If the cause of the contamination is due to a faulty component, the component must be repaired or replaced before the hydraulic system is flushed.

NOTE

The hydraulic oil should be warmed before the reservoir is drained.

1. Remove the drain plug and drain the oil into a suitable container. Allow sufficient time for all the oil to drain from the walls of the reservoir.
2. Install the drain plug. Fill the reservoir with a 50-50 mixture of kerosene and clean hydraulic oil.

3. Cycle the machine through all crane functions, and operate the gantry lift cylinders several times to circulate the flushing oil throughout the hydraulic system. It is important that all valves be operated so that the new oil goes through all lines.
4. Circulate the oil through the system until inspection shows the equipment to be in satisfactory condition, or until it is obvious that the system will have to be disassembled and cleaned manually.
5. Remove the drain plug and drain the flushing oil from the reservoir. Remove the cover from the top of the reservoir and clean the inside of the reservoir manually. Replace the drain plug and the reservoir cover. Refill the reservoir with clean hydraulic oil. Be sure to clean the system filter before refilling the system.
6. Cycle the machine through all crane functions and operate the gantry lift cylinders several times to force. the flushing oil back to the reservoir. This will also help filter out the remaining contaminants.

BLEEDING THE HYDRAULIC SYSTEM

Normally, it is not necessary to bleed the lines on the hydraulic components panel. On the other hand, lines from the control valves to the clutches, brakes, and other circuit components should be bled in the event that components in these lines are removed. To bleed the lines in the hydraulic system, proceed as follows:

1. Start the engine and build up pressure in the accumulator.
2. Shut the engine off and actuate the control valves to relieve most the pressure. The pressure gauge should show only a small amount (low end of amber area on the pressure gauge) of pressure remaining in the system.
3. Begin with the lowest hydraulic cylinder and work toward those cylinders at the highest point. Bleeder fittings on the rotating cylinder must be at the high point of travel. Attach a bleeder hose to the bleeder fitting, open the fitting and catch the hydraulic oil in a clean jar or can.
4. On the front and rear drum brakes, depress the brake pedal and allow a full stream of oil to come out of the bleeder hose.
5. Close the bleeder fitting when the air has been removed from that line. Remove the bleeder hose.
6. Bleed all the hydraulic cylinders in the manner described.

<u>WARNING</u>

Hydraulic oil must not come in contact with any brake or clutch lining during this bleeding operation. Hydraulic oil on the linings will cause the clutches or brakes to slip.

TROUBLESHOOTING GUIDE

GENERAL. The troubleshooting charts and maintenance hints that follow are of a general nature, but should provide an intuitive feeling for a specific system.

KNOWING THE SYSTEM. Probably the greatest aid to troubleshooting is knowing the system. Every component has a purpose in the system. The construction and operating characteristics of each one should be understood. Know how the system works and what the valve settings and pump output should be.

DEVELOPING SYSTEMATIC PROCEDURES. Analyze the system and develop a logical sequence of looking for trouble. Ask the operator how the machine performed when it started to fail or if there is anything unusual about it. Operate the machine to see if gauges are reading properly, that all controls operate smoothly, and check for unusual noises. Visually inspect the machine, looking for oil leaks. Examine filters and all lines, checking for heat, loose connections, or collapsed hoses. Develop a cause and effect troubleshooting guide similar to the charts which follow. The initial time spent on such a project could save hours of downtime.

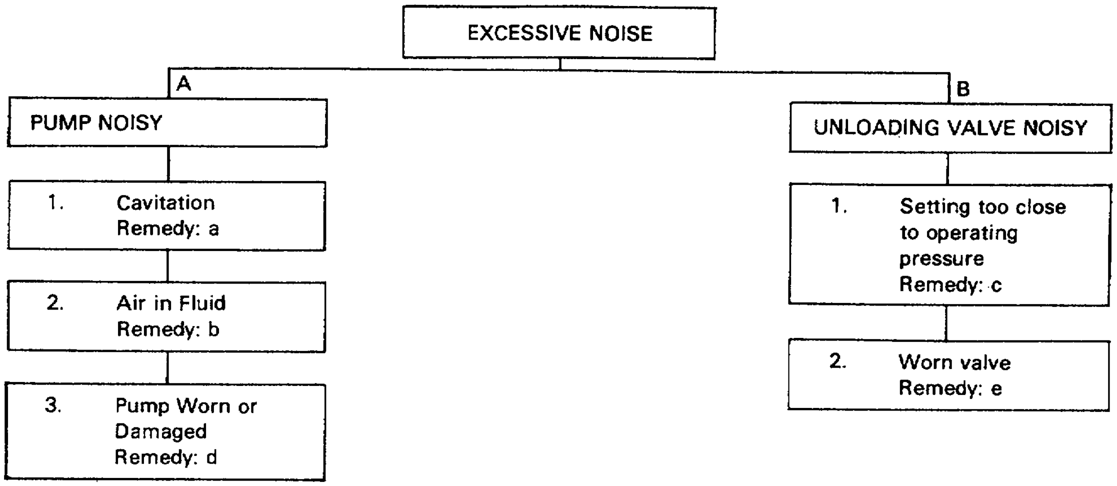
RECOGNIZING TROUBLE INDICATIONS. The ability to recognize trouble indications in a specific system is usually acquired with experience. However, a few general trouble indications can be discussed.

1. Excessive heat means trouble. A misalign pump places an excessive load on bearings and can be readily identified by the heat generated. A warmer than normal return line indicates that the system is operating at the unloading valve setting. Hydraulic oil which have a low viscosity will increase the internal leakage of components resulting in a heat rise. Cavitation and slippage in a pump will also generate heat.
2. Excessive noise means wear, misalignment, cavitation or air in the oil. Contaminated oil can cause an unloading valve to stick and chatter. These noises may be the result of dirty filters, or fluid, high fluid viscosity, excessive drive speed, low reservoir level, or loose intake lines.

MAINTENANCE. Three simple maintenance procedures have a great effect on hydraulic system performance, efficiency, and life. They are:

1. Change filters.
2. Maintain a sufficient quantity of clean hydraulic fluid of the proper type and viscosity in the reservoir.
3. Keep all connections tight, but not to the point of distortion, so that air is excluded from the system.

Chart 5A-1. Excessive Noise



REMEDIES:

a. Any or all of the following: Replace dirty filters — Clean clogged inlet line — Clear reservoir breather vent — Change system fluid

b. Any or all of the following: Tighten leaky inlet connections — Fill reservoir to proper level — Replace pump shaft seal

c. Install pressure gauge and adjust to correct pressure

d. Overhaul or replace

e. Replace

Chart 5A-2. Excessive Heat

EXCESSIVE HEAT

A — PUMP HEATED

1. Fluid heated
   Remedy: See column C
2. Cavitation
   Remedy: a
3. Air in fluid
   Remedy: b
4. Unloading valve set too high
   Remedy: d
5. Excessive load
   Remedy: c
6. Worn or damaged pump
   Remedy: e

B — UNLOADING VALVE

1. Fluid heated
   Remedy: See column c
2. Valve setting incorrent
   Remedy: d
3. Worn or damaged valve
   Remedy: g

C — FLUID HEATED

1. Accumulator pre-charge pressure too high
   Remedy: d
2. Unloading valve set too high
   Remedy: d
3. Fluid dirty or low supply
   Remedy: f
4. Incorrect fluid viscosity
   Remedy: f
5. Worn pump, accumulator valve, cylinder or other component
   Remedy: e

REMEDIES:

a. Any or all of the following: Replace dirty filters — Clean clogged inlet line — Clean reservoir breather vent — Change system fluid

b. Any or all of the following: Tighten leaky inlet connections — Fill reservoir to proper level — Replace pump shaft seal

c. Check drive belt and condition of seals and bearings — Locate and correct mechanical binding

d. Install pressure gauge and adjust to correct pressure

e. Overhaul or replace

f. Change filters and also system fluid if of improper viscosity — Fill reservoir to proper level

g. Replace

Chart 5A-3. Incorrect Flow

INCORRECT FLOW

A — NO FLOW

1. Pump not receiving fluid
   Remedy: a
2. Pump drive not operating
   Remedy: f
3. Pump drive shaft sheared
   Remedy: c
4. Entire flow passing over unloading valve
   Remedy: d
5. Damaged pump
   Remedy: c

B — LOW FLOW

1. Unloading valve set too low
   Remedy: d
2. External leak in system
   Remedy: b
3. Accumulator pre-charge pressure low
   Remedy: g
4. Worn pump, accumulator, cylinder, or other component
   Remedy: e

REMEDIES:

a. Any or all of the following: Clean dirty filters in tank — Clean clogged inlet line — Clean reservoir breather vent — Fill reservoir to proper level

b. Tighten leaky connections

c. Check for damaged pump or pump drive

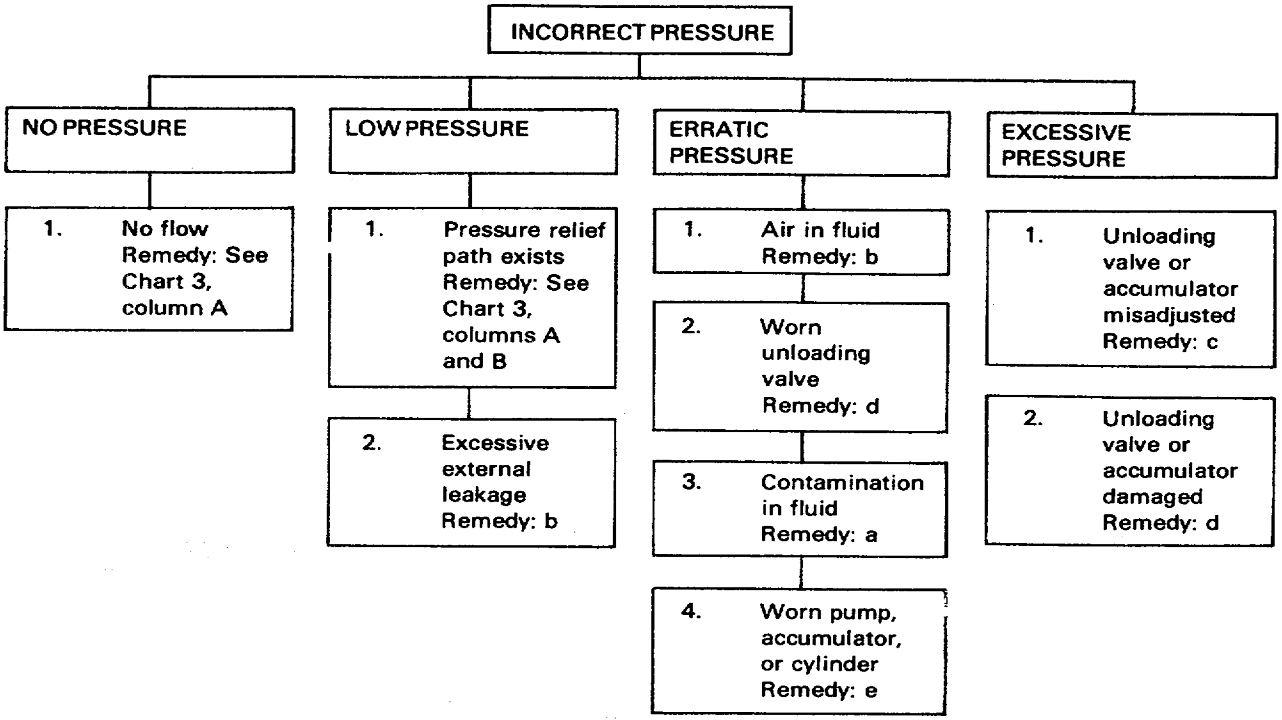
d. Replace unloading valve

e. Overhaul or replace

f. Check pump drive belt — Replace if necessary

g. Check accumulator precharge

Chart 5A-4. Incorrect Pressure



REMEDIES:

a. Replace dirty filters and system fluid

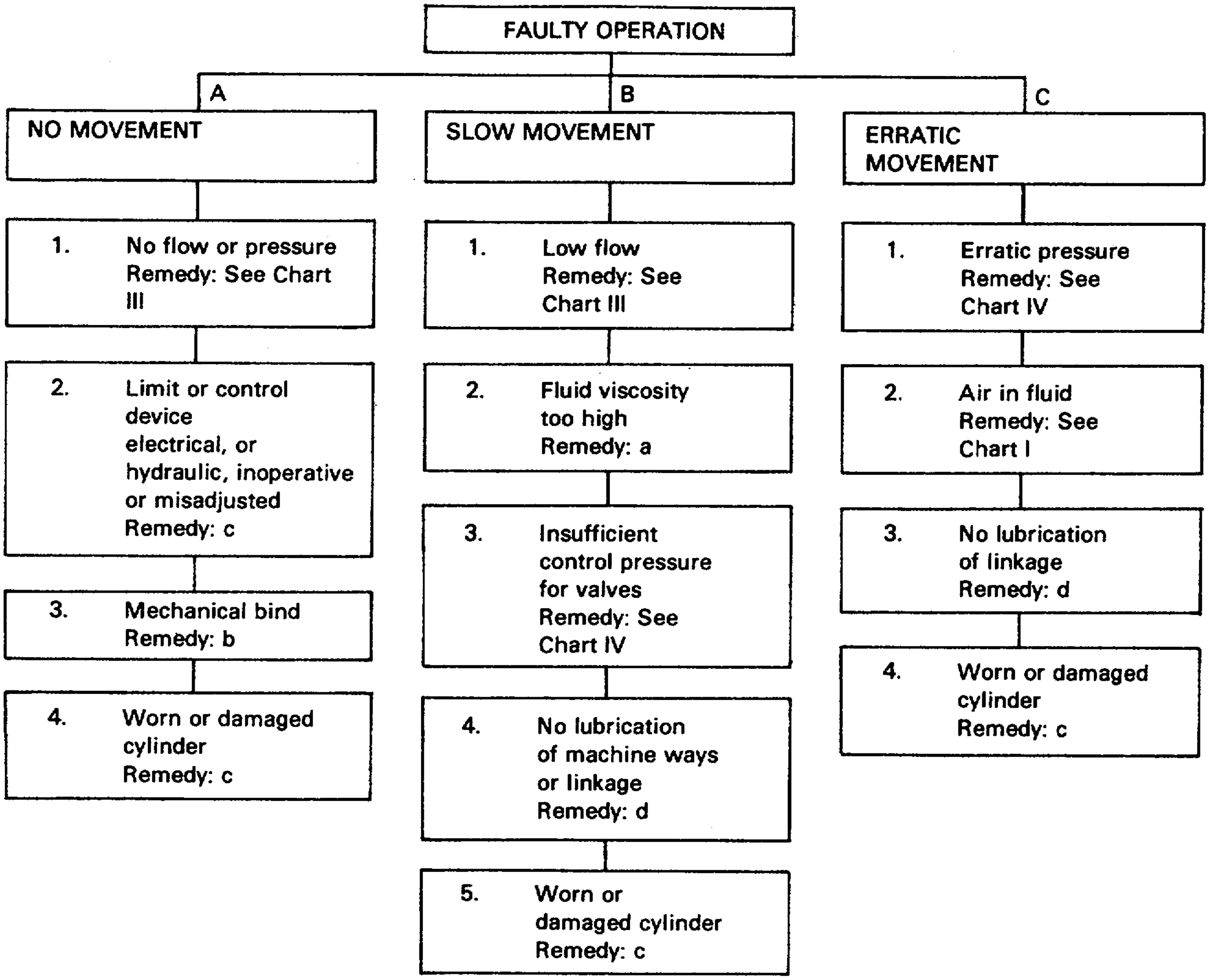
b. Tighten leaky connections — Fill reservoir to proper level

c. Adjust

d. Replace

e. Overhaul or replace

Chart 5A-5. Faulty Operation



REMEDIES:

a. Fluid may be too cold or should be changed to clean fluid of correct viscosity
b. Locate bind and repair
c. Overhaul or replace
d. Lubricate

SYSTEM DESCRIPTIONS
BASIC MACHINE

PUMPING CIRCUIT. The pumping circuit consists of the reservoir, pump, filters, unloading valve and accumulator.

The pump is mounted on, and belt driven by, the torque converter. When the pump is driven, oil is drawn from the reservoir through the tank suction filter and is forced out into the system. The oil leaving the pump flows through a high pressure filter, and then to the accumulator. The oil will continue to fill the accumulator until maximum operating pressure is reached. When the accumulator reaches maximum operating pressure, the unloading valve will open and direct pump output back to the reservoir.

The oil will continue to circulate back to the tank as long as the control valves are in the neutral position. When the op-erator actuates the controls, oil will be drawn from the accumulator causing accumulator pressure to drop to the low end of operating pressure. At this point, the unloading valve will close and the pump will again recharge the accumulator to maximum operating pressure. This charging and discharging of accumulator pressure will show up on the pressure gauge as a gradual decrease in pressure, followed by a rapid increase to maximum operating pressure.

BOOM HOIST CIRCUIT. To raise the boom, the operator pulls the control lever back. In this position hydraulic oil passes from the accumulator, through the control valve, through the energized boom solenoid valve, through a shuttle valve, to the boom hoist brake cylinder, and to the boom hoist clutch cylinder. Oil flow to the boom hoist brake cylinder causes the cylinders to extend and release the boom hoist brakes. Oil to the boom hoist clutch cylinder causes the cylinder to extend and engage the clutch to lift the boom.

The boom hoist solenoid is de-energized whenever the boom reaches maximum boom angle. At this point, the oil is directed back to the tank causing the brake to set and the boom hoist clutch to release.

To lower the boom, the operator pushes the control lever forward. In this position, oil is fed through the boom hoist interlock valve, to the boom hoist planetary brake cylinder, boom hoist pawl cylinder, and through a shuttle valve to the boom hoist brake cylinder. This action engages the planetary brake, shifts the boom hoist pawls, releases the boom hoist brake, and lowers the boom.

The boom hoist interlock valve is energized whenever the master switch is "on" to allow the boom to be lowered. When the master switch is "off" the interlock valve is de-energized. In this position the interlock valve will block the flow of oil to the boom hoist planetary brake, boom hoist pawl, and boom hoist brake cylinders, if the control lever should be moved forward.

GANTRY ASSIST CIRCUIT. To raise the gantry, the operator moves the gantry control valve to the "up" position. In this position hydraulic oil passes from the accumulator through the control valve to the blind end of the gantry lift cylinders. Oil flowing into the blind end of the gantry lift cylinders will cause the cylinders to extend and partially lift the gantry. Oil will flow out the head end of the cylinders and return to the reservoir.

To lower the gantry, the operator moves the gantry control valve to the "down" position. In this position hydraulic oil passes from the accumulator through the control valve to the head end of the gantry lift cylinders. Oil flowing into the head end of the gantry lift cylinders will cause the cylinders to retract and lower the gantry. Oil will flow out of the blind end of the cylinders and return to the reservoir.

SWING CIRCUIT. Swing operation is performed electrically by the two Magnetorque units. However, the swing brake is released by hydraulic pressure. To release the swing brake, the operator moves the swing brake switch to the "on" position. In this position the swing brake solenoid is energized and hydraulic pressure from the accumulator is allowed to enter the swing brake cylinder, releasing the swing brake. To apply the swing brake, move the swing brake switch to the "off" position. Moving the switch to the off position de-energizes the swing brake solenoid, blocks pressure from the accumulator and allows fluid to flow out of the swing brake cylinder to the reservoir. Oil flowing out of the swing brake cylinder will cause the cylinder to retract and allow springs to apply the swing brake.

HOIST CIRCUIT. The hoist circuit includes the front and rear drum brakes, planetary brakes, brake locks, pawls, and clutch control. This circuit, except for the front and rear drum brake valves, is pressurized through an interlock sole-noid that is energized and de-energized by means of the master switch. When the master switch is "on" the inter-lock solenoid is energized, allowing accumulator fluid to flow to the operator’s module distributor and to the solenoids of the drum brake locks and pawls. When the master switch is in the "off" position, accumulator fluid is blocked at the interlock valve and returns system pressure to tank. This will then allow above mentioned spring set devices to set.

To lift a load the operator moves the brake lock switch to the "off" position, moves the pawl switch to the "off" position and pulls the drum lever back. In these positions, the drum pawl and lock solenoids are energized and hydraulic oil passes from the accumulator to the pawl cylinder and lock cylinder. Oil also flows through the drum control valve, to the drum clutch cylinder. Oil flowing into the drum brake lock cylinder will cause the cylinder piston to extend and re-lease the drum brake. Oil flowing into the pawl cylinder will cause the cylinder piston to extend and release the drum pawl. Oil flowing into the drum clutch cylinder will cause the cylinder piston to extend, applying the clutch and lifting the load.

To stop drum rotation, depress the drum brake pedal and move the drum control lever to neutral. In these positions, hydraulic oil passes from the accumulator, through the drum brake valve, to the drum brake cylinder. Oil will also flow out of the drum clutch cylinder, through the drum con-trol valve, to the reservoir. Oil flowing into the drum brake cylinder will cause the cylinder piston to extend and apply the drum brake to stop rotation of the drum. Oil flowing out of the drum clutch cylinder will cause the cylinder piston to retract and allow springs to release the drum clutch.

Lowering the load can be done by gravity, manipulation of the modulated control, or with planetary lowering. Lower-ing the load by manipulation of the modulated control is the same as lifting the load only the clutch is slipped until the load lowers.

To lower a load by gravity, the operator slowly releases the brake pedal. This allows oil to flow out of the brake cylinder, through the drum brake valve, to the reservoir. Oil flowing out of the brake cylinder will cause the cylinder piston to re-tract, allowing springs to release the drum brake and lower the load.

To power down a load, the operator moves the drum con-trol forward and slowly releases the drum brake pedal. In these positions hydraulic oil passes from the accumulator, through the planetary brake valve, to the planetary brake cylinder. Releasing the brake pedal allows oil to flow out of the brake cylinder, through the brake valve, to the reservoir. Oil flowing into the planetary brake cylinder causes the cylinder piston to extend applying the planetary brake to power down a load. Oil flowing out of the brake cylinder will cause the cylinder to retract, allowing springs to release the drum brake.

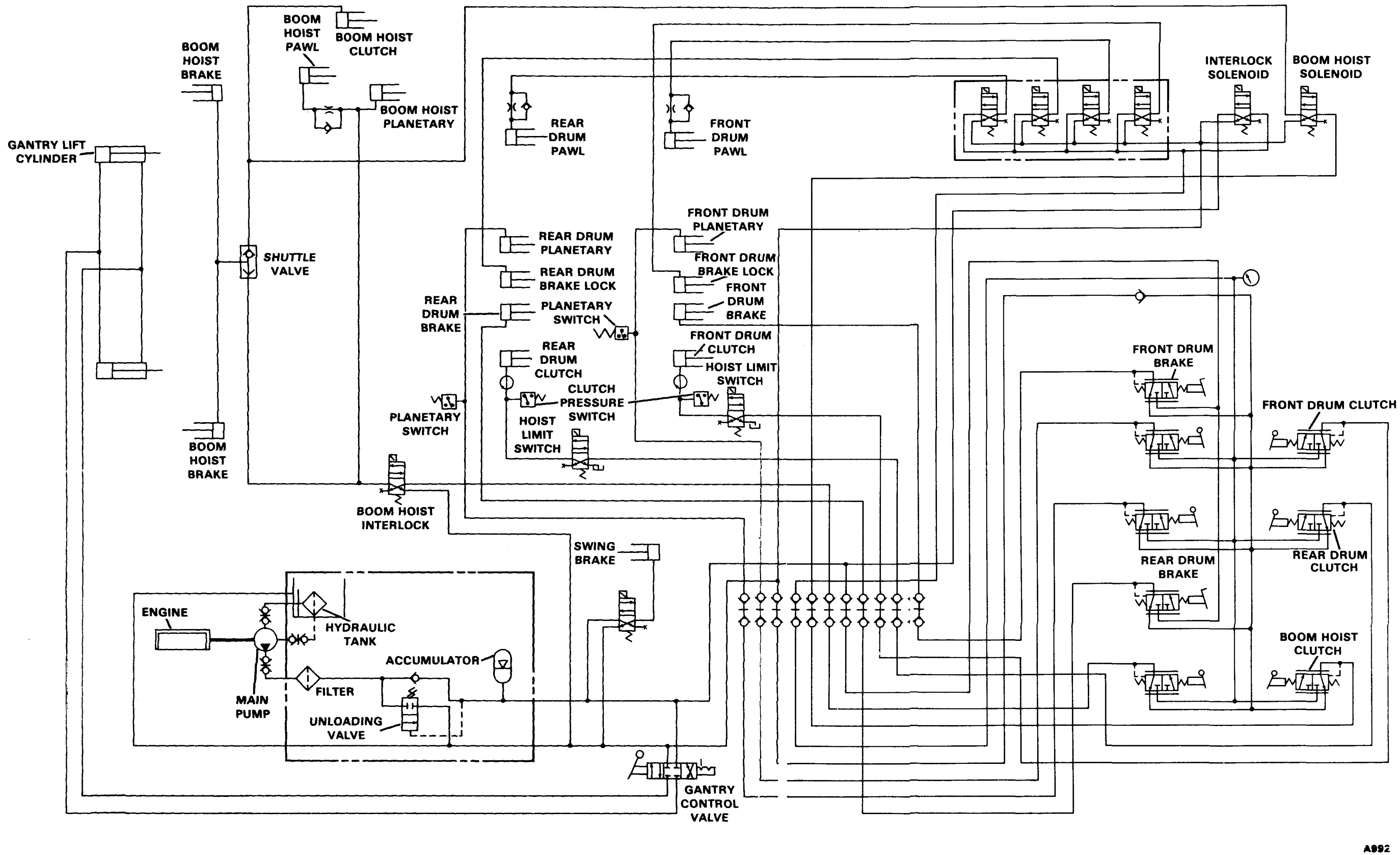


Figure 5A-1. Hydraulic Schematic

PUMPS

GENERAL

This subsection contains the information necessary to remove, disassemble, repair, assemble, and install the pumps used in the hydraulic control system.

PUMP (37Q9)

DESCRIPTION

The pump used in the hydraulic system is of the axial piston, fixed displacement type. Rotation of the pump drive shaft, by means of the torque converter, causes the pistons to reciprocate (move forward and backward alternately) with respect to their cylinder block bores (see Figure 5B-1). This reciprocating action is a result of the angularity be-tween the drive shaft axis of rotation and the plane of the piston shoe bearing surface on the swash plate. Each piston reaches two dead-center positions in one revolution.

As a piston revolves past the top dead-center position (when the piston is nearest the valve plate), it begins to withdraw from the cylinder block bore and make its intake stroke. During a piston's intake stroke, fluid is drawn from the reservoir into the bore through a porting arrangement in the valve plate and the cylinder block.

At the point when the piston reaches bottom dead-center (when the piston is farthest from the valve plate), the intake stroke is completed. This point is 180° from top dead-center. Additional rotation of the cylinder block and piston starts the return (discharge) stroke of the piston toward the valve plate. During the discharge stroke, fluid is forced out of the cylinder block bore, through the outlet port of the valve plate and out to the system.

When the piston again reaches top dead-center, the discharge stroke is completed and a new cycle begins. The pumping cycle descirbed here is made by each piston as the piston and the cylinder block revolve through 3600. Since this unit is a fixed displacement pump, the swash plate angle cannot be varied. Consequently, the output is deter-mined by the pump size and the speed of rotation.

REMOVAL

To remove the pump, proceed as follows (see Figure 5B-2):

1. Shut the engine down and operate the controls until pressure in the system drops to zero.

2. Drain the oil from the control reservoir.

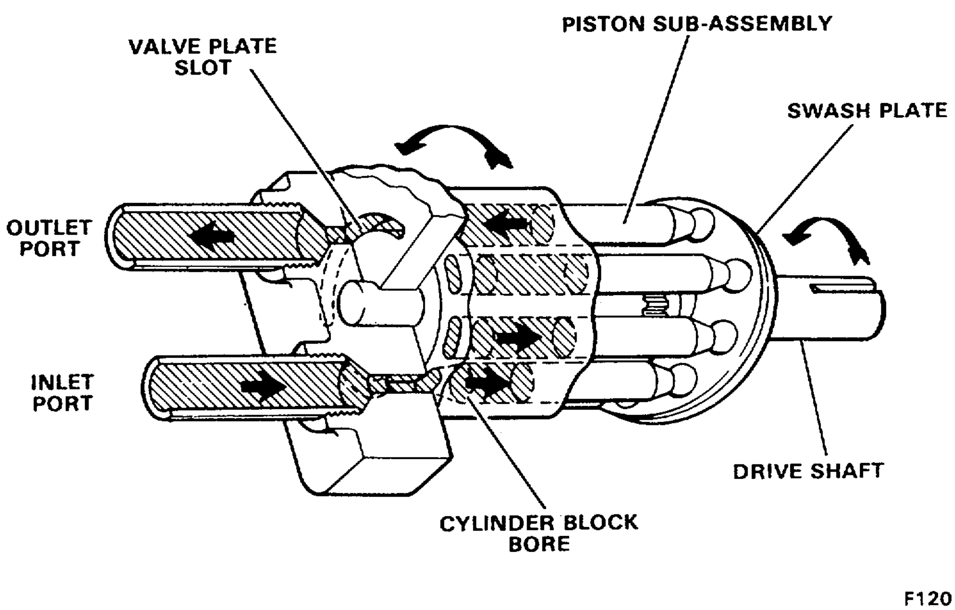


Figure 5B-1. Hydraulic Pump Operation

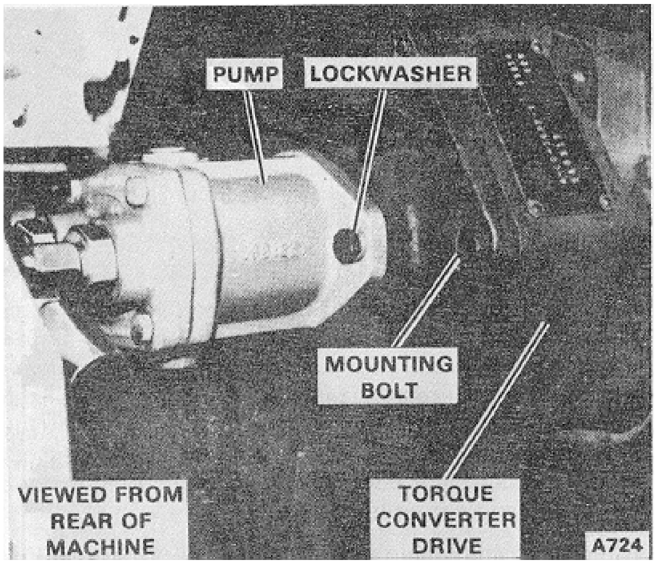


Figure 5B-2. Pump Mounting Assembly.

3. Disconnect and cap the suction, discharge, and drain lines attached to the pump.
4. Remove the pump mounting bolts and lockwashers. Remove the pump.

OVERHAUL

GENERAL. Disassembly should only be attempted on a bench in as clean an area as possible. The workbench, the mechanic's hands, and tools must be clean and the disassembed pump must be protected from airborne dust. During disassembly, pay particular attention to the identification of the parts in order that the pump can be properly reassembled.

DISASSEMBLY. To disassemble the pump, proceed as follows (see Figure 5B-3):

1. Remove the valve plate by removing the four bolts that attach it to the housing. Remove the gasket from the valve plate face.
2. If the valve plate bearing is damaged, remove it with a suitable bearing puller.

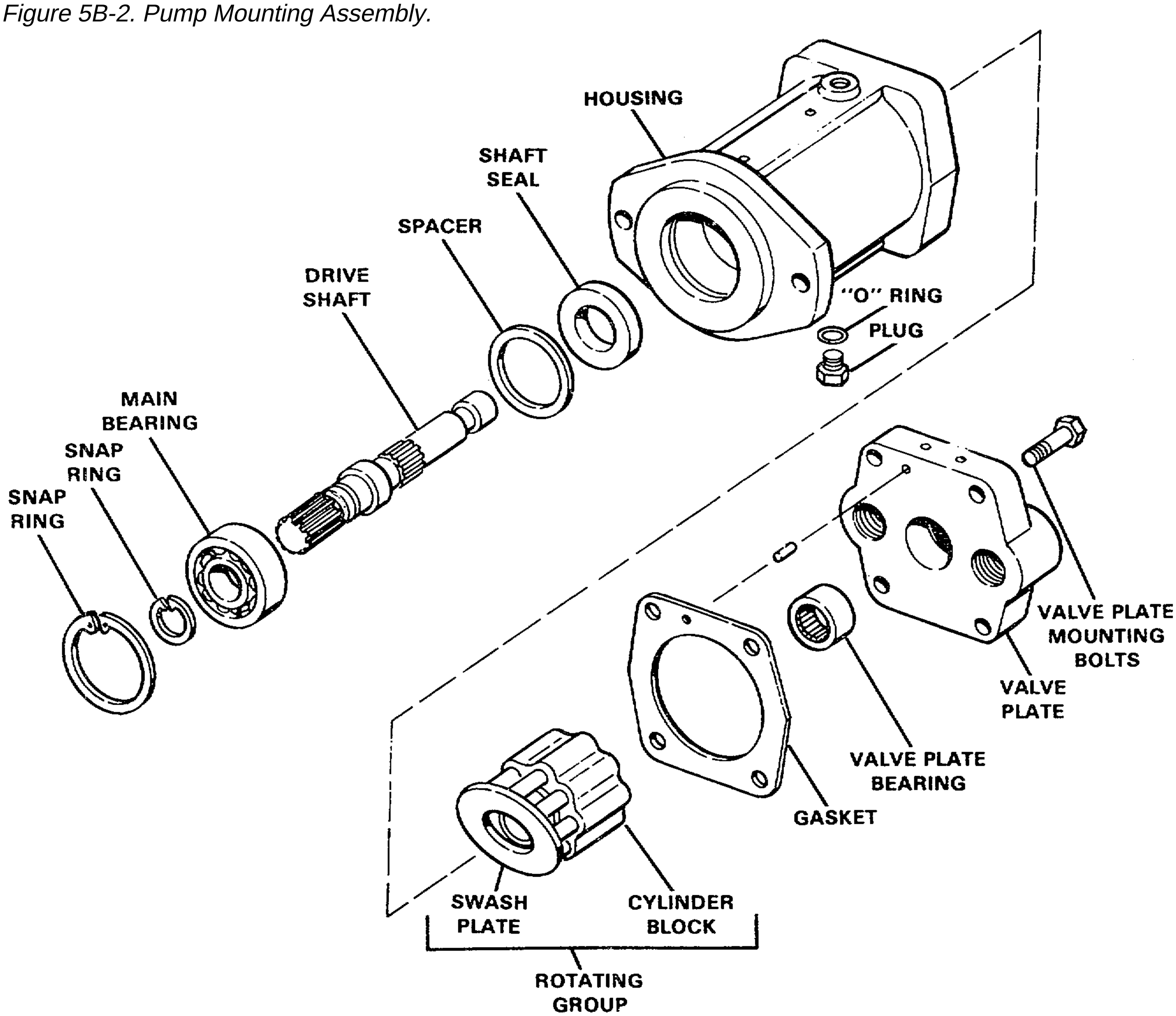


Figure 5B-3. Pump (37Z106)

3. Turn the rotating group slightly to free it from the swash plate. Tilt the housing and remove the rotating group. Be careful not to separate the cylinder block from the rotating group during removal from the housing.

WARNING

Do not disassemble the rotating group. The sudden release of the cylinder block spring can cause bodily injury.

4. To remove the drive shaft, first remove the large snap ring with a snap ring pliers. Then tap the opposite end of the drive shaft with a soft hammer to free the shaft and bearing from the housing. It may be necessary to use a bearing puller to remove the main bearing from the housing.

5. Remove the shaft seal from the housing. Remove the plug and O-ring from the bottom of the housing.

INSPECTION AND REPAIR. Clean the disassembled parts thoroughly with a mineral oil cleaning solvent prior to inspection and after any lapping or machining.

1. Inspect the flat surface of the valve which mates with the cylinder block for wear or scoring. Minor defects can be removed by lightly stoning the surface; however, any lapping should not exceed 0.0004 inches (0.01 mm). Excessive lapping will remove the hardened portion of the surface. Replace the valve plate if damage or wear is excessive. Minor defects on the surface of the cylinder block, that mates with the valve plate, can be removed by light stoning.

2. When parts of the rotating group are worn or damaged, replace the complete group. A kit which includes all the parts of the rotating group is available. The rotating group replacement is preassembled and pretested.

3. Examine the bearing for roughness or excessive play and replace if necessary.

4. Inspect the shaft seal area of the shaft for scoring or wear. Replace the drive shaft if it is bent or excessively worn.

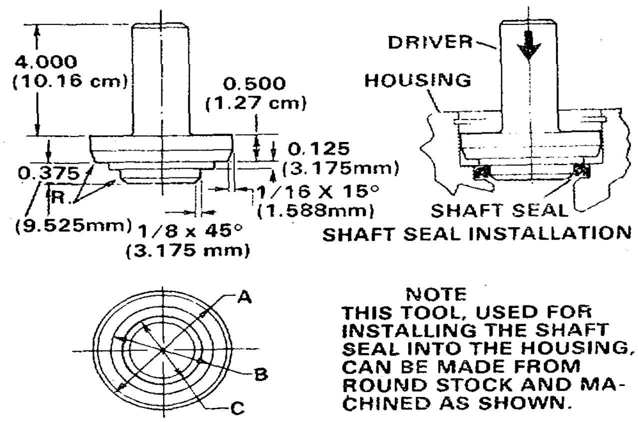
ASSEMBLY. Assembly is basically the reverse of disassembly. Install new gaskets, seals, and O-rings. Coat all parts with clean hydraulic oil to facilitate reassembly and provide initial lubrication.

Assemble the pump as follows (see Figure 5B-3):

1. Install a new shaft seal in the housing using a shaft seal driver, as shown in Figure 5B-4. Place the spacer next to the shaft seal.

2. Make sure that the bearing is half filled with a good grade of high temperature ball bearing grease. Place the bearing on the shaft and install the small snap ring. Then in-stall the drive shaft and bearing into the housing. Secure the bearing with the large snap ring.

3. Install the swash plate with the chamfered edge toward the shaft seal.



ALL DIMENSIONS ARE IN INCHES

PUMP SIZE	DIMENSION		
	A	B	C
5 G.P.M.	2.043 (5.189 cm)	1.625 (4.128 cm)	0.968 (2.459 cm)

F123

Figure 5B-4. Shaft Seal Driver

4. Holding the cylinder block and shoe plate to keep the pins and washers intact; install the rotating group onto the drive shaft. Slightly rotate the rotating group during assembly to align the spherical washer and cylinder block splines with those of the drive shaft.

5. If necessary, install a new valve plate bearing into the valve plate. Attach the valve plate and gasket to the housing with the four mounting bolts. Torque the bolts to 12.5-15 ft-lbs (1.7-2.1 kg-m).

INSTALLATION

To install the pump, proceed as follows:

1. Engage the pump splines with the torque converter drive coupling. Push the pump all the way onto the converter drive and install the mounting lockwashers and bolts. Tighten the bolts securely.

2. Reconnect the pump section, discharge, and drain lines.

3. Refill the oil reservoir to the proper level with the recommended lubricant. Start the engine. Allow the engine to run at idle speed, with no load applied to the hydraulic system, to prime the system.

NOTE

When first starting it may be necessary to bleed air from the pump outlet line to permit priming and re-duce noise. Bleed any air by loosening an outlet con-nection fitting. Allow fluid to flow into a container until a solid stream appears. Retighten the fitting.

4. Run the engine at moderate speed and load for a short period of time. Check the reservoir oil level and add oil if re-quired.

SUBSECTION 5C
CONTROL VALVES

GENERAL

This subsection contains the information necessary to re-pair the directional control valves used to direct hydraulic fluid to the various actuating cyliners.

REMOVAL

Use the following procedure to remove the control valves:

1. Shut off the engine and tag the master switch to warn against starting the engine, or remove the key until the valve is reinstalled.

2. Operate the controls to relieve all pressure in the system.

3. Remove the cover plates, if necessary, to gain access to the valve.

4. Clean the valve to be removed and the fittings on it with a suitable solvent. Dry the fittings and valve with compressed air.

5. Disconnect the hydraulic line at the valve and cap and mark the line. Plug the valve port to prevent the entry of contaminants.

6. Disconnect the control linkage at the rod end.

7. Remove the bolts and lockwashers attaching the valve to the manifold or side stand and remove the valve.

INSTALLATION

Use the following procedure to install the control valves.

1. Install the valve on the manifold or support with the bolts and lockwashers.

2. Remove the protective cap and connect the hydraulic line to the cylinder port.

3. Connect the operating linkage to the control rod.

4. Start the engine and operate the control. Observe the valve for leaks, binding or other problems.

5. Reinstall any cover plates removed.

CONTROL VALVE (36Z316 & 36Z447)

DESCRIPTION. Several of these valves are used to control the clutch and brake cylinders with the exception of the front and rear drum brakes. The valves are mounted beneath the control levers and pedals on a distribution manifold (see Figure 5C-1).

When the valve is engaged, oil is directed to the appropriate actuator. Pressure build up at the actuator creates a back pressure at the valve which shifts the valve spool to the block position (see Figure 5C-2). In this position, oil is pre-vented from flowing to the actuator until the control lever position is changed or the pressure within the system changes. When the control lever is returned to the neutral position, pressurized oil is blocked and the oil at the actuator is allowed to return to the reservoir.

REMOVAL. To remove the valve refer to the topic, Removal, earlier in this subsection.

DISASSEMBLY. To disassemble the valve, proceed as follows (see Figure 5C-3):

1. Peel back the rubber boot and remove the stem attached to the control rod. Discard the rubber boot.

2. Using a small, thin blade screwdriver, remove the lock ring from the valve body. With the lock ring removed, pull the rod assembly out of the valve body.

3. Tip the valve and remove the spool assembly.

4. Remove the valve gland from the rod by sliding it off the eyebolt end. Also remove the spring, small washers and large washer from the rod.

NOTE

Some models of this valve have only one small washer and no large washer on the rod.

5. Remove the spring and spring block from the spool assembly. Remove the small snap ring from the inside of the spring guide to separate the spring guide from the spool.

6. Remove the large outer O-ring, the inner seal ring and the lip seal from the valve gland.

INSPECTION AND REPAIR. Inspect the spool and spool bore for excessive wear, nicks or scratches. If either of these parts is damaged, the entire valve must be replaced. Inspect all parts for cracks and distortions. Replace parts which are questionable. The seals and O-rings should be renewed upon assembly.

NOTE

A repair kit is available. See the Replacement Parts Manual.

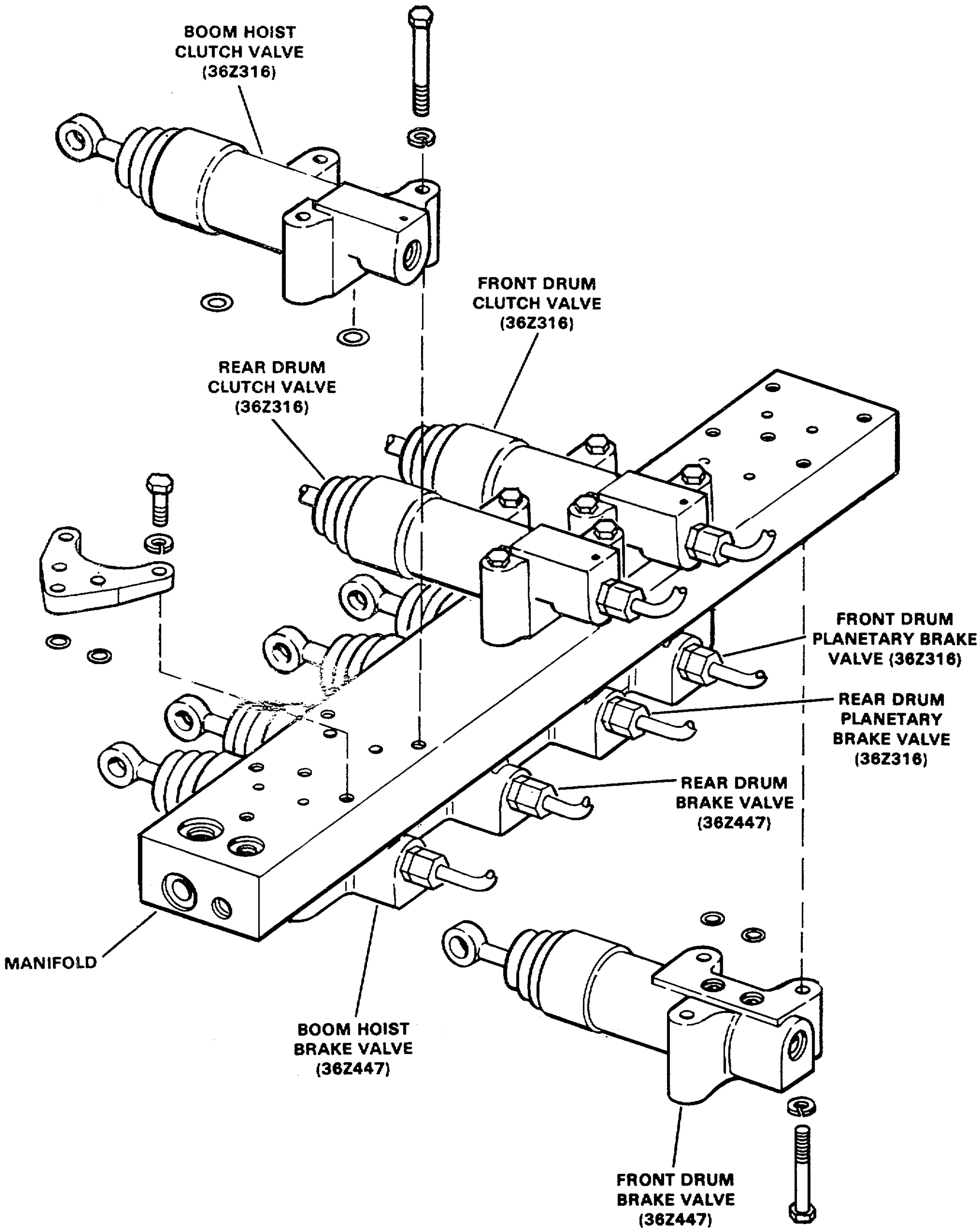


Figure 5C-1. Control Valve Removal

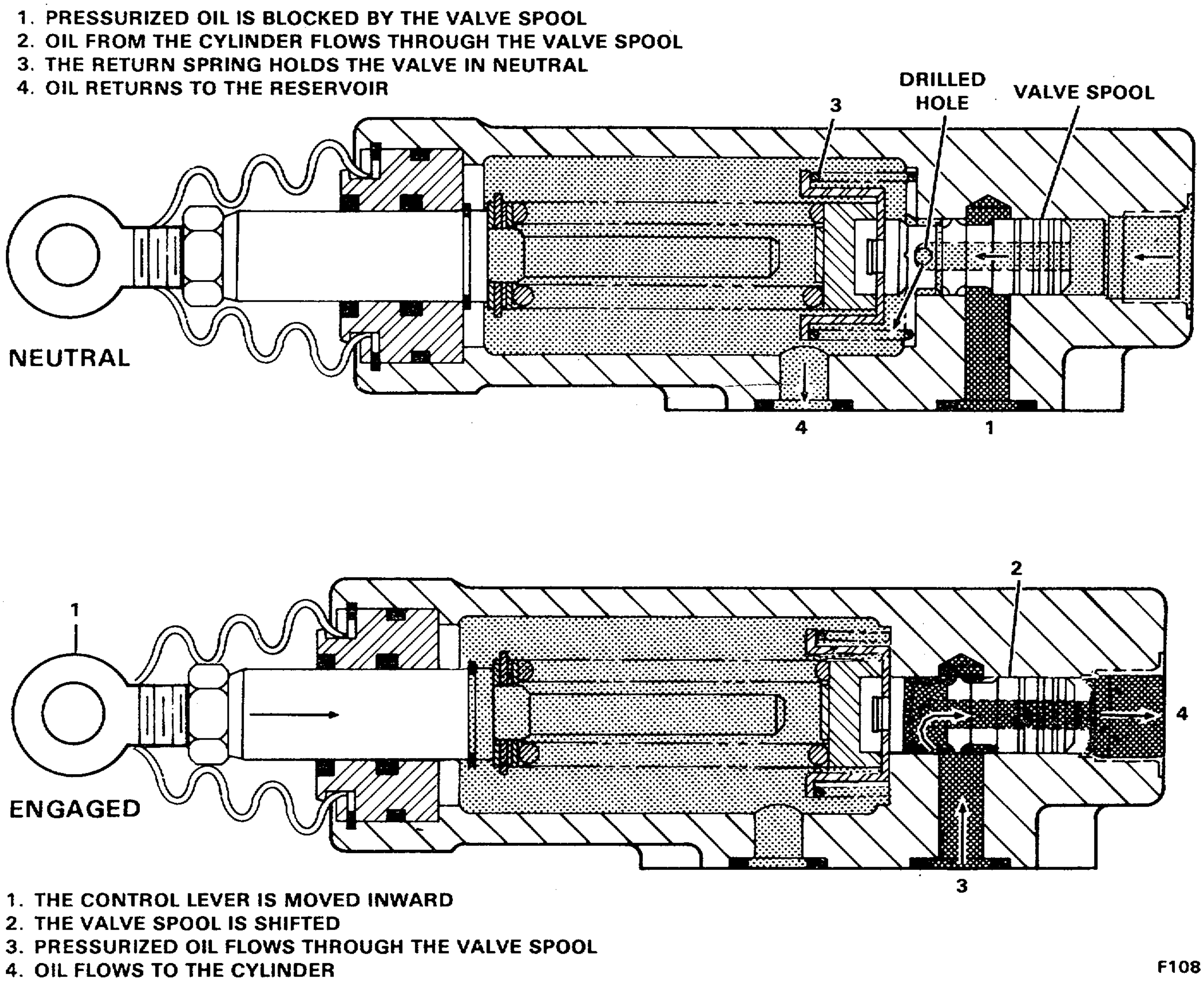


Figure 5C-2. Control Valve Operation (36Z316 & 36Z447)

Wash all parts in a suitable solvent and dry with compressed air.

ASSEMBLY. To reassemble the valve, proceed as follows (see Figure 5C-3):

1. Generously coat all parts to be assembled with hydraulic oil.

2. Attach the spring guide to the valve spool with the small snap ring. Also install the spring block into the spring guide and place the spring on the spring guide.

3. Tip the valve body up so the cylinder port faces up and install the spool assembly into the valve body. Do not tip the valve body so the cylinder port faces down and drop the spool assembly into the valve body. Damage to the spool and valve body could result.

4. Install the large O-ring on the valve gland. Insert the seal ring and lip seal in the valve gland.

5. Install the snap ring on the rod. Slide the valve gland on the rod.

6. Install one small washer, then the large washer and then the other small washer on the rod. Place the control spring on the rod.

7. Install the assembled rod into the valve body.
8. Push the rod down and install the lock ring.

9. Install a new boot on the stem and thread the stem into the rod. Tighten the stem to the rod using the jam nut. Slip the boot over the shoulder of the valve body.

10. Install new O-rings into the pressure and return ports of the valve body.

INSTALLATION. To install the valve, refer to the topic, Installation, earlier in this subsection.

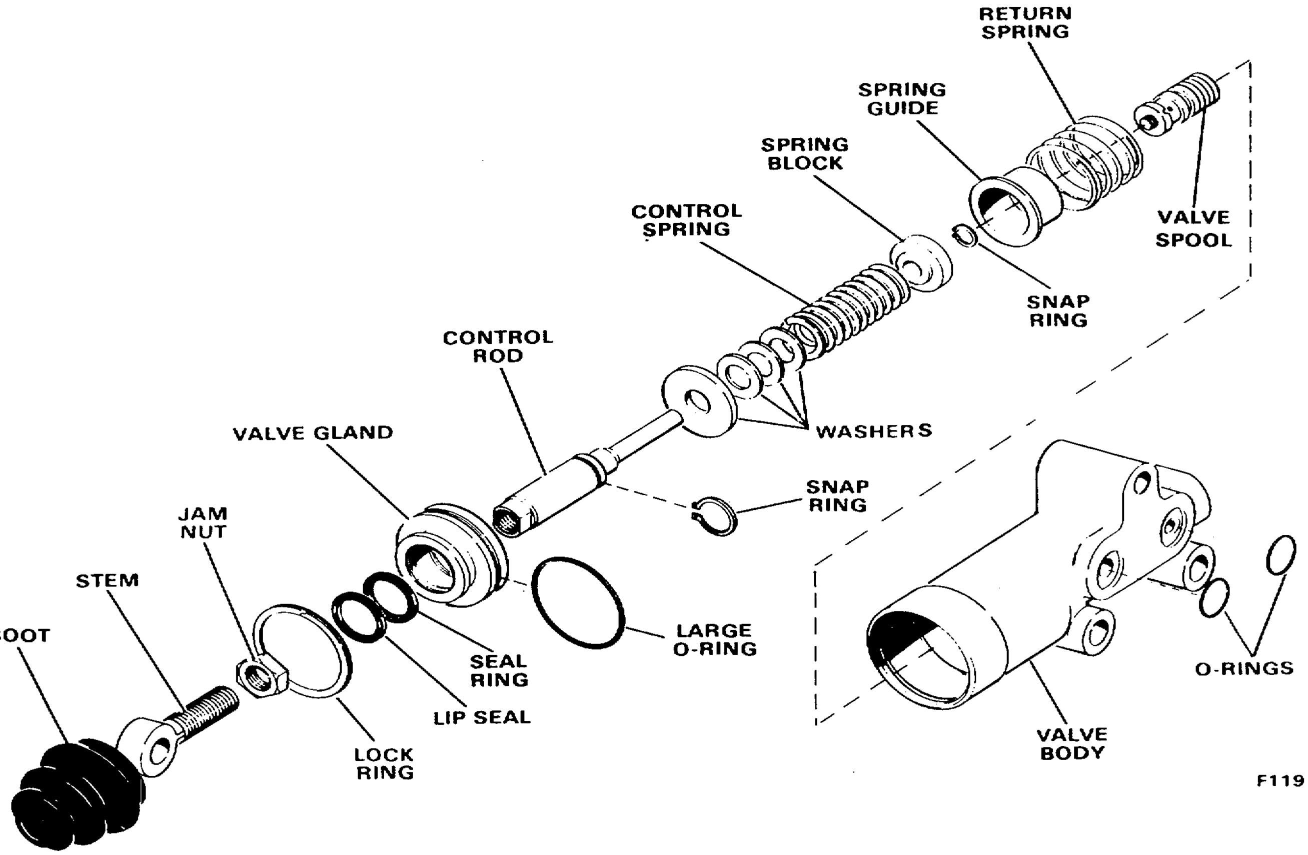


Figure 5C-3. Control Valve (36Z316 & 36Z447)

CONTROL VALVE (36Z938 & 36Z506)

DESCRIPTION. This is a 4-way, 3-position, rotary selector valve used to control the gantry assist lift cylinders.

REMOVAL. To remove the valve, refer to the topic, Removal, earlier in this section.

DISASSEMBLY. To disassemble this valve, proceed as follows (see Figure 5C-4):

1. Remove screws (03) and lockwashers (04). Pull body (22) from housing (05).

2. Remove O-ring (18) from body (22). Remove O-ring (20), shear seal seat (1 9), and washer (21)from each port of body (22).

3. Slowly remove shaft (16) from housing (05). Remove O-ring (17) from shaft (16).

4. Remove rotor (15), disc (14), thrust bearing (13), and thrust washer (12) from housing (05).

5. Remove detent ball (08) and spring (07) from housing (05).

INSPECTION AND REPAIRS. Inspect shaft (16), body (22), and housing (05) for excessive wear, nicks, or scratches. If any of these parts are damaged the entire valve must be replaced.

Inspect all parts for cracks or distortions. Replace parts which are questionable. All O-rings and seals should be re-placed upon assembly.

NOTE

A service kit is available. See the Replacement Parts Manual.

Wash all parts in a suitable solvent and dry with compressed air.

ASSEMBLE. To reassemble the valve, proceed as follows (see Figure 5C-4):

1. Generously coat all parts to be assembled with hydraulic oil.

2. Install spring (07) and ball (08) into housing (05).

3. Place thrust washer (12) over ball (08) and stop pin (09). Set thrust bearing (13) on thrust washer (12).

4. Set disc (14) and rotor (15) on bearing (13).

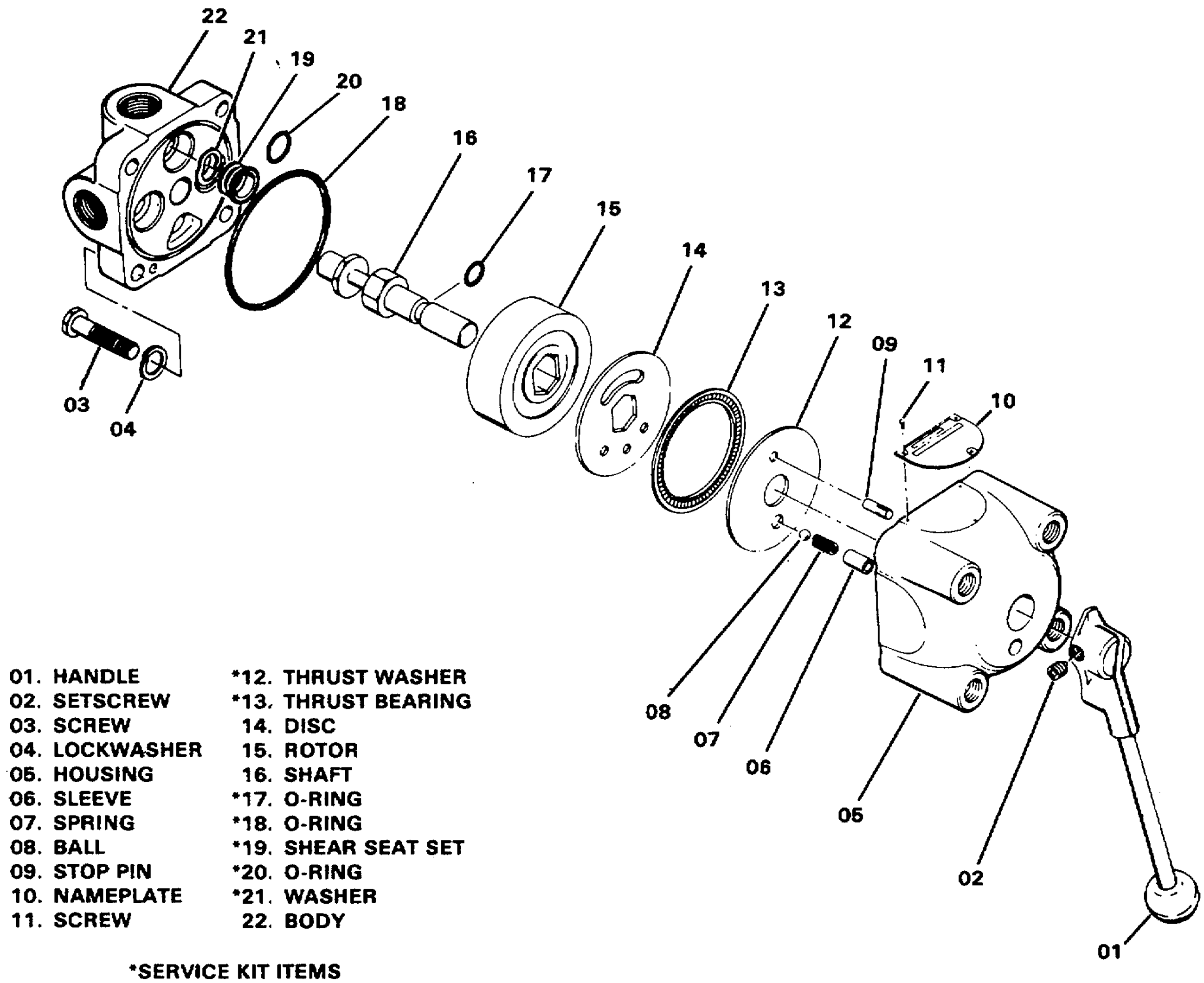


Figure 5C-4. Control Valve (36Z938 & 36Z506)

5. place O-ring (17) on shaft (16) and slowly install shaft (16) through the items just installed.

6. In each port of body (22) install one washer (21), shear seal seat (19), and O-ring (18) into the groove of body (22).

7. Line up body (22) with housing (05) and install lock-washers (04) and screws (03). Securely tighten screws (03).

INSTALLATION. To install the valve, refer to the topic, Installation, earlier in this section.

SUBSECTION 5D
HYDRAULIC COMPONENTS

GENERAL

This subsection contains information on repairing the balance of the system components including the accumulator, unloading valve, actuating cylinders, relief valves, limit devices, shuttle valves, swivels, and rotary joints.

GENERAL REMOVAL

Prior to removing any of the components in this section shut down the engine to prevent operation of the machine while the item is being serviced. Operate the controls to relieve all pressure in the system and also clean the area around the item being removed to prevent the entry of contaminants.

UNLOADING VALVE (36Z1266)

DESCRIPTION. The function of the unloading valve is to keep system pressure within preset limits. Pump pressure is used to charge up the accumulator, which acts as a pres-sure storage reservoir. When a preset upper pressure is reached the unloading valve directs the pump flow back to the reservoir at atmospheric pressure. Each time a hydrau-lic valve is operated, oil from the accumulator is used and system pressure begins to fall until a preset low limit is reached. At this point, the unloading valve will direct the flow of oil from the pump to the accumulator to recharge the system.

The unloading valve is located below the hydraulic reservoir on the hydraulic units panel (see Figure 5D-1). This valve is considered non-repairable. If the valve is faulty, the complete valve should be removed and replaced with a new valve.

REMOVAL. To remove the valve, proceed as follows:

1. See General Removal at the beginning of this section.

2. Disconnect the hydraulic lines at the valve and position the lines to avoid interference as the valve is removed. Cap the lines to prevent the entry of contaminants.

3. Remove the three capscrews an lockwashers attaching the valve to the hydraulic units panel.

4. The valve can now be removed.

INSTALLATION. To install valve, proceed as follows:

1. Line up the valve with the three holes in the hydraulic units panel. Install and fully tighten the three capscrews and lockwashers.

2. Remove the protective caps and connect the hydraulic lines to the pressure, tank and pilot ports.

3. Start the engine and observe the valve for leaks. Allow the engine to run for several minutes and then check the pressure gauge in the operator's cab to see that system op-erating pressure reaches 1550 to 1650 psi (106.9 to 1 13.8 bars). When system operating pressure is reached, operate the controls until pressure drops. When minimum pres-sure of 1550 psi (106.9 bars) is reached the unloading valve should close and again recharge the system.

ACCUMULATOR (45U47)

DESCRIPTION. This is a one gallon, nitrogen charged, bladder type accumulator, which acts as a pressure storage reservoir (see Figure 5D-2). It helps eliminate rapid cycling of the unloading valve to prevent overheating of the oil and it smooths out pressure surges in the system.

Hydraulic oil from the pump is supplied to the accumulator until operating pressure is reached. This hydraulic oil in the accumulator is supplied to the control valves the instant a control valve is operated. When the accumulator is properly charged, the pressure gauge will show a gradual de-crease in pressure when the control valves are actuated. When minimum pressure is reached, the pump will again charge the accumulator to operating pressure. The pres-sure gauge will also show a gradual decrease in pressure when the engine is turned off.

The most important function of the accumulator occurs in the event of pump or unloading valve malfunction. If the pump or unloading valve malfunctions, the stored oil in the accumulator will enable the operator to make several clutch or brake engagements, thus allowing him to get the load to the ground.

MAINTENANCE. This accumulator is considered non-repairable. If the accumulator is faulty, it may be due to loss of percharge pressure or it may be due to a defective bladder or housing. If the housing or bladder is faulty, the complete ac-cumulator must be removed and replaced with a new accumulator.

REMOVAL. To remove the accumulator, proceed as follows:

1. See General Removal at the beginning of this section.

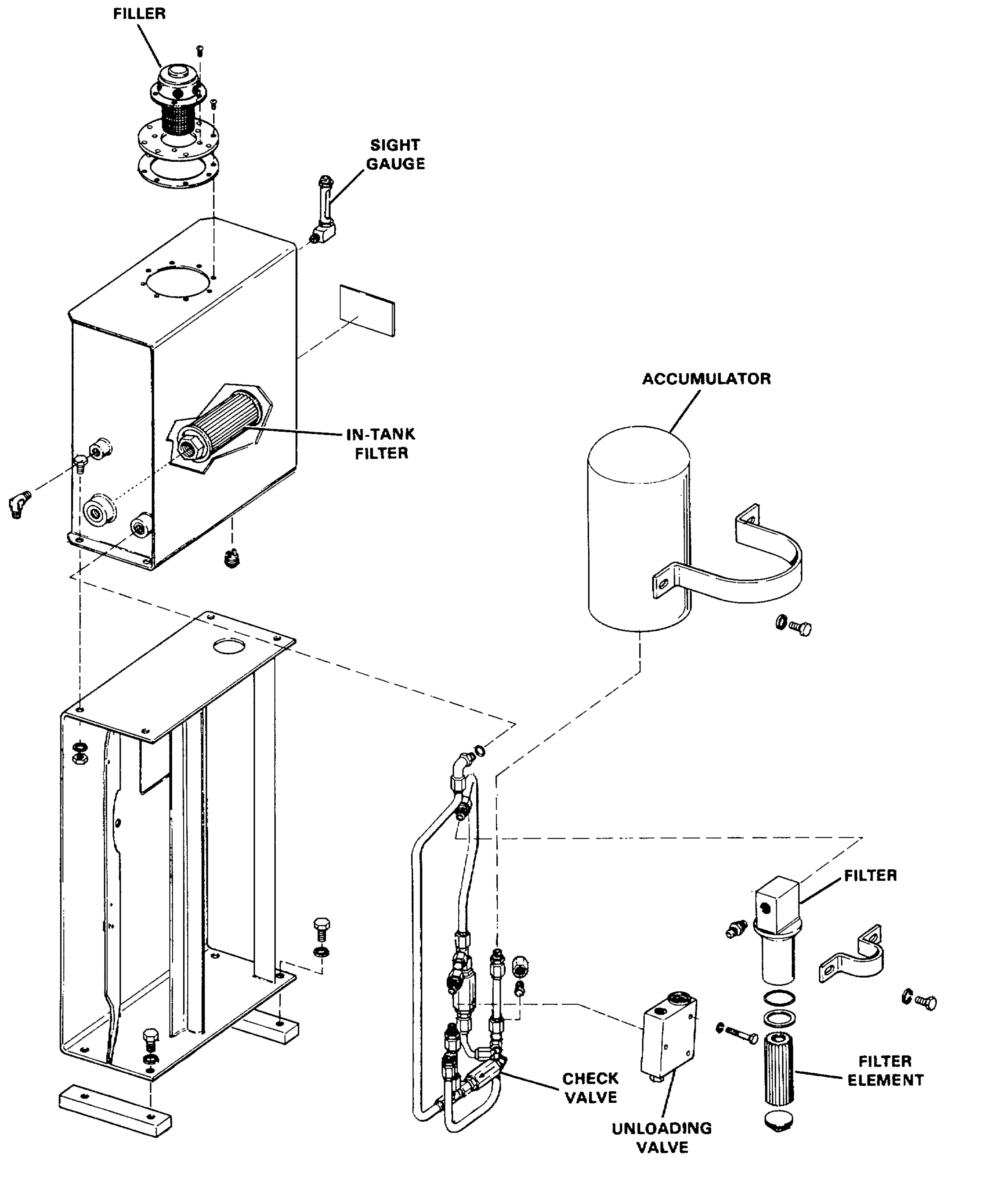


Figure 5D-1. Hydraulic Units Panel

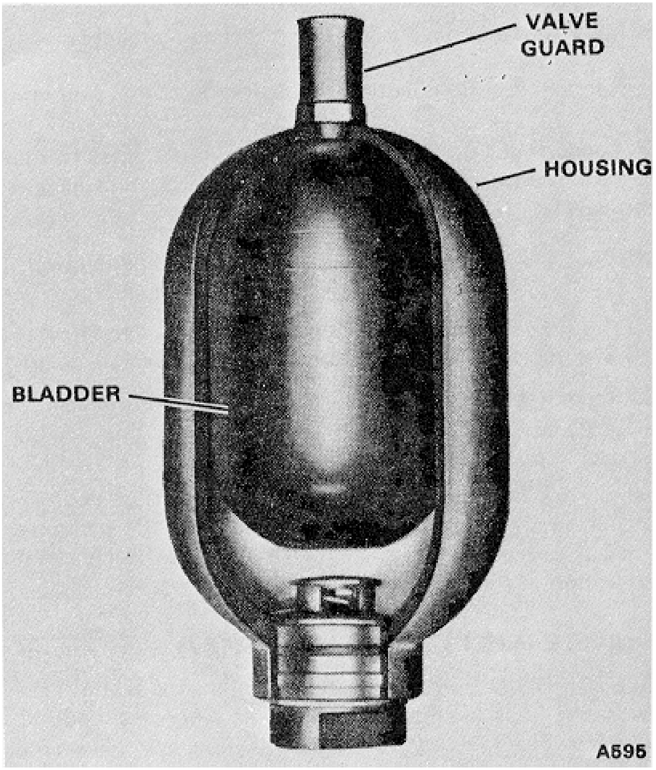


Figure 5D-2. Accumulator (45U47)

2. Disconnect the hydraulic line at the accumulator and position the line to avoid interference as the accumulator is removed. Cap the line to prevent the entry of contaminants.

3. Remove the two capscrews and lockwashers attaching the accumulator and clamp to the hydraulic units panel.

4. The accumulator can now be removed.

INSTALLATION. To install the accumulator, proceed as follows:

1. Line up the clamp and accumulator with the two holes in the hydraulic units panel. Install and fully tighten the two lockwashers and capscrews.

2. Remove the protective cap and connect the hydraulic line to the accumulator.

3. Start the engine and observe the accumulator for leaks. Also, see that the accumulator charges to full operating pressure.

PRECHARGING PROCEDURE. There are two conditions under which the accumulator precharge pressure should be checked. The first is when a new accumulator is instal-led and the second is when it is found that the reason for a faulty accumulator is the loss of precharge pressure. The accumulator is precharged with oil pumped nitrogen, only, to 700 + 25 psi (48.3 + 1.7 bars) at room temperature, 70°F (21 C). A precharging kit (45Z232) is available from Harnischfeger for performing this operation.

Precharge the accumulator with the precharging kit as follows (see Figure 5D-3):

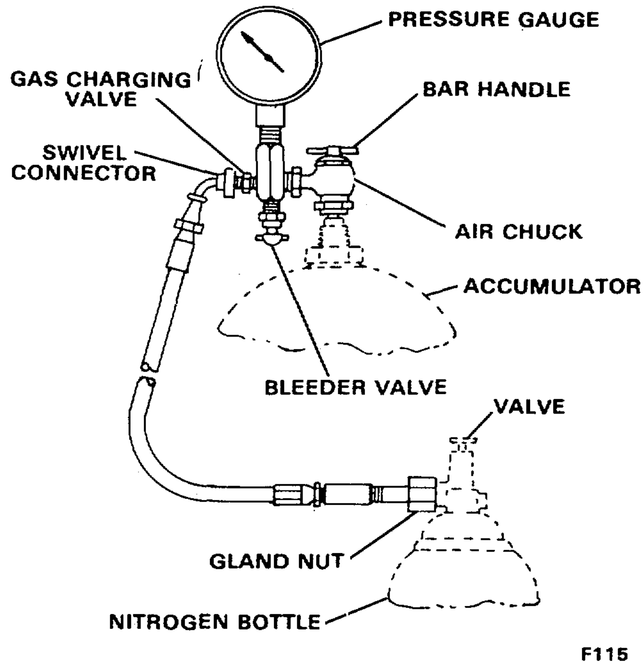


Figure 5D-3. Gauging Head Installation

1. Remove the valve guard and valve cap from the accumulator.

NOTE

To read or adjust the precharge pressure, hydraulic fluid must be completely drained from the fluid side of the accumulator.

2. To mount the gauging head, retract the shaft in the air chuck by turning the bar handle counterclockwise until it stops. Mount the swivel of the air chuck on the accumula-tor's gas valve stem, compressing the gasket in the swivel to prevent gas leakage. Turn the bar handle clockwise until the shaft depresses the valve core in the gas valve of the accu-mulator.

3. Mount the gland nut of the hose assembly on the nitrogen bottle.

4. Remove the cap from the gas charging valve and attach the swivel connector of the hose assembly. Hand tighten sufficiently to compress the gasket in the swivel connector in order to prevent gas leakage.

5. Proceed to inflate the accumulator to 700 + 25 psi (48.3 + 11.7 bars) by opening the valve on the nitrogen bottle slowly, closing it occasionally to allow the needle of the pressure gauge to settle in position, thus giving an accurate reading of the precharge pressure. When the correct precharge has been reached, close the valve in the nitro-gen cylinder securely.

6. The bleeder valve can be used to let out any gas pressure in excess of desired precharge.

7. Retract the shaft of the air chuck by turning the bar handle counterclockwise to the full stop position before disconnecting the swivel, thereby preventing excess leakage

of gas from the accumulator. Remove the chuck from the accumulator gas valve stem.

8. The charging and gauging assembly may either be coiled around the nitrogen cylinder or the assembly may be re-moved from the cylinder and stored.

9. Check the accumulator gas valve assembly for leaks with a soapy water solution or oil. If the valve core is leaking, depress the valve once or twice to reseat the core.

10. Replace the accumulator gas valve cap and tighten one-half turn beyond hand tightness.

11. Replace the accumulator valve guard.

12. Check for precharge loss within one week after installation.

SHUTTLE VALVE (36Z1 171)
DESCRIPTION. Shuttle valves are used in several places in the system to direct the flow of hydraulic fluid into a com-mon line from either of two other lines. When pressurized oil is available at either of the side ports, the floating piston (shuttle) moves to the opposite side of the valve to close the opposite side port. Oil is allowed to flow out the top port to a common line.

REPAIRS. The shuttle valve is considered non-repairable. If the valve is faulty, the complete valve should be removed and replaced with a new valve.

REMOVAL. To remove the valve, proceed as follows:

1. See General Removal at the beginning of this section.

2. Disconnect the hydraulic lines at the valve and position the lines to avoid interference as the valve is removed. Cap the lines to prevent the entry of contaminants.

3. Remove the two capscrews which secure the valve. The valve can now be removed.

INSTALLATION. To install the valve, proceed as follows:

1. Position the valve and install the two capscrews. Fully tighten the capscrws to secure the valve.

2. Remove the protective caps and connect the hydraulic lines to the valve.

3. Start the engine and operate the controls. Observe the valve for leaks, binding or other defects.

FLOW CONTROL VALVE (36Z883)
DESCRIPTION. This is a meter-out flow control valve used to control the front and rear drum pawls. It allows the drum pawls to disengage rapidly, but slowly engages them.

REPAIRS. The flow control valve is considered non-repairable. If the drum pawl is engaging rapidly and the problem is traced to this valve it should be removed and replaced with a new one.

REMOVAL. To remove this valve, proceed as follows:
1. See General Removal at the beginning of this section.

2. Loosen, but do not remove, the hydraulic lines to the valve to relieve any pressure. Remove the lines and discard the valve.

INSTALLATION. To install this valve, proceed as follows:
1. The flow direction is stamped on the valve. Free flow is toward the drum pawl cylinder.

2. Reconnect the hydraulic lines as indicated in step 1.

3. Start the engine and operate the appropriate drum pawl switch. Observe the operation of the pawl. If it engages rapidly and disengages slowly, the valve may have been installed improperly. It this is so, disconnect the hydraulic lines and reverse the connections to the valve. Recheck the operation of the pawl.

SWIVELS (44Q137, 44Z474 & 45Z467)
DESCRIPTION. Swivels are provided at the input end of the hydraulic lines to clutches and brakes wherever required. The swivel allows hydraulic fluid to flow into a rotating member to apply a clutch or brake.

REPAIRS. The swivel is considered non-repairable. If the swivel is faulty the complete swivel should be removed and replaced.

REMOVAL. To remove the swivel, proceed as follows:
1. See General Removal at the beginning of this section.

2. Disconnect the hydraulic line at the swivel and position the line to avoid interference as the swivel is removed. Cap the line to prevent the entry of contaminants.

3. Remove the swivel by backing it out of the shaft.

INSTALLATION. To install the swivel, proceed as follows:
1. Install the O-ring on the swivel. Thread and tighten the swivel into the shaft.

2. Remove the protective cap and connect the hydraulic line to the swivel.

3. Start the engine and operate the controls. Observe the swivel for leaks.

BRAKE, CLUTCH, AND PAWL CYLINDERS (38U34, 38U39, 38U45 & 38U104)
REMOVAL. To remove the actuating cylinder, proceed as follows:

1. See General Removal at the beginning of this section.

2. Disconnect the hydraulic line to the cylinder. Cap the line and install a dust cap in the cylinder to prevent the entry of contaminants.

3. Relieve any tension on the brake, clutch or pawl operating mechanism springs. Remove the linkage from the yoke or eyebolt end of the cylinder.

NOTE

See the particular brake, clutch or pawl instructions on how to relieve spring tension in the operating mechanism and how to remove the linkage from the yoke or eyebolt.

4. Remove the capscrew and lockwasher securing the cylinder to the operating mechanism.

DISASSEMBLY. Use the following procedure to disassemble the cylinder (see Figure 5D-4):

1. Remove the piston and spring from the cylinder body.

2. Remove the seals, back-up rings, and the O-ring from the cylinder body. Note the position of the seals when re-moving them.

INSPECTION AND REPAIRS. Inspect the piston and cylinder bore for excessive wear, nicks or scratches. If either of these parts are damaged, the entire cylinder must be repaired.

NOTE

A service kit is available. See the Replacement Parts Manual.

ASSEMBLY. To reassemble the cylinder, proceed as follows (see Figure 5D-4):

1. Generously coat all parts to be assembled with hydrau-lic oil.

2. Install the inner seal, larger diameter back-up ring, 0-ring, small diameter back-up ring, and outer seal.

NOTE

Cylinders (38U34 and 38U104) have a metal and rub-ber outer seal. Cylinders (38U39 and 38U45) have a rubber outer seal.

3. Install the spring and piston in the cylinder body.

INSTALLATION. To install the actuating cylinder, proceed as follows:

1. Secure the cylinder to the operating mechanism with the lockwasher and capscrew.

2. Attach the linkage to the yoke or eyebolt end of the cylinder.

3. Remove the dust cap from the cylinder and remove the cap from the hydraulic line. Connect the hydraulic line. Connect the hydraulic line to the cylinder.

4. Bleed the hydraulic cylinder to remove any air trapped in the hydraulic line. See Bleeding Procedure in this section to bleed the cylinder.

5. Start the engine and operate the controls. Observe the cylinder for leaks, binding and proper operation.

GANTRY LIFT CYLINDER (38Z269)

REMOVAL. To remove this cylinder, proceed as follows:

1. See General Removal at the beginning of this section.

2. Disconnect the hydraulic lines at the cylinder. Cap the lines and plug the cylinder ports to prevent the entry of con-taminants.

3. Remove the cotter pins and pin that secures the cylinder to the revolving frame anchor.

4. Maneuver the cylinder out of the protective boot and out of the machine.

DISASSEMBLY. Use the following procedure to disassemble the cylinder (see Figure 5D-5):

1. Use a spanner wrench, or brass drift and hammer, to unscrew the cylinder head from the cylinder body. Remove the entire rod assembly.

2. Remove the locknut and piston from the cylinder rod.

3. Remove the piston seals from the piston. Note the positioning of the seals so that they may be reinstalled properly..

4. Remove the cylinder head from the cylinder rod.

5. Remove the wiper seal, head and rod seals, and the back-up washer from the head. Note which way the lips of the seals face so that they may be reinstalled properly.
INSPECTION AND REPAIR. Inspect the cylinder rod, piston, head, and cylinder body bore for excessive wear, nicks, or scratches. If any of these parts are damaged, the entire cylinder must be replaced.

NOTE

A repair kit is available. See the Replacement Parts Manual.

ASSEMBLY. To reassemble the gantry lift cylinder, proceed as follows (see Figure 5D-5):

1. Generously coat all parts to be assembled with hydraulic oil.

2. Assemble the wiper seal, head and rod seals, and the back-up washer on the head. Slide the cylinder head assembly onto the cylinder rod.

3. Install the piston seals on the piston. The lips of the outer seals should face the locknut and head.

4. Slide the piston on the cylinder rod and secure in place with the locknut.

5. Install the rod assembly into the cylinder body bore. Screw the cylinder head on the cylinder body using a spanner wrench.

INSTALLATION. To install a gantry lift cylinder, proceed as follows:
1. Position the cylinder into the boot and line it up with the anchor on the revolving frame. Install the pin and cotter pins.

2. Remove the dust caps from the cylinder and the plugs from the hydraulic lines. Connect the lines to the cylinder.

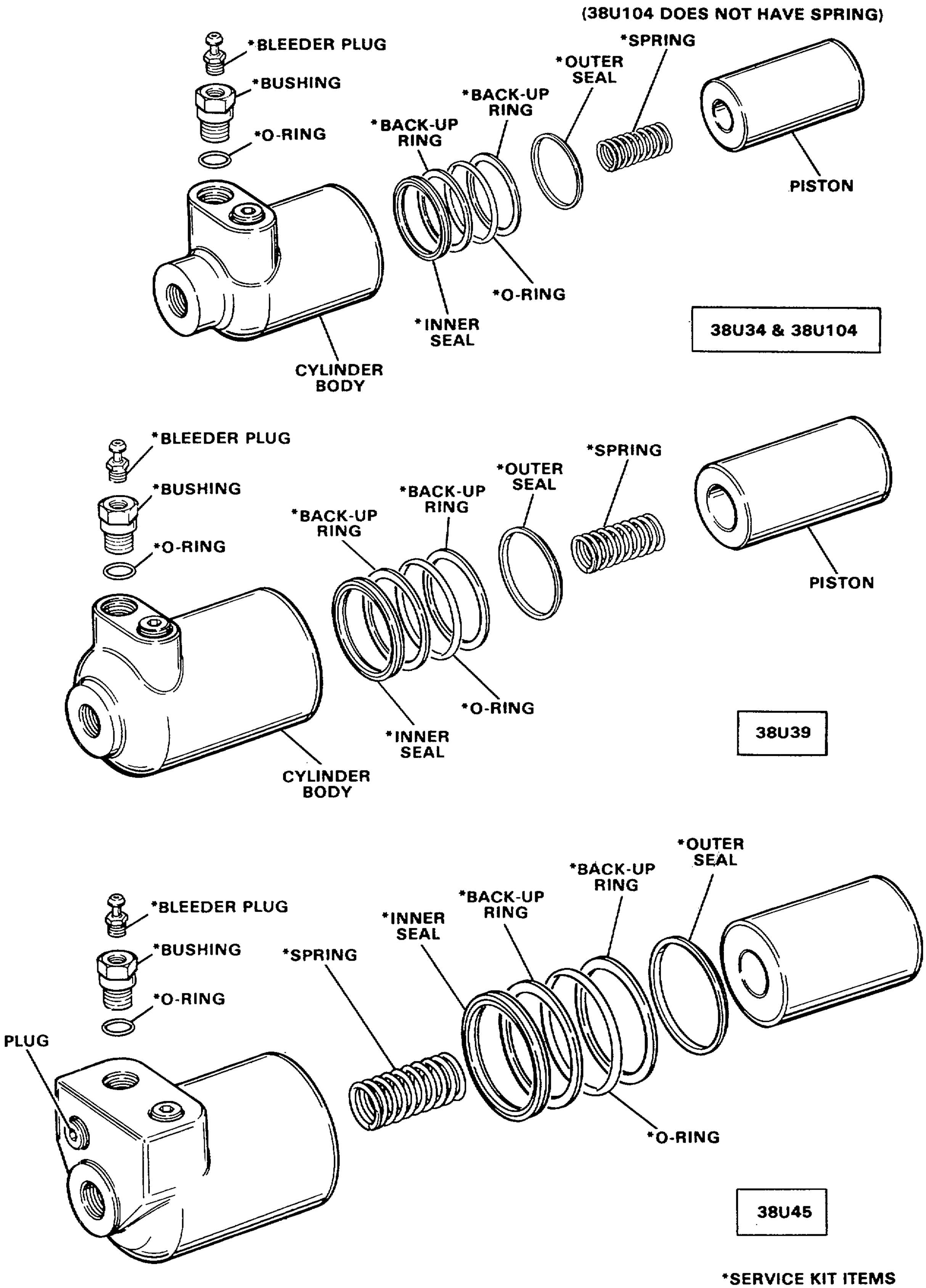


Figure 5D-4. Actuating Cylinders

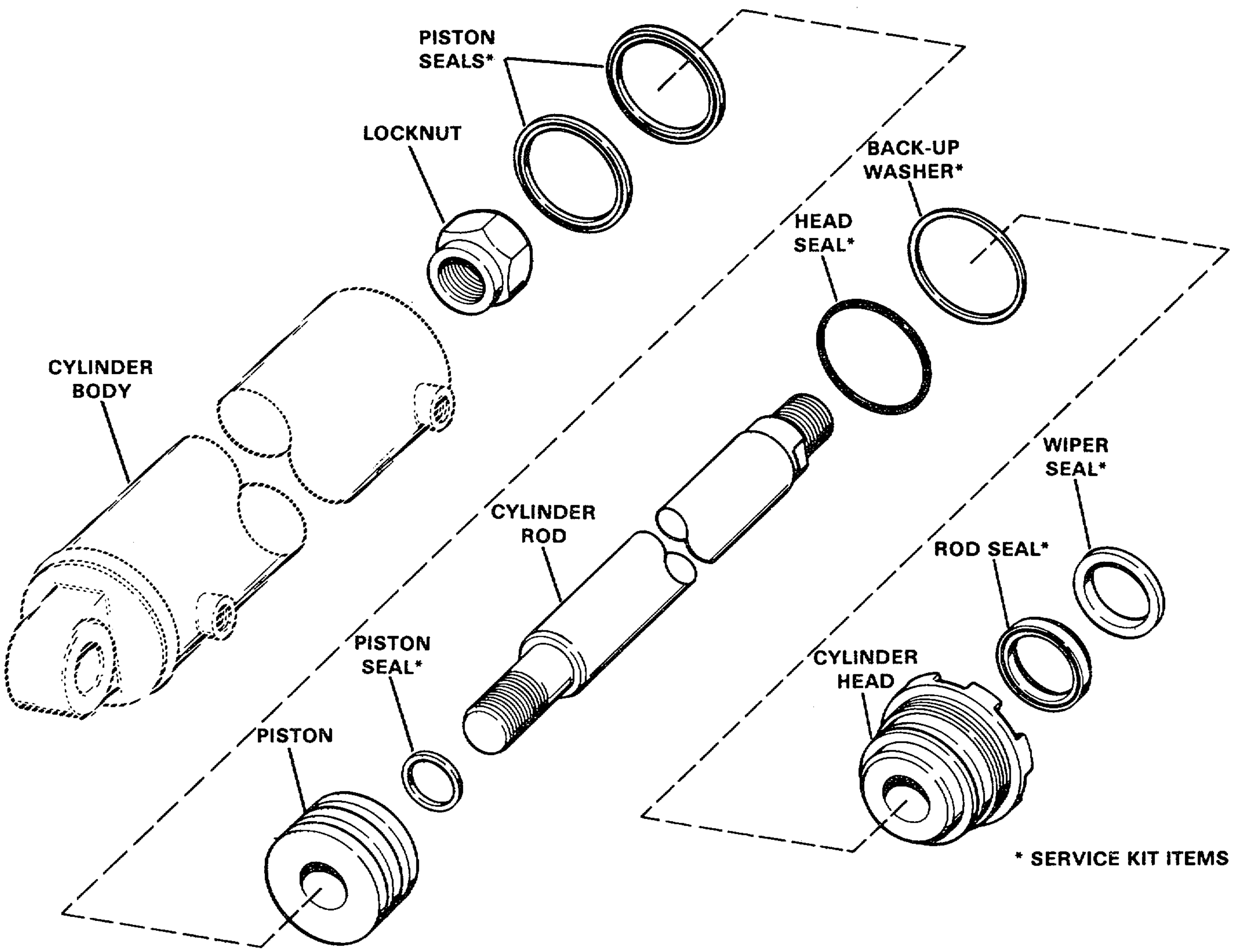


Figure 5D-5. Cylinder (38Z269)C

3. Start the engine and operate the gantry control valve to extend and retract the cylinder rod. Observe the cylinder for leaks, binding and proper operation.

SOLENOID VALVE (36Z1349 & 36Z1423)

DESCRIPTION. Each unit is a 4-way, 2 position, spring off-set, solenoid operated valve. These valves are located on a panel directly behind the operator's module and on the upper deck.
In the energized position, oil flow is from the pressure port, through the valve and to the cylinder port to allow oper-ation of the brake, clutch or the controls system.

In the de-energized position (spring offset), the pressure port is blocked. Oil flow is from the cylinder port to the exhaust port and then to the reservoir.

A manual plunger is provided at the end of the solenoid coil so the valve can be shifted manually in the event of an elec-trical malfunction.

Four valves, mounted on a single manifold, function as front and rear drum pawl valves, and as front and rear drum lock valves. These four valves control the pawls and locks on the front and rear drums. There are four valves mounted inde-pendently and function as the swing brake valve, interlock solenoid, boom hoist interlock and boom hoist solenoid.

TROUBLESHOOTING. The table and maintenance hints that follow are of a general nature, but should provide helpful information when combined with the schematic in Sub-section 5A.

Table 5D-1 lists the common difficulties experienced with directional valves and systems. It also indicates the probable causes and remedies for each of the troubles listed.

It should always be remembered that many apparent valve failures are actually the failure of other parts of the system. The cause of improper operation is best diagnosed with adequate testing equipment and a thorough understand-ing of the complete hydraulic system.

SOLENOID REPLACEMENT. It is not necessary to remove the valve to replace the solenoid coil. After determining the solenoid coil is defective, proceed as follows(see Figure 5D-6):

CAUTION

Before breaking an electrical circuit, be sure the power is OFF. To do this, disconnect the battery ground cable.

1. Remove plate (01), gasket (02) and disconnect the wires from the coil to the terminal strip. Make tags to identify the wires for proper assembly.

2. Remove snap ring (29) and pull coil (30) from solenoid (27). Remove the manual plunger and install in the new coil.

NOTE

Attach a piece of wire or cord to the wire ends of coil (30). This will make assembly easier.

3. Attach the wires to the new coil to the cord (wire) and pull the wires into body (05). Push the coil into the solenoid.

4. Install the snap ring and connect the coil wires to the terminal strip.

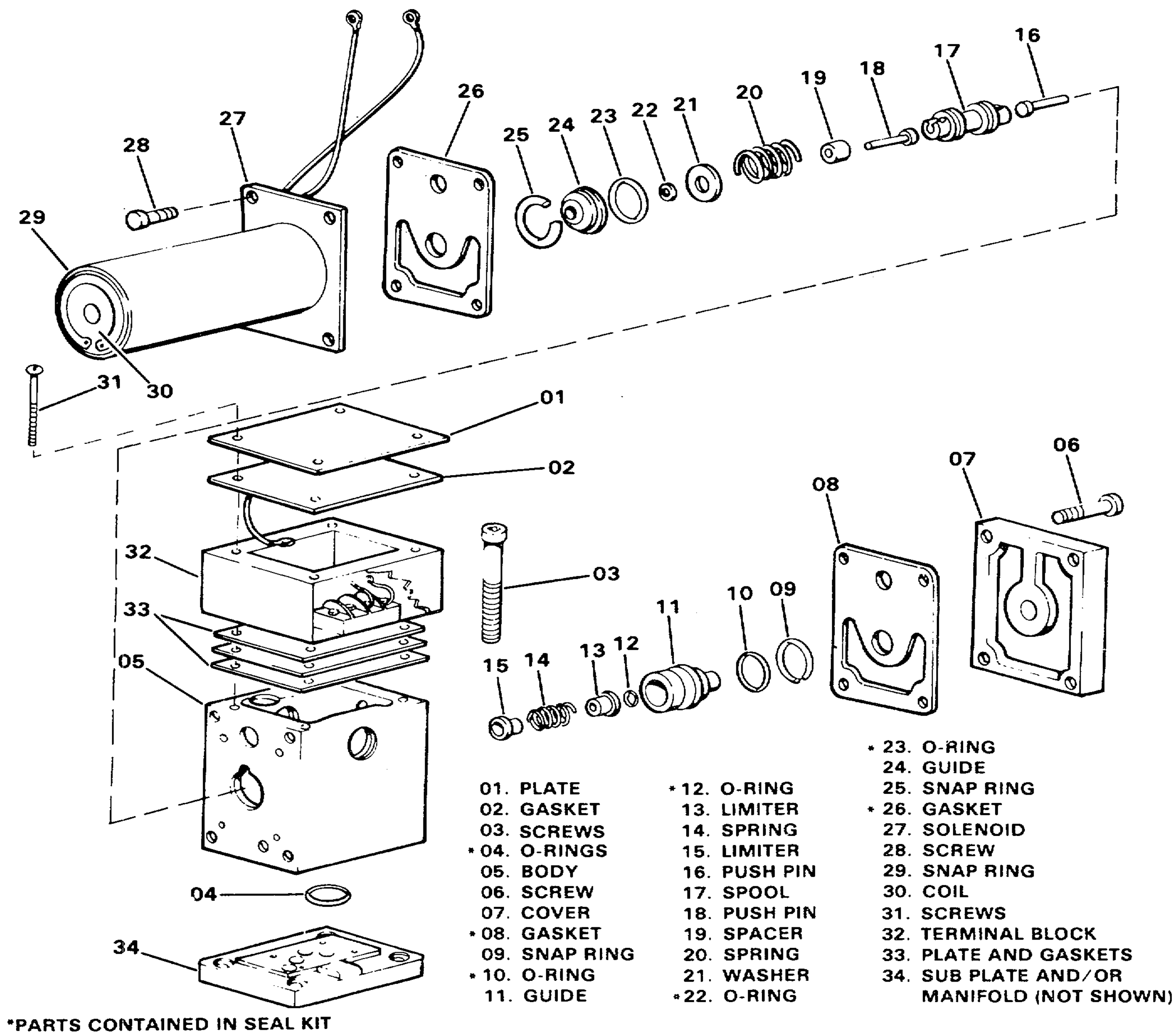


Figure 5D-6. Solenoid Valves (36Z1349 and 36Z1423)

5. If removed on disassembly, connect wire on gasket (02) to ground and install plate (01).

REMOVAL. The removal of any of these valves does not re-quire the disconnection of hydraulic lines. Each valve is held to a subplate or a manifold by four socket head screws. To remove a valve, proceed as follows (see Figure 5D-6):

CAUTION

Before breaking any circuit, be sure all pawl locks are engaged and block or lower any load whose movement could generate pressure.

1. Complete the General Removal instructions at the be-ginning of this subsection.

2. Remove plate (01), move gasket (02) aside and disconnect the solenoid wiring. Mark or tag the wires to ensure proper assembly.

3. Remove the four socket head screws from the wiring cavity inside the valve body. The valve can now be removed from the machine. Be ready to catch the oil that is retained in the lines and the valve.

4. Cap all the system openings to prevent the entrance of contaminants.

DISASSEMBLY. To disassemble the valve, proceed as follows (see Figure 5D-6):

1. Loosen screws (28) and remove solenoid (27) from the valve.

2. Loosen screws (06) and remove cover (07) from the other end of the valve body.

3. Remove snap ring (09), then remove guide (11), O-rings (10 and 12), limiters (13 and 15) and spring (14). Apply force to push pin (1 6) as this will aid in removing guide (11) from the valve body.

4. Remove snap ring (25), now remove guide (24), O-rings (22 and 23) and washer (21).

NOTE

Discard and replace all O-rings and gaskets removed in disassembly except gasket (02) unless it is dam-aged. Refer to the Parts Manual for the applicable seal kit number.

5. Remove spring (20) and spacer (19).

6. Slide spool (17) from the valve body with push pins (16 and 18). Remove the push pins from the spool, then mark the spool as noted below.

NOTE

Certain spool types are not symmetrical. To provide correct assembly, it is recommended that the spool and body be marked with a metal scribe. The spool should be marked on the minor diameter, not across the sealing lands.

CLEANING. The importance of cleaning the valve and all its parts cannot be overemphasized. All parts must be thor-oughly cleaned and kept clean during inspection and assembly. The close tolerance of 'the valve body and spool makes this requirement more stringent than usual. Clean all removed parts, using commercial solvent that is compatible with the system fluid. Compressed air may be used in cleaning the valve, but it must be filtered to remove water and contamination. Clean compressed air is particularly useful in cleaning the spool orifices and body passages.

INSPECTION AND REPAIR. Inspect, repair, and replace the valve and all its parts as follows:

1. Visually inspect the internal bore of valve body (05) for scratches or erosion across the spool land sealing areas. If scratches or erosion are found, replace the complete valve.

CAUTION

Do not stone the edges of the sealing lands on the valve spool. Rather, use a 500 grit abrasive paper to remove any burrs found on the spool. Use the paper very lightly on the outer diameter of the spool only.

Table 5D-1. Troubleshooting Chart

TROUBLE	PROBABLE CAUSE	REMEDY
Valve spool fails to move.	Dirt in system.	Disassemble, clean and flush.
	Solenoids inoperative.	Check electrical source and solenoids.
	Improper assembly after overhaul.	See Figure 5D-6 to check proper assembly of unit.
	Improper installation connec-tion.	Check installation.
Valve produces undesirable response in work unit.	Improper assembly of valve or improper installation con-nections.	Check Figure 5D-6 for assembly and the schematic diagram in Subsection 5A for installation

2. Inspect the spool for burrs or small scratches. If any are found, remove them with 500 grit abrasive paper. Then in-sert the spool into the bore, rotate it while moving it back and forth to check for binding. If any binding or side move-ment exists, the spool must be replaced.

3. If a new spool (1 7) is required, use a very fine grit stone to break the feathered edges of the balancing grooves. Use 500 grit paper to lightly polish the outside diameter of the spool.

4. Inspect all the other parts for wear or damage and re-place as necessary.

5. Check the grooves where any seals are placed; grooves and detents should be free of any rough edges to prevent damage to the new seals on assembly.

6. Perform a continuity check on the solenoid coil. The coil should have a resistance value of 24 ohms.

ASSEMBLY. To assemble the valve, proceed as follows:

1. Lubricate all the parts and O-rings with clean hydraulic oil to aid in assembly and provide initial lubrication.

2. The assembly of the valve is basically the reverse of the disassembly procedure. The following items require special attention:

A. Check the special marks on the spool and valve bore to ensure correct assembly.

B. Insert the heads of push pins (1 6 and 18) into the spool before installing the spool into the valve body.

C. Check for secure installation of snap rings (09 and 25).

D. Complete the wiring connection of the solenoid at in-stallation.

INSTALLATION. To install the solenoid valve, proceed as follows:

1. Place O-rings (04) in the ports at the bottom of the valve body if not already done. Now set the valve on the subplate or manifold on its correct position and secure with the four socket head screws.

2. Complete the wiring of the solenoid and attach the ground wire of gasket (02). Install the plate and fasten with the screws.

3. Bleed the system of air as described in Subsection 5A.

4. Connect the battery cable, start the engine, and check for leaks. If none, test the valve for proper operation.

SECTION VI.

SWING SYSTEM AND COMPONENTS

SUBSECTION 6A

SWING SYSTEM

GENERAL

This section describes the mechanical components required to transmit swing torque from the jackshaft to the slewing ring. The swing clutches, which are primarily elec-trical assemblies, are covered in this section in order to in-corporate all mechanical swing components in the same section.

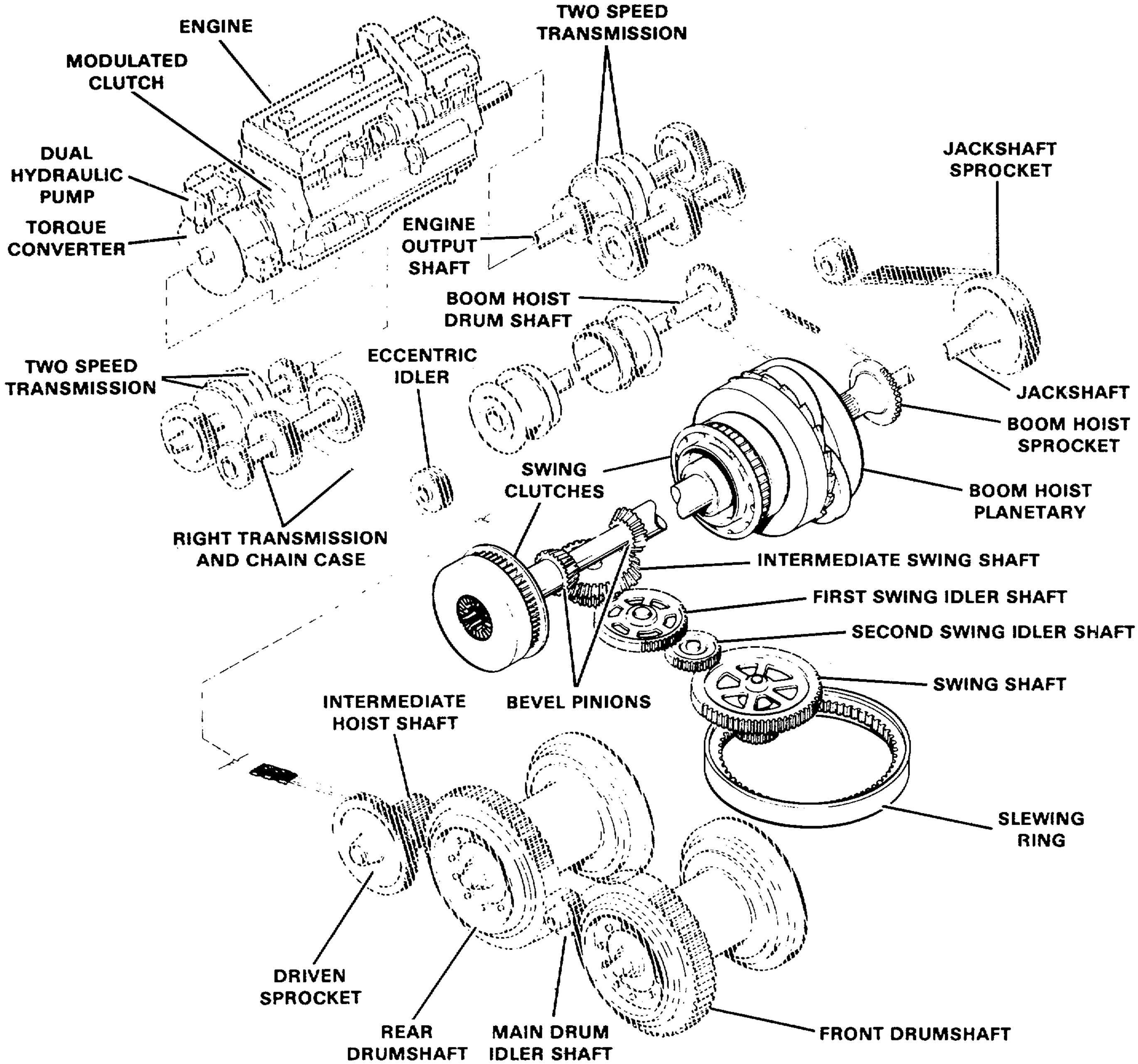
The swing system consists of the jackshaft, intermediate swing shaft, first swing idler shaft, second swing idler shaft, swing shaft, slewing ring, and the swing brake, as shown in Figure 6A-1.

DESCRIPTION

The swing system is powered by the upper engine through the jackshaft by a two speed transmission, chain, sprocket, and universal joint arrangement. The jackshaft turns continuously while the engine is running and the two speed transmission is engaged. However, the operator must energize one of the swing clutches to swing the upper.

When one of the swing clutches is energized, the bevel pinions on the jackshaft transmit torque to the slewing ring by means of the swing shaft, second swing idler shaft, first swing idler shaft and the intermediate swing shaft. The intermediate swing shaft gear meshes with the bevel pinions on the jackshaft to provide the first reduction. The second reduction is obtained by the meshing of the inter-mediate shaft pinion and the first swing idler shaft gear. The third reduction is obtained by the meshing of the first idler shaft gear meshing with the second idler shaft gear. The fourth reduction is obtained by the meshing of the second idler shaft gear meshing with the swing shaft gear. The swing shaft pinion, which is splined to the swing shaft, provides the fifth reduction as it meshes with the slewing ring.

The swing brake is a mechanical brake controlled by a hydraulic cylinder connected to the brake linkage. The swing brake is located on the right side of the jackshaft.



NOTE 1: END OF SWING CLUTCH SHAFT EXTENDS THROUGH BOOM HOIST SPROCKET.

NOTE 2: MANY ITEMS HAVE BEEN MOVED IN ORDER TO SHOW THE OPERATION OF THE MACHINE MORE CLEARLY.

Figure 6A-1. Swing Gear Train

SUBSECTION 6B

JACKSHAFTS

GENERAL
This subsection contains the information necessary to remove, disassemble, assemble, and install the jackshaft.
JACKSHAFT (910J355-9)

GENERAL. The jackshaft includes the swing clutches and the boom hoist planetary. The swing clutch units, when energized, couple the inner member of the swing clutch to the outer member of the same swing clutch, thus causing the bevel pinions to turn the intermediate swing shaft in the direction selected.

REMOVAL. To remove the jackshaft, proceed as follows (see Figure 6B-2):

1. Swing the upper so the left corner of the upper is even with the left side of the carrier (approx. 450) In this position, the carrier deck can be used as a work platform.

2. Raise the machine up on outriggers and place blocking under the rear counterweights.

3. Lower the boom onto blocking, pin the upper spreader to the boom base and wind the boom hoist cable onto the drums. Raise or lower the outriggers until the pins in the left hand horizontal tension member of the gantry are loose. Remove the pins and the tension member.
4. Remove left hand side panels and the top roof panels. Also remove the deck roof panel with the air cleaner attached.
5. Remove the upper engine radiator.
6. Remove the boom hoist chain case (see Section VIII).
7. Remove the U-joint from the jackshaft to the left hand transmission.

8. Disconnect the swing brake at the point where it is pinned to the revolving frame (see Subsection 6D).

9. Remove the boom hoist planetary brake support and disconnect the boom hoist planetary brake bands (see Subsection 8D).
10. Remove the swing clutch brush holders.

11. Remove the jackshaft pedestal cover and the left side bearing cap. Remove the jackshaft as an assembly, using a suitable sling and lifting device. Be very careful to avoid striking the left hand support. Also check to see that nothing interferes with the jackshaft removal before lifting the unit out.
12. Set the jackshaft on blocking in preparation for disassembly.

DISASSEMBLY. Disassembly of the swing clutches and the boom hoist planetary are covered in the following steps since both assemblies are part of the jackshaft. To disassemble the jackshaft, proceed as follows (see Figure 6B-2):

NOTE

Steps 1 through 5 apply specifically to the right hand swing unit. The left hand unit can be disassembled in a similar manner following disassembly of the boom hoist planetary.

1. Remove shroud (116), locknut (115) and lockwasher (114).
2. Pull clutch drum (outer member) (113) from jackshaft (38). Be sure to support the weight of the drum adequately during the removal.
3. Remove locknut (112) and lockwasher (11 1). The entire inner member (105), including swing brake drum (104), may now be removed from shaft (38). If necessary remove brake drum (104) from inner member (105).
4. Remove split collar (109). All of the remaining items mounted on the right end of shaft (38), including bevel pinion (96), can be removed. Remove oil seal (108) and snap ring (107) to gain access to bearing (106).
5. Remove spacer (100) from pinion (96). Remove and discard oil seal (101) from spacer (100). Also remove shims (98) and oil seal (99) from spacer (100). Before removing shims (98) mark them as to original location to prevent mix-up.
6. If necessary, remove bearings (97 and 95) from pinion (96).
7. Remove bracket (61) and disconnect tube (62) from connector (63).
8. Remove covers (58, 31 and 40) and gaskets (57, 32 and 41). Remove keeper plates (43 and 54) at each end of shafts (50). Remove pinions (46 and 53), bearings (47 and 52) and spacers (48 and 51). Push shafts (50) outward, away from spider (71). As shafts (50) are removed, also remove gears (49).

9. Remove keeper plate (04) and pull yoke (06) from shaft (38). Remove and replace stato-seals (03) and oil seal (07). Remove spacer (08).

10. With the above completed, all items mounted to the left of locknut (17) and lockwasher (16) can be removed from shaft (38) as a unit. Carefully support the entire assembly, which includes planetary carrier (66), spider (34), sprocket (11), and all parts mounted on these items and tap them off the left end of shaft (38). Remove spacer (15).

11. Support the assembly with sprocket (11) up, preferably on suitable supports, and remove locknut (17) and lockwasher (16).

12. Remove capscrews (19) from plate (18). Remove sprocket (11), tapping or jacking against the locknut end of the sprocket as necessary to drive it out of the hub of carrier (66). Remove bearings (22), spacer (26), and plate (18) from sprocket (11).

13. With sprocket (11) out of the assembly, the remaining parts may now be disassembled from the top down, beginning with bearing retainer (24). This completes the disassembly of all parts up to pinion (67).

14. All parts between pinion (67) and locknut(76) may now be removed from the left end of jackshaft (38) as an assembly.

15. Remove locknut (76) and lockwasher (75). Press pinion (67) out of spider (71). All other parts mounted on the spider may now be removed.

16. Remove spacer (77). Remove O-ring (78) from spacer (77).

17. Remove shroud (80) then pull clutch drum (outer member) (81) from shaft (38). Be sure to support the weight of the drum adequately during the removal.

18. Remove locknut (83) and lockwasher (84). The entire inner member (82) may now be removed from shaft (38).

19. Remove split collar (89). All of the remaining items mounted on the left end of shaft (38), including bevel pinion (93), can be removed. Remove oil seal (90) and snap ring (91) to gain access to bearing (92).

20. Remove and discard oil seal (85) and also remove shims (86). Mark shims (86) as to original location to prevent mix-up.

21. If necessary remove bearing (87 and 94).

INSPECTION AND REPAIR. Prior to reassembly, all swing clutch parts should be inspected as follows:

1. Replace all gaskets, oil seals, O-rings and grease retainers. Any bearing which shows signs of wear or damage should be replaced.

2. If either of the swing pinions (93 or 96) or the bevel gear on the intermediate shaft are worn, replace all three gears. The three gears tend to wear uniformly and the use of a combination of old and new gears will make backlash adjustments difficult.

3. Planetary pinions (46 and 53) and sun gears (49) should not be replaced individually. If, for example, one of pinions (46) are worn, all three pinions (46) must be replaced. This is also true for pinions (53) and gears (49). The gears are machined in sets of three each and the match marks ("X") are properly located to permit gear timing to be easily achieved.

4. Replace all nuts which have rounded corners, all lockwashers and all other damaged or worn parts.

5. If inspection reveals nicks, mars or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded items are clean and that threads are not damaged. Studs must be tight before reinstalling parts that are mounted upon them.

6. Burrs caused by lockwashers should be removed to assure easy reassembly of the jackshaft.

7. Using a non-flammable solvent, thoroughly clean the field members and the clutch rims. It is important that all oil and dirt be removed from the cooling fins of the clutch rims.

8. Inspect the clutch rims and field members for any cracks, distortion, or broken field member wires. Under no circumstances are repairs allowed on the clutch rims or field members. If either of these members are damaged they must be replaced.

9. If the machine is equipped with a swing lock, inspect the engaging pin and the ring for breaks or cracks.

10. Inspect the swing brake components. See Subsection 6E.

11. Inspect the clutch brushes and slip rings for wear. See Subsection 13B for renewal of brushes and slip rings.

12. Seals (85 and 99) are available as split seals. See the Replacement Parts Manual.

ASSEMBLY. To assemble the jackshaft, proceed as follows (see Figure 6B-2):

1. Warm bearings (94 and 95) and install on each end of shaft (38). Press the bearings firmly against the shaft shoulders.

NOTE

If bearings (94 and 95) are shielded, the shield should face pinions (93 and 96):

2. Warm and install bearings (87 and 97) on pinions (93 and 96), seating the bearings firmly against the shoulders on the pinion shafts.

3. Install pinions (93 and 96) on shaft (38) and press the pinions firmly into place over bearings (94 and 95). Install bearings (92 and 106) and secure in place with snap rings (91 and 107). If pinions (93 and 96) are equipped with flush fittings, fill pinion cavaties with grease (P&H 472) until grease comes out through bearings (92 and 106). Install oil seals (90 and 108) at each pinion (93 and 96).

NOTE

The spring of oil seals (90 and 108) must face the bearing as shown in detail "C"

4. Install spacer (100), with oil seal (101), on pinion (96) then install oil seal (99) over spacer (100). Set oil seal (85) on field member (82).
5. If brake drum (104) was removed from field member (105), reinstall it at this time. Set oil seal (85) on field member (82). Install field members (82 and 105) over pinions (93 and 95).
6. Install O-rings (88 and 110) in place as shown in detail B.

NOTE

On some jackshafts O-rings (88 and 110) have spacers between them. If the machine is equipped with the spacers, install the O-rings and spacers.

7. Install split collars (109 and 89) on each pinion (93 and 96). Install lockwashers (84 and 111) and locknuts (83 and 1 12) on the ends of pinions (93 and 96). Snug the locknuts down firmly.
8. Apply a non-hardening gasket material (Permatex) to the splines of shaft (38) where clutch drums (81 and 113) mount on the shaft. Install the clutch drums on each end of the shaft. Install shrouds (80 and 116).
9. Install lockwasher (114) and locknut (115). Tighten securely.
10. Install O-ring (78) in spacer (77) and slide the spacer into position over the left end of shaft (38). The spacer must butt firmly against clutch drum (81).
11. Install spacer (68) on pinion (67). Warm the inner race of bearing (69) and install it on the hub of pinion (67)so that it butts firmly against spacer (68). Pack bearings (69 and 74) with grease. Install the outer race of bearing (69) in the outside bore of lowering spider (71).
12. Install spacer (73) on pinion (67). Install the outer race of bearing (74) in the inside bore of spider (71). Now install the subassembled pinion (67) into the hub of spider (71). Warm and install the inner race of bearing (74) and secure the assembly together with lockwasher (75) and locknut (76). Install oil seal (72) in spider (71).
13. Install the entire spider assembly on shaft (38). The assembly should firmly contact spacer (77).
14. Assemble and install planetary pinion shafts (50) in carrier (66) as follows:

A. Press bearings (47 and 52) and spacers (48 and 51) into the bores of the carrier.

NOTE

Each planetary shaft (50) has a notch on one of its spline teeth. Pinions (46 and 53) and gears (49) each contain an "X" which represents a match mark. When assembling the pinions onto their respective shafts, align the "X" on each pinion and the gear with the notched spline tooth on the shaft. See Figure 6B1. If the pinions are not installed with their match marks aligned with the notched spline tooth on the pinion shaft, gear timing will be off and reassembly of the planetary will be impossible.

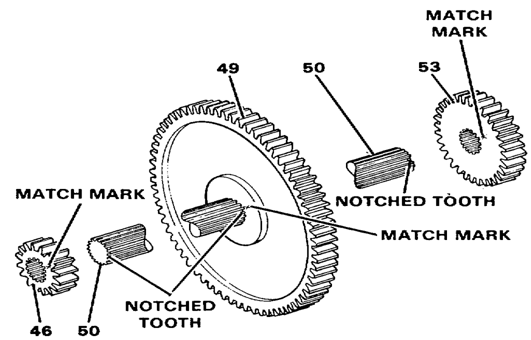


Figure 6B-1. Pinion Match Marks

B. Install pinions (46) on shafts (50), making sure that the match marked tooth on the pinion is located directly above the notched spline on shaft (50). Bolt and lockwire keeper plates (43) to shafts (50). Torque capscrews (45 and 56) to 65 ft-lbs (88.1 N m) lubricated.

C. Hold gear (49) between bearings (47 and 52) in carrier (66), noting the exact position of the "X" match mark on the gear. Insert the pinion shaft through bearings (47 and 52) and gear (49), making certain that the notched spline tooth on shaft (50) is aligned with the "X" match mark on the gear.

15. Clean the bores in spiders (34 and 71) using a solvent. Then apply a quick set adhesive (21Z516 or equal) to the bores. Install seals (39 and 70) into their respective bores. Secure in place with washers (35), lockwashers (36) and capscrews (37).
16. Lay the subassembled carrier (66) on suitable blocking around its outer diameter, with the hub of the carrier pointing upward.
17. Warm and install one inner race of bearing (27) on the hub of carrier (66). Pack the bearing with grease and install spacer (28). Install the outer races of bearing (27) in the bore of spider (34).
18. Carefully lower spider (34) onto the hub of carrier (66), making sure that oil seal (39) and bearings (27) are not damaged.
19. Warm and install the other inner race of bearing (27). Install spacer (26). Install oil seal (25) on retainer (24) and install this subassembly on spider (34).
20. Stand sprocket (11) on a bench, tooth end down. Slide mounting plate (18) onto the sprocket hub. Warm and install one inner race of bearing (22) on the sprocket hub. Install the bearing spacer, prepare the bearing with grease, install the outer race, and warm and install the other inner race.
21. Install snap ring (14) and bearing (13) in the inner end of sprocket (11).

22. Turn sprocket (11) over and install the splined end in the bore of carrier (66). Install lockwasher (16) and locknut (17). Install spacer (15) on shaft (38).

NOTE

Be sure that the lubrication holes in sprocket(1 1) line up with the lubrication holes in the hub of carrier (66).

23. Pick up the assembly, using a suitable hoist and carefully install it on the end of shaft (38). Be careful to avoid damage to bearing (13) while sliding the assembly up against spacer (15).

24. Keep the weight of the assembly supported by the hoist until spacer (12) and bearing (10) have been installed and secured in place by snap ring (09).

25. Complete the assembly of the shaft by installing spacer (08), oil seal (07), yoke end (06), gasket (05) and keeper plate (04). Stato-seals (03) are installed when keeper plate (04) is secured in place.

26. Install pinions (53) through the openings in covers (58). Be sure the "X" match mark on each pinion aligns with the notched spline on shaft (50). Install keeper plates (54) and secure in place with the capscrews and lockwire.

27. Install the grease fittings, grease piping, gaskets and covers to complete the assembly of the unit. Lubricate the assembly through all grease fittings until the pipes and lubrication chambers of the assembly are full. Be careful not to over-lubricate, since damage to seals can result.

INSTALLATION. To install the jackshaft into the machine, proceed as follows (see Figure 6B-1):

1. Lift the assembled jackshaft using a suitable sling and lifting arrangement and set the assembly on the pedestal bearing blocks. Use care to avoid damage to bearings (87 and 97), pinions (93 and 96) and the bevel gear.

2. Install shims (86 and 98) in front of bearings (87 and 97), making sure that each is in its original location. Enough end play should exist in shaft (38)to allow the shim halves to slip into place.

3. Measure the distance between the faces of pinions (93 and 96). This dimension should be 13.907 inches (35.324 cm) +0.004 inches (0.102 mm).

4. If bearings (87 and 97)and pinions(93 and 96) are all original, the above dimension should exist and the original shims can be reused as is.

5. If the pinions or any of the bearings have been replaced, shims (86 and 98) may have to be refitted to achieve the 13.907 inch (35.324 cm) dimension between the pinion faces.

6. If the dimension is less than 13.903 inches (35.314cm), stock must be ground off of each shim to increase the dimension. Subtract the measured dimension from 13.907 inches (35.324 cm). Reduce the thickness of each shim, by grinding, by approximately one-half the difference between 13.907 inches (35.324 cm) and the measured dimension. The thickness of the two shims must remain nearly equal. Reinstall the shims and again measure the dimension.

7. If the measured dimension is greater than 13.91 1 inches (35.334 cm), new shims must be obtained and fitted as necessary to reduce the dimension to 13.907 inches (35.324 cm). New shims are 0.250 inches (6.350 cm) thick and must each be ground to a thickness equal to the thickness of the original shim, plus one-half the error in the measured dimension. Install the new shims and recheck the dimension.

8. When the dimension between the pinion faces is within limits, the backlash between each pinion (93 and 96) and the swing bevel gear must be checked.

9. Each pinion and the swing bevel gear has a backlash dimension stamped on its face. Backlash measurements must be taken at the pitch diameter of a pinion gear tooth, preferably with a 0.001 inch dial indicator, while the opposite pinion is locked in position.

10. The measured backlash, at each pinion, should equal the sum of the backlash valves stamped on the bevel gear and that particular pinion. Backlash can be corrected by adding or removing shims from the intermediate swing shaft (see Subsection 6C). Adding shims will drop the intermediate swing shaft down, thereby increasing backlash. Removing shims will move the shaft up and decrease backlash.

11. When the above conditions are established, carefully install the pedestal cover, making sure that bearings (87 and 97) and shims (86 and 98) are properly seated in the cover recesses and seals (85 and 99) are not damaged.

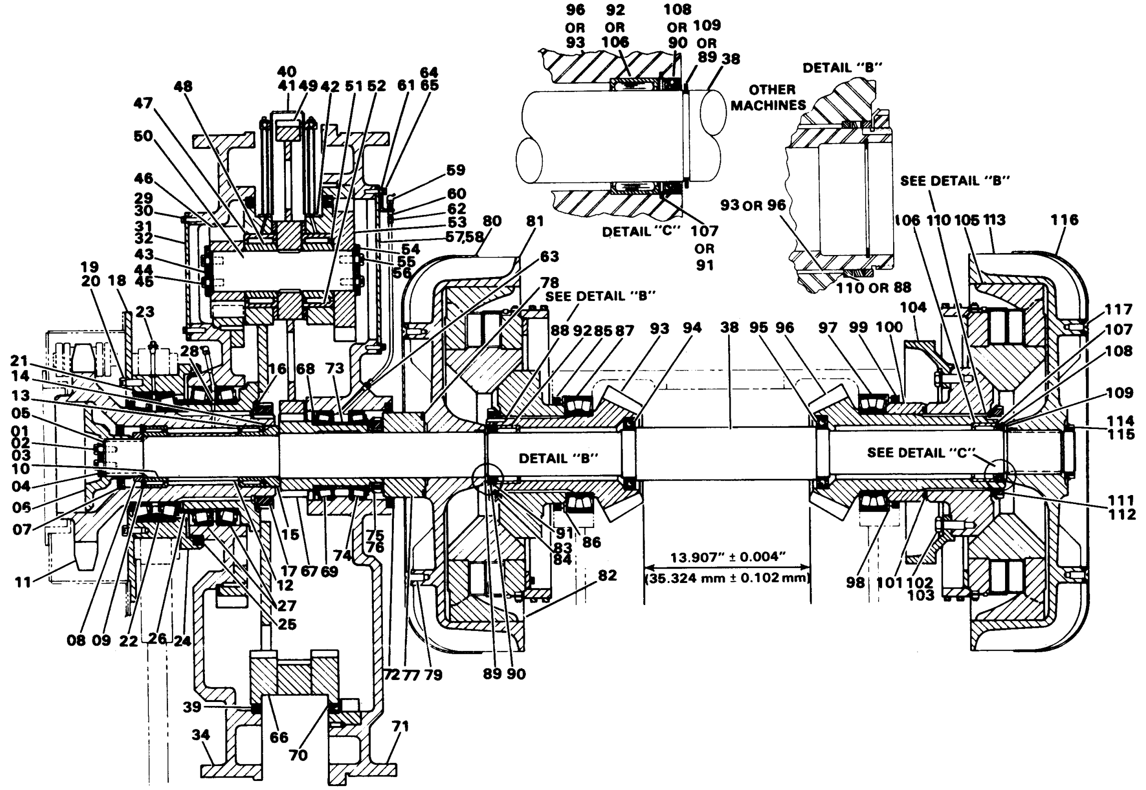
12. Reinstall the left side bearing cap. If the machine was equipped with the swing lock, reinstall it at this time.

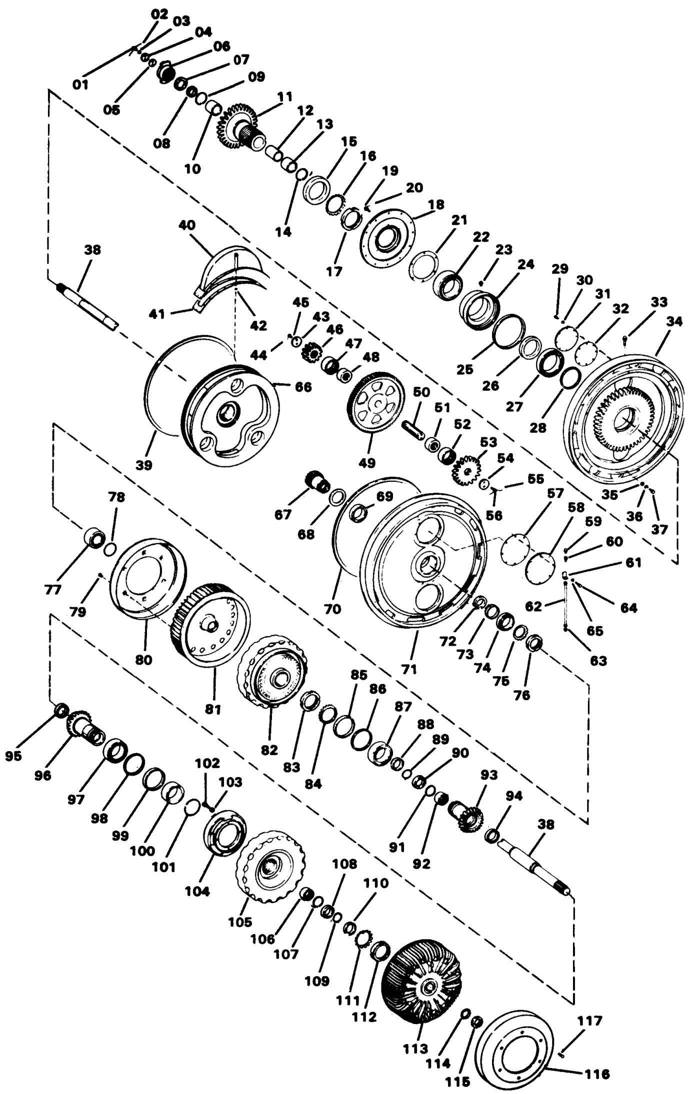
13. Reinstall the boom hoist planetary brake bands, brake support and the swing brake. Adjust the brakes (see Subsections 6D and 8D).

14. Reinstall the U-joint from the jackshaft to the left hand transmission (see Subsection 4E).

15. Reinstall the horizontal tension member, boom hoist chain case (see Subsection 8B), the upper engine radiator and all panels removed to gain access to the jackshaft. Also reinstall any guards removed.

16. Refill any cases with the proper type lubricant, see Section III.





01. CAPSCREW
02. TIE WIRE
03. STATO-SEAL
04. KEEPER PLATE
05. GASKET
06. YOKE
07. OIL SEAL
08. SPACER
09. SNAP RING
10. BEARING
11. SPROCKET
12. SPACER
13. BEARING
14. SNAP RING
15. SPACER
16. LOCKWASHER
17. LOCKNUT
18. MOUNTING PLATE
19. CAPSCREW
20. TIE WIRE
21. GASKET
22. BEARING
23. LUBE FITTING
24. RETAINER
25. OIL SEAL
26. SPACER
27. BEARING
28. SPACER
29. CAPSCREW
30. LOCKWASHER
31. COVER
32. GASKET
33. LUBE FITTING
34. SPIDER
35. WASHER
36. LOCKWASHER
37. CAPSCREW
38. SHAFT
39. OIL SEAL
40. COVER
41. GASKET
42. O-RING
43. KEEPER PLATE
44. TIE WIRE
45. CAPSCREW
46. PINION
47. BEARING
48. SPACER
49. GEAR
50. SHAFT
51. SPACER
52. BEARING
53. PINION
54. KEEPER PLATE
55. TIE WIRE
56. CAPSCREW
57. GASKET
58. COVER
59. LUBE FITTING
60. CONNECTOR
61. BRACKET
62. TUBE
63. CONNECTOR
64. CAPSCREW
65. LOCKWASHER
66. PLANETARY CARRIER
67. PINION
68. SPACER
69. BEARING
70. OIL SEAL
71. SPIDER
72. OIL SEAL
73. SPACER
74. BEARING
75. LOCKWASHER
76. LOCKNUT
77. SPACER
78. SEAL
79. SCREW
80. SHROUD
81. CLUTCH DRUM
82. FIELD MEMBER
83. LOCKNUT
84. LOCKWASHER
85. OIL SEAL
86. SHIM
87. BEARING
88. SEAL
89. SPLIT COLLAR
90. OIL SEAL
91. SNAP RING
92. BEARING
93. BEVEL PINION
94. BEARING
95. BEARING
96. BEVEL PINION
97. BEARING
98. SHIM
99. OIL SEAL
100. SPACER
101. OIL SEAL
102. CAPSCREW
103. WASHER
104. BRAKE DRUM
105. FIELD MEMBER
106. BEARING
107. SNAP RING
108. OIL SEAL
109. SPLIT COLLAR
110. OIL SEAL
111. LOCKWASHER
112. LOCKNUT
113. CLUTCH DRUM
114. LOCKWASHER
115. LOCKNUT
116. SHROUD
117. SCREW

Figure 6B-2. Jackshaft Assembly (910J355-9)

SUBSECTION 6C

SWING SHAFTS

GENERAL

This subsection will cover the removal, disassembly, repair, assembly and installation of the intermediate swing shaft, idler shafts and vertical swing shaft. It is important to note that during assembly and installation of the intermediate swing shaft, shims are used to set up end play and to check the bevel gear backlash with the jackshaft pinions.

INTERMEDIATE SWING SHAFT (910N483-1)

GENERAL. The intermediate swing shaft is mounted in the revolving frame with the bevel gear in contact with the jackshaft pinions. The bevel gear on the intermediate swing shaft and the pinions on the jackshaft are immersed in oil and continually lubricated.

REMOVAL AND DISASSEMBLY. Disassembly is accomplished during removal. To remove the intermediate swing shaft, proceed as follows (see Figure 6C-1):

1. Drain the swing gear cases by removing the two pipe plugs located beneath the revolving frame on each side of the intermediate swing shaft. Remove the pedestal cover.

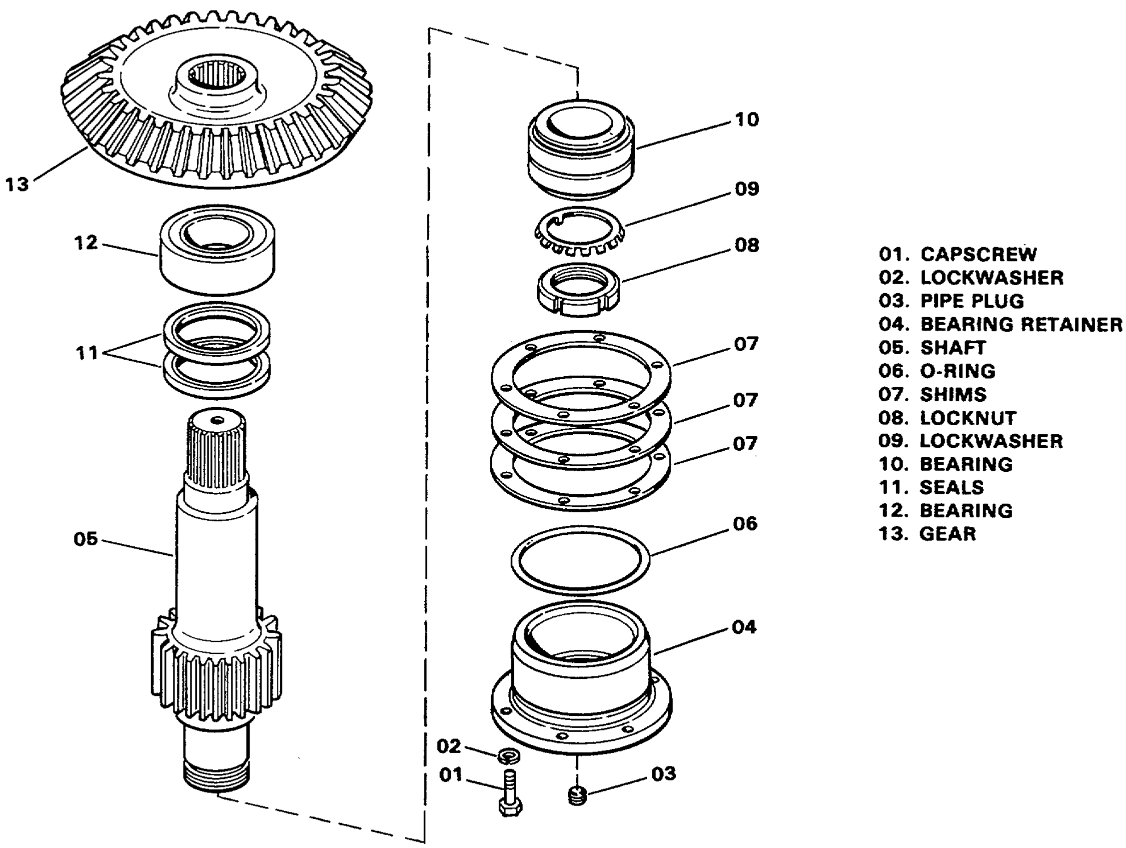


Figure 6C-1. Intermediate Swing Shaft (910N483-1)

CAUTION

Place adequate blocking beneath shaft (05) to prevent it from falling out the bottom of the revolving frame when retainer (04) is removed. It is advisable to thread an eyebolt into the top of shaft (01) and secure the shaft from above.

2. Remove capscrews (01) and drop bearing retainer (04) out of the revolving frame. Remove O-ring (06) and shims (07) from retainer (04).
3. Shaft (05) may now be lowered from the machine as an assembly, with the exception of gear (13), bearing (12) and seals (11). It may be necessary to use a bumping bar to start the shaft out of the pedestal.
4. Remove seals (11) out the bottom of the revolving frame.
5. Remove bearing (10) by removing locknut (08) and lockwasher (10).
6. If bevel gear (13) is going to be removed from the revolving frame, remove the jackshaft (see Subsection 6B).

INSPECTION AND REPAIR. Prior to reassembly, all intermediate swing shaft parts should be inspected as follows:

1. Replace O-ring (06) and oil seals (11).
2. If bevel gear (13) or either of the pinions on the jackshaft are worn, replace all three gears. The three gears tend to wear uniformly and the use of a combination of old and new gears, particularly bevel gears, will make backlash adjustments all but impossible. The bevel gear can be removed from the pedestal through the pedestal cover once the jackshaft has been removed.
3. Any bearing which shows any sign of wear or damage should be replaced.
4. Replace all capscrews which have rounded corners and all other damaged or worn parts.
5. If inspection reveals nicks, mars or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded items are clean and that threads are not damaged.

ASSEMBLY AND INSTALLATION. To assemble and install the intermediate swing shaft, proceed as follows (see Figure 6C-1):

1. If bearing (12) and gear (13) were removed, reinstall them at this time.
2. Reinstall seals (11) with the seal lips pointing upward. Warm the inner races of bearing (10) and assemble the bearing on shaft (05). Secure in place with lockwasher (09) and locknut (08).
3. Install O-ring (06) on retainer (04). Install retainer (04) over bearing (10), with original shim (07) in position. Hold the retainer in position until lockwashers (02) and capscrews (01) are installed.
4. Block bevel gear (13) in the pedestal so that it will not move. Check that the gear is centered above the bore in the pedestal.
5. Install the shaft assembly from below the revolving frame. Line up the splines on shaft (05) with the splines on gear (13) before pressing the shaft into the gear. Be careful not to damage oil seals (11) or bearing (12). Remove the bevel gear blocking.
6. Tighten capscrews (01). Reinstall the jackshaft at this time if it was removed.
7. Check the backlash between the bevel gear and the mating jackshaft pinions. Each jackshaft pinion and the bevel gear has a backlash dimension stamped on its face. Backlash measurements must be taken at the pitch diameter of a pinion gear tooth, preferably with a 0.001 inch (0.0245 mm) dial indicator, while the opposite jackshaft pinion is locked in position.
8. The measured backlash, at each pinion, should equal the sum of the backlash values stamped on the bevel gear and that particular jackshaft pinion. Backlash can be corrected by adding or removing backlash shim (07). Adding shims will drop the intermediate swing shaft down, thereby increasing backlash. Removing shims will move the shaft up and decrease backlash.
9. Reinstall any covers removed previously. Fill the swing cases with the proper amount of recommended lubricant (see Section III).

SWING IDLER SHAFTS (910J354-1 & 2)

GENERAL. The first swing idler is driven by the intermediate swing shaft pinion and transmits torque to the second swing idler. The second swing idler mates with the vertical swing shaft gear.

REMOVAL AND DISASSEMBLY. The swing idlers are identical, except for gears (02), and all of the removal and disassembly procedures listed below apply equally to each. To remove and disassemble the swing idler shafts, proceed as follows (see Figure 6C-2):

1. Drain the main gear case and remove the cab front enclosure.
2. Remove the main gear case cover and slide the cover forward, beneath the front drumshaft.
3. Support the swing idler shaft to be removed from below so that it will not fall.

NOTE

If the first idler shaft is going to be removed, it will be necessary to remove the second idler shaft.

4. Remove retaining plate (08), capscrews (12) and lockwashers (11). Bump shaft (01) out the bottom of the revolving frame.
5. If necessary, remove gear (02) from the revolving frame. Remove retaining ring (03) and remove bearing (09) parts from gear (02).
6. Remove any bearing parts from shaft (01)and remove O-ring (10).

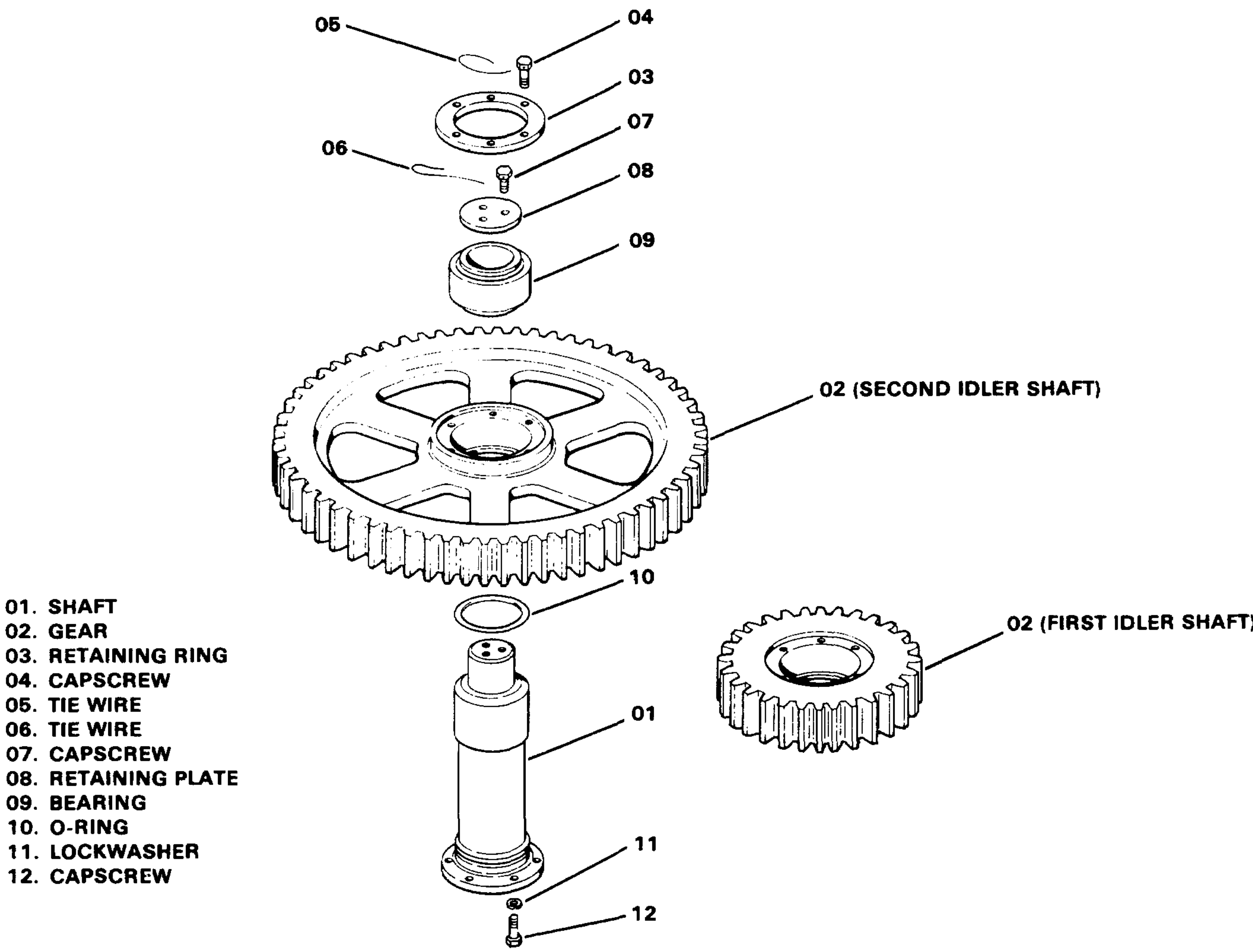


Figure 6C-2. Swing Idler Shafts (91OJ354-1& 2)

INSPECTION AND REPAIR. Prior to reassemly, all idler shaft parts should be inspected as follows:

1. Replace O-ring (10). If gear (02) is excessively worn, replace it.
2. If bearing (09) shows any sign of wear or damage replace it.
3. If inspection reveals nicks, mars or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded items are clean and that threads are not damaged. Replace all capscrews which have rounded corners and all other damaged or worn parts.

ASSEMBLY AND INSTALLATION. Both swing idler shafts are installed in the same manner. The first swing idler shaft should be installed before the second. To assemble and install the idler shafts, proceed as follows (see Figure 6C-2):

1. Place O-ring (10) on shaft (01). Heat and install the lower inner race of bearing (09) on the shaft.
2. Carefully slide shaft (01) through its bore, from below, and secure in place with lockwashers (11) and capscrews (12).
3. Install the outer race of bearing (09) into gear (02) and secure in place with retaining ring (03).
4. Set gear (02) onto the lower inner race of bearing (09). Install the spacer between the bearing inner races. Warm and install the upper inner race of bearing (09). Install retaining plate (08) and secure in place with the capscrews and tie wire.

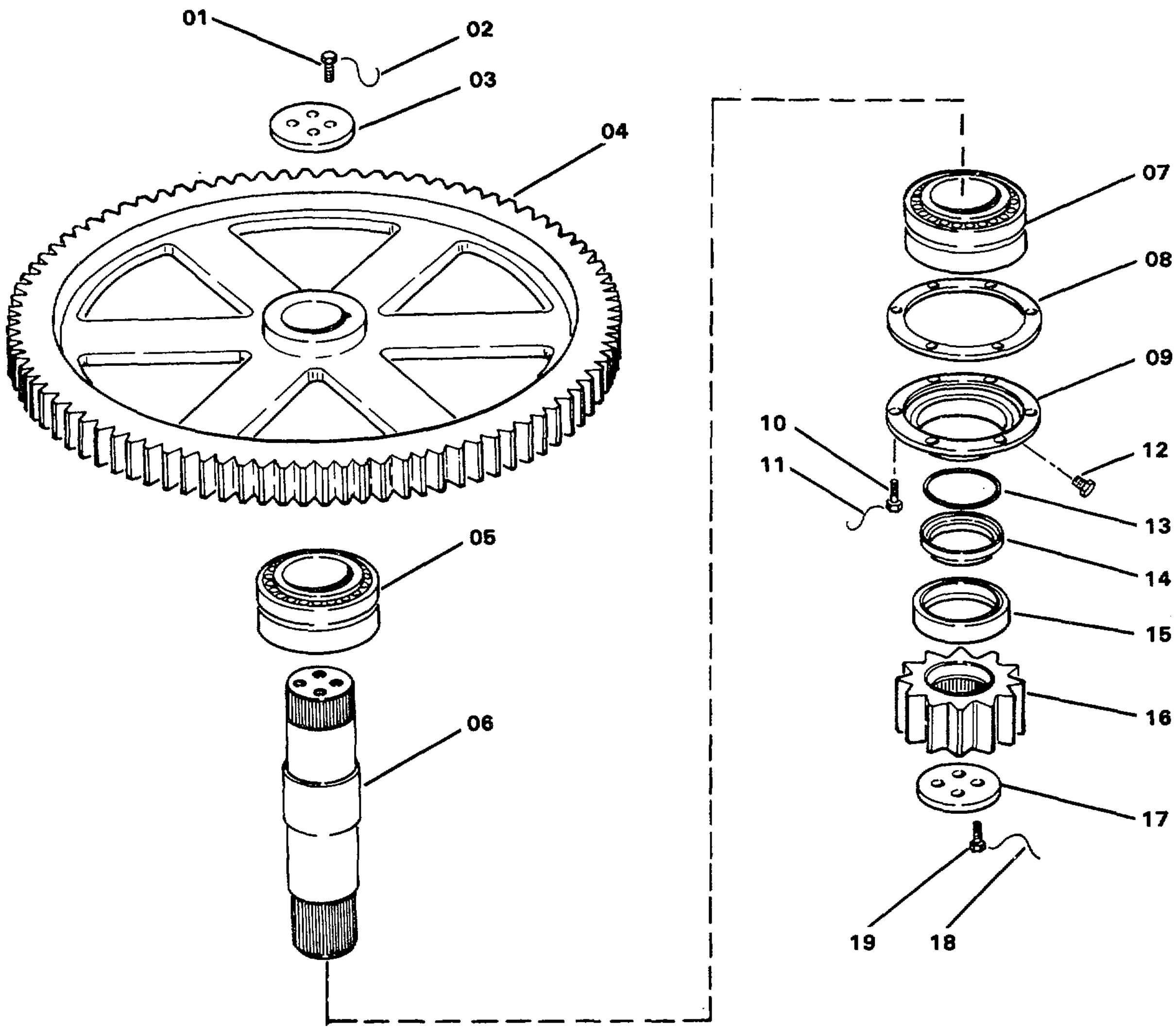
VERTICAL SWING SHAFT (910J360-1)

GENERAL. The vertical swing shaft is driven by the second swing idler. It transmits swing torque to the swing pinion, which mates with the teeth of the slewing ring. The swing pinion can be removed without removing the vertical swing shaft.

WARNING

Extreme caution must be exercised when removing the vertical swing shaft as it is necessary to remove the upper from the carrier. Every precaution must be taken to prevent the upper from falling or shifting while lifting the upper and when the upper is off the carrier.

REMOVAL AND DISASSEMBLY. The vertical swing shaft is disassembled during removal. To remove the vertical swing shaft, proceed as follows (see Figure 6C-3):



01. CAPSCREW	06. SHAFT	11. TIE WIRE	16. SWING PINION
02. TIE WIRE	07. BEARING	12. PIPE PLUG	17. END CAP
03. END CAP	08. GASKET	13. O-RING	18. TIE WIRE
04. GEAR	09. RETAINER	14. OIL SEAL	19. CAPSCREW
05. BEARING	10. CAPSCREW	15. SPACER	

Figure 6C-3. Vertical Swing Shaft (910J360-1)

1. Move the machine onto firm, level ground, and block the carrier so that it will not move while the upper is being removed. Position the upper over a hole in the carrier to allow removal of the swing pinion.

NOTE

If only the swing shaft pinion is to be removed, proceed to step 8.

2. Drain the main gear case in the revolving frame. Remove pipe plug (12) and drain the oil out of the shaft bore in the revolving frame.

3. Remove the main gear case cover and slide the cover forward, beneath the front drumshaft.

4. If gear (04) is going to be removed, see Swing Idler Shafts earlier in this subsection and remove the second swing idler shaft.

5. Block or support the upper using a suitable lifting device. Be sure the upper is blocked or supported adequately, because the next step of these instructions is to remove the bolts which secure the upper to the slewing ring.

6. Loosen all the bolts which secure the upper to the slewing ring, from below the outer race and allow them to drop onto the carrier.

7. Lift or jack the upper until the machine is above the top of the carrier ring. If you are lifting the upper off, place it on suitable blocking away from the carrier, or drive the carrier out from below the upper. If the carrier is driven out from below the upper, the upper should be placed on suitable blocking while the vertical swing shaft is being removed.

8. Support pinion (16) in position to prevent it from dropping when end plate (17) is removed. Remove the tie wire, capscrews and the end plate. Allow swing pinion (16) to slide off the swing shaft splines.

9. Remove retainer (09) with oil seals (14). Spacer (15) and O-ring (13) should also be removed at this time. If shaft (06) does not have to be removed, proceed to assembly and installation to install the items removed in steps 8 and 9.

10. Block up shaft (06) so that it cannot fall during removal.

11. Remove cap (03). Using a suitable drift, tap shaft (06) out the bottom of the machine.

12. Remove bearings (05 and 07) from shaft (06).

INSPECTION AND REPAIR. Prior to reassembly, all vertical swing shaft parts should be inspected as follows:

1. Replace oil seals (14), O-ring (13) and gasket (08).

2. Bearings that show any sign of wear or damage should be replaced.

3. Replace all capscrews which have rounded corners and all other damaged or worn parts.

4. If inspection reveals nicks, mars or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded items are clean and that threads are not damaged.

5. Check swing gear (04), pinion (16) and the gear on the second swing idler for wear, cracks or damage. If any are damaged, replace them.

ASSEMBLY AND INSTALLATION. To assemble and install the vertical swing shaft, proceed as follows (see Figure 6C3):

NOTE

If only the swing shaft pinion and retainer were removed, proceed to step 4 for installation.

1. Warm the inner races of bearings (05 and 07) and assemble the bearings on shaft (06). Make sure the bearings are firmly against the shaft shoulder.

2. Block gear (04) in position above the shaft bore, and raise the shaft into position in the gear. Check the alignment of the shaft splines with the gear.

3. Hold the shaft in position while installing end cap (03). Secure the end cap in place with the capscrews and tie wire.

4. Install oil seals(14) in retainer (09). Set gasket (08) on retainer (09). Install the assembled retainer and secure in place with the capscrews and lockwire.

NOTE

Pipe plug (12) must face toward the center of rotation.

5. Install O-ring (13) in spacer (15) and slide the spacer into position within oil seals (14). Do not use excessive force if resistance is encountered.

6. Install pinion (16) and secure in position with end cap (17). Install the capscrews and lockwire. If only the swing pinion was removed it is not necessary to proceed further. Be sure to refill the gear case if retainer (09) was removed.

7. Carefully lower the upper on the slewing ring. See Slewing Ring in Subsection 6E for mounting procedures.

8. Reinstall the second swing idler shaft if it was removed. See Swing Idler Shafts earlier in this subsection.

9. Reinstall the main gear case cover and fill the gear case to the proper level with the appropriate lubricant (see Section III).

SUBSECTION 6D

SWING BRAKES

GENERAL
This subsection contains the information necessary to remove, repair, install and adjust the swing brake.

SWING BRAKE (915J108-2)
GENERAL. The swing brake is located on the jackshaft and clamps on the brake drum. The brake is of the spring set-hy-

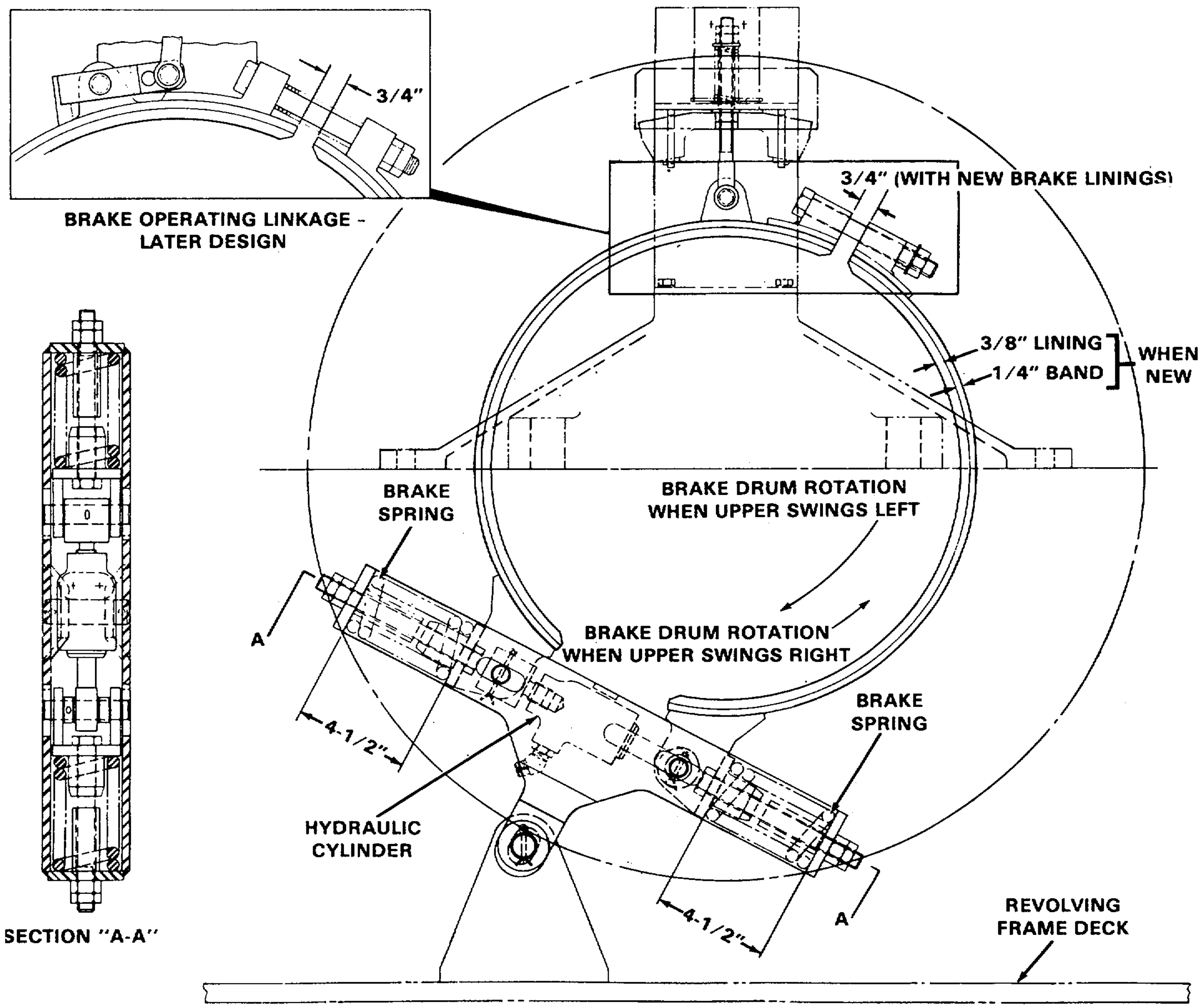


Figure 6D-1. Swing Brake (915J108-1 & 2) draulically released type. The purpose of the swing brake is to lock the upper in position in relation to the lower; while traveling, working, or moving to a new location. It is not intended or designed to stop the upper from swinging at the end of each swing cycle or as a control regularly used in operating the machine. It is more accurately described as a "locking" brake.

When the operator moves the swing brake lever to release the swing brake, hydraulic pressure is applied to the cylinder extending the piston and releasing the brake. When the operator moves the swing brake lever to engage the swing brake, hydraulic pressure is released from the cylinder, retracting the piston and allowing the springs to set the brake.

The length of the operating springs with the brake set (hydraulic pressure released from the cylinder) should be 41/2 inches (11.4 cm) when in proper adjustment (see Figure 6D-1). The brake band split dimension with the brake set and the linings new should be 3/4 inch (1.9 cm). As the brake lining wears, the operating spring lengths will increase. The swing brake should be relined when there is no longer sufficient gap at the band split for further adjustment.

REMOVAL. To remove the swing brake band, proceed as follows (see Figure 6D-2):

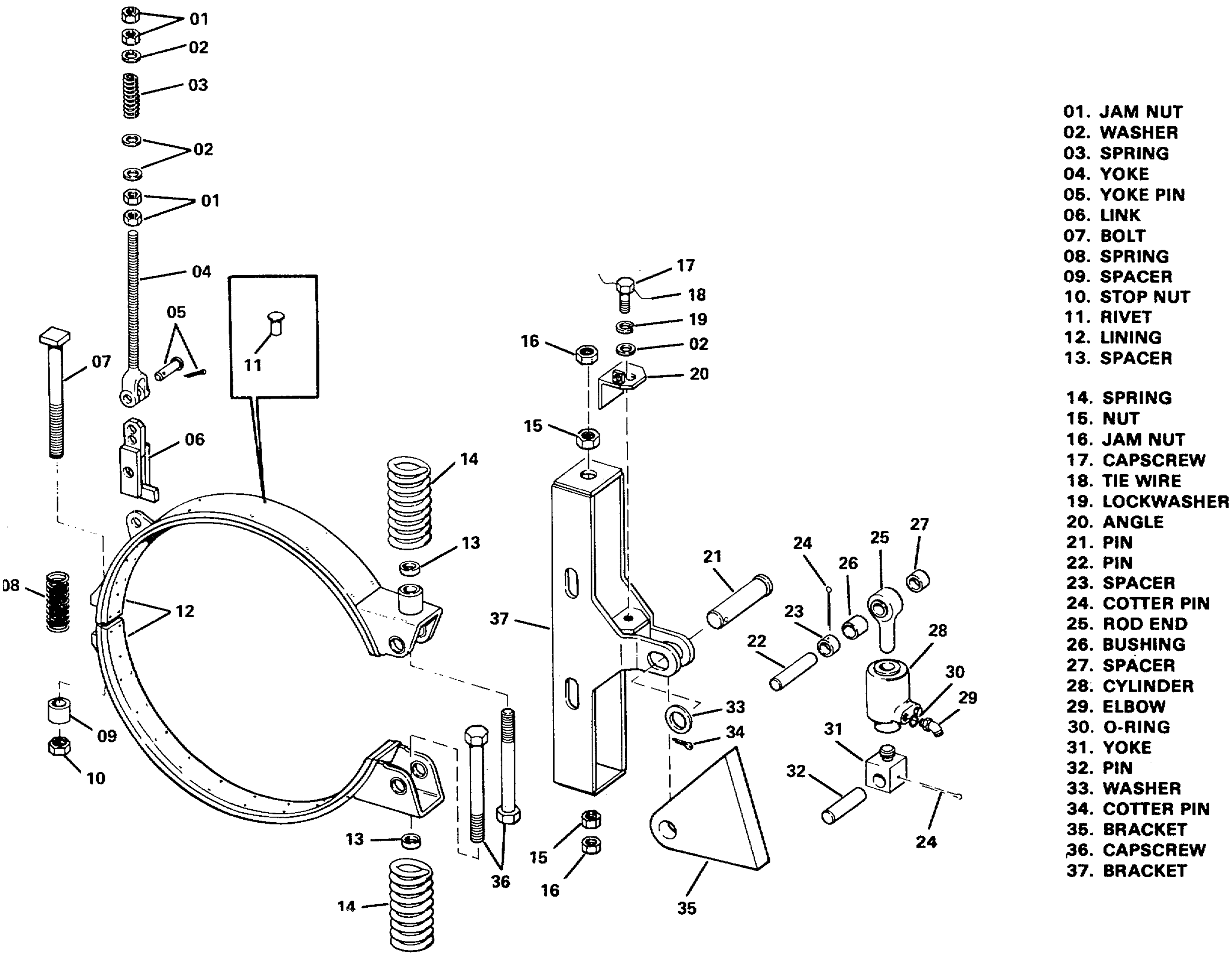


Figure 6D-2. Swing Brake (915J108-2)

1. Shut down the engine and operate the controls in the cab to relieve all pressure in the system. Crack open the hydraulic hose fitting on cylinder (28) to allow any pressure to release. Remove the hose when pressure is released. Cap the hose and plug the cylinder.
2. Loosen jam nuts (16) and tighten nuts (15) to compress springs (14).
3. Release the tension on the brake band suspension assembly by loosening jam nuts (01) below the support bracket.
4. Remove yoke pin (05). Remove nut (10), spacer (09), spring (08) and bolt (07).
5. Remove pin (21) and rotate the brake band as necessary. Remove cotter pins (24) from spacer (23) and yoke (31). Remove pin (22) and spacers (23 and 27). Remove pin (32).
6. Back off nuts (15) to relieve tension in springs (14). Remove jam nuts (1 6), nuts (15), springs (14), spacers (13) and capscrews (36). Remove the brake band halves from the drum. Set aside the remaining parts for reassembly.

INSPECTION AND REPAIR. Prior to reinstalling the brake band halves on the drum, inspect the following items (see Figure 6D-2):
1. Replace springs (03 and 14).
2. If cylinder (28) leaks or has been performing erratically, overhaul if necessary. See Subsection 5D.
3. Check the brake band halves for distortion.
4. Inspect the brake drum to see that it is not cracked, scored or otherwise damaged.

INSTALLATION. To install the brake band halves, proceed as follows (see Figure 6D-2):
1. Place the brake band halves in bracket (37).
2. Install bolts (36), spacers (13) and springs (14). Thread nuts (15) and jam nuts(1 6)on bolts (36). Tighten nuts (1 5)to compress springs (14).
3. Install pin (22) through bracket (37) and start it into the brake band half. Install spacers (23 and 27). At the same time push pin (22) through the spacers and yoke (25). Install cotter pin (24) in spacer (23).
4. Install pin (32) through bracket (37), the brake band half and yoke (31). Install cotter pin (24) into yoke block (31).
5. Install pin (21), washer (33) and cotter pin (34).
6. Install bolt (07), spring (08), spacer (09) and nut (10). Do not fully tighten at this time.
7. Install yoke (04) to link (06) and install pin (05). Secure with the cotter pin.
8. Reconnect the hydraulic hose to cylinder (28).

ADJUSTMENT. To adjust the swing brake, proceed as follows (see Figure 6D-1):

1. With the brake released, tighten the hanger spring adjusting nut to increase the tension on the brake band suspension assembly. Check that the band halves clear the drum all the way around.
2. With the brake set, back off the spring jam nuts and adjusting nuts to attain a set-up dimension of 4-1/2 inches (11.4 cm) on the operating springs.
3. Adjust the band split adjusting nut to attain a dimension of 3/4 inch (1.9 cm) between the brake band halves.

NOTE

This is an initial set-up dimension only. As the bard wears, this dimension will decrease.

4. It may be necessary to repeat the above steps until the brake band clears the drum all the way around and the setup dimension on the operating springs is attained.
5. Tighten all jam nuts before operating the brake.
6. Operate the swing brake several times. Recheck the setup dimension and check that the brake band clears the drum all the way around.

SUBSECTION 6E

SLEWING RINGS

GENERAL

The slewing ring is basically a large bearing upon which the upper is mounted. The outer race of the slewing ring is bolted to the upper, and the inner race is bolted to the carrier. An internal ring gear, machined into the inner race, mates with the swing pinion which projects downward from the vertical swing shaft. This arrangement allows the upper to rotate in a full circle, when the upper is driven by the mechanical drive from the swing clutch to the vertical swing shaft.

SLEWING RING (901J12)

REMOVAL. To remove the slewing ring, proceed as follows (see Figure 6E-1):

WARNING

Extreme caution must be exercised when removing the slewing ring, as it is necessary to completely remove the upper from the carrier. Every precaution must be taken to prevent the upper from falling or shifting while lifting the upper and when the upper is off the carrier.

1. Move the machine onto firm, level ground, and block the carrier so that it will not move while the upper is being removed. Remove all boom and counterweight. Shut down the engine.
2. Remove or disconnect all lines or wires that may interfere when the upper is removed. Also remove one of the fenders from the carrier to allow upper bolt removal and installation.
3. Block or support the upper using a suitable lifting device. Be sure the upper is blocked or supported adequately, because the next step of these instructions is to remove the bolts which secure the upper to the slewing ring.
4. Loosen the 48 bolts which secure the upper to the slewing ring from below the outer race and allow them to drop out.
5. Lift the upper until the revolving frame is above the carrier. Place the upper on suitable blocking away from the carrier.
6. Remove the 72 bolts which secure the inner race of the slewing ring to the carrier ring.
7. Install suitable eyebolts in two holes of the slewing ring which are 180 degrees apart. Attach a suitable lifting sling to these eyebolts, and lift the slewing ring from the carrier.

REPAIRS. The slewing ring is not a repairable item. If the slewing ring is no longer serviceable, it must be replaced with a new unit.

Any attempt to disassemble or repair the slewing ring will void any warranty expressed or implied.

INSTALLATION. To install a new slewing ring, proceed as follows (see Figure 6E-1): 1. Clean the carrier and the tapped holes in both the carrier ring and the revolving frame with a suitable cleaning solvent, and blow the surface and holes dry with compressed air.

2. Install eyebolts in the new slewing ring in the same manner as they were installed in the old slewing ring for removal, and lift the new slewing ring onto the carrier.

3. Position the slewing ring so that the word FRONT, stamped on the inner race, faces the rear of the carrier.
4. Align the holes in the slewing ring with the holes in the carrier ring. Lubricate all bolts with Never Seez and insert the bolts in the holes of the inner race. Finger tighten.
5. Tighten two bolts, which are 180 degrees apart on the centerline of the carrier, to 1 100 ft-lbs (1492 N m). Tighten two other bolts which are 180 degrees apart and 90 degrees from the first two bolts, to 1100 ft-lbs (1492 N m).

Continue this cross-bolting procedure until all the bolts have been torqued to 1100 ft-lbs (1492 N m).

6. Position the outer member of the slewing ring so that the word FRONT, stamped on the outer race, faces the front of the upper when the slewing ring is bolted on the revolving frame.
7. Install the upper bolts in the slewing ring. Lubricate all bolts with Never Seez. Check that the slewing ring is against the rear locating block when the upper is in place. Lower the upper onto the slewing ring checking that the swing pinion meshes with the slewing ring. Hand tighten the mounting bolts.

8. Tighten two bolts, which are 180 degrees apart on the centerline of the revolving frame, to 1160 ft-lbs (1573 N m). Alternating from one side of the centerline of the revolving

frame to the other, tighten two bolts 180 degrees apart to 1160 ft-lbs (1573 N m).

9. Reconnect any lines or wires that were disconnected for removal.

NOTE

Check the torque of all slewing ring mounting bolts after the first 200 hours of operation.

10. Reinstall the fender on the carrier.

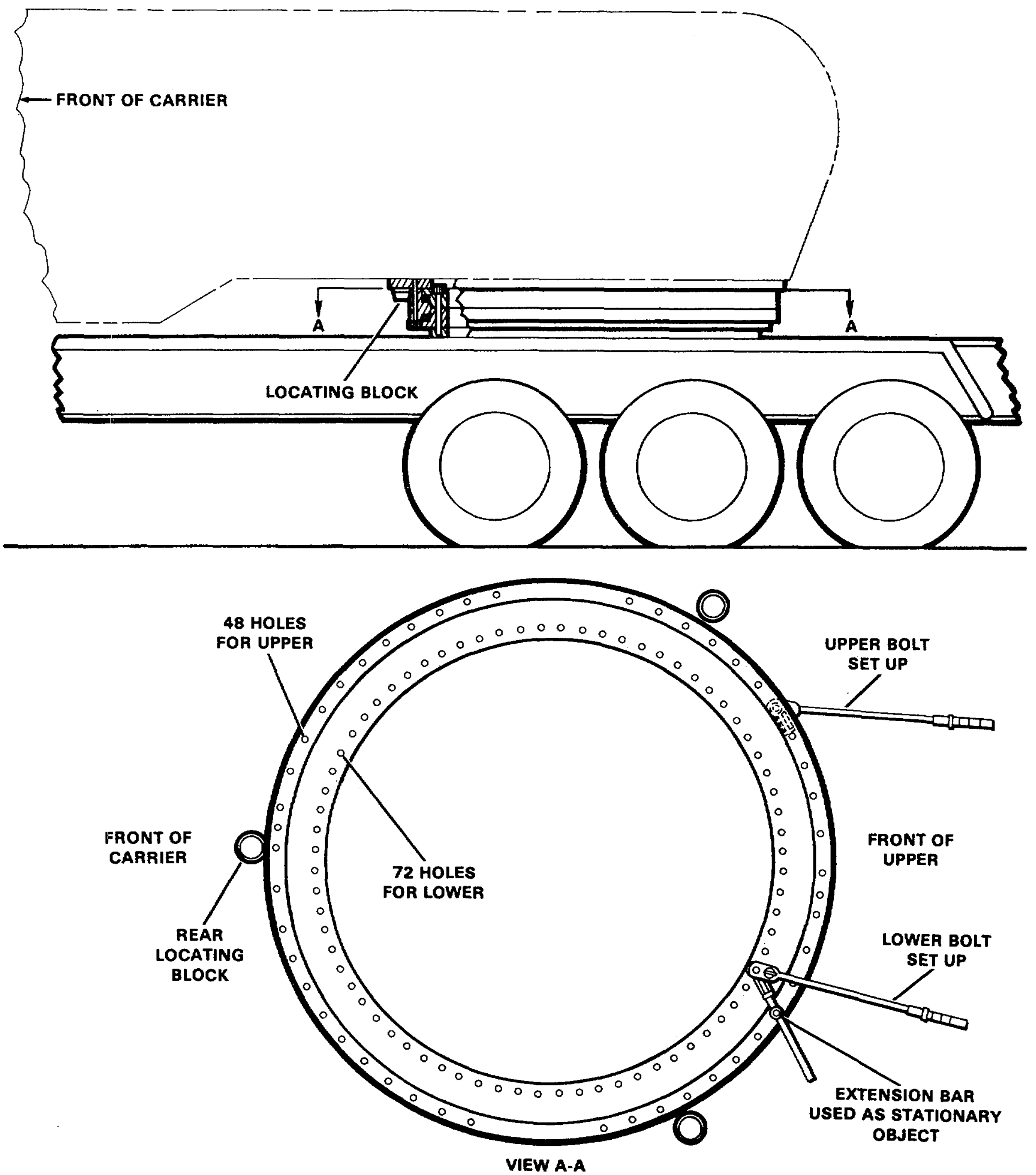


Figure 6E-1. Slewing Ring Mounting (100N2353)

SECTION VII.

HOIST SYSTEM AND COMPONENTS

SUBSECTION 7A

HOIST SYSTEM

GENERAL

The hoist system consists of the items illustrated in Figure 7A-1. In addition to the items identified in Figure 7A-1, this section includes the drum brakes, clutches and pawls.

DESCRIPTION

The hoist system is powered by the right hand two speed transmission. The drive sprocket in the transmission is coupled to the intermediate hoist shaft, which in turn transmits torque to the rear drumshaft gear. The rear drumshaft gear transmits torque to the front drumshaft gear through the main drumshaft idler. The main drumshaft idler is used to allow the drumshafts to turn in the same direction. Both drumshafts turn whenever the two speed transmission is engaged, but neither drum turns until the proper clutch, or planetary brake, is engaged by the operator.

Pawls which engage the ratchets of the front and rear drums are provided to stop and prevent the rotation of the drums when the operator so desires.

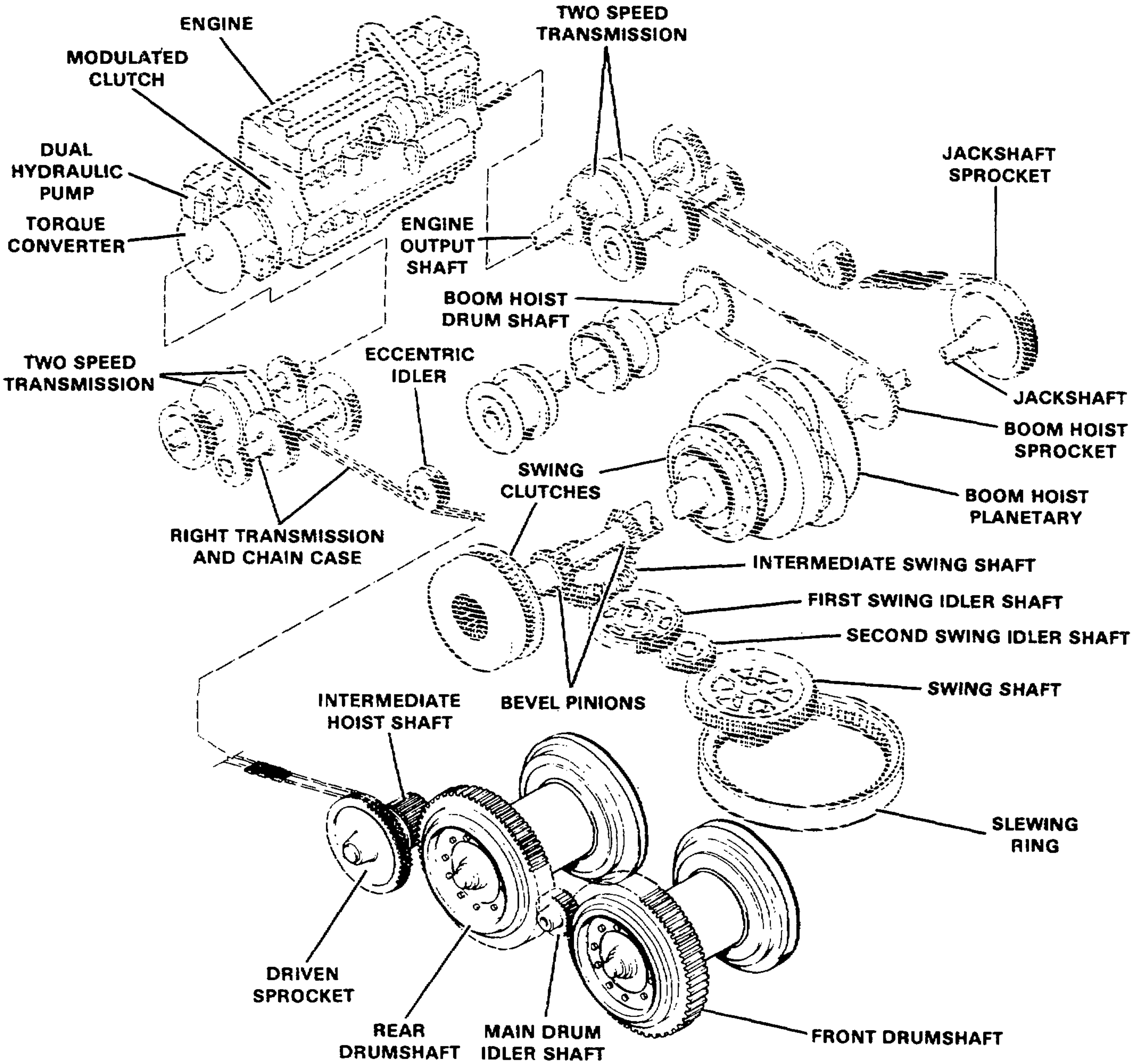
Front and rear drum planetary systems are included on this machine for power lowering a load. The planetary assemblies are identical on both the front and rear drums with a planetary brake band mounted over the planetary spider. To raise a load the drum clutch is engaged and shaft rotation is transmitted through the clutch to the drum lagging. The lagging, in this instance, rotates in the same direction as the drumshaft to take up on the hoist line and raise the load.

Because sun gear (A), Figure 7A-2, is splined directly to the shaft, pinions (B) and planetary brake drum (C) rotate with the lagging while raising a load.

While the drum clutch is disengaged and the drum brake is applied, the shaft continues to rotate. Sun gear (A) is splined to the shaft and rotates in the same direction as the shaft.

Rotation of the sun gear is imparted to pinions (B)which will walk around the stationary internal gear. This will rotate planetary brake drum (C) in the direction of the shaft.

To engage a planetary, the associated drum clutch lever must be moved into its forward position (away from the operator), thereby applying the planetary brake. The drum brake must also be released. Applying the planetary brake causes planetary brake drum (C) to stop. Rotation of the drum gear is imparted to pinions (B)via sun gear (A)which is splined to the shaft. This causes pinions (B) to rotate in the opposite direction of the drum gear. Rotation of pinions (B) is imparted to the internal gear which is bolted to the drum lagging causing the lagging to turn in the direction which pays out hoist line under power.



NOTE 1: END OF SWING CLUTCH SHAFT EXTENDS THROUGH BOOM HOIST SPROCKET.

NOTE 2: MANY ITEMS HAVE BEEN MOVED IN ORDER TO SHOW THE OPERATION OF THE MACHINE MORE CLEARLY.

Figure 7A-1. Hoist Gear Train Schematic

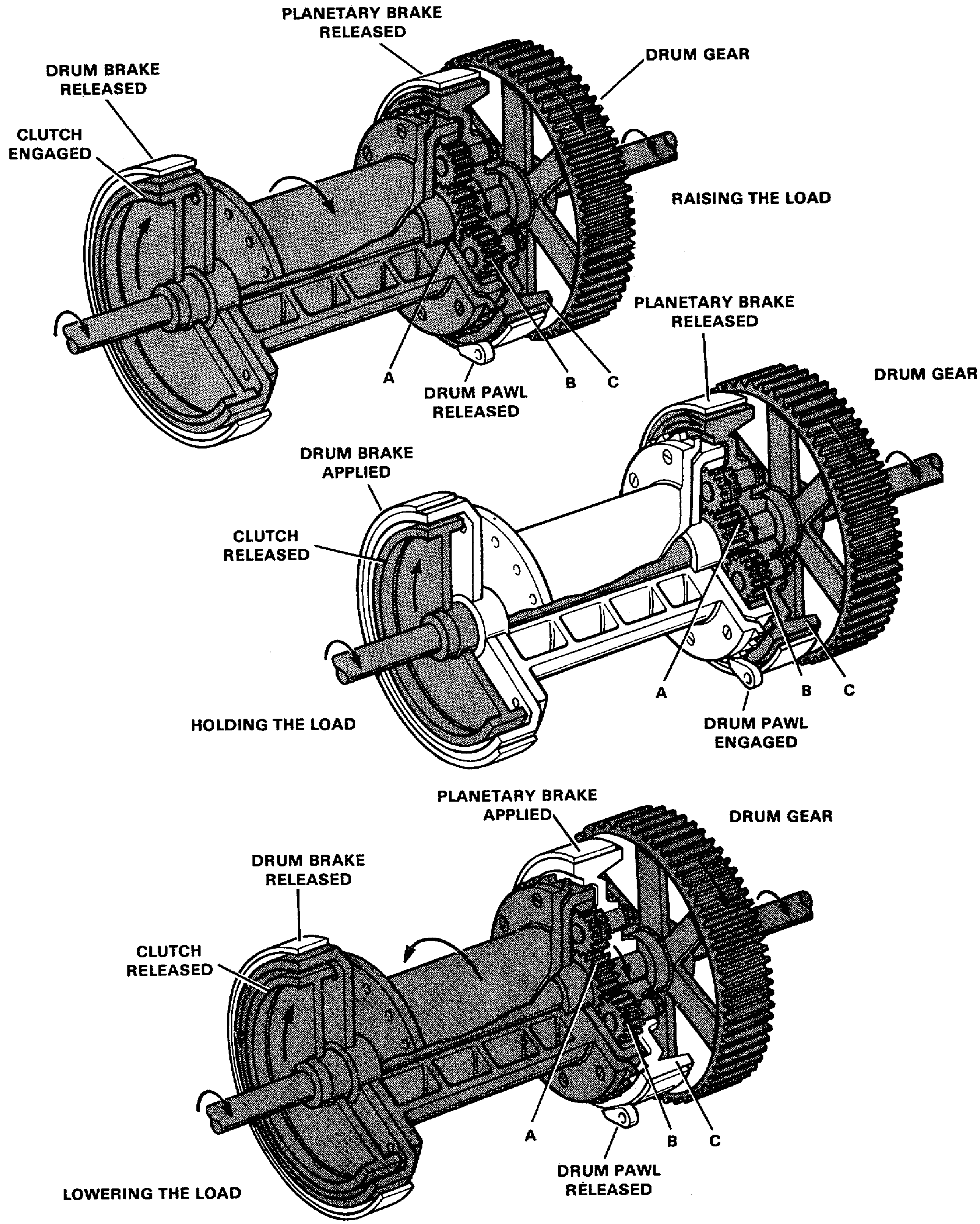


Figure 7A-2. Planetary Lowering Operation

SUBSECTION 7B
INTERMEDIATE HOIST SHAFTS

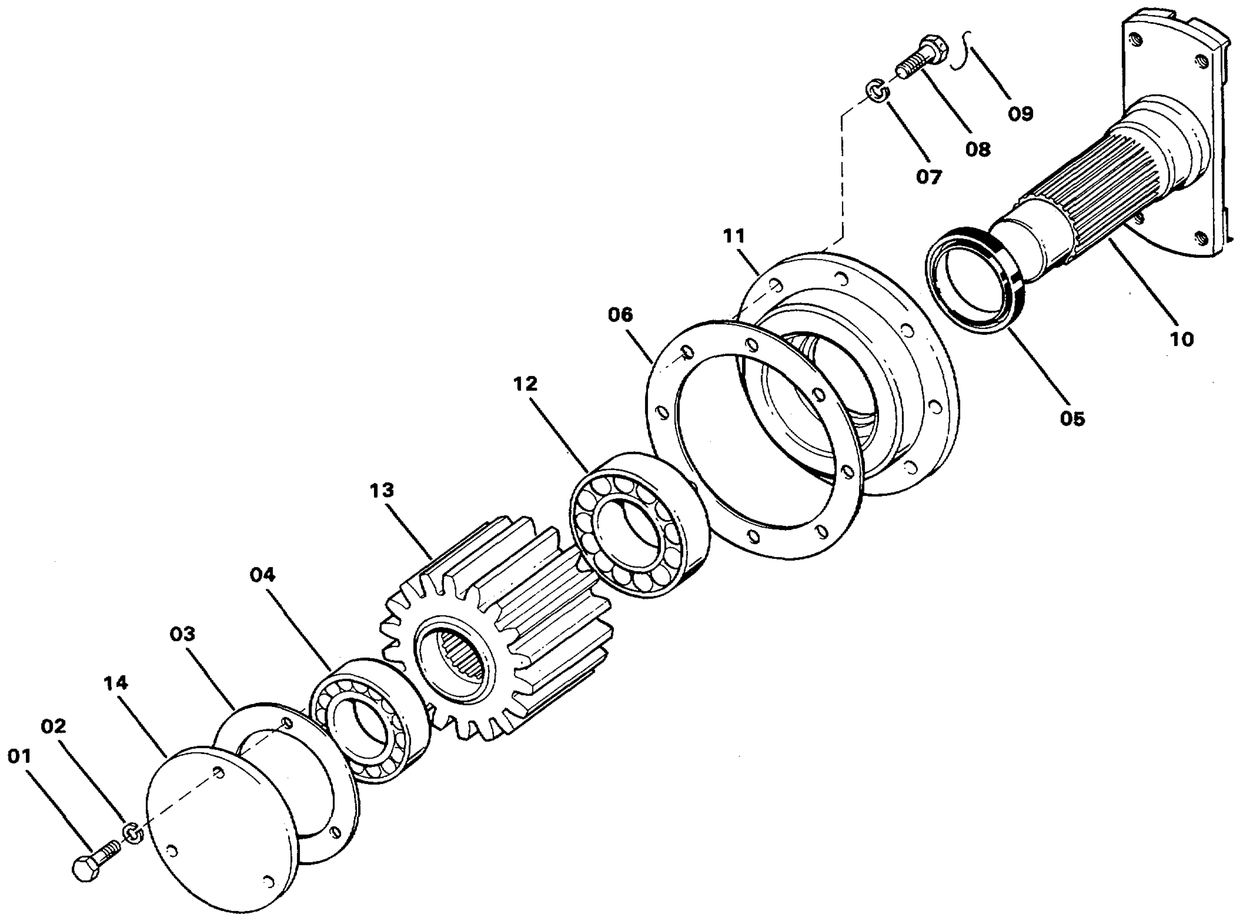
GENERAL

This subsection will cover the removal, disassembly, inspection and repair, and the assembly and installation of the intermediate hoist shaft.

INTERMEDIATE HOIST SHAFT (910N485-1)

GENERAL. The intermediate hoist shaft is mounted in the sidestand of the revolving frame. It is driven by the right hand chain case and transmits power to the rear drumshaft through a gear arrangement.

REMOVAL AND DISASSEMBLY. The intermediate hoist shaft is disassembled during removal. To remove the intermediate hoist shaft, proceed as follows (see Figure 7B-1):



01. CAPSCREW	08. CAPSCREW
02. LOCKWASHER	09. TIE WIRE
03. GASKET	10. SHAFT
04. BEARING	11. BEARING HOUSING
05. OIL SEAL	12. BEARING
06. GASKET	13. GEAR
07. WASHER	14. BEARING RETAINER

Figure 7B-1. Intermediate Hoist Shaft (910485-1)

1. Remove all necessary sheet metal to allow removal of the right hand transmission and chain case as an assembly. See Subsection 4D and remove the right hand transmission and chain case.
2. Remove bearing retainer (14) and gasket (03). Retain any shims for reuse when retainer (14) is reinstalled.
3. Remove capscrews (08) and washers (07). Remove the entire assembly out the right side of the sidestand.
4. Remove bearing (04), gear (13), bearing (1 2) and carrier (11) off the left side of shaft (10). Remove seal (05) and gasket (06) from carrier (11).

INSPECTION AND REPAIR. Prior to reassembly, all intermediate hoist shaft parts should be inspected as follows:
1. Replace all gaskets. Any bearing which shows signs of wear or damage should be replaced.
2. Inspect the intermediate hoist shaft gear and the rear drumshaft gear for wear or damage. If they are worn or damaged, they should be replaced.
3. Replace all capscrews which have rounded corners. Replace all lockwashers and all other damaged or worn parts.
4. If inspection reveals nicks, mars, or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded items are clean and that threads are not damaged.

ASSEMBLY AND INSTALLATION. To assemble and install the intermediate hoist shaft, proceed as-follows (see Figure 7B-1):

1. Install oil seal (05) in carrier (11) with the lips of the seal facing bearing (12). Set carrier (11) on the hub of shaft(10). Heat and install bearing (12) on shaft (10). Set gasket (06) on carrier (11).
2. Install gear (13) on shaft (10). Heat and install bearing (04) on shaft (10).
3. Install the assembly as a unit into the sidestandand secure in place with lockwashers (07) and capscrews (08). Lockwire the capscrews.
4. Install gasket (03), any shims and bearing retainer (14). Install lockwashers (02) and capscrew (01). Tighten securely.
5. Measure the shaft end play. An end play of 1/32 to 1/16 inch (0.79 to 1.59 mm) should exist. If end play is less than 1/32 inch (0.79 mm), insert additional gaskets under bearing retainer (14) to bring the end play to 1/32 inch (0.79 mm). If end play exceeds 1/16 inch (1.58 mm), remove gaskets from behind retainer (14) as required to achieve 1/32 inch (0.79 mm) end play.

NOTE

if all but one gasket has been removed and end play still exceeds 1/16 inch (1.58 mm), install a thinner gasket or remove sufficient stock from the bearing retainer's mounting face.

6. Reinstall the right' hand transmission and chain case as a unit as explained in Subsection 4D.

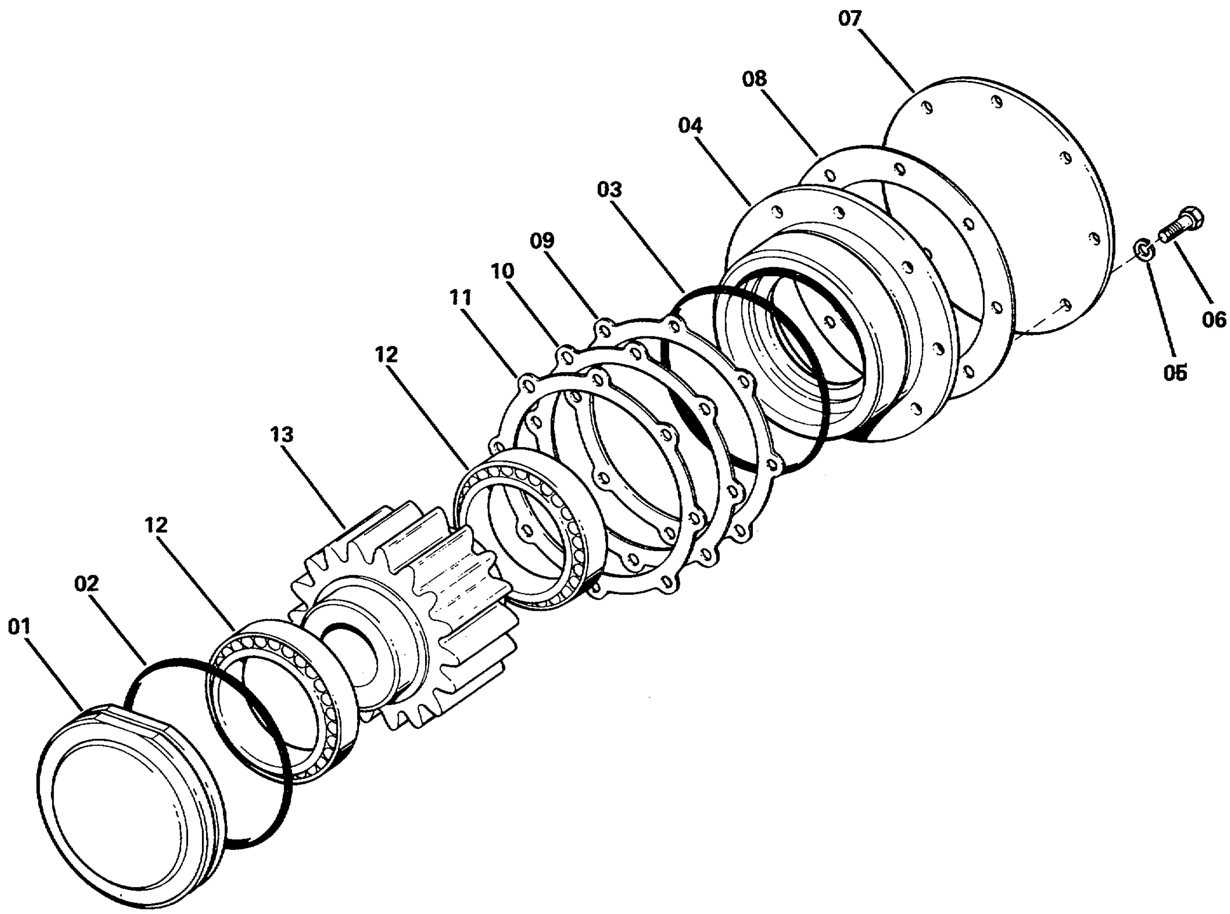
SUBSECTION 7C
MAIN DRUM IDLER SHAFTS

GENERAL
This subsection will cover the removal, disassembly, inspection and repair, and assembly and installation of the main drum idler shaft.

MAIN DRUM IDLER SHAFT (910N484-2)

GENERAL. The main drum idler shaft is located between the front and rear drumshafts. Its purpose is to transmit torque from the rear drumshaft to the front drumshaft and to reverse the direction of front drum rotation so that both drumshafts turn in the same direction.

REMOVAL AND DISASSEMBLY. The main drum idler shaft is disassembled during removal. To remove the idler shaft, proceed as follows (see Figure 7C-1):



01. RETAINER
02. O-RING
03. O-RING
04. BEARING RETAINER
05. LOCKWASHER
06. CAPSCREW
07. COVER
08. GASKET
09. SHIM
10. SHIM
11. SHIM
12. BEARING
13. GEAR

Figure 7C-1. Main Drum Idler Shaft (910N484-2)

1. Remove cover (07) and gasket (08). Position a sawhorse, or a similar solid support, at the fulcrum and insert a piece of timber in the hole of gear (13). Use this timber to support the weight of gear (13).

2. Remove bearing retainer (04) and slide gear (13) out of the sidestand. Retain any shims to reuse when the retainer is reinstalled.

3. Remove the outer race of bearings (12) from the bearing retainers. Remove O-rings (02 and 03) from the retainers.

4. If necessary remove the inner race of bearings (1 2) from gear (13).

INSPECTION AND REPAIR. Prior to reassembly, all idler shaft parts should be inspected as follows:
1. Replace all gaskets and O-rings. Bearings which show signs of wear or damage should be replaced.

2. Inspect gear (13) for wear or damage. If it is scored, pitted, ridged or worn it should be replaced. Also inspect the drumshaft gears for wear or damage.

3. Replace all capscrews which have rounded corners. Replace all lockwashers and any other damaged or worn parts.

4. If inspection reveals nicks, mars or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded items are clean and that threads are not damaged.

ASSEMBLY AND INSTALLATION. To assemble and install the main drum idler shaft, proceed as follows (see Figure 7C-1): 1. Heat and install the inner races of bearings(12) on to the hubs of gear (13).

2. Install the outer races of bearings (12) in retainers (01 and 04). Install O-rings (02 and 03) on the retainers. Install retainer (01) in the sidestand.

3. Place shims (09, 10 and 11) on retainer (04). Using a lever and fulcrum, install the assembly in the bore of the sidestand. Install gasket (08) and cover (07). Secure in place with lockwashers (05) and capscrews (06).

NOTE

Be sure to install the same amount of shims that were removed. This shim pack is selected to allow free gear rotation with no measurable axial end play.

SUBSECTION 7D

DRUMSHAFTS

GENERAL

This subsection contains the information necessary to remove, disassemble, repair, assemble and install the front drumshaft, rear drumshaft, and third drum.

FRONT AND REAR DRUMSHAFT (910J357-6)

REMOVAL. To remove the front or rear drumshaft, proceed as follows (see Figure 7D-1):

1. Remove all necessary sheet metal to allow the removal of the drum and gear case cover through the roof of the machine.
2. Disconnect and cap all hydraulic lines to the drumshaft assembly. Plug all connections where hydraulic lines were removed. Also remove any other hydraulic lines which might interfere with the drumshaft removal.
3. Remove the gantry compression members and the gantry "A" frame.
4. Disconnect and remove all brake bands on the drumshaft assembly. See Subsection 7E.
5. Remove rotary seal (01). Remove bearing retainers (05 and 101). When the retainers are removed be sure to retain all shims. These shims (06, 07, 08, 107, 108 and 109) are used to establish end play when the shaft is reinstalled.
6. Remove all capscrews and lockwashers securing the gear case cover to the revolving frame. Using a suitable lifting device, lift the gear case cover straight up to avoid damage to the drumshaft gears and remove the case from the machine. Remove and replace the gasket set, or O-ring, which seals the gear case to the revolving frame.

7. Remove the pillow block securing the drumshaft to the revolving frame.

WARNING

This unit weighs approximately 6,500 pounds (2,948 kg). Use an adequate sling and lifting device when removing the drumshaft assembly.

8. Check that nothing interferes with the drumshaft removal and lift the drumshaft out of the machine. Set the assembly on suitable supports to prevent it from moving.

DISASSEMBLY. To disassemble the drumshaft, proceed as follows (see Figure 7D-1):

1. Remove one piece of lagging (105) then remove grease tube (70), nipple (68) and connectors (69 and 71). Remove the other half of lagging (105).
2. Remove locknuts (09 and 110) and lockwashers (10 and 111). Pull bearings (12 and 113) off of shaft (72). Remove spacers (13 and 114).
3. Remove spacers (15 and 116). Pull O-rings (16 and 117) and oil seals (14 and 115) from the spacers.
4. Slide clutch spider (34) and drum gear (100) off of shaft (72). Remove adapter (99) from drum (87). Pull oil seal (97) and O-rings (98) off of the adapter.
5. Disconnect and remove all external lubrication tubing from the planetary assembly.
6. Work the complete planetary assembly, except gear support (73) off of shaft (72). Support the assembly at all times with a suitable hoist.
7. Remove capscrews (96) from locknut (95) and remove the locknut from sun gear (75).
8. Remove locknut (94) and lockwashers (92 and 93) from each planetary pin (78). Mark the position of the four planetary pins in brake drum (87) to permit easy alignment of the grease passages during assembly.
9. Remove pins (78) and pinions (80) as assemblies.
10. Pull outer bearing (77) from the hub of sun gear (75) and brake drum (87). Apply the pressure only against the inner race.
11. Pull brake drum (87) off of inner bearing (77), using care to prevent the drum from tilting and damaging bearing (77).
12. Using a bearing puller, remove the cone of inner bearing (77) from the hub of sun gear (75). With gear support (73) adequately supported, drive it to the left off of bearing (65).
13. Using a bearing puller, remove bearing (65). Gear support (73) and seal (59) can then be removed from the right end of shaft (72).
14. Working from the left end of shaft (72), remove spacer (58), O-ring (57) and oil seal (59).
15. Remove capscrews (61). Bearing retainer (67) and gasket (66) are now free on shaft (72).

16. Adequately support brake drum (62), so that it cannot tilt and damage bearing (65), and slide the drum off the left end of shaft (72). Use a bearing puller to remove bearing (65). Remove gasket (66) and retainer (67) from shaft (72).

INSPECTION AND REPAIR. Prior to assembly all drumshaft parts should be inspected as follows: 1. Replace all gaskets, oil seals, and O-rings. Any bearing which shows signs of wear or damage should be replaced.

2. Clean out all lube lines and grease passages to insure free flow of lubrication.

3. Inspect all pinions and gears for wear or damage. If they are scored, pitted, ridged or worn, they should be replaced.

4. If inspection reveals nicks, mars or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded items are clean and that threads are not damaged. Studs must be tight before reinstalling parts that are mounted to them.

5. Replace all nuts which have rounded corners, all lockwashers and all other damaged or worn parts.

6. Burrs caused by lockwashers should be removed to assure easy reassembly of the drumshaft.

7. Inspect all clutch and brake linings at this time. Replace the linings, if necessary, before reinstalling them on the drumshaft.

8. Inspect the drum cooling fins for cracks or breaks. Repair or replace if necessary.

9. Inspect the brake and clutch rims for cracks, scratches or discoloration. Repair or replace if necessary.

ASSEMBLY. To assemble the drumshaft, proceed as follows (see Figure 7D-1):

1. Lubricate all O-rings and seals prior to assembly.

2. Set retainer (67), with gasket (66), on shaft (72). Install the outer race of bearing (65) in drum (62). Heat the first inner race of bearing (65) and press it into place against the shoulder of shaft (72). Using a suitable hoist, install brake drum (62) over the inner race. Install the. spacer of bearing (65) against the first inner race and pack the bearing with grease. Heat the second inner race of bearing (65) and press it on shaft (72) until it is seated in the outer race.

3. Install capscrews (61) into retainer (67). Check the alignment of the retainer and brake drum grease passage.

4. Install oil seal (59) into brake drum (62). Place O-ring (57) into spacer (58) and install the spacer on shaft(72). The lips of seal (59) should face bearing (65) and O-ring (57) toward clutch spider (34).

5. Set oil seal (59) on shaft (72). The lips of oil seal (59) should face sun gear (75). Install the outer race of bearing (65) into support (73). Heat the first inner race of bearing (65)and press it into place against the shoulder of shaft (72). Install support (73) on shaft (72) until the outer race of bearing (65) is over the inner race. Support (73) must be parallel to shaft (72).

6. Install the spacer of bearing (65) against the first inner race and pack the bearing with grease. Heat the second inner race of bearing (65) and press it on shaft (72) until it is seated in the outer race. Install oil seal (59) into support (73).

7. Install the outer races of bearing (77) into brake drum (87). Install spacers (74 and 76) on the hub of sun gear (75). Heat the inner races and install the first inner race of bearing (77) onto the hub of sun gear (75). Install sun gear (75) into brake drum (87). Install the second inner race onto the hub of sun gear (75). Install spacer (74).

8. Install locknut (95) and capscrews (96).

9. Set pinions (80) on pins (78) then install the units as assemblies into drum (87). Orient pins (78) so that the grease passages in the pins and pin bores are properly aligned using the alignment marks made previously.

10. Install lockwashers (92 and 93) and locknuts (94) on each pin (78). Tighten securely. Lift the entire planetary assembly and work it onto shaft (72).

11. Install oil seal (97) into adapter (99). Also install O-ring (98) onto adapter (99). Install adapter (99) onto drum gear (87). The lips of oil seal (97) should face away from gear (87).

12. Slide drum gear (100) on the right end of shaft (72) and slide clutch spider (34) on the left end of shaft (72).

13. Install O-rings (16 and 117) and oil seals (14 and 115) on spacers (15 and 116). Install the spacers on shaft (72).

14. Heat the first inner race of bearings (12 and 113) and press them onto shaft (72) against the spacers. Install the bearing spacers, outer races and finally the other inner races.

15. Install lockwashers (10 and 111) and locknuts (09 and 110). Tighten the locknuts.

16. Install one piece of lagging (105) then install grease tube (70), nipple (68) and connectors (69 and 71). Install the other half of lagging (105).

INSTALLATION. To install the drumshaft, proceed as follows (see Figure 7D-1):

1. Using a suitable hoist and sling, install the assembled drumshaft on the machine.

2. Install the pillow block on the left side of the drumshaft, securing the drumshaft to the revolving frame. Do not tighten the pillow block nuts at this time.

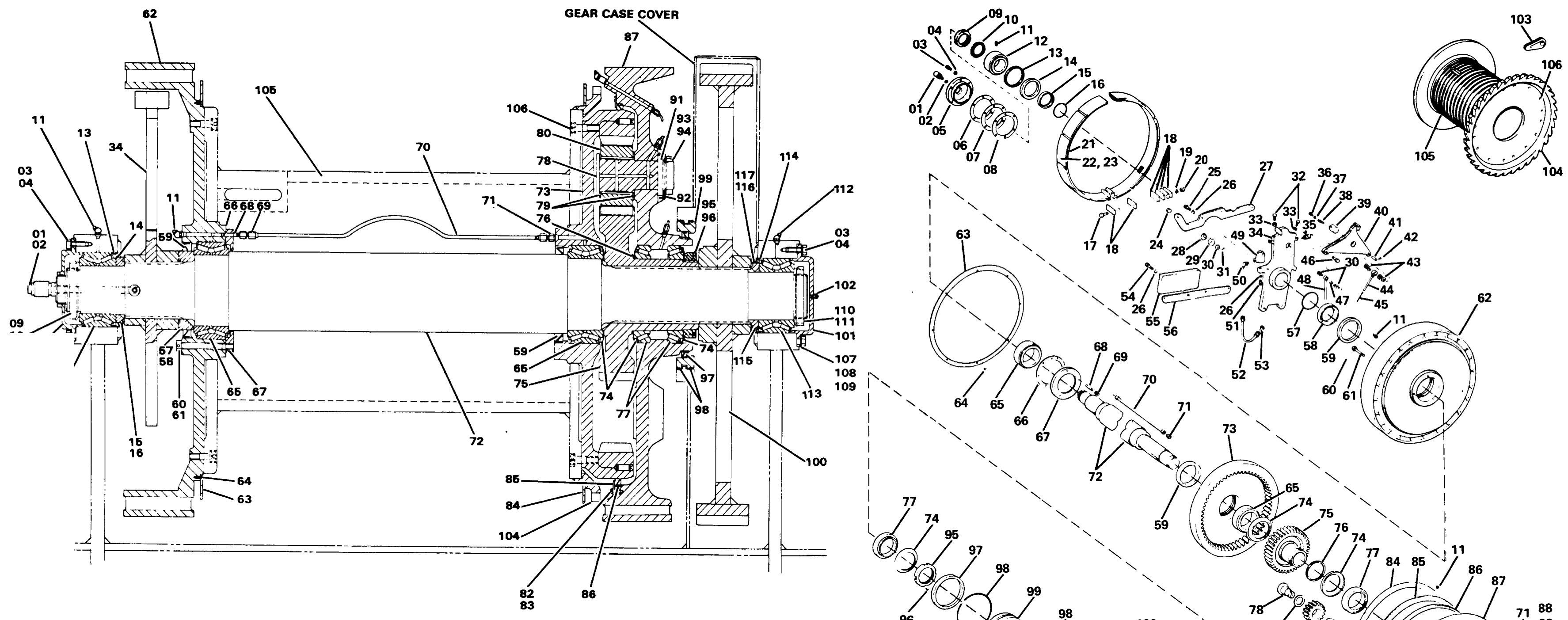
3. Install the gasket set on the gear case. Using a suitable sling and lifting device, install the gear case cover on the revolving frame. Install and fully tighten all capscrews.

4. Install shims (06, 07, 08, 107. 108 and 109) and bearing retainers (05 and 101). It may be necessary to adjust the pillow block to align bearing retainer (05). Tighten all capscrews and the pillow block nuts.

5. Check shaft end play. End play should be 0.030 inch (0.762 mm).

6. Install rotary seal (01). Secure in place with a locking compound.

7. Remove the caps and plugs from all hydraulic hoses and connections. Install the hydraulic lines.



'ARY SEAL
ING
'SCREW
KWASHER
RING RETAINER
M
M
M
KNUT
KWASHER
ING
12. BEARING
13. SPACER
14. OIL SEAL
15. SPACER
16. O-RING
17. CAPSCREW
18. SPACER
19. LOCKWASHER
20. NUT
21. LINING
22. RIVET
23. RIVET
24. NUT
25. CAPSCREW
26. LOCKWASHER
27. BRACKET
28. ADJUSTING BOLT
29. ROLLER
30. WASHER
31. COTTER PIN
32. SETSCREW
33. JAM NUT
34. SPIDER
35. SPRING
36. CAPSCREW
37. LOCKWASHER
38. ROD END
39. PIN
40. LEVER
41. PIN
42. COTTER PIN
43. WASHER
44. EYEBOLT
45. SPRING
46. CAPSCREW
47. BUSHING
48. EYEBOLT
49. CYLINDER
50. ELBOW
51. CAPSCREW
52. HOSE
53. CONNECTOR
54. CAPSCREW
55. COUNTERWEIGHT
56. BRACKET
57. O-RING
58. SPACER
59. OIL SEAL
60. TIE WIRE
61. CAPSCREW
62. BRAKE DRUM
63. GUARD
64. SCREW
65. BEARING
66. GASKET
67. RETAINER
68. NIPPLE
69. CONNECTOR
70. TUBE
71. CONNECTOR
72. SHAFT
73. SUPPORT
74. RING SEAL
75. SUN GEAR
76. SPACER
77. BEARING
78. PIN
79. THRUST WASHER
80. PINION
81. BUSHING
82. CAPSCREW
83. LOCKWASHER
84. GUARD
85. RETAINER
86. SEAL
87. PLANETARY BRAKE DRUM
88. TUBE
89. TUBE
90. TUBE
91. KEY
92. LOCKWASHER
93. LOCKWASHER
94. LOCKNUT
95. LOCKNUT
96. CAPSCREW
97. OIL SEAL
98. O-RING
99. ADAPTER
100. GEAR
101. RETAINER
102. FITTING
103. WEDGE
104. RATCHET
105. LAGGING
106. BOLT
107. SHIM
108. SHIM
109. SHIM
110. LOCKNUT
111. LOCKWASHER
112. FITTING
113. BEARING
114. SPACER
115. OIL SEAL
116. SPACER
117. O-RING

Figure 7D-1. Front and Rear Drumshaft (910J357-6)

8. Install and adjust all brake bands on the drumshaft assembly (see Subsection 7E).

9. Install the gantry "A" frame and the gantry compression members.

10. Install all sheet metal.

11. Bleed the hydraulic cylinders to remove any air trapped in the hydraulic lines. See Bleeding Procedure in Subsection 5A.

12. Lubricate the complete drumshaft assembly in accordance with the lubrication specifications given in Section III.

SUBSECTION 7E
DRUM BRAKES

GENERAL

This subsection contains the information necessary to remove, repair, install, and adjust the main and planetary brakes.

Several terms are often misunderstood when used in reference to brake bands on this machine. The following definitions as used in this manual are as follows:

1. Brake Set: This means the brake band is tightened around a rotating member to stop or prevent the rotation of that member.
2. Live End: This is the end of a brake band to which force is applied.
3. Dead End: This is the anchor end of a brake band. Typically, most lining wear will occur at this end of the band.

DRUM BRAKES (100J3399-12)

GENERAL

Each main hoist drum is equipped with a main and a planetary brake. Although different in function, the main and planetary brake assemblies are nearly identical in construction.

MAIN BRAKES DESCRIPTION. Both the front and rear main brake bands are connected to two hydraulic cylinders with opposing springs (see Figure 7E-1). When there is no pressure in the lock cylinder, each brake is set by the lock spring which opposes the lock cylinder. When the operator moves a brake lock switch to the OFF position, hydraulic pressure is applied to the lock cylinder extending the piston and compressing the lock spring. This releases the brake so that it may be operated by the brake cylinder.

When the operator depresses the brake pedal, hydraulic pressure is applied to the brake cylinder, extending the piston and setting the brake. When the operator releases the brake pedal, hydraulic pressure is released from the brake cylinder, retracting the piston and releasing the brake.

When the brake linings are new and the brakes are in proper adjustment, one dimension should be noted. With the brake set and hydraulic pressure released from the cylinders the correct set dimension as shown in Figure 7E-1 should be 8-7/8 inches (22.5 cm).

When the lining starts to wear the 8-7/8 inch (22.5 cm) dimension will decrease. As the lining wears and the dimension decreases to 8-3/4 inches (22.2 cm) the brakes will need adjusting. See the Operator's Manual for the method of adjusting the brakes for normal lining wear.

The main brakes should be relined when brake lining thickness reaches 1/4 inch (6.4 cm) as measured at the dead end of the band.

REMOVAL. To remove the main brake bands, proceed as follows (see Figure 7E-1):

1. Shut down the engine and operate a control lever until all hydraulic pressure is exhausted from the system.
2. If any rope remains on the drum to be worked on, set the drum pawl to prevent the rotation of the drum.
3. Remove the sheet metal from around the brake band to be worked on.
4. If necessary back off the retaining plate stop nuts and remove the retaining plate to gain access to the brake cylinder and lock spring. Also remove the support pin to gain access to the lock cylinder and brake spring.
5. Release the tension on the hanger spring jam nuts. Remove the hanger springs from the band.
6. Remove the brake band adjusting bolt and spring by removing the nut and spacer.
7. Remove the dead end link pin to free the dead end of the band from the dead end links. Remove the live end pin to free the live end of the band from the live end links.
8. Remove the brake band halves from the machine and reline them.

NOTE

A lining kit is available. See the Replacement Parts Manual.

INSPECTION AND REPAIR. Before reinstalling the band and operating mechanism, inspect the following items (see Figure 7E-1):

1. Replace any weak or distorted spring.
2. Inspect all pins, bushings and operating rods for wear. Replace any worn parts. Also check that operating levers are not bent.

3. If any cylinder leaks, or has been performing erratically, remove and overhaul, if necessary. See Subsection 5D.
4. Check the brake bands for distortion.
5. Inspect the brake drum surfaces for cracks, scoring or other damage.

INSTALLATION. After relining the brake bands, install the band halves and operating mechanism as follows (see Figure 7E-1):

1. Set the brake band halves on the drum. Install the live end pin through the links and the live end of the band. Install the dead end pin through the dead end links and the dead end of the band. Install all cotter pins.
2. Install the spring, adjusting bolt and spacer on the band halves. Hold these items in place with the adjusting nut.
3. Install the hanger springs on the brake band. Initially adjust the hanger springs with the stop nuts so that the brake band clears the drum.
4. Reinstall the support pin through the lock cylinder and brake spring. Install the cotter pins.
5. Reinstall the retaining plate and secure in place with the stop nuts.
6. Bleed the hydraulic cylinders to remove any air trapped in the hydraulic lines (see the Bleeding Procedure in Sub-section 5A of this manual).

ADJUSTMENT. The actual adjusting of the main brakes is done with hydraulic pressure released from the cylinders.

To adjust the main brakes when the brake bands have been removed, proceed as follows (see Figure 7E-1):

1. Initially set the brake band split to 3-1/4 inches (8.26 cm).
2. With the brake set, hydraulic pressure released from both cylinders, the correct set dimension is 8-7/8 inches (22.5 cm). If the dimension is not 8-7/8 inches (22.5 cm) adjust to this dimension by turning the brake band adjustment bolt until the dimension is achieved.
3. Check the brake adjustment by lifting a capacity load an inch or two off of the ground and applying the foot brake. Move the brake lock switch to the ON position (this bleeds pressure from the lock cylinder to set the brake). Release the foot brake pedal. The load must now be held, without drifting, by the lock spring.
4. If the load drifts during this test, lower the load to the ground.

CAUTION

Reapply the foot brake pedal before moving the brake lock switch away from the operator and lower the load under the control of the foot brake.

Repeat the adjustment instructions above until the load does not drift.

5. After the brakes have been properly adjusted, check the adjustment of the hanger springs. The hanger springs should be adjusted so that the brake band clears the drum uniformly around its circumference with the brakes released.

PLANETARY BRAKES

DESCRIPTION. The front and rear drum planetary brakes are provided to power lower loads. These brakes are mounted over the planetary brake drum. These brakes are hydraulically set-spring released brakes. When there is no pressure in the planetary brake cylinder, its piston is retracted and the planetary brake is released.

When the operator engages a planetary brake by means of the control lever, hydraulic fluid is directed to the planetary brake cylinder. With hydraulic pressure applied to the cylinder, its piston extends and applies force to the linkage which contracts the brake bands and sets the brake (see Figure 7E1).

When the linings are new and the brakes are in proper adjustment, one dimension should be noted. With the brake set (hydraulic pressure applied) the correct set dimension as shown in Figure 7E-1 should be 8-7/8 inches (22.5 cm).

When the lining starts to wear the 8-7/8 inch (22.5 cm) dimension will decrease. As the lining wears and the dimension decreases to 8-3/4 inches (22.2 cm) the brakes will need adjusting. See the Operator's Manual for the method of adjusting the brakes for normal lining wear.

The planetary brakes should be relined when brake lining thickness reaches 1/4 inch (6.4 mm) as measured at the dead end of the band.

REMOVAL. To remove the planetary brake bands, proceed as follows (see Figure 7E-1):

1. Shut down the engine and operate a control lever until all hydraulic pressure is exhausted from the system.
2. If any rope remains on the drum to be worked on, set the drum pawl to prevent the rotation of the drum.
3. Remove the sheet metal from around the brake band to be worked on.
4. If necessary back off the retaining plate stop nuts and remove the retaining plate to gain access to the cylinder. Also remove the support pin to gain access to the spring.
5. Release the tension on the hanger spring jam nuts. Remove the hanger springs from the band.
6. Remove the brake band adjusting bolt and spring by removing the nut and spacer.
7. Remove the dead end link pin to free the dead end of the band from the dead end links. Remove the live end pin to free the live end of the band from the live end links.
8. Remove the brake band halves from the machine and reline them.

NOTE

A lining kit is available. See the Replacement Parts Manual.

INSPECTION AND REPAIR. Before reinstalling the band and operating mechanism, inspect the following items (see Figure 7E-1):

1. Replace any weak or distorted spring.

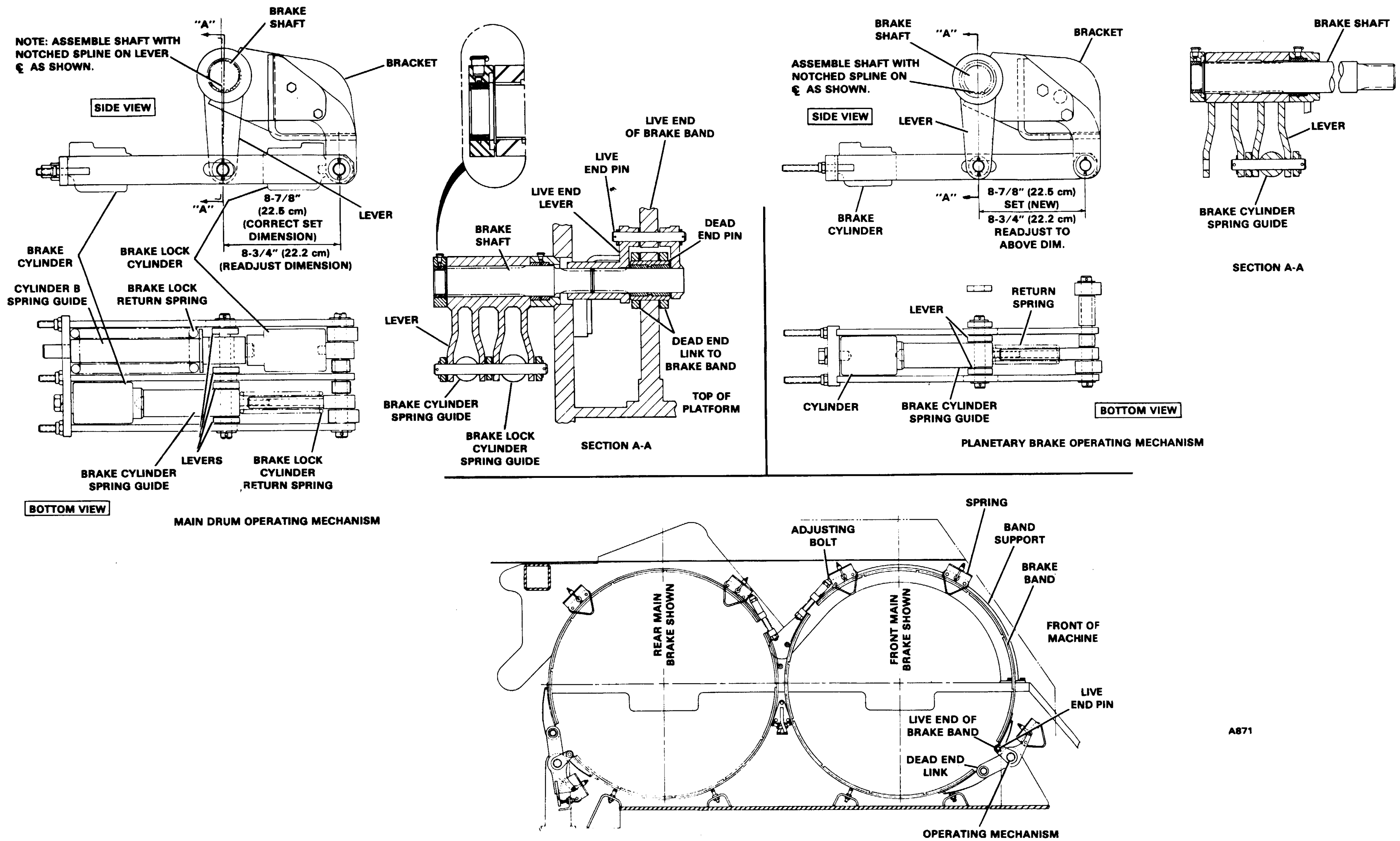


Figure 7E-1. Hoist Drum Brakes Bands (100J3399-12)

2. Inspect all pins, bushings and operating rods for wear. Replace any worn parts. Also check that the operating levers are not bent.

3. If the cylinder leaks or has been performing erratically, remove and overhaul if necessary. See Subsection 5D.

4. Check the brake bands for distortion.

5. Inspect the brake drum surfaces for cracks, scoring or other damage.

INSTALLATION. After relining the brake bands, install the band halves and operating mechanism as follows (see Figure 7E-1):

1. Set the brake band halves on the drum. Install the live end pin through the links and the live end of the band. Install the dead end pin through the dead end links and the dead end of the band. Install all cotter pins.

2. Install the spring, adjusting bolt and spacer on the band halves. Hold these items in place with the adjusting nut.

3. Install the hanger springs on the brake band. Initially adjust the hanger springs with the stop nuts so that the brake band clears the drum.

4. Reinstall the support pin through the spring. Install the washers and cotter pins.

5. Reinstall the retaining plate and secure in place with the stop nuts.

6. Bleed the hydraulic cylinders to remove any air trapped in the hydraulic lines (see the Bleeding Procedure in Subsection 5A of this manual).

ADJUSTMENT. The actual adjusting of the planetary brakes is done with hydraulic pressure released from the cylinder. The checking of the dimensions is done with pressure applied and the brake set. To adjust the planetary brakes when the brake bands have been removed, proceed as follows (see Figure 7E-1): 1. Initially set the brake band split to 3-1/4 inches (8.26 cm).

2. With the brake set, hydraulic pressure applied to the cylinder, the correct set dimension is 8-7/8 inches (22.5 cm). If the dimension is not 8-7/8 inches (22.5 cm) adjust to this dimension by turning the brake band adjustment bolt until the dimension is achieved.

3. Check the operation of the front and rear planetary brakes. Repeat step 2 if necessary.

4. After the brakes have been properly adjusted, check the adjustment of the hanger springs. The hanger springs should be adjusted so that the brake band clears the drum uniformly around its circumference with the brakes released.

SUBSECTION 7F

CLUTCHES

GENERAL

This subsection contains the information necessary to remove, repair, install and adjust the front and rear drum clutches.

FRONT AND REAR DRUM CLUTCHES (91 0J357-6)

DESCRIPTION. The front and rear drum clutches are located on the left hand ends of their respective drumshafts.

These clutches are hydraulically applied, spring released. When there is no pressure in the clutch cylinder, the return spring applies force to the actuating levers to contract the band and release the clutch. When the operator moves a clutch control lever to apply a clutch, hydraulic fluid is forced into the cylinder. This causes the piston to extend and apply force on the actuating levers to expand the band and apply the clutch.

Since wear will usually be greatest at the dead end of the clutch linings, the clutch bands may be interchanged when wear has reduced the thickness of the lining atthe dead end to 1/4 inch (0.64 cm). When wear has reduced the thickness of the other lining to 1/4 inch (0.64 cm), both linings should be replaced. See the Operator's Manual to adjust the clutches for normal lining wear.

REMOVAL. To remove the clutch bands, proceed as follows (see Figure 7F-1):

1. Shut down the engine and operate a control lever until all hydraulic pressure is exhausted from the system.
2. If any rope remains on the drum to be worked on, set the drum pawl to prevent the rotation of the drum.
3. Remove any material that may interfere with the removal of the clutch band halves.
4. Loosen jam nuts (33) and turn in bolts (34). Also loosen stop nuts (10) and turn adjusting nuts (11) until there is adequate clearance for removal of clutch band (01).
5. Remove springs (42) from spider (32). Remove pin (40) and washers (31) then remove eyebolt (30) and spring (29).
6. Remove nut (10) from bolt (25) then pull the bolt and washers (26) out of eyebolt (27). Remove capscrew (35) and remove rod end (37) from pin (38).
7. Remove lever (39) by removing pin (38).
8. If necessary, remove brackets (18 and 09) by removing the attaching hardware. Remove rollers (12) by removing stop nuts (10).

NOTE

The clutch is dynamically balanced by counterweight (17). For that reason, each counterweight should be kept with its original clutch assembly, since the weights of the counterweights are not all the same.

9. Separate the clutch band halves by removing nuts (06), lockwashers (05) and capscrews (03). The clutch band halves may now be removed and relined.

NOTE

A lining kit is available. See the Replacement Parts Manual.

INSPECTION AND REPAIR. Prior to reinstalling the clutch band halves on the drum, inspect the following items (see Figure 7F-1):
1. Replace all worn springs.
2. Remove bushing (28) from eyebolt (27) and replace it.
3. Inspect rollers (12)for cracks, distortion, or flat spots. Replace if necessary.
4. If cylinder (20) leaks or has been performing erratically remove and overhaul if necessary. See Subsection 5D.

5. Check the brake bands for distortion.
6. Check actuating lever (39) and spider (32) for wear. Replace if necessary. To replace spider (32) it will be necessary to remove the drumshaft. See Subsection 7D.
7. Inspect the clutch drum to see that it is not cracked, scored or otherwise damaged.

ASSEMBLY AND INSTALLATION. To assemble the drum clutch and install the clutch band halves, proceed as follows (see Figure 7F-1): 1. Place the clutch band halves in the clutch drum and connect the two halves by installing capscrews (03), lockwashers (05) and nuts (06).
2. Install rollers (12) on brackets (18 and 09). Connect the brackets to spider (32) and secure in place with the attaching hardware.

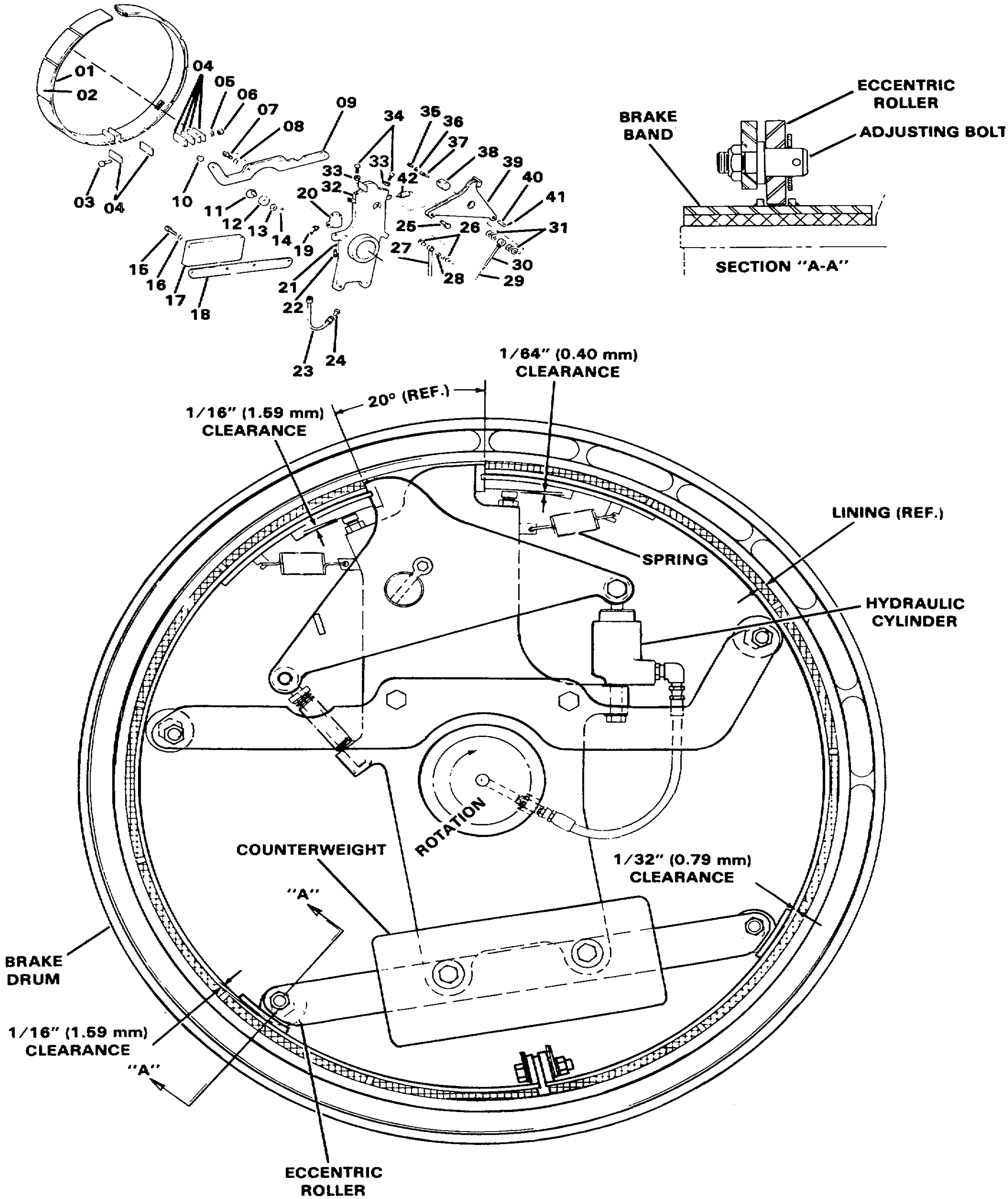


Figure 7F-1. Front and Rear Drum Clutch (910J357-6)

LEGEND FOR FIGURE 7F-1

01. LINING	22. CAPSCREW
02. RIVET	23. HOSE
03. CAPSCREW	24. CONNECTOR
04. SPACER	26. CAPSCREW
06. LOCKWASHER	26. WASHER
06. NUT	27. EYEBOLT
07. CAPSCREW	28. BUSHING
08. LOCKWASHER	29. SPRING
09. BRACKET	30. EYEBOLT
10. STOP NUT	31. WASHER
11. ADJUSTING BOLT	32. CLUTCH SPIDER
12. ROLLER	33. JAM NUT
13. WASHER	34. BOLT
14. COTTER PIN	35. CAPSCREW
16. CAPSCREW	36. LOCKWASHER
16. WASHER	37. ROD END
17. COUNTERWEIGHT	38. PIN
18. BRACKET	39. LEVER
19. ELBOW	40. PIN
20. CYLINDER	41. COTTER PIN
21. WASHER	42. SPRING

3. Install lever (39) on spider (32). Install pin (38) through lever (39) and spider (32). Secure pin (38) with rod end (37) and capscrew (35).

4. Attach eyebolt (27) to lever (39) using washers (26), capscrew (25) and nut (10).

5. Place spring (29) on eyebolt (30). Install eyebolt (30) into spider (32). Install pin (40), with washers (31) through lever (39) and eyebolt (30). Secure with cotter pins (41).

6. Connect clutch band (01) to spider (32) using springs (42).

7. Bleed the hydraulic cylinder to remove any air trapped in the hydraulic line. See the Bleeding Procedure in Subsection 5A.

ADJUSTMENT. To adjust the clutch after it has been removed, proceed as follows (see Figure 7F-1):

1. Adjust the position of bolts (34) and roller adjusters (11) to center the lining in the clutch drum and maintain the dimensions given. Tighten jam nuts (33) and stop nuts (10) after adjustments are made.

2. Operate the clutch several times and check that the clutch band does not drag when it is not engaged. If necessary, repeat Step 1 above.

DRUM PAWLS

GENERAL

This subsection will cover the removal, adjustment, and installation of the front and rear drum pawls.

MAIN DRUM PAWLS (100J3858-1)

DESCRIPTION. Both the front and rear drums are provided with identical pawls (see Figure 7G-1). These pawls are spring set-hydraulically released. They should be engaged in the drum ratchet at all times except when a load is being lowered.

REMOVAL AND DISASSEMBLY. If upon inspection it is revealed that the pawl is worn down, cracked, or broken it will be necessary to remove the pawl and replace it. If the cylinder is performing erratically it will be necessary to remove and overhaul it. To remove the pawl or cylinder proceed as follows (see Figure 7G-1):

1. Lower the boom and support it on blocking. Make sure all tension is removed from the wire rope of the drum being worked on.

2. Shut down the engine and operate a control lever until all hydraulic pressure is exhausted from the system. Remove the hydraulic line from cylinder (31).

3. Remove capscrew (01) and plate (03) from pawl (09) of the appropriate assembly. Drive pawl (09) out the side stand and tube support (10). Remove pawl (09) from the machine.

4. If necessary remove pin (20), lever (04) and spacer (05). Then remove tube support (10) by removing the capscrews. Remove bushing (06) and O-rings (11 and 12)from the tube support.

5. To remove cylinder (31), remove all tension in spring (25) and allow trunnion (33) to disengage push rod (32). Remove capscrew (28) and take cylinder (31) out of the assembly.

INSPECTION AND REPAIR. Prior to assembly all pawl parts should be inspected as follows (see Figure 7G-1):

1. Replace spring (25) and all cotter pins.

2. If cylinder (31) has been performing erratically, see Subsection 5D to overhaul it.

3. Inspect bushing (06) and replace if necessary.

4. If pawl (09) is worn, cracked, or broken, replace the pawl.

5. Inspect the drum ratchet for wear, cracks, or broken teeth. Repair or replace if necessary. See Subsection 7D.

ASSEMBLY AND INSTALLATION. To assemble and install the pawl and cylinder, proceed as follows (see Figure 7G-1):

1. Set push rod (32) into cylinder (31) and set the cylinder in brackets (27). Install lockwasher (23) and capscrew (28). Tighten securely.

2. Install O-rings (11 and 12) on tube support (10). Install the tube support in the machine and secure with capscrews (07). Install pawl (09) through tube support (10).

3. Install bushing (06) in tube support (10). Install spacer (05), lever (04) and end plate (03). Secure in place with capscrew (01) and tighten securely. Reinstall pin (20) and secure with cotter pin (21).

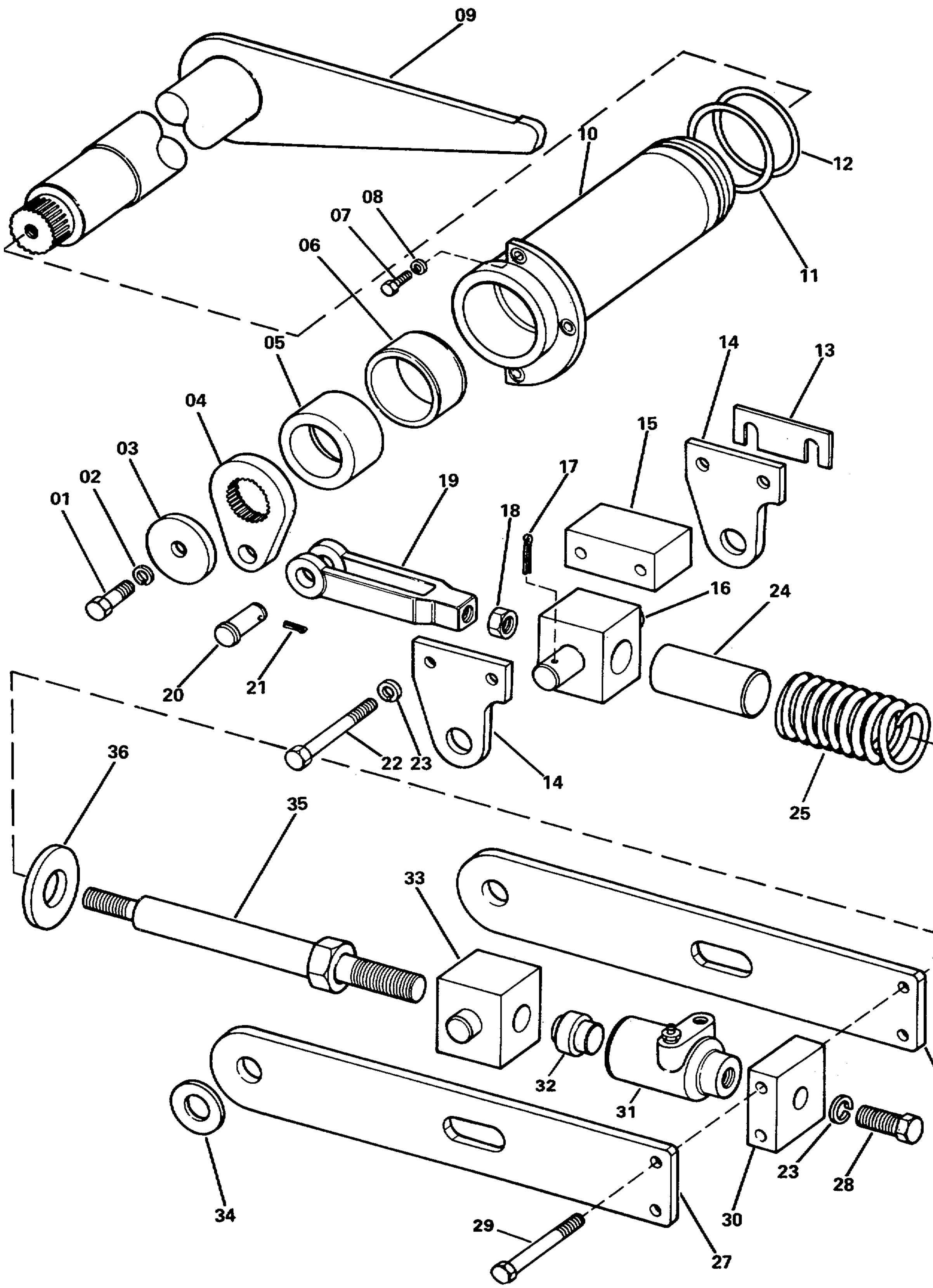
ADJUSTMENT. To adjust the pawl after it has been replaced, proceed as follows (see Figure 7G-2):

1. Inspect the linkage to make certain that everything pivots freely when the pawl is engaged and disengaged.

2. With the pawl engaged (hydraulic pressure released) make certain that the trunnion is firmly seated against the cylinder piston and that the piston is fully retracted. Using the adjusting bolt, adjust the length of the pawl spring to 4-3/32 inches (10.40 cm).

3. With the pawl still engaged make certain thatthe pawl is fully engaged in the ratchet teeth. If necessary back off the jam nut, remove the clevis pin and adjust the yoke end until the pawl engages the ratchet fully.

4. After all adjustments are made, tighten the jam nut and again check the operation of the pawl.



01. CAPSCREW
02. LOCKWASHER
03. WASHER
04. LEVER
05. SPACER
06. BUSHING
07. CAPSCREW
08. LOCKWASHER
09. SHAFT
10. TUBE SUPPORT
11. O-RING
12. O-RING
13. SHIM
14. BRACKET
15. SPACER
16. TRUNNION
17. COTTER PIN
18. JAM NUT
19. YOKE END
20. PIN
21. COTTER PIN
22. CAPSCREW
23. LOCKWASHER
24. SPACER
25. SPRING
26. NUT
27. LINK
28. CAPSCREW
29. CAPSCREW
30. END PLATE
31. CYLINDER
32. PUSH ROD
33. TRUNNION
34. WASHER
35. ADUSTING BOLT
36. WASHER

Figure 7G-1. Drum Pawls (100J3858-1)

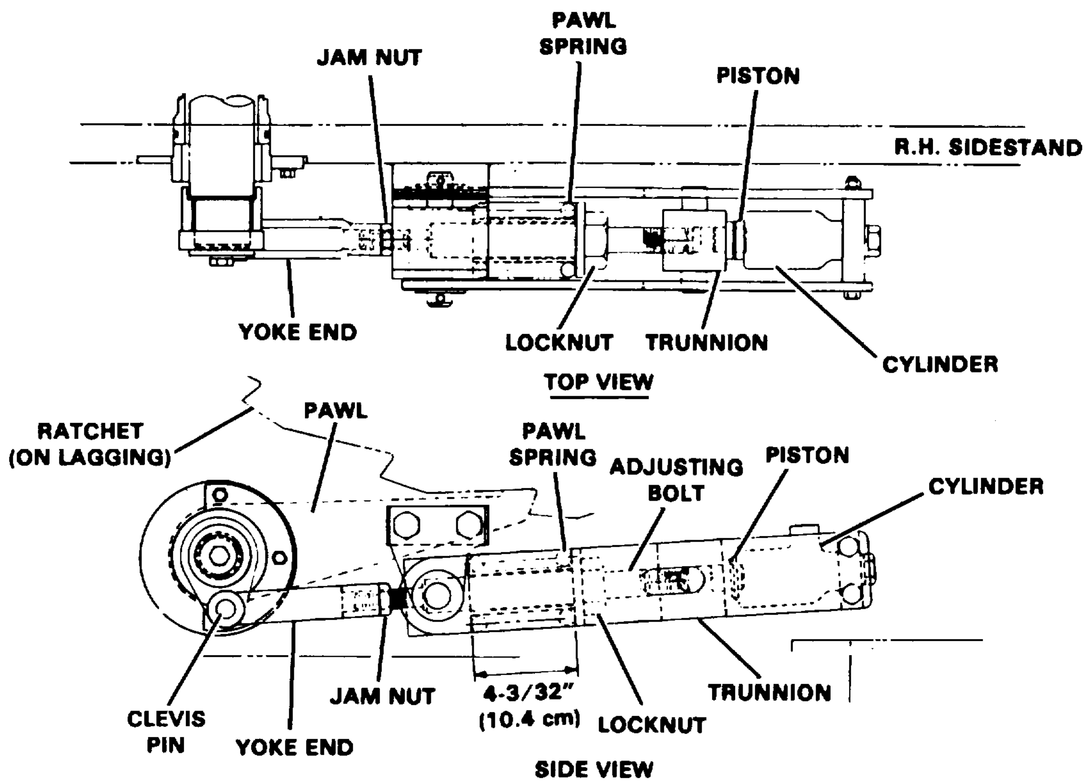


Figure 7G-2. Pawl Adjustment (100J3858)

SECTION VIII

BOOM HOIST SYSTEM AND COMPONENTS

BOOM HOIST SYSTEM

GENERAL The boom hoist system consists of the items illustrated in Figure 8A-1. In addition to the items identified in Figure 8A1 this section includes the boom hoist planetary pawl, drum pawl, planetary brakes, and drum brakes.

DESCRIPTION The boom hoist system raises, holds, and lowers the boom. Power for the system is provided by the left side two speed transmission. Power is transmitted by the two speed transmission to the jackshaft which in turn drives the boom hoist planetary system mounted on the jackshaft. The boom is both lifted and lowered by this planetary drive mounted on the jackshaft. The output sprocket is chain coupled to the boom hoist shaft to raise and lower the boom.

In the descriptions that follow, the engine is running and the two speed transmission is engaged.

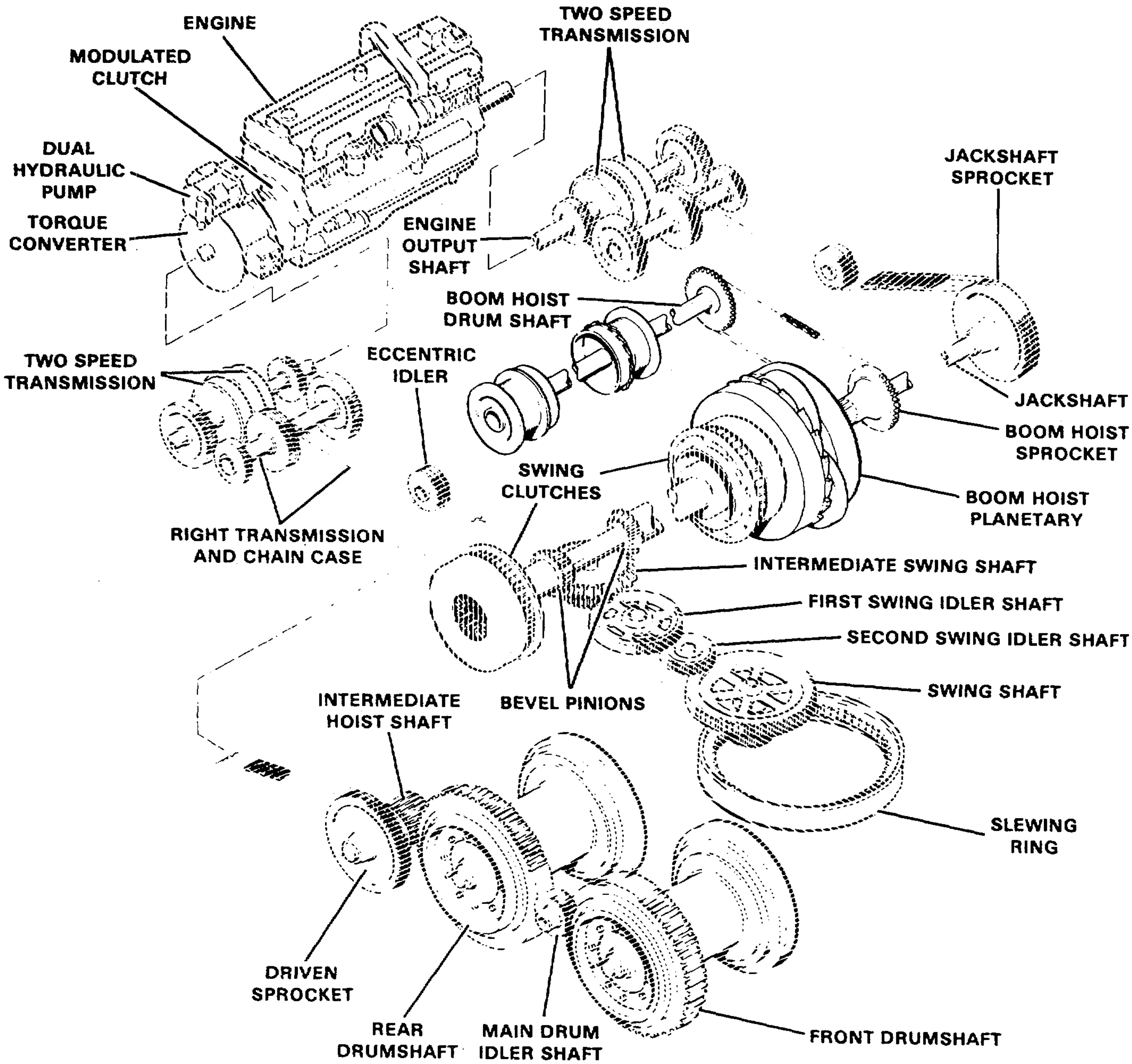
With the boom stationary the pinions rotate in the same direction. Since one pinion engages the hoist external gear and the other pinion engages the planetary internal gear, both spiders revolve in opposite directions. No power is transmitted to the output sprocket so the boom is neither raised or lowered.

When the boom is being raised the hoist spider is held stationary and the carrier will "walk" around the external ring gear of the hoist spider. Since the carrier is splined to the output sprocket, the output sprocket turns in the same direction as the carrier and transmits torque to the boom hoist shaft by means of the chain. During boom lowering, the direction of rotation is reversed through the planetary system so that the boom is always lowered under power.

The boom hoist drum brakes and pawls are spring set-hydraulically released and remain engaged except when the boom is being lowered. The boom hoist planetary brake and pawl are hydraulically set-spring released and remain released except when the boom is being lowered. See Table 8A-1 for brake and pawl operation.

Table 8A-1

	Boom Raising	Boom Lowering	Boom Stationary
Drum Brakes	Released	Released	Applied
Drum Pawl	Engaged	Disengaged	Engaged
Planetary, Brake	Released	Applied	Released
Planetary Pawl	Disengaged	Engaged	Disengaged



NOTE 1: END OF SWING CLUTCH SHAFT EXTENDS THROUGH BOOM HOIST SPROCKET.

NOTE 2: MANY ITEMS HAVE BEEN MOVED IN ORDER TO SHOW THE OPERATION OF THE MACHINE MORE CLEARLY

Figure 8A-1. Boom Hoist Gear Train

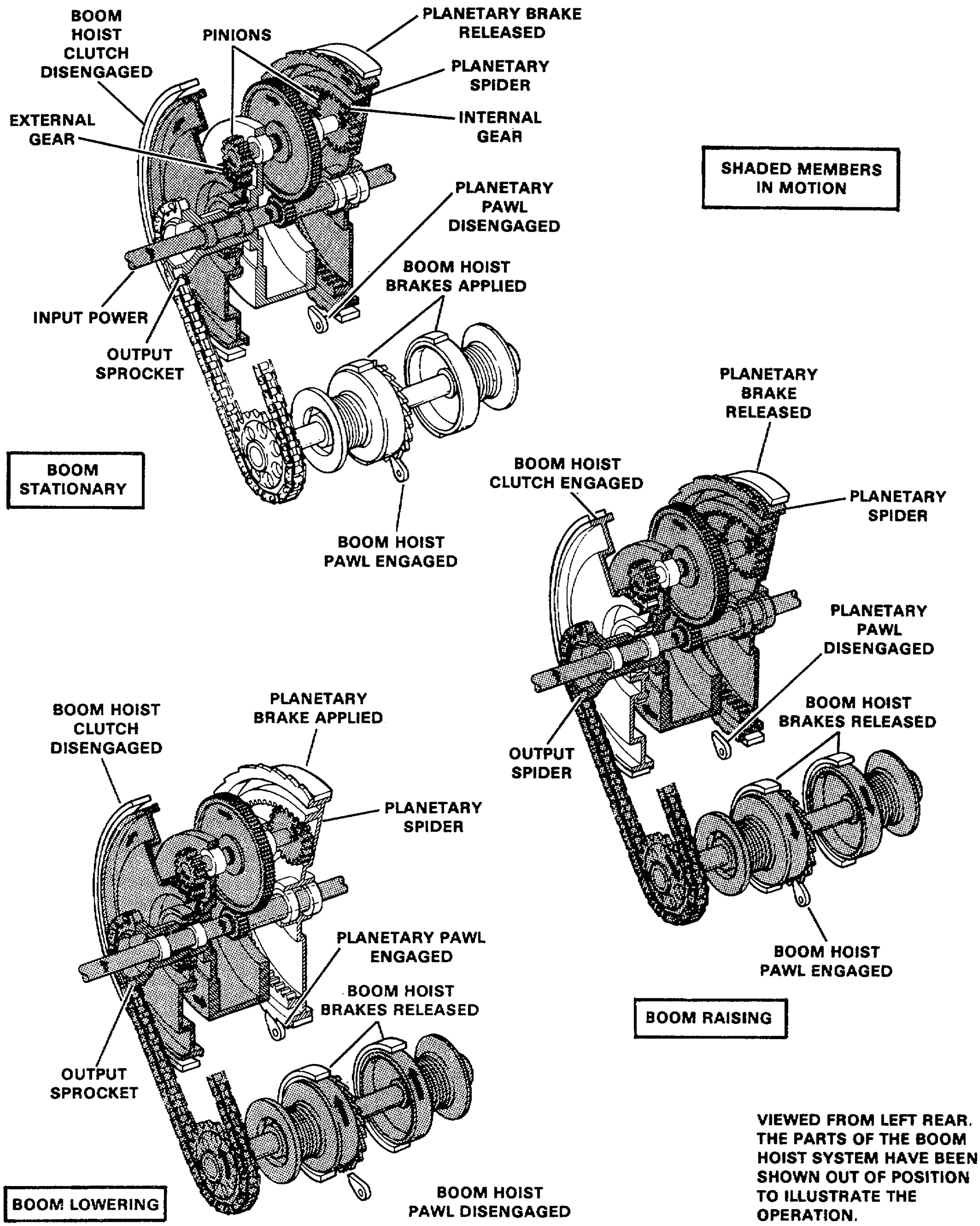


Figure 8A-2. Boom Hoist Planetary System

SUBSECTION 8B

BOOM HOIST SHAFTS

GENERAL

This subsection contains the information necessary to remove, repair, and install the double drum boom hoist shaft assembly.

BOOM HOIST SHAFT (910J356-3)

REMOVAL AND DISASSEMBLY. To remove and disassemble the boom hoist shaft, proceed as follows (see Figure 8B1):

1. Set the carrier on fully extended outriggers and swing the machine over the side of the carrier. Lower the boom onto blocking and remove the boom hoist cable.
2. The shaft can be removed by means of a fork lift or a chain hoist hooked to a tripod built over the engine base of the upper.
3. Remove the left hand transmission as a unit (see Subsection 4E). Also remove the batteries and the tank on the right hand side. The cover on the tank will have to be removed to lower the tank. Disconnect and tag all hoses removed from the tank.
4. Remove capscrews (06) and nuts (08). Pull cover (09) off of back plate (16). Remove gasket (17). If necessary, remove retainer (04), gasket (05) and oil seal (03) from cover (09).
5. Disconnect chain (13) and remove it from the machine. Remove keeper plate (49) and pull sprocket (48) off of shaft (34). Remove and retain shims (45, 46 and 47). Remove capscrews (43) and pull back plate (1 6) from the sides and. Also remove gaskets (20 and 41).
6. Secure shaft (34) and remove the boom hoist brake bands (see Subsection 8D). Also disengage the boom hoist pawl from the drum ratchet (see Subsection 8E). Remove retainer (23) and keeper plate (27), then remove bearing housing (29) with bearing (28) from shaft (34). Remove oil seal (31) from housing (29). Also remove spacer (32).
7. Remove bearing housing (40) with bearing (44) from shaft (34). Remove oil seal (37) from housing (40). Remove spacer (36) from the shaft.
8. Move shaft (34) to the left until the right hand end of the shaft clears the sidestand. Drop the right hand end of the shaft below the sidestand and remove the shaft from left to right.
9. Set shaft (34) on blocking and pull drums (33 and 35) off of the shaft.

INSPECTION AND REPAIR. Before reinstalling the boom hoist shaft, inspect the following items (see Figure 8B-1):

1. Inspect shaft (34) for excessive wear and/or distortion.
2. Check the drums for cracks, excessive wear, or other irregularities.
3. Bearings which show signs of wear or damage should be replaced. Replace all oil seals and gaskets.
4. Replace all capscrews or bolts which have rounded corners and all other damaged or worn parts.
5. If inspection reveals nicks, mars or burrs on machined or ground surfaces, use a fine mill file or India Stone for removal. Be sure all threaded and grooved items are clean and that thread is not damaged.

ASSEMBLY AND INSTALLATION. To assemble and install the boom hoist shaft, proceed as follows (see Figure 8B-1):

1. Lubricate all seals prior to assembly.
2. Assemble drums (33 and 35) on shaft (34). Assemble the drums so that the wedge sockets line up as closely as the drum shaft splines allow.
3. Cover the end of shaft (34) with metal sleeves.
4. Position the shaft assembly in the bores of the revolving frame. Block the shaft in a centered position and remove the metal sleeves.
5. Install spacers (32 and 36). Install oil seals (31 and 37) and bearings (32 and 44) into their respective housings (29 and 40). Tap the housing assemblies on shaft (34) and into the bores of the revolving frame. Be sure the holes for fittings (30 and 38) are at the bottom.
6. Install keeper plate (27) and secure with capscrews and lockwire. Install lock plate (24) and place bearing retainer (23) in position. Secure the retainer with capscrews and lockwashers.
7. Install gaskets (20 and 41) and backplate (16) on the machine. Secure with capscrews (43 and 53). Secure with tie wire.
8. Install shims (45, 46 and 47) as necessary to line up sprocket (48) with the boom hoist sprocket on the jackshaft. Install sprocket (48) and secure with keeper plate (49). When the sprockets are properly aligned, install the capscrews and lockwire.

9. Wrap chain (13) around the sprockets, bringing the free ends together on one sprocket. Insert the pins of the connecting link in the two end links of the chain, then install the free plate of the connecting link. Fasten the plate using the cotters, spring clip or other fastener supplied. After the fastener has been inserted, it is important that the ends of the chain pins be tapped back so that the fastener comes up snugly against the outside of the connecting link plate.

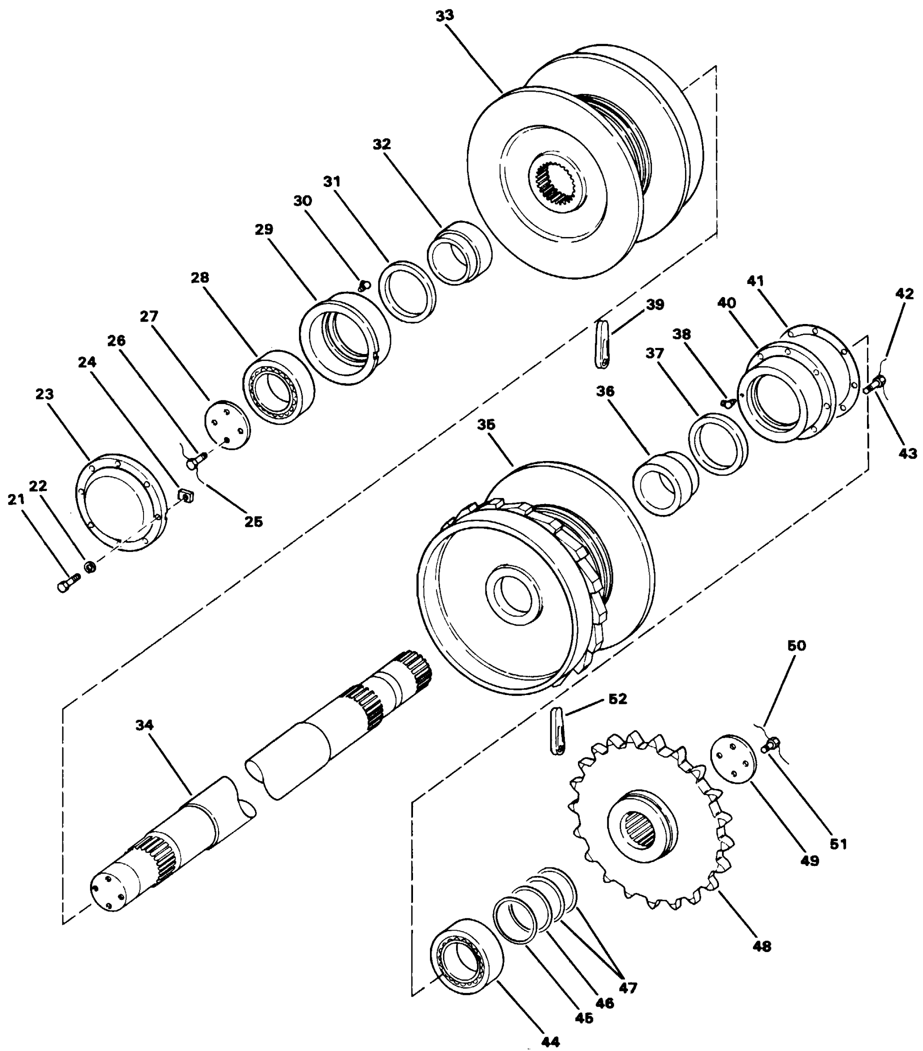
10. Install cover (09) with gasket (17) to back plate (16). Secure with capscrews (06) and nuts (08). If removed, reinstall gasket (05), retainer (04) and oil seal (03). Secure with lockwashers and capscrews.

11. Replace the right hand tank and hoses. Also reinstall the batteries and left hand transmission (see Subsection 4E).

12. Reinstall the boom hoist brake bands and adjust them as indicated in Subsection 8D. Engage the boom hoist pawl. Adjust if necessary. See Subsection 8E.

13. Replace the oil in the chain case and lubricate bearing (28 and 44). See Section III.

01. CAPSCREW
02. LOCKWASHER
03. OIL SEAL
04. RETAINER
05. GASKET
06. CAPSCREW
07. LOCKWASHER
08. NUT
09. COVER
10. CAPSCREW
11. LOCKWASHER
12. FILTER CAP
13. CHAIN
14. GASKET
15. COVER
16. BACK PLATE
17. GASKET
18. LOCKWASHER
19. CAPSCREW
20. GASKET
21. CAPSCREW
22. LOCKWASHER
23. BEARING RETAINER
24. LOCK PLATE
25. TIE WIRE
26. CAPSCREW
27. KEEPER PLATE
28. BEARING
29. BEARING HOUSING
30. FITTING
31. OIL SEAL
32. SPACER
33. DRUM
34. SHAFT
35. DRUM
36. SPACER
37. OIL SEAL
38. FITTING
39. WEDGE
40. RETAINER
41. GASKET
42. TIE WIRE
43. CAPSCREW
44. BEARING
45. SHIM
46. SHIM
47. SHIM
48. SPROCKET
49. KEEPER PLATE
50. TIE WIRE
51. CAPSCREW
52. WEDGE
53. CAPSCREW
54. TIE WIRE



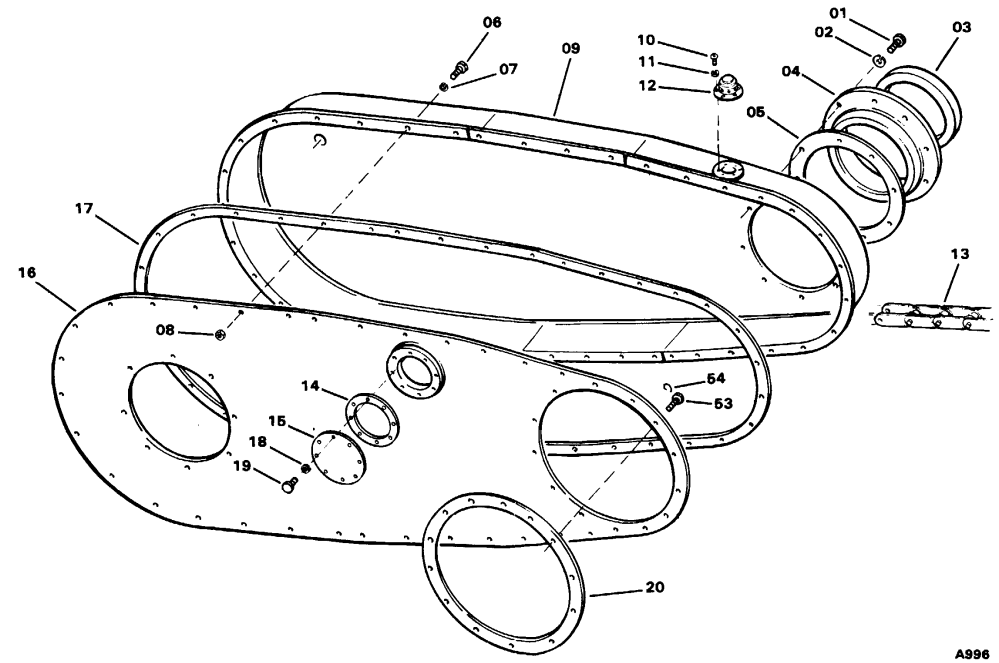


Figure 8B-1. Boom Hoist Shaft (910J356-3) and Chain Case (100J3890-1)

SUBSECTION 8C

BOOM HOIST PLANETARIES

GENERAL

This subsection contains the information necessary to remove, repair, and install the boom hoist planetary assembly.

BOOM HOIST PLANETARY (910J355-9)

REPAIRS. Since the boom hoist planetary is an integral part of the jackshaft (91 0J355-9) the information required to repair this planetary assembly is covered in Subsection 6B.

SUBSECTION 8D

BOOM HOIST BRAKES AND CLUTCHES

GENERAL

This subsection covers the removal, installation, and adjustment of the boom hoist planetary brakes, drum brakes and clutches.

BOOM HOIST PLANETARY BRAKE AND CLUTCH (100J3881-1)

DESCRIPTION. The planetary brake and clutch are of the hydraulically set-spring released type. When there is no pressure in the brake or clutch, its piston is retracted and the springs release the brake or clutch.

When the linings are new and the brake or clutch is in proper adjustment, the distance between the two operating mechanism pins, with the brake set (hydraulic pressure applied), should be 8-5/8 inches (21.9 cm). When the brake or clutch lining starts to wear, this dimension will decrease (with the brake set). See the Operator's Manual for the method of adjusting the brakes for normal lining wear.

The brake and clutch should be relined when lining thickness reaches 1/4 inch (6.35 mm) as measured at the dead end of the band.

REMOVAL AND DISASSEMBLY. To remove and disassemble the brake or clutch assembly, proceed as follows (see Figure 8D-1):

1. Shut down the engine and operate a control lever until all hydraulic pressure is exhausted from the system.

2. Disconnect and cap the hydraulic line to the cylinder. Plug the connections where the line is removed.

3. Release the tension in the hangers by backing off jam nuts (03). Release the tension in springs (15) by backing off jam nut (14).

4. Remove jam nut (14), spacer (13), springs (15) and bolt (12).

5. Remove pins (42 and 36), then remove the bands from the machine.

6. If necessary, remove cylinder (21) by backing off jam nuts (25) and removing capscrew (24) and lockwasher (23).

7. To remove spring (28), remove pin (33) and spring guide (29) from the operating mechanism.

INSPECTION AND REPAIR. Prior to assembly, all boom hoist planetary brake or clutch parts should be inspected as follows (see Figure 8D-1):

1. Replace springs (15 and 28) and all cotter pins.

2. If cylinder (21) leaks or has been performing erratically, remove and overhaul if necessary. See Subsection 5D.

3. Check the band halves for distortion, cracks, or other irregularities.

4. Inspect the surfaces of the planetary spiders checking for cracks, scores, or other damage.

5. Inspect the brake or clutch linings and replace if necessary.

NOTE

A lining kit is available. See the Replacement Parts Manual.

ASSEMBLY AND INSTALLATION. To assemble and install the planetary brake or clutch assembly, proceed as follows (see Figure 8D-1):

1. If spring (28) was removed, reinstall it on spring guide (26), then install spring guide (29) and pin (33). Secure with cotter pins.

2. Reinstall cylinder (21) by securing it to plate (22) with lockwasher (23) and capscrew (24). Tighten nuts (25).

3. Attach the dead end of the band by installing pin (42) through links (38) and the dead end of the band. Secure pin (42) with cotter pin (41).

4. Attach the live end of the band by installing pin (36) through lever (30) and the live end of the band. Install washers (37) and secure with cotter pins (32).

5. Start bolt (12) through the band, springs (15) and hanger (11). Install spacer (13) and nut (14).

6. Attach hooks (19) to the brake band. Connect the hydraulic line to cylinder (21). Bleed cylinder (21) to remove any air trapped in the hydraulic lines. See Subsection 5A.

ADJUSTMENT. The boom hoist clutch and the planetary brake are hydraulically set-spring released, and must be checked with the brake set (hydraulic pressure applied). To adjust the clutch or brake when the bands have been removed, proceed as follows (see Figure 8D-1):

1. With the brake or clutch set (hydraulic pressure applied) check the distance between the centerlines of pins (33). This length must be 8-5/8 inches (21.9 cm).
2. If the distance between the centerlines of pins (33) is not 8-5/8 inches (21.9 cm), release the hydraulic pressure and adjust jam nut (14).
3. With the brake or clutch released, adjust nut (03) until the band clears the drum.
4. Engage the boom hoist clutch or planetary brake several times and check for proper operation.

BOOM HOIST DRUM BRAKES (9215J97-1 & 2)

DESCRIPTION. The boom hoist brake is a spring set-hydraulically released type brake. When there is no pressure in the boom hoist brake cylinders, its piston is retracted and springs apply the boom hoist brake.

When the linings are new and the brake is in proper adjustment, the length of the operating mechanism spring, with the brake set (hydraulic pressure released), should be 15.570 inches. When the brake lining starts to wear, this dimension will increase (with the brake set). See the Operator's Manual for the method of adjusting the brakes for normal lining wear.

The boom hoist brake should be relined when brake lining thickness reaches 3/16 inch as measured at the dead end of the band.

REMOVAL AND DISASSEMBLY. To remove and disassemble the boom hoist drum brake assembly, proceed as follows (see Figure 8D-2):

1. Lower the boom and support it on blocking. Make sure all tension is removed from the boom hoist rope.
2. Shut down the engine and render the starting system inoperative. Operate a control lever until all hydraulic pressure is exhausted from the system.
3. Disconnect and cap the hydraulic lines to the boom hoist brake cylinders. Plug the cylinder ports.
4. Release the tension in spring (19) by loosening jam nuts (30) and backing out adjusting bolts (18). Also back off jam nuts (31 and 33). Remove spring (03) from brake band (01).
5. Remove cotter pins(14 and 20), washers (15 and 17) and pins (13 and 16) to drop the brake mechanism from the machine.
6. Remove cotter pins (11 and 27), washers (25 and 10) and pins (09 and 12) from the band halves. Remove jam nut (31) and adjusting bolt (32). Align the band halves around to drum until they can be easily removed.
7. Remove adjusting bolts (18) along with jam nuts (30). Remove tie wire (23) and capscrews (22), then remove end plate (21) from the operating mechanism. Remove capscrews (26) and remove cylinder (24). If necessary, remove shaft (28) and spring (19) from the operating mechanism.

INSPECTION AND REPAIR. Prior to reinstalling the boom hoist drum brake assembly, inspect the following items (see Figure 8D-2):

1. Replace springs (03 and 19).
2. If cylinder (24) leaks or has been performing erratically, check and overhaul it if necessary. See Subsection 5D.
3. Check the brake band halves for distortion, cracks, or other irregularities and replace if necessary.
4. Inspect the brake surface on the boom hoist drum and check for cracks, scores or other damage.
5. Inspect the boom hoist linings and replace if necessary.

NOTE

A lining kit is available. See the Replacement Parts Manual.

ASSEMBLY AND INSTALLATION. To assemble and install the brake assembly, proceed as follows (see Figure 8D-2):

1. Set spring (19) on shaft (28) and set the assembly in the operating mechanism. Secure cylinder (24) to end plate (21) with capscrew (26) and set the assembly in the operating mechanism. Secure with capscrews (22) and tie wire the capscrews together.
2. Install adjusting bolts (18), with jam nuts (30) into end plate (21). Initially set the adjusting bolts into the end plate approximately 3.500 inches as indicated.
3. Install the brake bands on the drum and secure to brackets (04 and 02) with pins (12 and 09), washers (10 and 25) and cotter pins (11 and 27). Also install bolt (32) and jam nut (31).
4. Secure the operating mechanism to brake lever (04)and the machine using pins (13 and 16), washers (15 and 17) and cotter pins (14 and 20). It may be necessary to back off adjusting bolts (18) to make the connection to brake lever (04).
5. Install spring (03) on brake band (01).

ADJUSTMENT. The boom hoist drum brakes are spring set hydraulically released and must be checked and adjusted with the brake applied (hydraulic pressure released from the cylinder). To adjust the boom hoist drum brakes after the bands have been removed, proceed as follows (see Figure 8D-2):

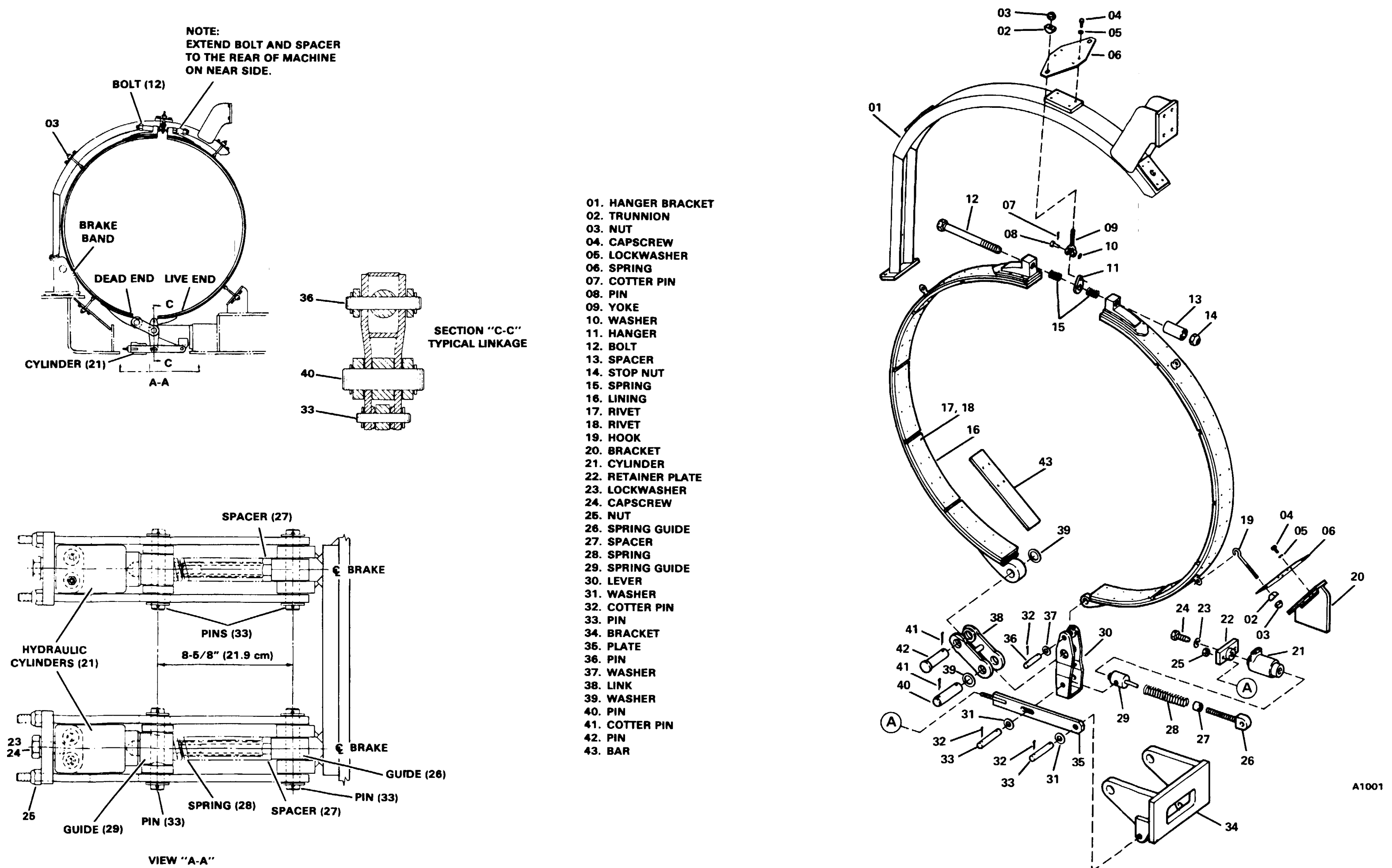


Figure 8D-1. Boom Hoist Clutch and Planetary Brakes (100J3881-1) A1001

1. Adjust bolts (18) to obtain a dimension of 15.570 inches on spring (19).

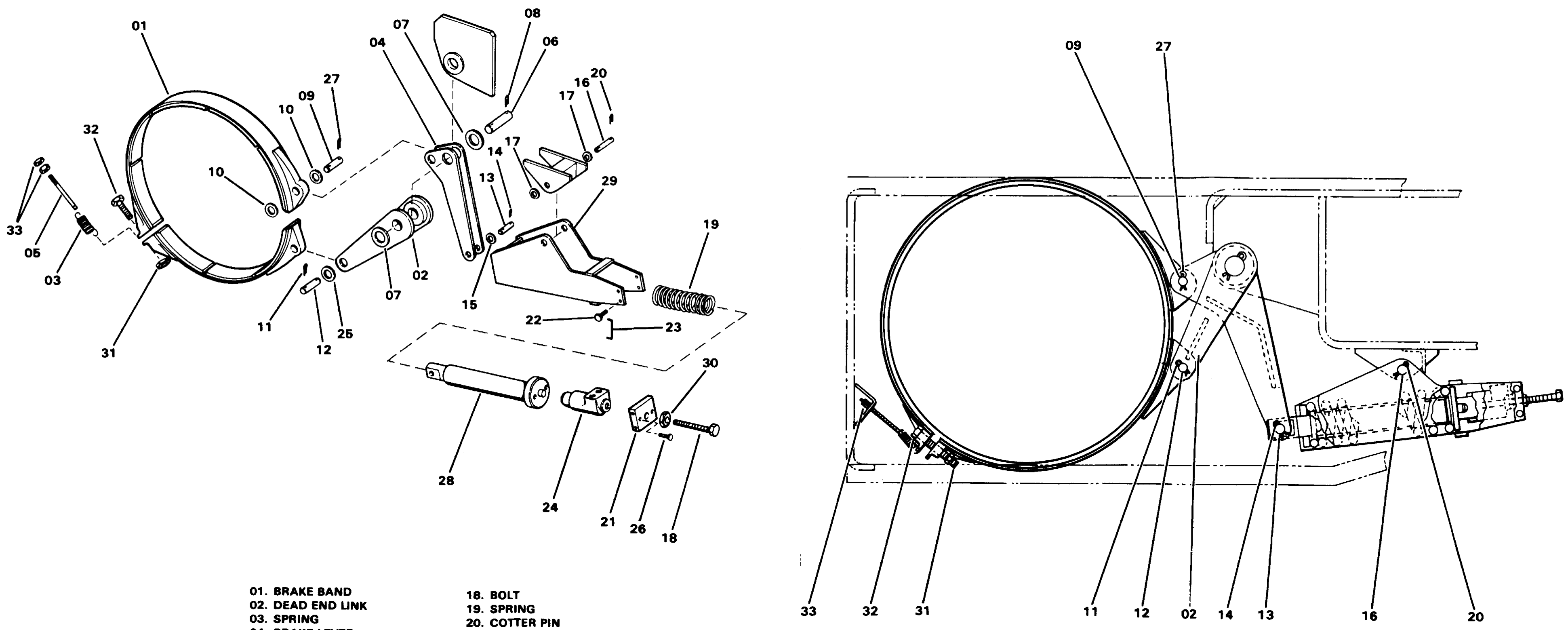
2. Tighten jam nut (31) and recheck the 15.570 inch dimension on spring (19).

3. Back off adjusting bolts (18) to 3.500 inch or less, dimension shown and lock the bolts with jam nuts (30).

WARNING

At not time should the 3.500 inch dimension given for adjusting bolts (18) be greater than 3.500 inch when the machine is in operation. This could cause brake application interference if the dimension is allowed to become greater than 3.500 inches. The 3.500 inch or less, dimension must be held at all times.

4. Check the boom hoist and planetary pawl adjustment after adjusting the boom hoist brakes (see Subsection 8E). Make a low angle test lift after each boom hoist brake and pawl adjustment to check system operation



01. BRAKE BAND
02. DEAD END LINK
03. SPRING
04. BRAKE LEVER
05. EYEBOLT
06. PIN
07. WASHER
08. COTTER PIN
09. PIN
10. WASHER
11. COTTER PIN
12. PIN
13. PIN
14. COTTER PIN
15. WASHER
16. PIN
17. WASHER
18. BOLT
19. SPRING
20. COTTER PIN
21. END PLATE
22. CAPSCREW
23. TIE WIRE
24. CYLINDER
25. WASHER
26. CAPSCREW
27. COTTER PIN
28. SHAFT
29. BRACKET
30. JAM NUT
31. JAM NUT
32. BOLT
33. JAM NUTS

A1277

Figure 8D-2. Boom Hoist Brakes (9215J97-1&2)

SUBSECTION 8E

BOOM HOIST PAWLS

GENERAL This subsection contains the information necessary to remove, disassemble, assemble, install and adjust the boom hoist pawls.

BOOM HOIST PAWL ASSEMBLY (100J3872-4) REMOVAL AND DISASSEMBLY. If upon inspection it is revealed that the pawls are worn down, cracked, or broken it will be necessary to remove and replace them. To remove the pawls, proceed as follows (see Figure 8E-1):

1. Lower the boom and support it on blocking. Make sure all tension is removed from the boom hoist rope.
2. Shut down the engine and operate a control lever until all hydraulic pressure is exhausted from the system.
3. Disconnect and cap the hydraulic line to cylinder (40).
4. Relieve the pressure in spring (33) by backing off jam nut (36) and threading adjusting bolt (35) into trunnion (38).
5. Remove capscrew (09) and pull yoke (10) off of pawl 1(06).
6. Remove capscrew (01) and rod end (02). Pull pin (05) out of bracket (52) and remove pawl (06).
7. Hold levers (19) together and remove pin (16) from lever (19) closest to pawl (28). Remove rod end socket (27) and spring (26).
8. Loosen capscrew (14) and remove shaft (23) from bracket (52). Remove pawl (28) and one of levers (19). Retain keys (22) for reassembly.
9. If it is necessary to remove cylinder (40) remove capscrews (47) from links (41) and plate (43). Remove capscrew (45) and lockwasher (44) and set cylinder (40) aside for inspection.

INSPECTION AND REPAIR. Prior to assembly all boom hoist pawl parts should be inspected as follows (see Figure 8E-1):

1. Replace springs (33, 26 and 12) and all cotter pins.

2. If cylinder (40) leaks or has been performing erratically, overhaul if necessary. See Subsection 5D.

3. Insect bushings (20 and 07) and replace if necessary.

4. If pawls (06 or 28) are worn, cracked, or broken replace them.

5. Inspect the boom hoist and planetary ratchets for wear, cracks, or broken teeth. Repair or replace if necessary. See Subsection 8B for boom hoist drum removal and see Subsection 6B for planetary ratchet repairs.

ASSEMBLY AND INSTALLATION. To assembly and install the boom hoist pawls, proceed as follows (see Figure 8E-1):

1. Secure cylinder (40) to plate (43) with lockwasher (44) and capscrew (45) then secure the plate to links (41) with capscrews (47).
2. Start shaft (23) into bracket (52). Set pawl (28) in the bracket and slide shaft (23) further in, then set lever (19) in bracket (52) and push the shaft further in. Tighten capscrew (14).
3. Set spring (26) on rod end (25). Start rod end socket (27) into rod end (25) and secure to lever (19) with pin (16).
4. Set pawl (06) in bracket (52) and install pin (05). Secure pin (05) with rod end (02) and capscrew (01).
5. Install yoke end (10) on pawl (06) and secure with capscrew (09).
6. Remove the plug from the hydraulic line to cylinder (40). Attach the line to the cylinder.
7. Bleed cylinder (40) to remove any air trapped in the lines. See Subsection 5A.

ADJUSTMENT. The boom hoist pawl is a spring set-hydraulically released pawl. The pawl engages in the ratchet of the boom hoist drum when the boom is being raised or held stationary. The pawl is disengaged by hydraulic pressure when the boom is being lowered.

The boom hoist planetary pawl is a hydraulically set-spring released pawl. The pawl engages in the ratchet of the planetary spider when the boom is being lowered. The pawl is disengaged by a spring when the boom is being raised or held stationary.

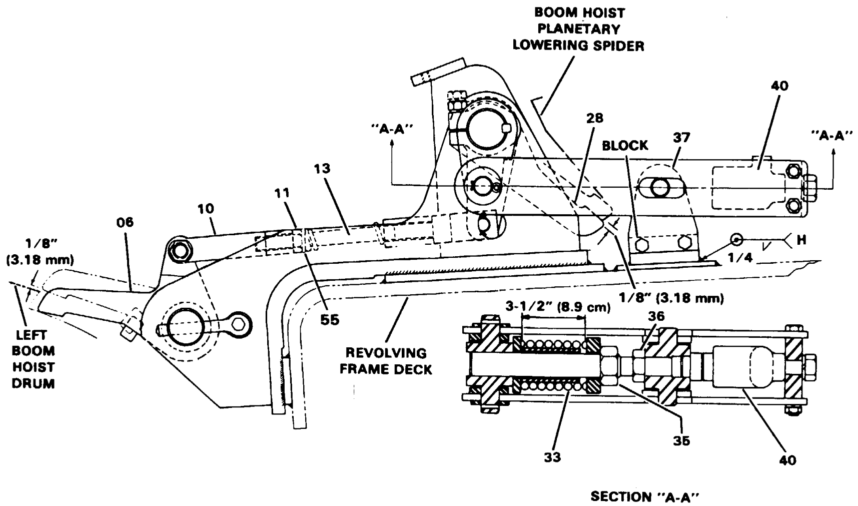
To adjust the pawls after they have been replaced or repaired, proceed as follows (see Figure 8E-1):

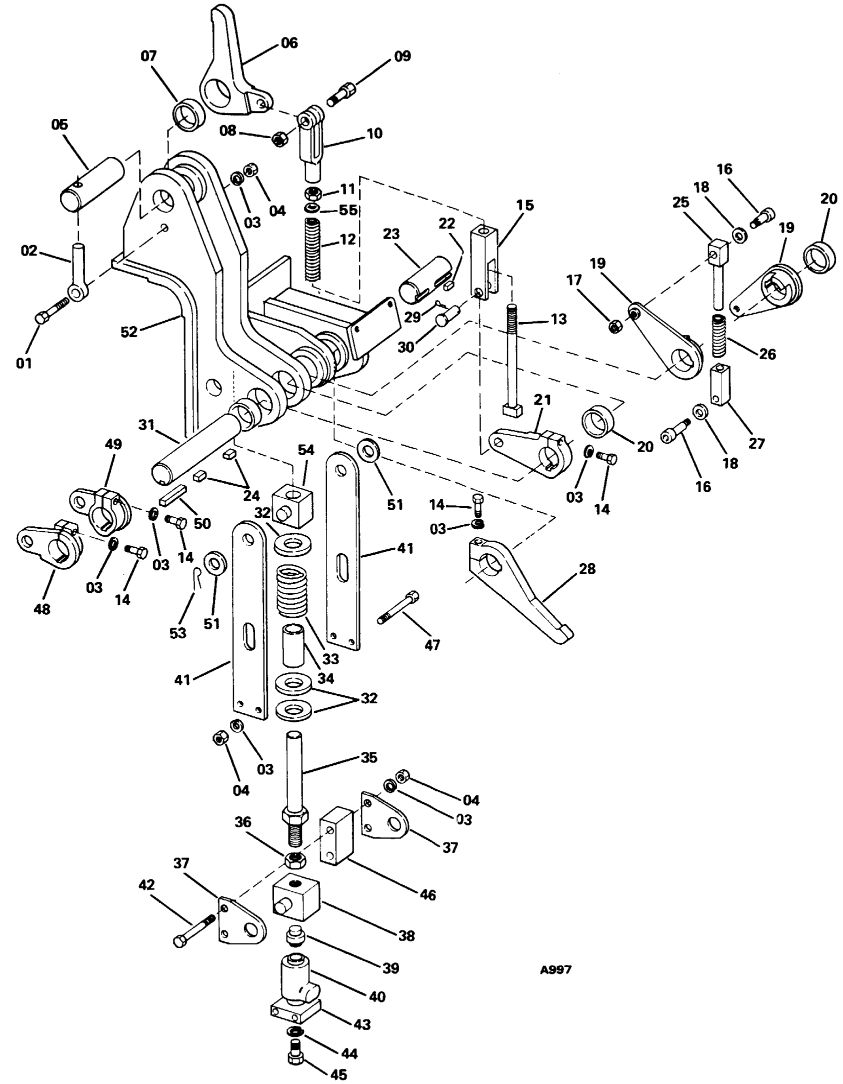
1. With pawl (28) disengaged from the planetary spider, back off jam nut (36) and use adjusting bolt (35) to compress spring (33) to 3-1/2 inches (8.9 cm). Tighten jam nut (36).
2. With pawl (28) still disengaged check that pawl (28) clears the top of the spider ratchet teeth by 1/8 inch (3.18 mm). If the pawl does not clear the teeth by this amount it

will be necessary to remove and reposition block (46) on the revolving frame.

3. With pawl (28) fully engaged (hydraulic pressure applied to cylinder (40)) check that pawl (06) clears the boom hoist ratchet teeth by 1/8 inch (3.18 mm). If the pawl does not clear the teeth by this amount, loosen jam nut (11), remove pin (09) and adjust yoke (10). Reinstall pin (09), tighten jam nut (11) and recheck that pawl (06) clears the boom hoist ratchet teeth by 1/8 inch (3.18 mm).

4. Inspect the assembly to make sure it has been properly secured and every item is tightened. Operate the boom hoist through several boom raising and lowering cycles and check the operation of the pawls. Check that 1/8" (3.18 mm) clearances are maintained (see steps 2 and 3) yet travel of both pawls are sufficient to fully seat into bottom of ratchet teeth.





01. CAPSCREW
02. ROD END
03. WASHER
04. NUT
05. PIN
06. PAWL
07. BUSHING
08. NUT
09. PIN
10. YOKE END
11. JAM NUT
12. SPRING
13. ROD
14. CAPSCREW
15. YOKE
16. PIN
17. JAM NUT
18. WASHER
19. LEVER
20. BUSHING
21. LEVER
22. KEY
23. SHAFT
24. KEY
25. ROD END
26. SPRING
27. SOCKET
28. PAWL
29. COTTER PIN
30. PIN
31. SHAFT
32. WASHER
33. SPRING
34. SPACER
35. ADJUSTING BOLT
36. JAM NUT
37. BRACKET
38. TRUNNION
39. PUSH ROD
40. CYLINDER
41. LINK
42. CAPSCREW
43. PLATE
44. LOCKWASHER
45. CAPSCREW
46. BLOCK
47. CAPSCREW
48. LEVER
49. LEVER
50. KEY
51. WASHER
52. BRACKET
53. COTTER PIN
54. TRUNNION
55. WASHER

Figure 8E-1. Boom Hoist Pawls (100J3872-4)

SECTION IX.

CARRIER POWER TRAIN

SUBSECTION 9A

ENGINES

GENERAL

The information contained in this subsection is limited to troubleshooting, removal and installation of the engine. Information concerning maintenance and repair of the engine can be obtained from the engine manufacturer.

TROUBLESHOOTING

A troubleshooting chart at the end of this subsection lists some of the difficulties which may be experienced with the engine and associated systems. No information is given as to the actual procedure for correcting the problem since this will vary, depending on the make of the engine. Refer to the engine manufacturer's manual for repair procedures.

ENGINE (51Q322)

REMOVAL. If it is determined that the engine must be removed from the carrier, it is easier to remove the engine with the transmission attached than it is to remove it without the transmission. To remove the carrier engine proceed as follows:

WARNING

The upper must be placed over the side of the carrier to gain access to the cover plates over the engine and transmission. The outriggers should be fully extended, with the locking cams engaged. The boom should be lowered onto blocking. It may be necessary to shorten the boom to avoid exceeding over the side stability.

1. Position the upper over the side of the carrier.

2. Remove all sheet metal over the engine, radiator, and main transmission.

3. Drain the engine cooling system and crankcase.

4. Remove the radiator braces and all radiator attaching capscrews. Remove the radiator hoses by loosening the clamps and hoses. Attach a suitable lifting device to the radiator and remove the nuts, lockwashers, and insulators from below the radiator. Slowly lift the radiator out of the machine. Set the radiator mounting material aside until installation..

5. Remove the propeller shaft at the main transmission. Disconnect the universal joint by bending the lock straps away from the capscrews, and remove the capscrews, lock straps, and the bearings and retaining cap subassemblies. Allow the propeller shaft to hinge at the auxiliary transmission.

6. Disconnect the muffler, muffler bracket and all exhaust piping from the engine.

7. Disconnect the air cleaner tubing from the intake manifold and disconnect the air cleaner. Set the material aside until installation.

8. Disconnect the battery cables and all necessary electrical wiring. Tag all electrical leads before disconnecting them.

9. Disconnect the accelerator linkage, main transmission shift linkage and the retarder linkage. Also check that the auxiliary transmission air shift hoses will not interfere with engine removal. If necessary remove the hoses.

10. Disconnect all fuel, air, hydraulic and oil lines from the engine.

11. Make a thorough visual inspection of the engine and engine compartment to be sure that all necessary electrical, air, fuel and water lines have been disconnected and are out of the way to allow removal of the engine.

12. Attach a suitable lifting sling to the lifting eyes on the engine. Remove the mounting bolts which secure the engine to the engine mounts and the front of the engine and at each rear corner of the engine. The engine can now be removed from the carrier.

REPAIRS AND ADJUSTMENTS. Engine repairs and adjustments are covered in Section 16 of this manual.

INSTALLATION. To install an engine in the carrier, proceed as follows:

1. Make a thorough inspection of the engine compartment to be sure that all wiring, fuel, air and water lines are clear of the engine mountings and frame.

2. Install the rear motor mounts including the insulators, lockwashers, and nuts if they were removed. Also install

the front center bonded mounts and washers if they were removed.

3. Set the engine into the engine compartment using a suitable sling attached to the lifting eyes on the engine.

4. Lubricate the mounting and socket lightly with a rubber lubricant or water. Insert -the driving bolts through the tubular spacer (do not allow the driving members to overhang the O.D.); apply sufficient pressure to seat the mounting in the socket. Tighten the nuts until the supported member and snubbing washer are snug against the spacer. The rebound shoulder is formed automatically.

5. Place the radiator insulators and spacers on the radiator and set the radiator on the frame. Secure the radiator with the radiator mounting hardware. Reconnect the upper and lower radiator hoses.

6. Install the propeller shaft between the main transmission and the auxiliary transmission.

7. Connect all electrical wiring that was disconnected.

8. Connect all fuel, air, hydraulic and oil lines that were disconnected.

9. Reconnect the accelerator linkage, main transmission shift linkage and retarder cable. If the auxiliary transmission air shift hoses were removed, reconnect them at this time.

10. Install all exhaust and air cleaner material.

11. Reinstall all sheet metal.

12. Fill the cooling system and crankcase with water and oil respectively.

CAUTION

Before engine start-up, recheck all wiring, fuel, water and mechanical connections. Be prepared to shut down the engine if there should be some malfunction.

13. Start and run the engine. Check for oil, water, fuel, hydraulic and air leaks.

Troubleshooting Guide

Category	Cause	Low Power	Poor Performance, or Erratic Action	Rough Idle, Engine Vibrating	Excessive Engine Smoke - Black	Excessive Engine Smoke - White or Blue	Low Oil Pressure	Abnormal Coolant Temperature	Hard or No Starting	Recommended Remedy
GENERAL	Excessive oil in or Restriction of Air Cleaner.	X	X	X	X	X			X	Service or Replace Filter as Required.
GENERAL	Faulty Injection Pump(s).	X	X	X	X	X			X	Have Pump Removed and Repaired.
GENERAL	Contaminated or Poor Quality Fuel.	X	X	X	X				X	Drain, Clean Tanks and Filter and Refill per Engine Mfg. Specs.
GENERAL	Cranking R.P.M. Too Low (Cold or Hot).								X	Check Battery and Starter. Replace if Necessary.
GENERAL	Low Compression.	X	X	X	X	X			X	Overhaul Engine.
GENERAL	Exhaust Blockage.	X	X	X				X		Remove Obstruction, Check for Bent or Crushed Pipes.
GENERAL	Incorrect Calibration.	X	X	X	X				X	Have Engine Re-calibrated.
TIMING	Injection Pump-to-Engine Timing Incorrect.	X	X	X	X				X	Re-Time to Engine Manufacturer's Specifications
TIMING	Injection Pump Drive (Train) Worn – Coupling Keyway.	X	X	X					X	Remove, Inspect and Replace Worn Parts.
TIMING	Injection Pump Internal Timing Incorrect.	X	X	X	X	X			X	Remove Injection Pump. Re-Time (Internally).
TIMING	Timing Advance Device Not Operating Properly.	X	X	X	X	X			X	Remove Injection Pump. Replace or Repair Advance Unit.
GOVERNOR	Throttle Linkage Mis-Adjusted.	X	X	X						Adjust to Engine Manufacturer's Specifications.
GOVERNOR	Throttle Linkage Sticking, Binding or Worn.	X	X							Check for Binding, Worn or Loose Parts, Foreign Particles. Repair or Replace Parts and Adjust to Specifications.
GOVERNOR	Improper Governor Operation.	X	X	X						Adjust or Repair to Permit Proper Governor Operation.
GOVERNOR	Control Rack(s) or Governor Linkage Sticking or Binding.	X	X	X						Remove Injection Pump. Repair
GOVERNOR	Worn or Loose Governor Linkage or Components or Weak or Broken Governor Torsion Spring.	X	X	X						Repair or Replace.

Troubleshooting Guide (cont'd)

Category	Cause	Low Power	Poor Performance, or Erratic Action	Rough Idle, Engine Vibrating	Excessive Engine Smoke - Black	Excessive Engine Smoke - White or Blue	Low Oil Pressure	Abnormal Coolant Temperature	Hard or No Starting	Recommended Remedy
NOZZLES	Nozzle Defective – Leaking – Worn.	X	X	X	X				X	Remove, Repair or Replace, Reassemble, Test, Set Opening Pressure.
	Incorrect Nozzle Opening Pressure	X	X	X	X				X	Re-Set to Specifications.
	Nozzle Cap Nut Incorrectly Torqued.	X	X	X	X				X	Remove, Retighten Cap Nut Using Proper Nozzle Centering Sleeve, Replace Copper Gasket, Clean Engine Recess and Re-Install in Engine.
	Nozzle Incorrectly Installed or Torqued in Engine.	X	X	X	X				X	Remove, Replace Copper Gasket, Clean Recess, Reassemble to Engine (Tighten Evenly to Require Torque Value).
	Nozzle Valve Sticking.	X	X	X	X				X	Remove, Clean, Repair or Replace as Required.
	Nozzle Spray Holes Plugged or Partially Plugged.	X	X	X					X	Remove Nozzle. Clean Holes or Replace Nozzle as Required.
	Incorrect Nozzle in Engine.	X	X	X	X				X	Always Use The Correct Nozzle Recommended For The Engine. Do Not Mix Nozzles in The Same Engine Unless Permitted By Manufacturer.
OIL LEAKAGE	Oil Lines or Connections Leaking.						X			Repair or Replace.
	Lube Oil Diluted.					X	X	X		Check for Internal Oil or Water Leak. Drain and Replace Oil.
	Fuel Supply Pump Leaking					X	X			Replace.
	Faulty Gasket or Oil Seal.						X			Replace.
	Defective Oil Pressure Sending Unit.						X			Check Unit and Gauge. Replace if Necessary.
COOLING SYSTEM	Insufficient Coolant.		X					X		Add Necessary Coolant.
	Loose or Broken Fan Belt.							X		Check and Adjust or Replace.
	Faulty Thermostat.							X		Replace.
	Defective Water Pump.		X					X		Repair or Replace.
	Coolant Passages Clogged.		X					X		Drain and Flush Cooling System. Check Hoses.
	Defective Water Temperature Sending Unit.							X		Check Unit and Gauge. Replace if Necessary.

	CAUSE	LOW POWER	POOR PERFORMANCE, OR ERRATIC ACTION	ROUGH IDLE, ENGINE VIBRATING	EXCESSIVE ENGINE SMOKE - BLACK	EXCESSIVE ENGINE SMOKE - WHITE OR BLUE	LOW OIL PRESSURE	ABNORMAL COOLANT TEMPERATURE	HARD OR NO STARTING	RECOMMENDED REMEDY
FUEL SUPPLY PRESSURE	Fuel Filters Clogged or Restricted.	X	X	X					X	Remove and Clean or Replace.
	External or Internal Fuel Leaks.	X	X						X	Inspect and Repair.
	Air Leaks In Fuel Suction System.	X	X	X					X	Inspect and Correct. Replace Parts Where Required.
	Restriction in Fuel Suction Lines.	X	X	X						Clean and Repair or Replace Parts as Required.
	Little or No Fuel In Tank		X	X					X	Fill Tank With Proper Grade Fuel
	Supply Pump Worn or Damaged.	X	X	X					X	Remove Supply Pump, Replace or Repair.
	Supply Pump Relief Valve Worn or Stuck Open, or Spring Broken.	X	X	X					X	Remove Supply Pump. Replace or Repair.
	Overflow Valve Leaking or Stuck Open, or Spring Broken.	X	X	X					X	Clean and Repair or Replace.
	Supply Pump Check Valves Not Operating Properly or Damaged.								X	Remove Supply Pump. Repair.
	Air in Fuel System.	X	X	X					X	Prime System with Hand Priming Pump to Force Out Trapped Air.
	Fuel Return Line to Tank Restricted.		X	X						Clean and Flush. Replace if Necessary.
	Improper Grade Fuel for Temperature.	X	X	X	X				X	Drain Fuel. Fill With Correct Grade.
	Fuel Pump Inoperative.								X	Inspect and Correct. Replace Parts Where Required.
OIL SUPPLY	Improper Oil Viscosity					X	X	X	X	Drain and Replace Oil With Proper Viscosity for Conditions.
	Oil Cooler or Filter Clogged.						X			Remove, Clean or Replace.
	Clogged Pump Intake.						X			Remove and Clean, or Replace.
	Faulty Cooler or Pump Relief Valve.						X			Remove, Clean, Repair or Replace
	Oil Pump Damaged.						X			Remove and Replace.
	Low Crankcase Oil Level.						X	X		Check and Add Oil.

SUBSECTION 9B

AUXILIARY TRANSMISSION

GENERAL

he information contained in this subsection is limited to troubleshooting, removal and installation of the auxiliary transmission.

TROUBLESHOOTING

A troubleshooting guide at the end of this subsection lists some of the difficulties which may be experienced with the transmission and associated systems.

Prior to checking any part of the system from a hydraulic or mechanical standpoint, the air and electrical systems (which ever applies) must be studied and understood. Air and electrical schematics are provided in the appropriate subsections. It is imperative that the electrical circuits be operational and that air leaks be kept to a minimum.

One of the major causes of bearing and gear failures in the transmissions is poor driving habits. Drivers should be taught to always use the low speed or reductions available in the auxiliary unit and keep the main transmission in the higher ratios, not vice versa.

AUXILIARY TRANSMISSION (53Z520)

REMOVAL

To remove the auxiliary transmission, proceed as follows:

1. Disconnect the front and rear propeller shaft from the auxiliary transmission.
2. Drain the transmission.
3. Disconnect all lines, cables, and wires from the transmission.
4. Support the transmission from below the carrier.
5. Remove the mounting hardware and lower the auxiliary transmission from the carrier.

DISASSEMBLY

A suitable holding fixture or overhaul stand is desirable but not necessary to rebuild this unit. The flat bottom of the transmission case provides a suitable working platform when the unit is placed on a sturdy shop table. For easier working conditions, table height should be 28-30 inches (71.1-76.2 cm). A light chain hoist should be used to handle the mainshaft and countershafts during removal and reassembly procedures.

Transmissions should be steam cleaned prior to disassembly. Seal all openings before steam cleaning to prevent entry of dirt and water which can damage serviceable parts.

Dirt is abrasive and will cause premature wear of bearings and other parts. We suggest the mechanics have a small wash tank to clean parts just prior to reassembly.

When a transmission is removed at relatively low mileage, bearings should be removed with pullers designed for this purpose. Wrap the bearings to keep out dirt. Clean, inspect and lubricate all bearings just prior to reassembly. If accumulated mileage is over 150,000 miles, we suggest that all bearings be replaced.

Hammering on end yokes and flanges, to remove or install them is not only destructive to the yoke or flange itself, but can also cause serious internal damage. Hammering destroys or mutilates the pilot diameters and warps or bends the flange. Hammering on end yokes will close-in the bearing bores or misalign yoke lugs and result in early failures of journal needle bearings, etc.

Serious damage can be done internally to bearings, thrust faces and washers, pilot bearings, etc., by hammering on external parts.

In most designs when the yoke/flange locknuts are tightened and secure, the internal bearings and gears are in proper location. When the yoke/flange is driven on the shaft, two conditions can exist.

A. If the bearing fit is tight on the shaft, then usually the bearings will brinell as they must absorb the pounding forces.
B. If the bearing is loose, the shaft will keep moving inward until it is stopped by the internal parts such as pilot bearing thrust washers, etc.

Exploded views are provided at the end of the write up and may be used as a reference for disassembly and assembly of this unit.

SHIFTER HOUSING REMOVAL. To remove the shifter housing, proceed as follows:

1. Remove the capscrews and two Allen head screws holding the shifter housing and gasket to the adapter plate. Lift

the shifter housing up and off the adapter plate, Figure 9B-1.

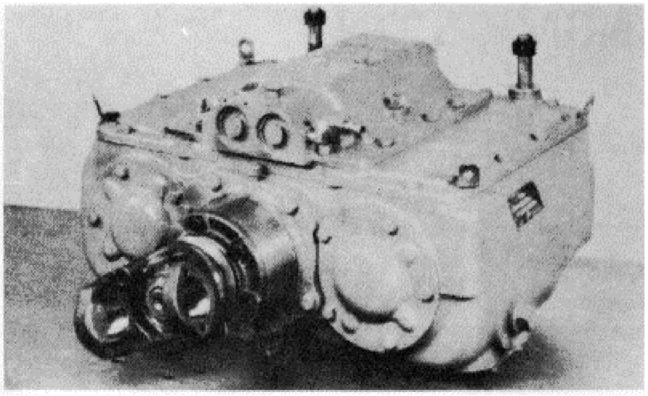


Figure 9B-1. Removing Cover Screws

2. Remove the two anchor nuts and washers from the rear anchor studs. Remove the capscrews holding the adapter plate and gasket to the case. Lift the adapter plate up and off the case, Figure 9B-2.

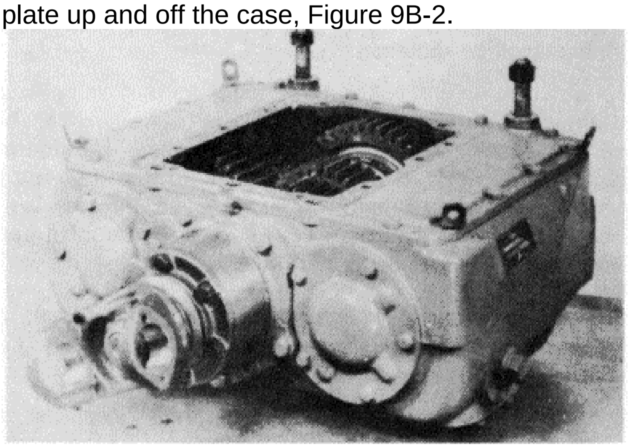


Figure 9B-2. Removing Adapter Plate

MAIN SHAFT AND COUNTERSHAFT REMOVAL. To remove the mainshaft and countershaft, proceed as follows:

1. Lock the auxiliary in two gears by moving the two shift collars on the mainshaft forward into 2nd and 3rd gear. Use a 2-9/1 6" socket to remove the drive gear and mainshaft companion flange locknuts and washers. Remove the drive gear and mainshaft rear companion flanges, Figure 9B-3. Use a puller if the companion flanges will not come off readily.
2. Remove the capscrews from the drive gear bearing retainer, Use soft hammer and tap on trunnion bearing face of drive gear bearing retainer until it is separated from the case. Then use a pair of pry bars, between the case and the retainer, and pry evenly until the bearing retainer and drive gear assembly is removed from the case bore, Figure 9B-4.
3. Remove the capscrews from the front countershaft bearing caps. Remove the front bearing caps and gaskets, Figure 9B-5.

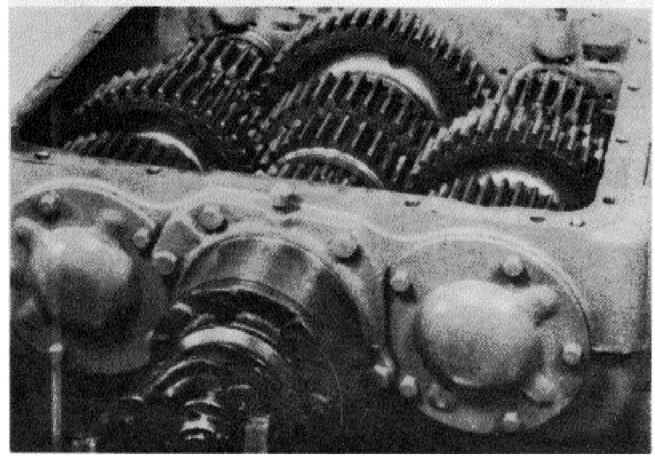


Figure 9B-3. Remove Yokes

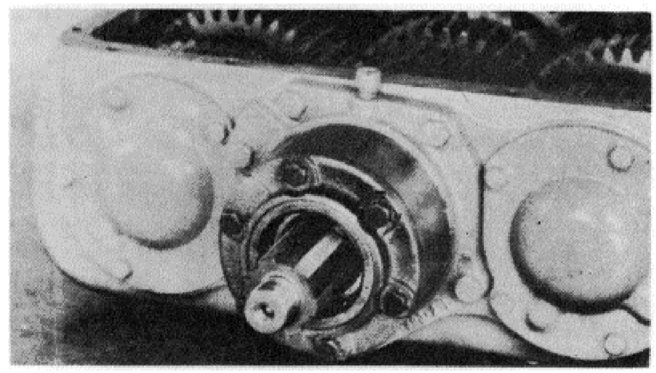


Figure 9B-4. Removing Drive Gear Assembly

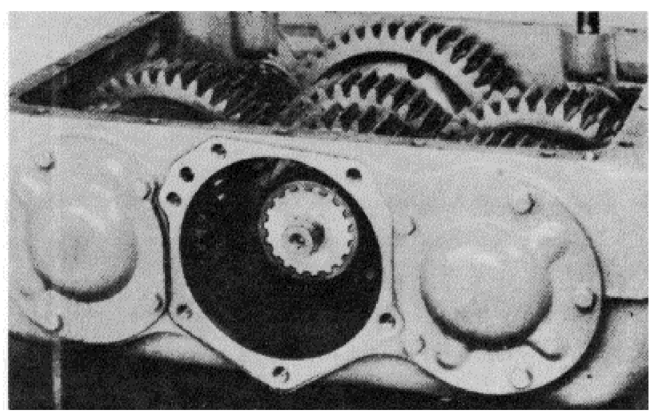


Figure 9B-5. Removing Front Bearing Caps

4. Cut and remove the lockwire from the capscrews on the front of the countershafts. Remove the capscrews and bearing retaining plates, Figure 9B-6.

NOTE

Later models have eliminated the bearing retaining plates and capscrews. A snap ring on the front of the countershaft is now used to hold the countershaft front bearing in place.

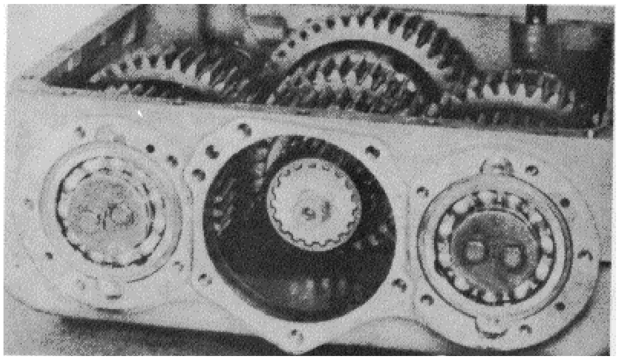


Figure 9B-6. Removing Bearing Retainers

5. The 3rd-4th speed shift collar can be pulled from the mainshaft through the front of the case, Figure 9B-7.

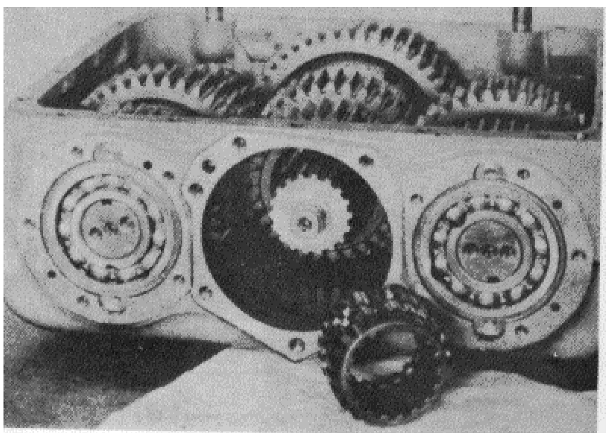


Figure 9B-7. Removing Shift Collar

6. Remove the capscrews from the countershaft rear bearing caps and the mainshaft rear bearing cap. The mainshaft and countershaft rear bearing caps and gaskets can now be removed from the face of the case, Figure 9B-8.

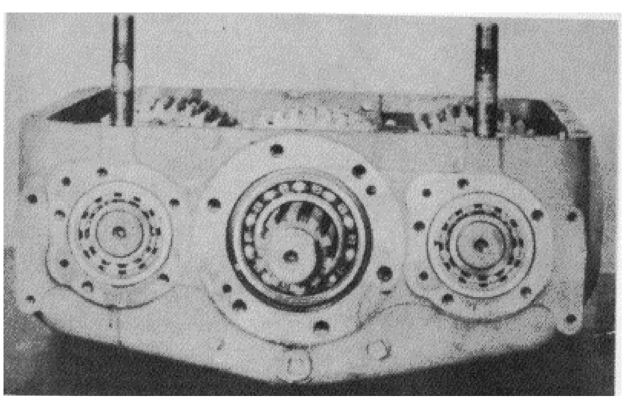


Figure 9B-8. Removing Rear Bearing Caps

7. Use soft hammer to tap on the rear of each countershaft. Tap on the countershafts until the front bearings have moved forward about 1/4", enough to get the puller on the outside snap rings of the front bearings, Figure 9B-9.

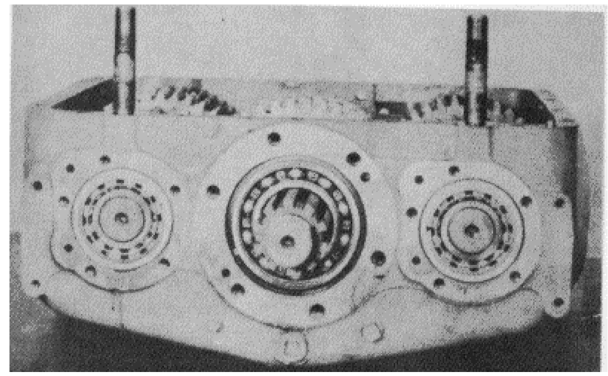


Figure 9B-9. Removing Shaft Snap Rings

8. The front countershaft bearing bores have been machined out to allow enough clearance for the jaws of a bearing puller. Place the puller on the snap ring of the bearing and pull the bearing off the shaft and out of the case bore, Figure 9B-10.

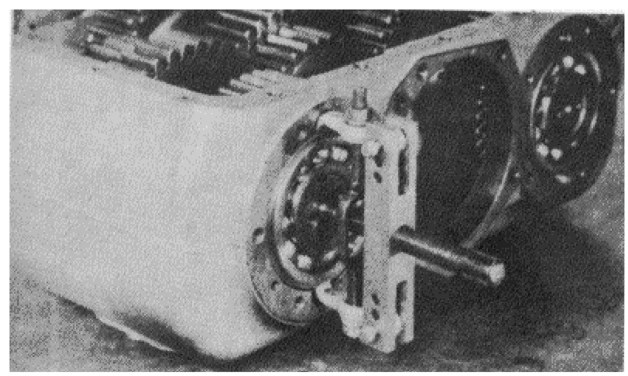


Figure 9B-10. Removing Countershaft Bearing

9. Here the countershaft front bearings on the right and left side have been removed, Figure 9B-11.

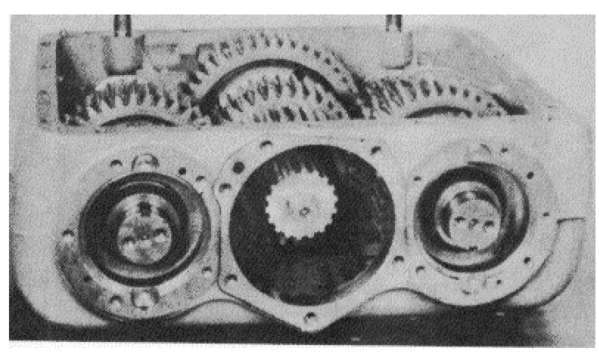


Figure 9B-11. Countershaft Bearings Removed

10. With the aid of a light chain hoist and a hook to relieve some of the weight of the mainshaft, use a soft mallet to drive the mainshaft assembly to the rear of the case, Figure 9B-12.

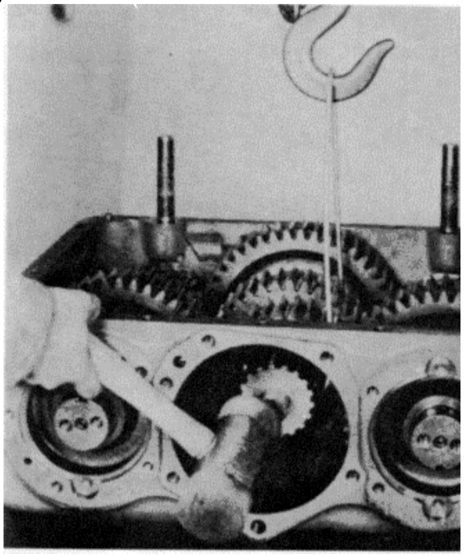


Figure 9B-12. Removing Main Shaft

11. It may be necessary to move the hoist and the hook to either of the countershafts and drive on them to move the mainshaft far enough to the rear to expose the rear bearings from the bores of the case, Figure 9B-13.

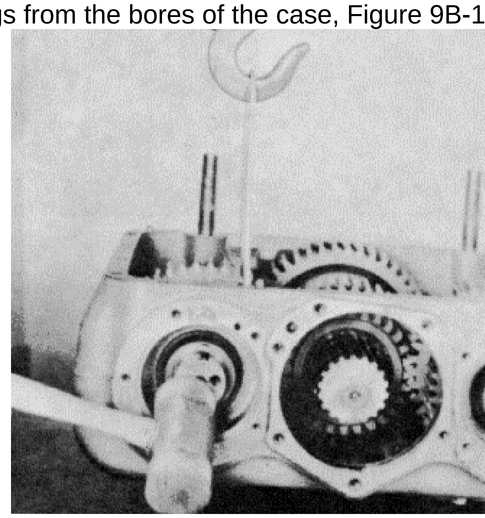


Figure 9B-13. Driving Countershafts to Rear

12. The rear countershaft bearings are two-piece bearings. The outer race and roller assembly can be removed from the inner race, Figure 9B-14. Do not remove the inner race from the shaft unless the bearing is going to be replaced.

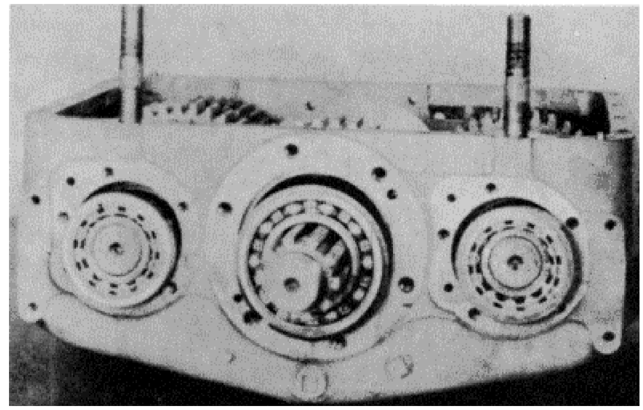


Figure 9B-14. Removing Countershaft Bearings

13. A puller can now be used to remove the mainshaft rear bearing from the mainshaft, Figure 9B-15.

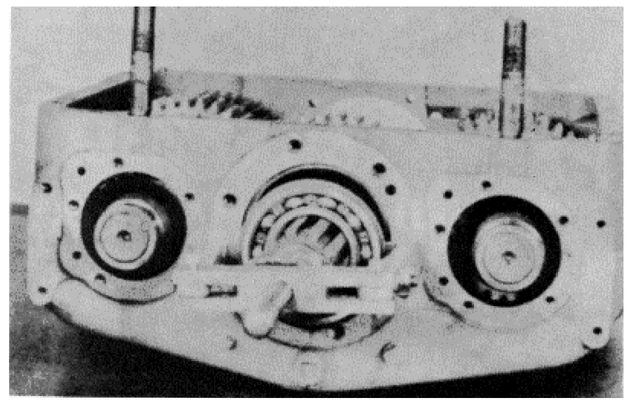


Figure 9B-15. Removing Main Shaft Bearing

14. Remove the mainshaft spacer from the mainshaft, Figure 9B-16.

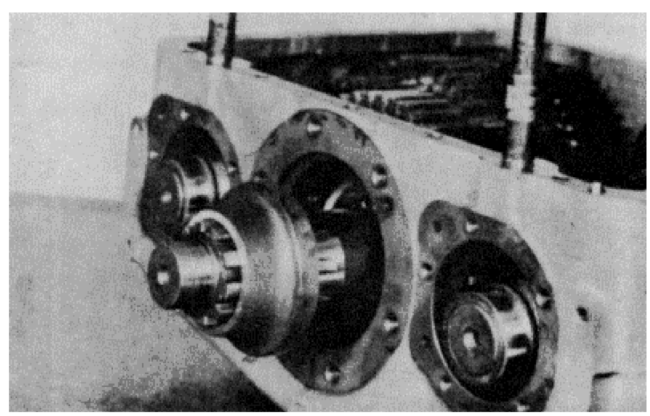


Figure 9B-16. Removing Main Shaft Spacer

15. Use a lift strap around the 1st-2nd shift collar and lift the mainshaft subassembly up and out of the case, Figure

9B-1 7. Lay the mainshaft subassembly on a work bench for disassembly of gears and related parts.

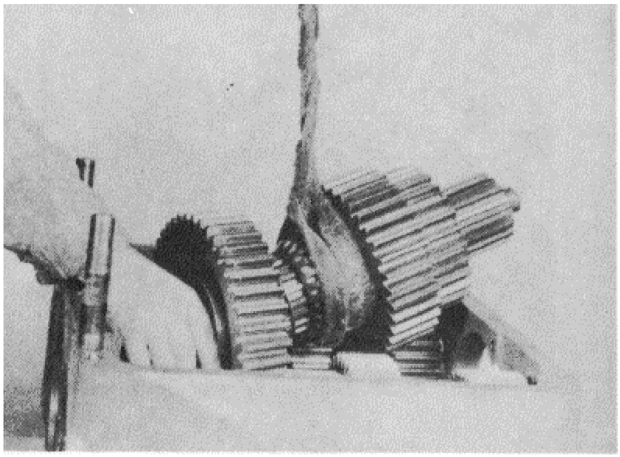


Figure 9B-17. Removing Main Shaft

16. Use a lift strap around the countershaft behind the head end gear and lift the countershaft assembly up and out of the case, Figure 9B-18. Do the same for the other countershaft.

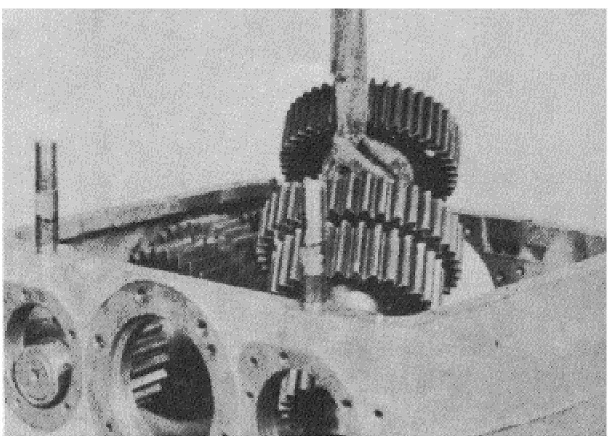


Figure 9B-18. Removing Countershaft

MAIN SHAFT DISASSEMBLY. To disassemble the mainshaft, proceed as follows:

1. With the mainshaft removed from the case and lying on the bench, remove the 1st speed gear (Lo-Lo) from the rear of the mainshaft, Figure 9B-19.

2. Remove the internal spline thrust washer from the rear of the mainshaft, Figure 9B-20.

3. Slide the 3rd-4th speed curvic shift collar from the front of the mainshaft, Figure 9B-21.

4. Remove the snap ring from the groove in the mainshaft under the bore of the 4th speed gear (overdrive), Figure 9B-22.

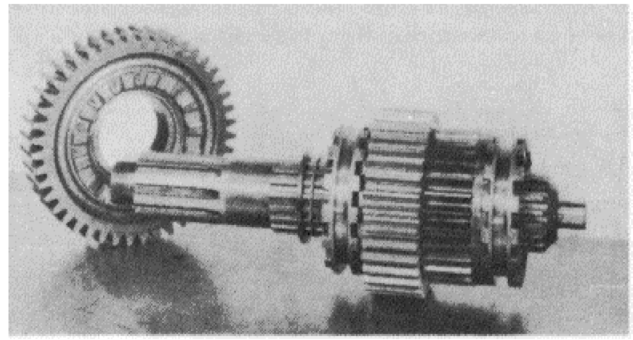


Figure 9B-19. Removing 1st Speed Gear

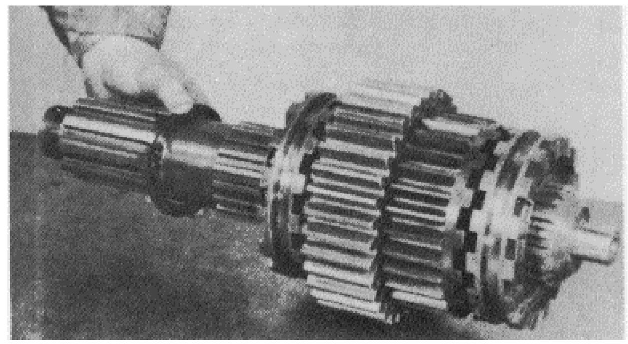


Figure 9B-20. Removing Thrust Washer

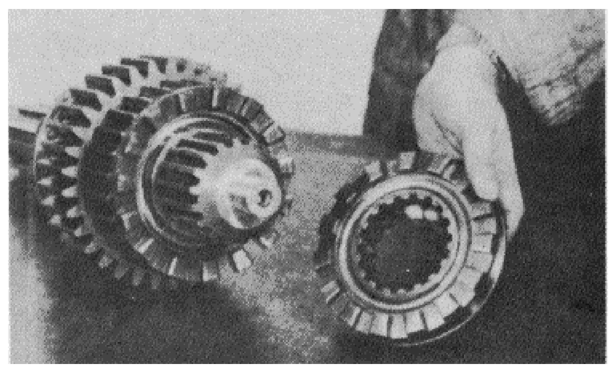


Figure 9B-21. Removing Shift Collar

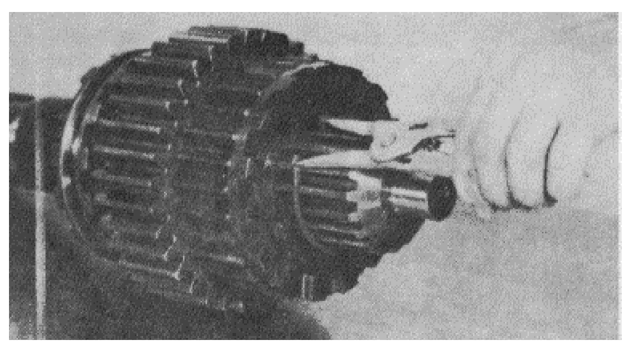


Figure 9B-22. Removing Snap Ring

5. Remove the internal spline thrust washer and the 4th speed gear (overdrive) from the mainshaft, Figure 9B-23.

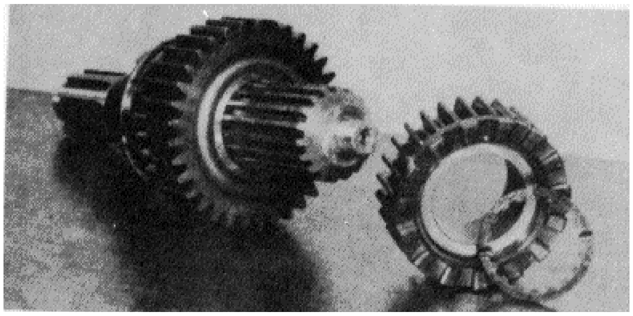


Figure 9B-23. Removing Thrust Washer and 4th Gear

6. Remove the 2nd speed gear (underdrive) and internal spline thrust washer from the mainshaft, Figure 9B-24.

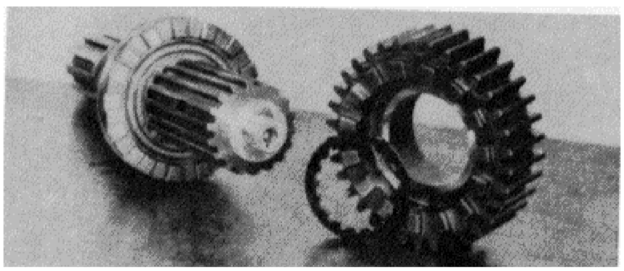


Figure 9B-24. Removing 2nd Gear and Thrust Washer

7. Remove the snap rings in the grooves of the mainshaft on either side of the 1 st-2nd speed curvic shift collar. Slide the curvic collar off the mainshaft, Figure 9B-25.

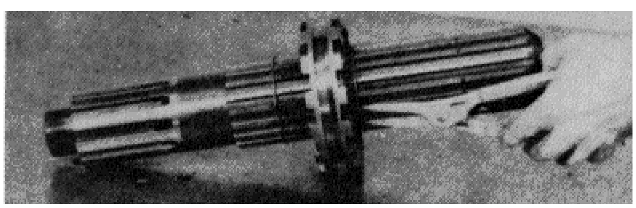


Figure 9B-25. Removing Shift Collar

COUNTERSHAFT DISASSEMBLY. To disassemble the countershaft, proceed as follows:

1. If the countershaft rear bearings are to be replaced, use a brass drift or similar tool to drive the inner race off the countershaft, Figure 9B-26.

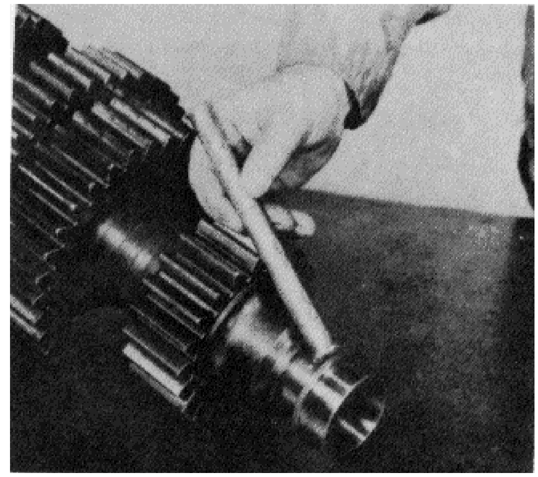


Figure 9B-26. Removing Rear Bearings

NOTE

If gears on countershaft require replacement because of tooth damage, or ratio change, etc., press all gears but integral Lo-Lo gear off the shaft.

2. Support head end (direct drive) gear with parallel bars as close to the hub as possible. Using an arbor press, press countershaft out of head end gear, Figure 9B-27.

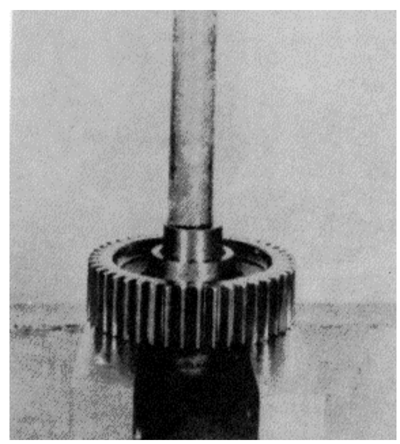


Figure 9B-27. Removing Shaft

NOTE

Countershaft has a long continuous keyway. As each gear is pressed from the shaft, the key may come away with the gear instead of staying in the keyway.

3. Support underdrive gear (2nd speed gear) with parallel bars as close to the hub as possible. Using an arbor press, press countershaft out of 4th speed gear and 2nd speed gear at the same time, Figure 9B-28. Remove 4th speed gear as its bore clears the shaft.

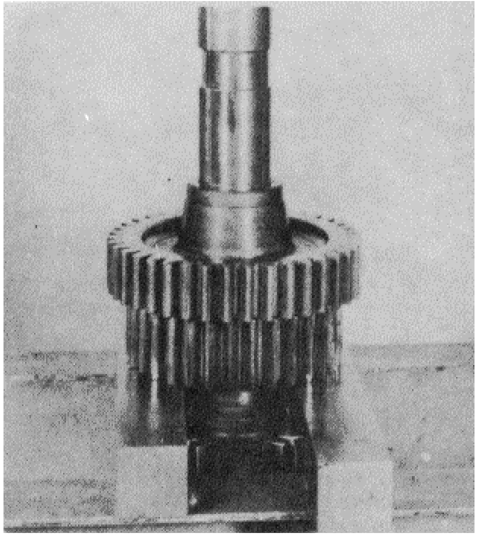


Figure 9B-28. Removing Shaft and 4th Gear

4. The Lo-Lo gear (1st speed gear) is an integral part of the countershaft and does not press off, Figure 9B-29. Keys are still intact in the keyway of the countershaft and can be removed, if necessary.

NOTE

The later model countershafts no longer use three separate keys. One long key is now assembled to the countershaft keyway.

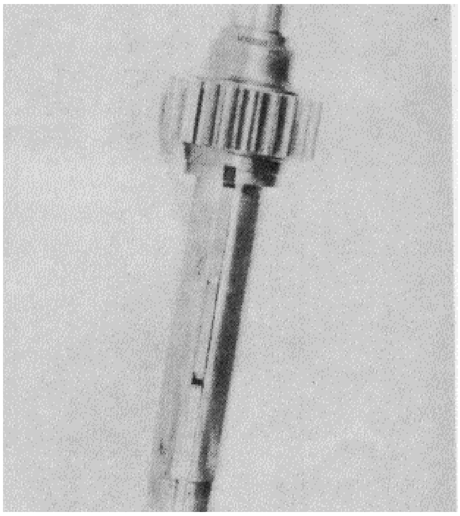


Figure 9B-29. Countershaft

DRIVE GEAR AND BEARING RETAINER DISASSEMBLY. To disassemble the drive gear and bearing retainer, proceed as follows:

1. The drive gear front bearing cap and drive gear assembly as it was removed from the front of the case, Figure 9B-30.

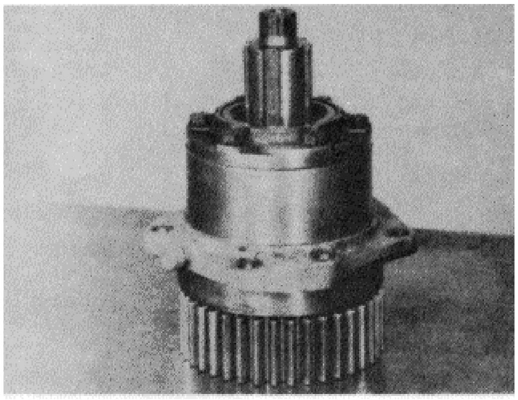


Figure 9B-30. Drive Gear Assembly

2. The capscrews holding the front bearing cap and gasket to the drive gear bearing retainer have been removed. The bearing cap has been removed from the retainer, Figure 9B-31. Remove front bearing cap oil seal if it is damaged and requires replacement, Figure 9B-31.

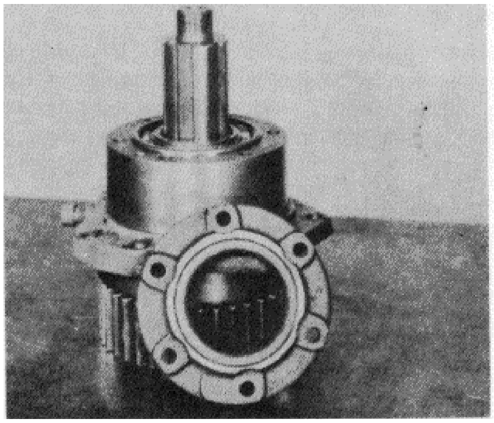


Figure 9B-31. Removing Bearing Cap

3. Support bearing retainer assembly on its flange and press drive gear free of bearing retainer, bearings and spacer, Figure 9B-32.

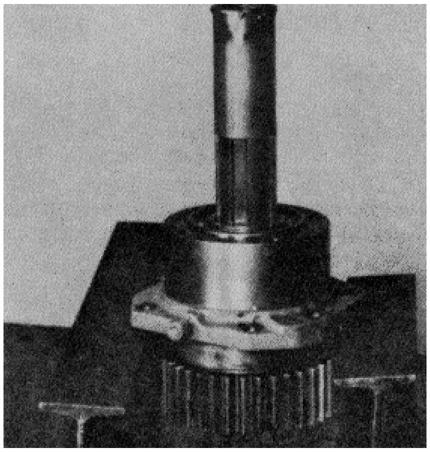


Figure 9B-32. Removing Drive Gear

4. Use puller to remove inner race of drive gear rear bearing from the drive gear, Figure 9B-33.

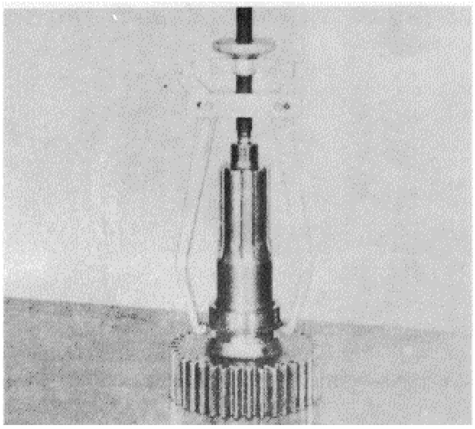


Figure 9B-33. Removing Bearing Race

5. Remove the drive gear pocket bearing by prying out with a large screwdriver or equivalent, Figure 9B-34. Use caution not to mar, or gouge pocket machined diameter with screwdriver or similar tool. Note timing marks painted white on drive gear.

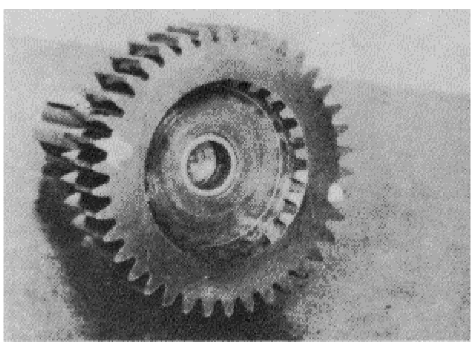


Figure 9B-34. Removing Drive Gear Bearing

6. Use a brass drift to remove bearing from the front of the drive gear bearing retainer, Figure 9B-35. The drive gear spacer can be removed from inside the retainer, at this time.

7. Use a brass drift to remove the outer race and roller assembly of the drive gear rear bearing from the retainer, Figure 9B-36.

SHIFTER HOUSING DISASSEMBLY. To disassemble the shifter housing, proceed as follows:

1. Remove the two air connectors and two elbows at the front of the shifter housing, Figure 9B-37.

2. Remove the two retaining plugs and stop pins from the top of the shifter housing, Figure 9B-38.

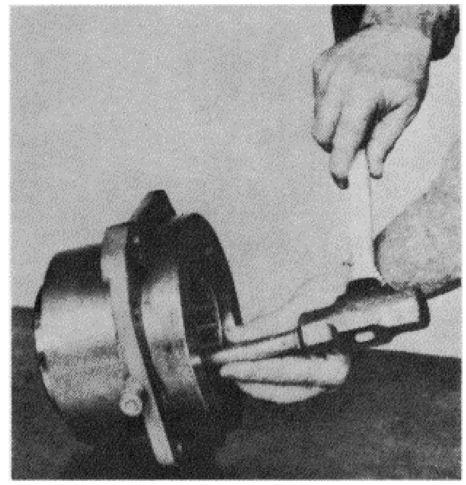


Figure 9B-35. Removing Bearing from Retainer

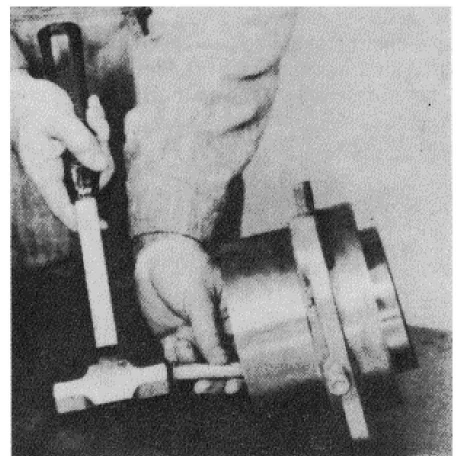


Figure 9B-36. Removing Outer Race

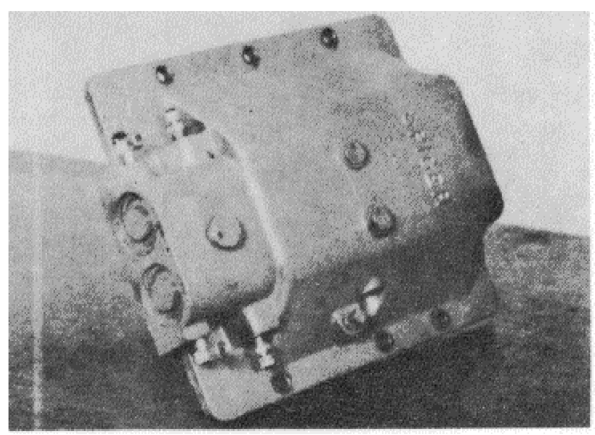


Figure 9B-37. Removing Air Connectors

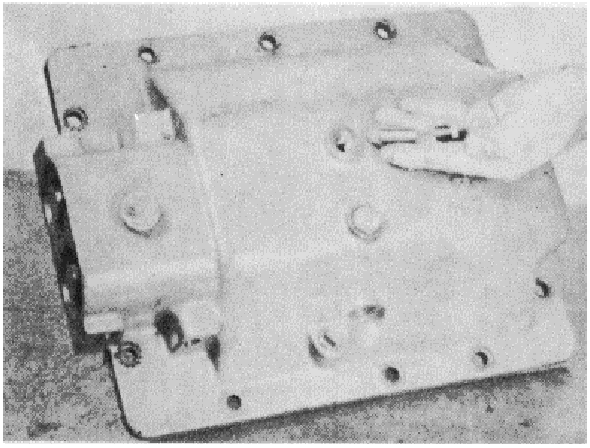


Figure 9B-38. Removing Stop Pins

3. Remove the snap ring from in front of the piston cylinder cap, Figure 9B-39.

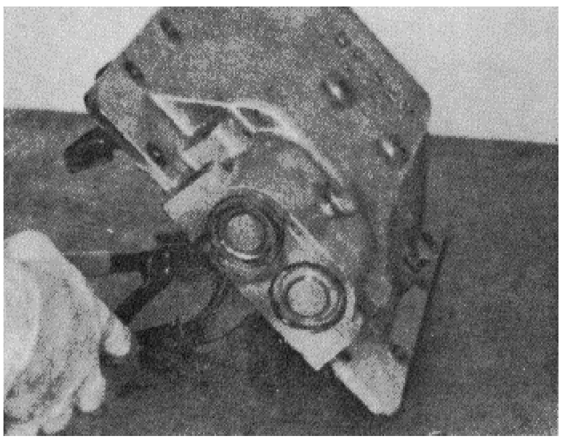


Figure 9B-39. Removing Snap Ring

4. Remove the piston cylinder cap with O-ring and washer, Figure 9B-40. Follow the same procedure for the adjacent shift rail.

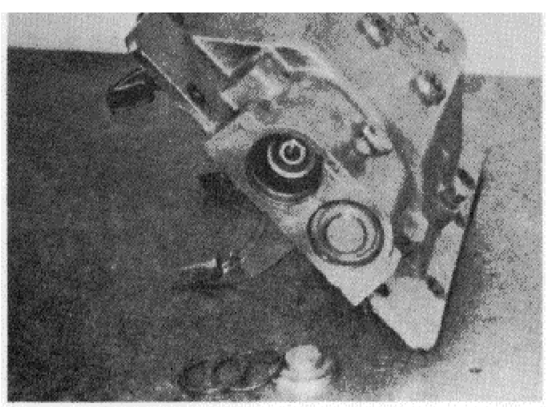


Figure 9B-40. Removing Piston Cylinder Cap

5. Remove the snap ring from inside each of the piston housing bores, Figure 9B-41. Also remove the locknut from the 3rd-4th piston rod.

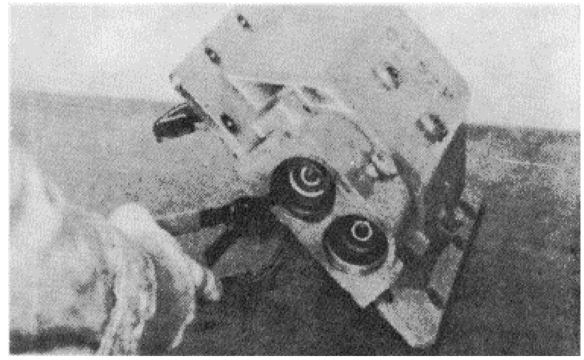


Figure 9B-41. Removing Snap Ring and Locknut

6. Now remove the setscrew holding the 3rd-4th speed shift fork to the piston rod, Figure 9B-42.

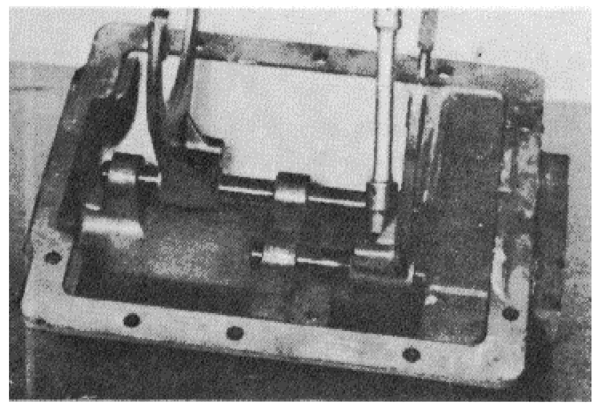


Figure 9B-42. Removing Setscrew

7. Use a brass drift to drive the 3rd-4th speed piston rod forward, Figure 9B-43. As the rod comes forward, the internal

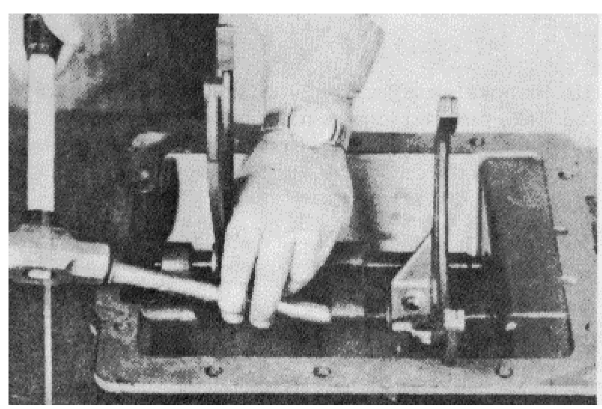


Figure 9B-43. Driving Out Piston Rod

piston can be removed from the front of the housing. The piston rod with the brass piston rod bushing can also be pulled from the front of the housing.

8. Remove the locknut from the 1 st-2nd speed piston rod,

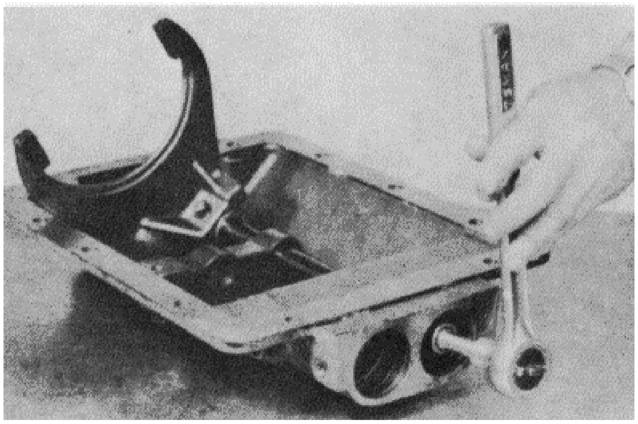


Figure 9B-44. Removing Locknut

9. Use a soft mallet to drive the 1 st-2nd speed piston rod forward, Figure 9B-45.

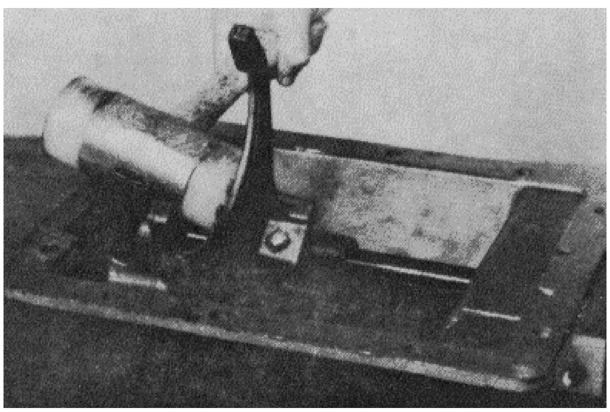


Figure 9B-45. Driving Out Piston Rod

10. Remove the setscrew holding the shift fork to the piston rod. Take the shift fork from the piston rod, Figure 9B-46. The internal piston with the front external piston can be removed from the end of the rod. Remove the 1 st-2nd speed piston rod with the piston rod brass bushing from the housing.

11. The piston rod with brass piston rod bushing and the internal piston, Figure 9B-47.

12. Remove the cylinder snap ring from the bore of the piston housing, Figure 9B-48.

13. Remove the rear external piston from the piston housing bore, Figure 9B-49. Repeat the same procedures for the adjacent piston side.

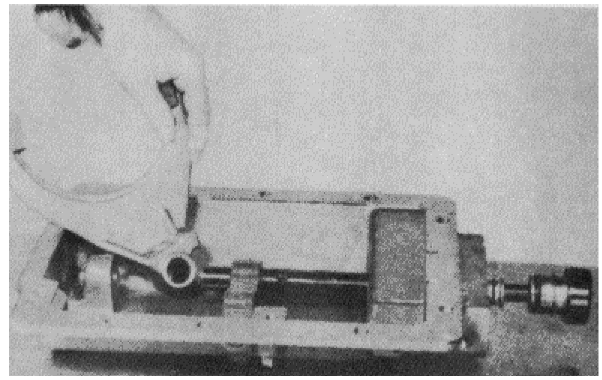


Figure 9B-46. Removing Shift Fork

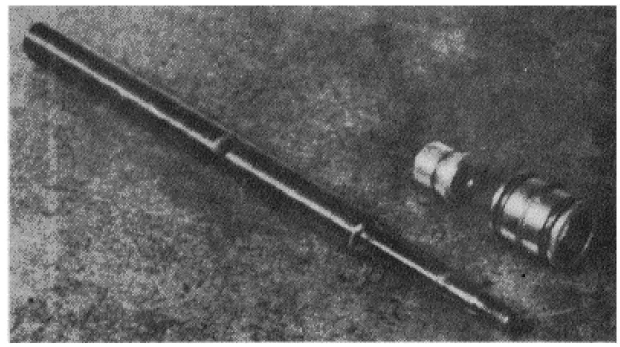


Figure 9B-47. Piston and Piston Rod

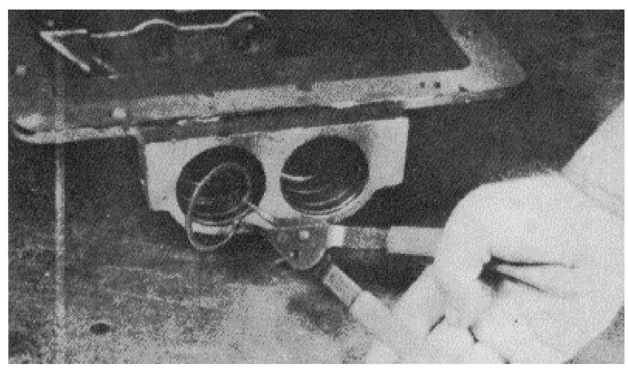


Figure 9B-48. Removing Cylinder Snap Ring

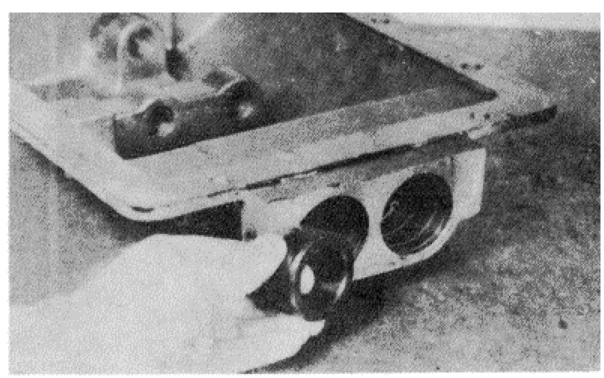


Figure 9B-49. Removing External Piston

14. Remove the two external piston O-rings in each of the piston housing bores, Figure 9B-50.

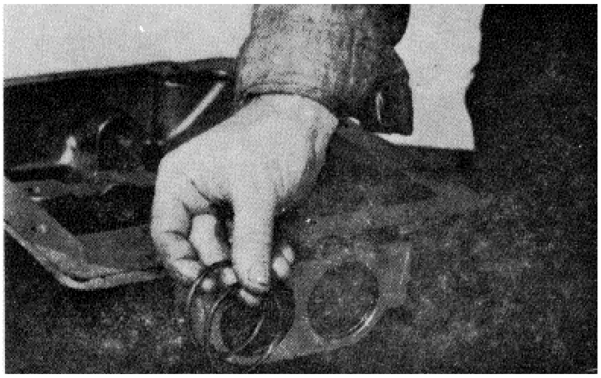


Figure 9B-50. Removing Piston O-Rings

CLEANING AND INSPECTION

The following steps are given as an aid to cleaning and inspecting parts when the transmission is overhauled.

1. All parts must be clean to permit effective inspection. At assembly, it is very important that no dirt or foreign material is allowed to enter the transmission. Even minute particles can cause the malfunction of close fit parts.
2. All metallic parts of the transmission, except bearings, should be cleaned thoroughly with volatile mineral spirits or by the steam cleaning method. *Do not use caustic soda solution for steam cleaning.*
3. Parts should be dried with compressed air. Steam cleaned parts should be oiled immediately after drying.
4. Clean oil passages by working a piece of wire back and forth through the passages and flushing with spirits. Dry the passages with compressed air.
5. Examine parts, especially oil passages, after cleaning, to make certain they are entirely clean. Re-clean them, if necessary.
6. Bearings that have been in service should be thoroughly washed in volatile mineral spirits. If the bearings are particularly dirty or filled with hardened grease, soak them in the spirits before trying to clean them. Before inspection, oil the bearing with the same type of oil that will be used in the transmission.

NOTE

Never dry bearings with compressed air. Do not spin bearings while they are not lubricated.

7. Inspect bores for wear, scratches, grooves and dirt. Remove scratches and burrs with crocus cloth. Remove foreign matter. Replace parts that are deeply scratched or grooved.
8. Inspect mounting faces for nicks, burrs, scratches, and foreign matter. Remove such defects with crocus cloth or a soft stone. If scratches are deep, replace the damaged parts.
9. Inspect threaded openings for damaged threads. Chase damaged threads with the correct size used tap.
10. Replace housing or other cast parts that are cracked.
11. Inspect all machined surfaces for damage that could cause oil leakage or other malfunction of the part. Replace the faulty part.
12. Inspect bearings for roughness of rotation. Replace a bearing if its rotation is still rough after cleaning and oiling.
13. Inspect bearings for scored, pitted, scratched, cracked, or chipped races, and for indication of excessive wear of rollers or balls. If one of these defects is found, replace the bearing.
14. Inspect a defective bearing's housing and shaft for grooved, burred, or galled conditions that indicate that the bearing has been turning in its bore or on its shaft. If damage cannot be corrected with crocus cloth, replace the damaged parts.
15. Inspect bushings for scores, burrs, roundness, sharp edges and evidence of overheating. Remove scores with crocus cloth. Remove burrs and sharp edges with a scraper or knife blade. If the bushing is out-of-round, deeply scored, or excessively worn, replace it with the proper size bushing.

NOTE

Sometimes it is necessary to cut out a damaged bushing. Be careful not to damage the bore into which the bushing fits.

16. Inspect thrust washers for distortion, scores, burrs and wear. Replace the thrust washer if it is worn or damaged.
17. Inspect seal rings for cuts and hardness. Replace seal rings if these defects are found.
18. When replacing lip-type oil seals, the spring loaded side must be toward the oil to be sealed in (toward the inside of the unit). Use a non-hardening sealing compound on the outside diameter of the seal to prevent oil leaks. Coat the inside diameter of the seal with high temperature grease (MIL-G-3534A or equivalent) to protect the seal during shaft installation and to provide lubrication during initial operation.
19. Replace all composition gaskets.
20. Inspect gears for scuffed, burred, nicked or broken teeth. If the damage cannot be removed with a soft stone, replace the gear.
21. Inspect gear teeth for wear that may have destroyed the original tooth shape. If this condition is found, replace the gear.
22. Inspect the thrust face of gears for scores, scratches and burrs. Remove such defects with a soft stone. If scratches and scores cannot be removed with a soft stone, replace the gear.
23. Inspect splined parts for stripped, twisted, chipped or burred splines. Remove burrs with a soft stone. Replace the part if other damage is found. Spline wear is not considered detrimental except where it affect tightness of fit of the splined parts.

24. Inspect snap rings for nicks, distortion, and excessive wear. Replace the snap ring if any of these defects are found. The snap ring must snap-tight in its groove for proper functioning.
25. Inspect springs for signs of overheating, permanent set, or wear due to rubbing adjacent parts. Replace the spring if any of these conditions are found.
26. Expendable parts such as oil seals and O-rings should never be reused even though inspection may show these items as being serviceable for future use. The cost of these items is negligible compared to the costs involved in replacing such items if they do not function properly. Service kits are available for each subassembly, as presented by these overhaul instructions.
27. All replacement parts should be given your final inspection to ensure that no damage has resulted after the final factory inspection was made.

ASSEMBLY

SHIFTER HOUSING ASSEMBLY. To assemble the shifter housing, proceeds as follows:

Inspect and replace all damaged or worn O-rings before re-assembly of the cover.

1. Place the 1 st-2nd speed piston rod into the shifter housing. Place the 1 st-2nd speed shift fork on the piston rod with the long hub toward the front, Figure 9B-51. Place the brass internal piston rod bushing on the end of the rod. Check and make sure the interlock is still in the cross hole between the rods.

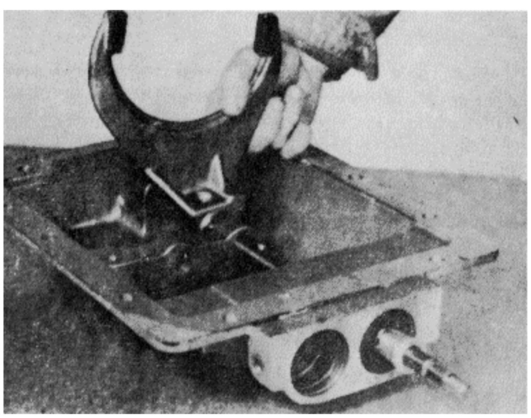


Figure 9B-51. Installing Piston Rods and Shift Forks

2. Secure the shift fork to the piston rod with the setscrew. Torque the setscrew to 40-50 lbs. ft (54.2-67.8 N•m). Use a suitable driver to drive the piston rod bushing into the piston housing bore, Figure 9B-52. Flange on bushing will seat against the face inside the piston housing bore.

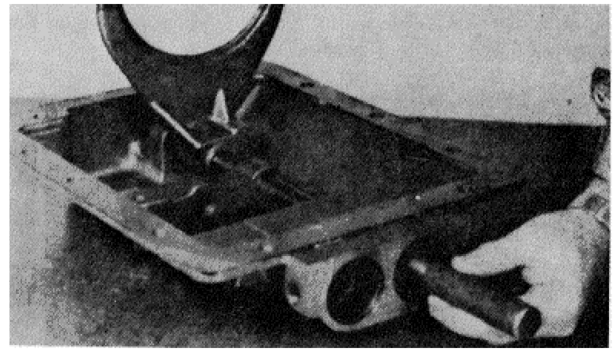


Figure 9B-52. Installing Piston Rod Bushing

3. Repeat the same procedures for the adjacent piston rod fork. Place the rear outer piston O-ring into each piston housing bore, Figure 9B-53.

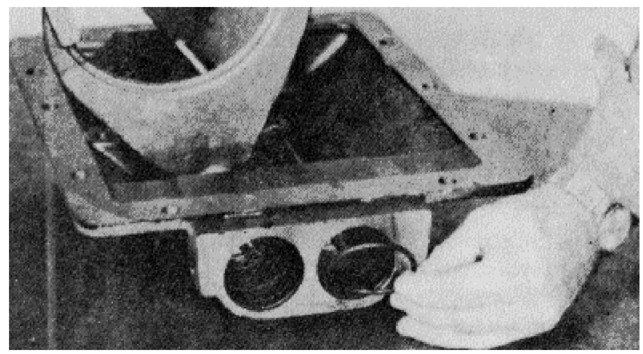


Figure 9B-53. Installing Piston O-Ring

4. Place the rear outer piston into each piston housing bore, Figure 9B-54.

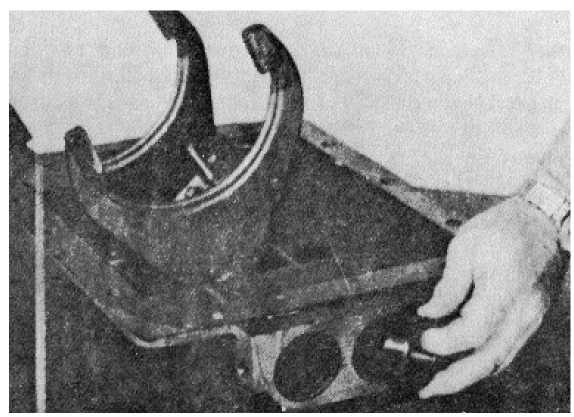


Figure 9B-54. Installing Outer Piston

5. Assemble a snap ring into each piston housing bore, Figure 9B-55.

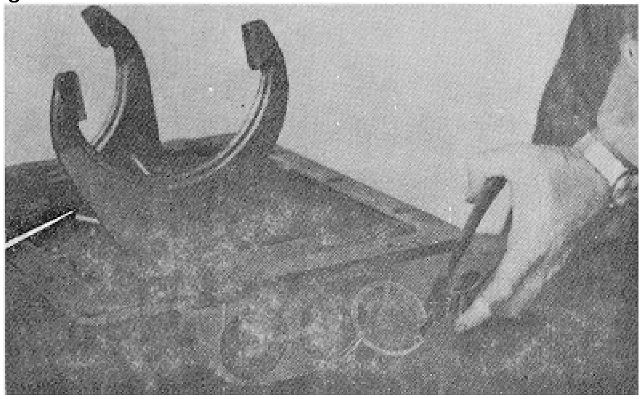


Figure 9B-55. Installing Snap Rings

6. Assemble the front outer piston O-ring into each piston housing bore, Figure 9B-56.

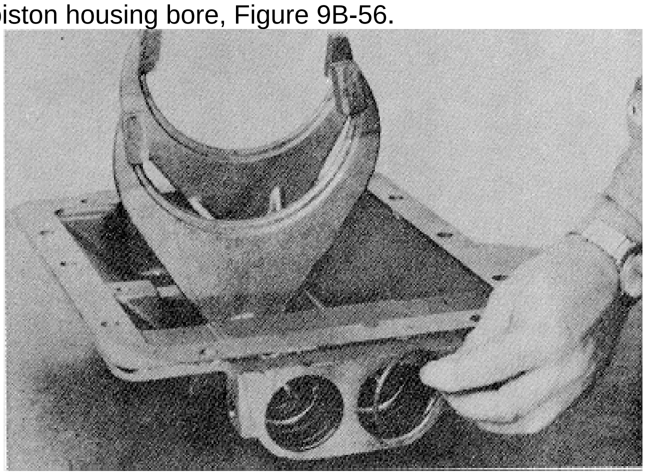


Figure 9B-56. Installing O-Ring

7. Place the internal piston with the front outer piston assembled to it, into the bore and onto the piston rod, Figure 9B-57. Repeat the same procedure for the adjacent piston rod.

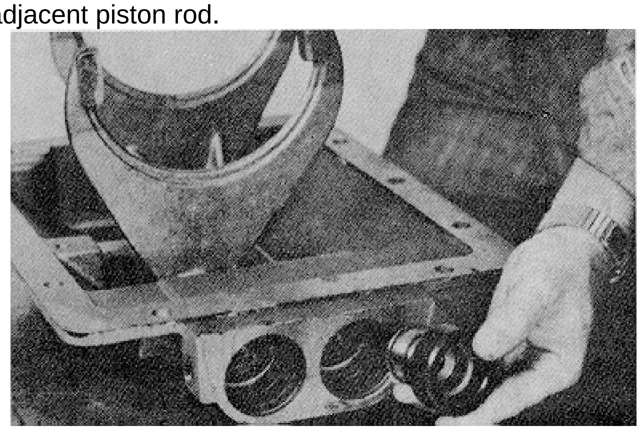


Figure 9B-57. Installing Internal Piston

8. Secure the internal pistons on the piston rods with the locknuts, Figure 9B-58.

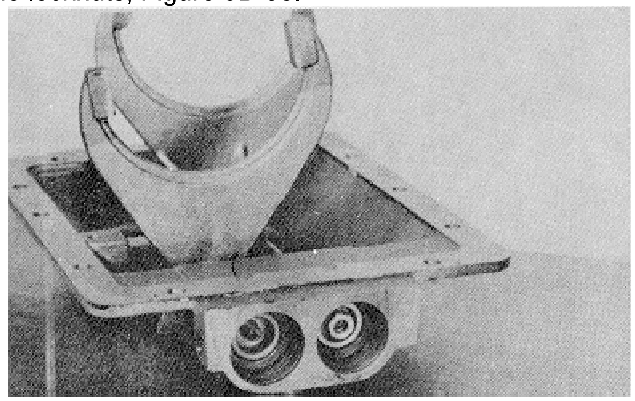


Figure 9B-58. Installing Locknuts

9. Assemble the snap ring to each piston housing bore, Figure 9B-59.

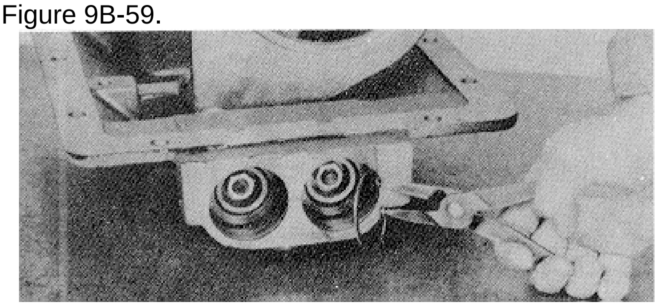


Figure 9B-59. Installing Snap Ring

10. Assemble the cylinder caps with O-ring and washer in each piston housing bore, Figure 9B-60.

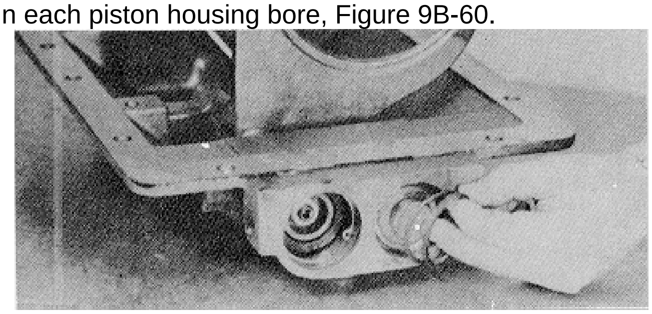


Figure 9B-60. Installing O-Ring and Washer

11. Place the snap ring at the front of each cylinder cap, Figure 9B-61.

12. Place the stop pins and plugs in the top of the shifter housing, Figure 9B-62.

13. Assemble the air fittings to the front of the shifter housing, Figure 9B-63.

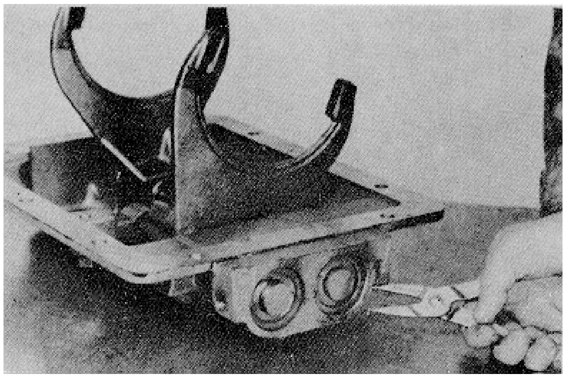


Figure 9B-61. Installing Snap Ring

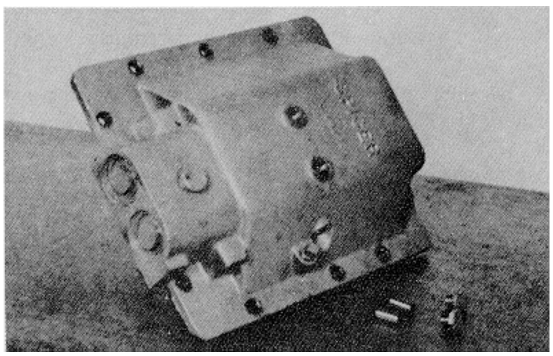


Figure 9B-62. Installing Stop Pins and Plugs

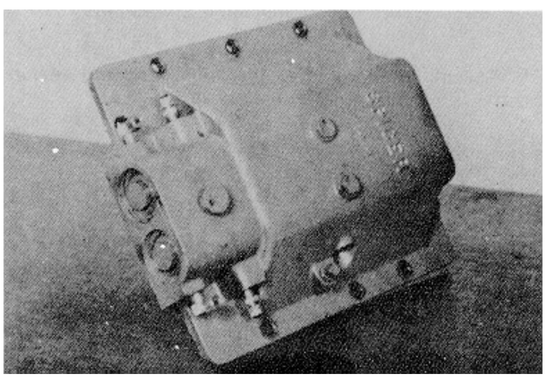


Figure 9B-63. Installing Air Fittings

MAINSHAFT ASSEMBLY. To assemble the mainshaft, proceed as follows:

NOTE

The two curvic shift collars are interchangeable and can face the front or rear.

1. Place the 1 st-2nd speed shift collar on the mainshaft between the two snap ring grooves at the rear of the shaft. Assemble a snap ring in the grooves on the mainshaft on either side of the shift collar, Figure 9B-64.

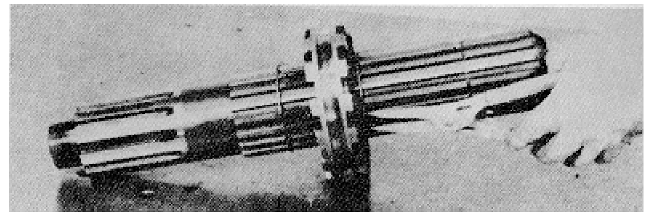


Figure 9B-64. Installing Shift Collar

2. Place an internal spline thrust washer on the mainshaft. Slide the 2nd speed gear (under drive) on the shaft with the clutch teeth of the gear facing the 1 st-2nd speed shift collar, Figure 9B-65.

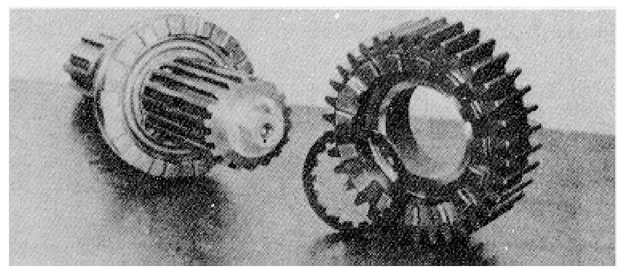


Figure 9B-65. Installing 2nd Gear

3. Assemble the 4th speed gear (overdrive) to the mainshaft with the clutch teeth facing away from the 2nd speed gear, Figure 9B-66. Assemble an internal spline thrust washer on the mainshaft.

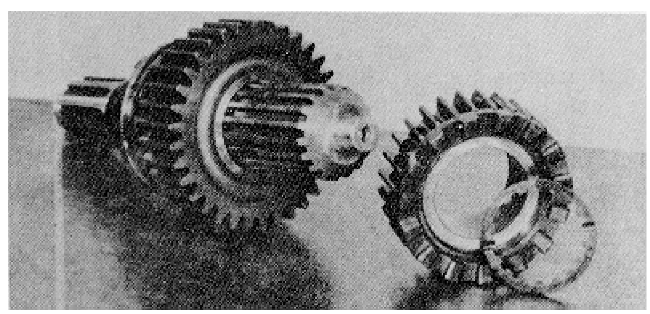


Figure 9B-66. Installing 4th Gear

4. Assemble a snap ring in the groove on the mainshaft under the bore of the 4th speed gear (overdrive), Figure 9B-67).

5. Place the 3rd-4th speed shift collar on the end of the mainshaft, Figure 9B-68.

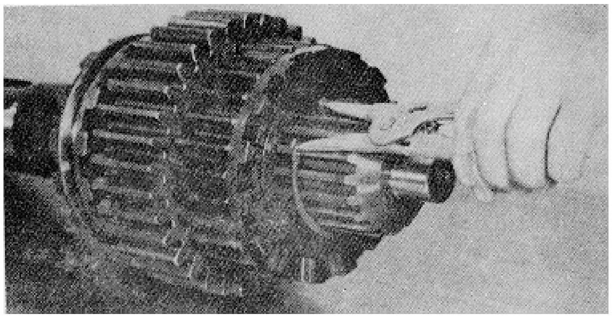


Figure 9B-67. Installing Snap Ring

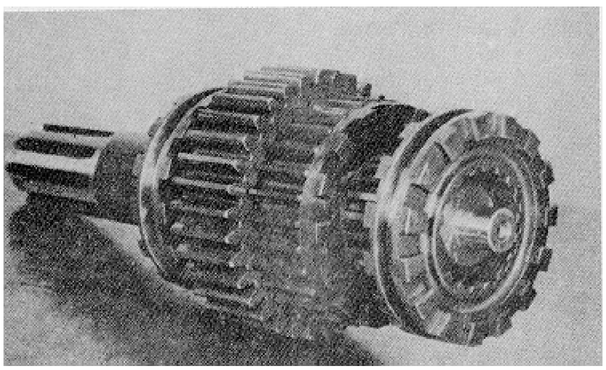


Figure 9B-68. Installing Shift Collar

6. Assemble an internal spline thrust washer on the rear of the mainshaft. Place the 1 st speed gear (Lo-Lo) on the rear of the mainshaft, Figure 9B-69. The clutch teeth of the 1st gear facing the lst-2nd speed shift collar.

Place the mainshaft assembly aside for later installation into the case.

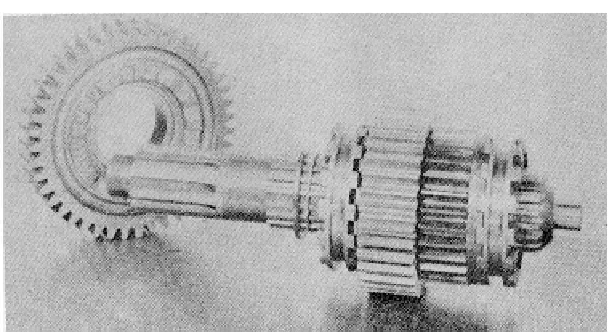


Figure 9B-69. Installing 1st Gear

COUNTERSHAFT ASSEMBLY. To assemble the counter shafts, proceed as follows:

NOTE

It is advisable to coat bores of all the gears with oil when pressing the gear on the countershaft.

We recommend that the keys for each gear be installed in the shaft keyway one at a time, as the countershaft is pressed into the gear bore. Note that all three keys are the same size, so that they can be used interchangeably in any gear. If keys become mutilated or burred after assembly to the shaft keyway, use mill file to align sides, remove burrs, etc.

This prevents chips and slivers from peeling off and lodging between gear hub faces.

As the countershaft is pressed into each gear, make certain any metal chips or slivers are removed from the gear hub faces.

1. Secure the key into keyway of countershaft by driving on the key with a hammer. Support 2nd speed gear (under-drive) with long hub up. Align key with gear keyway and press shaft and key into gear, Figure 9B-70. Seat the gear face of shaft firmly against the face of 2nd speed gear (underdrive). Key must be under the face of gear.

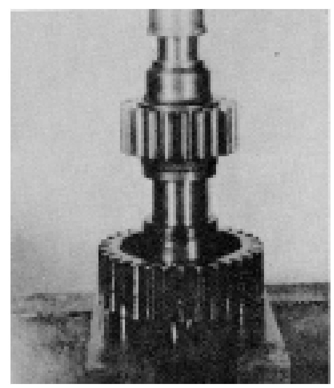


Figure 9B-70. Installing 2nd Gear

2. Secure the key for the 4th speed gear (overdrive) into the countershaft keyway. Support the overdrive gear with the long hub down. Press the shaft and key into the gear, Figure 9B-71. Seat the gear face firmly against the face of the underdrive speed gear. The key must be under the face of the gear.

3. Secure the third key in the keyway of the countershaft. Support the 3rd speed gear (direct drive) with the long hub up. Press the shaft into the gear, seating the gear face firmly against the face of the 4th speed gear (overdrive), Figure 9B-72. The key must be under the face of the gear.

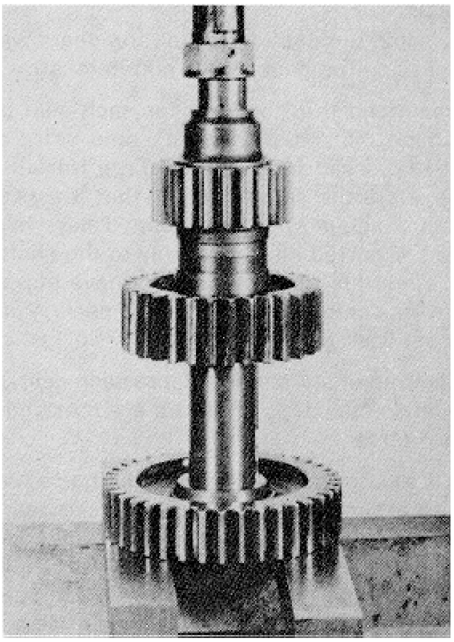


Figure 9B-71. Installing 4th Gear

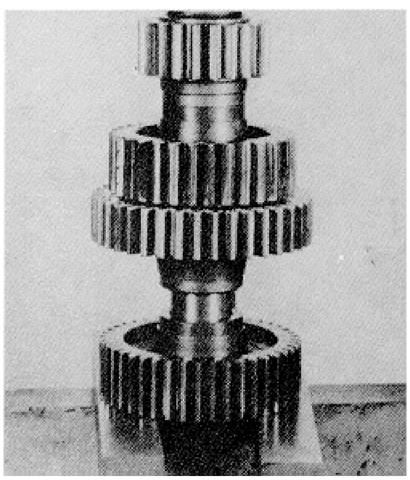


Figure 9B-72. Installing 3rd Gear

NOTE

The key face must not protrude beyond the face of the 3rd speed gear (direct drive) because the countershaft front bearing inner race face rests against the face of the gear hub.

Notice there is a tooth timing mark "V" on the tooth web of the 3rd speed gear(direct drive). Be sure that it aligns itself to the center of the gear keyway. Use white paint on the timing marks "V" for easy identification on later assembly.

The later model countershafts no longer use three separate keys. One long key is now assembled to the countershaft keyway.

DRIVE GEAR AND BEARING RETAINER ASSEMBLY. To assemble the drive gear and bearing retainer, proceed as follows:

1. Place the inner race of the drive gear rear bearing on the drive gear. The flange of the inner race goes toward the gear. Use a suitable driver to seat the flange of the inner race against the front face of the drive gear, Figure 9B-73.

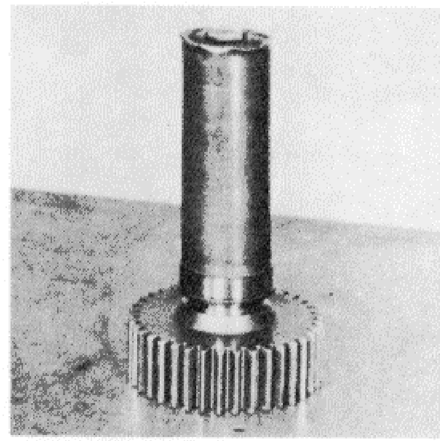


Figure 9B-73. Installing Bearing Inner Race

2. Place the outer race and roller assembly of the drive gear rear bearing over the drive gear shaft and onto the inner race, Figure 9B-74.

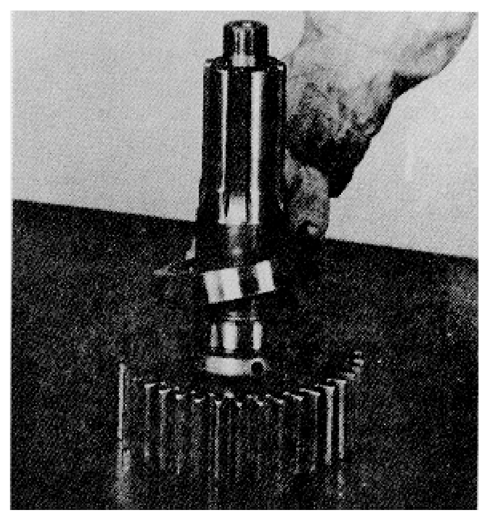


Figure 9B-74. Installing Outer Race and Roller

3. Install the bearing retainer onto the drive gear and bearing, Figure 9B-75. The wide trunnion bearing face of the retainer faces up.

4. Place the spacer on the drive gear stem, Figure 9B-76. It will rest against the drive gear rear bearing.

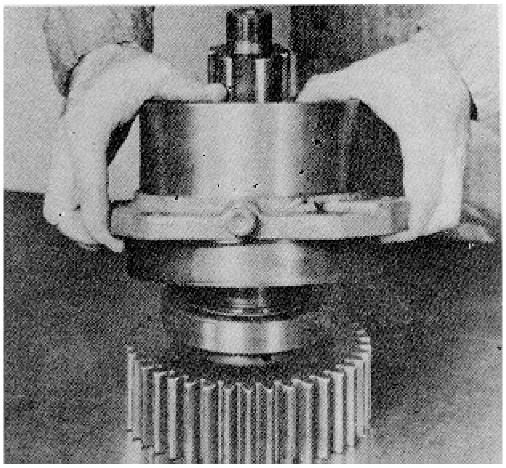


Figure 9B-75. Installing Bearing Retainer

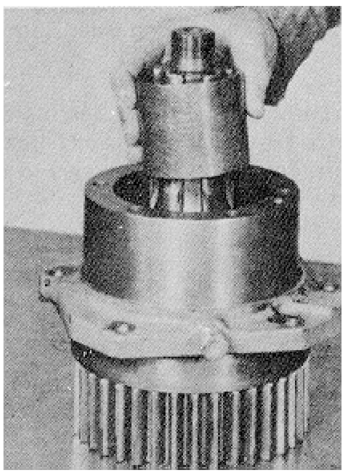


Figure 9B-76. Installing Spacer

5. Place the drive gear front bearing on the drive gear stem. Use a suitable driver to press on the bearing inner race. Seat the bearing firmly against the face of the spacer and against the shoulder of the bore in the bearing retainer, Figure 9B-77.

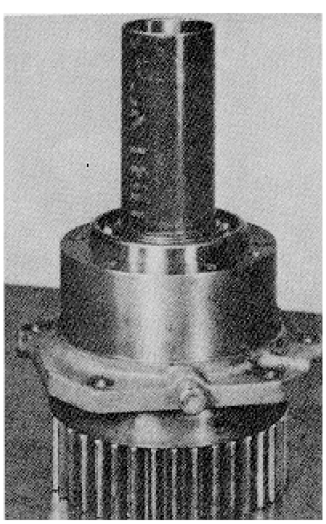


Figure 9B-77. Installing Drive Gear Bearing

6. The drive gear front bearing cap and gasket with the oil drain holes aligned has been assembled to the bearing retainer, Figure 9B-78. Torque the capscrews to 25-32 lbs. ft. (33.943.4 N.m). Before assembling the cap to the retainer inspect the oil seal and if damaged replace it with a new seal.

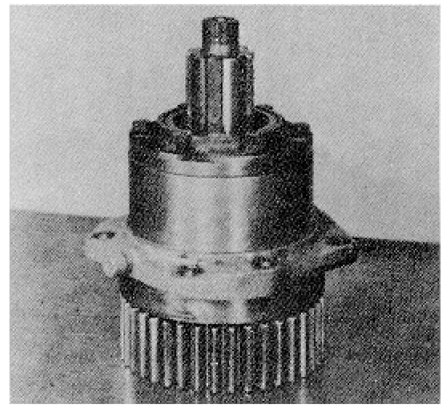


Figure 9B-78. Installing Bearing Cap

7. If the pocket bearing of the drive gear has not already been installed do so at this time. The pocket bearing should seat firmly against the pocket shoulder and the bearing part number facing out. The timing marks" "on the face of the drive gear teeth should be painted white for easy identification on later assembly, Figure 9B-79. Lay the drive gear bearing retainer subassembly aside for later installation after the mainshaft subassembly has been installed into the case.

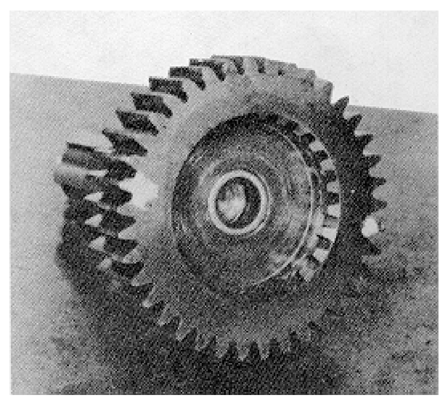


Figure 9B-79. Drive Gear

MAINSHAFT COUNTERSHAFT DRIVE 'GEAR ASSEMBLY INTO CASE. To assemble the mainshaft and countershaft into the case, proceed as follows:

1. Take either countershaft subassembly and place it inside the case on the left side, Figure 9B-80. Try to keep the timing mark "V'" of the head end gear toward the center of the case. This timing mark must be mated to the drive gear timing mark "'A" later in assembly. Install the right side countershaft subassembly in the

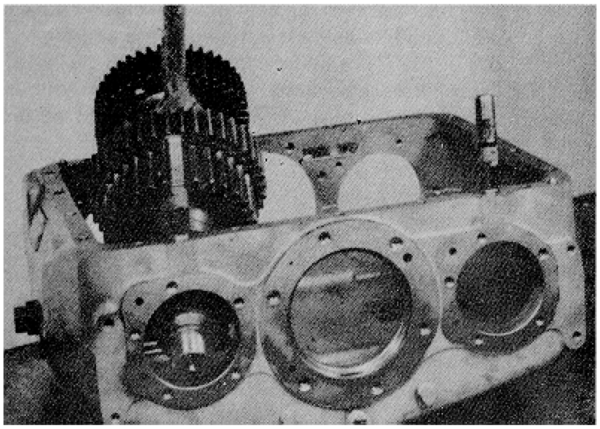


Figure 9B-80. Installing Countershaft

same manner. Do not install countershaft front or rear bearings at this time.

2. With a sling placed around the 1st-2nd speed shift collar and the use of a light chain hoist, lower the mainshaft assembly into position in approximate center of the case rear bore, Figure 9B-81.

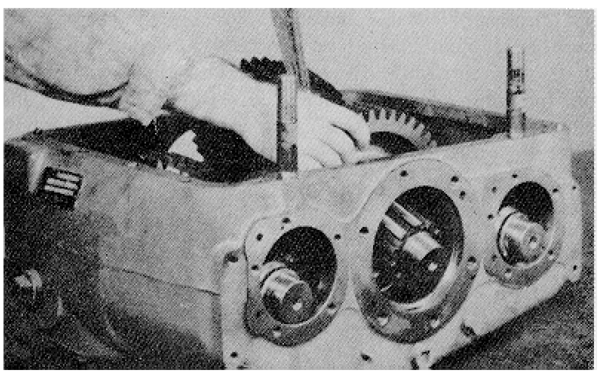


Figure 9B-81. Installing Main Shaft

3. Leave the hoist and sling in place for support on the mainshaft in its position until the drive gear assembly and mainshaft rear bearing have been assembled into the case, Figure 9B-82. Place the 3rd4th speed shift collar on the mainshaft.

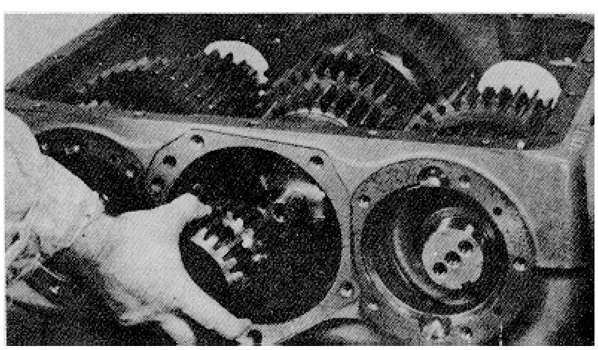


Figure 9B-82. Installing Shift Collar

4. Place the mainshaft gear spacer on the shaft with the large flat side going against the hub of the lst-2nd speed gear, Figure 9B-83.

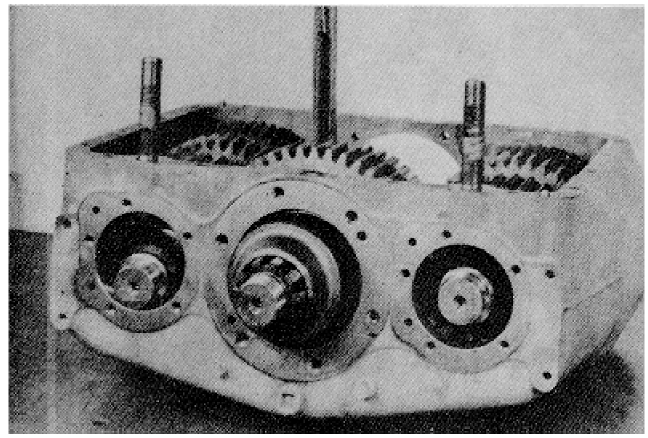


Figure 9B-83. Installing Gear Spacer

5. Install the front drive gear and bearing cap assembly with gasket into the front case bore and onto the pilot stem of the mainshaft. Torque the capscrews to 6080 lbs. ft. (81.4108.5 N.m), Figure 9B-84.

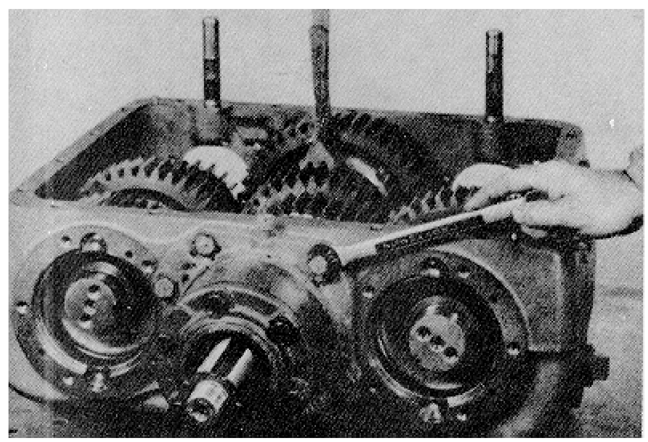


Figure 9B-84. Installing Drive Gear and Bearing Cap

6. Use a piece of tubing or suitable driver to drive on the inner race of the mainshaft rear bearing, Figure 9B-85. Seat the outer snap ring on the bearing against the main case counterbore.

7. If the speedometer driven gear was removed from the bearing cap, assemble it at this time. Inspect and replace the mainshaft rear bearing cap oil seal, if necessary. Align the oil port holes to the return holes on the bearing cap. Install the rear bearing cap with gasket on the mainshaft rear bearing and case face, Figure 9B-86. Torque the capscrews to 6080 lbs. ft. (81.4108.5 N.m).

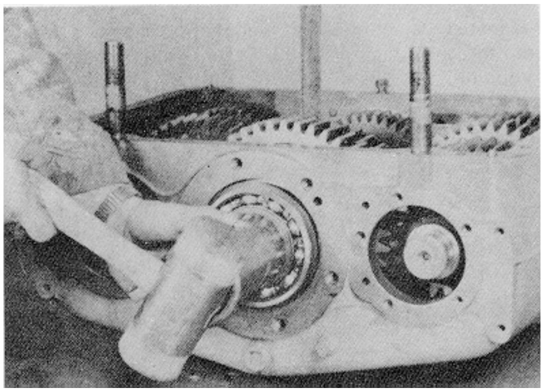


Figure 9B-85. Installing Main Shaft Rear Bearing

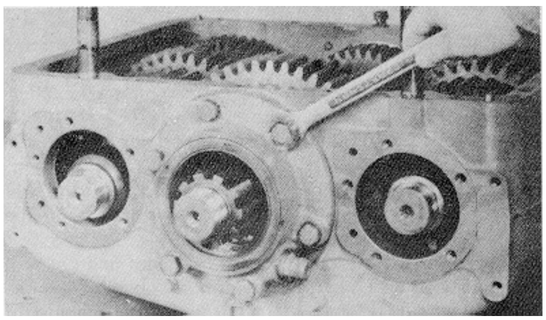


Figure 9B-86. Installing Rear Bearing Cap

8. With all timing gears painted, bring timing teeth of countershaft head end gears parallel to bottom of case, or pointing to the center of the case. Position drive gear timing teeth (two) where they will match and mate to the timing teeth o the countershft gears, Figure 9B-87.

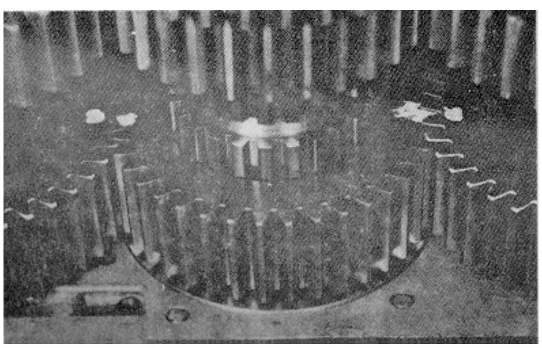


Figure 9B-87. Timing Marks

9. Remove the sling from the 1st-2nd shift collar. Use the sling or hook with hoist to center the left side countershaft 'in the bearing bore. Assemble the inner race of the countershaft rear bearings if they had been removed, Figure 9B-88. Flange of the inner race toward the inside.

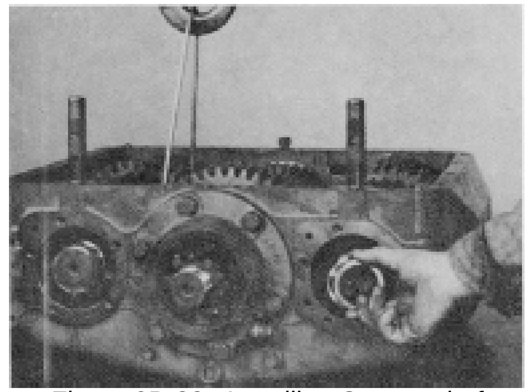


Figure 9B-88. Installing Countershaft Bearing Inner Race

10. Install the countershaft front bearing onto the countershaft. Using a piece of tubing to drive on the inner race, seat the outside snap ring to the face of the case, Figure 9B-89. Install the outer front countershaft bearing in the same manner. Make certain timing marks of countershaft head end gear and drive are still in mesh, Figure 9B-87.

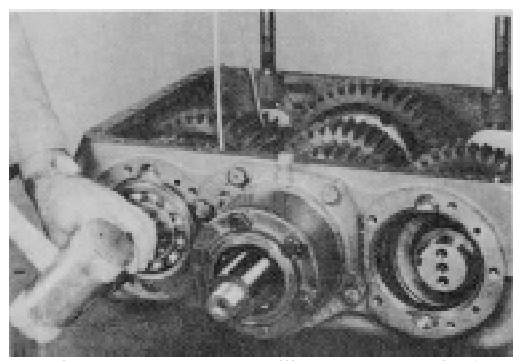


Figure 9B-89. Installing Countershaft Bearing

11. Install the countershaft front bearing retaining plates, Figure 9B-90. Secure with the capscrews and torque to 6080 lbs. ft. (81.4108.5 N.m). Secure with lockwire.

NOTE

Later models have eliminated the bearing retaining plates and capscrews. A snap ring on the front of the countershaft is now used to hold the countershaft front bearing in place.

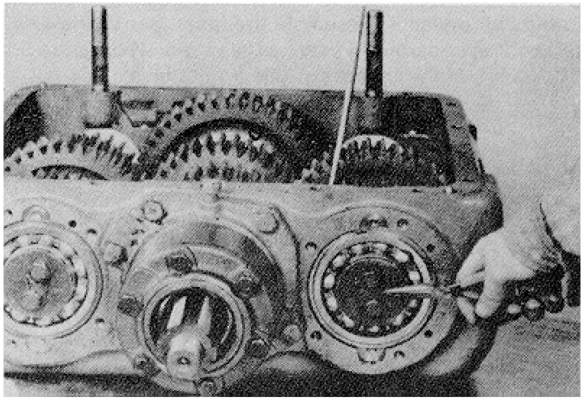


Figure 9B-90. Installing Retainers

12. Install the countershaft front bearing caps with gaskets to the case face, Figure 9B-91. Secure the caps with the capscrews and torque to 25-35 lbs. ft. (33.9-43.4 N.m).

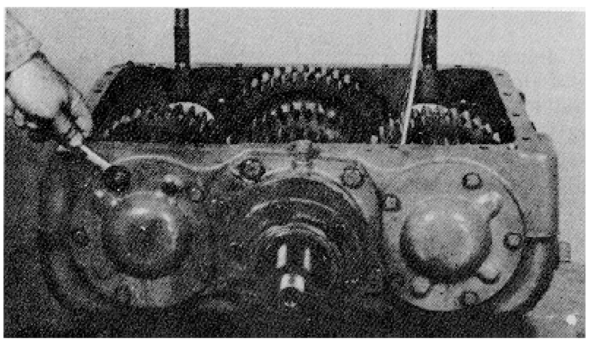


Figure 9B-91. Installing Bearing Caps

13. Install outer race and roller assembly of the countershaft rear bearing onto each shaft. Tap the bearing outer race with roller assembly onto the inner race and into the case bore of each countershaft, Figure 9B-92.

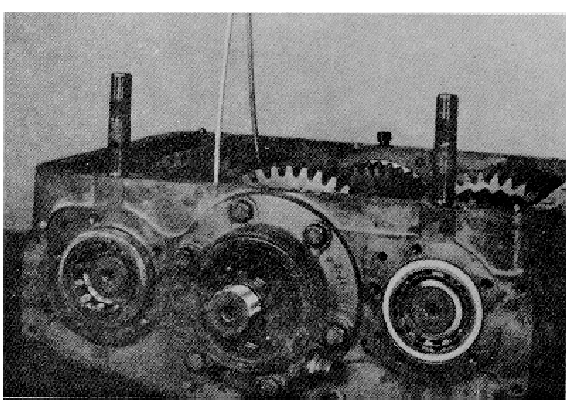


Figure 9B-92. Installing Countershaft Outer Race and Roller

14. Install the countershaft rear bearing caps and gaskets onto the case, Figure 9B-93. Secure with capscrews and torque to 2532 lbs. ft. (33.943.4 N.m).

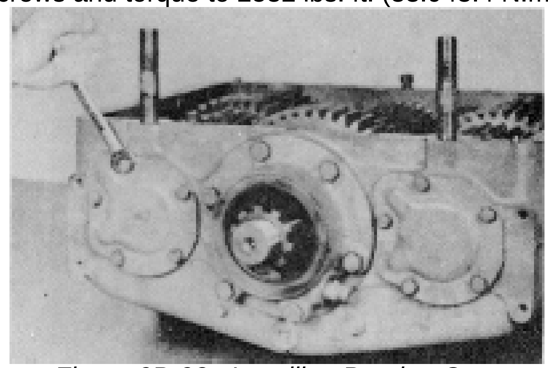


Figure 9B-93. Installing Bearing Caps

15. Shift the lst2nd and 3rd4th speed shift collars into gear, locking it into two gears. Install the companion flanges onto the drive gear stem and mainshaft splines. Install the washers on the shafts with the locknuts. Use a 29/16" socket wrench to torque the drive gear shaft and mainshaft locknuts to 550600 lbs. ft. (745.8813.6 N.m). Move the 1 st2nd shift collar to the neutral position. Turn the drive gear companion flange to roll the gear train. If the teeth timing marks are in their correct position, the entire gear train will roll freely. If the timing teeth have not been set correctly, or have escaped from their proper position, the gear train will lockup after several turns of the drive gear. If this happened, the shafts must be retimed. If the timing is correct, move the 3rd4th shift collar to the neutral position and proceed with the final installation of the shifter housing.

NOTE

We recommend using a torque wrench for verification of the specified 550600 lbs. ft. (745.8813.6 N.m) torque on the input and output shaft locknuts.

16. Place the shifter housing gasket on the case. With the shift rails and forks of the shifter housing in the neutral position, lower the shifter housing onto the case, Figure 9B-94. The shift forks must engage the slots on the shift collars when lowering the housing on the case.

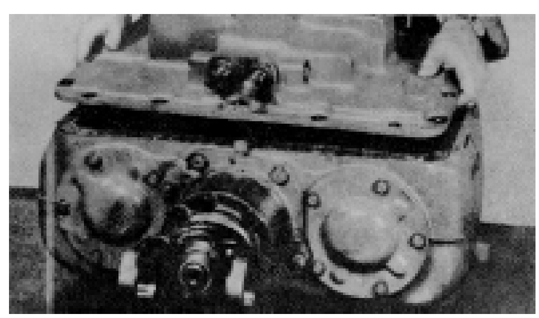


Figure 9B-94. Installing Shifter Housing

17. Secure the shifter housing to the case with the capscrews, Figure 9B-95. Torque the capscrews to 2532 lbs. ft. (33.943.4 N.m).

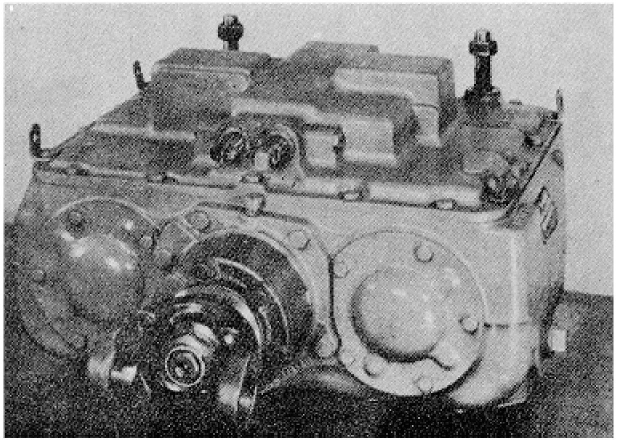


Figure 9B-95. Securing Shifter Housing

INSTALLATION

To install the auxiliary transmission, proceed as follows:

1. Refill transmission with proper lubricant. See Section III.

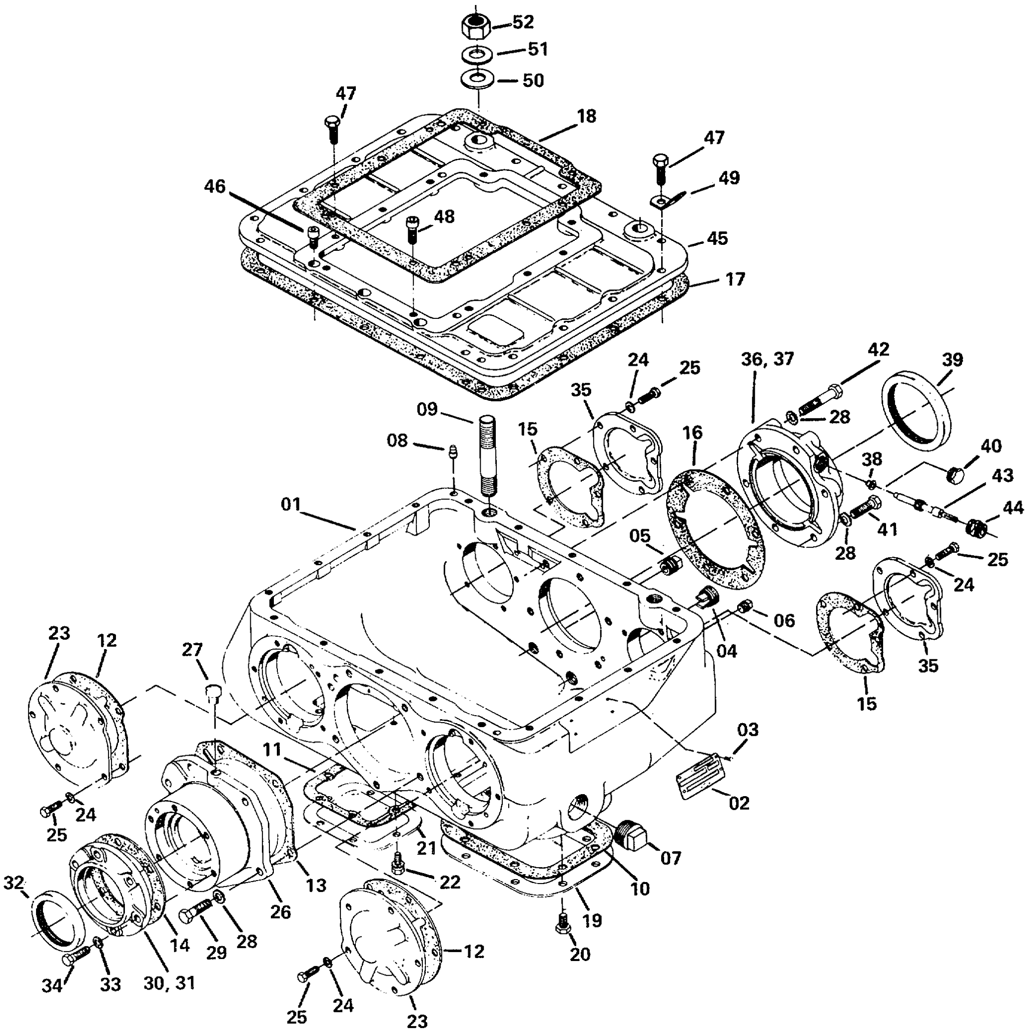
2. If the front and rear supports were removed, reinstall them at this time.

3. Raise the auxiliary transmission into position under the carrier.

4. Install the mounting bolts, lockwashers and nut which secure the transmission to the carrier. Fully tighten the bolts.

5. Install all lines, cables and wires.

6. Connect the front and rear propeller shafts to the auxiliary transmission.



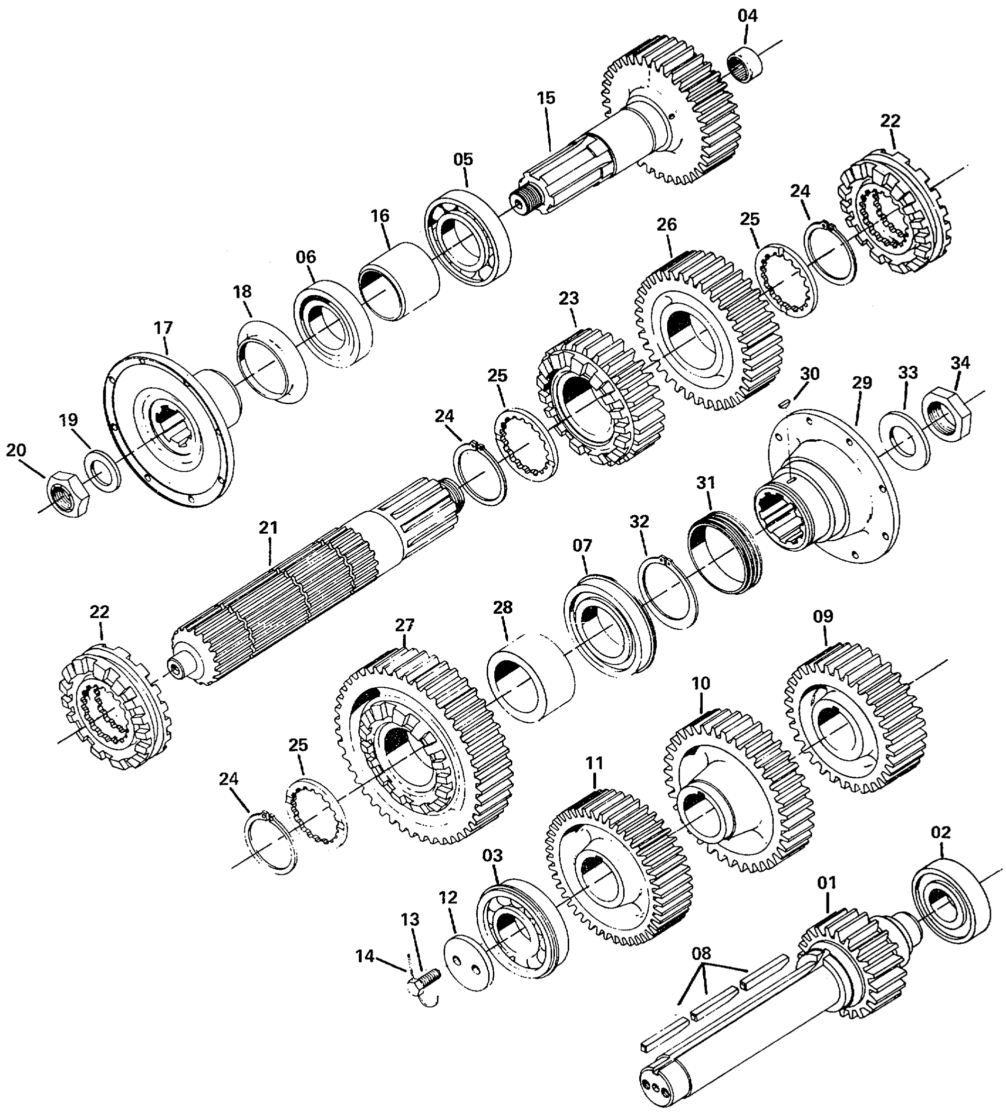
01. CASE
02. NAMEPLATE
03. PIN
04. DRAIN PLUG
05. PLUG
06. PLUG
07 MAGNETIC PLUG
08. DOWEL PIN
09. STUD
10. GASKET
11. GASKET
12. GASKET
13. GASKET
14. GASKET

15. GASKET
16. GASKET
17. GASKET
18. GASKET
19. P.T.O. COVER
20. CAPSCREW
21. P.T.O. COVER
22. SCREW
23. CAP
24. LOCKWASHER
25. CAPSCREW
26. BEARING RETAINER
27. BREATHER
52. NUT

28. LOCKWASHER
29. CAPSCREW
30. CAP ASSEMBLY
31. CAP
32. OIL SEAL
33. LOCKWASER
34. CAPSCREW
35. CAP
36. CAP AND SEAL
37. CAP AND BUSHING
38. BUSHING
39. OIL SEAL
40. PLUG
41. CAPSCREW
42. CAPSCREW
43. GEAR
44. SLEEVE
45. ADAPTER PLATE
46. SCREW
47. SCREW
48. SCREW
49. LIFT HOOK
50. WASHER
51. WASHER
52. NUT

Figure 9B-96. Transmission Case, Bearing Caps and Related Parts

01. COUNTERSHAFT
02. COUNTERSHAFT REAR BEARING
03. COUNTERSHAFT FRONT BEARING
04. POCKET BEARING
05. REAR DRIVE GEAR BEARING
06. FRONT DRIVE GEAR BEARING
07. MAIN SHAFT REAR BEARING
08. KEY
09. 2ND SPEED GEAR
10. OVERDRIVE GEAR
11. 3RD SPEED GEAR
12. WASHER
13. SCREW
14. LOCKWIRE
15. DRIVE GEAR
16. SPACER
17. FLANGE



18. DIRT FINGER
19. WASHER
20. NUT
21. MAIN SHAFT
22. CLUTCH COLLAR
23. OVERDRIVE GEAR
24. SNAP RING
25. THRUST WASHER
26. 2ND SPEED GEAR
27. 1ST SPEED GEAR
28. SPACER
29. COMPANION FLANGE
30. KEY
31. SPEEDOMETER GEAR
32. SNAP RING
33. WASHER
34. NUT

Figure 9B-97. Transmission Gears and Related Parts

01. HOUSING
02. PLUG
03. BREATHER
04. SHIFT ROD
05. SHIFT FORK
06. SCREW
07. PISTON ROD BUSHING
08. EXTERNAL PISTON
09. SNAP RING
10. INTERNAL PISTON
11. SNAP RING
12. NUT
13. PISTON END CAP
14. PISTON END CAP WASHER
15. INTERLOCK
16. SHIFT ROD
17. STOP PIN
18. PLUG
19. PLUG
20. OUTER PISTON O-RING
21. PISTON ROD O-RING
22. PISTON ROD O-RING
23. O-RING
24. PISTON O-RING
25. PISTON END CAP O-RING
26. PLUG
27. SCREW
28. GASKET
29. SCREW
30. CONNECTOR
31. ELBOW

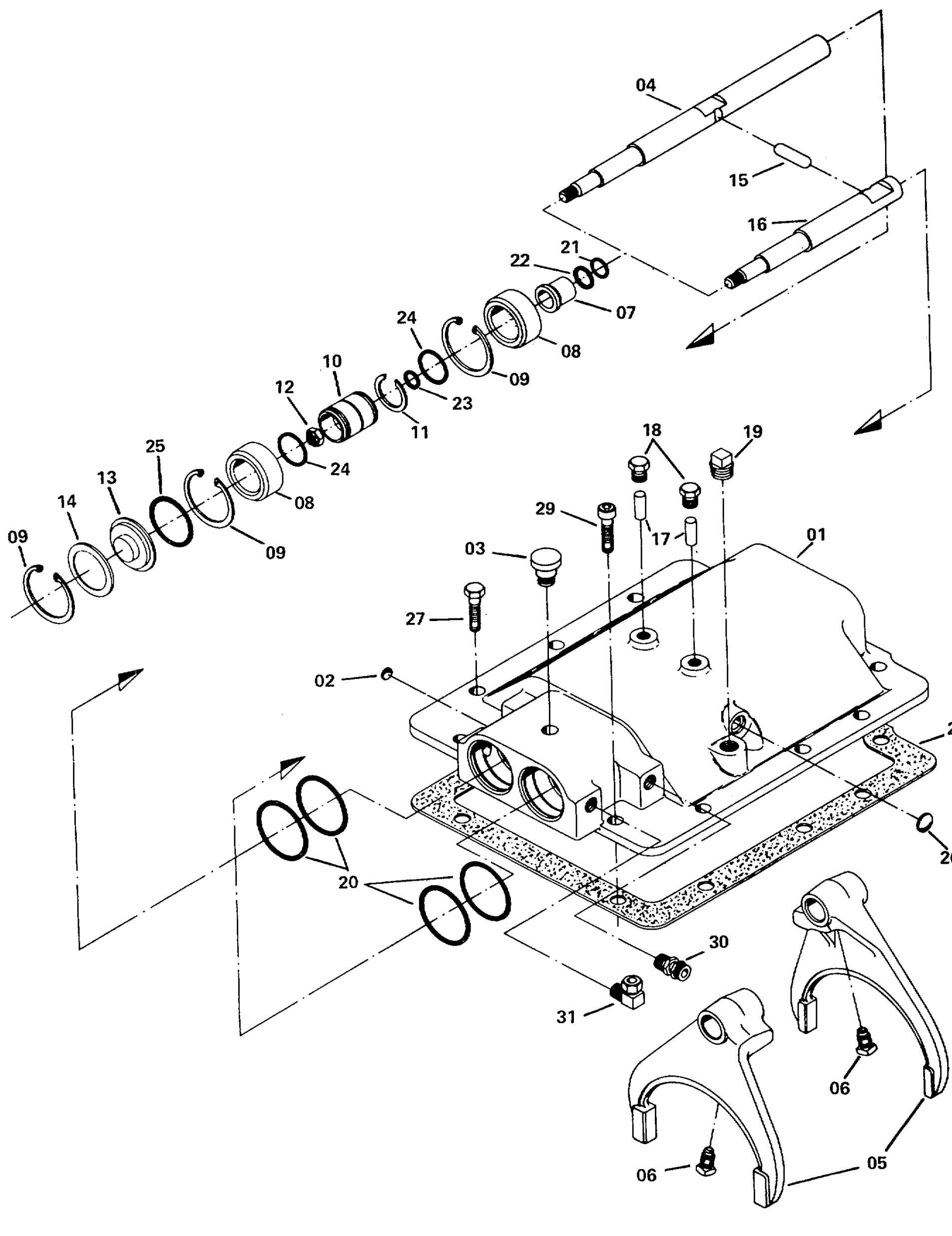


Figure 9B-98. Shifter Housing

Table 9B-1. Auxiliary Transmission Troubleshooting Chart

SYMPTOM	PROBABLE CAUSE
Noisy Operation - Noise is usually very elusive and generally not the fault of the auxiliary. If the noise appears to be in the auxiliary try to break it down into the following classifications. If possible determine. what position the gear shift lever is in when the noise occurs. If the noise is evident in only one gear position, the cause of the noise is generally traceable to the gears in operation	Fan out of balance Defective vibration dampers Crankshaft out of balance Flywheel out of balance Flywheel mounting bolts loose Engine rough at idle producing rattle in gear train Engine mounts loose or broken P.T.O. gear nut fully engaged or housing not properly shimmed Universal joints worn out Propeller shafts out of balance Center bearing in drive line dry Wheels out of balance Tire treads humming or vibrating at certain speeds Air leaks on suction side of induction system, especially with troubochargers Improper, or lack of lubricant
Growl and humming or a grinding noise	Worn, chipped, rough or cracked gears
Hissing, thumping or bumping-type noise	Bad bearing Bearing retainers breaking up
Metallic rattles	Engine torsional vibrations A defective or faulty injector would cause a rough or lower idle speed and a rattle in the unit Excessive backlash in P.T.O. unit mounting
Squealing	Free running gear seizing on the thrust face temporarily and then letting go.
Gear whine	Lack of backlash between mating gears
Noise in neutral	Misalignment Worn or scored countershaft bearings Worn drive gear bearings Spring, or worn countershafts Excessive backlash in gears Worn mainshaft pocket bearing Scuffed gear tooth contact surface Insufficient lubrication Use of incorrect grade of lubricant
Noise in gear Rough, chipped, or tapered sliding gear teeth Noisy speedometer gears Excessive end play of mainshaft gears Refer to conditions listed under Noise in Neutral	Worn, or rough mainshaft rear bearing

Table 9B-1. Auxiliary Transmission Troubleshooting Chart (Continued)

SYMPTOM	PROBABLE CAUSE
Oil leaks	Oil level too high Wrong lubricant in unit Non-shielded bearing used at front or rear bearing cap (where applicable) Seals defective or omitted from bearing cap wrong type seal used, etc. Transmission breather omitted, plugged internally, etc. Capscrews loose, omitted or missing from shifter housing, bearing caps, etc. Oil drain back openings in bearing caps or case plugged with varnish, dirt, covered with gasket material, etc. Broken gaskets, gaskets shifted or squeezed out of position, pieces still under bearing caps, etc. Cracks or holes in castings Drain plug loose Leakage from engine
Walking out of gear	Interference or resistance in the shift mechanism preventing full engagement of the sliding clutch gear. On new or rebuilt units the wrong parts or old defective parts may have been used Deterioration or rounding of clutch teeth Walkout on coast side could be caused by lack of hopping guard feature for this particular gear position
Jumping out of gear	Shift rod poppet springs broken Shift rod poppet notches worn Shift fork pads not square with shift rod bore Excessive end play in drive gear, mainshaft or countershaft caused by worn bearings, retainers, etc. Thrust washers or faces worn excessively, missing, etc.
Hard shifting	Lack of or worn lubricant causing buildup of sticky varnish and sludge deposits on splines of shaft and gears Driver not familiar with proper shifting procedure for this transmission Drive gear pocket bearing seized, rough, or dragging Gear seizure on thrust face Thrust washer malfunction Air leak Air shift cylinder malfunctioning Air shift control malfunctioning

Table 9B-1. Auxiliary Transmission Troubleshooting Chart (Continued)

SYMPTOM	PROBABLE CAUSE
Sticking in gear	Chips wedged between or under splines of shaft and gear Air leaks Air shift cylinders and/or control malfunctioning
Bearing malfunction	Worn out due to dirt Fatigue of raceways or balls Wrong type or grade of lubricant Lack of lubricant Vibrations - breakup of retainer and brinnelling of races - fretting corrosion Bearings tied up due to chips in bearings Bearings set up too tight or too loose Improper assembly - brinnelling bearing Improper fit of shafts or bore Acid etch of bearing due to water in lube Overloading of vehicle. Overload from engine

SUBSECTION 9C
REAR AXLES

GENERAL

The information in this subsection describes the removal, repair and installation of the rear axles.

REAR AXLE (10Z468)

REMOVAL

If it is necessary to remove a rear axle, proceed as follows:

1. Lift the machine off the ground using the outriggers, and place jacks or blocks under the frame. Lower the machine onto jacks or blocks under the frame, so that the machine is not supported by the outriggers.

2. Remove the wheels.

3. Remove the propeller shaft(s). See Subsection 9D.

4. Disconnect the air lines attached to the brake chambers, and move them out of the way so that they do not interfere with the removal of the axle.

5. Place suitable jacks under the axles to prevent them from moving while the axle mounting hardware is being removed.

6. Disconnect the attaching hardware and lower the axle out from beneath the carrier.

OVERHAUL OF REAR DRIVE AXLES

The following instructions will cover the disassembly and assembly of the front rear or rear rear drive axle in a sequence that would normally be followed after the axle has been removed from the vehicle. The front rear axle has an output shaft out of the axle housing to drive the rear rear axle, this is the main difference between the two.

Cleanliness is of extreme importance and an absolute must in the repair and overhaul of this axle. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.

DISASSEMBLY. To disassemble the rear axle, proceed as follows:

1. Remove thrust cap from planetary carrier, Figure 9C-1.

2. Remove planetary carrier assembly, Figure 9C-2.

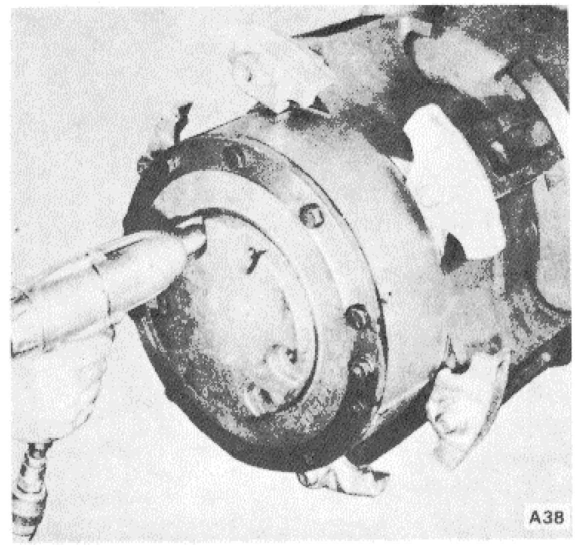


Figure 9C-1. Removing Thrust Cap

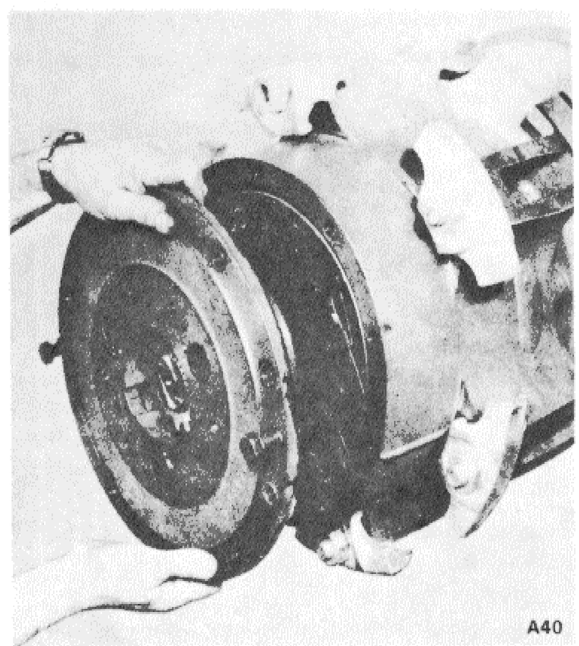


Figure 9C-2. Removing Planetary Carrier

3. Remove snap ring and sun gear from axle shaft. Pull axle shaft from housing tube, Figure 9C-3.

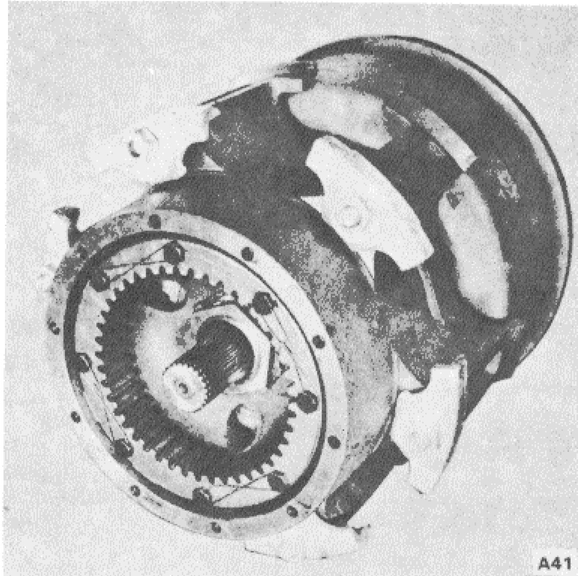


Figure 9C-3. Removing Hub Assembly

4. Unclinch axle tube nut lock, Figure 9C-4. Remove lock-nut, nut lock and adjusting nut.

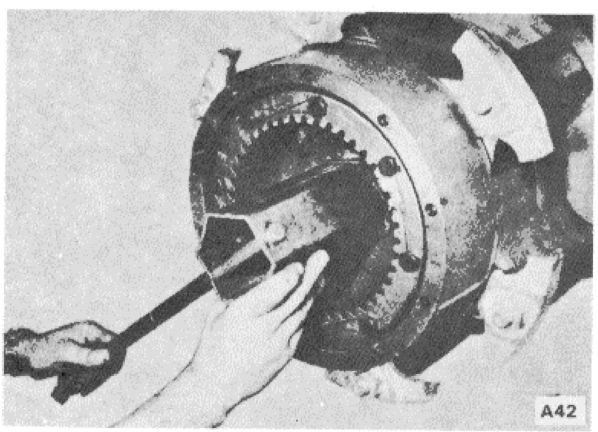


Figure 9C-4. Removing Nut Lock

5. Remove internal gear and hub assembly, Figure 9C-5

6. Remove wheel hub and drum assembly, Figure 9C-6. Inner and outer hub bearing cup and inner bearing cone will come out with hub and drum.

7. Remove brake shoe return springs, Figure 9C-7.

8. If brakes are being relined disassembly of axle need not go any farther. Remove release spring. Brake shoes may now be separated. Relining can be done now, but it is recommended shoes be removed. Remove anchor pin set-screw and anchor pin. Remove brake shoes.

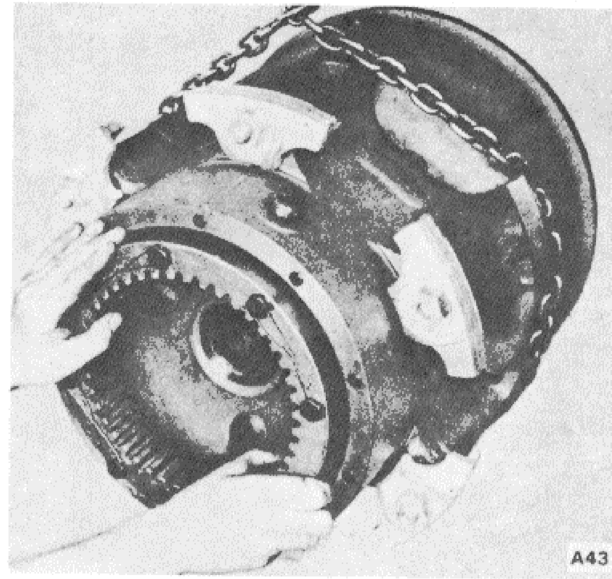


Figure 9C-5. Removing Hub Assembly

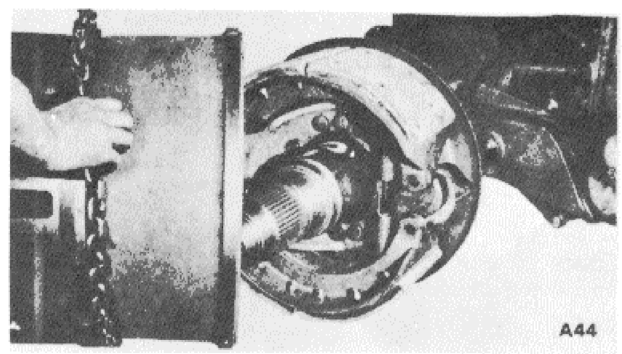


Figure 9C-6. Removing Drum Assembly

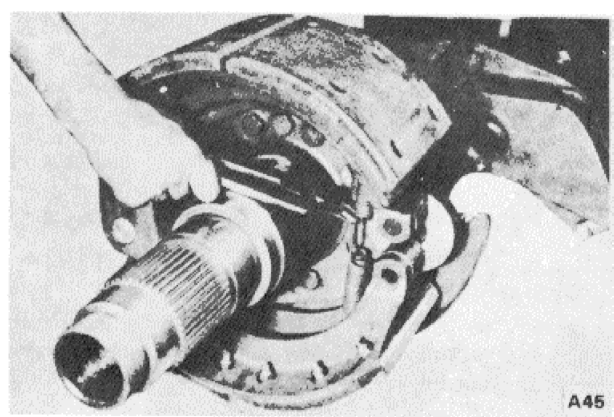


Figure 9C-7. Removing Brake Spring

NOTE

When installing new brake lining tighten lining bolt nuts to 200-220 inch lbs. (22.6-24.9 N.m) torque, dry threads.

9. Remove rear camshaft to slack adjuster retainer ring and washer, Figure 9C-8

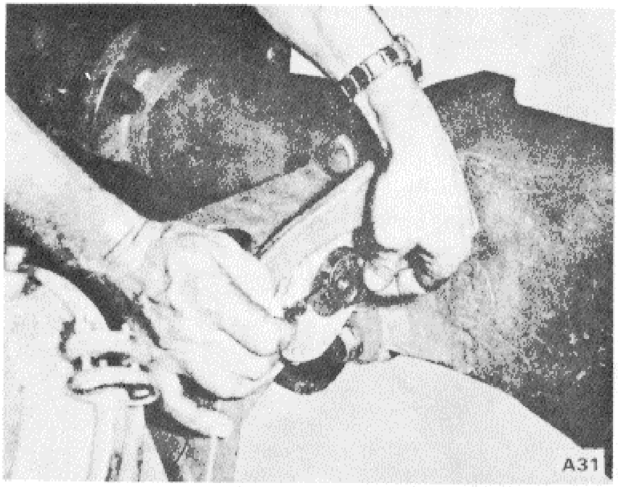


Figure 9C-8. Removing Retaining Ring.

10. Remove front camshaft retainer ring and washer, Figure 9C-9. Remove camshaft from axle housing and brake assembly.

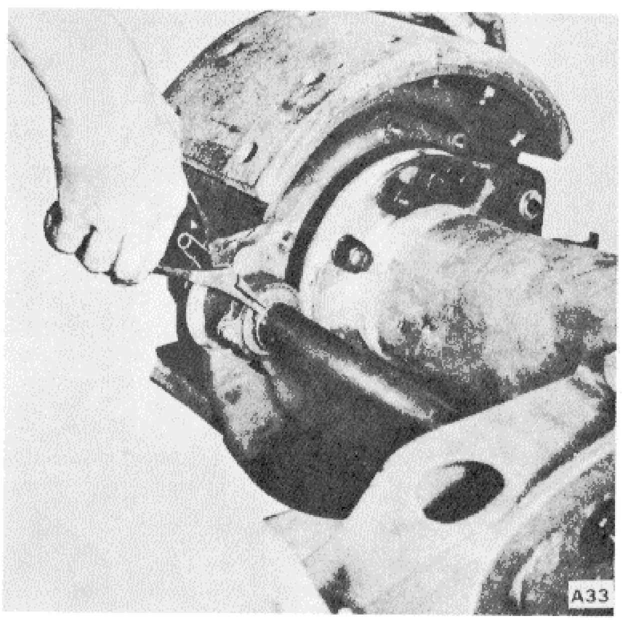


Figure 9C-9. Removing Camshaft

11. Remove brake dust cover and brake anchor pin lock, Figure 9C-10.

12. Remove rear output shaft and yoke assembly, Figure 9C-11. (Front rear drive axle only.)

13. Disassemble rear output shaft as shown in Figure 9C-12. (Front rear drive axle only.)

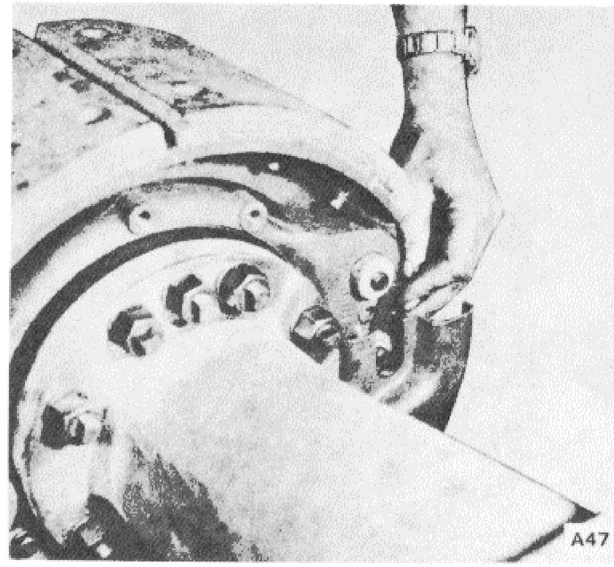


Figure 9C-10. Removing Dust Cover.

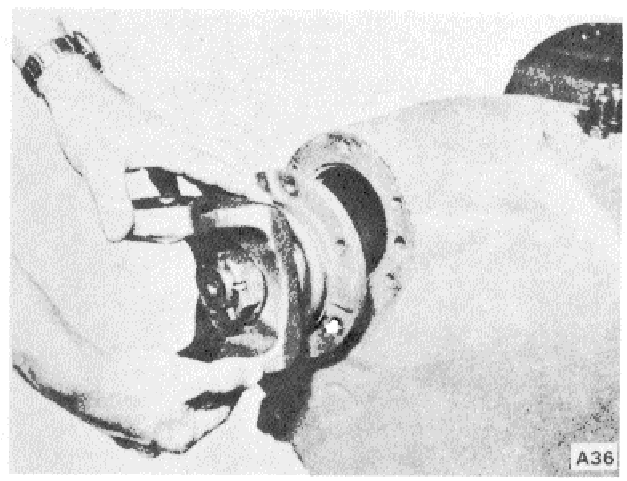


Figure 9C-11. Removing Rear Output Shaft

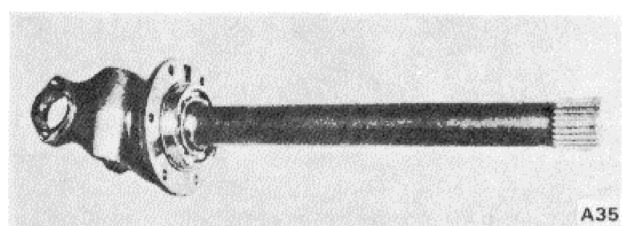


Figure 9C-12. Rear Output Shaft

14. Disassemble planetary carrier parts, Figure 9C-14.

INSPECTION AND REPAIR. Cleanliness of the respective parts is absolutely necessary in reassembling. Dirt in its many forms can and will cause trouble. Therefore, before reassembling the axle or

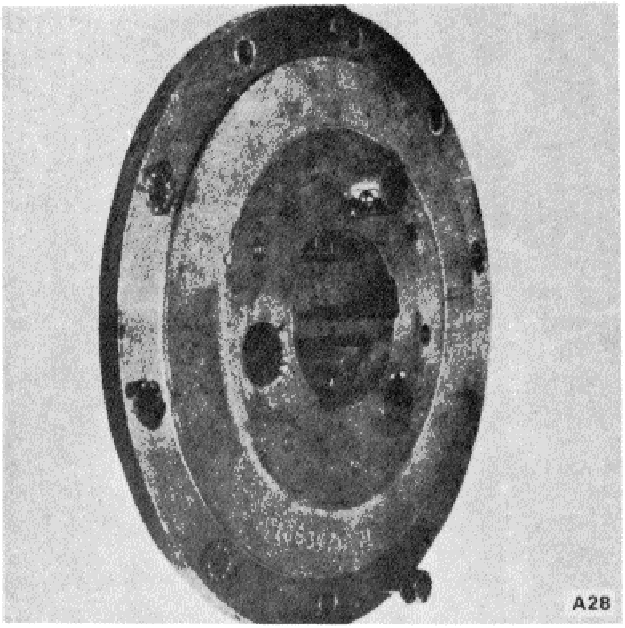


Figure 9C-13. Planetary Carrier

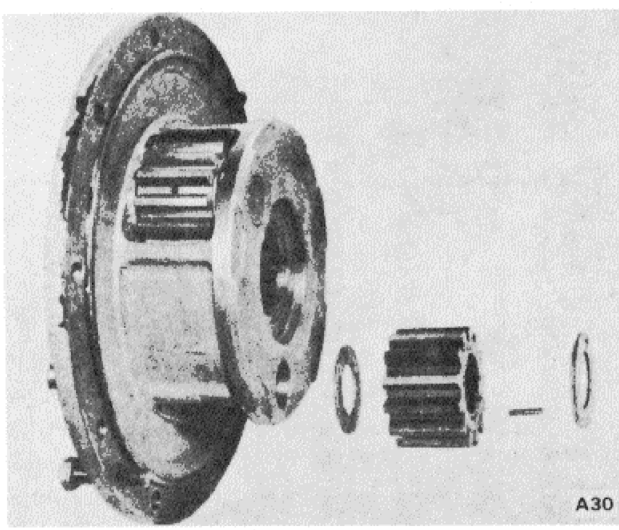


Figure 9C-14. Planetary Carrier

differential or any of its parts be sure all parts have been thoroughly cleaned with a suitable cleaning fluid. After cleaning, all parts should be dried with moisture free compressed air.

A thorough visual examination of all parts should be made before reassembly. Any parts that show excessive wear or damage should be replaced. Small nicks or burrs maybe removed with a hone or crocus cloth. It is recommended that all gaskets, oil seals, O-rings and internal lockwashers be replaced.

ASSEMBLY. To assemble the rear axle, proceed as follows:

1. If differential was removed, coat axle housing with Permatex No. 2 and install differential in axle housing; secure with taper dowels, nuts, bolts and lockwashers. Tighten to 115-1 27ft-lbs(155.9-172.2 N.m)torque. If axle spindle end and/or brake spider have been removed, reassemble to axle housing tightening bolt nuts to 501-550 ft-lbs (679.4-745-8 N.m) torque.

2. Install shoe and lining assembly and secure with brake anchor pins, Figure 9C-15.

NOTE

When installing anchor pins make sure slots are lined up with lockscrew holes, to allow lock to be installed. Install anchor pin lock and screw.

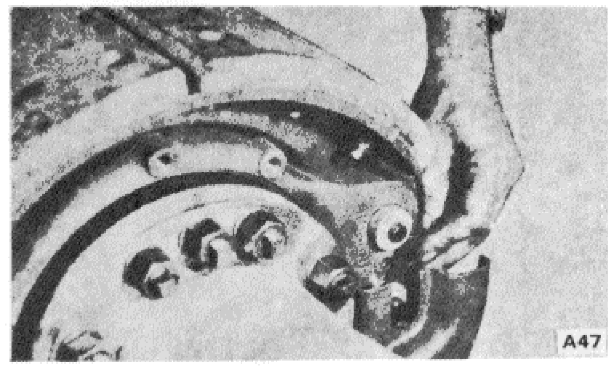


Figure 9C-15. Installing Shoe and Lining

3. Install brake shoe return springs, Figure 9C-16.

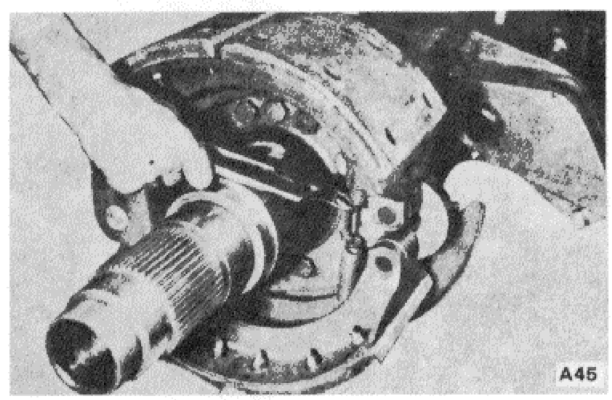


Figure 9C-16. Installing Brake Shoe Spring

4. Block brake shoes as shown in Figure 9C-17. This will allow an easier installation of the camshaft. Use caution as not to over stretch return spring.

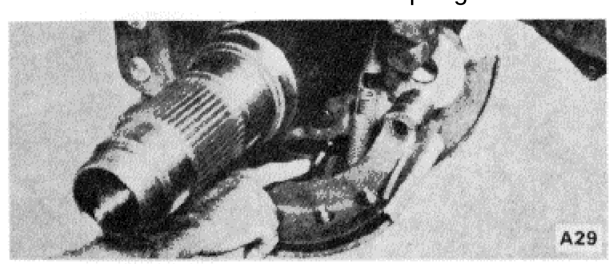


Figure 9C-17. Blocking Brake Shoes

5. Install O-ring and camshaft thrust washer into position between brake spider and roller ends of brake shoe. Camshaft may now be installed through brake spider camshaft support boss, Figure 9C-1 8. Slide grease retainer, retainer washer and retainer ring on camshaft. Push camshaft through air chamber and slack adjuster.

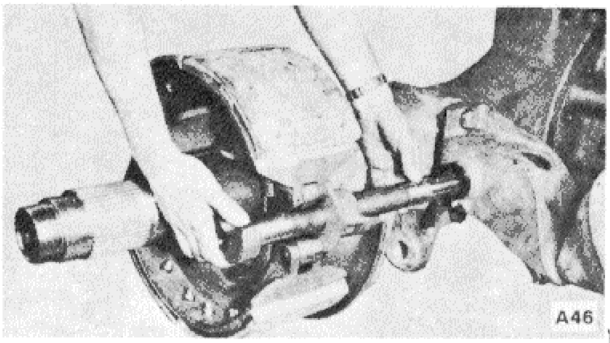


Figure 9C-18. Installing Camshaft

6. Install rear slack adjuster washer and retainer ring, Figure 9C-19.

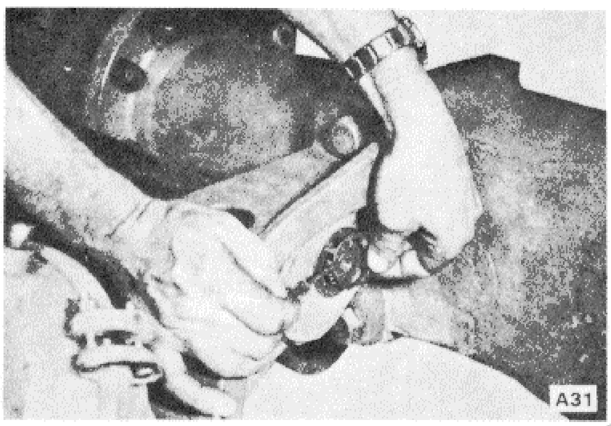


Figure 9C-19. Installing Washer and Retaining Ring

7. Install front camshaft retainer ring, Figure 9C-20.

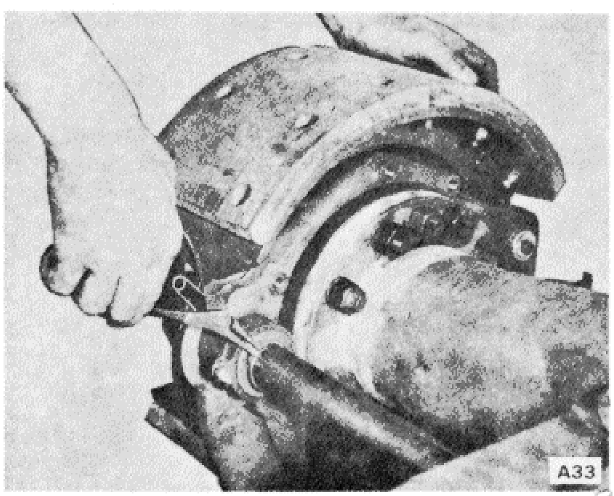


Figure 9C-20. Installing Camshaft Retaining Ring

8. Install brake dust cover, Figure 9C-21.

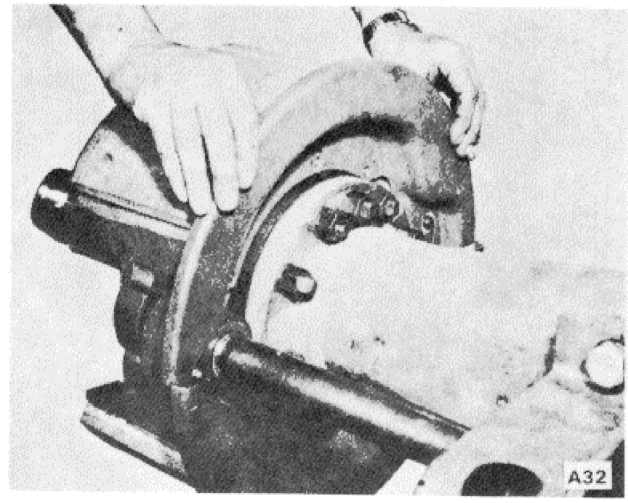


Figure 9C-21. Installing Brake Dust Cover

9. If wheel hub and brake drum have been disassembled, reassemble same and tighten bolts to 282-310 ft-lbs (382.4-420.4 N.m) torque. Lockwire in pairs to prevent loosening, Figure 9C-22.

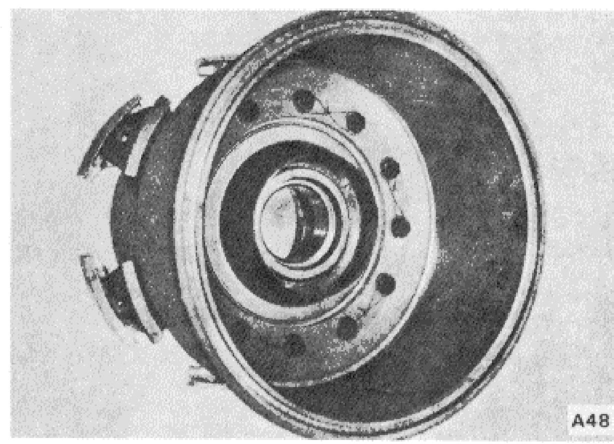


Figure 9C-22. Brake Drum

10. Install wheel hub and brake drum assembly on axle housing, Figure 9.C-23. See Operator's Manual, Section V, Preventive Maintenance, and adjust brakes.

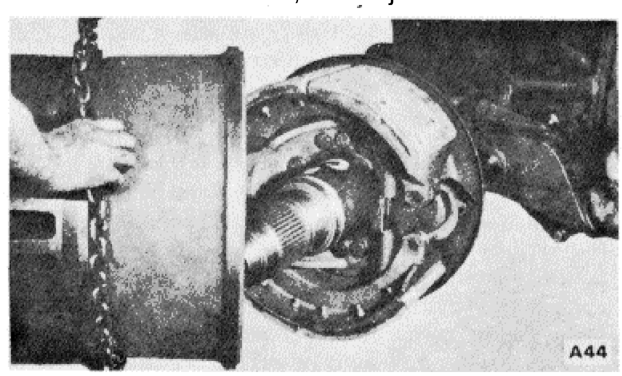


Figure 9C-23. Installing Drum

11. Internal gear and hub assembly showing sequence of parts. Tighten bolts to 128-141 ft-lbs (173.6-191.2 N.m) torque. Lockwire bolts in pairs to prevent loosening, Figure 9C-24.

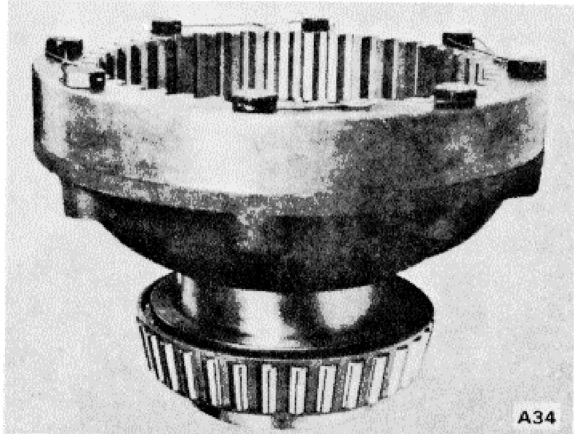


Figure 9C-24. Internal Gear

12. Install internal gear, hub and bearing assembly on splines of spindle end, Figure 9C-25.

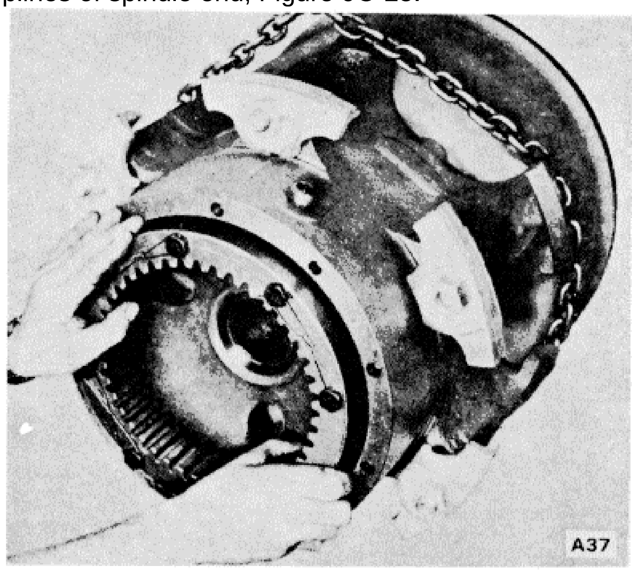


Figure 9C-25. Installing Internal Gear

13. Install axle nut and adjust wheel bearing as follows: Before wheel bearing adjustment is made, it is imperative all tapered bearings and bearing cups be pressed to full position in their respective locations. Do not depend on the wheel bearing adjusting nut to "shoulder" tapered bearings and cups.

A. The wheel bearing adjusting nut should be tightened to its limit while rolling the wheel. Strike the rim and surrounding parts with a mallet to shock the wheel end and better seat the parts (cups and cones) that may not already be seated. Reverse the adjusting nut and again strike the rim with a mallet. Loosen adjusting nut until a slight bearing end play is detected.

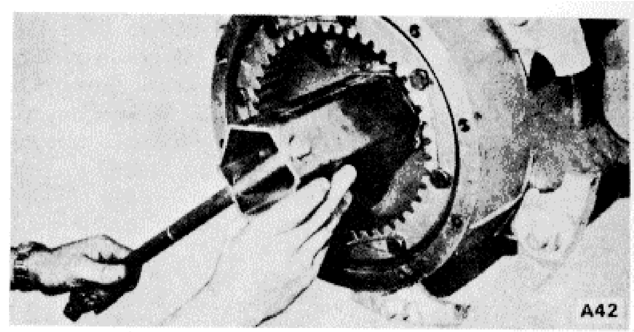


Figure 9C-26. Installing Nut Lock

B. Using the torque wrench adaptor bar shown in Figure 9C-27 determine the rolling torque of the wheel end

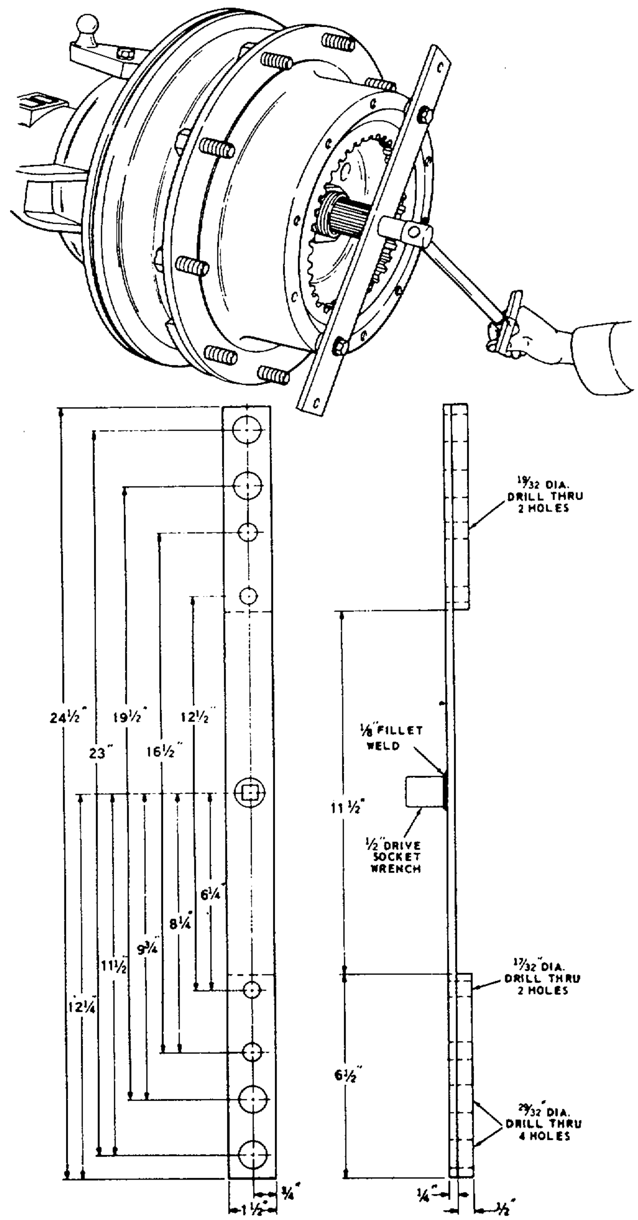


FIGURE "A"

Figure 9C-27. Torque Adapter

with the bearings in a no-load end play condition. Due to unbalance of parts, etc. there will be a variation of rolling torque as the wheel hub is rotated. Record the maximum value of rolling torque throughout a revolution. This figure is the "No-load rolling torque" value.

C. Using Table 9C-1, tighten the adjusting nut to achieve a bearing pre-load in foot pounds (N.m) above the "No-load rolling torque" value recorded. It is best to use the lowest pre-load value as the pre-load may increase when the jam nut is installed and tightened. Also record wrench torque when tightening adjusting nut.

Example: 10 ft-lbs (13.6 N.m) "No-load rolling torque"
7 ft-lbs (9.5 N.m) "A" Series Axle (New Bearings)
17 ft-lbs (23.1 N.m) Pre-loaded rolling torque

Table 9C-1. Bearing Torque

	TORQUE VALUE
New Tapered Bearings	7 to 1 2 ft-lbs (9.5-16.3 N.m) torque greater than "No-load rolling torque"value.
Used Tapered Bearings	3 to 5 ft-lbs (4.1-6.8 N.m) torque plus no-load value.

14. When proper pre-load is achieved install adjusting nut lock and jam nut. Tighten jam nut to a higher wrench torque than the adjusting nut. Recheck rolling torque. Pre-load must not be greater than highest value in Table 9C-1, "No-load rolling torque" value. Bend two tangs of nut lock on flats of inner nut and two tangs on flat of jam nut, Figure 9C-28.

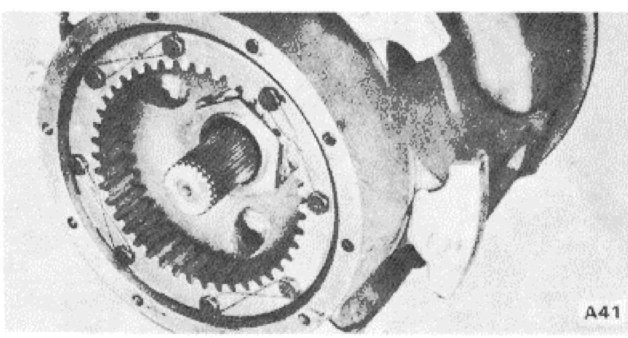


Figure 9C-28. Installing Nut

15. Use Permatex No. 2 on planetary assembly. Assemble planetary assembly to wheel hub, Figure 9C-29. Install axle shaft sun gear and retaining ring.

16. Tighten planetary carrier to hub bolts to 115-127 ft-lbs (155.9-172.2 N.m) torque, Figure 9C-30.

17. Use Permatex No. 2 on thrust cap and install cap to planetary assembly, Figure 9C-31. Tighten bolts to 37-41 ft- lbs (50.2-55.6 N.m) torque.

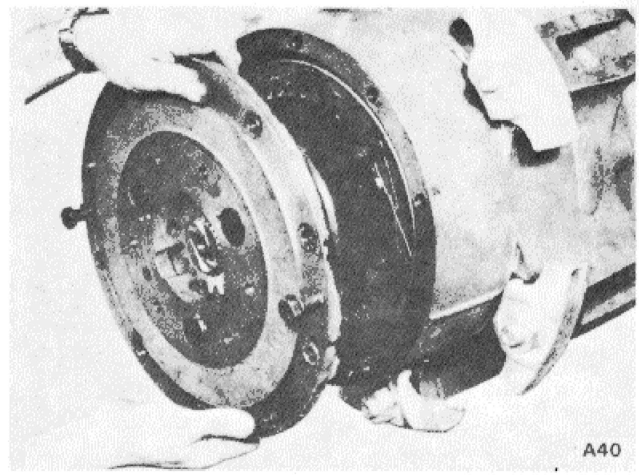


Figure 9C-29. Installing Planetary Assembly

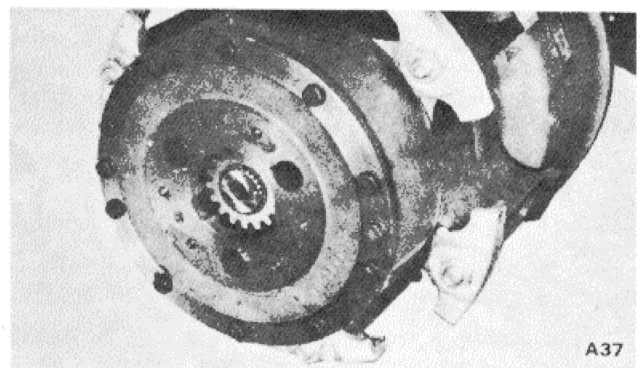


Figure 9C-30. Installing Bolts

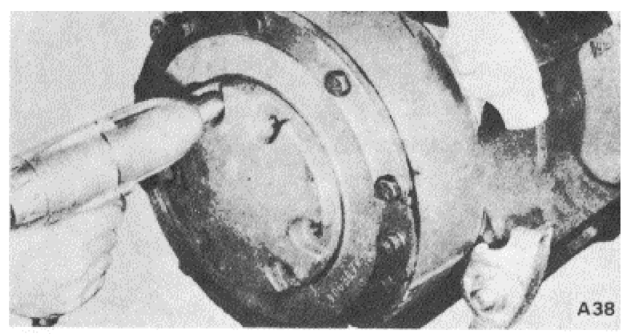


Figure 9C-31. Installing Thrust Cap

18. Install output shaft assembly (front rear drive axle only) in axle housing, aligning splines of output shaft with internal splines of different input shaft, Figure 9C-32. Tighten capscrews to 23-25 ft-lbs (31.2-33.9 N.m) torque.

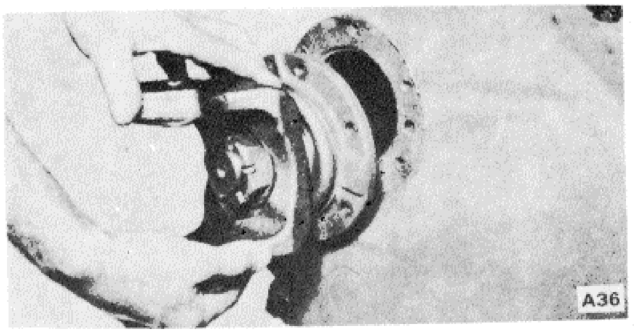


Figure 9C-32. Installing Output Shaft

OVERHAUL OF DIFFERENTIAL

The following instructions will cover the disassembly and assembly of the differential and carrier in a sequence that would normally be followed after the differential has been removed from the axle housing.

Cleanliness is of extreme importance and an absolute must in the repair and overhaul of this differential. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.

DISASSEMBLY. To disassemble the differential, proceed as follows:

1. Remove input flange bolt, washer and input flange, Figure 9C-33.

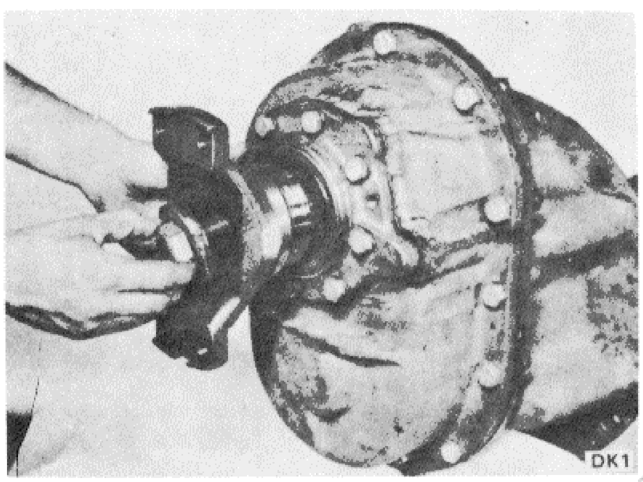


Figure 9C-33. Removing Input Flange

2. Remove oil seal retainer bolts, Figure 9C-34. Install two bolts in threaded holes and use as jack screws to remove retainer.

3. Remove drop gear cover bolts. Remove drop gear cover, Figure 9C-35.

4. Remove input shaft and taper bearings as an assembly, Figure 9C-36. Remove nut cotter, nut and pinion gear.

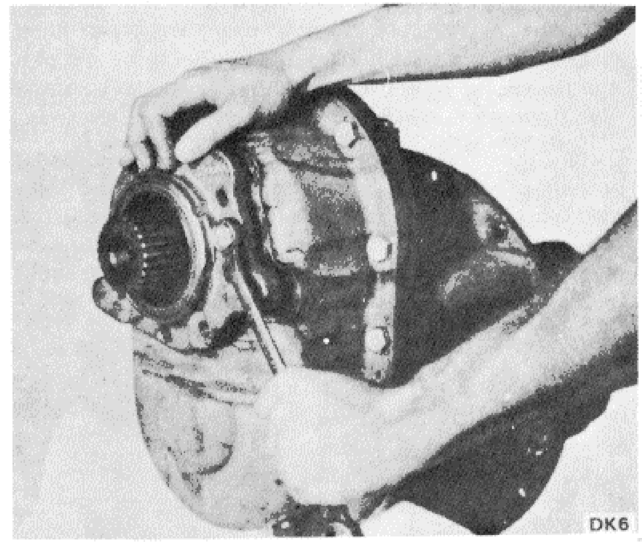


Figure 9C-34. Removing Retainer

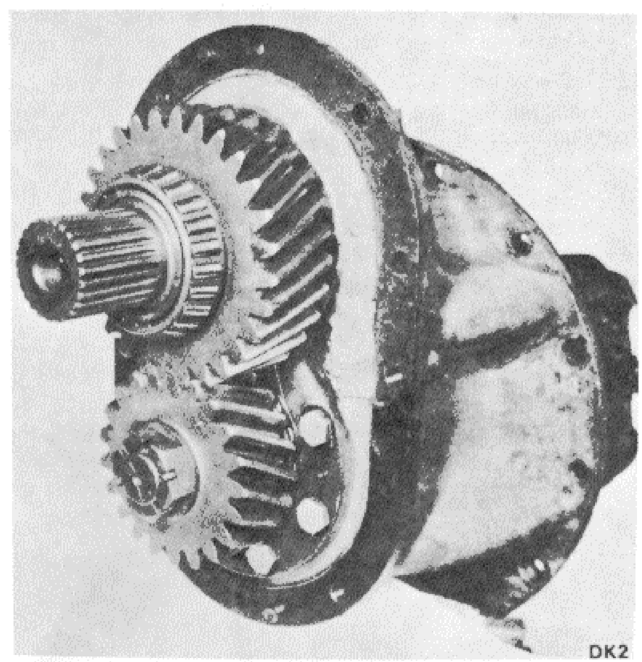


Figure 9C-35. Removing Drive Gear Cover

5. Remove pinion shaft and bearing cage assembly from housing, Figure 9C-37.

NOTE

Jack screw holes are provided in bearing cage to facilitate disassembly. Use caution not to damage shims located between bearing cage and differential housing.

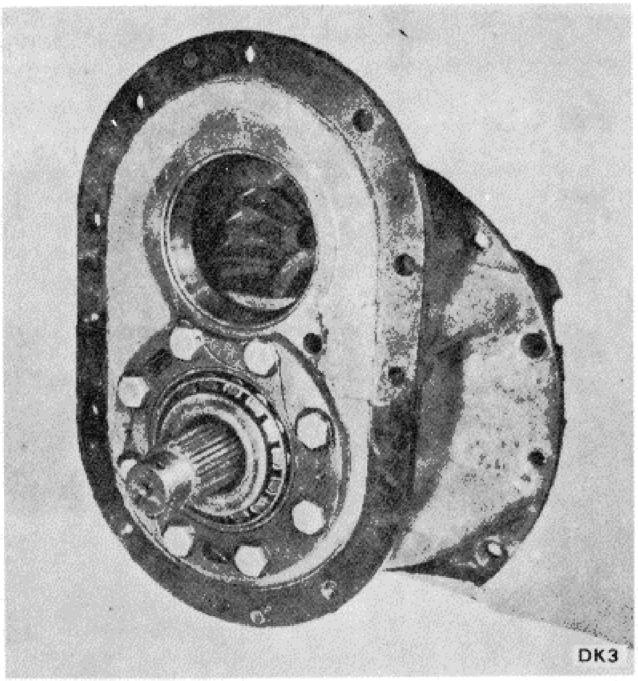


Figure 9C-36. Removing Input Shaft

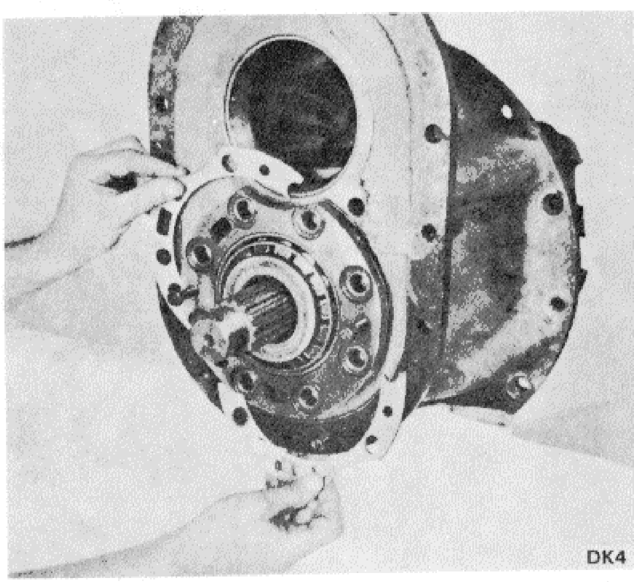


Figure 9C-37. Removing Pinion Shaft

6. Straighten tangs on thrust screw nut lock. Remove lock-nut and thrust screw, Figure 9C-38.

7. Remove differential bearing adjusting nut lock screw and lock, Figure 9C-39.

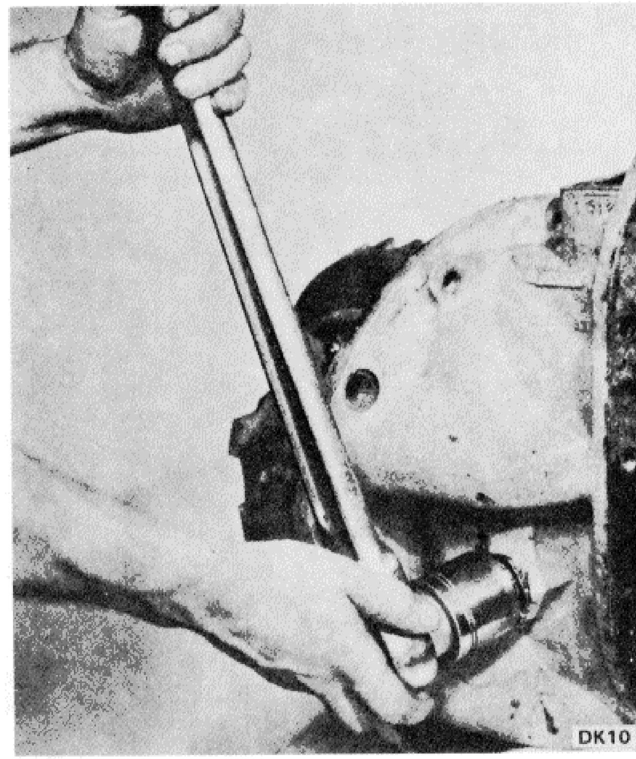


Figure 9C-38. Removing Thrust Screw

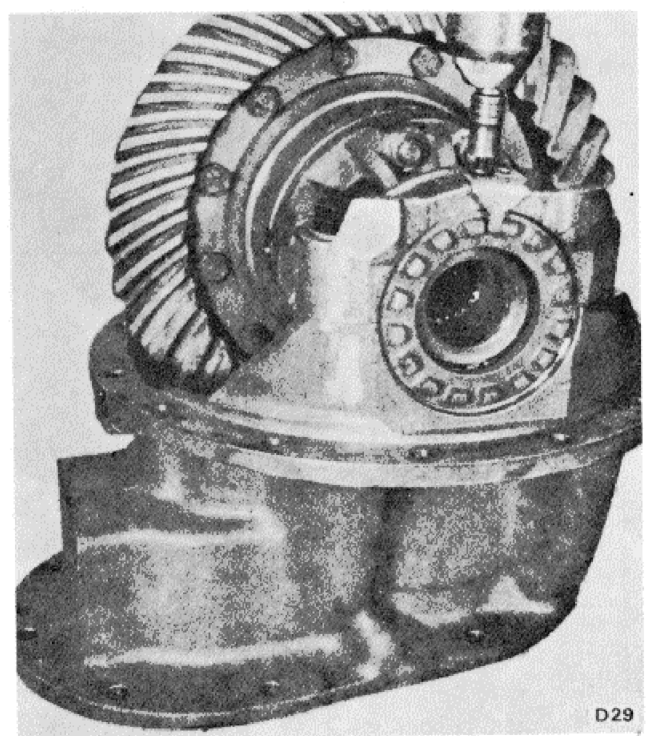


Figure 9C-39. Removing Bearing Lock

8. Remove differential carrier caps, Figure 9C-40.

NOTE

Each cap must be marked, as they must be reassembled on the same side as they were removed.

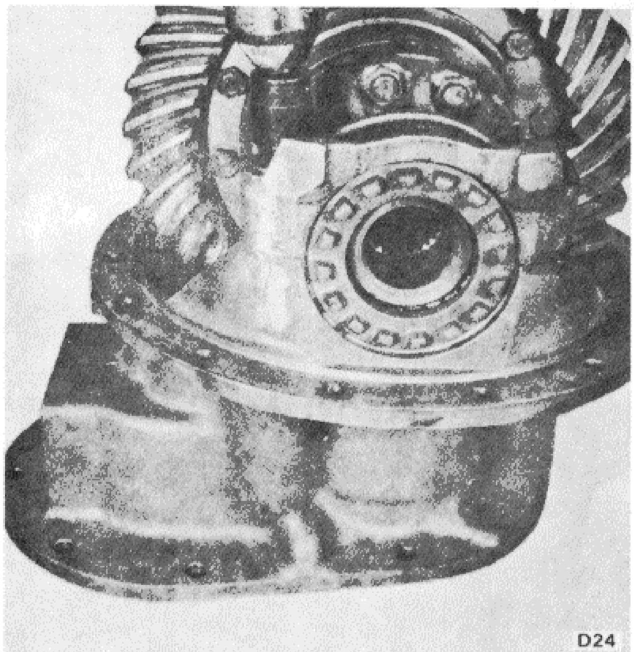


Figure 9C-40. Removing Bearing Cap

9. Remove ring gear and differential case assembly from carrier housing. Differential bearing may be removed, should either the bearing or differential case need replacing, Figure 9C-41.

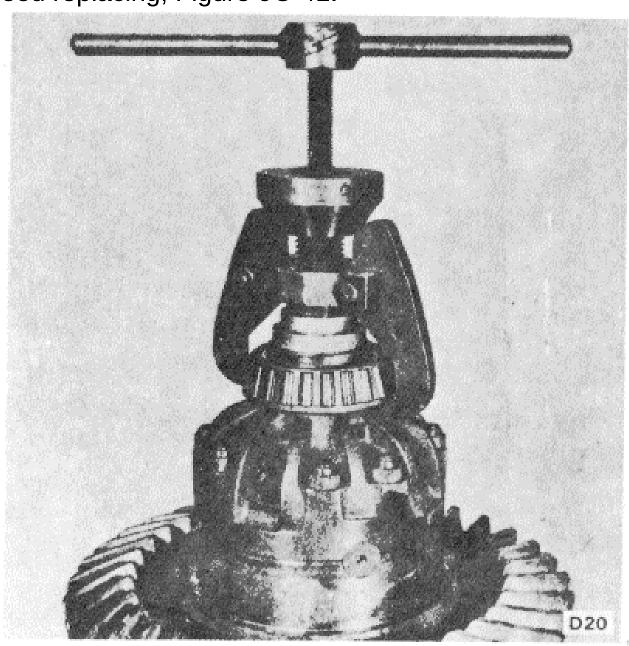


Figure 9C-41. Removing Differential Bearing

10. Differential plain case half and flange case half must be marked so they can be reassembled at the same place they were removed. Remove differential case bolts and nuts, Figure 9C-42.

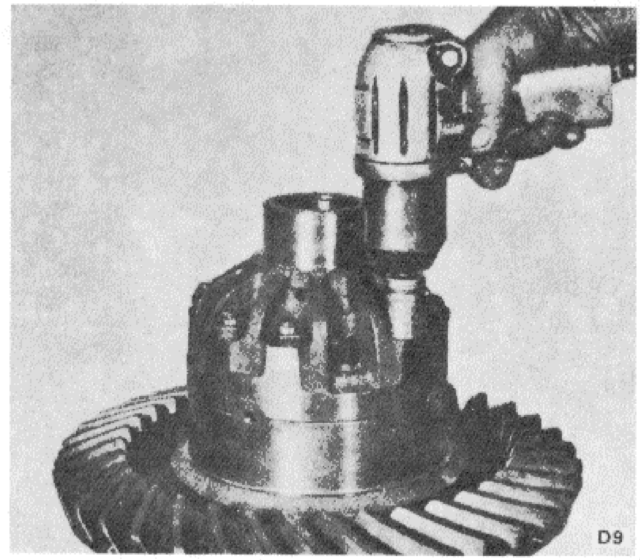


Figure 9C-42. Removing Differential Bolts

11. Lift plain half case from flange half case, Figure 9C-43.

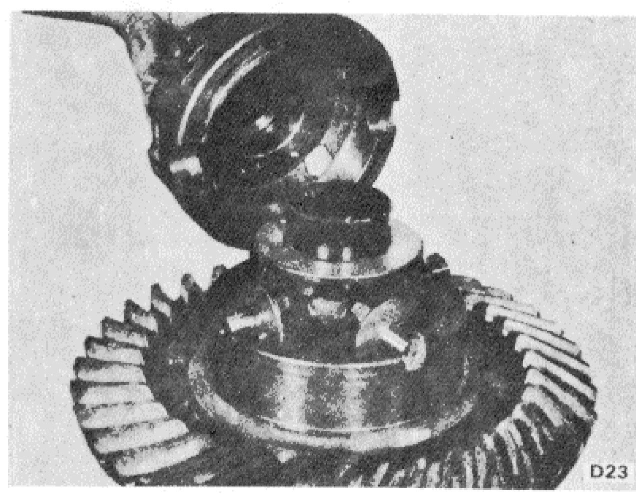


Figure 9C-43. Removing Plain Half Case

12. Lift side gear and thrust washer from flange half, Figure 9C-44.

13. Remove differential pinions, washers and spider as an assembly, Figure 9C-45.

NOTE

There are two rows of needle rollers under each pinion gear, do not lose these rollers.

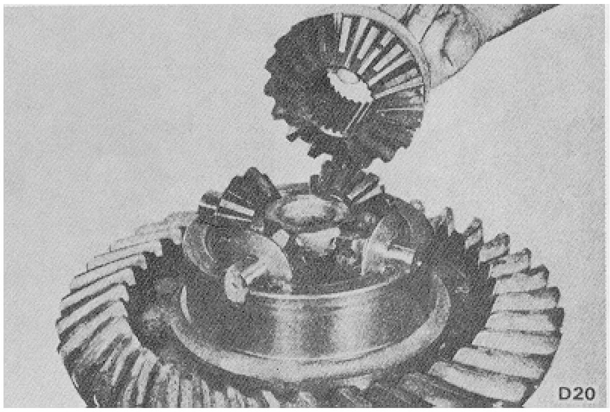


Figure 9C-44. Removing Side Gear

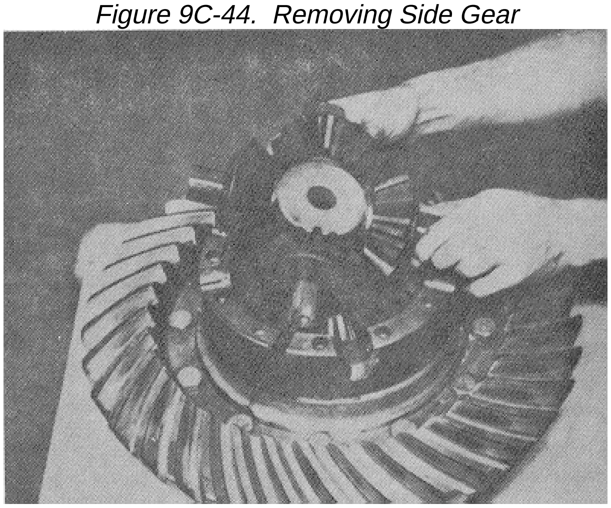


Figure 9C-45. Removing Spider Assembly

14. This procedure is used to remove ring gear, when only ring gear and pinion are to be replaced, Figure 9C-46.

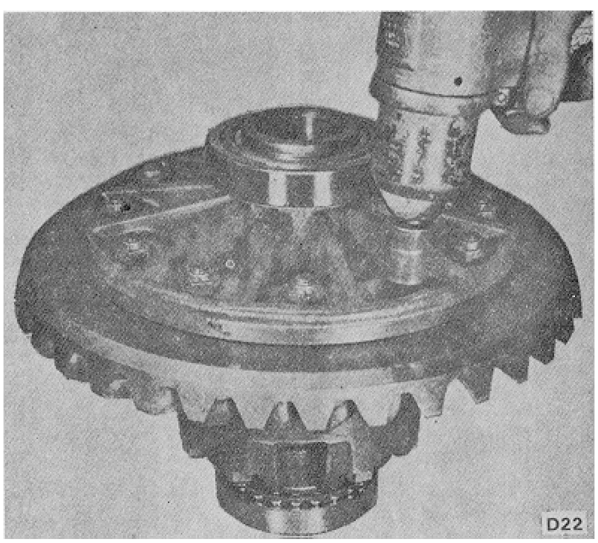


Figure 9C-46. Removing Ring Gear

Pinion bearing cage may be pressed from pinion. Outer bearing will be removed with bearing cage. Center bearing and bearing spacer will remain on pinion. Pull center bearing from pinion. Press inner pinion bearing from pinion shaft.

CLEANING. Clean all parts thoroughly using solvent type cleaning fluid. It is recommended that parts be immersed in cleaning fluid and moved up and down slowly until all old lubricant and foreign material is dissolved and parts are thoroughly cleaned.

CAUTION

Care should be exercised to avoid skin rashes, fire hazards and inhalation of vapors when using solvent type cleaners.

Remove bearings from cleaning fluid and strike larger side of cone flat against a block of wood to dislodge solidified particles of lubricant. Immerse again in cleaning fluid to flush out particles.

Repeat above operation until bearings are thoroughly clean. Dry bearings using moisture-free compressed air. Be careful to direct air stream across bearing to avoid spinning. Do not spin bearings when drying. Bearings may be rotated slowly by hand to facilitate drying process.

Clean interior and exterior of housings, bearing caps, etc., thoroughly. Cast parts may be cleaned in hot solution tanks with mild alkali solutions providing these parts do not have ground or polished surfaces. Parts should remain in solution long enough to be thoroughly cleaned and heated. This will aid the evaporation of the cleaning solution and rinse water. Parts cleaned in solution tanks must be thoroughly rinsed with clean water to remove all traces of alkali. Cast parts may also be cleaned with steam cleaner.

CAUTION

Care should be exercised to avoid skin rashes and inhalation of vapors when using alkali cleaners.

Thoroughly dry all parts cleaned immediately by using moisture-free compressed air or soft, lintless absorbent wiping rags free of abrasive materials such as metal filings, contaminated oil or laping compound.

Do not use solvents or cleaning fluids on brake shoes or parking brake bands. Thoroughly clean brake shoes, bands and linings with wire brush.

INSPECTION. The importance of careful and thorough inspection of all parts cannot be overstressed. Replacement of all parts showing indication of wear or stress will eliminate costly and avoidable failures at a later date.

Carefully inspect all rollers, cages and cups for wear, chipping or nicks to determine fitness of bearings for further use. Do not replace a bearing cone or cup individually without replacing the mating cup or cone at the same time. After inspection, dip bearings in clean light oil and wrap in clean lintless cloth or paper to protect them until installed.

Replacement of spring loaded oil seals, gaskets and snap rings is more economical when unit is disassembled than to risk premature overhaul to replace these parts at a future time. Loss of lubricant through a worn seal may result in failure of other more expensive parts of the assembly. Sealing members should be handled carefully, particularly when being installed. Cutting, scratching, or curling under lip of seal seriously impairs its efficiency. At reassembly, lubricate lips of oil seals with Lubriplate.

If magna-flux process is available, use process to check parts. Examine teeth and ground and polished surfaces on all gears and shafts carefully for wear, pitting, chipping, nicks, cracks or scores. If gear teeth are cracked or show spots where case hardening is worn through, replace with new gear. Small nicks may be removed with suitable hone. Inspect shafts to make certain they are not sprung, bent, or splines twisted, and that shafts are true. Differential pinions and side gears must be replaced as sets. Differential ring gear and bevel pinion must also be replaced as a set if either is damaged.

Inspect housing, covers, planet spider, and differential case to be certain they are thoroughly cleaned and that mating surface, bearing bores, etc., are free from nicks or burrs. Check all parts carefully for evidence of cracks or conditions which would cause subsequent oil leaks or failures.

ASSEMBLY. To assemble the differential, proceed as follows:

NOTE

All parts must be lubricated with recommended axle lubricant when reassembling (see Section III). No part should be reassembled dry.

1. Position inner needle roller bearing spacer on differential spider, Figure 9C-47. See Figure 9C-53 for cross section reference.

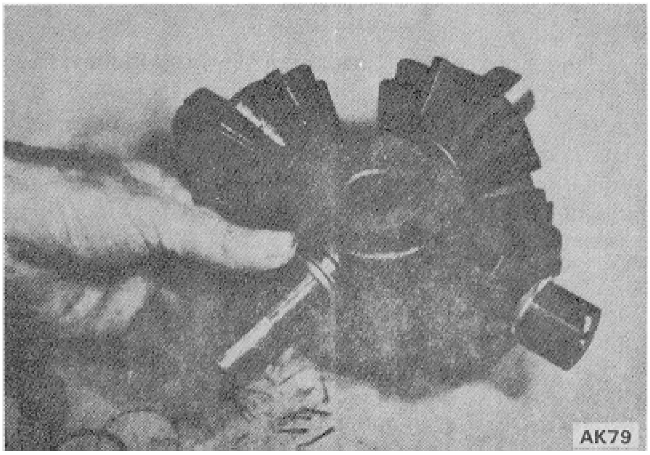


Figure 9C-47. Installing Spacer

2. Using a rubber band to facilitate assembly, install one row of needle roller bearings, Figure 9C-48.

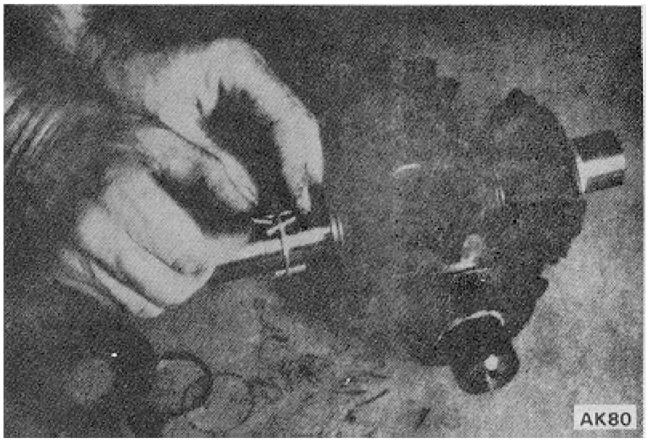


Figure 9C-48. Installing Needles

3. Install center roller bearing spacer, Figure 9C-49.

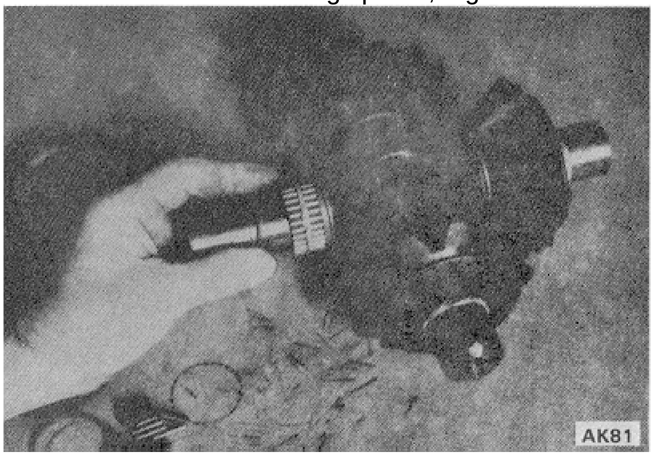


Figure 9C-49. Installing Bearing Spacer

4. Using another rubber band install outer row of needle roller bearings, Figure 9C-50.

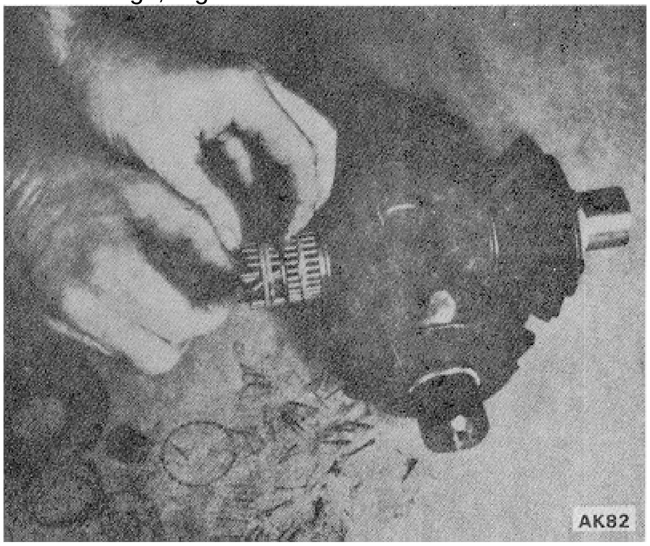


Figure 9C-50. Installing Needles

5. Position pinion gear on needles as shown, Figure 9C-51. Remove first rubber band. Slide pinion gear over second row of needles, remove second rubber band.

Figure 9C-51. Installing Pinion Gear

6. Install outer roller bearing spacer and pinion thrust washer, Figure 9C-52. A rubber band was used on each end of the spider after pinion installation to keep pinion gear in place until assembly into flange half case.

7. Place side gear thrust washer and side gear in flange half of the differential.

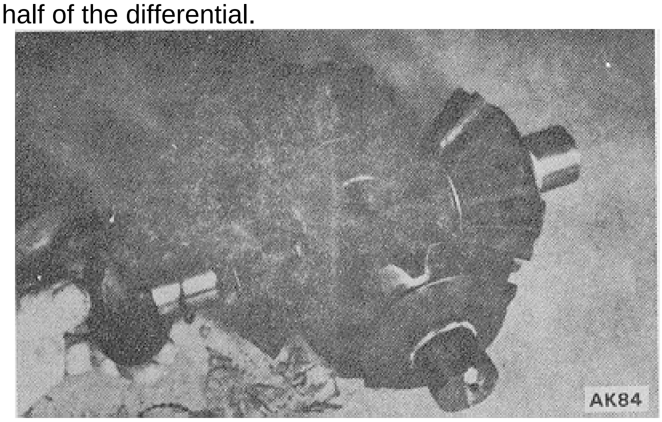


Figure 9C-52. Installing Spacer and Thrust Washer

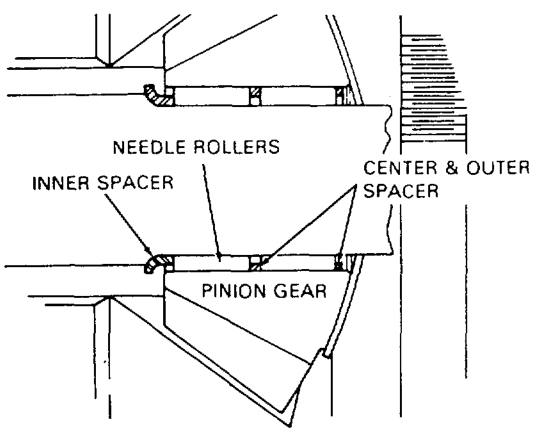


Figure 9C-53. Cross Section, Differential Spider

Remove rubber bands holding pinion gears into position on differential spider. Place assembly on side gear, Figure 9C-54.

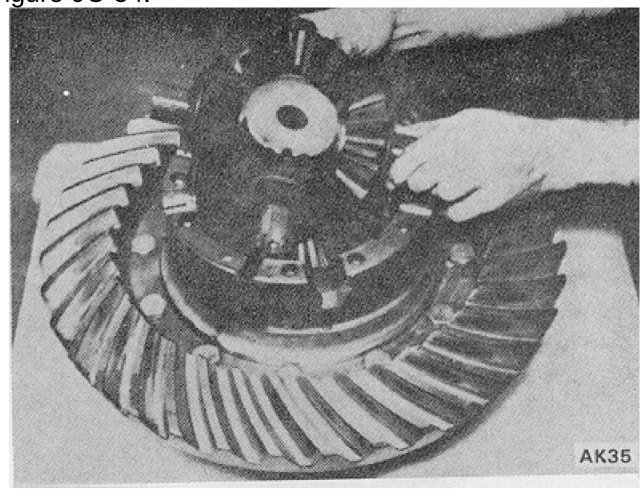


Figure 9C-54. Installing Spider Assembly

8. Place side gear and thrust washer in position on pinions, Figure 9C-55.

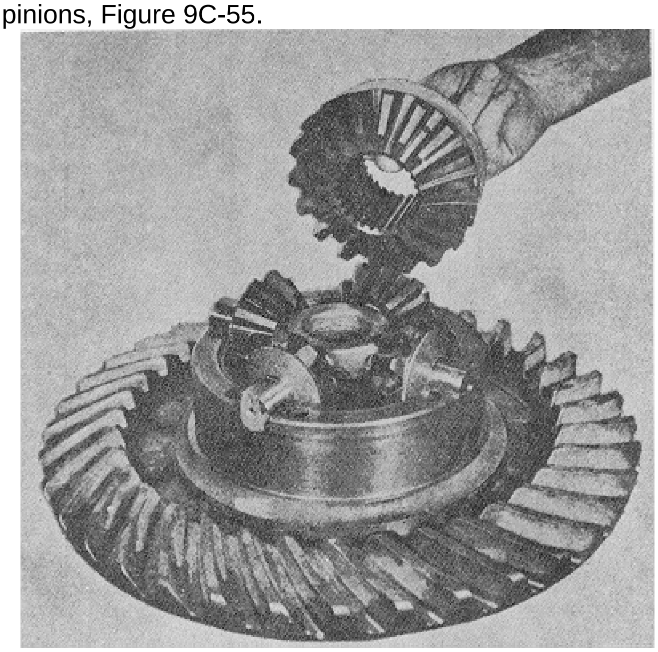


Figure 9C-55. Installing Side Gear

9. Place plain half of differential case in position on flange half, Figure 9C-56.

NOTE

Make certain matching marks of both halves are in alignment.

10. Install differential case bolts and self locking nuts, Fig-ure 9C-57. Tighten to 180-198 ft-lbs (244.1-268.5 N.m) torque.

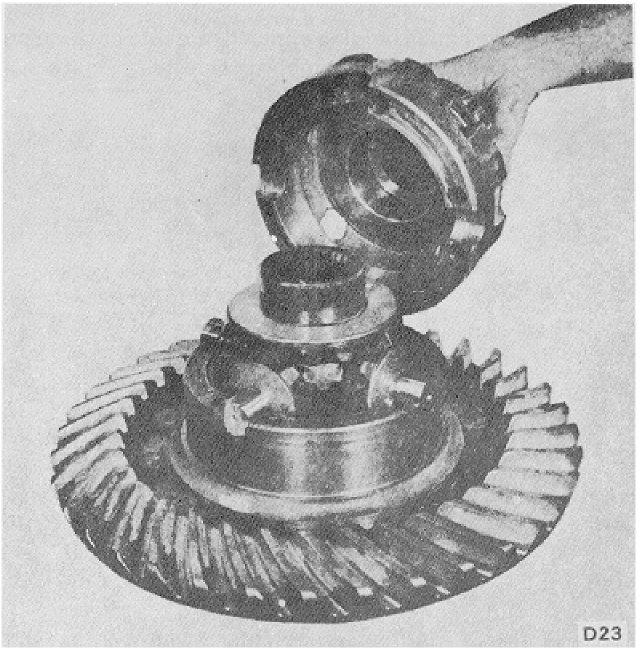


Figure 9C-56. Installing Plain Half of Case

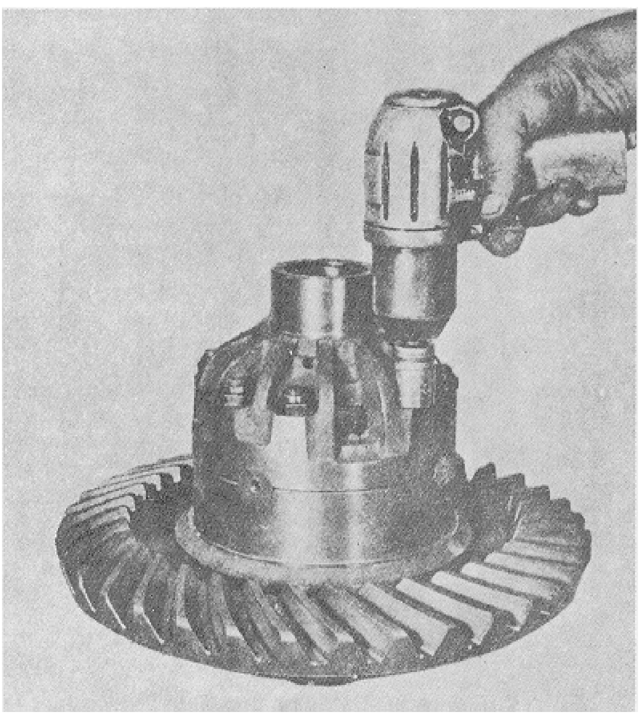


Figure 9C-57. Installing and Tightening Bolts

11. Press bearing cones and install differential and bearing assembly In differential carrier. Place adjusting nuts in position, Figure 9C-58. Install differential carrier caps, but do not tighten.

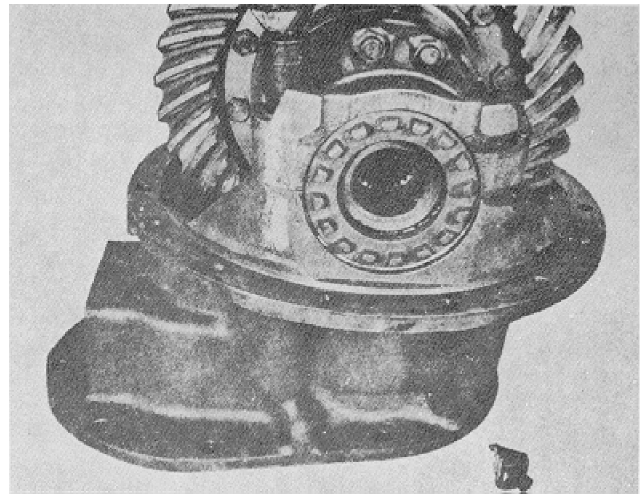


Figure 9C-58. Assembling Carrier

NOTE

Make certain carrier caps are reassembled on the same side they were removed.

12. Assemble pinion bearings as follows (see Figure 9C-59):

A. Press center bearing cone onto pinion shaft, with rollers upward; then slide bearing spacer into place, making certain the inside chamfer is toward the cone.

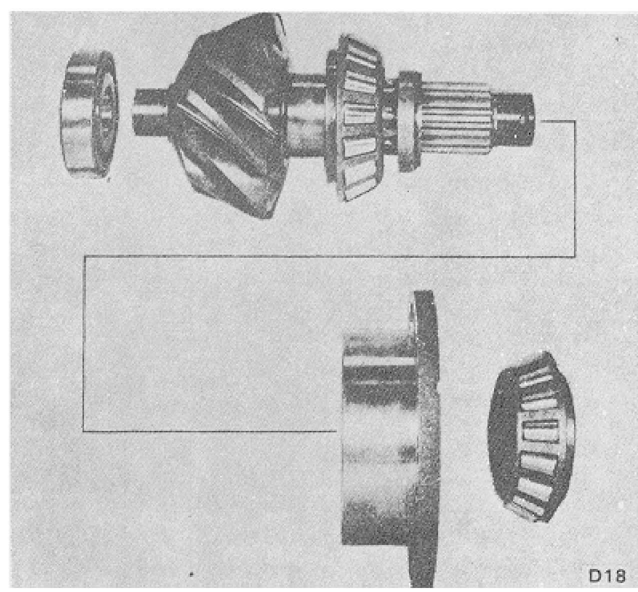


Figure 9C-59. Assembling Pinion Shaft

NOTE

In the event that the bearing cage does not require replacement, the spacer furnished as original equipment may be reinstalled. This spacer as provided in the original assembly is ground to proper length to obtain the specified bearing preload of 13 to 23 inch-lbs (1.5-2.6 N.m) rolling pinion bearing resistance. Should a new pinion bearing cage or pinion bearings be used in reassembly, a service spacer and shim kit must be used.

B. Press pinion bearing cups into bearing cage, then set cage and cup assembly in place over shaft and press outer cone onto pinion shaft and into position in cup. Maintain full pressure on the cone and check for proper bearing preload. To increase preload, shims may be removed; to decrease preload, shims may be added.

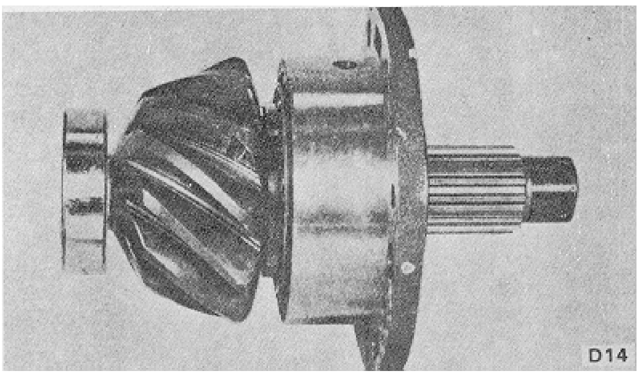


Figure 9C-60. Assembled Pinion Shaft

13. Press pinion and bearing assembly into carrier until outer pinion bearing cage is approximately 1/4" (6.35 mm) from face of carrier. During this operation, be certain the oil return holes are in line.

14. Split shims are used to adjust pinion to ring gear contact, Figure 9C-61.

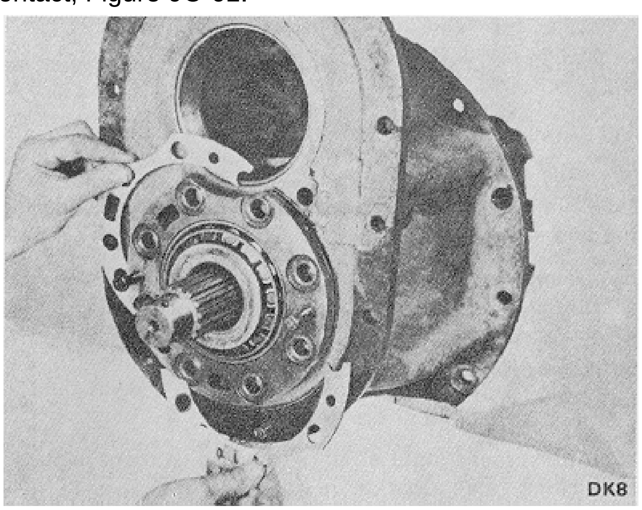


Figure 9C-61. Shims.

NOTE

Remove jack screws from pinion bearing cage. Use the same thickness shims for reassembly as were removed at disassembly. Shims may be added or removed as required to move pinion inward or outward. Shims are installed between bearing cage and face of carrier. Draw pinion assembly into position by tightening bolts evenly. 1 13-1 24 ft-lbs (153.2-168.1 N.m) 7 bolts; 57-63 ft-lbs (77.3-85.4 N.m) 1 bolt.

15. Adjust backlash to specification -0.009-0.015" (0.23-0.38 mm) as follows:

A. If backlash is too great, back off adjusting nut on plain half of case and tighten opposite side until all lash is removed. Tighten nut on plain half case solidly to seat bearings. Back off nuts in flange side, one notch at a time and follow with opposite nut until correct backlash is obtained.

B. If backlash is below 0.009" (0.23 mm), back off nut on flange half and tighten nut on opposite side. Operation should be done in one notch steps until correct back-lash is obtained.

C. Tighten carrier caps and recheck backlash. If backlash has changed, repeat above procedure to correct.

NOTE

Carrier cap bolts should be tightened to 296-326 ft-lbs (401.4-442.1 N.m) torque.

16. Install pinion drop gear on pinion shaft (long hub outward). Place washer on shaft and install pinion nut. Tighten to 600 ft-lbs (813.6 N.m) torque.

Paint 3 or 4 teeth of the ring gear with red lead and rotate pinion by turning pinion gear. Check tooth contact with tooth contact chart, Figure 9C-66 and correct by adding or omitting shims from the pinion bearing cage. After proper tooth contact and backlash is achieved, remove pinion gear and lockwire bearing cage bolts, reinstall pinion gear, nut and washer. Tighten to 296-326 ft-lbs (401.4-442.1 N.m) torque.

17. Install differential bearing adjusting nut locks and secure with screw and lockwasher. Tighten to 23-25 ft-lbs (31.2-33.9 N.m) torque. Lockwire nut locks, see Figure 9C-62.

18. Adjust thrust screw as follows:

A. Turn thrust screw (item No. 3) IN to contact ring gear (item No. 4), Figure 9C-63.

B. Install a dial indicator on end of thrust screw.

C. Turn thrust screw AWAY from ring gear until a 0.012" (0.305 mm) reading is taken on the dial indicator. The specification is 0.010 to 0.015" (0.254 to 0.381 mm) distance from end of thrust screw to side of ring gear. 0.012" (0.305 mm) was used as an in-between reading.

D. Hold thrust screw and tighten locknut to 300 ft-lbs (406.8 N.m) torque.

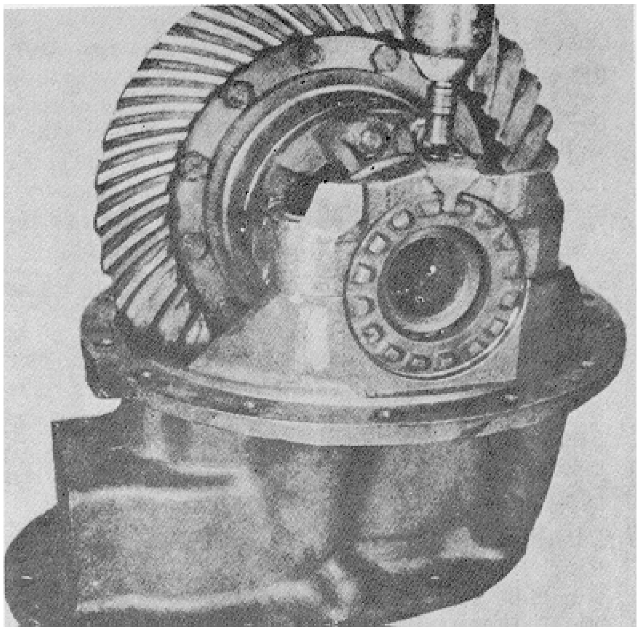


Figure 9C-62. Installing Nut Locks

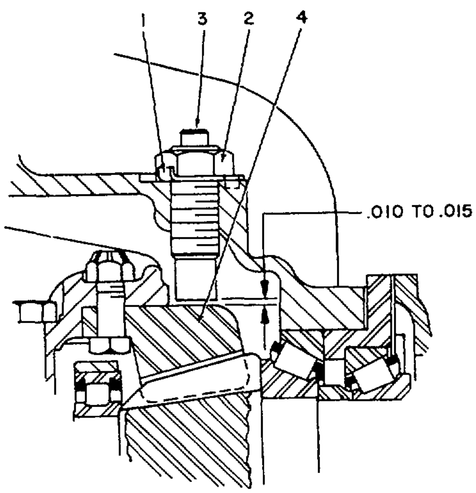


Figure 9C-63. Adjusting Thrust Screw

NOTE

Dial indicator reading must not move during this operation. Bend one tang of nut lock over flat side of housing and one tang over flat side of the locknut.

19. Press inner taper bearing (small diameter out) on rear of input shaft.

20. Install drop gear on input shaft, Figure 9C-64.

NOTE

Drop gear is counterbore to prevent spline interferences. This counterbore must face rear input bearing.

21. Press outer taper bearing (small diameter out) on front of input shaft.

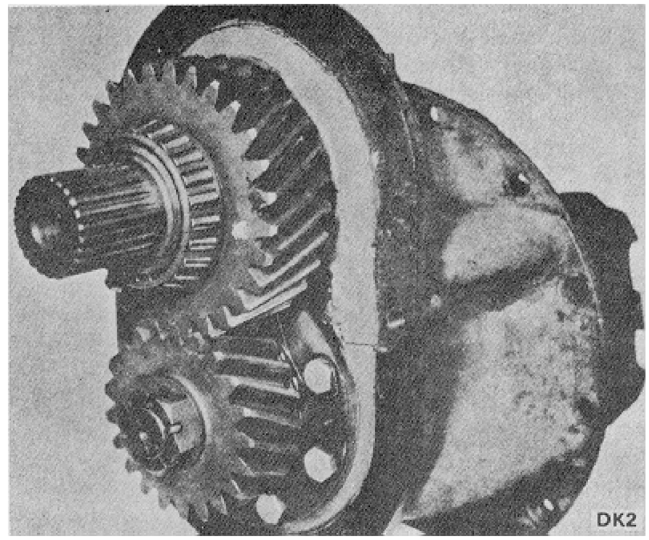


Figure 9C-64. Installing Drop Gear

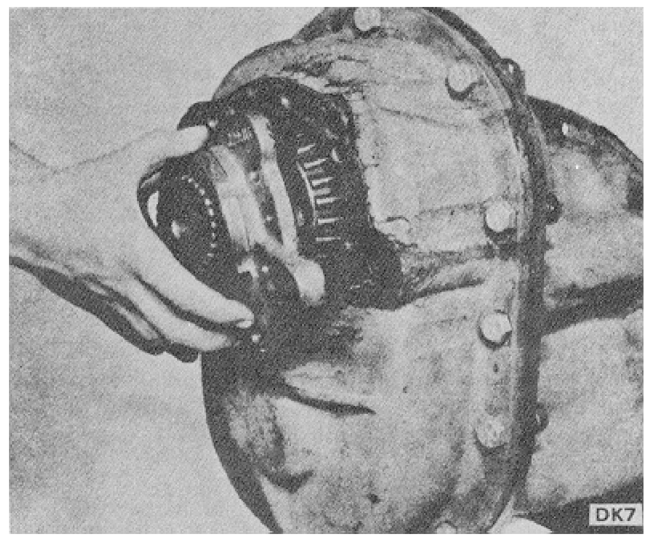


Figure 9C-65. Installing Bearing Retainer

22. Install input shaft outer bearing cup in cup and seal retainer.

23. Install input shaft assembly in differential housing. Install drop gear cover.

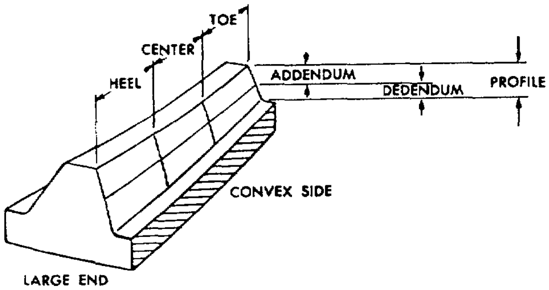
24. Shims are used between drop gear cover and bearing cup and seal retainer.

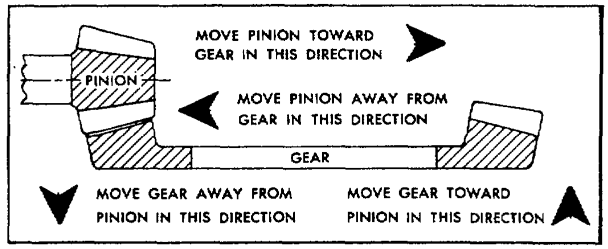
25. Shims are added or omitted to obtain a 0.004to 0.006" (0.102 to 0.152 mm) end play on the input shaft.

NOTE

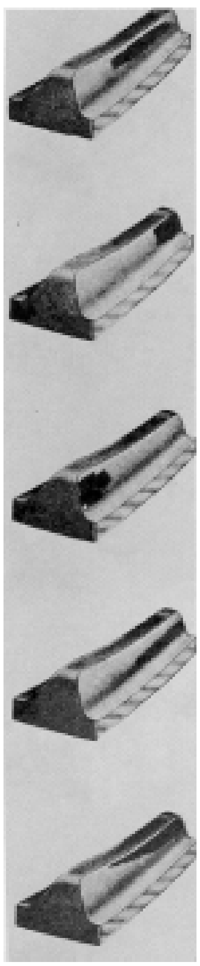
Bearing retainer bolts must be torqued each time shims are added or omitted.

26. After proper input shaft bearing adjustment is made, install input yoke. Coat entire end of input shaft with No. 2 permatex and install retaining washer and bolt. Tighten to 57-63 ft-lbs (77.3-85.4 N.m) torque. Lockwire bolt to prevent loosening.





ALL CONTACT BEARINGS SHOWN BELOW ARE ON RIGHT HAND SPIRAL RING GEAR - THE DRIVE IS ON THE CONVEX SIDE OF THE TOOTH.



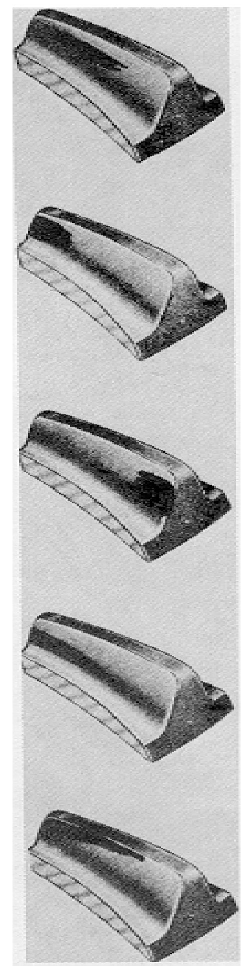
TYPICAL PREFERRED BEARING ON BOTH SIDES OF TOOTH WHILE UNDER A LIGHT LOAD

TOE BEARING ON BOTH SIDES OF TOOTH - GEAR SET NOISY. TO MOVE BEARING TOWARD HEEL INCREASE BACKLASH WITHIN LIMITS BY MOVING GEAR AWAY FROM PINION.

HEEL BEARING ON BOTH SIDES OF TOOTH - GEARSET NOISY AND COULD RESULT IN EARLY GEAR FAILURE. TO MOVE BEARING TOWARD TOE DECREASE BACKLASH WITHIN LIMITS BY MOVING GEAR TOWARD PINION.

LOW BEARING ON GEAR AND HIGH BEARING ON PINION. CORRECT BY PULLING PINION AWAY FROM GEAR (INCREASE MOUNTING DISTANCE.

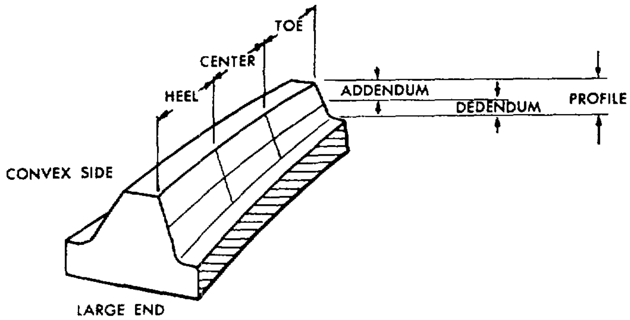
HIGH BEARING ON GEAR AND LOW BEARING ON PINION. CORRECT BY MOVING PINION IN TOWARD GEAR (DECREASE MOUNTING DISTANCE.

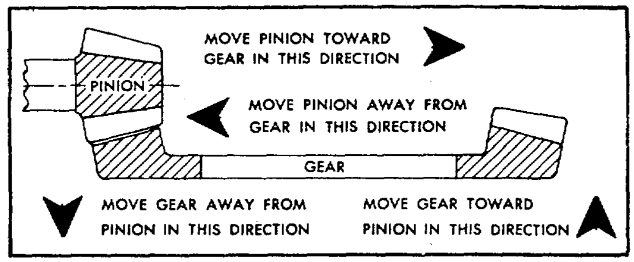


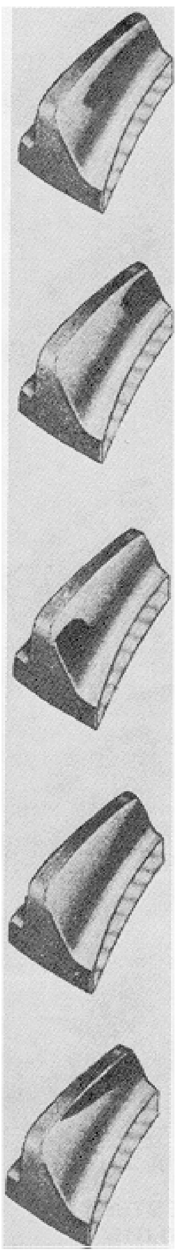
BACKLASH

BACKLASH SHOULD BE MEASURED WITH A DIAL INDICATOR RIGIDLY MOUNTED WITH THE STEM PERPENDICULAR TO THE TOOTH SURFACE AT THE EXTREME HEEL. BACKLASH IS 0.009 TO 0.015" 10.23 TO 0.38 mm).

Figure 9C-66. Spiral Bevel and Hypoid Tooth Bearing Contact Chart (Sheet 1 of 2)







ALL CONTACT BEARINGS SHOWN BELOW ARE ON LEFT HAND SPIRAL RING GEAR - THE DRIVE IS ON THE CONVEX SIDE OF THE TOOTH.

TYPICAL PREFERRED BEARING ON BOTH SIDES OF TOOTH WHILE UNDER A LIGHT LOAD

TOE BEARING ON BOTH SIDES OF TOOTH - GEAR SET NOISY. TO MOVE BEARING TOWARD HEEL INCREASE BACKLASH WITHIN LIMITS BY MOVING GEAR AWAY FROM PINION.

HEEL BEARING ON BOTH SIDES OF TOOTH - GEARSET NOISY AND COULD RESULT IN EARLY GEAR FAILURE. TO MOVE BEARING TOWARD TOE DECREASE BACKLASH WITHIN LIMITS BY MOVING GEAR TOWARD PINION.

LOW BEARING ON GEAR AND HIGH BEARING ON PINION. CORRECT BY PULLING PINION AWAY FROM GEAR (INCREASE MOUNTING DISTANCE.

HIGH BEARING ON GEAR AND LOW BEARING ON PINION. CORRECT BY MOVING PINION IN TOWARD GEAR (DECREASE MOUNTING DISTANCE.

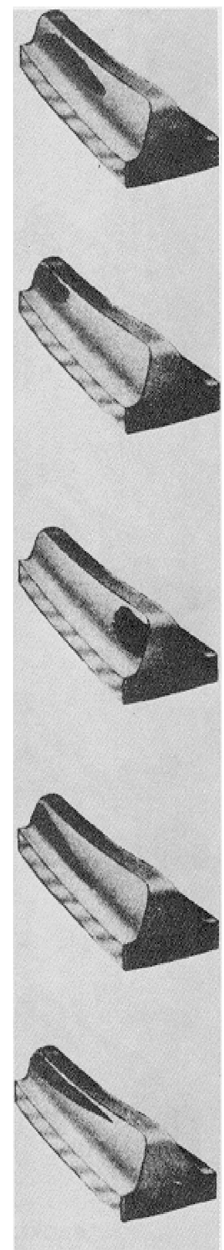


Figure 9C-66. Spiral Bevel and Hypoid Tooth Bearing Contact Chart (Sheet 2 of 2)

INSTALLATION

To install an axle on this machine, proceed as follows:

1. Position the axle under the machine, and install the mounting material.

2. Connect the air lines to the brake chamber.

3. Install the propeller shaft(s).

4. Install the wheels.

5. Remove the blocking or jacks under the machine frame.

SUBSECTION 9D

FRONT AXLES

GENERAL

This subsection will cover the removal, repair and installation of the front axle. Information on brake repair and lining replacement is also included.

AXLE REMOVAL

To remove a front axle, proceed as follows:

1. Lift the machine off the ground using the outriggers, and place jacks or blocks under the frame. Lower the machine onto the jacks or blocks under the frame, so that the machine is not supported by the outriggers.

2. Remove the wheels.

3. Disconnect the air lines attached to the brake chambers, and move them out of the way so that they do not interfere with the removal of the axle.

4. Place suitable jacks under the axles to prevent them from moving while the axle mounting hardware is being removed.

5. Disconnect the attaching hardware and lower the axle out from beneath the carrier.

AXLE DISASSEMBLY

Proceed as follows to disassemble the front axle (see Figure 9D-1):

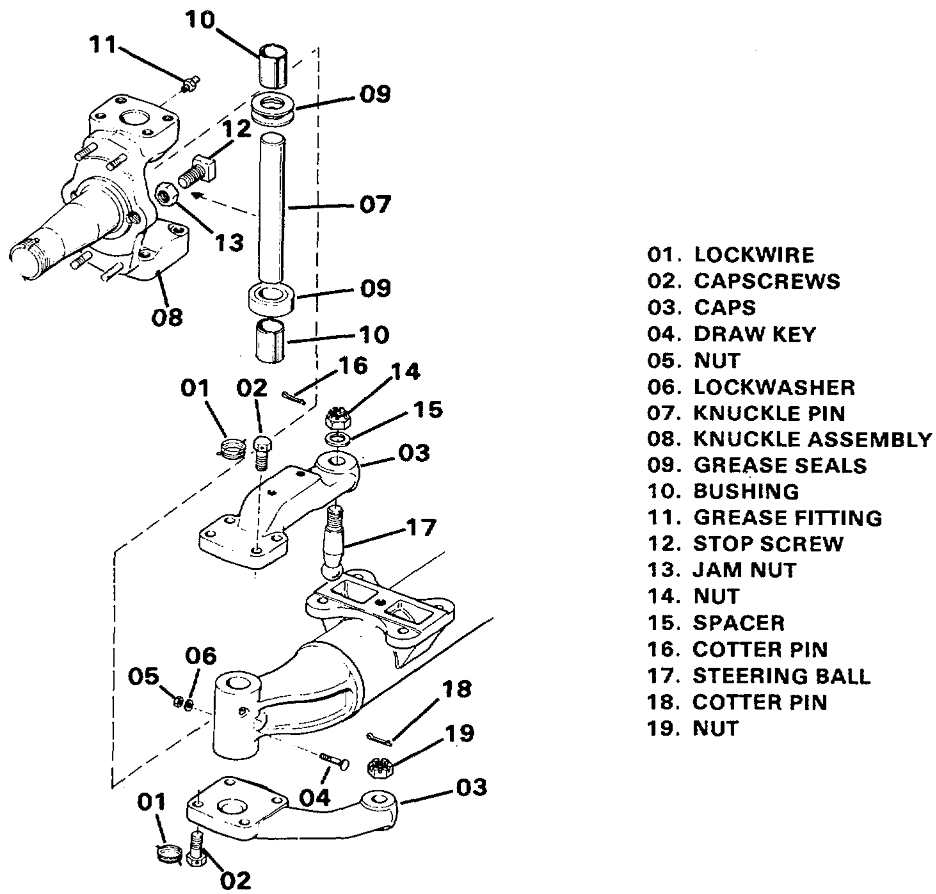


Figure 9D-1. Steering Knuckle

1. Remove the hub cap from hub. Then, remove jam nut, wheel bearing adjusting nut and lockwashers from knucklespindle.

2. Remove the outer wheel bearing cone.

3. Remove wheel and hub assembly.

4. Remove brake assembly from steering knuckle.

5. Remove cross tube end nut and disassemble cross tube assembly from cross tube arm.

6. Remove lockwire (01) steering knuckle cap capscrews (02), caps (03) and gaskets from top and bottom of knuckle.

7. This axle uses a tapered draw key (04) that is threaded on small end and drawn into place by nut (05). Remove nut (05) and lockwasher (06). Drive the draw key out by use of brass hammer on threaded end. See Figure 9D-2.

CAUTION

Do not strike these hardened steel pieces directly with a steel hammer.

Figure 9D-2. Removing Draw Key

8. Tap out knuckle pin (07) by use of a bronze drift.

9. Lift off knuckle assembly (08).

10. With the steering knuckle assembly removed from the axle center, inspect grease seals (09) for tears, rips and deterioration. Do not attempt to remove the seals from the steering knuckle unless replacement is necessary. If seals must be removed, follow these procedures:

A. Place steering knuckle bottom side up in a vise equipped with soft metal jaws. Position upper knuckle boss (top end down) between jaws of vise and lock securely.

B. With the top end of the knuckle held firmly in this position, insert a screwdriver or other suitable tool between the knuckle counterbore and the seal case and pry the seal out of knuckle.

C. Remove knuckle from vise for inspection.

D. Refer to INSPECTION for cleaning, inspection and component repairs.

E. Repeat procedure for other seal.

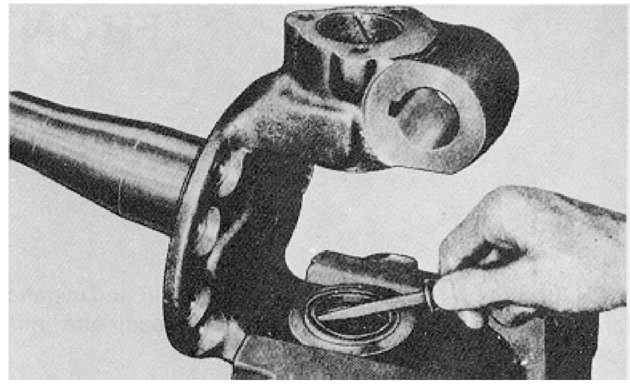
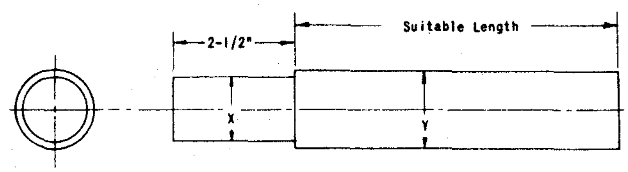


Figure 9D-3. Seal Removal

NOTE

The tool utilized for removal of old and installation of new steering knuckle bushings (10) is shown in Figure 9D-4. The tool can be made from a piece of round bar stock which is ground with a step to serve as a pilot.



DIMENSION "X" IS 0.010" LESS THAN THE BUSHING BORE.
DIMENSION "Y" IS 0.010" LESS THAN THE STEERING KNUCKLE BORE.

Figure 9D-4. Bushing Removal and Installation Tool

11. The worn bushings are pressed out of the knuckle, employing tool shown in Figure 9D-5.

12. The new bushings should be installed with the same tool. The pilot of this tool prevents collapse or distortion of bushing during installation. The bushing should be pressed into the knuckle in three or more steps to allow it to align itself with the bore. Oil hole in bushing must line up with oil hole in knuckle.

13. First press bushing into knuckle approximately 1/8" and relieve press pressure, press bushing in another 1/2" and relieve press pressure. The bushing can now be pressed in until it is flush with the inner machined surface of the knuckle. Then press bushing in until it is flush with the surface of the seal counterbore.

14. This applies to both upper and lower bushings.

15. To finish a bushing, either a burnishing bar or reamer must be employed. The dimensional limits of these tools at finishing surfaces should correspond to those listed in columns "B" and "C" of Table 9D-1.

CAUTION

Utilization of burnishing ball for this operation must be avoided, as it does not insure a true alignment between the two bushings.

Table 9D-1. Reamer Dimensions

A	B	C	D	E	X (+.001)	Y (+.001)
2.0485 2.0505	2.0635 2.0645	2.0580 2.0600	12.750	11.875	2.047	2.179

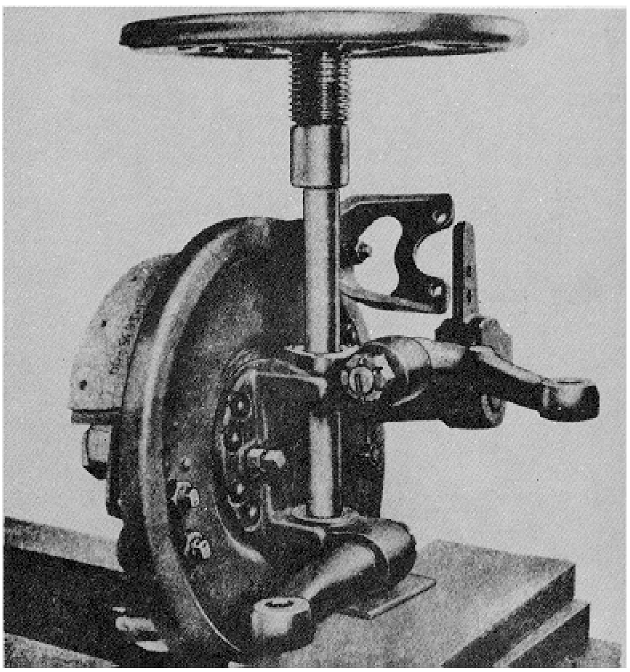


Figure 9D-5. Bushing Removal

16. Two sets of. reamers, shown in Figure 9D-7, are designed to permit line reaming of the bushings without removing the dust shields. Reamers "Types 1 and 1A" comprise one set while the second set, "Type 2", consists of a reamer and pilot.

17. When using the "Types 1 and 1 A" reamer set to ream the bushings, use reamer "Type 1 " first to ream the upper bushing, then "Type 1A" to ream the lower bushing.

18. To use reamer "Type 2", first insert the pilot into the reamer to ream upper bushing then remove the pilot to

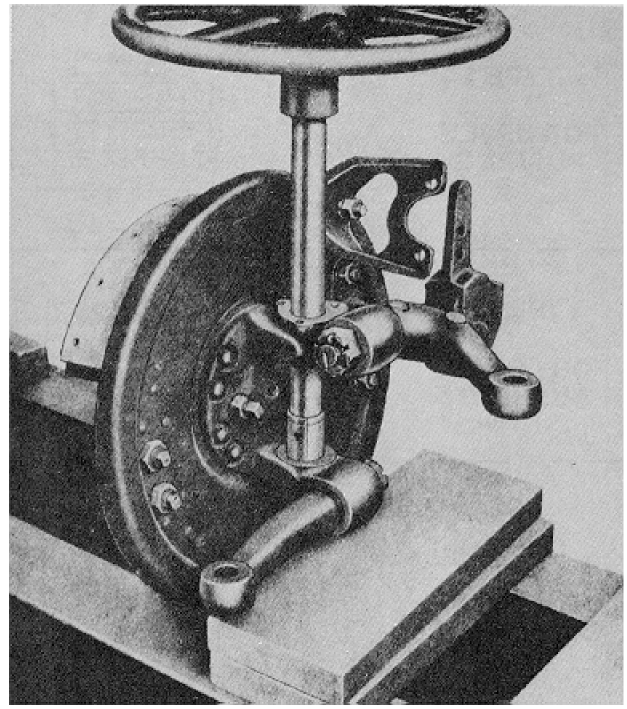


Figure 9D-6. Bushing Installation

ream the lower bushing. Length of "D" dimension is dependent on mode.

19. Avoid the possibility of tapering or enlarging the upper bushing while inserting the tool to ream the lower bushing. To do this, the reamer should be turned slightly in the noncutting direction. Do not turn it in excess of 900, as this may damage the cutting edges of the reamer.

Both the "Types 1 and 1 A" reamer set and the "Type 2" reamer and pilot can be made by a reliable tool source from the specifications in Figure 9D-7.

NOTE

Reamers may be purchased from Wright Tool Company, 1738 Maplelawn, Troy, Michigan 48084, or from L.O. Beard Company, Lancaster, Pennsylvania.

AXLE INSPECTION AND REPAIR

Inspect and repair the front axle as follows:

1. Parts having ground and polished surfaces, such as knuckle pins and spindles, should be cleaned in a suitable solvent such as kerosene or diesel fuel oil.

CAUTION

Gasoline should be avoided.

2. DO NOT clean these parts in a hot solution tank or with water and alkaline solutions such as sodium hydroxide, orthosilicates or phosphates.

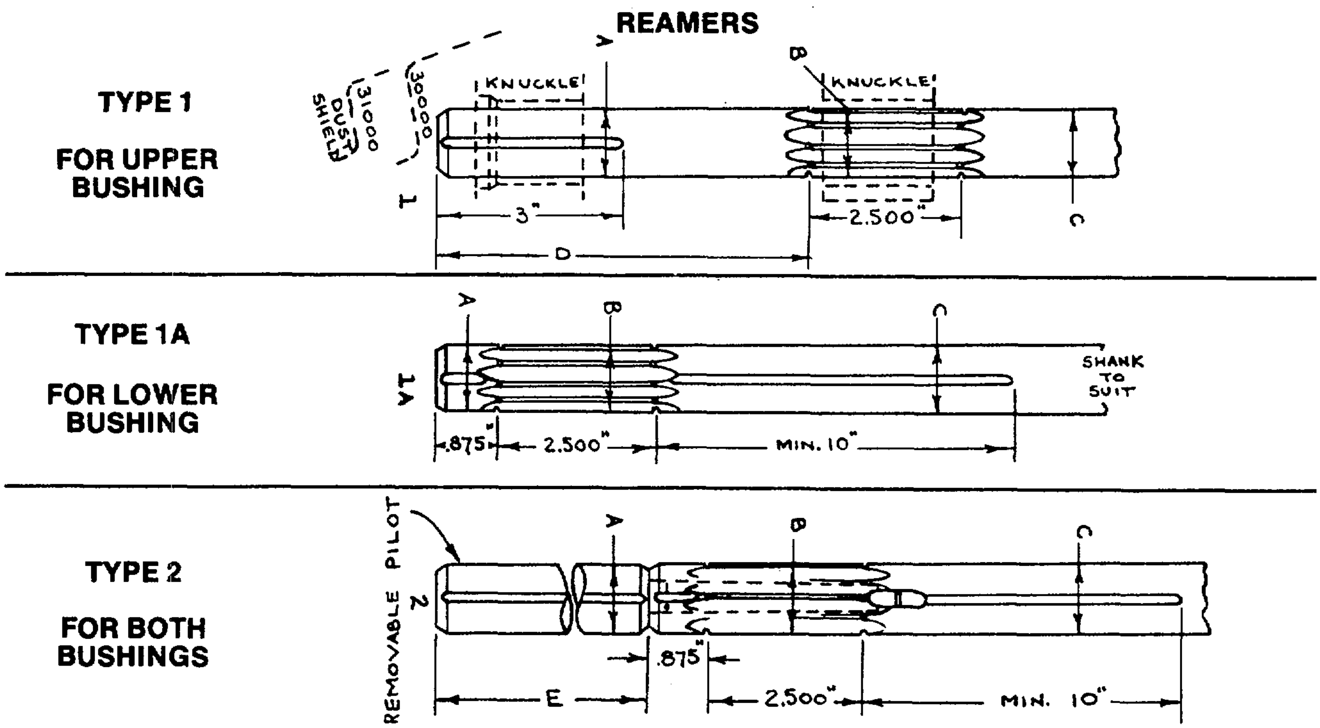


Figure 9D-7. Reamers

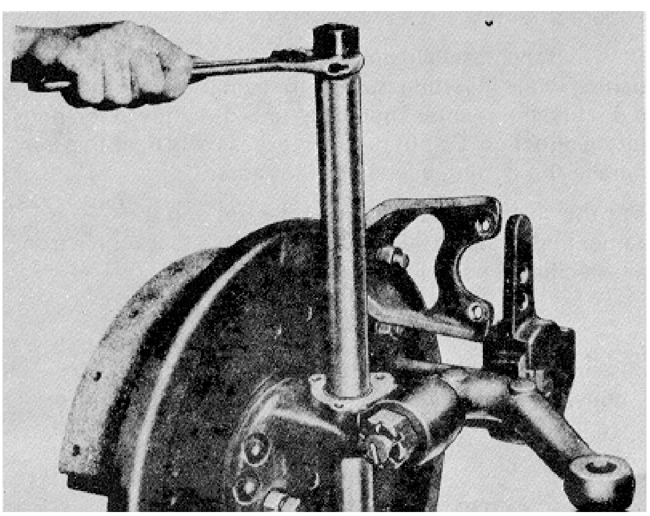


Figure 9D-8. Ream Upper Bushing First - Type 1

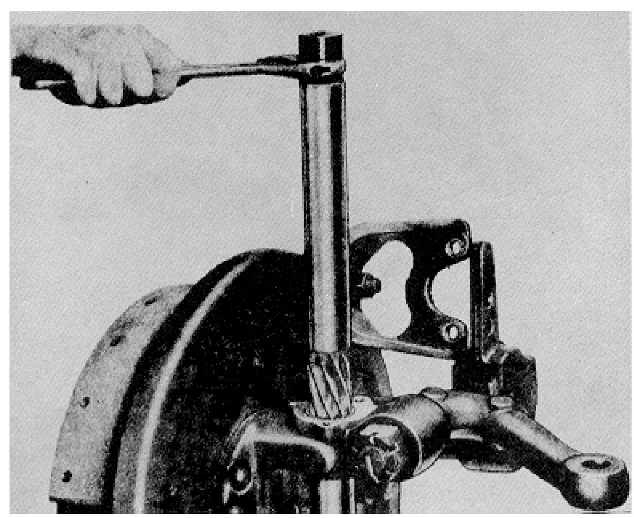


Figure 9D-9. Ream Lower Bushing Second - Type 1A

3. Rough parts such as cast brackets and some brake parts, may be cleaned in hot solution tanks with mild alkali solutions, providing these parts are not ground or polished. The parts should remain in the tank long enough to be thoroughly cleaned and heated. This will aid the evaporation of the rinse water. The parts should be thoroughly rinsed after cleaning to remove all traces of alkali.

CAUTION

It is not recommended to salvage damaged cross tube ends by repacking and replacing the boot seal on non-greasable ends.

4. Parts should be thoroughly dried immediately after cleaning. Use soft, clean, lintless, absorbent paper towels or wiping rags free of abrasive material, such as lapping compound, metal filings or contaminated oil. Bearings should never be dried by spinning with compressed air.
5. Parts that have been cleaned, dried, inspected and are to be immediately reassembled, should be coated with light oil to prevent corrosion. If these parts are to be stored for any length of time, they should be treated with a good RUST PREVENTATIVE and wrapped in special paper or other material designed to prevent corrosion.
6. It is impossible to overstress the importance of careful and thorough inspection of steering knuckle components prior to reassembly. Thorough visual inspection for indications of wear or stress, and the replacement of such parts as are necessary, will eliminate costly and avoidable front end difficulties.
7. Inspect the steering knuckle thrust bearing, wheel bearing cones and cups. Replace if rollers or cups are worn, pitted or damaged in any way. If wheel bearing cups are to be replaced, remove from hubs with a suitable puller. Avoid the use of drifts and hammers as they may easily mutilate cup bores.
8. Inspect the steering knuckles and replace if indications of weakness or excessive wear are found.
9. Check the tightness of the steering connections such as cross tube arms, steering arm, etc.
10. Check knuckle pin seals for rips, tears and excessive wear. Do not remove seals from steering knuckle counter-bore unless replacement is necessary.
11. Remove lower knuckle pin seal from thrust bearing case and inspect seal for wear, rips and tears.
12. Check knuckle pin bushings for flaking and galling. Compare with correct specification. Do not remove bushings from steering knuckle unless replacement is necessary.

WARNING

Any indication of looseness in the total steering linkage arrangement under normal steering loads is sufficient cause to immediately check all pivot points for wear, regardless of accumulated mileage. Steering linkage pivot points should be checked each time the axle assembly is lubricated. If any indication of lateral movement is found, cross tube ends should be removed for inspection. Looseness at the steering linkage pivot points can be visually detected during movement of the vehicle steering wheel.

13. Check cross tube seals visually for any indications of damage. Also check to make sure seal is securely seated on socket. If cross tube end has a grease fitting, replace damaged seals.

CAUTION

It is not recommended to salvage damaged ends by repacking and replacing the boot seal on nongreasable ends.

14. Check the turning torque value between the cross tube end assembly stud and the ball cavity. If torque value is less than five (5) inch pounds, the cross tube end assembly should be replaced. This is not to say the end assembly will fail at this point, but it can no longer provide the type of steering control designed into it once lateral movement develops between the stud and ball cavity.
1 5. Wheel bearings should be very closely inspected at the time of knuckle inspection or when knuckle repair is being made.
16. Remove all the old grease from the wheel bearings, spindle, hub cavity, and hub cap. (The old grease may contain moisture which would lead to an early bearing failure if not removed.) Use kerosene or diesel fuel and a stiff brush. Gasoline and heated solvents, which are commonly used, should be avoided.
17. Allow the cleaned parts to dry, or dry them with a clean absorbent cloth or paper. Clean and dry hands and all tools used in the service operation. Grease will not adhere to a surface which is wet with solvent, and solvent may dilute the lubricant.
18. Bearings must be replaced if any of the following conditions exist:
A. Large ends of rollers worn flush to recess or radii at large ends of rollers worn sharp.

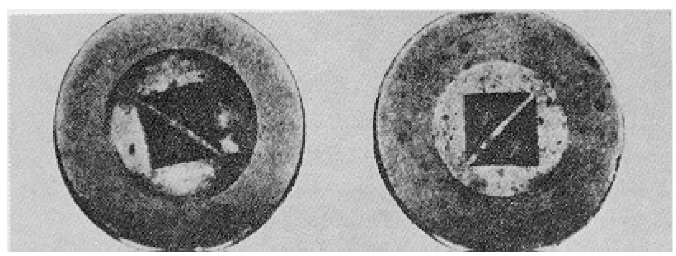


Figure 9D-10. Worn Rollers

B. Visible step wear, particularly at the small end of the roller track.
C. Deep indentations, cracks or breaks in bearing cup and/or cone surfaces.
D. Bright rubbing marks on the dark phosphate su rfaces of the bearing cage.
E. Etching or pitting on functioning surfaces.
F. Spalling or flaking on bearing cup and/or cone surfaces.

19. In the interest of safety and preserving the service life of front axle assemblies, it is recommended that front axle assemblies not be repair welded. Repair welding can detract from the structural integrity of a component, particularly as to heat-treated parts where the benefit of heat treatment may be nullified by the welding.

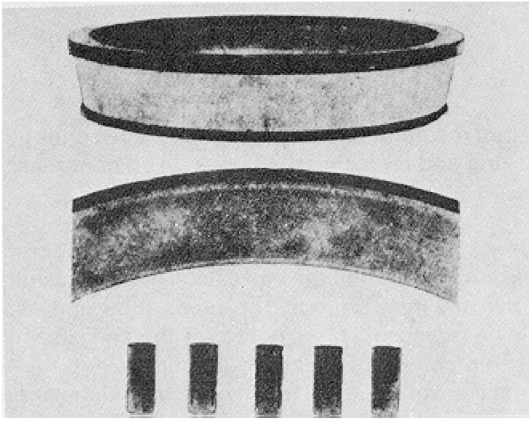


Figure 9D-1 1. Worn Bearings

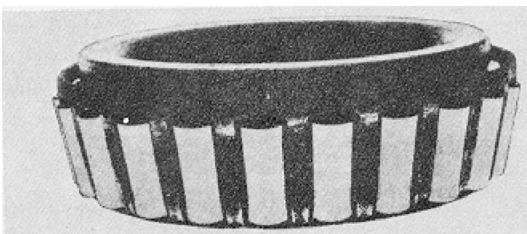


Figure 9D-12. Rubbing Marks On Cage

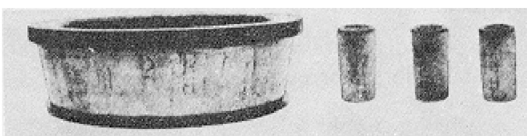


Figure 9D-13. Pitted Bearings

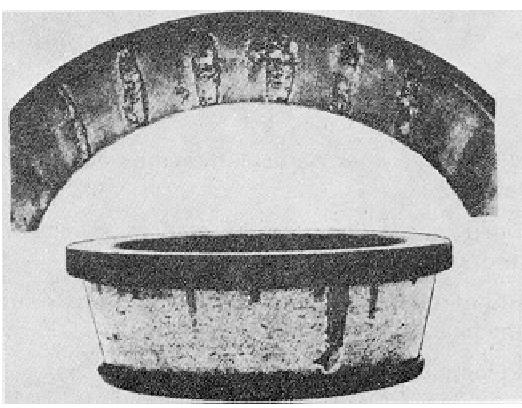


Figure 9D-14. Spalling or Flaking

Since it can be extremely hazardous and detrimental to repair weld components of any kind, repair welding can be approved only where stringent controls are imposed and equipment . . . customarily located only at manufacturing facilities . . . is employed, so as to minimize the potentially detrimental effects of repair welding.

20. Straightening of bent parts should be done cold. Various components are heat-treated and hot straightening would destroy some of the heat-treatment.

NOTE

It is not recommended to straighten steel forged nondriving front axle centers.

NOTE

The axle manufacturer disapproves of any straightening, repair welding, or drilling on the aluminum forged axle center. Actions of this type will void any expressed warranty.

21. Bent steering arms, cross tube arms or steering knuckles should be replaced rather than straightened. (It is not necessary to remove steering arms and cross tube arms from the knuckle unless replacements are required.)

AXLE ASSEMBLY

To assemble the front axle, proceed as follows:

1. It is impossible to overstress the importance of proper grease seal installation in both the top and bottom positions of the steering knuckle. Incorrect installation could result in premature lubricant contamination and a need for more frequent lubrication and overhaul service intervals. Therefore, for maximum operating service from the front axle assembly, grease seals should be installed by the following procedures:

A. If it was necessary to remove the upper seal from the steering knuckle, use the following to install a new seal.
   1. Place steering knuckle bottom side up in a vise equipped with soft metal protectors. Position upper knuckle boss (top end down) between jaws of vise and lock securely.
   2. With the top end of the knuckle held firmly in this position, place the seal over the knuckle counterbore, with the rubber lip facing up.
   3. Using a suitable sleeve and a bronze drift, tap the seal into the knuckle counterbore until it bottoms, Figure 9D-15.

B. Before attempting to install the thrust bearing and lower seal assembly on the steering knuckle, make certain the lower seal is positioned correctly over the thrust bearing retainer lip.

NOTE

To facilitate correct positioning, hold thrust bearing with thrust bearing gasket face down. Then, snap lower seal over the thrust bearing chamfered side as shown.

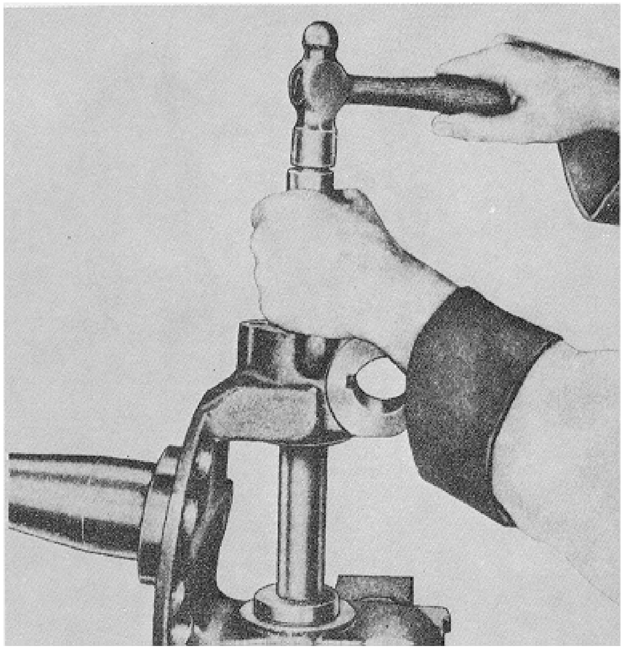


Figure 9D-15. Installing Upper Seal

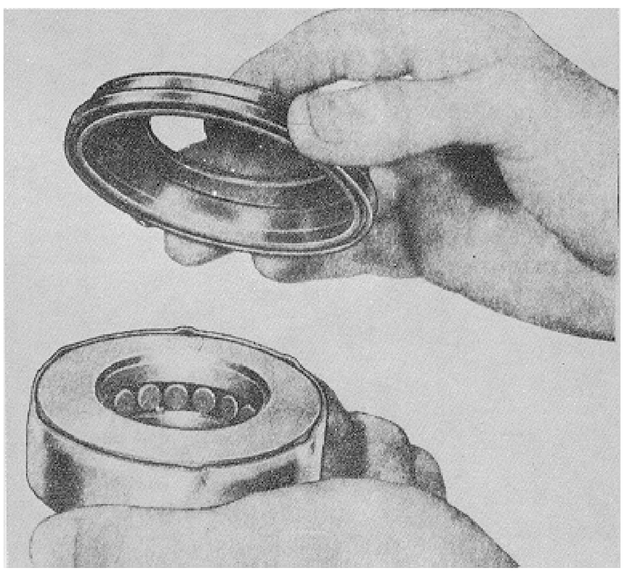


Figure 9D-16. Checking Seal

2. With the knuckle pin hole in the axle center clean and dry, position and support the steering knuckle on the axle.

3. With the seal positioned over the thrust bearing, slide the thrust bearing and lower seal assembly between the lower face of the axle center and the lower knuckle boss, Figure 9D-17.

CAUTION

The bottom side of the thrust bearing must be seated on the face of the lower knuckle yoke. The lower seal must be positioned beneath the bottom face of the axle center.

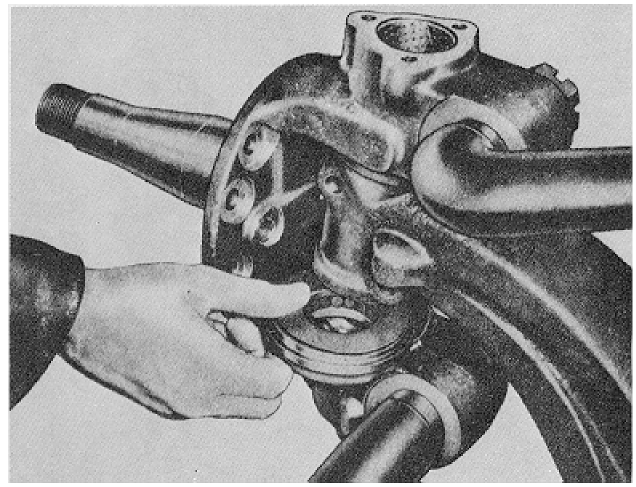


Figure 9D-17. Installing Seal

4. Make certain that knuckle pin hole in axle center is clean and dry.

5. Position and support the steering knuckle assembly on the axle center.

6. Slide the thrust bearing between the lower face of axle center and lower steering knuckle yoke, Figure 9D-18. Thrust bearings that are not marked "top" to indicate proper installation position, must be positioned with retainer lip down.

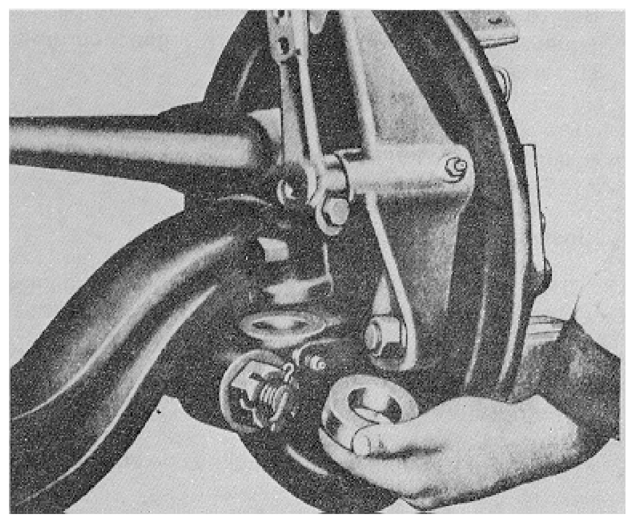


Figure 9D-18. Installing Bearing

7. Align the steering knuckle yoke holes with axle center and thrust bearing holes.

8 lace a jack under the lower side of steering knuckle yoke and raise knuckle so that all clearance is taken up between lower yoke, thrust bearing and lower face of axle center end.

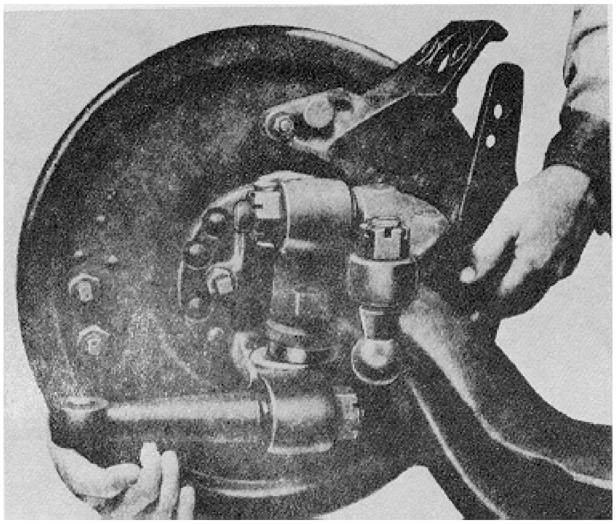


Figure 9D-19. Installing Bearing

CAUTION

Do not strike these hardened steel pieces directly with a steel hammer.

10. Install the draw keys so that the flat on the key mates with the corresponding flat on the knuckle pin.

NOTE

Before setting the draw key, center knuckle pin to equalize gap between upper and lower gap mounting surfaces.

11. Draw keys should be installed one from each side of the axle center. DO NOT INSTALL BOTH KEYS FROM THE SAME SIDE.

12. Install the draw key nuts and tighten.

13. Check the clearance between the top face of upper axle center end and lower face of upper knuckle pin boss. It is not recommended to measure clearance tolerances on steering knuckles with shim gauges (feeler gauge). Use only a dial indicator.

14. Procedure for measurement of knuckle end play when axle is being assembled is as follows:

A. Attach the dial indicator with a "C" clamp or magnetic base to the knuckle spindle such that the knuckle can be turned freely, Figure 9D-20.

B. Place the dial indicator plunger on the exposed end of the knuckle pin so that its line of action is approximately parallel to the knuckle pin center line, Figure 9D-21.

C. Zero the dial indicator.

D. Measure the knuckle clearance (end play) by using a suitable lever to lift the knuckle while observing the dial indicator. Make a note of the measurement, Figure 9D-23.

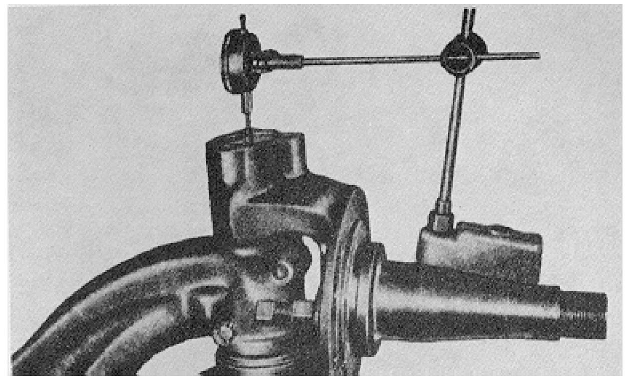


Figure 9D-20. Checking End Play

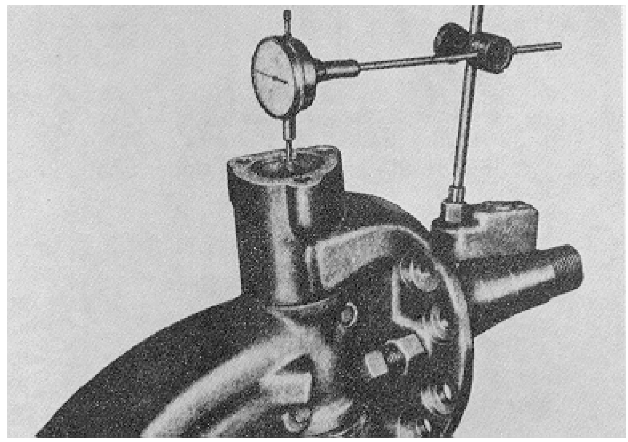


Figure 9D-21. Checking End Play

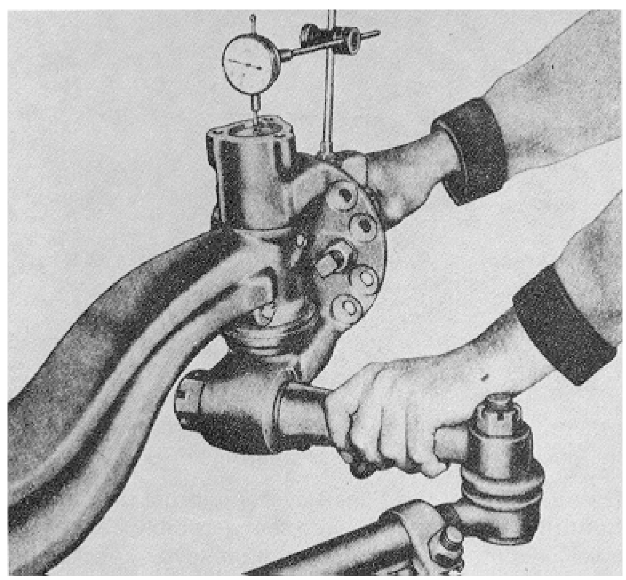


Figure 9D-22. Checking End Play

9. Straight knuckle pin units (steel axle centers): Align knuckle pin flat (or flats) to mate with draw key holes, and tap knuckle pin through knuckle yoke, axle center and thrust bearing from top or bottom side.

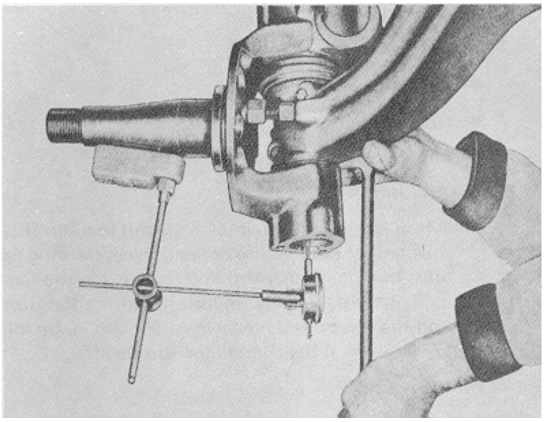


Figure 9D-23. Checking End Play

E. Repeat steps A through D with the knuckle in three positions. The three steering knuckle positions are necessary to obtain true end play reading with the dial indicator.

CAUTION

After measuring knuckle clearance (end play), add shims between upper knuckle pin boss and axle center end, as required, to obtain an end play of .005"-.025" (.1 2-.64mm) through full range of turn.

15. Procedure for measurement of knuckle end play with tire and wheel assembly mounted:

A. Securely block vehicle to prevent rolling.

B. Place a jack under the axle beam as close as possible to the knuckle end being checked and jack the vehicle up until the tire is clear of the floor.

C. Attach a dial indicator to the axle beam with a "C" clamp or magnetic base.

D. Place the dial indicator plunger on top of the knuckle pin cap so that its line of action is approximately parallel to the knuckle pin center line, Figure 9D-24.

E. Zero the dial indicator.

F. Measure the knuckle clearance (end play) by using a suitable lever to lift the knuckle while observing the dial indicator. Make a note of the measurement.

G. Three steering knuckle positions are necessary to accurately measure end play with the dial indicator. The positions are: full right turn, full left turn and the straight ahead position.

16. Specifications are the same for both methods of checking end play.

17. On axles in service, the end play may increase to a maximum of .065" (1.70mm) at which time it will be necessary

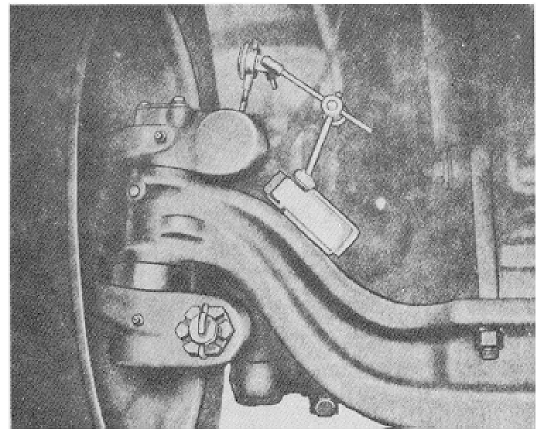


Figure 9D-24. Checking End Play - Axle On Machine

to re-shim end play back to .005"-.025" (.1 2-.64mm). Measure the knuckle clearance again after any shim corrections have been made.

NOTE

Both knuckles should be checked if an increase of end play is detected on either wheel end.

18. Install gaskets and steering knuckle caps at top and bottom of steering knuckle bosses. Install capscrews and lock-washers and tighten to specified torque. Lockwire cap-screws together.

1
9. Install steering arm and ball assembly into uppersteering knuckle boss and tighten steering knuckle nut to specified torque.

20. Install cross tube arm in lower steering knuckle boss and tighten cross tube arm nut to specified torque.

21. Assemble cross tube assembly and cross tube arm, and tighten cross tube end nut to specified torque.

22. Install wheel and hub assembly in reverse order of disassembly. Grease wheel bearings as shown in Figure 9D-25. Use P&H grease 472C.

23. Check wheel alignment and toe-in. See Subsection 10A.

WHEEL BEARING ADJUSTMENT. Adjust wheel bearings as follows:

1. Assemble bearings and hub on the axle spindle.

2. Install thrust washer.

3. Install the wheel bearing adjusting nut. Thread the nut against the thrust washer as the wheel is revolved. Be sure there is sufficient clearance between the brake shoe and drum so brake shoe drag will not interfere with the bearing adjustment.

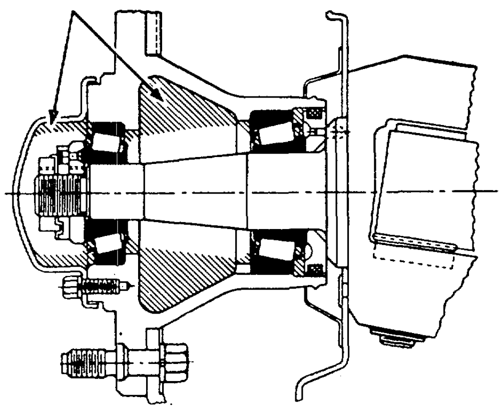


Figure 9D-25. Greasing Front Axle Bearings

NOTE

It is recommended that a torque wrench be employed for assembly of the adjusting nut and jam nut.

4. Tighten the adjusting nut to 50 lb. ft. (68 N.m) torque while rotating wheel in both directions to be sure all bearing surfaces are in contact.

5. Back off adjusting nut 1/6 to 1/4 turn. Assemble jam nut lock and jam nut. Tighten jam nut to 1 50ft-lbs (203 N.m) torque.

Bend the jam nut lock over the jam nut and over the adjusting nut.

6. The resulting end play must be within limits of 0.001 " to 0.010" (0.025 to 0.254mm) loose.

FRONT BRAKE DISASSEMBLY

To disassemble the front brakes, proceed as follows:

1. Remove front wheels and brake drums.
2. Remove shoe return springs.
3. Remove lock rings, retainers and felts from anchor pins.
4. Cut lock wire and remove anchor pin lock screws, Figure 9D-27.
5. Remove anchor pins and shoe assemblies.
6. Remove air chamber mounting stud nuts -and lockwashers.
7. Remove air chamber clevis pin cotter key, clevis pin and air chamber.
8. Remove cam end lock ring and flat washer.

9. Remove slack adjuster lever.

Table 9D-1. Axle Troubleshooting Guide

1. a. Rapid or Uneven Tire Wear
    - Incorrect toe-in setting
    - Improper tire inflation
    - Unbalanced tires
    - Improper steering geometry

   b. Toe-in Control
    - When setting toe-in, it is important to neutralize the component and tire deflections by backing up and then going forward and rechecking the toe-in. This is especially important with radial tires and the check and possible re-set should be followed even if bearing plates are used.

2. Hard Steering
    - Low power steering system pressure
    - Inadequate or improper lubrication of knuckle pins
    - Improper caster

3. Rapid Wear of Cross Tube Ends
    - Inadequate or improper lubrication
    - Improper installation of power steering cylinders
    - Severely contaminative environment
    - Failure of protective rubber boot

4. Bent or Broken Cross Tube. Broken Ball Stud. Bent or Broken Steering Arm or Cross Tube Arm
    - Excessive power steering system pressure
    - Misadjusted power steering cut-off
    - Operational (curbing)

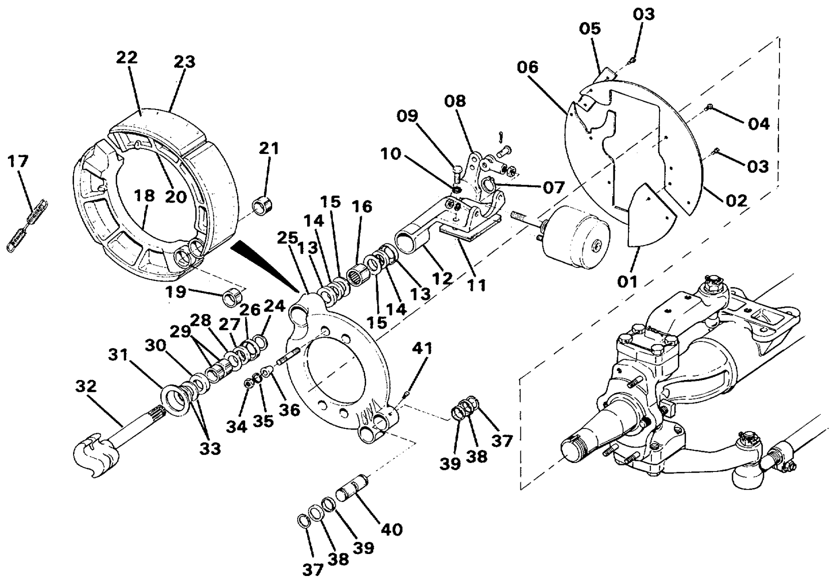
5. Heavily Worn Steering Arm Ballstud
    - Over tightened drag link
    - Inadequate or improper lubrication

6. Excessive Wear of Knuckle Pins and Bushings
    - Improper type of grease
    - Inadequate lubrication frequency
    - Improper lubrication technique
    - Inadequate lubrication frequency due to extreme operating conditions

7. Front Axle Shimmy or Vibration
    - Incorrect caster setting
    - Wheels and/or tires not properly balanced

10. Remove cam by tapping out from rear.

11. Remove chamber bracket mounting cap screws and lockwashers. Remove bracket.



01. DUST SHIELD
02. DUST SHIELD
03. DUST SHIELD CAPSCREW
04. DUST SHIELD CAPSCREW
05. DUST SHIELD
06. DUSTSHIELD
07. SNAP RING
08. SLACK ADJUSTER
09. CAPSCREW
10. LOCKWASHER
11. SHIM
12. CAMSHAFT BRACKET
13. FELT WASHER RETAINER
14. FELT WASHER
15. CAMSHAFT WASHER
16. NEEDLE BEARING
17. SHOE RETURN SPRING
18. SHOE AND LINING
19. BRAKE SHOE BUSHING
20. SHOE AND LINING
21. BRAKE SHOE BUSHING
22. BRAKE LINING
23. LINING RIVET
24. SNAP RING
25. BRAKE SPIDER, L.H.
26. FELT WASHER, RETAINER
27. FELT WASHER
28. CAMSHAFT WASHER
29. NEEDLE BEARING
30. OIL SEAL
31. CAMSHAFT WASHER
32. BRAKE CAMSHAFT
33. SPACING WASHER
34. NUT
35. LOCKWASHER
36. DOWEL
37. SNAP RING
38. RETAINER
39. WASHER
40. ANCHOR PIN
41. STUD

Figure 9D-26. Front Brake Assembly

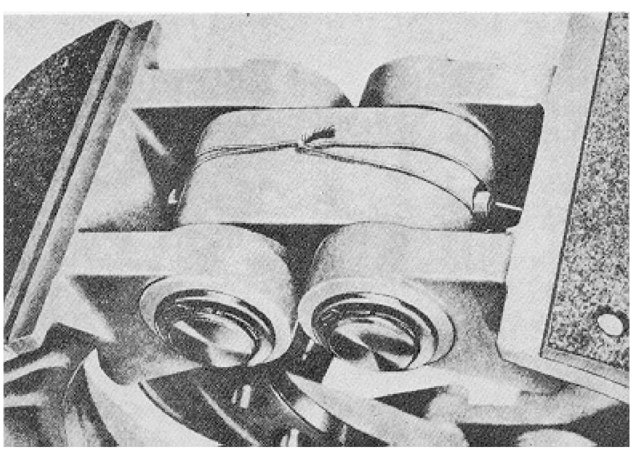


Figure 9D-27. Disassembling Brake

12. Remove needle bearings, only if replacement is to be made, by pressing out with a suitable sleeve.

FRONT BRAKE ASSEMBLY

To assemble the front brakes, proceed as follows:

1. Install new cage and needle bearing assemblies if replacement is necessary.

2. Locate and secure with capscrew and lockwashers the air chamber mounting bracket and tighten capscrews securely.

3. Lubricate needle bearings with lubricant.

4. Install slack adjuster on cam so that shoes are in a fully released position and install cam washer and cam groove lock ring.

5. Mount air chamber on bracket and secure with chamber mounting stud nuts and washers.

6. Connect slack adjusting lever to air chamber pushrod clevis with clevis pin and cotter key.

7. Install brake shoes with anchor pins and secure pins with felts, felt retainers and pin groove locking rings.

8. Install anchor pin locking screws and lock wire.

9 Connect brake shoe return springs, Figure 9D-28.

10. Adjust brakes as explained in Preventive Maintenance Section (Section V) of Operator's Manual.

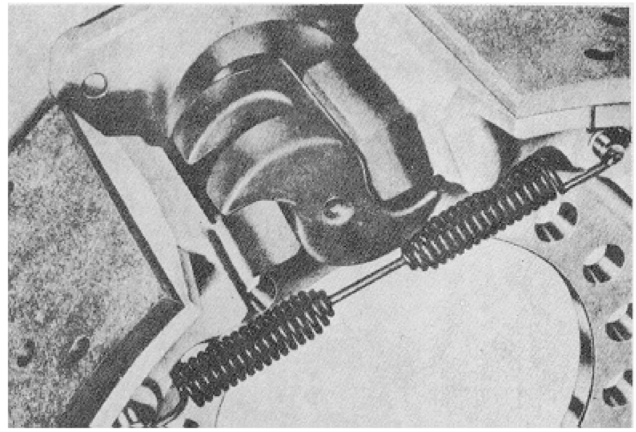


Figure 9D-28. Installing Return Springs

SUBSECTION 9E

PROPELLER SHAFTS

GENERAL

The information contained in this subsection covers the removal, repair, and installation of the propeller shafts. Repair of these propeller shafts is limited to the replacement of the parts furnished in the Service Kits for these propeller shafts. See the Replacement Parts Manual.

PROPELLER SHAFT (10U44)

GENERAL. These propeller shafts are used to connect the rear axles together. The slip joint end of the propeller shaft must always be installed nearest the power source. The slip joint allows for variations in the length of the propeller shaft caused by movement of the connected unit.
REMOVAL. To remove a propeller shaft, proceed as follows (see Figure 9E-1):

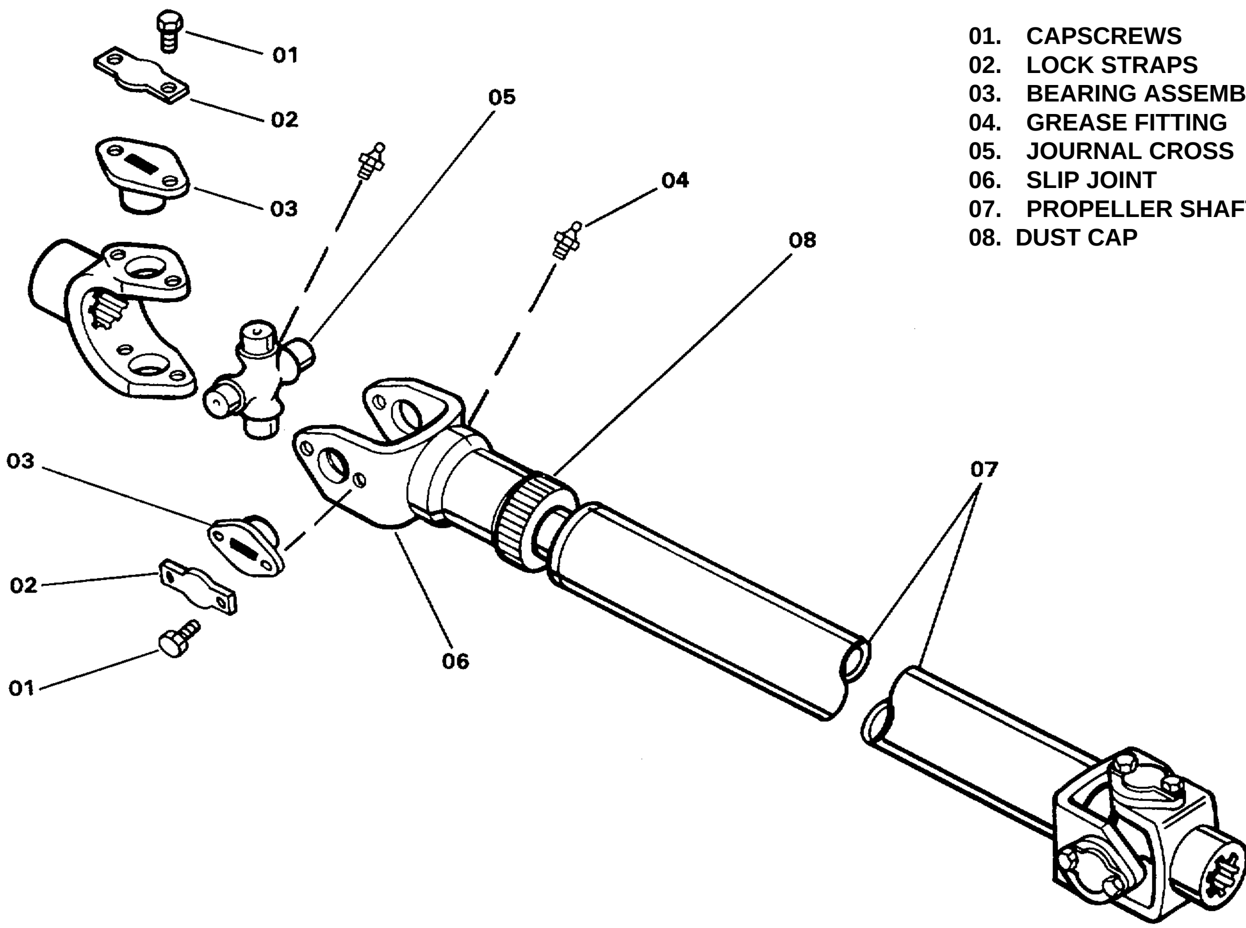
1. Remove capscrews (01), lock straps (02) and bearing assemblies (03) from the yoke at each end of the propeller shaft.

2. Remove the propeller shaft with the journal cross and bearing assemblies.

REPAIR. Repair of the propeller shafts is limited to replacing the journal cross, bearings and lock straps contained in the repair kit. To replace the bearing assemblies, proceed as follows:

1. Remove capscrews (01), lock straps (02) and bearing assemblies (03).

2. Tilt journal cross (05) to one side and remove it from the yoke.



01. **CAPSCREWS**
02. **LOCK STRAPS**
03. **BEARING ASSEMBLIES**
04. **GREASE FITTING**
05. **JOURNAL CROSS**
06. **SLIP JOINT**
07. **PROPELLER SHAFT**
08. **DUST CAP**

Figure 9E-1. Propeller Shaft (10U44)

NOTE

If slip joint (06) is removed from shaft (07), they must be reassembled in the same position. The match marking arrows on the shaft and sleeve must be visible before disassembly. If the arrow marks are not visible, mark both members before disassembling them.

ASSEMBLY. To assemble the bearing assemblies, proceed as follows:

1. Tilt journal cross (05) and insert it in the yoke.

2. Lubricate one set of bearings with multipurpose grease. Insert the bearings from the outside of the yoke. Press or tap the bearing into place with a soft drift punch.

3. Install lock straps (02) and capscrews (01).

INSTALLATION. To install the propeller shaft, proceed as follows:

1. Lubricate the other set of bearings with multipurpose grease. Insert the bearing from the outside of the yoke. Press or tap the bearings into place with a soft drift punch.

2. Install lock straps (02) and capscrews (01).

PROPELLER SHAFT (10U79)

GENERAL. This propeller shaft is used to connect the main transmission to the auxiliary transmission.

The slip joint end of the propeller shaft must always be installed nearest the power source. The slip joint allows for variations in length of the propeller shaft caused by movement of the connected units.

REMOVAL. To remove the propeller shaft, proceed as follows (see Figure 9E-2):

1. Remove the bolts securing the companion flange to the flange yoke at each end of the shaft.

2. Lower the propeller shaft from the carrier as a complete unit.

REPAIR. Repair of the propeller shaft is limited to replacing the journal cross, bearings and lock straps contained in the repair kit. To replace the bearing assemblies, proceed as follows:

1. Remove capscrews (01), lock straps (02) and bearing assemblies (03).

2. Tilt journal cross (05) to one side and remove it from the yoke.

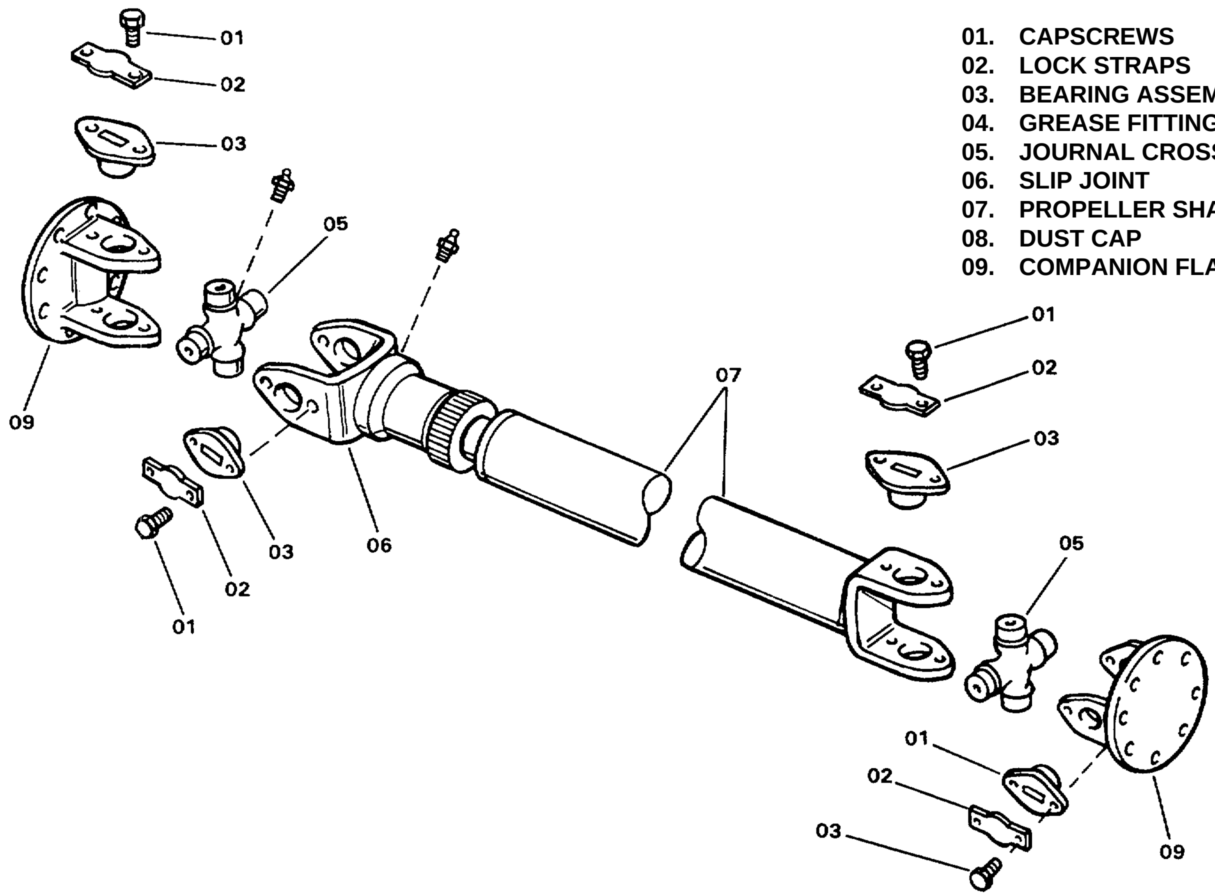


Figure 9E-2. Propeller Shaft (10U79)

NOTE

If slip joint (06) is removed from shaft (07), they must be reassembled in the same position. The match marking arrows on the shaft and sleeve must be visible before disassembly. If the arrow marks are not visible, mark both members before disassembling them.

ASSEMBLY. To assemble the bearing assemblies, proceed as follows:

1. Tilt journal cross (05) and insert it in the yoke.

2. Lubricate one set of bearings with multipurpose grease. Insert the bearings from the outside of the yoke. Press or tap the bearing into place with a soft drift punch.

3. install lock straps (02) and capscrews (01).

4. Repeat steps 2 and 3 for the other set of bearings.

INSTALLATION. To install the propeller shaft, place the propeller shaft between the connected units, and install the companion flange bolts. Tighten the bolts to 65 ft-lbs. (9.0 kg-m).

PROPELLER SHAFTS (10U65 & 10U66)

GENERAL. These propeller shafts are used to connect the auxiliary transmission to the forward rear axle. The major difference between the two is that 10U66 has a center bearing mounting and no slip joint.

REMOVAL. To remove the propeller shaft, proceed as follows (see Figure 9E-3):

1. Remove the bolts securing the companion flange to the flange yoke at one end of the shaft.

2. Remove capscrews (01), lock straps (02) and bearing assemblies (03) from the yoke at the other end of the propeller shaft.

NOTE

On shaft 10U66, remove the two bolts securing the center bearing mount to the frame.

3. Remove the propeller shaft with the journal cross and bearing assemblies.

REPAIR. Repair of the propeller shafts is limited to replacing the journal cross, bearings and lock straps contained in the repair kit. To replace the bearing assemblies, proceed as follows:

1. Remove capscrews (01), lock straps (02) and bearing assemblies (03).

2. Tilt journal cross (05) to one side and remove it from the yoke.

NOTE

On shaft 1 OU65, if slip joint (06) is removed from shaft (07) they must be reassembled in the same position. The match marking arrows on the shaft and sleeve must be visible before disassembly. If the arrow marks are not visible, mark both members before disassembling them.

ASSEMBLY. To assemble the bearing assemblies, proceed as follows:

1. Tilt journal cross (05) and insert it in the yoke.

2. Lubricate one set of bearings with multipurpose grease. Insert the bearings from the outside of the yoke. Press or tap the bearing into place with a soft drive punch.

3. Install lock straps (02) and capscrews (01).

INSTALLATION. To install the propeller shaft, proceed as follows:

1. On one end of the shaft lubricate the other set of bearings with multipurpose grease. Insert the bearing from the outside of the yoke. Press or tap the bearings into place with a soft drift punch.

2. Install lock straps (02) and capscrews (01).

3. On the other end, place the companion flange up to the connected units and install the companion flange bolts.

NOTE

On companion flange 1 OU66, tighten the companion flange bolts (dry) to 65 ft-lbs (9.0 kg-m). On companion flange 10U65, tighten the companion flange bolts (dry) to 240 ft-lbs (33.2 kg-m).

4. On companion flange 1 OU66, secure the center bearing mount to the frame with the capscrews, lockwashers and nuts. Tighten the capscrews (dry) to 20 ft-lbs (2.8 kg-m).

01. CAPSCREWS
02. LOCK STRAPS
03. BEARING ASSEMBLIES
04. GREASE FITTING
05. JOURNAL CROSS
06. SLIP JOINT
07. PROPELLER SHAFT
08. DUST CAP
09. COMPANION FLANGE

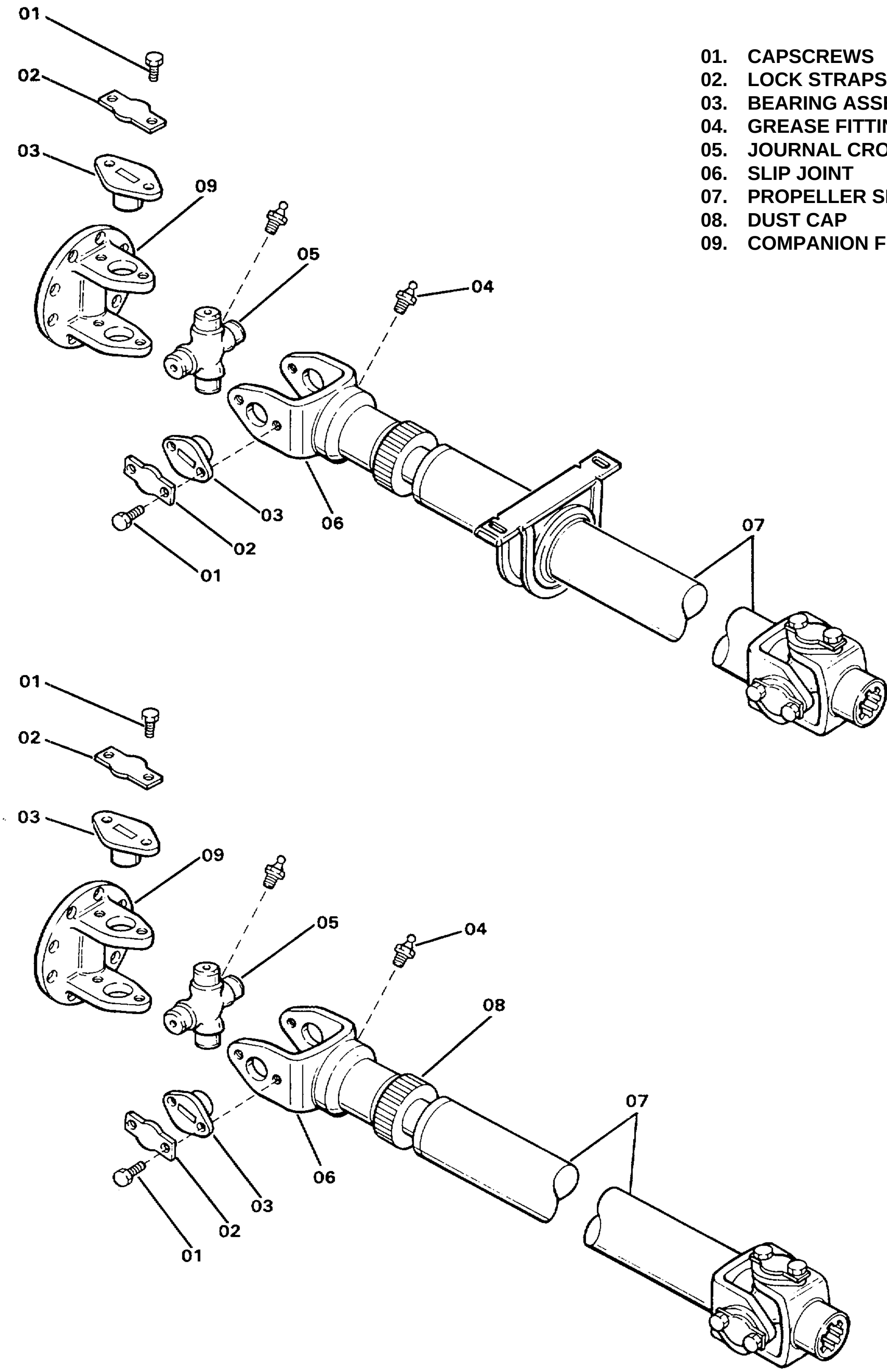


Figure 9E-3. Propeller Shaft (10U65 and 10U66)

SECTION X

OUTRIGGER SYSTEM AND COMPONENTS

SUBSECTION **PAGE**

SUBSECTION 1OA

OUTRIGGER SYSTEM

GENERAL
The outrigger system of this machine consists of devices used to control and actuate the outrigger extension cylinders and the vertical lift cylinders. The components included in this system are the horizontal cylinders, vertical lift cylinders lift cylinder locks and solenoid valves.

On these machines the outrigger system and the power steering system share some components such as the pump, selector valves, and the flow control relief valves. These shared components are covered in Section XI.

Schematics of complete outrigger systems, along with a description of each system's operation, are at the rear of this subsection.

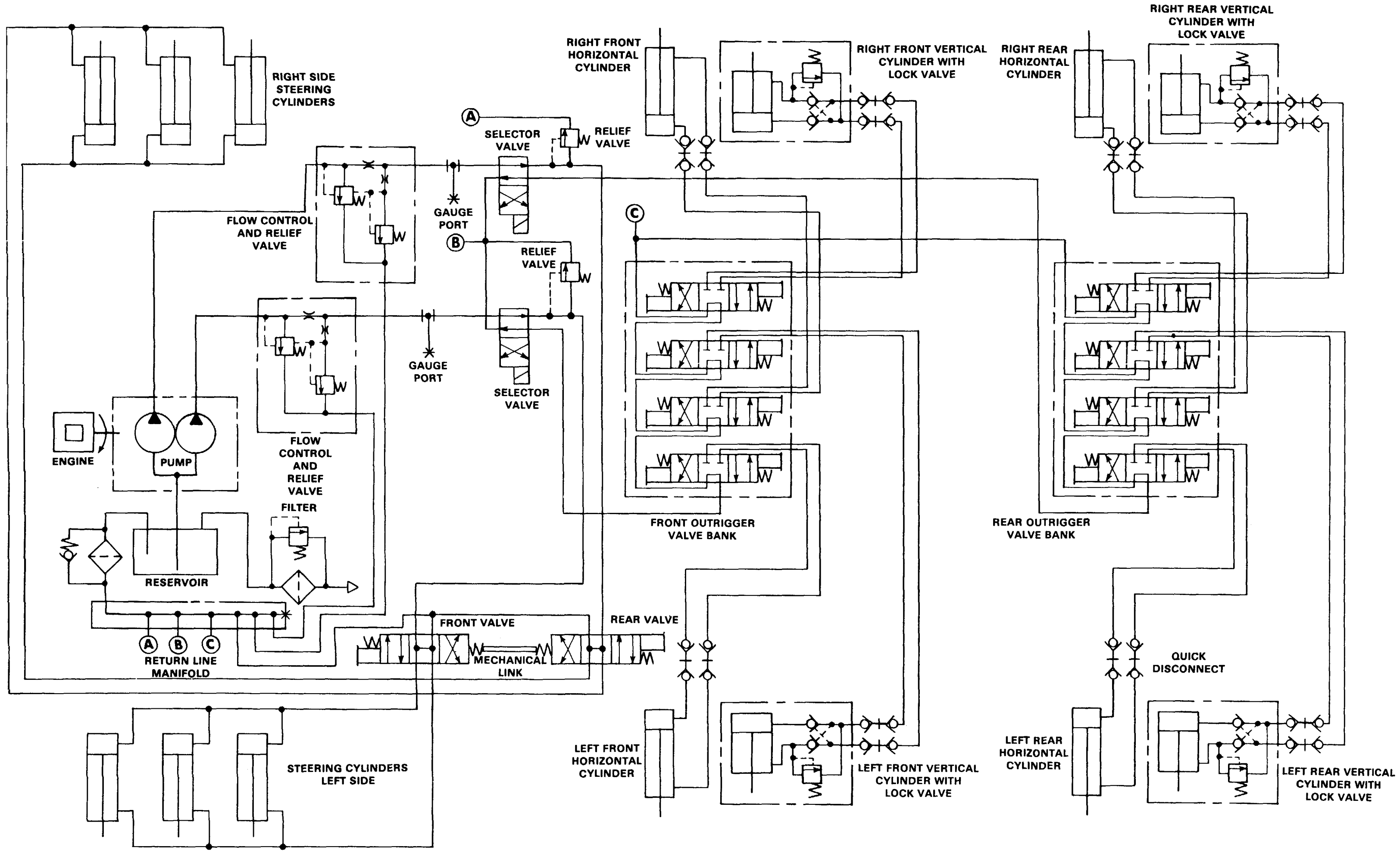
TROUBLESHOOTING
Table 1 OA-1 lists some of the problems which will prevent the outriggers from functioning properly. The troubleshooting chart also lists possible causes and remedies for each cause listed.

Table 10A-1. Outrigger Troubleshooting Chart

TROUBLE	CAUSE	REMEDY
Problem: All outriggers will not raise, lower, extend, or retract.		
1. Insufficient flow to outrigger circuit.	A. Pump not running due to broken driveshaft, or P.T.O. damage.	A. Repair pump and/or P.T.O.
	B. Flow control-relief valve bypassing oil.	B. Replace flow control-relief valve.
	C. Control box power switch malfunctioning and/or broken wire.	C. Replace switch and/or repair broken wire.
	D. Steering/outrigger selector valve faulty.	D. Repair or replace valve.
Problem: Individual outriggers will not raise, lower, extend or retract.		
1. Outrigger solenoid valves not shifting.	A. Faulty solenoid on individual outrigger selector valve.	A. Replace faulty solenoid.
	B. Faulty outrigger control switch.	B. Replace faulty switch.
	C. Broken wire between control switch and individual selector valve.	C. Repair broken wire. Add protective covering to prevent further damage.
	D. Lock valve failure on vertical lift cylinder.	D. Replace lock valve.

Table 10A-1. Outrigger Troubleshooting Chart (Continued)

TROUBLE	CAUSE	REMEDY
Problem: Outriggers will not lift machine.		
1. Insufficient pressure.	A. Worn or damaged pump.	A. Repair or replace pump.
	B. Damaged flow control-relief valve.	B. Replace flow control-relief valve.
	C. Excessive leakage through control valves.	C. Repair or replace control valve.
	D Lock valve failure on vertical lift cylinder.	D. Replace lock valve.
	E. Worn or damaged P.T.O.	E. Repair or replace P.T.O.
Problem: Individual outrigger will not support machine.		
1. Bypassing of oil within vertical lift cylinder.	A. Excessively worn seals. cylinders.	A. Repair or replace outrigger vertical
2. Outrigger lock valve leaking excessively.	A. Excessively worn lock valve.	A. Repair or replace lock valve.



OUTRIGGER/STEERING SYSTEM (8105N88)

These outriggers are hydraulically operated and designed so that each side is independently controlled by means of electric control boxes.

Examination of the hydraulic schematic will show that the same hydraulic pump, driven by a power take-off on the main transmission, is used to supply both the carrier power steering system and the outrigger system. The pump takes supply from the reservoir and discharges to a flow control-relief valve to the steering/outrigger selector valves. With the control box power switch "on" hydraulic fluid will now pass through the supply line to both the front and rear solenoid valve banks, and back to the hydraulic reservoir. No work will be done until one of the solenoid valves is actuated from one of the control boxes.

A998

Figure 10A-1. Carrier Hydraulic Schematic (8105N88)

SUBSECTION 10B

OUTRIGGER VALVES

GENERAL

This subsection is limited to the valves used to operate the outriggers of this machine. This includes such items as solenoid valves and lock valves.

SOLENOID VALVES (36Q75)

DESCRIPTION. The solenoid operated hydraulic outrigger control valves are located in two banks of four valves each. The front outrigger valve bank is bolted to the carrier just to the rear of the main transmission. The rear outrigger valve bank is bolted to the rear of the carrier just inside the removable rear outrigger bracket. Access to both valve banks can be obtained from below the carrier.

The directional control valves, within a valve bank, are three position four-way valves of the sliding spool type. In neutral, oil passes from the inlet of the first control valve through the remaining control valves in the valve bank, and back to the reservoir. Once a switch is depressed, at the outrigger control panel, an electric circuit is completed at the control valve. The control valve spool shifts allowing fluid to pass to a single cylinder port. The opposite cylinder port is opened to the reservoir.

Each control valve consists primarily of a body, a sliding spool, and solenoids which are used to position the spool. The spool is precision fitted to a bore through the longitudinal axis of the control valve body. The lands of the spool divide this bore into a series of separate chambers. Inlet and outlet ports in the control valve body lead into these chambers, so that the position of the spool determines which of the ports are opened and which are closed.

The spool is spring loaded at each end. When the solenoids are de-energized the springs return the spool to the center, or neutral position. The solenoids are energized by a two wire 12 volt DC system.

REMOVAL. It is not necessary to remove a complete valve bank to perform the repairs that are possible on the control valve. The only reason for removing the complete valve bank would be to replace seals between each control valve, or to replace a complete control valve or valves within the valve bank. If removal of the valve bank is not necessary, proceed to the paragraph on repairs. If removal of the valve bank is necessary, proceed as follows (see Figure 10B-1):

1. Disconnect the battery ground cable.

2. Tag and disconnect the electrical wires attached to the solenoids of the valve bank.

3. Tag and disconnect the hydraulic lines attached to each control valve of the valve bank.

4. Cap the hydraulic lines and all ports of the valve bank to prevent the entry of contaminants.

5. Remove the mounting hardware which secures the valve bank to the carrier and remove the valve bankfrom the machine.

REPAIR. Repair of the valves is limited to the replacement of the valve solenoids, guide tube assemblies, and the centering springs. These items can be replaced without removing the valve bank from the machine. Proceed as follows to repair a valve.

1. Disconnect the battery ground cable.

2. Loosen each of the four screws which secure the solenoid to the control valve a little at a time to relieve the spring tension on the nameplate. When the spring force is relieved, remove the nameplate and screws.

3. Slide the solenoid off the guide tube assembly. If only the solenoid is to be replaced, the new solenoid can be installed on the guide tube assembly and secured with the name plate and screws. Be sure to tighten the screws evenly to prevent distorting the guide tube assembly.

If the guide tube assembly is to be replaced, continue with the remaining steps of this procedure.

4. Remove the inner and outer flux sleeves, and the spring between them.

5. Remove the guide tube by pulling it outward with a slight twisting motion. Remove the female cone, if it did not come out with the guide tube, with the same twisting motion.

6. Discard the guide tube, plunger, female cone, push pin, and the O-rings attached to these parts.

7. Position the centering spring on the end of the valve spool.

8. Lubricate the valve body bore and the guide tube assembly with clean, recommended hydraulic oil. Then, install the replacement guide tube assembly with a pushing, twisting motion.

9. Install the solenoid on the guide tube assembly and secure it with the nameplate and screws. Be sure to tighten the screws evenly to prevent distortion of the guide tube assembly.

If it is determined that a complete control valve must be replaced, the following steps should be followed.

10. Remove the valve bank from the machine.

11. Loosen and remove the nuts and studs which position the control valves with respect to each other.

12. Remove the control valve or valves, or seals, to be replaced and position the new valve and seals in the valve bank.

13. Install the studs and nuts in the holes in the four control valves, and torque the nuts to 25 ft-lbs (3.5 kg-m).

INSTALLATION. To install a new or overhauled valve bank on this machine proceed as follows:

1. Position the valve bank on the machine and secure it to the carrier with the original mounting hardware.

2. Reconnect the electrical wires to the solenoids.

3. Reconnect the disconnected hydraulic lines.

4. Reconnect the battery ground cable.

5. Start the engine and operate the outrigger system in all positions to check the operation of the valve bank and to purge any air from the system. Check all hydraulic lines for leakage. Check the level of the hydraulic reservoir. Refill if necessary.

LIFT CYLINDER LOCK VALVE (36U154)

DESCRIPTION. A lock valve located on each outrigger vertical lift cylinder, is used to prevent cylinder movement in either direction, when there is no hydraulic pressure at the lock valve ports. This valve is considered non-repairable. If the valve is faulty the complete valve should be removed and replaced with a new valve.

REMOVAL. f it is necessary to remove the lock valve from the vertical lift cylinder, proceed as follows (see Figure 1 OB- 2):

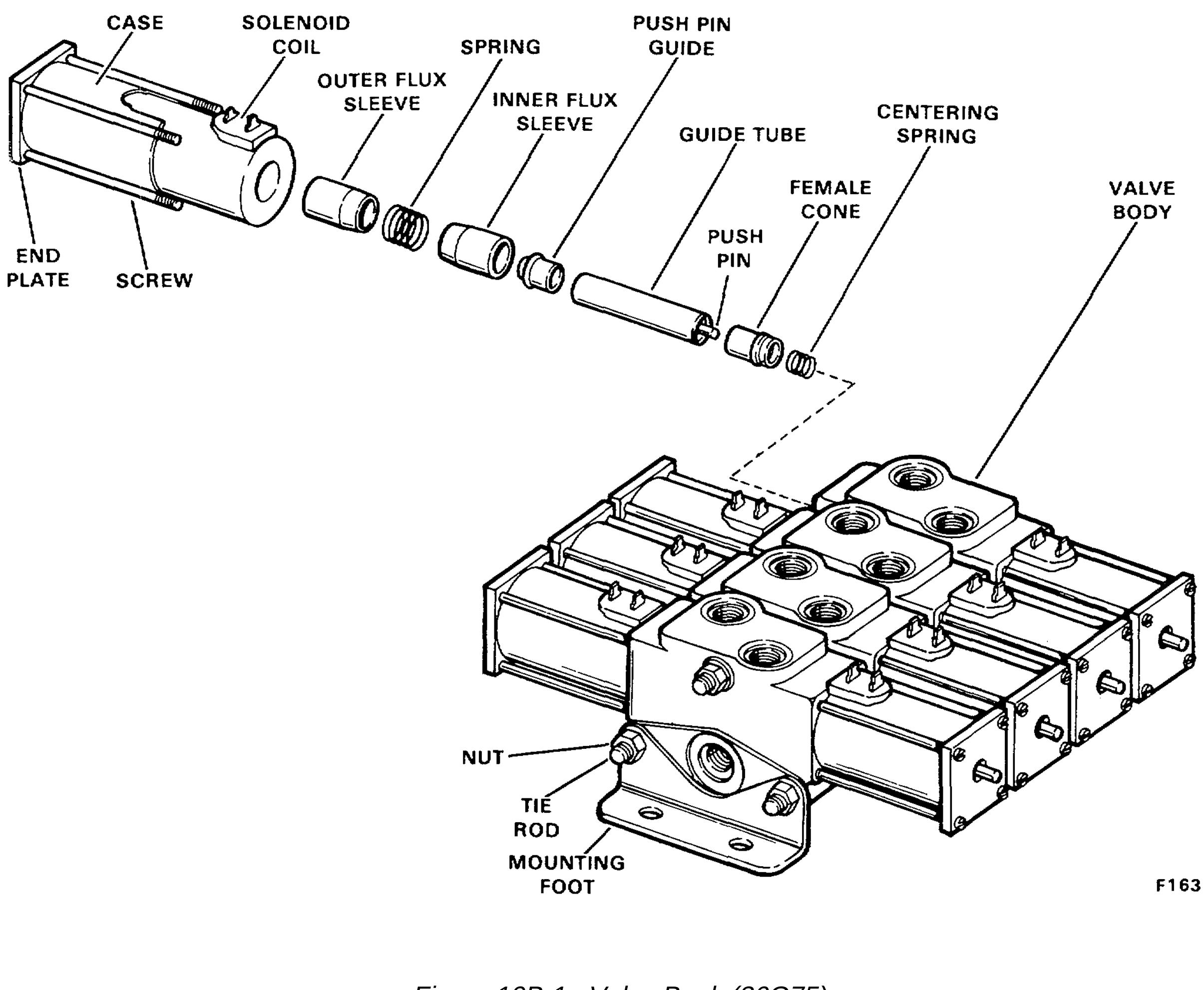


Figure 10B-1. Valve Bank (36Q75)

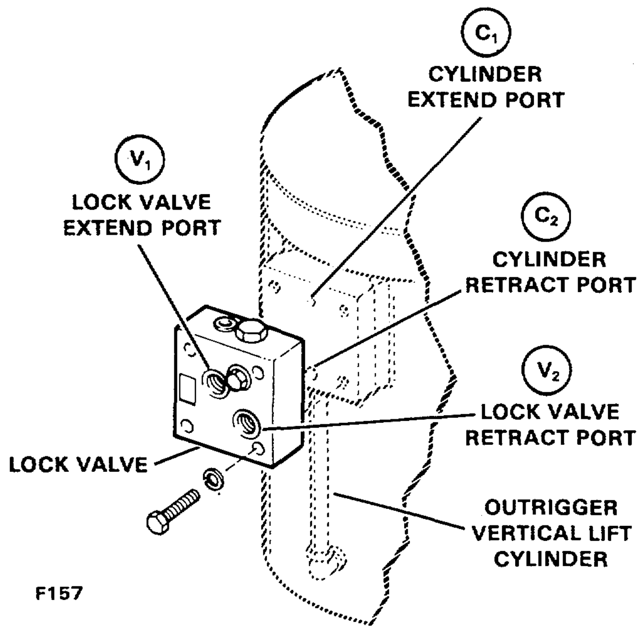


Figure 10B-2. Lock Valve

WARNING

The lock valve is holding the piston rod stationary in whatever position the piston may be in. When the hydraulic pressure in the cylinder is relieved, the piston rod may either extend or retract. Block under the outrigger box to prevent cylinder extension.

1. Stop the engine and tag the hydraulic lines, leading to the lock valve, for future identification.

2. Loosen, but do not remove, the fittings at the lock valve.

3. Tap the fittings lightly to relieve any trapped pressure, and disconnect the fittings.

4. Loosen, but do not remove, the four capscrews which secure the lock valve to the vertical lift cylinder.

5. Tap the lock valve lightly to relieve the pressure within the cylinder.

6. Remove the capscrews and lockwashers, and remove the lock valve.

INSTALLATION. Install a new lock valve to the vertical lift cylinder as follows:

1. Be sure that the O-rings, on the back of the lock valve, are in place and properly seated.
2. Align the lock valve holes to the holes on the vertical lift cylinder.
3. Check that the gauge port is toward the top and secure the lock valve to the vertical lift cylinder with the capscrews and lockwashers.
4. Connect the hydraulic lines to the lock valves.
5. Start the engine and stroke the cylinder completely several times, to bleed the system of any air. Check the lock valve for leaks, and fill the hydraulic reservoir as necessary with a recommended fluid.

OUTRIGGER CYLINDERS

GENERAL

This subsection covers the replacement and repair of the vertical and horizontal cylinders used to operate the outriggers.

DESCRIPTION

This machine has four horizontal cylinders which extend and retract the hydraulic outriggers, and four vertical lift cylinders to raise or lower the machine.

The cylinders are hydraulically operated and double acting. Fluid flow to a pressure port causes the cylinder piston to move away from pressure on one side and force fluid out of the cylinder on the other side.

HORIZONTAL CYLINDER REPLACEMENT

REMOVAL. To remove the horizontal cylinder, proceed as follows (see Figure 10C-1):

1. Stop the engine and tag the hydraulic lines at the horizontal cylinder for future identification.

2. Disconnect the hydraulic hoses at the quick disconnects.

3 Remove the cylinder head end pin, which is secured with cotter pins, and lower the cylinder head end.

4. Pull the outrigger beam out from the outrigger box.

CAUTION

Prior to disconnecting the rod end of the cylinder from the outrigger beam, the cylinder should be blocked to prevent it from falling inside the outrigger beam.

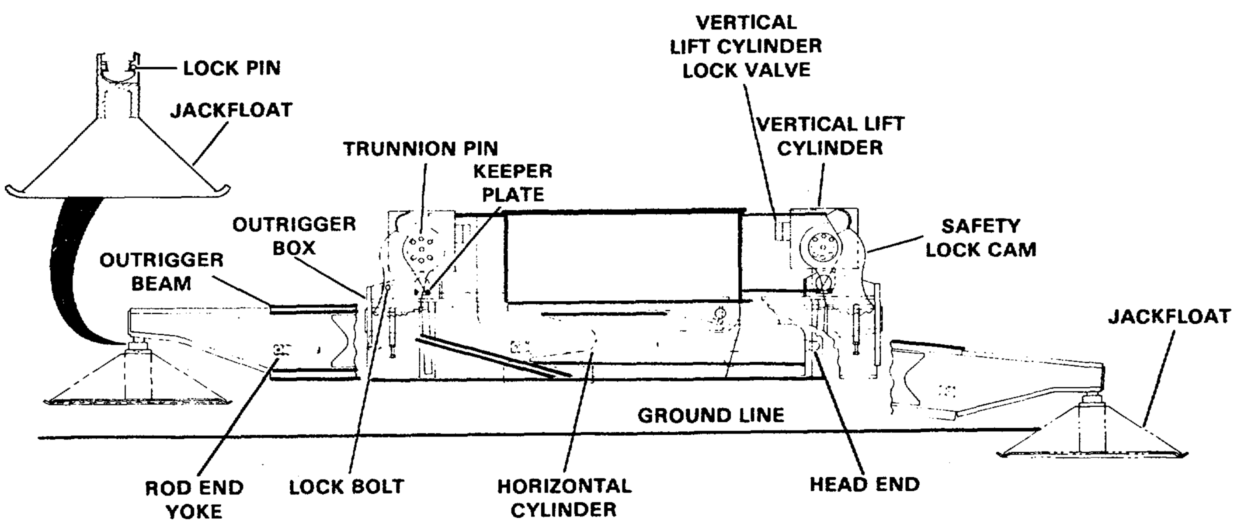


Figure 10C-1. Horizontal Cylinder Removal and Installation

5. Remove the beam-to-yoke pin which connects the cylinder to the outrigger beam, and remove the cylinder from the outrigger box.

NOTE

If the cylinder is being replaced with a new one, proceed to installation. Disassembly of the cylinder is only required for overhaul.

INSTALLATION. To install a new or overhauled horizontal cylinder, proceed as follows (see Figure 10OC-1):

1. Install the yoke to the rod end of the cylinder.
2. Insert the cylinder into the outrigger beam, and pin the yoke to the outrigger beam with the yoke pin.

3. Slide the outrigger beam into the outrigger box, and pin the head end of the cylinder to the outrigger box.

4. Reconnect the hydraulic lines.

5. Start the engine and operate the horizontal cylinder several times to bleed all air from the system. Check the cylinders for leaks, and refill the reservoir with recommended fluid as necessary (see Section III).

6. Remove any blocking from the outrigger beam.

HORIZONTAL CYLINDER OVERHAUL (938J256)

DISASSEMBLY. To disassemble a horizontal extension cylinder, proceed as follows (see Figure 10C-2):

1. Using a spanner wrench, unscrew the rod end bearing from the body.

2. Carefully pull the rod out of the body bore.

3. Remove the nut from the rear of the piston and pull the piston and spacer from the rod. Pull the rod end bearing from the rod.

4. Remove the rod wiper and rod seal from the inside diameter of the rod end bearing. Remove the O-ring and backup ring from the outside diameter of the rod end bearing.

5. Remove the piston seal and O-ring from the piston.

INSPECTION AND REPAIR. After the cylinder has been disassembled clean all parts in a suitable solvent and dry. Pay particular attention to the oil passages in the body to be sure they are clean and free of obstructions.

1. Carefully inspect the inside diameter of the body and the rod end bearing for excessive scoring or pitting.
Inspect the rod for the same defects.

2. Check for burrs on the edges of grooves and ports and remove these defects.

3. Carefully Inspect the body, piston, rod and rod end bearing for cracks. Pay particular attention to welded areas.

4. It is not economical to reuse seals and wear rings Replace these parts with the new ones found in the seal kits.

5. Replace parts which are found damaged.

ASSEMBLY. To assemble the horizontal extension cylinder, proceed as follows (see Figure 10C-2):

1. Thoroughly coat all parts, including seals, with clean hydraulic oil.
2. Place the back-up ring in hot oil or water to make it easier to install. Install the back-up ring in the rod end bearing groove nearest the large diameter end of the rod end bearing. Install the O-ring adjacent to the back-up ring.

3. When properly installed, the seal lips of the rod seal will point towards the small diameter end of the rod end bearing. Pinch the center of the rod seal together and fold the two loops over to meet each other while keeping the seal in its original plane. Do not allow the seal to become twisted. Insert the rod seal in the rod end bearing so that one edge of the seal engages the innermost groove. Slowly allow the rod seal to unfold in the groove.

4. With the wiper lips pointing towards the large diameter end of the rod end bearing, install the rod wiper in the remaining inside diameter groove.

5. Carefully slide the rod end bearing onto the rod while taking every precaution to prevent cutting the rod wiper or rod seal on the rod.

6. Install a new O-ring over the wear ring and into the center groove. Stretch the piston seal and install it over the O-ring.

7. Assemble the spacer and piston over the end of the rod. Install the nut. Torque the nut to 180 ft-lbs (lubricated)

8. Carefully slide the piston and rod into the body bore while compressing the piston seal as it enters the bore.

9. Assemble the rod end bearing to the body with a spanner wrench and torque to 200 ft-lbs.

VERTICAL CYLINDER (100J4481-3)

REMOVAL. To remove a vertical lift cylinder from this machine, proceed as follows (see Figure 10C-3):

WARNING

The lock valve, on the vertical lift cylinder, is holding the cylinder rod and outrigger box in a stationary position. The outrigger. box must be sufficiently blocked to prevent it from falling to the ground when the hydraulic lines are removed.

1. For future identification, tag the hydraulic lines leading to the lift cylinder lock valve.

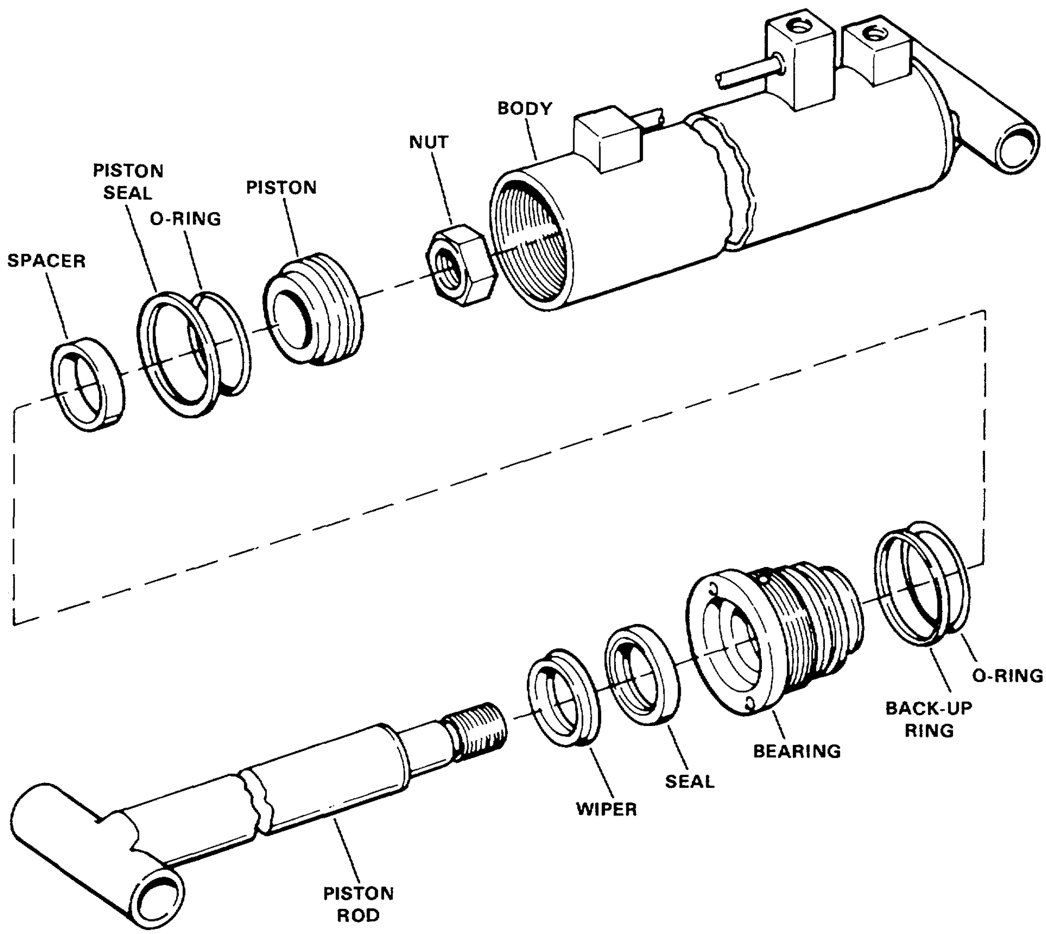


Figure 10C-2. Horizontal Cylinder (938J256)

2. Remove the lines at the quick disconnects.

3. Attach a suitable lifting device to the hooks on the vertical lift cylinder.

4. Remove the capscrews and lockwashers which secure the trunnion pins to the outrigger bracket. Remove the trunnion pins and shims from the outrigger bracket.

5. Remove the capscrews and lockwashers which secure the keeper plate to the outrigger box. Remove the keeper plates. Remove the piston rod pin.

6. Take up slack in the lifting device and remove the vertical lift cylinder. The locking cams will come off with the cylinder when it is removed.

DISASSEMBLY. To disassemble the vertical lift cylinder, proceed as follows (see Figure 10C-4):

NOTE

The lock valve, on the vertical lift cylinder, is not a repairable item. If it is unserviceable it must be replaced. See Subsection 10B.

1. Remove capscrews (16) and lockwashers (17). Pull bearing end (13) off. Remove wiper (15), seal (14), O-ring (11) and backup ring (12) from bearing end (13).

2. Pull rod (10)with piston (14) out of body (01). Unthread piston (04) from rod (10). Remove O-ring (07) and backup ring (08) from rod (10).

3. Remove piston ring (03), piston seal (06) and O-ring (05) from piston (04).

INSPECTION. Inspect the disassembled cylinder for evidence of excessive wear or scoring. Inspect all parts for cracks or distortion. Replace parts which are questionable and renew all seals and O-rings.

If cylinder body (01) is being replaced, retain the lock valve for future use.

ASSEMBLY. To assemble the vertical lift cylinder, proceed as follows (see Figure 1OC-4):

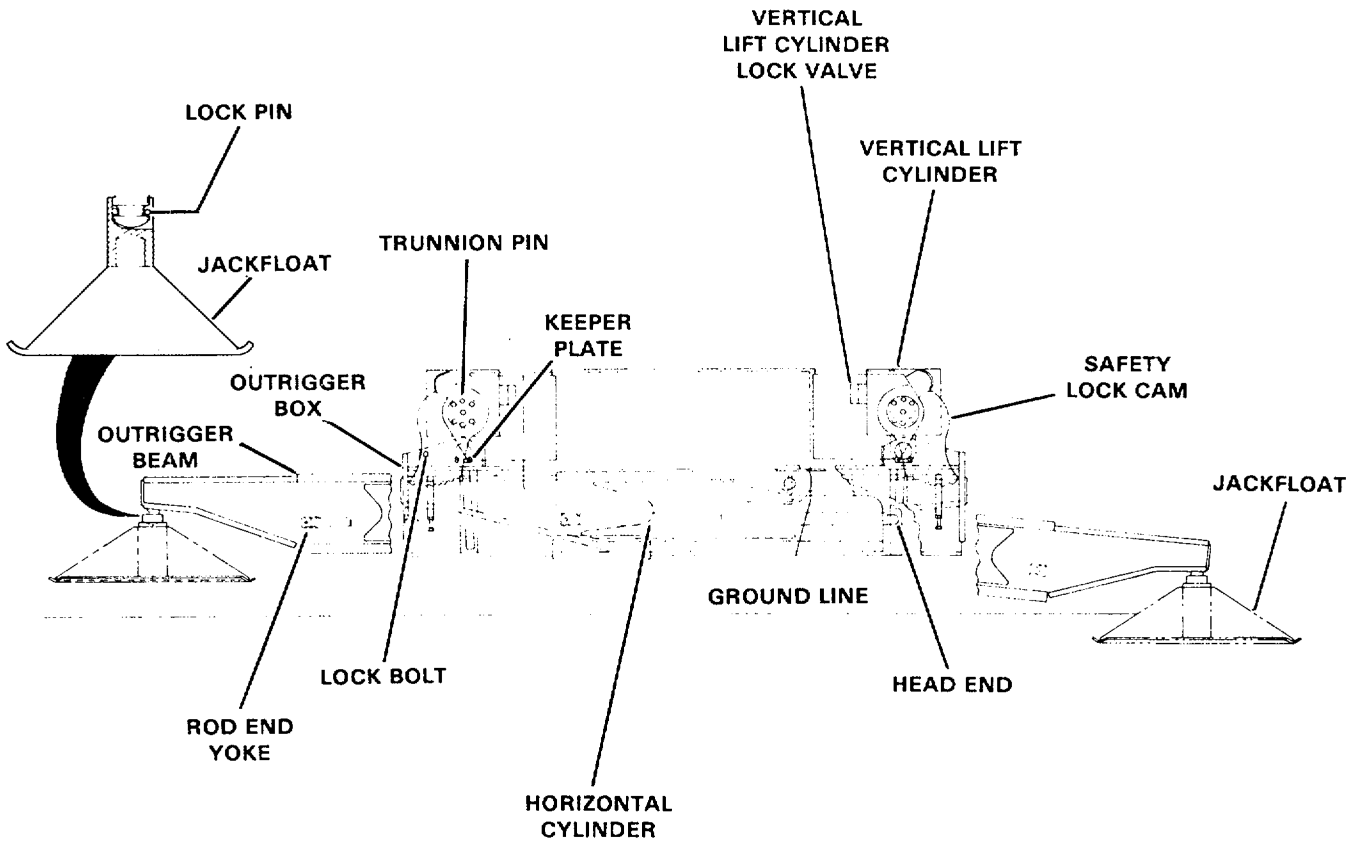


Figure 10C-3. Vertical Cylinder Removal and Installation

1. Install piston ring(03), O-ring(05)and piston seal (06) on piston (04).

2. Install backup ring (08) and O-ring (07) on rod (10). Thread piston (04) on rod (10).

3. Coat all parts and seals with clean hydraulic oil. Slide piston (04) with rod (10) into cylinder body (01).

4. Install backup ring (12), O-ring (11), seal (14) and wiper (1 5) on bearing end (13). Coat the parts with clean hydraulic oil.

5. Install bearing end (13) into cylinder body (01). Install lockwashers (17) and capscrews (1 6). Tighten capscrews (16) to 90 ft-lbs (12.4 kg-m).

INSTALLATION. To install a new or overhauled vertical lift cylinder, proceed as follows (see Figure 10C-3):

1. Use a suitable lifting device, attached to the hooks on the cylinder, and lift the cylinder into place. Set the lockplates on the sides of the cylinder.
2. Attach the piston rod to the outrigger box with the piston rod pin and fasten the pin to the box with the keeper plate, lockwashers and capscrews.

NOTE

The cylinder body must be free to pivot when the trunnion pins are installed. Shim the trunnion pins as necessary so the cylinder does not bind.

3. Place a suitable amount of shims on each trunnion, and insert the trunnions in the outrigger bracket holes until they engage the trunnion holes in the cylinder.

4. Fasten the trunnion pins securely to the outrigger bracket with the lockwashers and capscrews originally removed.

5. If the lock valve was removed from the cylinder body at disassembly, reinstall it at this time. Be sure that O-rings are installed in the recesses of the lock valve.

6. Reconnect the hydraulic lines to the lock valve.

7. Start the engine and operate the vertical lift cylinders several times to bleed all air from the system. Check the cylinder for leaks or binding.

8. Check the hydraulic reservoir and refill, if necessary, with the recommended fluid. See Section III.

01. BODY
02. BUSHING
03. PISTON RING
04. PISTON
05. O-RING
06. PISTON SEAL
07. O-RING
08. BACKUP RING
09. SCREW
10. ROD
11. O-RING
12. BACKUP RING
13. BEARING END
14. SEAL
15. WIPER
16. CAPSCREW
17. WASHER
18. NAMEPLATE

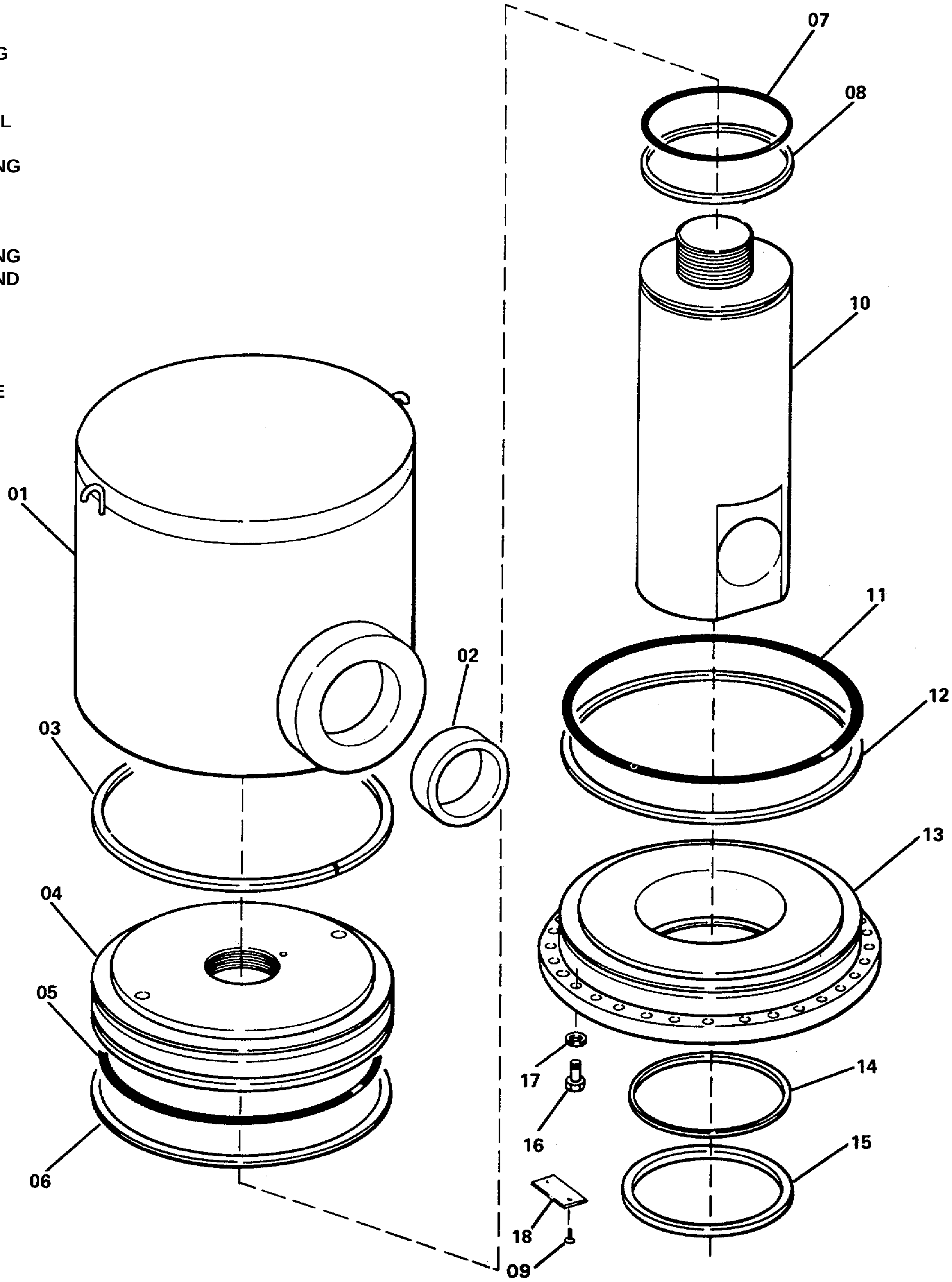


Figure 10C-4. Vertical Cylinder (1 00J4481-3)

SECTION XI.

POWER STEERING SYSTEM AND COMPONENTS

SUBSECTION 11A

POWER STEERING SYSTEM

GENERAL

The power steering system of this machine consists of the devices to control and actuate the steering mechanism. The components included in this system are the pumps, power take-offs, flow control valves, selector valves, relief valves, steering valves, filters, steering cylinders and steering gear units.

Schematics of complete power steering systems, along with a description of each system's operation, are at the rear of this section.

WHEEL ALIGNMENT

GENERAL. To obtain the best tire life and proper steering of the carrier, two types of alignment must be checked and maintained for the front wheels. The wheels on each axle must be adjusted so that they "toe in" to prevent the vehicle from wandering when steering in a straight ahead position on the highway.

In addition, parallel wheel alignment must be set so that the wheels on both axles are as nearly parallel to each other, relative to the centerline of the carrier, as possible. This adjustment is necessary to assure that the machine will track properly in the straight ahead position.

If the tires begin to show signs of excessive or uneven wear, and they have been maintained at the proper inflation pressure, check the alignment of the wheels as described below.

NOTE

> Toe-in must be adjusted properly before adjusting parallel alignment. All tires must be inflated properly, and matched in outer diameter, for the following adjustments must be made with the wheels set to steer in a straight ahead position, since the wheels turn at slightly different angles.

TOE-IN ADJUSTMENT. The recommended toe-in for this carrier is 1/16 inch (1.58 mm) + 1/16 inch (1.58 mm). To check and adjust the amount of toe-in, proceed as follows (see Figure 11A-1):

1. Place the carrier on flat, level concrete surface, and jack up the front of the carrier.

2. Whiten the center of the tread area of all the tires, around the circumference, with chalk. Scribe a straight line through the chalk, around the circumference of each tire, by positioning a scribe or other pointed instrument against the whitened area of the tire, and rotating the tire. Be sure to hold the scribe firmly in place.

NOTE

> Do not measure toe-in with the front axles jacked up. Toe-in must be measured with the weight of the carrier on the axles, so that the tires are in their normal loaded positions.

4. Measure the distance between the scribed lines at the rear of the tires on the front axle at the height of the hubs, using a trammel bar or other suitable measuring device. Measure the distance between the same lines at the front of the tires. Subtract the front measurement from the rear measurement to obtain the amount of toe-in.

5. If adjustment is necessary, loosen the tie rod clamps at both ends. Rotate the tie rod until the required toe-in is obtained. Tighten the tie rod clamps.

6. Repeat steps 4 and 5 to check and adjust the toe-in of the other axles.

7. Move the carrier backward and then forward approximately six feet. Recheck the toe-in as described above, and readjust if necessary.

PARALLEL WHEEL ALIGNMENT. Parallel wheel alignment is adjusted by means of the parallel adjusting links shown in Figure 1 1A-1. To adjust the parallel alignment, proceed as follows:

1. Checkt he alignment of the wheels on one axle relative to the wheels on the other axle, using a long straight edge. The wheels should be as nearly parallel to each other as possible.

2. If necessary, adjust the length of the parallel adjusting link in small increments. It may be necessary to loosen the adjusting link clamps. After each adjustment run the carrier backward and then forward over at least one full tire revolution, so that the wheels assume their normal driving positions. Retighten the adjusting link clamps.

IMPORTANT

B MINUS A EQUALS TOE-IN
TOE-IN RECOMMENDATION IS
1/16" (1.58 mm)+ 1/16" (1.58 mm)

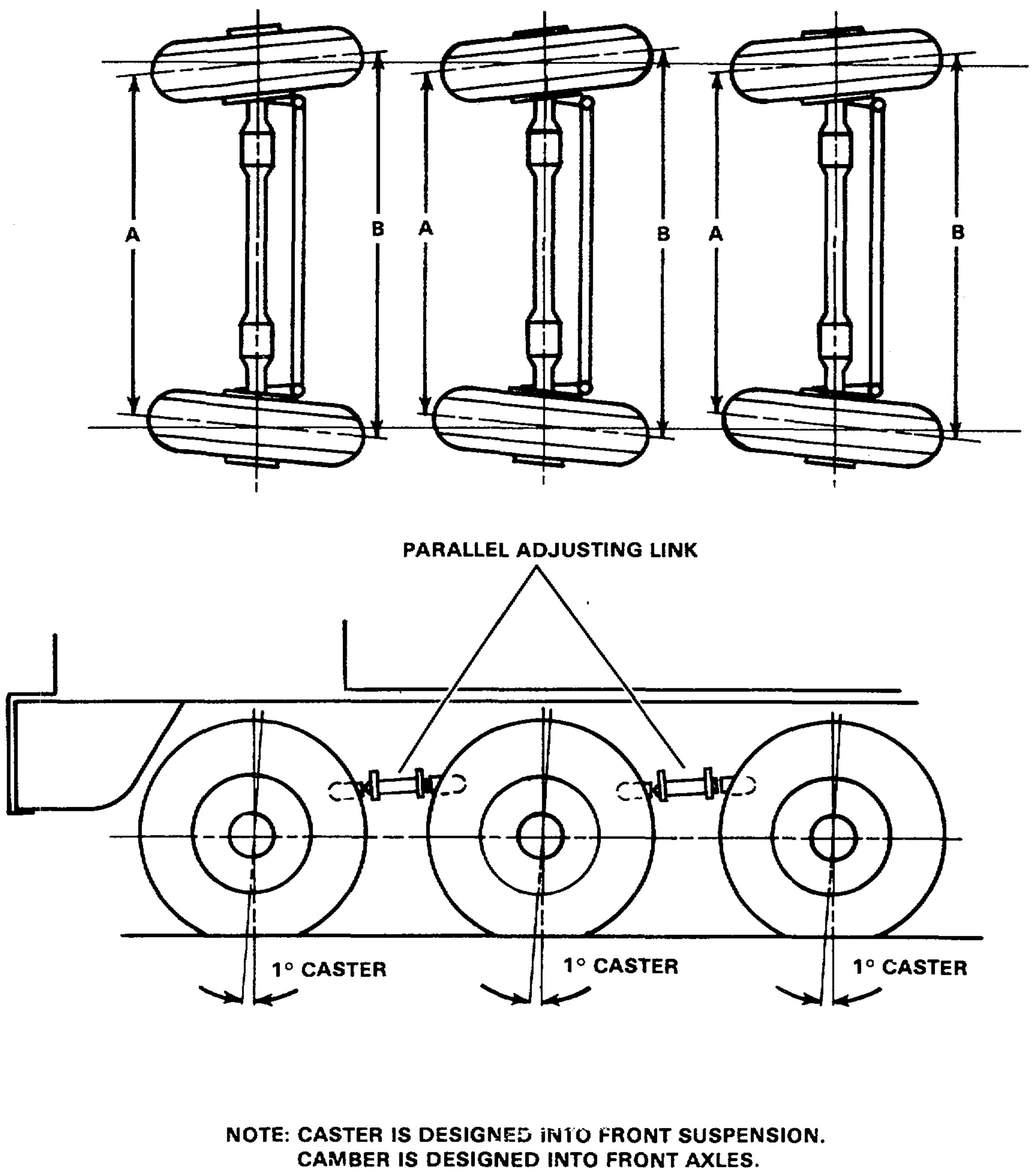


Figure 11A-1. Wheel Alignment

PITMAN ARM AND AXLE STOP ADJUSTMENTS (81OOJ1427)

GENERAL. The pitman arm stops should be adjusted so that maximum steering arm travel is limited by the pitman arm stops and not by the front axle stops. Maximum steering arm travel should allow the front axle stop bolts to come within 1/8 inch (3.22 mm) of the axle stop.

Machines which experience bending of the steering cylinder rods and/or tie rods, should be inspected and adjusted as follows (see Figure 11A-2):

1. Loosen the axle stop locknut and screw the axle stop bolt in, so that the axle stop bolt does not interfere with the adjustment of the pitman arm stops.

2. With the road wheels in the straight ahead position, turn the steering wheel 2-1/2 turns in a clockwise direction. Then adjust the pitman arm stop so that pitman arm travel is limited to 2-1/2 turns in a clockwise direction.

3. Turn the steering wheel 5-1/2 turns counterclockwise and adjust the other pitman arm stop. The total number of steering wheel revolutions, from fully clockwise to fully counterclockwise, should not exceed 5-1/2 turns.

4. With the road wheels facing straight ahead, check the location of the steering cylinder clamp to be sure that it is located at the point indicated in Figure 1 1A-2.

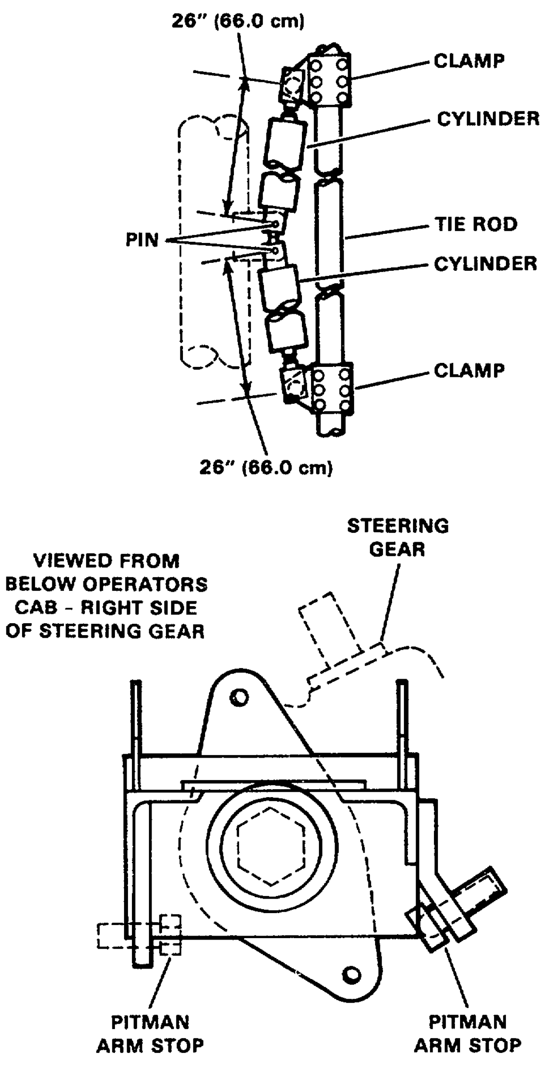


Figure 11A-2. Pitman Arm and Axle Stop Adjustments

5. Turn the steering wheel fully clockwise, and adjust the axle stop bolt until it is 1/8 inch (3.2 mm) from the axle stop. Turn the steering wheel fully counterclockwise and repeat the procedure for the other axle stop bolt.

CAUTION

Under no circumstance should the axle stop bolt come into contact with the axle stop when the road wheels are turned fully in either direction.

GENERAL MAINTENANCE

The hydraulic oil used in this system should be inspected occasionally for evidence of dirt, sludge, or water. If there is any evidence of dirt in the system, it should be flushed immediately and refilled with clean hydraulic oil. The in tank strainer and the high pressure filter should be removed and cleaned in kerosene or gasoline. Dip the strainer in clean hydraulic oil before replacing it in the tank.

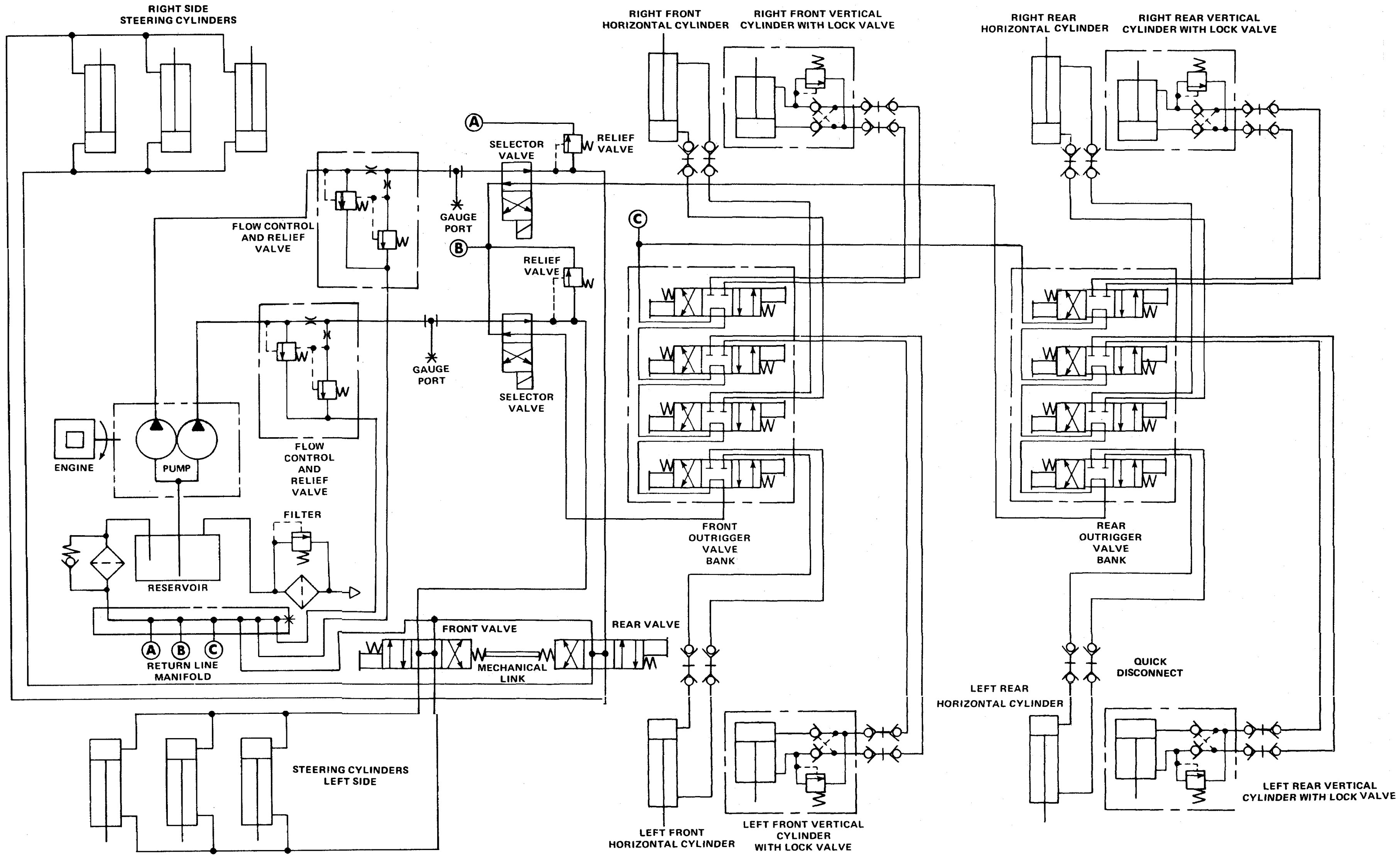
To change oil in the drag link valve and steering cylinder system, proceed as follows:

1. Drain the reservoir completely and fill with clean hydraulic oil. Start the engine and turn the steering wheel from full right to full left several times to circulate the fluid throughout the system. Also operate the outrigger lift and extension cylinders to circulate fluid throughout that system.

2. Stop the engine and drain the reservoir a second time. Clean the tank, strainer, and high pressure filter. Refill the reservoir with clean hydraulic fluid. Start the engine and circulate the fluid through the system by turning the steering wheel and operating the outrigger lift and extension cylinders.

3. Repeat this procedure until all dirt, sludge, or water is removed from the hydraulic system.

4. When all evidence of dirt, sludge, or water has been removed from the system, stop the engine and add hydraulic fluid. To bleed the system, loosen the pressure connections at the highest point in the system.



SYSTEM DESCRIPTIONS

COMBINED STEERING/OUTRIGGER TANK WITH DRAG LINK VALVES AND STEERING CYLINDERS (8100J1427)

This power steering system is of the power assist type, wherein steering motion is mechanically transmitted to drag link valves, which direct the flow of hydraulic fluid to the hydraulic cylinders to turn the wheels. The carrier is furnished with two steering cylinders for each steering axle. Operation of the system is as follows (see Figure 11A-3):

1. The dual pump dishcharges through flow control and relief valves to electrically operated selector valves. These valves select either the power steering system or the hydraulic outrigger system for operation by directing the hydraulic fluid to the proper circuit.

2. Since the selector valves are spring held in the power steering mode, the selector valve directs fluid to a relief valve. When pressure in this circuit reaches the internal setting of this valve, all fluid flow will be directed back to the tank.

3. When the operator turns the steering wheel, mechanical force is transmitted from the steering gear to the drag link valves. This force moves the internal parts of the drag link valves into position so that fluid passes through the valves to the power steering cylinders, thus turning the wheels in accordance with the distance the operator turns the steering wheel.

4. The drag link valves will automatically center themselves and thereby shut off the flow of hydraulic oil to the steering cylinders as soon as the operator stops turning the wheel.

A999

Figure 11A-3. Hydraulic System (8105N88)

SUBSECTION 11 B
POWER TAKE OFFS AND PUMPS

GENERAL

This subsection will cover the power take offs and pumps used to supply hydraulic fluid to the combined outrigger/steering systems.

POWER TAKE OFF (832T186)

GENERAL. This power take off unit is used to drive the dual hydraulic pump which supplies hydraulic fluid to the combined steering/outrigger system. The power take off unit is mounted on the right hand side of the main transmission.

REMOVAL. To remove the power take off assembly, proceed as follows:

1. Drain the reservoir.
2. Tag and remove the lines to the hydraulic pump. Remove the pump from the power take off unit by removing the mounting bolts.
3. Loosen the bolts securing the power take off to the main transmission and remove the power take off unit.

DISASSEMBLY. To disassemble the power take off proceed as follows:

NOTE

Numbered items in the following steps refer to Figure 1 1B-1.

1. Remove capscrews (05) and remove cover (12). Discard gasket (14).

01. HOUSING	12. COVER
02. SHAFT	13. THRUST WASHERS
03. GEAR	14. GASKET
04. GEAR	15. SET SCREW
05. CAPSCREW	16. BEARINGS
06. SPACER	17. CAPSCREW
07. IDLER PIN SHAFT	18. GASKET
08. SPACER	19. BEARING RACE
09. OPEN BEARING CAP	20. BEARING
10. CLOSED BEARING CAP	21. BEARING
11. GASKETS	22. SNAP RING

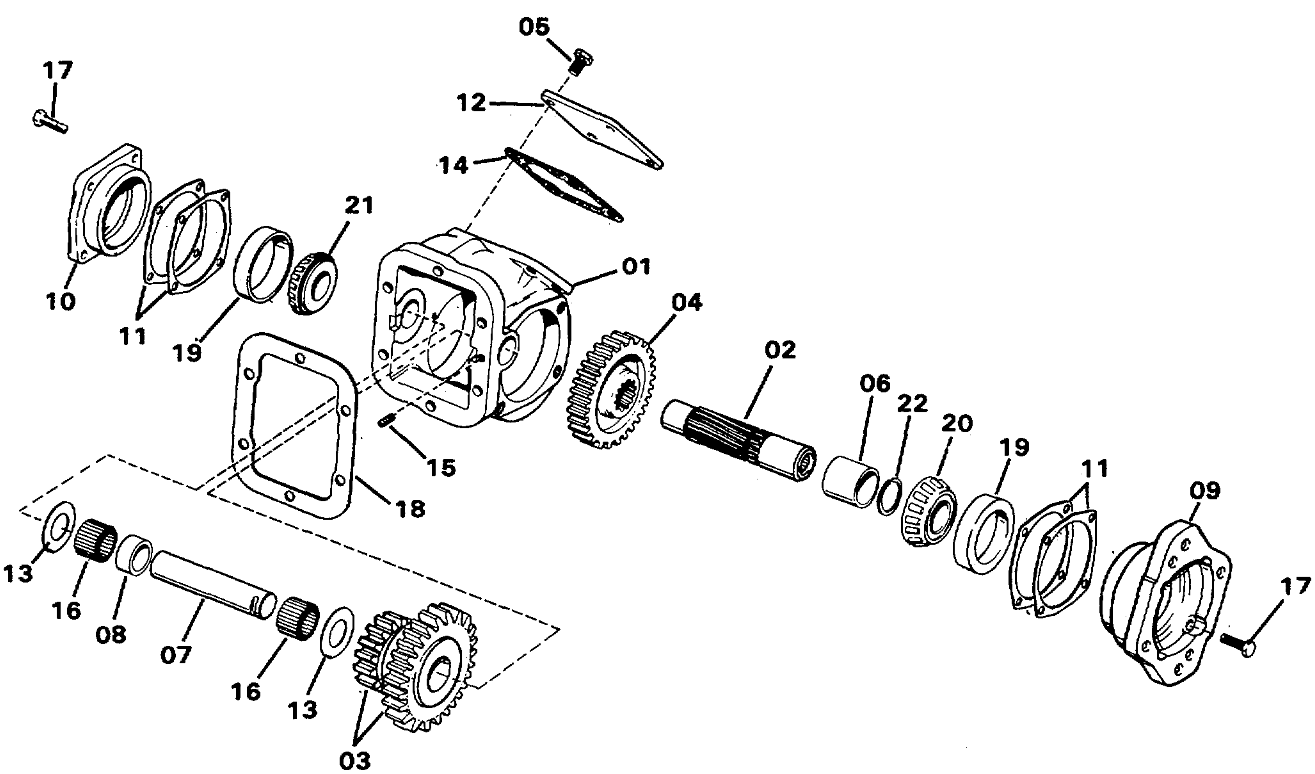


Figure 11B-1. Power Take Off

2. With 1/8" allen wrench, remove alien screw (15) from base of housing. See Figure 11B-2.

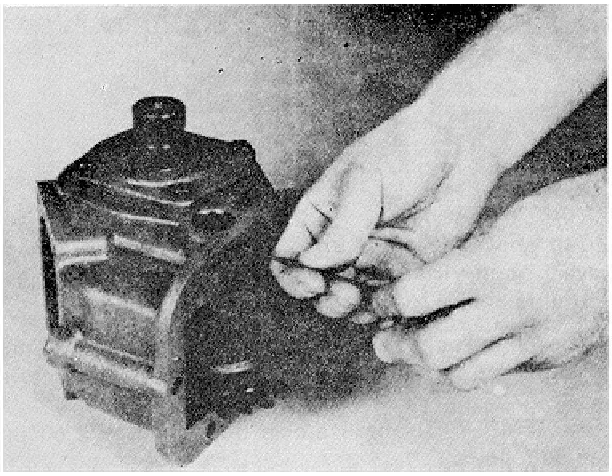


Figure 11B-2. Removing Allen Screw

3. Using a suitable piece of bar stock or a punch, drive idler pin shaft (07) through housing using a soft hammer or press. See Figures 11 B-3 and 11 B-4.

NOTE

The PTO has a pressure lube pin, plug will have to be removed.

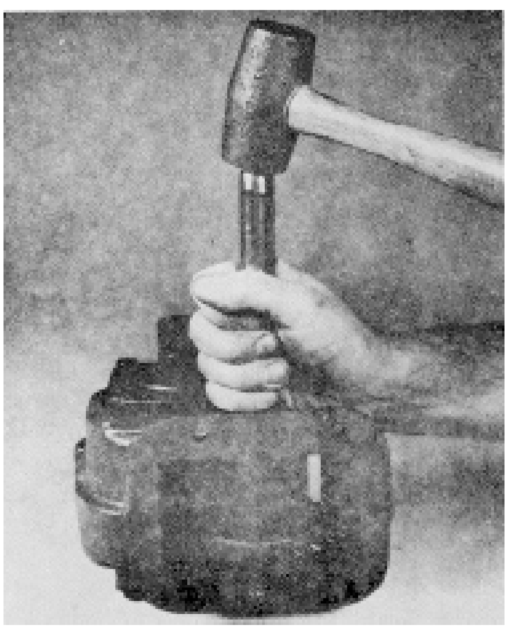


Figure 11B-3. Driving Idler Pin Shaft

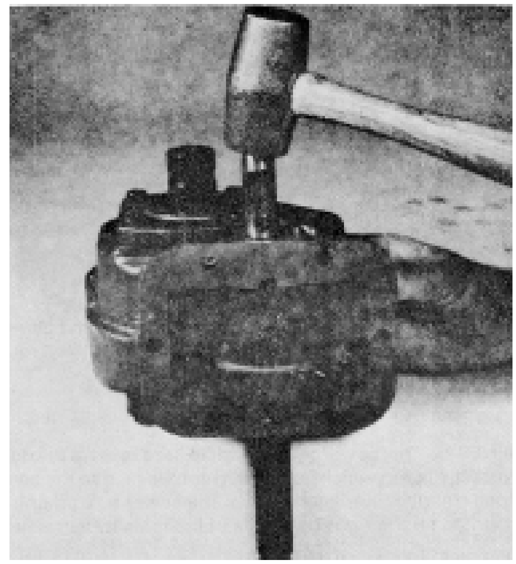


Figure 11B-4. Driving Out Shaft

4. Remove gear (03) and washers (13) from housing. Bearings (16) and spacer (08) can also be removed from the input idler gear so they can be cleaned, inspected and repacked with new bearing grease, Figure 11B-5.

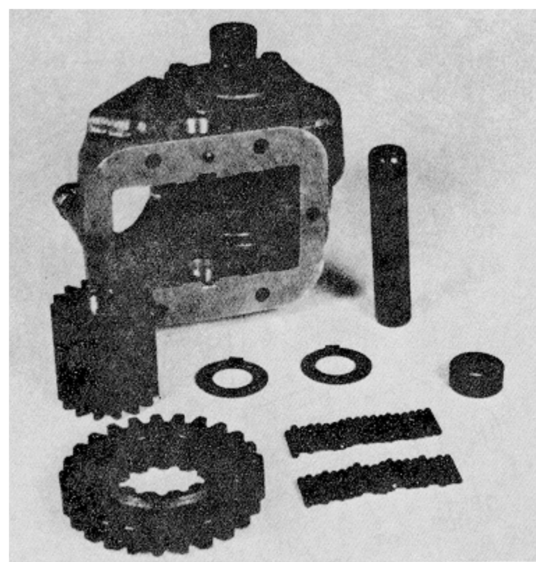


Figure 11B-5. Input Components

5. Set PTO on its side (output shaft up)and unbolt four capscrews (17) and remove open bearing cap (09). Discard gaskets.

6. Turn PTO over and proceed as in step 5 removing closed bearing cap (10). See Figures 11 B-6 and 11 B-7.

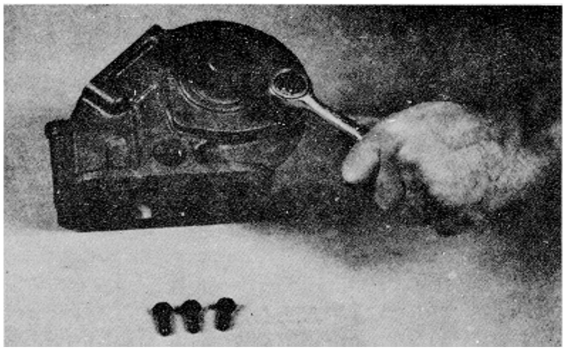


Figure 11B-6. Removing Closed Bearing Cap

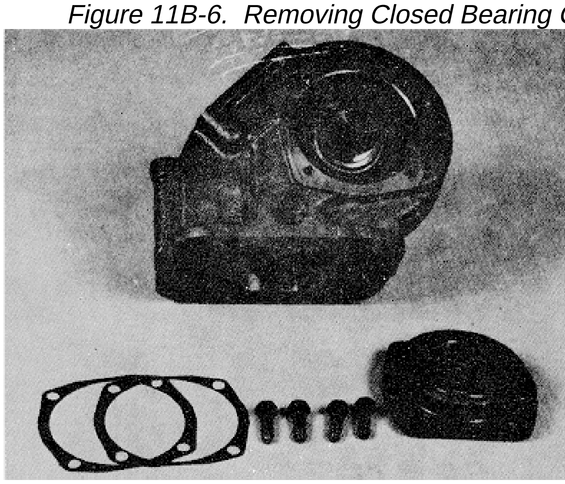


Figure 11B-7. Closed Bearing Cap Components

7. Using bearing pullers, remove bearing (21) from shaft (02). Figure 11B-8.
8. Remove snap ring (22) using a chisel and hammer, Figure 11B-9.
9. After removing shaft (02), gear (04) and spacer (06) will simply fall out of the housing, Figure 11 B-10.
10. Inspect all parts for excessive wear or other damage. All gaskets and seals should be discarded and all milled surfaces on the housing should be cleaned of any excess gasket material.

ASSEMBLY. To assemble the power take off, proceed as follows:

NOTE

Numbered items in the following steps refer to Figure 11 B-1.

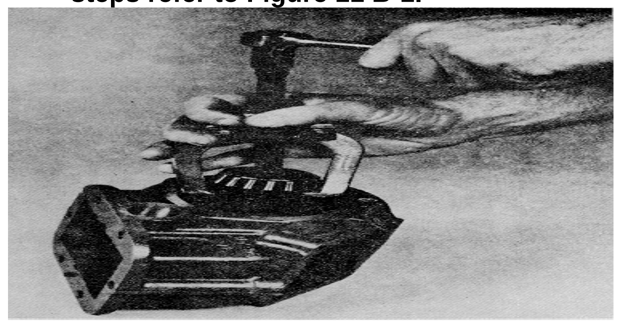


Figure 11B-8. Removing Bearing

1. Place output gear (04) in housing (01). See Figure 11 B-11.
2. Install shaft (02) through gear (04). Install spacer (06) and snap ring (22). See Figures 11B-12 and 11B-13.
3. Start small bearing (21) on shaft. Then turn unit over and start large bearing (20). Press or drive into place with a soft hammer or a hydraulic or arbor press. See Figures 11 B-14, 11B-15 and 11B-16.
4. Turn PTO over (output shaft down). Place gasket(s) on closed bearing cap (10) and install on unit using four capscrews (17). See Figures 11 B-17 and 11B-18.

NOTE

It is recommended to begin with two 0.020" gaskets on both sides. Minimum on either side is 0.010".

The offset in the bearing caps always points in the direction of the cover.

5. Turn unit over and install open bearing cap (09) using previous procedure (Step 4). Shaft should turn freely with a minimum of end play (less than 0.006 inch (0.152mm)).

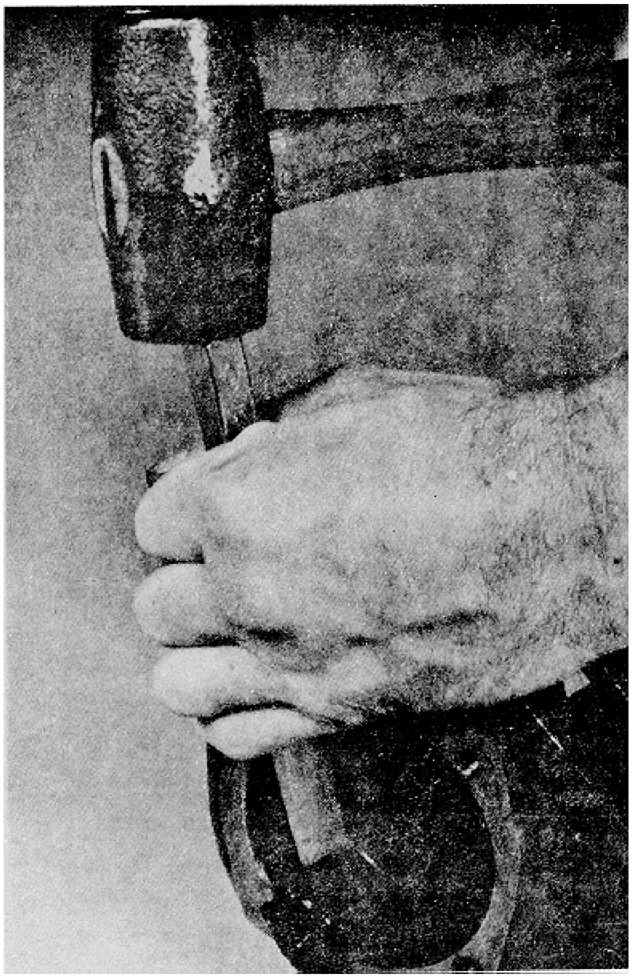


Figure 11B-9. Removing Snap Ring

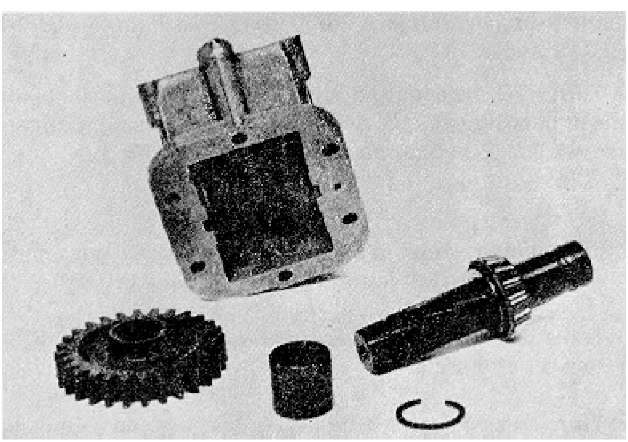


Figure 11B-10. Shaft Disassembly

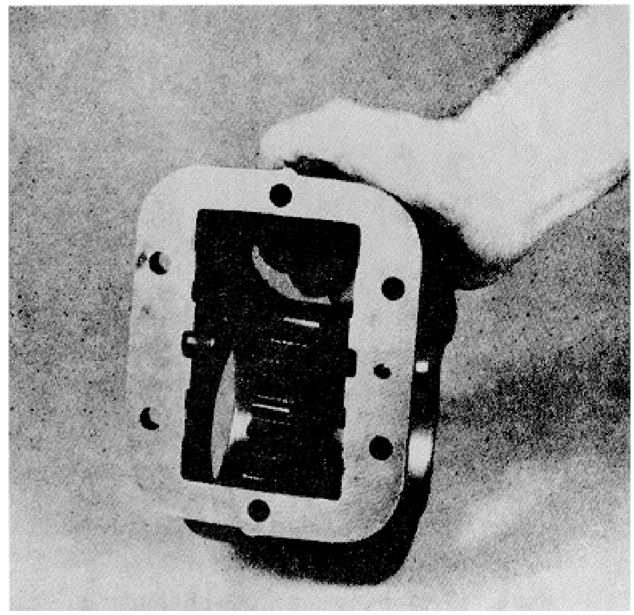


Figure 11B-11. Installing Output Gear

Figure 11B-12. Installing Shaft

6. Make sure bearings are seated by first tapping the shaft; then place the driver over the shaft and strike it with the hammer.
7. Check end play of shaft with indicator. Shaft should turn freely with a minimum amount of end play (less than 0.006 inch (0.152mm)).
8. Load gear (03) in the following manner:

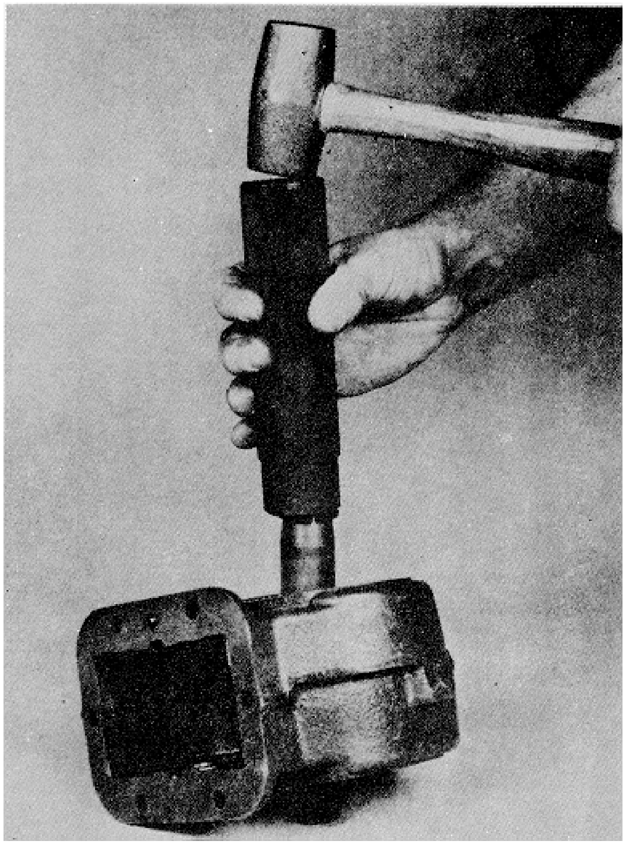


Figure 11B-13. Installing Shaft

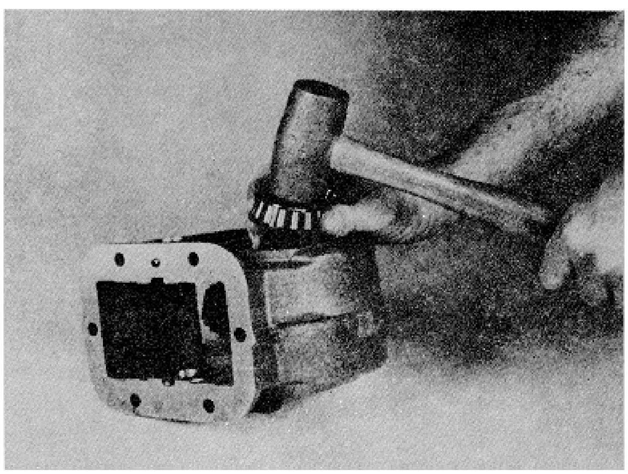


Figure 11B-14. Installing Small Bearing

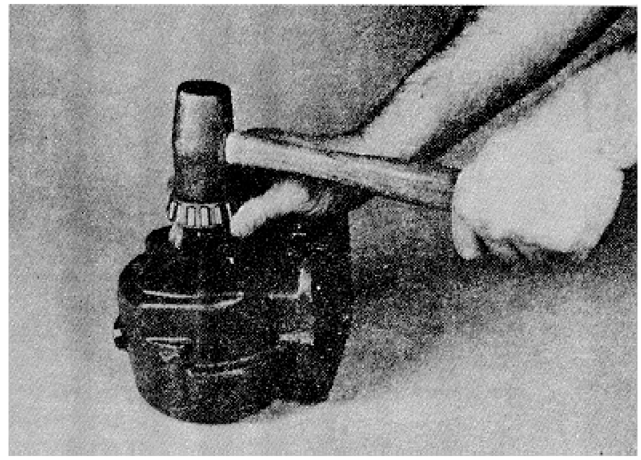


Figure 11B-15. Installing Bearing

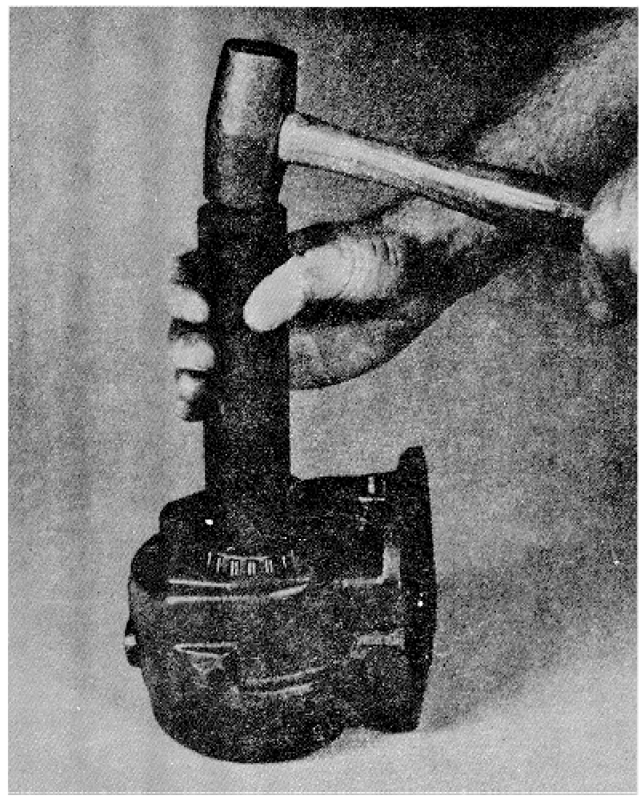


Figure 11B-16. Installing Bearings

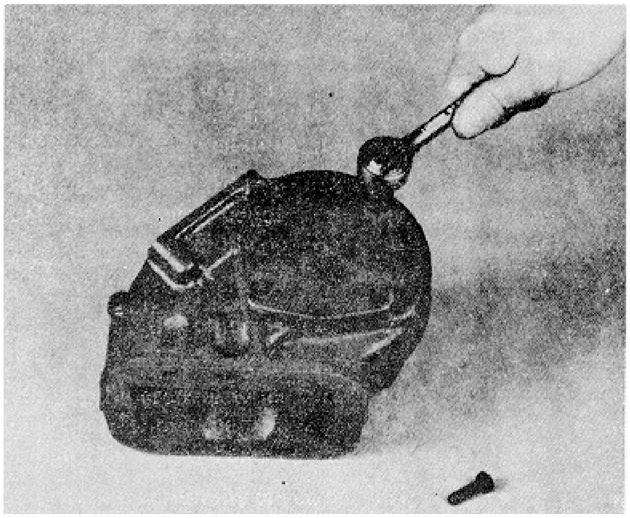


Figure 11B-17. Installing Bearing Cap

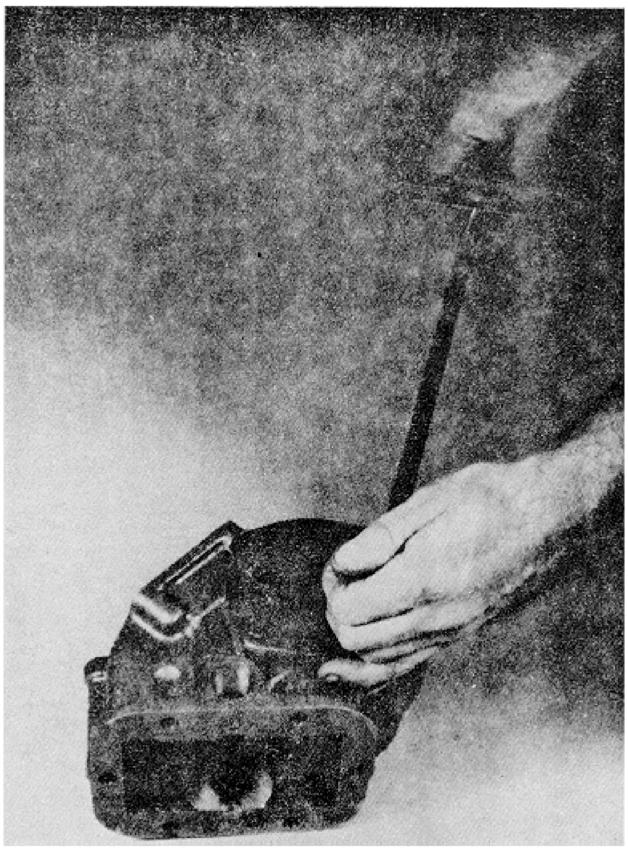


Figure 11B-18. Installing Bearing Cap

A. Place small amount of bearing grease in I.D See Figure 11B-19.

B. Put load pin in gear, Figure 118B-20.

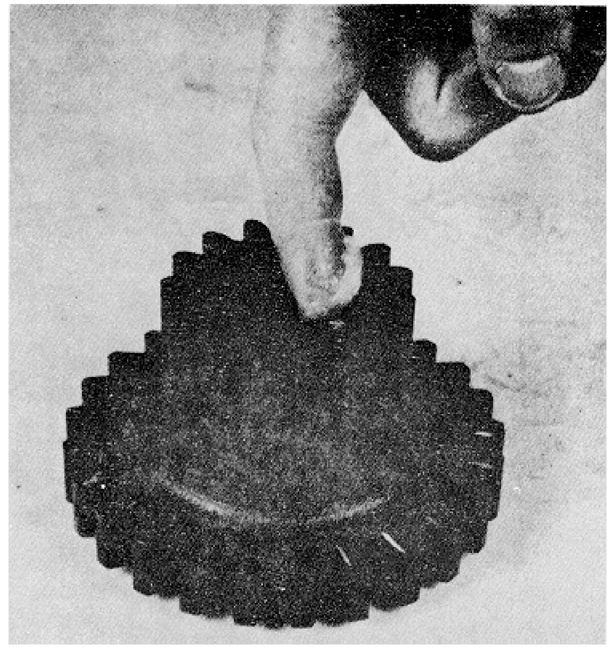


Figure 11B-19. Greasing Gear

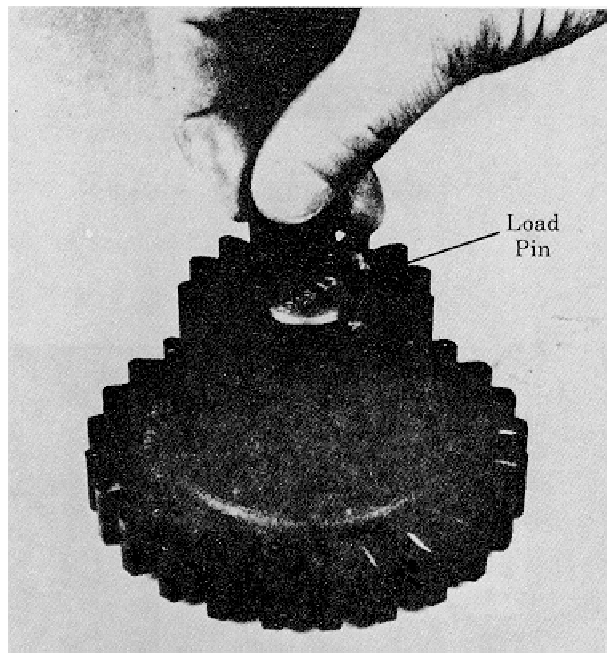


Figure 11B-20. Installing Load Pin

NOTE
The load pin is available from:
Chelsea
Drivetrain Service Division
Dana Corporation
P.O Box 321
Toledo, Ohio 43691
Part No. CT-8788

C. Load first row-of 19 bearings (16) around load pin, Figure 11B-21.

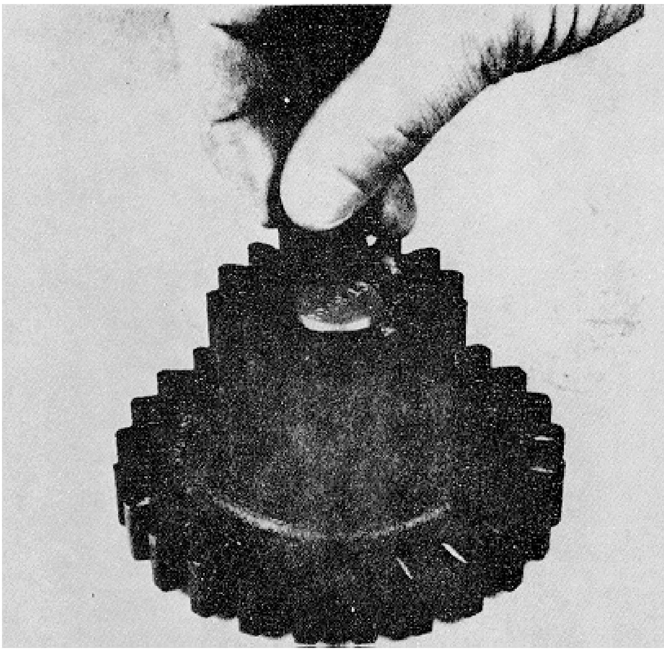


Figure 11B-21. Installing Bearings

D. Place spacer (08) in gear, Figure 11 B-22.

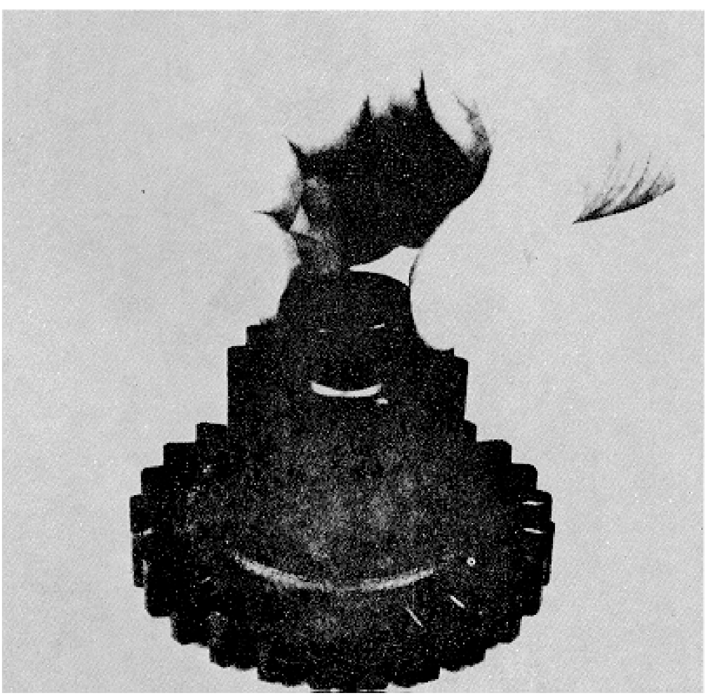


Figure 11B-22. Installing Spacer

E. Load second row of 19 bearings (16) around load pin, Figure 11 B-23.

9. Start idler pin (07) into housing from set screw side and drive until pin breaks through inside wall, Figure 11 B-24.

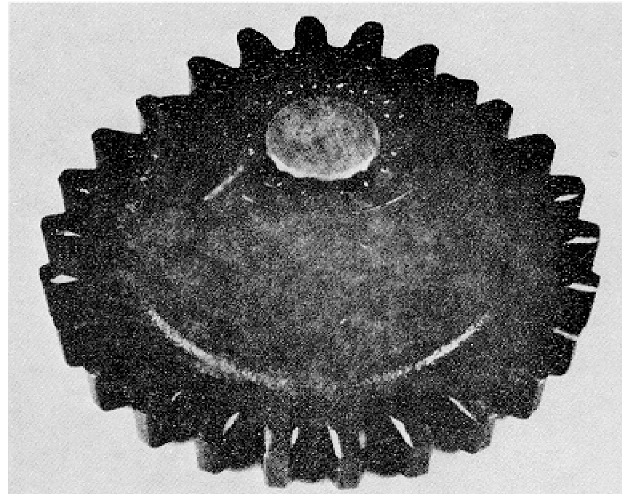


Figure 11B-23. Installing Bearings

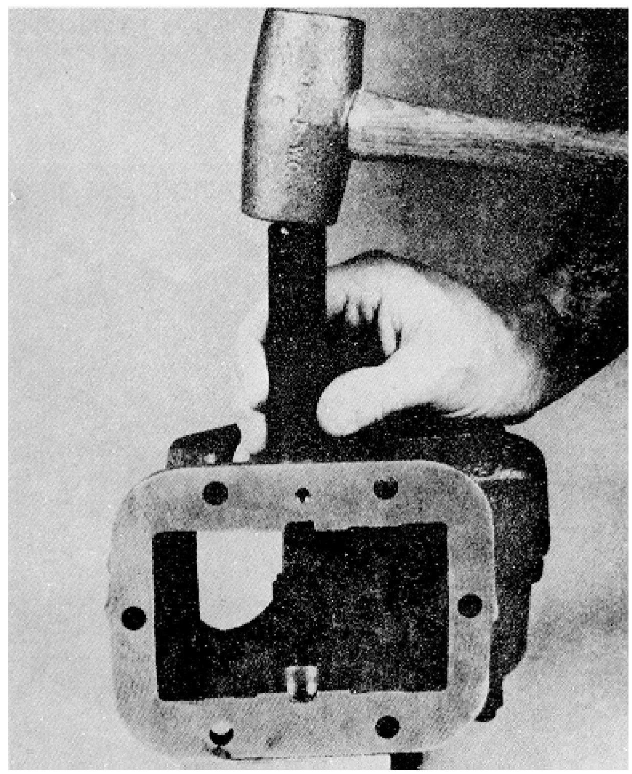


Figure 11B-24. Installing Idler Shaft

NOTE

Idler pin groove has to line up with set screw hole.

10. Place thrust washer (13) in housing (line up with idler pin hole - tab in slot), Figure 11 B-25.

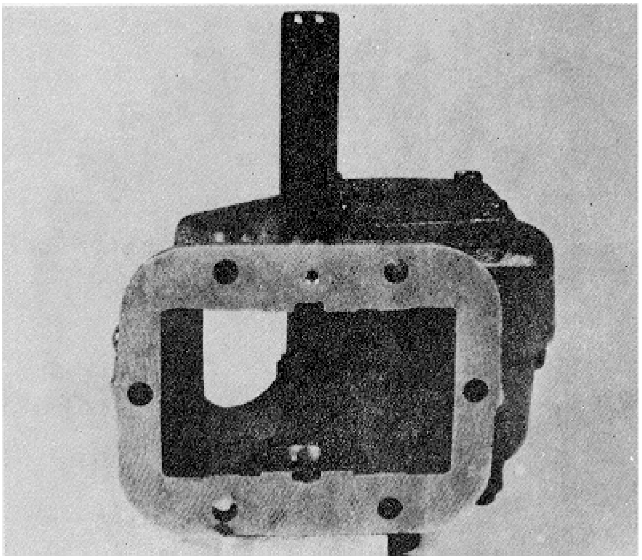


Figure 11B-25. Installing Thrust Washer

11. Place loaded gear (load pin still in place) in housing. Load pin should fall through idler pin hole if lined up properly. See Figures 11 B-26 and 11 B-27.

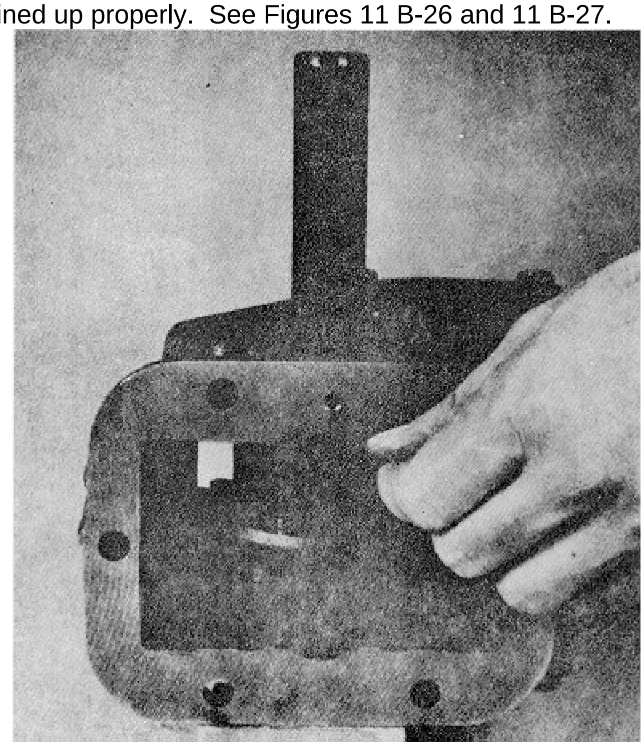


Figure 11B-26. Installing Gear

12. Insert thrust washer (13) and drive idler pin through so it goes into gear. Press idler pin through until it is flush with the housing. See Figures 11 B-28 and 11 B-29.

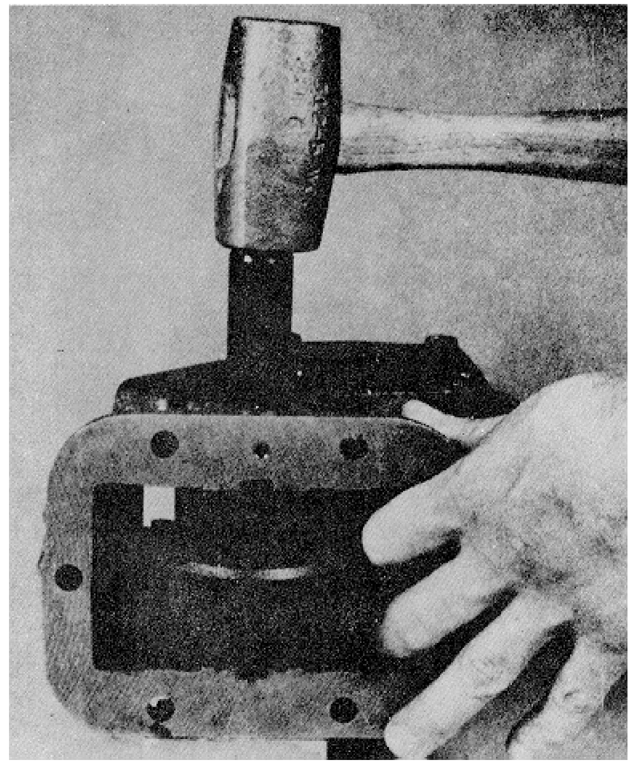


Figure 11B-27. Installing Shaft

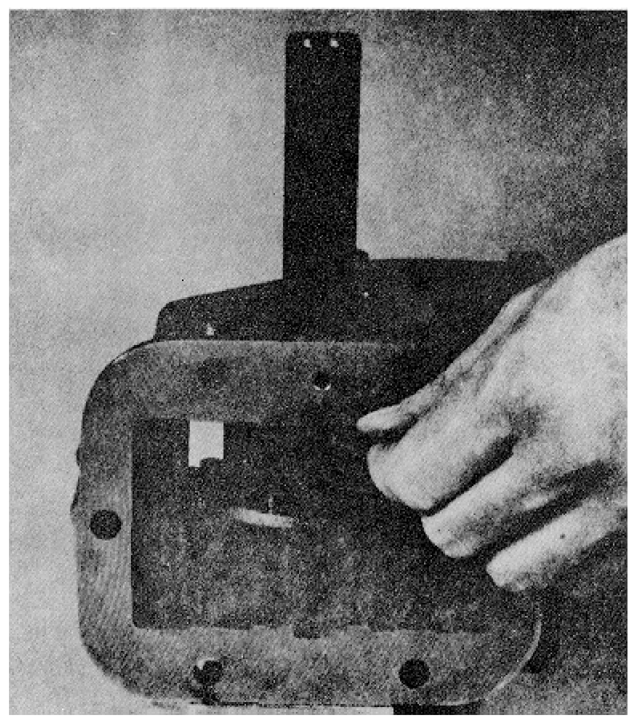


Figure 11B-28. Installing Thrust Washer

13. Insert proper set screw (18) in base of housing, Figure 11B-30.

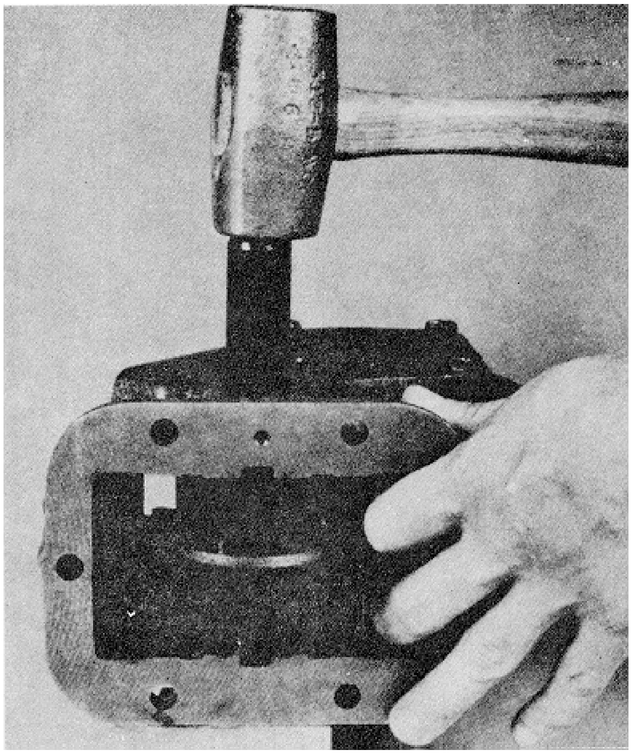


Figure 11B-29. Installing Shaft

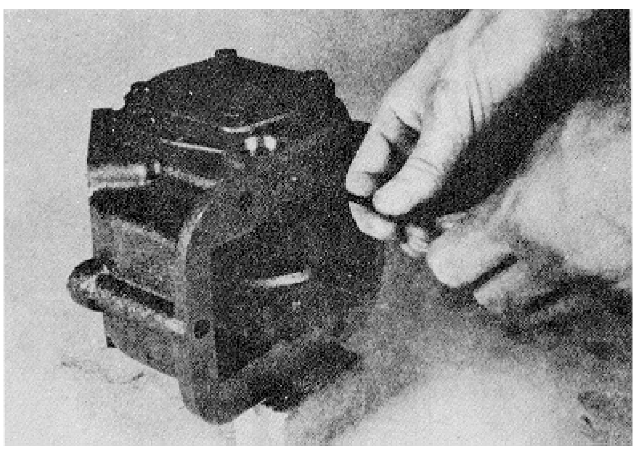


Figure 11B-30. Installing Set Screw

14. Install gasket(14) and cover (12). Secure in place with capscrews (05).
15. Check that shafts roll freely.

INSTALLATION. To install the power take off assembly, proceed as follows:

1. Rock the gears in the transmission and the PTO by hand to become familiar with the amount of backlash already designed into each unit. This will prove helpful in establishing backlash later.
2. Mount the PTO using gaskets between all mounting surfaces. Add or take away gaskets and establish backlash of 0.006-0.012 inches (0.152-0.305 mm). Do not stack more than four gaskets together. Usually one thick gasket 0.020 inches (0.508 mm) will be required. Check the backlash by holding the shaft of the transmission and rock the input shaft of the PTO.
3. Tighten the top and bottom capscrews to 45-50 ft-lbs 16.2-6.9 kg-m). Whenever possible the cover should be removed to check the backlash. Make sure the PTO gears operate smoothly.
4. Run the PTO momentarily and check for noise.

CAUTION

Since the transmission and PTO may not have lubrication at this time, running the PTO should be for as short a time as possible.

If the PTO whines, this indicates there is too little backlash and gaskets should be added. A clatter in the PTO indicates looseness (too much backlash) and gaskets should be removed. Add or subtract gaskets until the proper backlash has been established and the PTO operates quietly.

5. Install the remaining washers and nuts. Tighten the nuts.
6. Install the pump on the PTO and connect the hydraulic lines.
7. Refill the main transmission and the hydraulic reservoir to their proper levels and with proper lubricant. See Section III.
8. Run the PTO for 5-10 minutes and check for leaks, noise, and proper positioning of gears. A correctly installed PTO should operate reasonably quiet.
9. Recheck the reservoir for proper oil level.

PUMP (41Z44)

GENERAL. This hydraulic pump (Figure 11B-31)supplies fluid to the power steering and outrigger systems. The pump is driven by the power take off unit.

This is a dual cartridge, positive displacement vane type pump. It consists basically of an outlet body, inlet housing, outlet cover, driveshaft and two pumping cartridges. The principal components of the cartridge are an elliptical cam ring, a slotted rotor splined to the driveshaft, a pressure plate, wear plate, and ten vanes and inserts fitted to the rotor slots.

OPERATION. Fluid enters the pumping cartridge through the inlet port in the body and is discharged through the pressure plate to the outlet port in the cover. The action of a pumping cartridge is shown in Figure 11B-32.

The rotor is driven within the ring by the driveshaft. As the rotor turns, centrifugal force on the vanes, aided by the under-vane pressure fed from the outlet port, causes them to follow the elliptical inner surface of the ring.

Radial movement of the vanes and turning of the rotor causes the chamber volume between the vanes to increase as the vanes pass the inlet sections of the ring. This

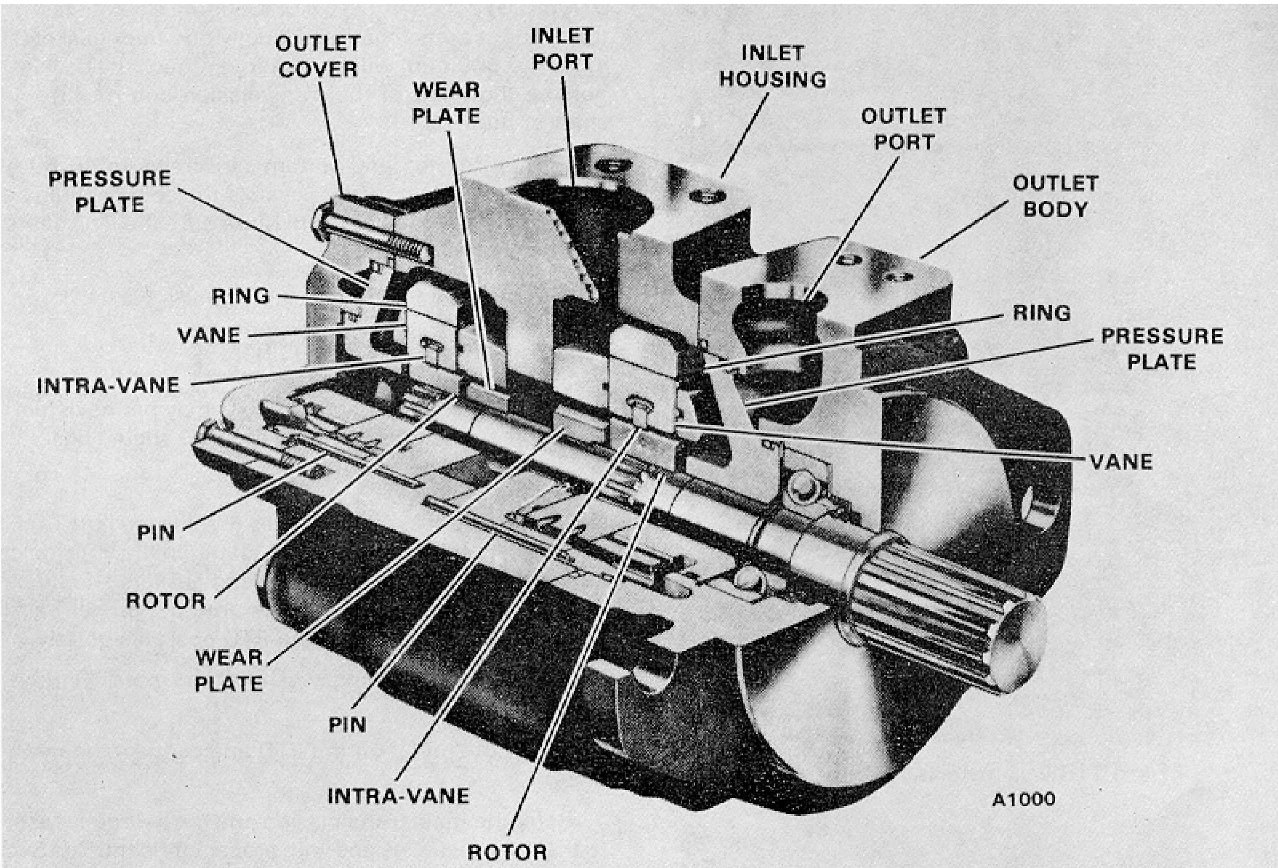


Figure 11B-31. Hydraulic Pump (41Z44)

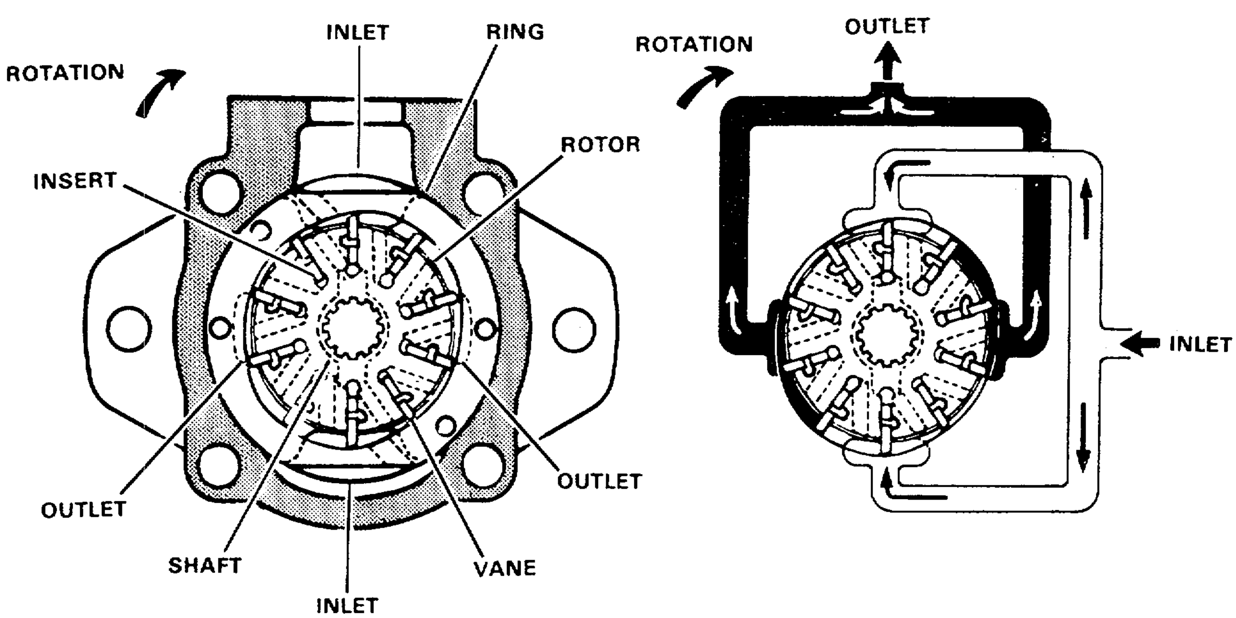


Figure 11B-32. Pump Operation

results in a low pressure condition which allows atmospheric pressure to force fluid into the chambers.

This fluid is trapped between the vanes and carried past a sealing land to the outlet section of the ring. As the outlet section is approached, the chamber volume decreases and the fluid is forced out into the system. System pressure is fed under the vanes, assuring their sealing contact against the ring during normal operation.

The pump ring is shaped so that the two pumping chambers are formed 180 degrees apart. Thus, opposing hydraulic forces which would impose side loads on the shaft cancel each other out.

The pressure plate seals the pumping chamber. System pressure is effective against the area at the back of the plate, which is larger than the area exposed to the pumping cartridge. Thus, an unbalanced force holds the plate against the cartridge. Thus, an unbalanced force holds the plate against the cartridge, sealing the cartridge and providing the proper running clearance for the rotor and vanes. The pressure plate also contains passages for feeding pressure to the space between the vanes and inserts.

TROUBLESHOOTING. If there are pressure and/or flow problems in the power steering system, consult the troubleshooting chart in Table 11 B-1 before actually removing and disassembling the pump. The problem may originate in an area other than the pump so it is important that you study the troubleshooting chart.

REMOVAL. To remove the pump, proceed as follows:
1. Drain the reservoir.
2. Loosen, but do not remove, the hydraulic lines to the pump. Allow any pressure to relieve, then tag and remove the lines. Plug the lines and the pump ports.
3. Remove the bolts securing the pump to the power take off unit. Remove the pump and gasket and set the pump aside for disassembly.

DISASSEMBLY. During disassembly, pay particular attention to the identification of the parts to assure correct reassembly. To disassemble the pump, proceed as follows (see Figure 11 B-33):
1. Clamp the pump in a vise or support it on blocks (see Figure 11 B-34). Mark the pump body, inlet housing and cover for correct reassembly.
2. Remove the cover screws and lift the cover off the pump. Remove the cover O-ring. Pull and/or pry out the cover end cartridge as shown in Figure 11 B-35.
3. Remove the screws attaching the inlet housing to the body. Lift off the inlet housing and the body O-ring. Turn the shaft to free the large cartridge and pull the cartridge from the body.
4. Remove the large snap ring and pull the shaft and bearing out. Drive the shaft seal and wiper out from the shaft end of the body. If it is necessary to remove the shaft bearing, first remove the small snap ring and then press the shaft out of the bearing, supporting the bearing inner race.

INSPECTION AND REPAIR. Inspect the pump components and make repairs as follows:
]

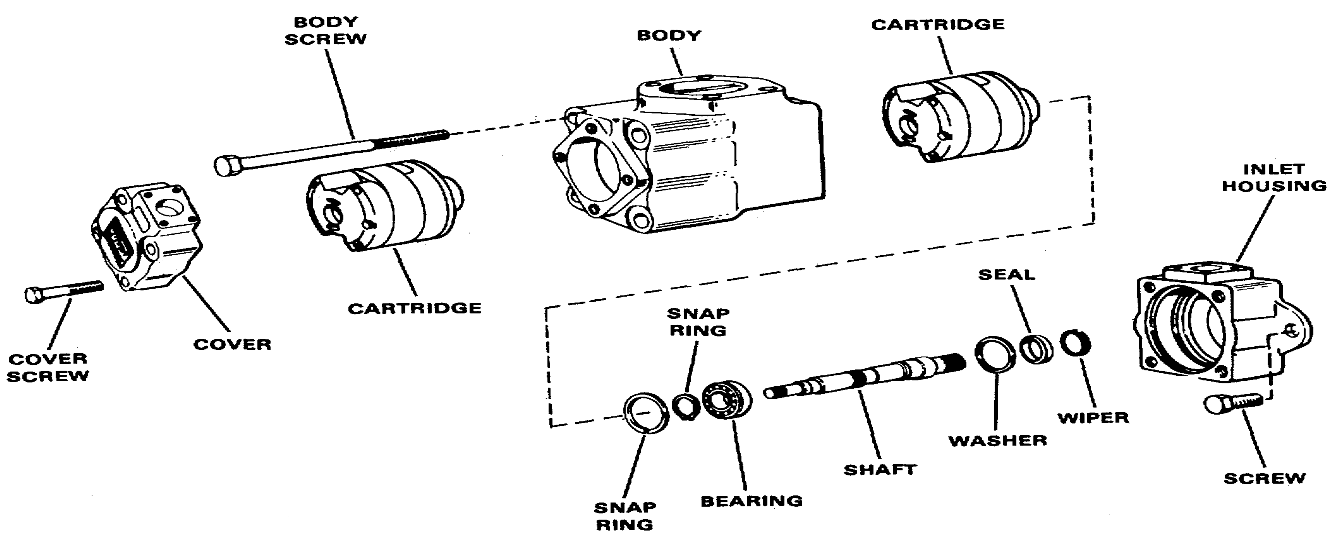


Figure 11B-33. Pump (41Z44)

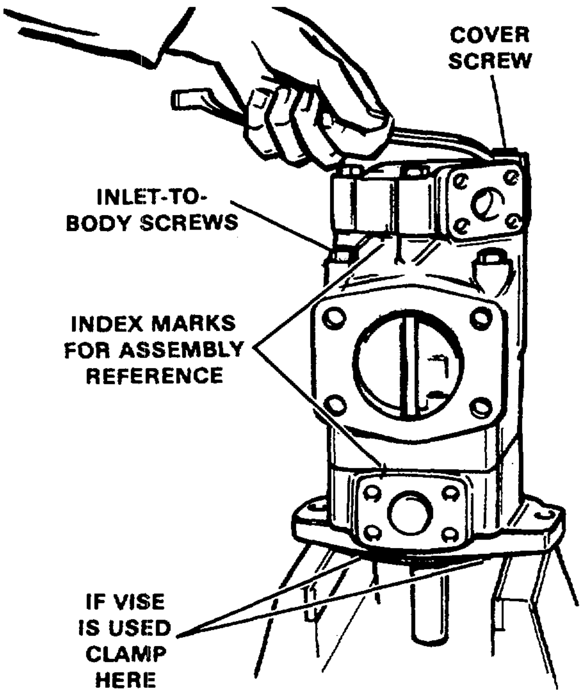


Figure 11B-34. Cover Removal

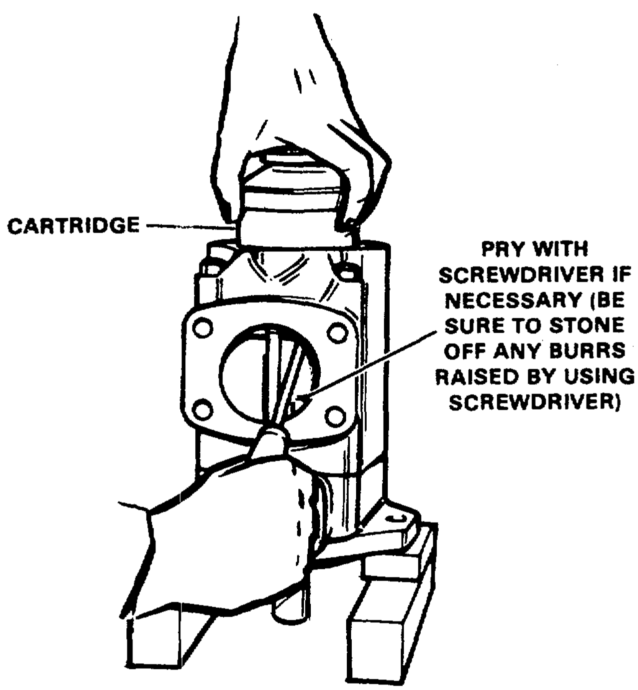


Figure 11B-35. Cartridge Removal

1. Discard the shaft seal, all O-rings and back-up rings. Wash the metal parts in clean mineral solvent, blow them dry with filtered compressed air and place them on a clean surface for inspection.

NOTE

Replacement cartridge kits, for each cartridge, and a seal kit are available. See the Replacement Parts Manual.

2. Check the wearing surface of the cartridge parts for scoring and excessive wear. Remove light score marks by lapping. An application of Lubrite or Moly-Kote (or their equivalent) is desirable after lapping to prevent seizure during start-up. The entire cartridge assembly will have to be replaced if any of the parts are heavily scored or badly worn. See the Replacement Parts Manual.
3. Rotate the bearing while applying pressure to check for wear, looseness and pitted or cracked races. Replace if necessary.
4. Inspect the seal and bushing mating surfaces on the shaft for scoring or wear. Replace the shaft if marks cannot be removed by light polishing.

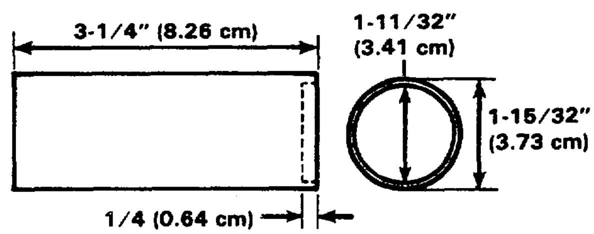


Figure 11B-36. Shaft Seal Driver

REASSEMBLY. To reassemble the pump, proceed as follows (see Figure 11B-33):

1. Coat all parts with hydraulic fluid to facilitate assembly and provide initial lubrication. Use small amount of petroleum jelly to hold O-rings in place during assembly.

NOTE

During handling and shipping of the precision machined cartridge parts, it is possible to raise burrs on the sharp edges. All burrs on the parts of a new cartridge kit should be lightly stoned prior to installation.

2. Soak a new shaft wiper in hydraulic fluid and install the wiper and seal. Use the seal installing tool (Figure 11 B-36) to avoid damaging the seal. Be certain the seal outer diameter is below the chamfer in the body.
3. Clamp the pump body in a vise or place it on blocks as was done at disassembly. Place the bearing spacer against the seal. Cover the end of the shaft with a "bullet" lubricated with grease or petroleum jelly to protect the seal. Press the shaft into the bearing in an arbor press, supporting the bearing inner race. Remove the "bullet". Install the small snap ring.

Table 11B-1. Troubleshooting Chart

TROUBLE	CAUSE	REMEDY
1. Pump not delivering fluid	A. Coupling or shaft sheared or dis engaged.	A. Disassemble the pump and check the shaft and cartridge for damage. Replace the necessary parts.
	B. Fluid intake pipe in reservoir restricted.	B. Check all strainers and filters for dirt and sludge. Clean if necessary.
	C. Fluid viscosity too heavy to pick up prime.	C. Completely drain the system. Add new filtered fluid of the proper viscosity.
	D. Air leaks at the intake. Pump not priming.	D. Check the inlet connections to determine where air is being drawn in. Tighten any loose connections. See that the fluid in the reservoir is above the intake pipe opening. Check the minimum drive speed which may be too slow to prime the pump.
	E. Flow control relief valve stuck open.	E. Disassemble and thoroughly clean flow control relief valve. If parts are worn or damaged replace the valve.
	F. Vane(s) stuck in the rotor slot(s).	F. Disassemble the pump. Check for dirt or metal chips. Clean the parts thoroughly and replace with new rotor kit. If necessary flush the system and refill it with clean fluid.
2. Insufficient pressure	A. Remove and replace valve.	A. Flow control relief valve faulty.
	B. Worn parts causing internal leakage of pump delivery.	B. Replace pump cartridge.
3. Pump making noise.	A. Service the intake strainers. Check	A. Pump intake partially blocked.
the fluid condition and, if necessary, drain and flush the system. Refill with clean fluid.		
B. Air leaks at the intake or shaft seal.	B. Check the inlet connections and seal	
(Oil in reservoir would probably be foamy.) -		to determine where air is being drawn in. Tighten any loose connec- tions and replace the seal if neces sary. See that the fluid in the reser- voir is above the intake pipe opening.
	C. Pump drive speed too slow or too fast.	C. Operate the pump at the recom- mended speed.
	D. Coupling misalignment.	D. Check if the shaft seal bearing or other parts have been damaged. Replace any damaged parts. Realign the coupled shafts.

4. Tap the shaft and bearing gently into the body and install the snap ring.

5. Install the O-ring and then the back-up ring on the cartridge pressure plate hub. Lay the body O-ring in place and install the large back-up ring and then the O-ring on the cartridge. Carefully install the cartridge in the body so one of the chamfers or flats on the ring will align with the inlet port when the inlet housing is installed.

6. Place the inlet housing over the cartridge so the locating pins are properly engaged and the inlet is in the correct position with respect to the body outlet. Install the capscrews and tighten to 65-75 ft-lbs (9.0-10.4 kg-m).

7. Install the cover end cartridge, being certain the pins engage in the housing. Place the large back-up ring and then the O-ring on the pressure plate.

8. Install the small O-ring and then the back-up ring on the pressure plate hub. Put the cover O-ring in place in its groove. Install the cover and screws. Tighten to 40-50 ft-lbs (5.5-6.9 kg-m).

INSTALLATION. To install the pump, proceed as follows:

1. Set the pump up to the power take off unit and install the mounting hardware. Tighten securely.
2. Remove the plugs from the pump and hydraulic lines. Install the hydraulic lines on the pump in the same manner as they were removed.
3. Refill the reservoir to the proper levee. cover Section III.
4. Start the engine. Allow the engine to run at idle speed, with no load applied to the hydraulic system, to prime the pump. Then run the engine at moderate speed and load for a short period of time. Check the reservoir oil level and add oil if necessary.

SUBSECTION 11 C
POWER STEERING GEARS

GENERAL

This subsection contains the information necessary to remove, disassemble, assemble, install, and adjust the power steering gears.

STEERING GEAR (53Q55)

REMOVAL

To remove the steering gear from the carrier, proceed as follows (see Figure 11 C-1):

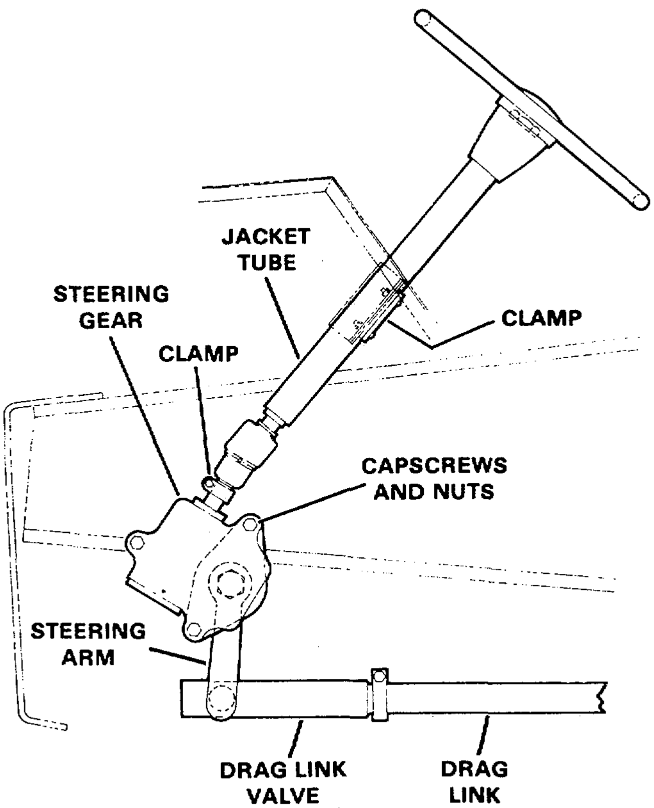


Figure 11C-1. Steering Gear Mounting

1. Loosen the clamp that secures the steering column to the steering gear.
2. Disconnect the drag link from the steering arm of the steering gear.
3. Remove the steering gear mounting bolts, lockwashers, and nuts. Remove the steering gear.

DISASSEMBLY

To disassemble the steering gear, proceed as follows (see Figure 11 C-2):

1. Remove the steering arm by removing locknut (17) and lockwashers (16).
2. Rotate input shaft (06) to place roller shaft (10) on the center or straight ahead position.
3. Loosen locknut (15) and remove shaft cover screws (22).
4. Remove roller shaft (10) and shaft cover (18), separate roller shaft (10) by removing locknut (15) and turning adjusting screw (11) clockwise.
5. Remove worm cover (20) and shims (04) by removing capscrews (22).
6. Remove bearing cup (08)and bearing cone (09)by pressing on the end of the input shaft. If bearing cup (08)cocks, do not use force to remove it. Tap the bearing cup back into place and repeat the removal procedure.
7. Remove worm and input shaft assembly (06 and 07).
8. Remove bearing cone (09). Remove and discard old seals (05).

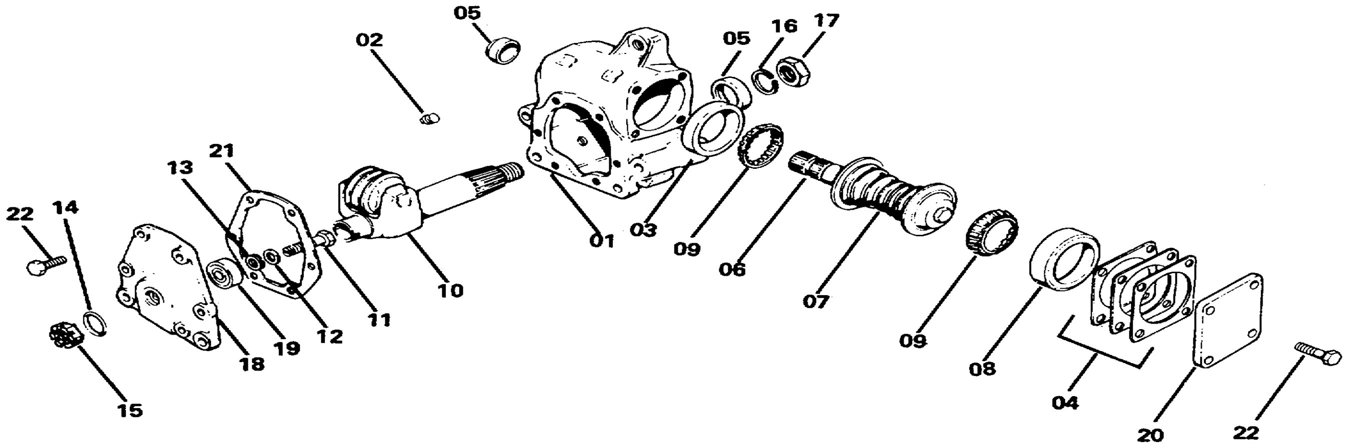
INSPECTION AND REPAIR

To repair components in the steering gear, proceed as follows (see Figure 11 C-2):

CAUTION

This steering gear is available in two gear ratios. The manufacturer states in his service bulletin that the guarantee will be void if any steering unit is serviced with noncompatible components due to different gear ratios, or if non-genuine factory replacement parts are used.

1. Inspect cover bushing (19) and the outboard shaft bearing surface. If clearance exceeds 0.010 inches (0.254 mm), replace bushing (19). Use a piloted mandrel to install a new bushing flush with the outer face of the bushing boss.



15. NUT
01. HOUSING
02. PIPE PLUG
03. BEARING CUP
04. SHIMS
05. SEAL
06. INPUT SHAFT
07. WORM
08. BEARING CUP
09. BEARING CONE
10. ROLLER SHAFT
11. ADJUSTING SCREW
12. THRUST WASHER
13. ADJUSTING SCREW RETAINER
14. O-RING
16. LOCKWASHER
17. NUT
18. COVER
19. BUSHING
20. COVER
21. GASKET
22. CAPSCREW

Figure 11C-2. Steering Gear (53Q55)

NOTE

If bushing (19) is a bronze bushing, replace the cover and bushing assembly.

2. Replace oil seals (05).

3. Inspect bearing cups (03 and 08) and bearing cones (09) on each end of worm (07) for pitting or brinnelling. If the bearing parts are worn or damaged, replace them.

NOTE

It is recommended that the bearing components be replaced only in full sets.

4. Inspect roller shaft (10) for wear or pitting. The bearing surface may be lightly polished with very fine abrasive cloth, if necessary. Check the roller for freedom of movement, excessive lash, and roughness. Replace the entire roller shaft if necessary.

CAUTION

All 28.4 worms must be mated with a 50035roller shaft and a 28.4 housing. All 32.5 worms must be mated with a 7DF236 roller shaft and a 32.5 housing. The housings are marked on the inside face of the casting, the worms are stamped on the finished end, and the rollers are stamped on the top of one of the roller shaft teeth.

ASSEMBLY

To assemble the steering gear, proceed as follows (see Figure 11 C-2):

1. Coat all parts with lubricant to facilitate assembly and provide initial lubrication. An SAE No. 90 oil is preferred.

2. Assemble bearing cone (09) into bearing cup (03) and insert in the housing bore.

3. Insert worm and input shaft assembly (06 and 07) into housing (01).

4. Place other bearing cone (09) in the housing bore. Insert bearing cup (08) into the housing bore.

5. Install shims (04) and cover (20). Finger tighten cover screws (22).

CAUTION

Do not fully tighten cover screws (22) at this time. Rotate input shaft assembly (06) with one hand while slowly tightening the cover screws with the other hand to prevent damaging the bearing surfaces if the initial amount of shims is inadequate. Once a light preload is obtained by using a torque gauge on the input shaft, torque the cover screws 45-55 ft-lbs (6.227.61 kg-m). See adjustments following for preload values.

6. Insert adjusting screw (11) into cover (18)from the bearing side of the cover. Install roller shaft (10) into the cover bearing until the shaft bottoms in cover (18), then reverse adjusting screw (11) one full turn.

7. Place gasket (21) on cover (18). Insert cover (18) and roller shaft (10) into housing (01).

8. Install and finger tighten cover screws (22). Rotate shaft (10), one-half turn from each end of travel, lash must be present, in each position, with no noticeable binding. Torque the cover screws 45-55 ft-lbs (6.22-7.61 kg-m).

9. Make adjustment for output shaft and total mesh preload. See Adjustments following, for procedure.

10. Carefully press in new shaft seals (05). Assemble the lubricated seals in the counter bore with the longer lip facing into the steering gear. Use a mandrel of a size to contact all around the seal case. Drive the seals to firmly contact the bottom of the counter bore.

11. Attach the steering arm to the steering gear using lockwasher (16) and locknut (17).

12. Fill the steering gear housing to the proper level using the lubricant specified in Section' III.

INSTALLATION

To install the steering gear to the carrier, proceed as follows (see Figure 11 C-1):

1. Slide the steering gear shaft end into the steering column U-joint.
2. Install the steering gear mounting bolts and tighten securely.
3. Tighten the steering column clamp.
4. Connect the drag link to the steering gear arm.

ADJUSTMENTS

GENERAL. The steering gear is of the worm and roller type. Because most steering action occurs near the center (straight ahead) position, maximum wear occurs in the center of the worm. This wear is compensated for by the introduction of backlash in the off center position. This permits readjustment for lost motion in the center position without causing binding in the off center areas. This backlash begins approximately one half turn on each side of the center position and gradually increases to the maximum at the end of travel. Adjustment to eliminate lost motion due to wear is by means of preload adjustments of the worm bearings and the output shaft.

NOTE

Never disturb the steering gear adjustments until the steering linkage has been checked for free play, and such play has been eliminated.

STEERING LINKAGE INSPECTION. Before making any adjustments to the steering gear, jack up the front wheels of the vehicle and inspect all linkage from the pitman arm to the wheel bearings for excessive play. Eliminate all such excess play if it is present.

WORM PRELOAD ADJUSTMENT CHECK (GEAR IN VEHICLE). Turn the steering wheel to the straight ahead driving position. Secure the steering wheel in this position and shake the front wheels from side to side as far as possible. This will enable any play in the steering gear bearings to be felt at the pitman arm ball. If any bearing play exists, adjustments should be made as follows:

1. Disconnect the linkage from the input shaft. Turn the input shaft to the end of its travel in either direction. Back off about one quarter turn.
2. Check the worm bearing preload by placing a torque gauge on the input shaft and rotating (oscillating) the input shaft. The torque required to turn the input shaft should be from 7 to 14 in-lbs (0.081-0.161 kg-m).
3. If the torque required to turn the input shaft does not fall within the force given in step 2, proceed as follows to correct worm preload:

A. Remove the drain plug and the lubricant.

B. Remove the input shaft cover bolts and remove the cover.

C. Remove one of the shims, but do not remove the rubber covered shims.

D. Assemble the remaining shims and install the cover.

NOTE

Rubber covered shims, if applicable, must be assembled with the rubber side against the housing and worm cover.

E. Install the cover screws, finger tight. Rotate the input shaft with one hand while slowly tightening the cover screws with the other hand. Finally torque the cover screws 45-55 ft-lbs (6.22-7.61 kg-m).

4. Repeat steps 2 through 3E until the correct preload is obtained. A different combination of shims may be used to obtain the correct preload.

OUTPUT SHAFT OR TOTAL MESH ADJUSTMENT. After completing the worm preload adjustment, place the worm in the center position by turning it from one end of the travel completely to the other end of travel. Then back off exactly half way. This will place the roller of the output shaft in the center of the worm, which is the straight ahead steering position. Rotate the input shaft, with a torque gauge (approximately 1800) through the center position. The correct torque reading is 20-31 in-lbs (0.231-0.357 kg-m). If the torque reading does not fall within that given, proceed as follows (see Figure 11 C-2):

1. Loosen locknut (15).
2. turn adjusting screw (11) clockwise to increase preload and check the preload as described above. Continue turning adjusting screw (11) until the total preload falls within the specified limits.
3. Hold adjusting screw (11) in place and tighten locknut (15) to 20-25 ft-lbs (2.77-3.46 kg-m).
4. Recheck the preload as described above.
5. Refill the steering gear with the amount and type of lubricant, specified in Section III.
6. Reinstall all items removed from the steering gear.

SUBSECTION 11 D

POWER STEERING COMPONENTS

GENERAL
This subsection contains the information necessary to re-pair the remaining components in the power steering sys-tem. This includes the drag link valves, power steering cylinders, steering/outrigger selector valves, steering column and the flow control and relief valves.

DRAG LINK VALVE (36Z625 & 36Z1402)

OPERATION. The drag link valve is actuated when turning effort is applied to the steering wheel of the vehicle, which in turn directs hydraulic fluid from the pump directly to the steering cylinders located on the steering linkage. The valve piston is normally centered by the hydraulic pressure against the reaction rings (Figure 11 D-1). When the operator's effort at the steering wheel exceeds the hydraulic force at the reaction ring, the control valve is actuated and hydraulic power is provided for power steering.

When the valve piston is in the center (neutral) position, the pressure at the cylinder ports of the valve is low. Under this condition there is no circulation of fluid to the steering cylinders. The fluid is circulating, however, from the pump, through the valve and to the reservoir with sufficient pressure to overcome the resistance due to friction in the valve, lines and fitting.

When the effort in turning the steering wheel of the vehicle overcomes the centering effect of the force against the re-action rings, the valve piston moves axially to restrict the flow of fluid to one of the cylinder ports. At the same instant, the passage in the second cylinder port opens, thus causing an immediate increase in pressure differential be-tween the ports of the power steering cylinders.

While the fluid under pressure enters one end of the cylinders, fluid from the discharge end of the cylinders returns through the valve return port to the reservoir.

Full hydraulic pressure is obtained in the steering cylinders with a valve piston travel of about 0.035 inch (0.889 mm). However, the slightest movement of the piston causes a pressure differential at the valve cylinder ports. When the effort at the steering wheel is released, the valve piston returns to center (neutral) position.

Whenever the steered wheels are subjected to shock loads, the movement of the steering linkage tends to actuate the valve in the drag link momentarily. This action moves the valve piston axially in the appropriate direction, thereby di-verting the hydraulic fluid to the proper side of the steering cylinder piston, and thus resisting the force of the shock. This blocking action prevents "kick-backs" at the steering wheel and stabilizes the steering.

Very little maintenance is required to keep the power steer-ing drag link valve operating properly. The internal parts are hardened and ground to a precise finish; therefore, wear of the working parts will be negligible under clean operating conditions. However, foreign matter in the hydraulic sys-tem may score the polished surfaces of the piston and body resulting in cut seals. This will eventually result in leakage and reduced power output for steering.

TROUBLESHOOTING. If there are power steering problems, consult the troubleshooting chart in Table 11 D-1 be-fore actually removing and disassembling the drag link valve. The power steering problem may originate in an area other than the drag link valve so it is important that you study the troubleshooting chart.

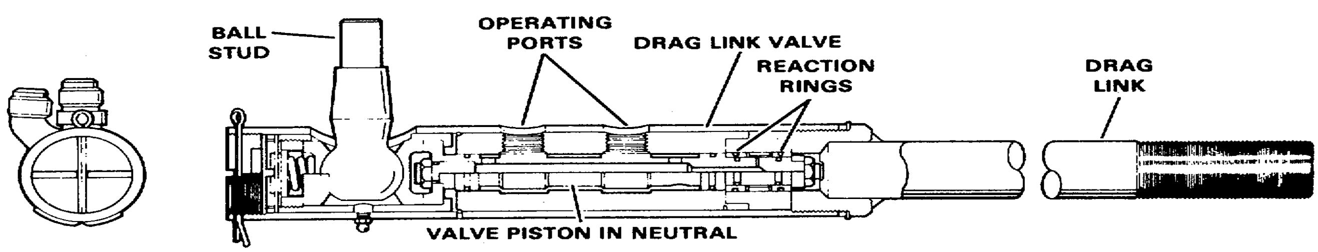


Figure 11D-1. Drag Link Valve (36Z625 & 36Z1402)

Table 11D-1. Drag Link Valve Troubleshooting

TROUBLE	CAUSE	REMEDY
1. Hard steering	A. Insufficient pump pressure. B. Low oil level. C. Sticky relief valve. D. Piston in steering valve sticking. E. Valve piston not traveling full stroke. F. Excessive leakage in power cylinders. G. Steering gear not adjusted properly. H. Improper front end alignment.	A. Check pump with pressure gauge. B. Refill reservoir and system. C. Repair or replace relief valve. D. Overhaul valve as outlined in service instructions. E. Adjust position of end plug per instructions. F. Check cylinders for broken piston or rings. Check condition of cylinder wall. Replace if necessary. G. Adjust in accordance with manufacturers specifications. H. Align in accordance with manufacturers specifications.
2. No recovery from turn to. straight ahead	A. Low pump output. B. Piston in steering valve sticking (prevents centering). C. Ball stud adjustment too tight. D. Steering linkage too tight. E. Insufficient wheel caster. F. Steering gear too tight (out of adjustment)	A. Check pump and replace if necessary. B. Disassemble valve and inspect for sticking. C. Adjust for proper clearance. D. Readjust. E. Readjust per manufacturers specifications. F. Readjust per manufacturers specifications.
3. Excessive lost motion at	A. Loose ball socket connections or steering wheel B. Excessive backlash in steering gear. C. End plug on steering valve not properly positioned.	A. Tighten and readjust. other linkage connections. B. Readjust per manufacturers specifications. C. Make adjustment as outlined in service instructions.
4. Noise.	A. Low oil level. B. Air in system. C. Worn pump. D. Hydraulic hose lines in direct contact with vehicle frame or sheet metal.	A. Refill system. B. Bleed system by loosening fitting on power cylinder to let air escape. Check all fitting connections for tightness. C. Repair or replace. D. Insulate lines from frame contact with rubber grommets.
5. Steering shimmy or chatter.	A. Loose ball socket connections or other linkage connections. B. Wheels out of balance. C. Excessive caster. end checked. D. Excessive backlash in steering gear. E. Area of valve reaction rings too low.	A. Tighten and readjust. B. Balance. C. Correct and have alignment of front D. Readjust gear. E. Select rings with greater area.

REMOVAL. If the power steering problem can be traced to the drag link valve it will have to be removed and disassembled. To remove the drag link valve, proceed as follows (see Figure 11 D-2):

1. Loosen the hydraulic line fittings on the drag link valve and allow any pressure to relieve. Disconnect and cap the hydraulic lines from the valve. Note the position in which each line is connected to the drag link valve so each can be reassembled in the original position.
2. Remove cotter pin (31) and end plug (30).
3. Remove wire lock (29) and socket plug (28). Washer (27), spring (26), ball seat (25), and the ball stud may now be removed. Remove capscrew (01), lockwasher (02) and nut (03) to loosen the drag link valve from the drag link. Unscrew the drag link valve from the drag link and remove the valve from the machine.

DISASSEMBLY. To disassemble the drag link valve, proceed as follows (see Figure 11 D-2):

1. Hold the valve in a vise for disassembly. Clamp only in the center section of housing (20), since this is the heaviest section.
2. Lock ring (07) has been crimped into a notch in adapter (06). Straighten the lock ring and remove the adapter with a pipe wrench.
3. Disassemble ball socket (23) before attempting to re-move body (18) from housing (20). To do so, place a punch into an oil passage hole in piston (16) to prevent the piston from turning. Remove nut (32) from the ball socket end of piston (16). Use a 3/4 inch (1.91 cm) hex socket and a 4 inch (10.16 cm) extension. Remove ball socket (23) and ball socket bearing (24).
4. Valve body assembly (18) can now be removed from housing (20). The housing contains retaining ring (19). It is not necessary to remove retaining ring (19).
5. To disassemble valve body (18) from piston (16), hold the assembly in a vise, clamping on the body. Place a punch in the oil passage hole in piston (16) to keep it from turning in the body and remove nut (08) from the gland end of the piston with a 3/4 inch (1.91 cm) hex socket.
6. Remove washer(09). Hold piston (16) in body (18) and re-move gland (13), reaction rings (11), and spacer (12). Do not attempt to remove the gland and piston together, as the 0-ring seals on the piston will be damaged. When removing piston (16), first move it toward the gland end of the body just far enough to permit removing one O-ring (15). Then move piston (16) in the opposite direction just far enough to remove the other O-ring (15) from the other end. Finally, slide piston (16) out from the gland end of the body.

INSPECTION AND REPAIR. Clean and wash all parts thor-oughly in solvent or kerosene. Handle the parts separately and carefully to avoid damaging the finished surfaces. Wear of parts such as the piston, reaction rings, and the valve body is negligible as these parts operate in circulating oil. It is impractical for a field service shop to attempt to measure wear. Therefore, a careful visual inspection of all parts is most important.

Examine the surfaces of the piston and the bore of the body for scoring or damage that may have been caused by foreign matter in the fluid. Parts that are badly scored and scratched should be replaced. Light scratches can be re-moved by polishing with fine crocus cloth. Do not "round-off" or chamfer the port edges of the piston or body. These edges should remain sharp to insure proper sealing. If they are broken the result will be excessive leakage and reduced hydraulic power.

The gland, felt plug, and all O-rings should be replaced before assembly.

ASSEMBLY. To assemble the drag link valve, proceed as follows (see Figure 11 D-2):

1. Hold valve body(18) in a vise and install valve piston (1 6).

Insert piston (16) into the gland end of body (18) for easy assembly. Install one O-ring (15) on piston (16) opposite the gland end first and then move piston (16) into body (1 8)just far enough to permit installation of the other O-ring (15) on the gland end of the piston. Center the piston on the body so that the shoulder on the gland end of the piston is flush with the bottom of the counterbore in the body.

CAUTION

When installing O-rings (15) on piston (16), do not move the piston in the body any further than is required to assemble the O-ring. If the O-ring on the gland end of the piston drops into the cavity in the body, it is likely to be cut or damaged. Apply light lubricating oil to the piston and seals when assembling.

2. Install O-rings (14) on the gland end of piston (16).
3. Install O-rings (10) on reaction rings (1). Install one re-action ring (11) on piston (16), then install gland (13) in body (18) and the second reaction ring (11) on the end of piston (16). Install spacer (12) in gland (13) between reaction rings (11) and assemble in body (18).
4. Install washer (09) and nut (08). Tighten nut (08) to 30-35 ft-lbs (4.15-4.84 kg-m) torque. To hold the piston stem from turning while tightening nut (08), place a punch in the oil passage hole in piston (16).
5. Place the body assembly in housing (20) and assemble drag link adapter (06) with lock ring (07)and tighten enough to hold the body in position. Be sure the interior of the housing is clean and that no obstructions prevent the body assembly from bearing against the stop ring in the housing. This can be observed through the opening in the housing.
6. Place the assembly in a vise with the ball stud opening in the housing facing upward.

CAUTION

Clamp only in the center of the valve, as this is the heaviest section.

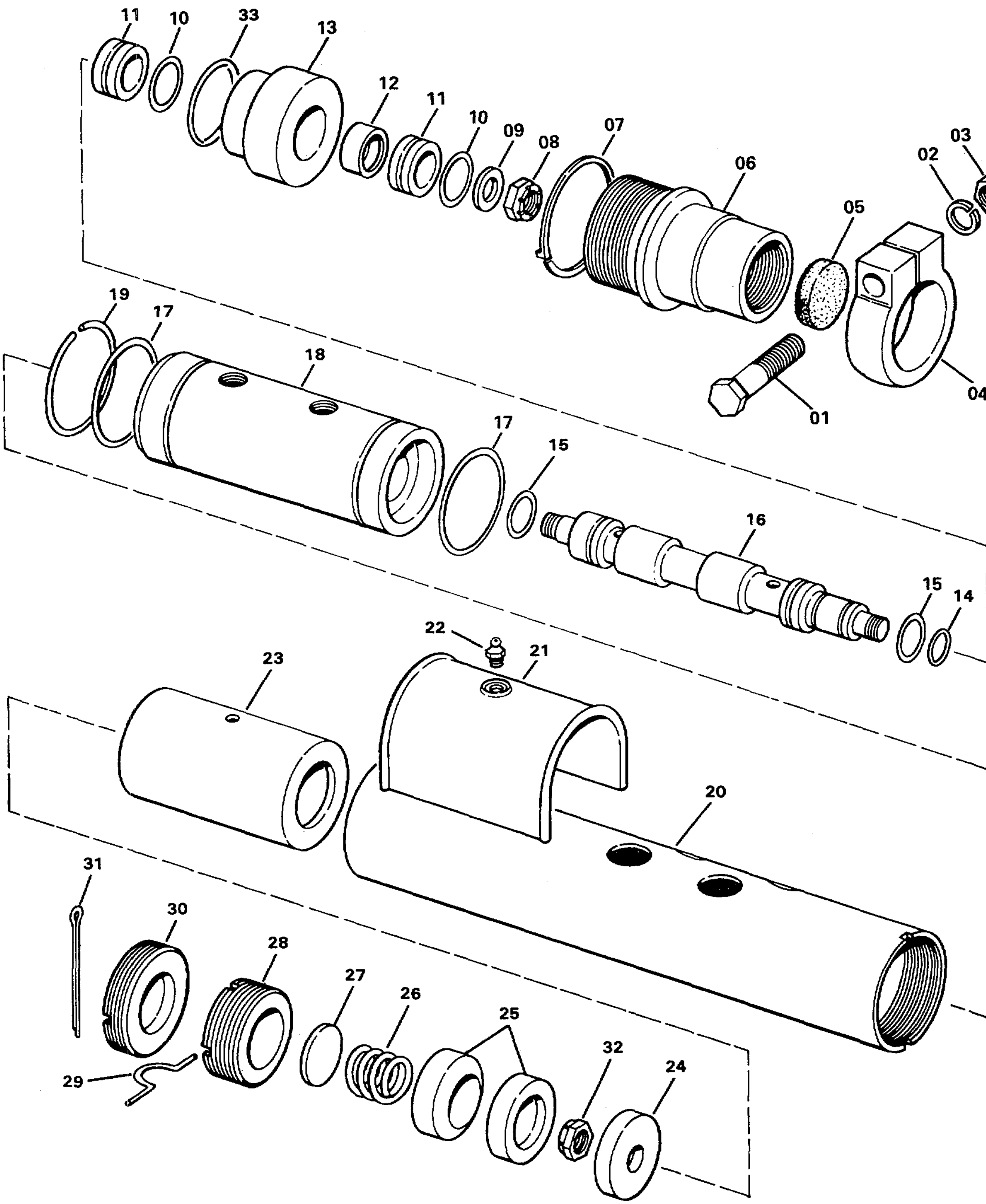


Figure 11D-2. Drag Link Valve (36Z625 & 36Z1402)

LEGEN D FOR FIGURE 11 D-2

	17. O-RING
01. CAPSCREW	**18. VALVE BODY**
02. LOCKWASHER	**19. RETAINING RING**
03. NUT	**20. VALVE HOUSING**
04. CLAMP	**21. DUST SHIELD**
05. FELT PLUG	**22. GREASE FITTING**
06. ADAPTER	**23. BALL SOCKET**
07. LOCK RING	**24. BEARING**
08. NUT	**25. BALL SEAT**
09. WASHER	**26. SPRING**
10. O-RING	**27. WASHER**
11. REACTION RING	**28. PLUG**
12. SPACER	**29. LOCK**
13. GLAND	**30. PLUG**
14. O-RING	**31. COTTER PIN**
15. O-RING	**32. NUT**
16. PISTON	**33. O-RING***

***THIS O-RING USED ON DRAG LINK VALVE (36Z625) ONLY.**

7. Place ball socket bearing (24) in ball socket (23). The counterbored side of bearing (24) should face toward the socket opening.

8. Assemble socket (23) in the housing and secure with nut (32). Tighten nut (32) to 30-35 ft-lbs (4.15-4.84 kg-m) torque.

9. Tighten drag link adapter (06) to 170-175 ft-lbs (23.51-24.20 kg-m) torque. Bend the edge of lock ring (07) into a slot in the rim of adapter (06).

INSTALLATION AND ADJUSTMENT. To install and adjust the drag link valve, proceed as follows (see Figure 11 D-2):

1. Screw the drag link valve to the drag link and secure in place with capscrew (01), lockwasher (02) and nut (03).

2. Place one ball seat (25) into ball socket (23) and assemble the drag link valve over the ball stud on the vehicle steer-ing arm. Assemble the other ball seat (25), spring (26), washer (27), and ball socket end plug (28). Tighten end plug (28) until it bottoms, then back it off until the nearest set of holes in socket (23) lines up with the slot in end plug (28) to permit installation of plug lock (29).

3. Attach the hydraulic lines to the valve ports. The lines must be attached to the same ports from which they were originally removed.

4. When installing valve housing end plug (30), particular attention should be given to positioning it properly. The plug provides a stop which limits the outward stroke of valve piston (16). There should be a 1/16 inch (1.588 mm) maxi-mum gap between the end of ball socket (23) and the face of end plug (30) when valve piston (16) is in a centered (neutral) position (see Figure 11 D-3).

To obtain the proper end plug position, proceed as follows (see Figure 11 D-3):

A. After the power steering system is installed completely, fill the reservoir to the specified level with the type of fluid recommended (see Section III). Start the engine to allow the hydraulic fluid to circulate through the sys-tem. Have the front axle jacked up so that the wheels are clear. Turn the wheels full right and full left a few times to allow the steering cylinders and lines to fill. Check the fluid level in the reservoir and replenish if necessary.

B. Increase the engine speed to about 900 to 1000 rpm. Hydraulic system pressure will center the valve piston in the neutral position.

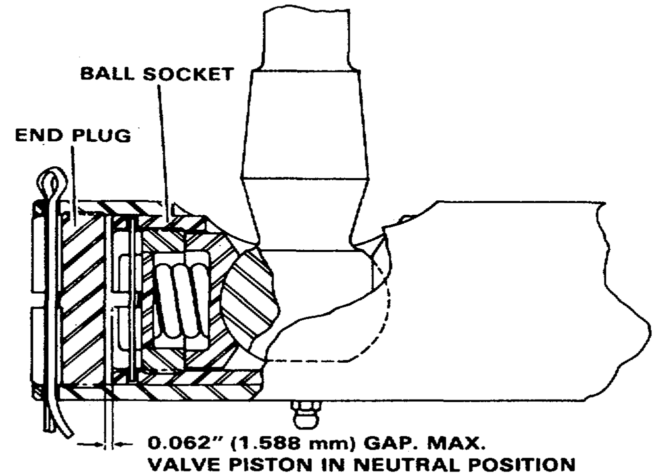


Figure 11D-3. Adjusting End Plug Gap

C. Turn the housing end plug inward until there is a 1/16 inch (1.588 mm) gap between the two end plugs. This di-mension can be measured by inserting a feeler gauge shim .0625 inch (1.588 mm) between the plugs through the inspection hole in the valve housing. Remove the gauge and continue turning the end plug inward until the nearest set of holes in the housing line up with the slot in the end plug, and install cotter pin (31).

5. If the valve is to be installed when it is not possible to operate the engine for hydraulic power as described in the preceeding paragraphs, use the following procedure to make the end plug adjustment.

A. Assemble the valve on the steering arm ball stud and assemble the ball socket end plug as described in the first two steps in the installation and adjustment instructions.

B. Move the valve so that the valve piston and ball socket travel inward. Hold the valve against the stop and turn the housing end plug inward until there is a 1/8 inch (3.175 mm) gap between it and the ball socket end plug. Insert gauge 0.125 inch (3.175 mm) between the plugs through the inspection hole in the housing to check the measurement. Remove the gauge and continue turning the end plug inward until the nearest set of holes in the housing lines up with the slot in the end plug, and in-stall cotter pin (31).

6. It is important that the end plug adjustment be made properly to assure that it provides for a stop when the ball socket moves outward. This eliminates the possibility of placing tension on the valve piston when the valve is actuated during steering operation.

7. Always provide a dust shield to cover the ball socket opening. A lubrication fitting is provided for the valve ball socket and stud. See Section III for instructions.

8. Before placing the vehicle into operation, recheck all line fittings on the valve, steering cylinders, and the hydraulic pump. Check the end plug in the ball socket on the drag link valve and on the power steering cylinder rods.

POWER STEERING CYLINDER (45Z357-D2)

GENERAL. Two of these double acting hydraulic cylinders per front axle are used to turn the front wheels of this ma-chine. One cylinder is attached to each tie rod. They are con-nected hydraulically to operate in conjunction with one another.

REMOVAL. To remove the power steering cylinders, proceed as follows:

1. Block the machine so it will not move while repairs are being made to the cylinders.

2. Disconnect and cap the hydraulic lines from the cylinder. Be sure to identify the hydraulic lines so that they are reinstalled in the same position as they were before removal.

3. Remove pivot pin from cylinder mounting block and cylinder.

4. Remove the cotter pin from the ball socket assembly. Back out the end plug and remove the cylinder from the machine.

REPAIR. To repair the steering cylinder proceed as follows (see Figure 11 D-4):

1. Loosen the ball socket assembly clamp bolt. Unscrew the ball socket assembly from the cylinder rod.

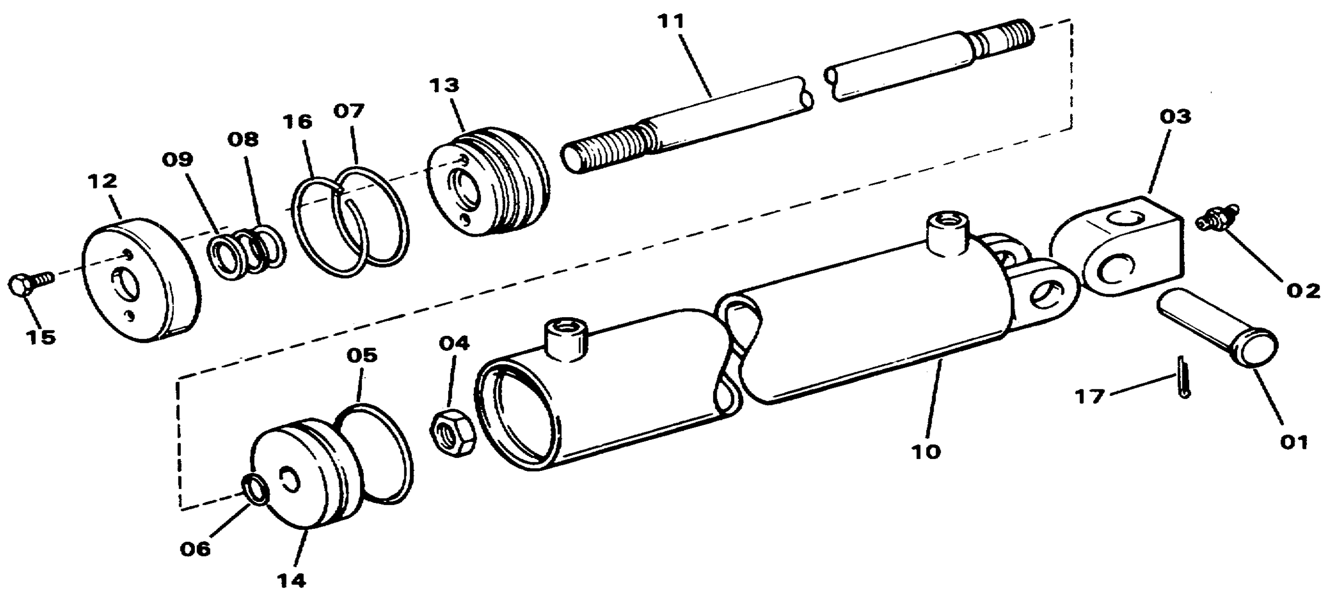
2. Remove capscrews (15) and cap (12). Push in on sleeve (13) and remove lock wire (16).

3. Clamp mounting end of cylinder body (10) in a vise and hold cylinder rod (11). Pull on cylinder rod to pull out sleeve assembly and piston.

4. Remove nut (04) and slide off sleeve (13) and piston (14).

5. Remove O-ring (06) from cylinder rod (11). Remove 0-ring and back-up rings (05) from piston (14).

6. Remove dust seal(09), O-ring and back-up ring (08)from inside of sleeve (13). Remove O-ring (07) from outside of sleeve (13).



01.	PIN	*09.	DUST SEAL
02.	GREASE FITTING	10.	CYLINDER BODY
03.	MOUNTING BLOCK	11.	CYLINDER ROD
		12.	CAP
		13.	SLEEVE
		14.	PISTON
04.	LOCKNUT	15.	CAPSCREW
*05.	O-RING W/BACK-UP RINGS	16.	LOCK WIRE
*06.	O-RING	17.	COTTER PIN
*07.	O-RING		
*08.	O-RING W/BACK-UP RING		*SEAL KIT ITEMS

Figure 11D-4. Power Steering Cylinder (45Z357-D2)

7. Wash all components in suitable solvent. Inspect sleeve (13) and piston (14) for damage, Replace if necessary.

8. Inspect the inner wall of the cylinder tube and rod (11)for scoring. Light scratches can be removed by buffing with crocus cloth. Replace if necessary.

9. Lubricate all seals and parts with clean hydraulic oil before reassembly.

10. Install O-ring and back-up ring (08) in sleeve (13). The back-up ring goes to the outside of the sleeve. Install dust seal (09) in sleeve (13). The lips of the dust seal go to the outside of sleeve (13). Install O-ring (07) on sleeve (13).

11. Install O-ring and back-up rings (05) on piston (14). A back-up ring goes on each side of the O-ring.

12. Install O-ring (06) on cylinder rod (11). Carefully slide piston (14) and sleeve (13) on cylinder rod(11). Use care not to cut the O-rings or dust seal. Install and tighten nut (04).

13. Slide the assembled cylinder rod into cylinder body (10). Push sleeve back and install lock wire (16). Pull the cyl-inder rod out to seat sleeve (13) against the lock wire.

14. Install cap(12). Line up holes in cap with holes in sleeve (13) and install capscrews (15).

15. Install the ball socket assembly on the end of the cylinder rod. Adjust the ball socket assembly to the dimension shown in Figure 11D-5. Tighten the clamp bolt after ad-justment is correct.

INSTALLATION. To install the cylinder, reverse the removal procedure.

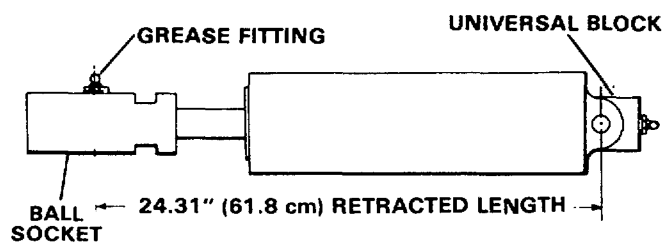


Figure 11D-5. Steering Cylinder Adjustment

STEERING COLUMN (20Z1144)

DISASSEMBLY. To disassemble the steering column, proceed as follows:

1. Disconnect the horn indicator light and turn signal cables.

2. Remove the entire steering column as follows:

A. Loosen the clamp that secures the steering wheel tube to the steering gear (see Figure 11 D-6):

B. Remove the column clamp which supports the steering column in the cab.

C. Remove the steering column.

3. Remove the horn button (02), Figure 11 D-7, by twisting it counterclockwise.

4. Remove horn contact cup (03) and spring (04).

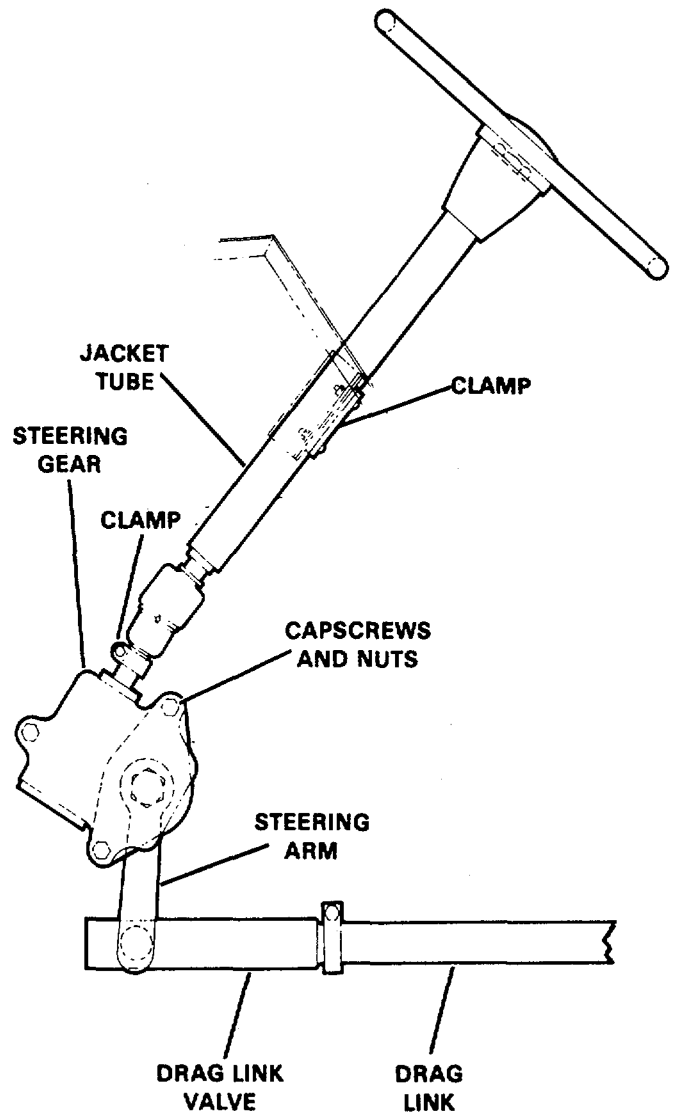


Figure 11D-6. Steering Gear and Column Mounting

5. Remove wheel nut (07). Then remove wheel (08) with a wheel puller or by reinstalling wheel nut (07) about 4 turns. Grasp the wheel with both hands at the spokes and pull up steadily as the wheel is rocked back and forth slightly.

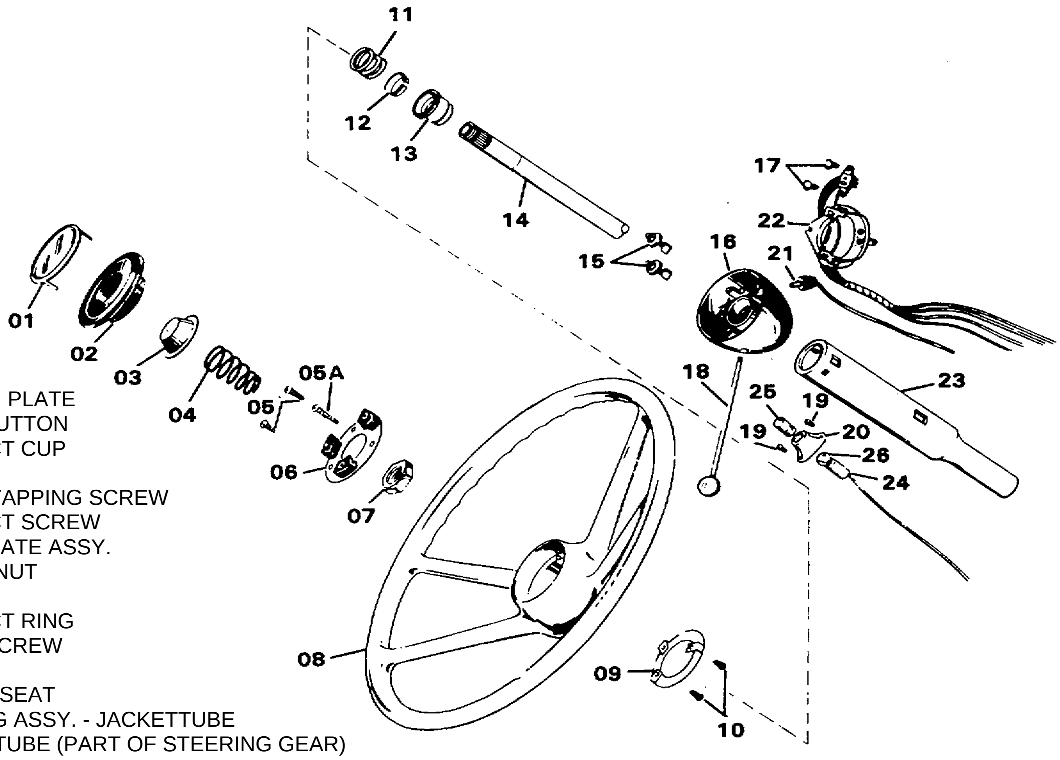
6. Remove bearing spring (11) and spring seat (12).

7. Remove turn signal control lever (18) by unscrewing it from the turn signal switch plate pivot post.

8. To disconnect the turn signal switch plate from the switch assembly proceed as follows. The switch and switch plate are joined by means of a sliding pin in the switch assembly extending through the switch plate just inside the detent point. The pin is held in position by a small spring loaded "C" washer.

A. Compress the spring and slide the "C" washer off the pin. Then remove the spring.

B. Remove the turn signal switch plate by lifting it straight up out of switch housing (16).



01. EMBLEM PLATE
02. HORN BUTTON
03. CONTACT CUP
04. SPRING
05. METAL TAPPING SCREW
05A. CONTACT SCREW
06. BASE PLATE ASSY.
07. WHEEL NUT
08. WHEEL
09. CONTACT RING
10. DRIVE SCREW
11. SPRING
12. SPRING SEAT
13. BEARING ASSY. - JACKETTUBE
14. WHEEL TUBE (PART OF STEERING GEAR)
15 "U' BOLT ASSY.
16. TURN SIGNAL HOUSING
17. PAN HEAD MACH. SCREWS
18. SWITCH LEVER
19. METAL TAPPING SCREW
20. PILOT LIGHT HOUSING
21. HORN CONTACT ROLLER ASSY.
22. DIRECTIONAL SWITCH ASSY.
23. JACKET TUBE ASSY.
24. PILOT LIGHT SOCKET AND CABLE
25. PILOT LIGHT COVER
26. PILOT LIGHT BULB

Figure 11D-7. Steering Column (20Z1144)

NOTE

Carefully note the way the wiring is laid in the housing. Incorrect routing of the wiring at reassembly may cause binding of the switch plate or shorting of the circuit.

9. Carefully pull the disconnected cable assemblies out of the wire trough in jacket tube (23) and out of switch housing (16).

10. Remove J-bolts (15).

NOTE

Remove turn signal housing (16); spring (11), spring seat (12), and jacket tube bearing (1 3) will also be removed.

11. Remove signal housing (16).

REASSEMBLY. To reassemble the steering column proceed as follows:

1. Lubricate jacket tube bearing (13) lightly with lubriplate.

2. Reassemble horn cable and contact assembly (21) in the new switch plate. (Be certain roller contact is on the same side of the switch plate as the cancelling cams and springs.)

3. Gather horn cable (21), indicator light cable (24) and turn signal cables with terminals slightly staggered to prevent bunching.

4. Wrap the terminal ends lightly with tape and insert them into the opening in turn signal housing (16), and feed them through jacket tube (23), until they start out the opening in the lower portion of the jacket tube.

5. Slip the plastic protector tube over the cable assembly and carefully pull the cable assembly on down while properly locating the cables in the base of switch housing (16).

6. Insert the turn signal switch plate pivot pin in the pivot hole of the housing after lubricating it lightly with lubri-plate or similar lubricant.

7. Reassemble the switch plate on the switch pin and in-stall the spring and "C" washer on the switch pin.

8. Install control lever 18) and actuate the switch in both directions several times to be certain there is no binding. If there is friction or binding, recheck the position on the wiring in the switch housing and reposition if necessary.

9. Install spring seat (12) and spring (11) on wheel tube (14).

10. Place the turn signal switch in the off or neutral position.

11. Install steering wheel (08).

12. Install wheel nut (07) and torque it to 55-65 foot-pounds (7.6-8.9 kg-m).

13. Install horn contact spring (04)and contact cup (03)and replace horn button (02) and emblem assembly (01) by pressing button down hard and turning it clockwise.

14. Remove the tape from the cable terminals and reconnect the wires. Check the horn, emergency flasher switch and turn signal switch to be sure they are functioning properly.

15. Check the gap between the upper face of turn signal switch housing (16) and lower edge of the steering wheel skirt. This gap must be a minimum of 3/32 inch (2.4 mm). If adjustment is necessary, loosen the jacket tube clamp at the steering gear upper cover and move the jacket tube up or down to obtain the necessary clearance. Tighten the jacket tube clamp bolt to 30-35 ft-lbs (4.1-4.8 kg-m).

16. Install the completed steering column in the carrier as follows:

A. Place the steering column in place, sliding the U-joint end of the steering column over the splined shaft of the steering gear.

B. Fasten the clamp which holds wheel tube (14) to the steering gear.

C. Install the support U-bolt, for the steering column.

FLOW CONTROL AND RELIEF VALVE (36Z293)

DESCRIPTION. Maximum pump delivery and maximum system pressure are determined by the two flow control and relief valves located on the right front carrier frame. These valves act to control the outrigger/steering system. They function both as a compound relief valve and a bypass type pressure compensated flow control. This valve is con-sidered non-repairable. If the valve is faulty the complete valve should be removed and replaced with a new one.

REMOVAL. To remove the flow control relief valve, pro-ceed as follows:

1. Shut off the engine and slightly crack open the hydrau-lic lines on the valve to relieve any pressure in the lines. Tag the lines to correspond with the markings on the valve and remove the lines. Cap and plug the lines and valve.

2. Remove the capscrews, lockwashers and nuts securing the valve. Remove the valve.

INSTALLATION. To install the valve proceed as follows:

1. Set the valve in place and secure with capscrews, lock-washers and nuts. Tighten securely.

2. Remove the protective caps and connect the hydraulic lines to the valve in the same manner as they were removed.

3. Start the engine and observe the valve for leaks, binding or other defects.

RELIEF VALVE (36Z667)

DESCRIPTION. These valves are on the "down" side of the circuit selector valves to limit the system pressure to the steering system. These valves are located on the middle front carrier frame to the left of the circuit selector valves. This valve is considered non-repairable. If the valve is faulty the complete valve should be removed and replaced with a new one.

REMOVAL. To remove the relief valve, proceed as follows:

1. Shut off the engine and slightly crack open the hydraulic lines on the valve to relieve any pressure in the lines. Tag the lines to correspond with the marking on the valve and remove the lines. Cap and plug the lines and valve.

2. Remove the capscrews, lockwashers, and nuts securing the valve to the carrier frame. Remove the valve.

INSTALLATION. To install the relief valve, proceed as follows:

1. Set the valve in place and secure with the capscrews, lockwashers and nuts. Tighten securely.

2. Remove the protective caps and connect the hydraulic lines to the valve in the same manner as they were removed.

3. Start the engine and observe the valve for leaks or other defects.

SELECTOR VALVE (36Q143)

DESCRIPTION. This is a two-way solenoid operated directional valve. It is used to switch the hydraulic pump output from the outrigger system to the power steering system and back to the outrigger system, as required.

REMOVAL. To remove a circuit selector valve, proceed as follows:

1. Shut off the engine and slightly crack open the hydraulic lines on the subplates to relieve any pressure in the lines. Tag and remove the lines. Cap and plug the lines and valve.

2. Remove the electrical leads to both selector valves.

3. Remove the nuts, lockwashers and capscrews securing the valves, and subplates to the support bracket. REPAIRS. Repair of this valve is limited to the replacement of the coil and several O-rings. See Figure 11D-8. When the solenoid assembly is removed, all that is required to replace the O-rings is to remove the snap ring, remove the closure and replace the 0-rings. The O-rings between the valve and subplate are also included in the kit..

NOTE

If the spool or body are damaged the complete valve should be replaced.

INSTALLATION. To install a circuit selector valve, proceed as follows:

1. Install the O-rings between the circuit selector valve and the subplate.

2. Set one valve and subplate against the support bracket, install the capscrews and set the other valve and subplate against the support bracket. Install the lockwashers and nuts. Tighten securely.

3. Install the electrical leads removed previously.

4. Remove the protective caps and connect the hydraulic lines to the subplate in the same manner as they were removed.

5. Start the engine and observe the valve for leaks, binding or other defects.

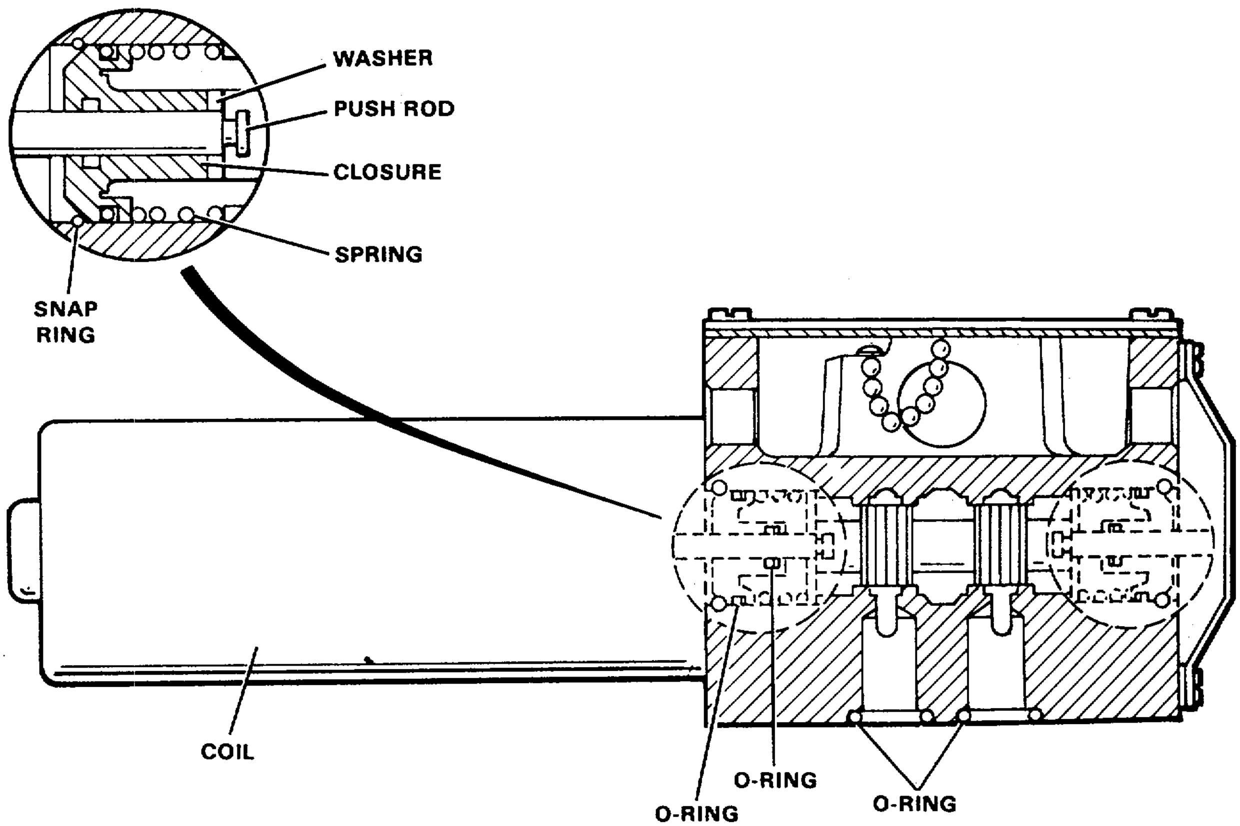


Figure 11D-8. Circuit Selector Valve (36Q143)

SECTION XII.

AIR SYSTEMS

AIR SYSTEMS

GENERAL

The air system consists of the devices used-to control and actuate the carrier brakes, the air horn, tire inflation valve, and the air shift used on the carrier transmission.

TESTING FOR SERVICEABILITY

To ensure that the brake system is functioning properly, and to aid in scheduling brake system service, a systematic method of checking the serviceability of the system must be employed to be sure that all parts of the system are in-spected. The procedure outlined below is one such method.

WARNING

Do not use brake system to hold the machine while performing the following test. Hold the machine by blocking the wheels with wheel chocks.

1. Drain Air Tanks. Charge the air brake system. Open the drain cocks on each air tank. Close the drain cocks after all devices have been completely drained of all air pressure and condensation.

2. Check Stop Light Switch. With no air pressure in the sys-tem, start the engine, depress the brake pedal, and observe the dash gauge pressure when the stop lights light up. Stop lights should normally light when the dash gauge registers approximately 5 psi (0.34 bars). Release the brake pedal and the stop light should go out.

3. Check Brake Chamber Push Rod Travel. Apply the brakes and check the push rod travel of each rear brake. Adjust if the stroke is excessive.

4. Check Low Air Pressure Light. Run engine, continuing pressure build-up. Low pressure light must remain lit until dash gauge pressure reaches approximately 60 psi (4.13 bars), at which point the light should go out.

5. Pressure Build-Up Test. Run the engine at fast idle. Time required to raise the air pressure from 50 to 90 psi (3.44-6.20 bars) will vary, but should not exceed 5 minutes.

6. Governor Setting Test. Run the engine. Governor should cut out, stopping further compression, at approximately 1 20 psi (8.27 bars). Reduce air pressure by making a series of brake applications. The governor should cut in, resuming compression, at approximately 105 psi (7.24 bars).

7. Leakage Test. Run the engine until the governor cuts out. Stop the engine. Wait until the air pressure stabilizes. With the brakes released, dash gauge pressure drop should not exceed 2 psi per minute (0.13 bar/min). Make a full brake application and hold it. Allow the pressure to stabilize. Pressure drop should not exceed 3 psi per minute (0.20 bar/min). Check system connections and applicable devices if leakage in either test is excessive.

8. Operating Tests. Connect an accurate test gauge to the brake valve delivery line(s). Fully charge the air brake sys-tem. Depress the brake pedal fully. Test gauge pressure should approximately equal dash gauge pressure. Hold the pedal in several different positions; delivery should vary rapidly in accordance with changes in pedal position. Check for quick application and release of all brakes.

With the engine stopped, reduce air pressure to approxi-mately 30 psi (2.06 bars) by making a series of brake ap-plications. The Maxibrake control knob should move inward to the applied position automatically when the pressure drops below 30 psi (2.06 bars). Check the rear brakes to be sure they are in the applied position when the Maxibrake control valve is in the applied position.

Push in the Emergency Release Valve knob and pull out the Maxibrake control valve knob. Pressure from the emer-gency air tank should be transferred to the Maxibrake con-trol valve and the Maxibrakes should release.

TROUBLESHOOTING

1. INSUFFICIENT BRAKES
   Brakes need adjusting, lubricating or relining
   Low air pressure in the brake system (below 80 pounds)
   Brake valve delivery pressure below normal

2. BRAKES APPLY TOO SLOWLY
   Brakes need adjusting or lubricating
   Low air pressure in the brake system (below 80 pounds)
   Brake valve delivery pressure below normal
   Excessive leakage with brakes applied
   Restricted tubing or hose line

3. BRAKES RELEASE TOO SLOWLY
   Brakes need adjusting or lubricating
   Brake valve not returning to fully released position
   Restricted tubing or hose line
   Exhaust port of brake valve or quick release valve restricted or plugged
   Defective brake valve or quick release valve

4. BRAKES DO NOT APPLY
   No air pressure in brake system
   Restricted or broken tubing or hose line
   Defective brake valve

5. BRAKES DO NOT RELEASE
   Brake rigging binding
   Brake valve not in fully released position
   Defective brake valve
   Restriction in tubing or hose line

6. BRAKES GRAB
   Grease on brake lining - reline brakes
   Brake drum out of round
   Defective brake valve
   Brake rigging binding

7. UNEVEN BRAKES
   Brakes need adjusting, lubricating or relining
   Grease on brake lining - reline brakes
   Brake shoe release spring or brake chamber release spring broken
   Brake drum out of round
   Brake chamber diaphargm leaking

8. AIR PRESSURE WILL NOT RISE TO NORMAL
   Defective air gauge (registering incorrectly)
   Excessive leakage
   Reservoir drain cock open
   Cut-out cock open
   Governor out of adjustment
   No clearance at compressor unloading valves
   Slipping compressor drive belt
   Defective compressor

9. AIR PRESSURE RISES TO NORMAL TOO SLOWLY
   Excessive leakage
   Clogged compressor air strainer
   No clearance at compressor unloading valves
   Engine speed too slow
   Compressor discharge valves leaking
   Compressor drive belt slipping
   Worn compressor
   Excessive carbon in compressor cylinder head or discharge line

10. AIR PRESSURE RISES ABOVE NORMAL
    Defective air gauge (registering incorrectly)
    Compressor governor out of adjustment
    Defective compressor governor
    Restriction in line between governor and compressor unloading mechanism
    Too much clearance at compressor unloader valves
    Unloading valve cavities or unloading passage in compressor cylinder head blocked with carbon
    Compressor unloading valves stuck closed

11. AIR PRESSURE DROPS QUICKLY WITH ENGINE STOPPED AND BRAKES FULLY RELEASED
    Leaking brake valve
    Leaking tubing or hose line
    Compressor discharge valve leaking
    Compressor governor leaking
    Excessive leakage elsewhere in the Air Brake System

12. AIR PRESSURE DROPS QUICKLY WITH ENGINE STOPPED AND BRAKES FULLY APPLIED
    Leaking brake chamber
    Cut-out cock open
    Leaking brake valve
    Leaking tubing or hose line

13. COMPRESSOR KNOCKS CONTINUOUSLY OR INTERMITTENTLY
    Loose drive pulley
    Backlash in drive gears or drive coupling
    Worn or burnt out bearings
    Excessive carbon deposits in compressor cylinder head

14. SAFETY VALVE "BLOWS OFF"
    Safety valve out of adjustment
    Air pressure in the Air Brake System above normal
    Governor cut-out not functioning properly

15. EXCESSIVE OIL OR WATER IN THE BRAKE SYSTEM
    Reservoirs not being drained often enough
    Compressor passing excessive oil
    Compressor air strainer dirty

CARRIER AIR SCHEMATIC (8105N126)

GENERAL. This machine is equipped with a dual air brake system which serves three separate functions. These functions are; service brakes, parking brakes and emergency brakes. The operation of each of these subsystems is described below.

Compressed air for the operation of the brake system is supplied by an engine driven air compressor, and is stored in a number of tanks on the machine. A governor mounted on the air compressor, senses the pressure of the air in the tanks, and controls the compressor output. Compression starts when the pressure drops to approximatly 105 psi (7.24 bars) and is stopped by the governor when it reaches approximately 120 psi (8.27 bars).

SERVICE BRAKES. Supply air from the front and rear supply tanks is available at the brake treadle valve and the relay valves at all times. When the operator depressses the brake treadle, air from the supply tanks passes through the treadle valve to the relay valves, which directs air from the tanks to the front and rear service brake chambers. Air pressure in the brake chambers force the brake shoes apart, placing them in contact with the brake drums, and braking force is applied to the wheels. Inasmuch as the air pressure delivered to the brake chambers is controlled by the treadle valve, the driver, by operating the treadle valve and controlling the air pressure delivered to the brake chambers, also controls the braking force being developed.

The relay valves are provided to speed up the application and release of the front and rear brakes. The valve operates as a remote controlled brake valve, delivering air to the front and rear service brake chambers which are at the same ressure as the pilot air which is delivered to the relay alves by the treadle valve. The relay valves vent air presure from the front and rear service brake chambers directy to atmosphere, making it unnecessary for the air to travel ack through the line to the treadle valve.

ARKING BRAKES. By depressing the Maxibrake control nob, on the carrier dash panel, the operator can use the laxibrakes as parking brakes. Depressing the Maxibrake ntrol knob cuts off pressure at the inlet of the quick rease valves, exhausting air from the spring chambers of e Maxibrakes. Venting the spring chambers allows the wer springs to expand and apply the front and rear wheel akes.

The brakes will remain set until air pressure is reapplied to the spring chambers, compressing the power springs and releasing the brakes.

Pulling out the Maxibrake control knob applies air pressure to the inlet of the quick release valves, closing off the exhaust port of the valves. Air pressure then passes through the movable seat of the valve, and into the spring chamber. This compresses the power springs, releasing the brakes.

EMERGENCY BRAKES. The basic purpose of the Maxibrakes is to provide a *means* of stopping the vehicle in the event that air pressure is lost or drops below a safe level when the vehicle is in motion.

The Maxibrake control valve functions automatically as well as manually. In the event that air pressure drops to 28 psi (1.93 bars) or less, pressure at the inlet port of the control valve will be overcome by the force applied to the valve shuttle by the spring, and the spring will shift the shuttle to the applied position. This will vent air pressure from the inlet of the quick release valves, thus venting air pressure from the spring chambers. The front and rear brakes will then be applied by the force created by the power springs.

Air pressure to compress the power springs is normally supplied by a rear dry tank, through the Maxibrake control valve, to the spring chambers. This arrangement does not provide a means of moving the vehicle from the point at which it was stopped by the Maxibrakes, if the loss of air pressure is due to a failure in an air line or the compressor. Therefore, an emergency air tank, which is isolated from the service air system by a check valve, is provided.

Since the emergency air tank is isolated from the service air system, air pressure will be available in the emergency tank to release the Maxibrakes. To release the Maxibrakes, after an air system failure, the operator must depress the emergency release valve knob and pull out the Maxibrake control knob. This directs air pressure from the emergency tank to the spring chambers, through the Maxibrake control valve and the quick release valves. This compresses the power springs, releasing the brakes.

AIR SHIFT DESCRIPTION. The air shift system selects the appropriate gear in the auxiliary transmission, by means of the air shift valve and the piston located in the top cover of the auxiliary transmission.

Manual selection of a gear position supplies air to the pistons (or cylinders) to attain a proper gear selection.

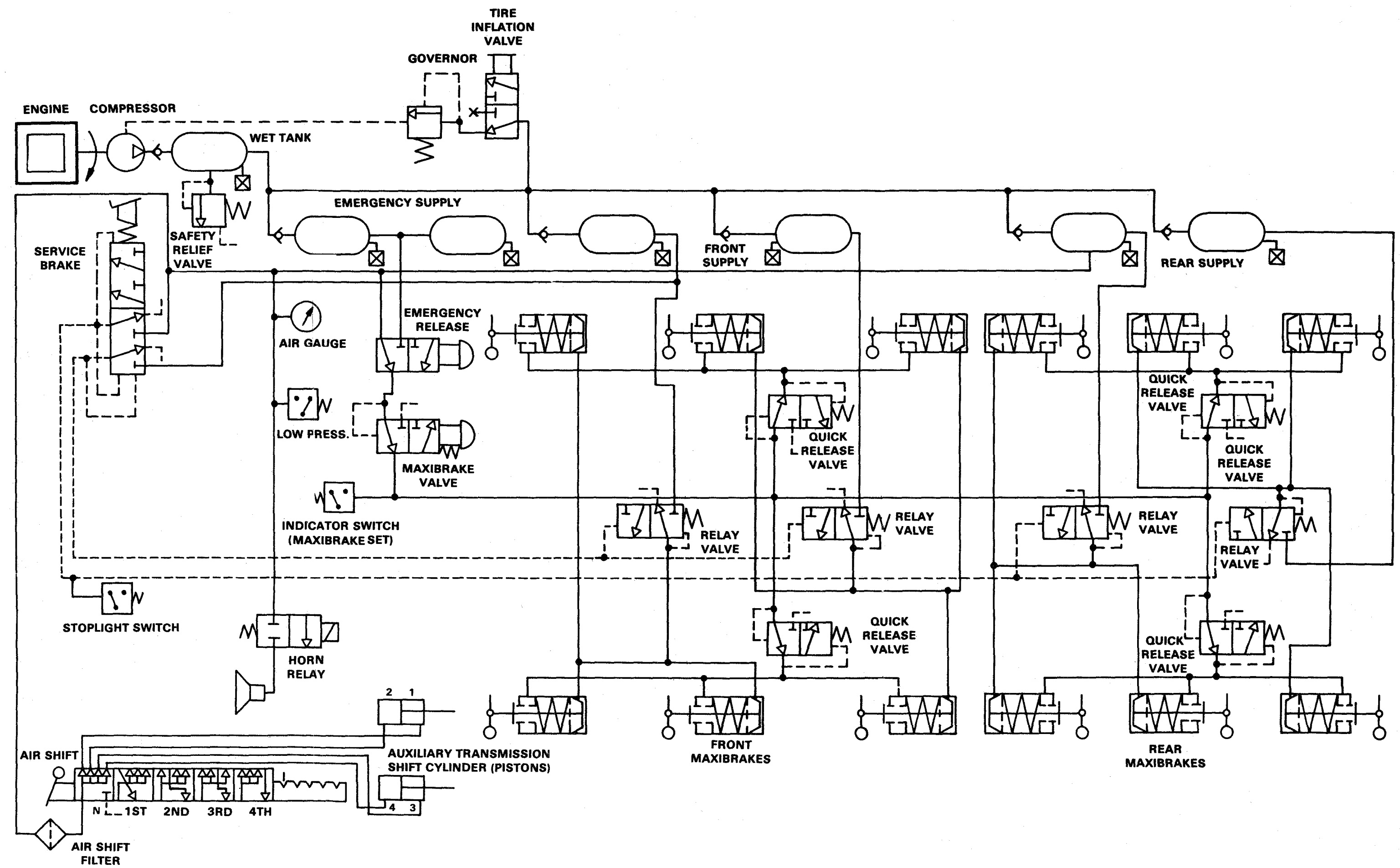


Figure 12A-1. Carrier Air Schematic (8105N126)

SUBSECTION 12B
AIR COMPRESSORS

GENERAL

The function of the air compressor is to build up and maintain the air pressure required to operate all of the air powered devices on the carrier. A troubleshooting chart is provided at the end of this subsection to aid in finding com-pressor problems.

SPECIAL TOOLS

The following tools or tools of comparable quality are necessary to repair or rebuild the air compressor.

Service Tool No.	Tool Name
ST-749	Mounting Plate
ST-302	Ball Joint Vise
ST-1249	Puller
ST-1143	Press
ST-1105	Bushing Mandrel

OPERATION

The compressor runs continuously while the engine is running, but actual compression of air is contolled by the governor which stops or starts the compression of air by loading or unloading the compressor in conjunction with its unloading rmechanism. This is done when the air pressure in the system reaches the desired maximum or minimum pressures.

During the down stroke of the piston, a slight vacuum created above the piston causes the inlet valve to move off its seat. Atmospheric air is drawn in through the compressor intake, by the open inlet valve, and onto the top of the piston. As the piston starts its upward stroke, the air that was drawn in on the down stroke is being compressed. Now, air pressure on the inlet valve plus the force of its spring, returns the inlet valve to its seat. The piston continues the upward stroke and compresses the air sufficiently to overcome the discharge valve spring and unseats the discharge valve. The compressed air then flows by the open discharge valve, into the discharge line and on to the air tanks.

As the piston reaches the top of its stroke and starts down, the discharge valve spring returns the discharge valve to its seat. This prevents the compressed air in the discharge line from returning to the cylinder bore as the intake and com-pression cycle is repeated.

When the pressure in the air tanks reaches the high pressure setting of the governor, the governor opens, allowing air to pass from the air tank through the governor and into the cavity beneath the unloader pistons. This lifts the un-loader pistons and plungers. The plungers move up and hold the inlet valves off their seats.

With the inlet valves held off their seats by the unloader pistons and plungers, air is merely pumped back and forth between the two cylinders. When air is used from the air tank and the pressure drops to the low pressure setting of the governor, the governor closes and in doing so exhausts the air from beneath the unloader pistons. The unloader spring forces the pistons and plungers down and the inlet valves return to their seats. Compression is then resumed.

SERVICE CHECKS

INSPECTION. The following service checks should be per-formed periodically to ensure proper operation of the air compressor.

WARNING

Do not use the brake system to hold the machine while testing or working on the air system. Hold the machine by blocking the wheels with wheel chocks.

1. It is of utmost importance that the compressor is taking in clean air. Be sure the compressor intake is air tight and that the connections are tight.

2. Check the compressor mounting to be sure it is secure.

3. Inspect the oil supply and return lines. Be sure the com-pressor is getting the proper supply of oil, and just as important, that the oil is returning to the engine properly.

4. Check the water lines to and from the compressor.

AIR LEAKAGE TEST. Leakage past the discharge valves can be detected by removing the discharge line, applying shop air back through the discharge port, and listening for escaping air. Also the discharge valves and unloader pistons can be checked for leakage by building up the air pressure until the governor cuts out, then stop the engine. With the engine stopped, carefully listen for escaping air at the intake. To pin-point leakage, if noted, squirt soapy water around the unloader pistons. If there is no noticeable leak-age at the unloader pistons, the discharge valves may be leaking.
If the compressor does not function as described above, or leakage is excessive, it is recommended that the nearest Cummins distributor be contacted for repair information, or that the compressor be returned for a factory rebuilt unit under the repair exchange plan.

REMOVAL

To remove the compressor, proceed as follows:

1. Drain the air from the system by opening the drain cocks on each air tank.

2. Drain the engine cooling system, and compressor cylinder head and block.

3. Disconnect all air, water and oil lines to and from the compressor.

4. Remove air compressor support.

5. Remove the compressor mounting bolts. Then remove the compressor from accessory drive housing; lift out splined drive.

DISASSEMBLY

To disassemble the compressor, proceed as follows:

1. Mount the air compressor to ST-749 mounting plate. This is used with ST-302 ball joint vise. Cylinder head removal may be made with the compressor on an engine.

2. Remove all air lines and water fittings. If the compressor is on an engine, drain the radiator and the air tanks.

3. Remove the capscrews and washers securing the air inlet connection. Lift off the connection and discard the gasket.

4. Remove the two air lines from the air unloader assembly to the two valve assembly retainers, Figure 12B-1.

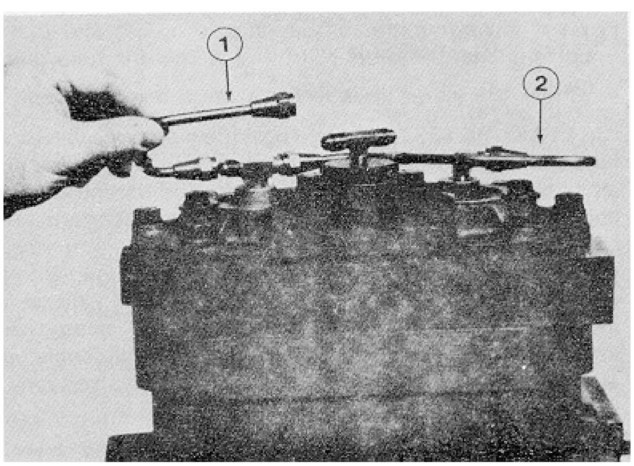


Figure 12B-1. Remove Air Lines

5. Remove the valve assembly retainers and unl3ader caps from both cylinders, Figure 1 2B-2.

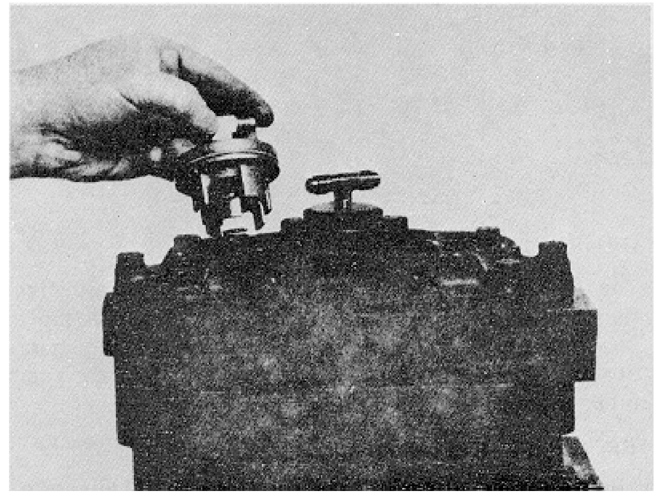


Figure 12B-2. Remove Valve Retainers and Unloader Caps

6. Remove the unloader caps from the valve assembly retainers, Figure 12B-3.

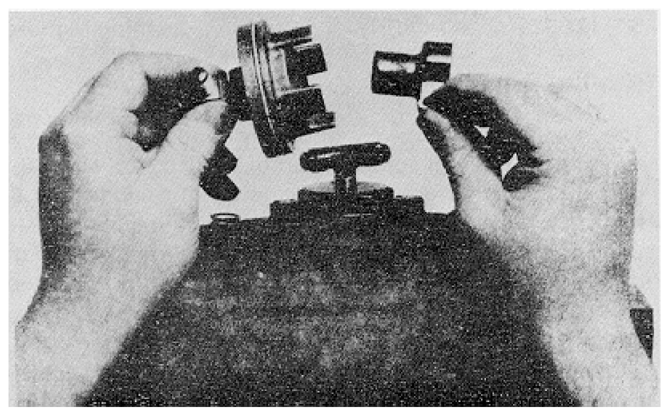


Figure 12B-3. Remove Unloader Caps

7. Remove the O-ring and the seal from the valve seat retainer. Discard the O-ring and seal, Figure 12B-4.

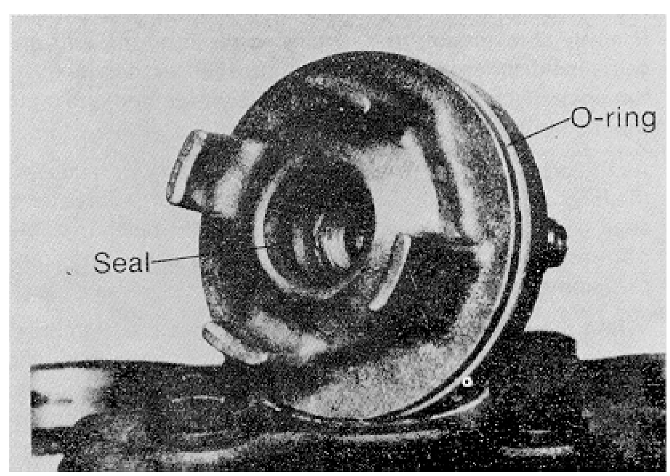


Figure 12B-4. Remove O-Ring and Seal

8. Lift the unloader springs from the valve assemblies, Figure 12B-5.

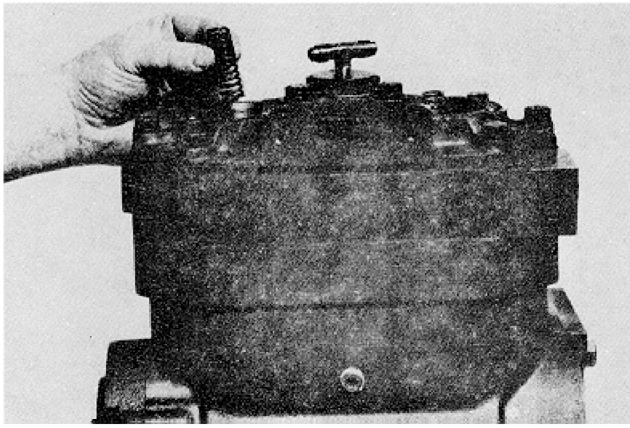


Figure 12B-5. Remove Intake Valve Spring

9. Remove the air unloader plug, T-fitting and copper seal-ing ring from the cylinder head cover, Figure 1 2B-6. Lift the unloader spring from the cylinder head cover.

Figure 12B-6. Remove Air Unloader Plug

10. Remove the unloader cap from the unloader plug, Figure 1 2B-7.

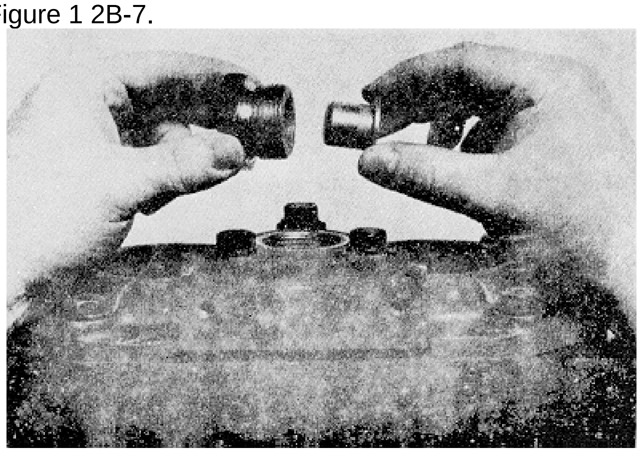


Figure 12B-7. Remove Unloader Cap

11. Remove and discard the seal in the unloader plug, Figure 12B-8.

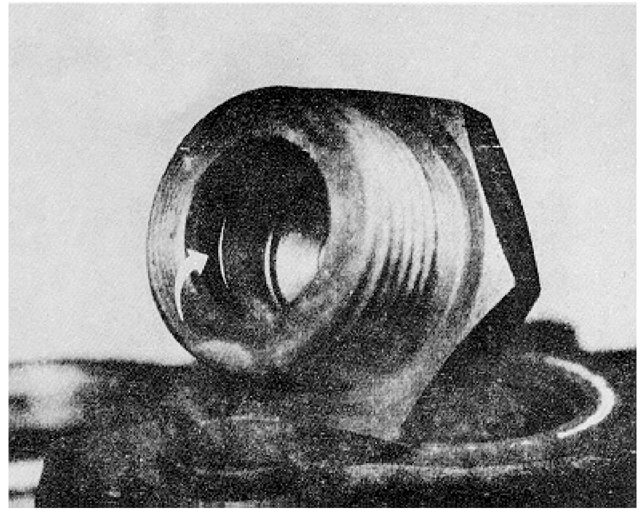


Figure 12B-8. Remove Seal from Unloader Plug

12. Lift the intake valve seats, intake valves and valve springs from the cylinder head, Figure 12B-9.

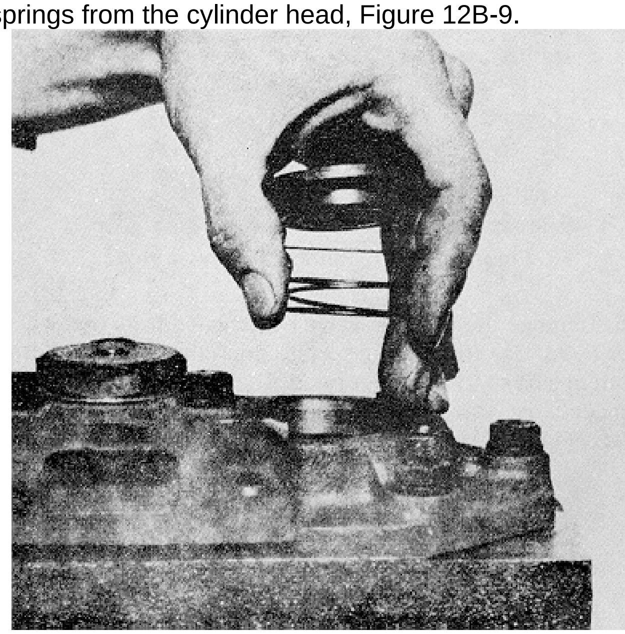


Figure 12B-9. Remove Intake Valve Assembly

13. Remove the capscrews and washers securing the cylinder head cover and the cylinder head to the air compressor crankcase. Lift the head cover from the head. Discard the gasket, Figure 12B-10.

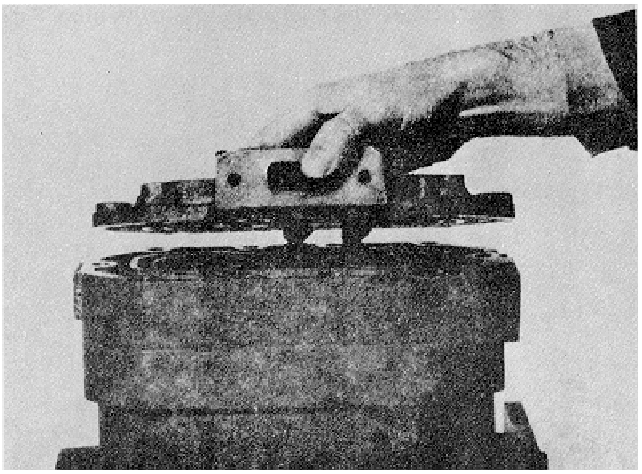


Figure 12B-10. Remove Cylinder Head Cover

14. Lift the cylinder head from the air compressor crank-case. Discard the gasket, Figure 12B-11.

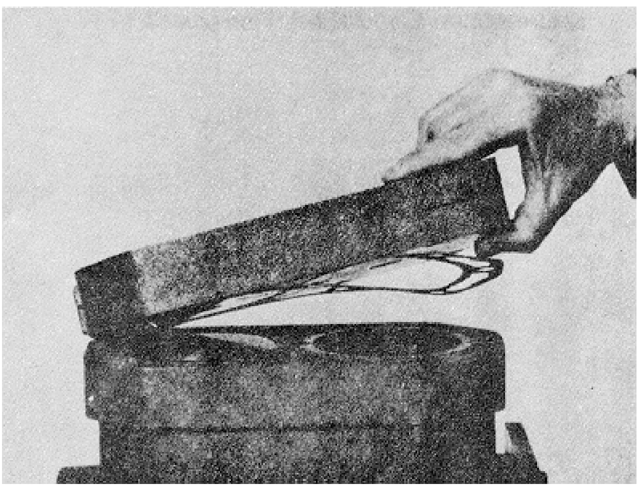


Figure 12B-11. Remove Cylinder Head

15. Remove the exhaust valve assemblies from the cylinder head. Use thumb pressure to push them out from the bottom side of the cylinder head. The assembly consists of the exhaust valve seat, exhaust valve, spring and wear plate, Figure 128-12.

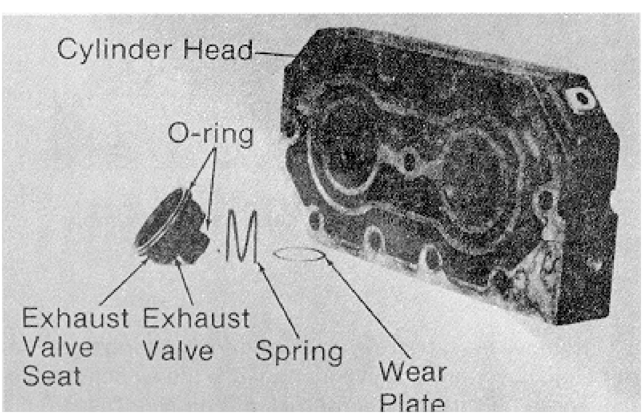


Figure 12B-12. Exhaust Valve Assembly

16. Remove and discard the O-rings from the exhaust valve seats. Lift the exhaust valve from the seat, Figure 12B-13.

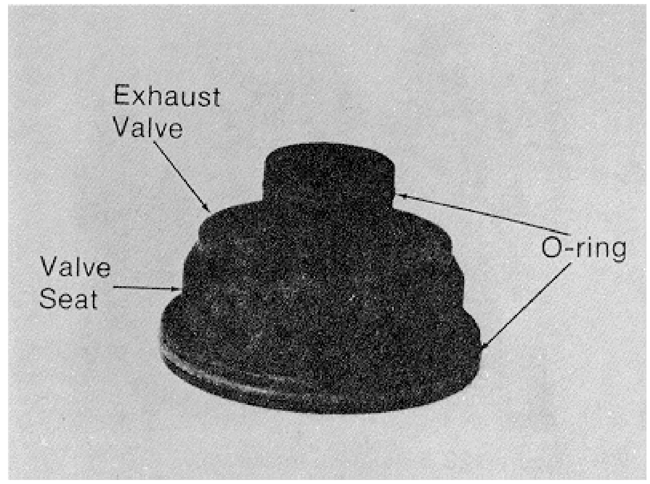


Figure 12B-13. Exhaust Valve and Seat

17. Use ST- 1249 to remove the spline coupling from the air compressor crankshaft.

A. Install ST-1249 over the coupling. Use the index pin to locate the puller teeth behind the coupling teeth.

B. Use wrenches as shown in Figure 12B-14. Hold the tool housing while turning the puller screw to remove the coupling.

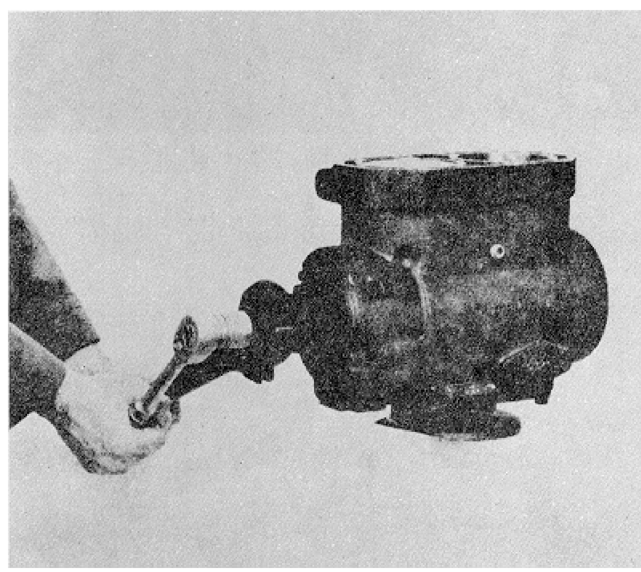


Figure 12B-14. Remove Coupling with ST-1249

18. Remove the outer thrust washer from the front sup-port, Figure 12B-15.

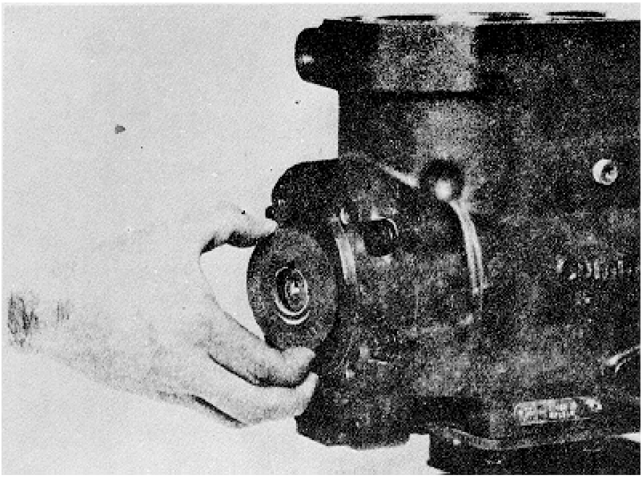


Figure 12B-15. Remove Thrust Washer

19. Remove the capscrews securing the front support to the crankcase. Lift the front support from the crankcase. Discard the gasket, Figure 12B-16.

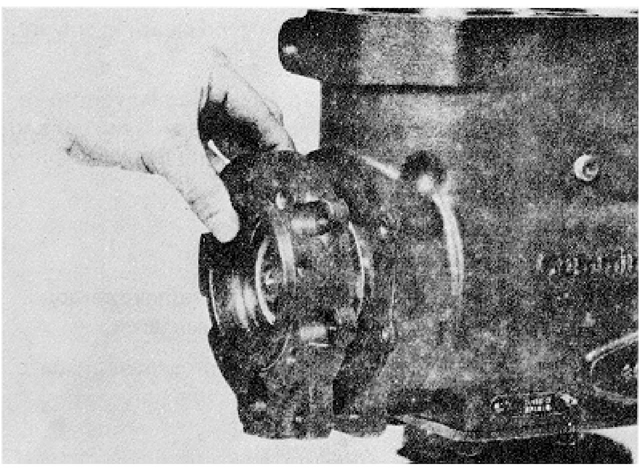


Figure 12B-16. Remove Front Support

20. Lift the inner thrust bearing from the front support, Figure 12B-17.

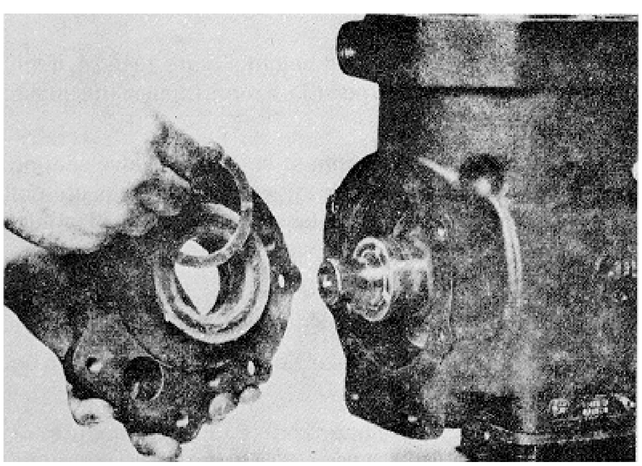


Figure 12B-17. Remove Thrust Washer

21. Remove the crankcase cover plate to provide access to the connecting rods. Discard the gasket.

22. Carefully rotate the crankshaft to bring one of the two connecting rods to approximately bottom dead center. Bend back the lock tabs on the connecting rod capscrews. Re-move the capscrews and the rod caps, Figure 1 2B-18. Follow the same procedure for the other connecting rod.

NOTE

Be sure that the connecting rods and caps are marked for assembly. Rods and caps are matched assemblies and cannot be mixed. The caps must be installed as they are removed. If the parts are not marked, place the cylinder number on the same side of the rod and the cap.

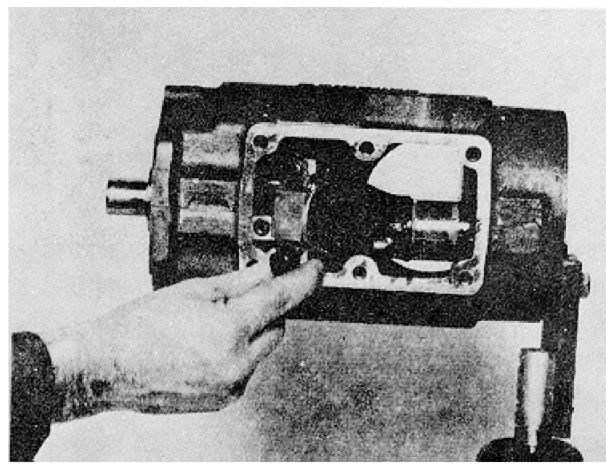


Figure 12B-18. Remove Connecting Rod Caps

23. Use emery cloth to remove carbon deposits and any worn ridge from the top of the cylinder.

24. Push the piston and connecting rod assemblies from the crankcase, Figure 12B-19.

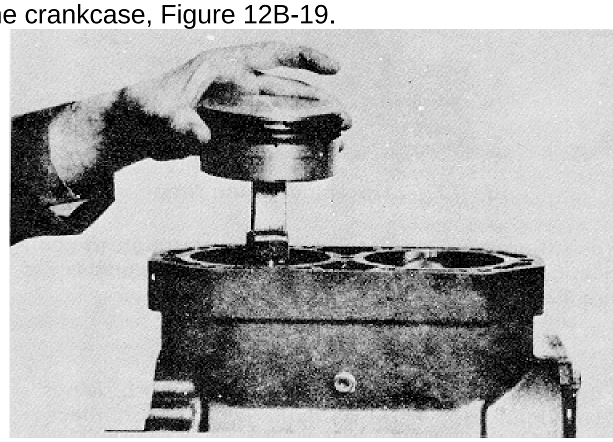


Figure 12B-19. Remove Piston and Connecting Rod

25. Remove the crankshaft from the crankcase. Use care not to damage the crankshaft bearing surfaces or crank-case bushings, Figure 12B-20.

26. Remove the piston rings from the piston. Discard the rings.

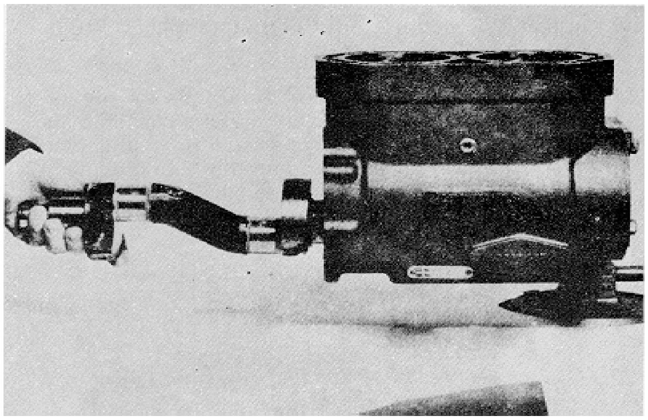


Figure 12B-20. Remove Crankshaft

27. Remove the pistons from the connecting rods.

A. Use snap ring pliers to remove the snap rings from the piston pin bores, Figure 12B-21.

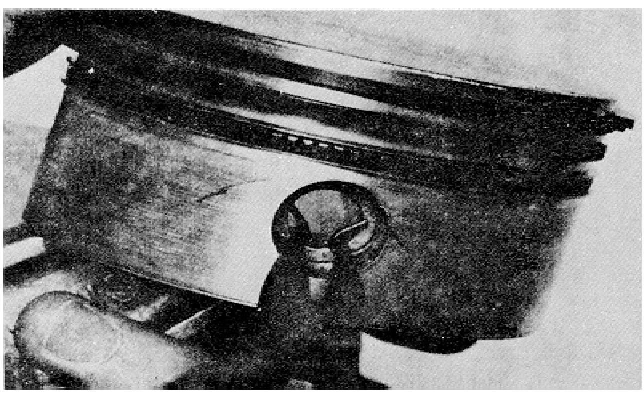


Figure 12B-21. Remove Snap Rings

B. Push the piston pin from the piston through the connecting rod. Lift the connecting rod from the piston, Figure 12B-22.

CAUTION

If the pin cannot be removed by hand pressure, do not drive the pin out. This may damage the piston. Place the piston in hot water to expand the pin bore. This will allow the pin to be removed by hand pressure.

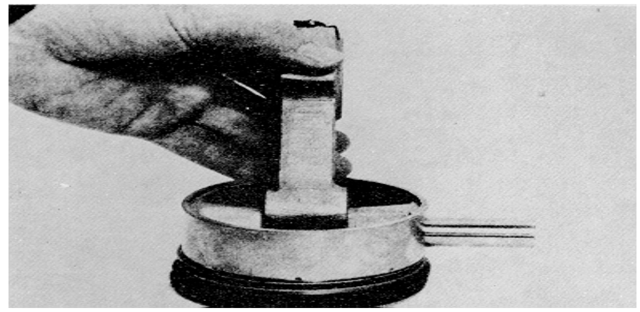


Figure 12B-22. Remove Connecting Rod

28. Remove all pipe plugs from the air compressor crank-case, cylinder head and crankshaft.

CLEANING

1. Clean all parts thoroughly with a good cleaning solvent. Blow the parts dry with compressed air.

2. Immerse the cylinder head in a cleaning solvent to re-move all carbon from the valve cavities as well as rust and scale from the water passages. Use compressed air to blow dirt from all passages.

CAUTION

Do not use a screwdriver or scraper to remove carbon and scale. This may damage sealing surfaces.

3. Clean all oil drillings in the air compressor crankcase, crankshaft and front support.

INSPECTION AND REPAIR

1. Check for visible cracks, breaks or other damage in the cylinder head and cover.

2. Check the exhaust valve seat height, Figure 12B-23. If the height is less than 0.485 inch (12.32 mm), replace the exhaust valve seat.

3. Check the intake valve seat height, Figure 12B-24. If the height is less than 0.270 inch (6.86 mm), replace the intake valve seat.

4. Apply "bluing" to the exhaust and intake valve seating surfaces to check the seats. If the seating surfaces are not 100 percent true, they may be lapped. If lapping will reduce the valve seat height beyond wear limits, discard and re-place the valve assembly.

5. If lapping is necessary to acquire a good valve seat:

A. Apply "bluing" to the surface of the exhaust valve to be capped and allow it to dry.

B. Apply the lapping compound (a 50/50 mixture of 38900A and A-600) to the exhaust valve and place the valve on the seat.

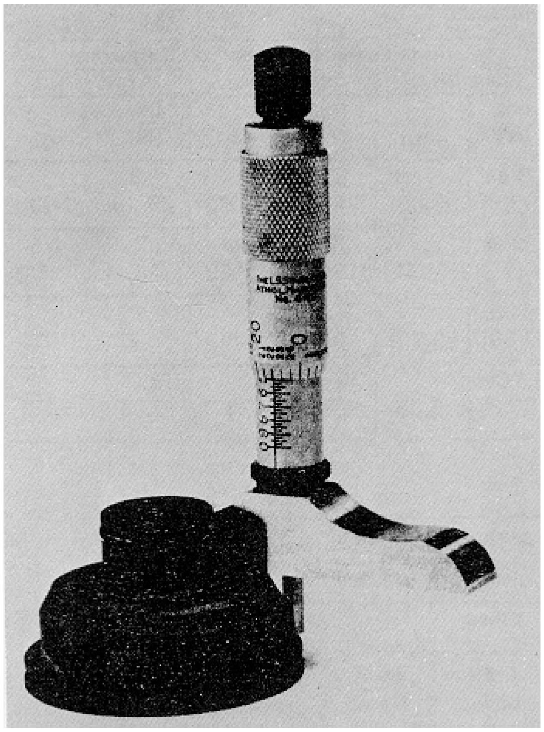


Figure 12B-23. Check Exhaust Valve Seat Height

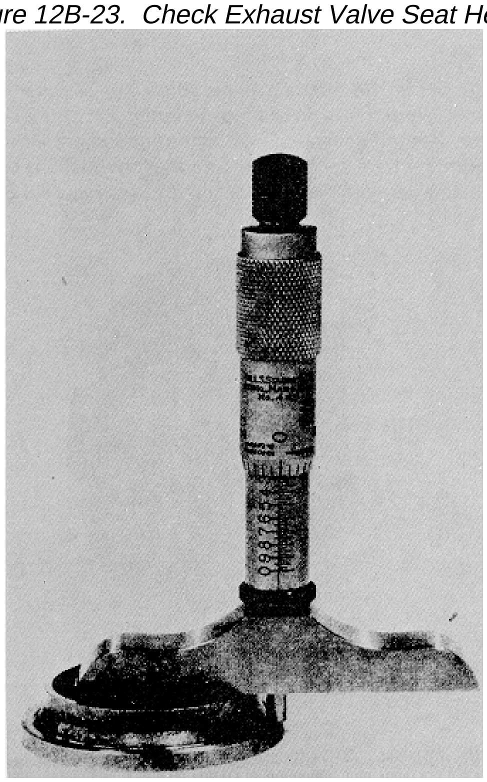


Figure 12B-24. Check Intake Valve Seat Height

C. Insert the valve seat in a lapping block, Figure 12B25.
D. Use a standard hand valve lapper and a rubber suction cup to lap the valve until a good seat is obtained. Check the seating by periodically checking the bluing. Add more lapping compound as needed.
E. The valve must be flat within 0.001 inch (0.03 mm) total indicator reading.
F. Clean the parts thoroughly to remove all lapping compound.

6. To lap the intake valve:
A. Install a rubber buffer in the top of the exhaust valve seat, Figure 12B25.
B. Apply "bluing" to the intake valve. Allow it to dry.
C. Apply lapping compound to the intake valve. Place the intake valve seat on the intake valve and lap until a good seat is obtained. The valve must be flat within 0.001 inch (0.03 mm) total indicator reading.
D. Remove all lapping compound and clean the parts thoroughly.

7. Check the upper part of the unloader cap where the packing seal seats for scoring or excessive wear. If the top of the unloader cap sticks to the bottom of the unloader body, clean and check the top of the unloader cap.
8. Check the seating area of the unloader cap for distortion, pitting or wear.
9. Test the springs on a spring tester that is capable of very accurate measurements of spring length and load, by means of standards and a dial indicator gauge. Spring data is given in Table 12B1.
10. Inspect the crankshaft for scratches, scoring and wear. Use a micrometer to measure the crankshaft at the points shown in Figure 12B26. Replace or regrind the crankshaft if it is damaged or worn beyond the limits given in Table 12B2.

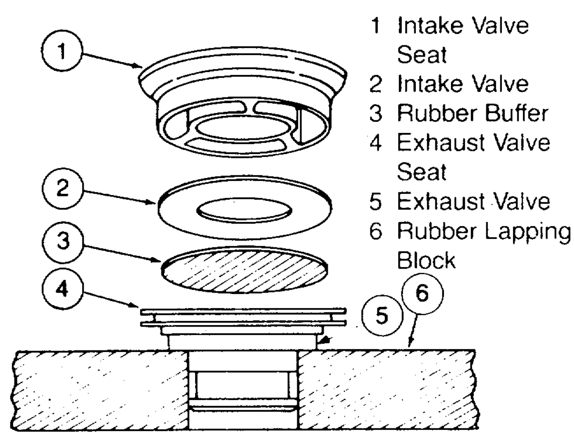


Figure 12B-25. Lap Valve and Valve Seat

Table 12B-1. Spring Data

Spring Use	Approximate Free Length In. (mm)	No. Coils	Wire Dia. Inch (mm)	Length Inch (mm)	Pounds Load Required To Compress: New Min. Lb. (N)	New Min. (kg)	New Max. Lb. (N)	New Max. (kg)	Worn Limit Lb. (N)	Worn Limit (kg)
Exhaust Valve	0.670 (17.02)	3	0.080 (2.03)	0.280 (7.11)	8.5 (37.8)	(3.86)	10.4 (4.63)	(4.72)	8.0 (35.6)	(3.63)
Unloading Valve	1.65 (41.91)	11.5	0.080 (2.03)	0.98 (24.89)	32.0 (142.3)	(14.52)	38.0 (169.0)	(17.23)	30.0 (133.4)	(13.61)
Intake Valve	0.500 (12.70)	2.75	0.062 (1.57)	0.280 (7.11)	0.65 (2.89)	(0.29)	1.10 (4.89)	(0.50)	0.55 (2.45)	(0.25)
Unloading Valve	1.65 (41.91)	10.75	0.065 (1.65)	.98 (24.89)	13.00 (57.8)	(5.83)	17.00 (75.6)	(7.62)	12.00 (53.3)	(5.38)

Table 12B-2. Crankshaft Dimensions

Table 12B-2. Crankshaft Dimensions

Front Support Journal Min. Inch (mm)	Front Support Journal Max. Inch (mm)	Front Support Journal Worn Limit Inch (mm)	Connecting Rod Journal Min. Inch (mm)	Connecting Rod Journal Max. Inch (mm)	Connecting Rod Journal Worn Limit Inch (mm)	Rear Coupling Journal Min. Inch (mm)	Rear Coupling Journal Max. Inch (mm)	Rear Coupling Journal Worn Limit Inch (mm)
1.872 (47.55)	1.873 (47.57)	1.871 (47.52)	1.5615 (39.662)	1.5625 (39.688)	1.5600 (39.624)	1.872 (47.55)	1.873 (47.57)	1.871 (47.52)

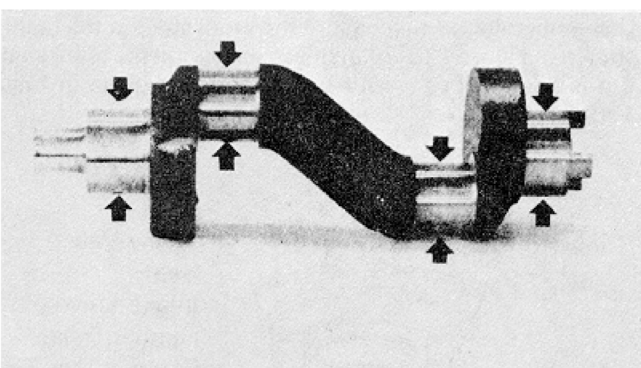


Figure 12B-26. Measure Crankshaft

11. Check the front support thrust faces for scratches, scoring or wear. Replace the support or the bushing if either is worn beyond the limits given in Table 12B3.

A. Use ST1143 to press the worn or damaged bushing from the support.

CAUTION

Support the front support flange while removing or installing bushings.

B. Lubricate the bushing bore. Align the oil hole in the bushing with the oil drilling in the support. Use ST1 143 to press the new bushing into the support until it is flush with the bore surface. Be sure that the bushing oil hole is aligned with the support oil drilling, Figure 12B27.

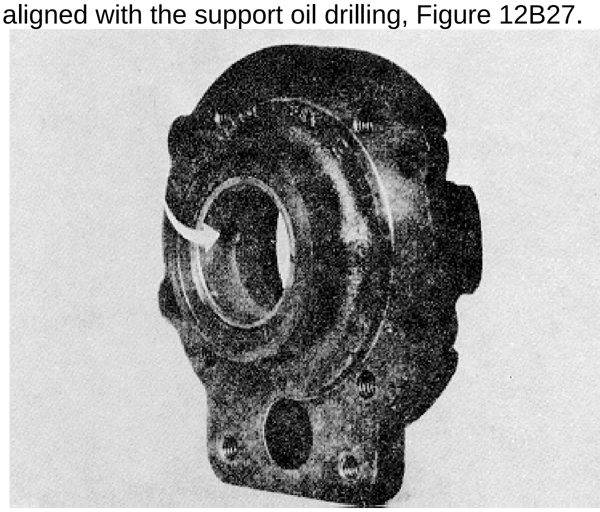


Figure 12B-27. Align Bushing Oil Hole

12. Inspect the crankshaft bushing in the crankcase for scratches, scoring and wear, Figure 12B28. Replace the bushing if it is damaged or if it is worn larger than 1.8780 inch (47.701 mm).

Table 12B-3. Support Flange Dimensions					
Distance Between Thrust Faces			Bushing Inside Dimension		
New Dimension		Worn	New Dimension		Worn
Min. Inch (mm)	Max. Inch (mm)	Replacement Limits Inch (mm)	Min. Inch (mm)	Max. Inch (mm)	Replacement Limits Inch (mm)
1.217 (30.91)	1.220 (30.99)	1.214 (30.84)	1.8745 (47.612)	1.8755 (47.638)	1.8770 (47.676)

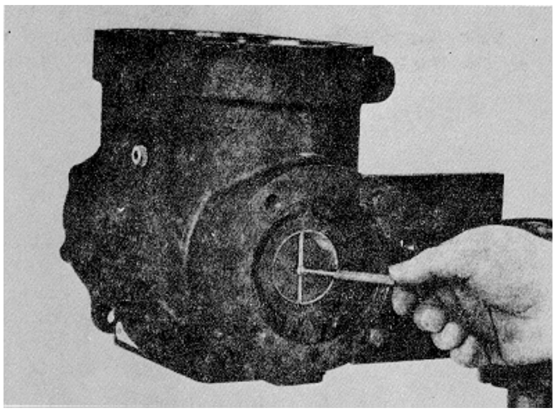


Figure 12B-28. Measure Crankshaft Bushing

A. Use ST1143 Bushing Mandrel to press the worn or damaged bushing from the crankcase.

CAUTION

Support the crankcase while removing or installing the bushings.

B. Lubricate the bushing bore. Align the oil hole in the bushing with the oil drilling in the bushing bore. Use ST1 143 to press the new bushing into the crankcase until it is flush with the bore. Be sure that the bushing oil hole is aligned with the crankcase oil drilling.

13. Visually inspect the cylinder bores for scratches, scoring and damage.
14. Use a dial bore gauge to inspect the cylinder bores for out-of-roundness and wear, Figure 12B-29.

A. Out-of-roundness must not exceed 0.0015 inch (0.038
mm).

B. The cylinder bore must not be worn larger than 3.6285
inch (92.164 mm).

The new crankcase cylinder bore is 3.625 to 3.626 inch (92.08 to 92.10 mm).

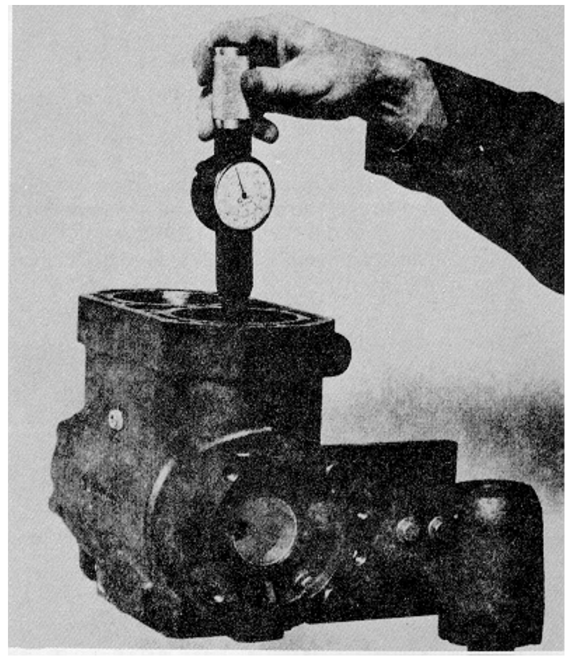


Figure 12B-29. Measure Cylinder Bore

NOTE

If the above limits are exceeded, the cylinder may be bored and honed to accept a 0.010, 0.020 or 0.030 inch (.25, .51 or .76 mm) oversize piston.

15. Inspect the connecting rods for scoring and wear.

A. Use a telescoping gauge or inside micrometer to measure the crankshaft end of the connecting rod, Figure 12B30. It must not be worn larger than 1.5665 inch (39.789 mm).

B. Inspect the piston pin end. It must not be worn larger than .6890 inch (17.501 mm).

C. Check the threaded holes and capscrews for damage.

NOTE

Connecting rods are available in 0.010 inch (.25 mm) undersize on the crankshaft end for use with reground crankshafts.

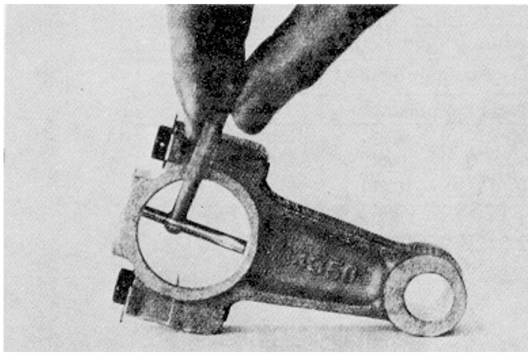


Figure 12B-30. Measure Connecting Rod

16. Inspect the connecting rod for bend and twist. Bend must not exceed 0.002 inch (.05 mm). Twist must not exceed 0.004 inch (.10 mm).

17. Use a micrometer to measure the piston pin outside diameter, Figure 1 2B31. The piston pin must be replaced if it is worn smaller than 0.6872 inch (17.455 mm). A new piston pin outside diameter is 0.6875 to 0.6876 inch (17.463 to 17.465 mm).

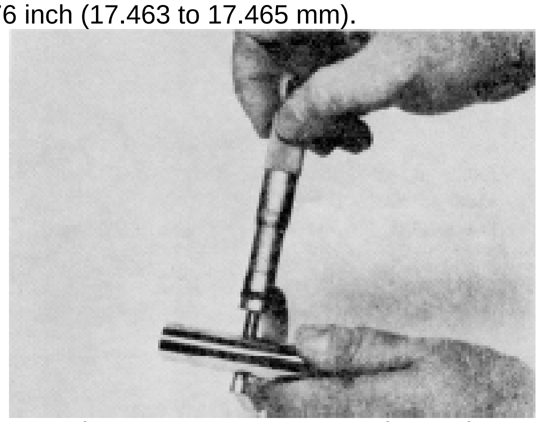


Figure 12B-31. Measure Piston Pin

18. Inspect the pistons for scoring, cracks, wear or other damage.

A. Measure the piston wear one inch below and at a right angle to the piston pin bore, Figure 1 2B32. The piston must be replaced if the skirt is worn smaller than 3.6165 inch (91.859 mm). A new piston skirt diameter is 3.619 to 3.620 inch (91.92 to 91.95 mm).

B. Use an inside micrometer or a telescoping gauge to measure the piston pin bore, Figure 12B33. The bore should be measured with the piston at 700F (21 °C). The piston must be replaced if the bore is worn larger than 0.6885 inch (17.488 mm). A new piston pin bore is 0.6875 to 0.6880 inch (17.463 to 17.475 mm).

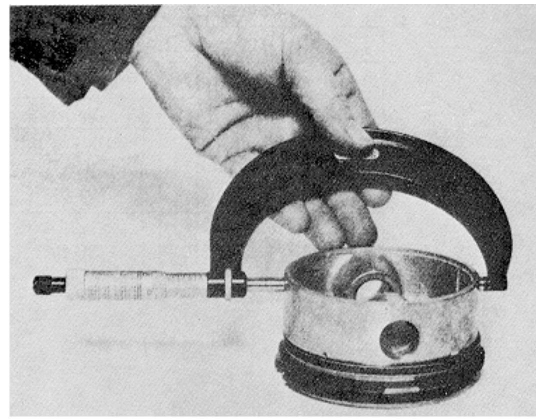


Figure 12B-32. Measure Piston

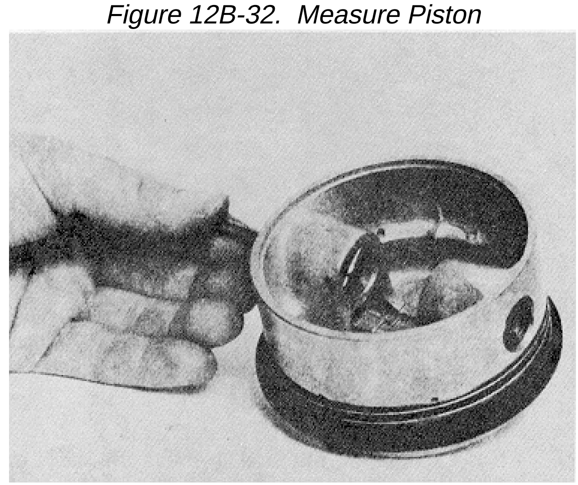


Figure 12B-33. Measure Piston Pin Bore

19. Inspect the piston ring groove for wear.

A. Install a new ring in the piston ring groove.

B. Insert a 0.004 inch (.10 mm) feeler gauge between the ring and the side of the ring groove, Figure 12834.

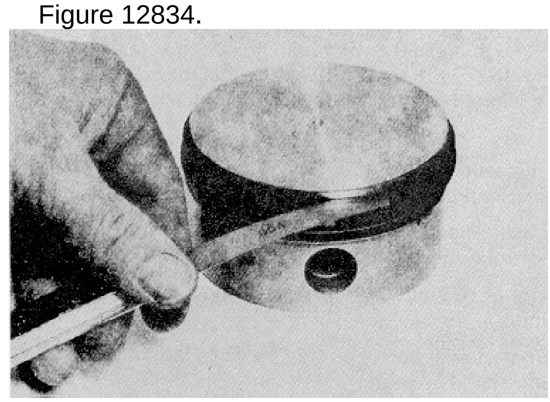


Figure 12B-34. Check Ring Groove Wear

C: Compress the ring into the groove. If the ring goes below the piston land surface with the feeler gauge in place, the wear is excessive and the piston should be replaced.

20. Inspect the piston ring end gap.

A. Insert one ring at a time into the cylinder bore. Seat the ring with a piston head squarely in an unworn portion of the cylinder bore.

B. Measure the ring end gap with a feeler gauge or end gap gauge, Figure 12B35.

C. The gap should be 0.010 to 0.020 inch (.25 to .51 mm).

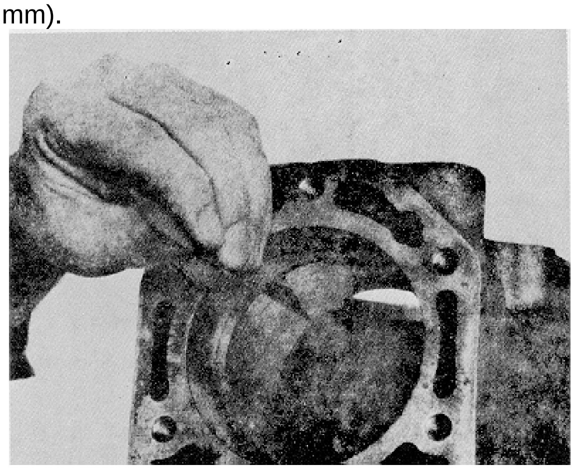


Figure 12B-35. Measure Ring End Gap

ASSEMBLY

To assemble the compressor, proceed as follows:

1. Install and tighten all pipe plugs in the cylinder head, crankcase and crankshaft. Refer to Table 12B6 on page 12B17 for pipe plug torque specifications.

2. Lubricate the bearing surfaces of the front support thrust washers. Place the inner thrust washer in the front support. The grooved side of the thrust washer faces away from the support. Lubricate the crankshaft bearing surface. Insert the end of the crankshaft into the front support, Figure 12B36.

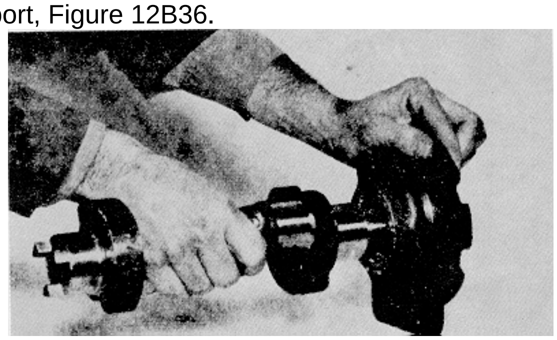


Figure 12B-36. Install Crankshaft into Front Support

Lubricate the bearing surface of the outer thrust washer. Place the thrust washer over the end of the crankshaft and into the front support, Figure 12B37.

The grooved side of the washer goes toward the support.

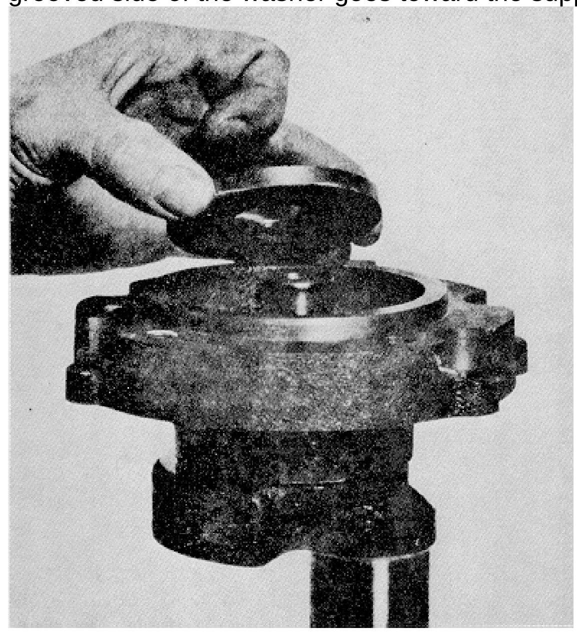


Figure 12B-37. Install Outer Thrust Washer

3. Lubricate the inside diameter of the splined coupling with a high pressure lubricant. Support the crankshaft. Press the splined coupling onto the crankshaft until it bottoms, Figure 12B38.

NOTE

The splined coupling is installed with the ridge toward the support.

4. Check crankshaft end clearance.

A. Use a dial indicator mounted on the front support with the indicator located on the end of the crankshaft.

B. Bring the crankshaft completely to one end of its travel. Set the dial indicator to "O". Move the crankshaft to the opposite end of its travel and record the reading.

C. Normal end clearance is 0.0015 to 0.0075 inch (.038 to .191 mm). See Table 12B4. Table 12B5 gives the various thrust bearing sizes that may be used to return crankshaft end play to within limits.

5. Install the crankshaft and support assembly into the crankcase.

Table 12B-4. Crankshaft End Clearance

Cold Min.		Cold Max.		Worn Replacement	
Inch	(mm)	Inch	(mm)	Inch	(mm)
0.0015	(0.038)	0.0075	(0.191)	0.011	(0.28)

Table 12B-5. Thrust Bearings Size in Support Flange

Thrust Bearing	Size	
	Inch	(mm)
Front	0.2400-0.2480	(6.096-6.299)
Rear	0.0895-0.0905	(2.273-2.299)

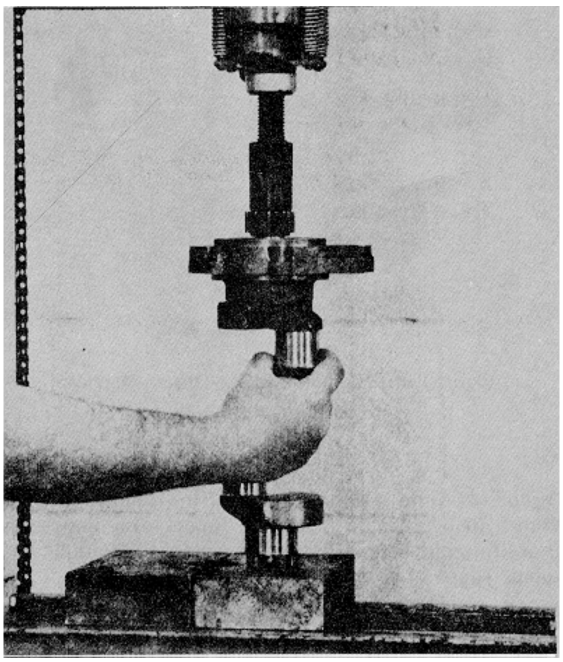


Figure 12B-38. Install Splined Coupling

A. Lubricate the crankshaft journals and the crankcase bushing.
B. Place a new front support gasket over the crankshaft onto the front support.
C. Insert the crankshaft and front support assembly into the crankcase, Figure 12B39. Be careful not to damage the crankshaft journals or bushing surfaces.
D. Secure the front support to the crankcase with four "twelve point" capscrews and two "hex head" capscrews and washers. The two hex head capscrews go in the two bottom support holes. Tighten all capscrews to 30 to 35 ft lb (41 to 47 N.m).

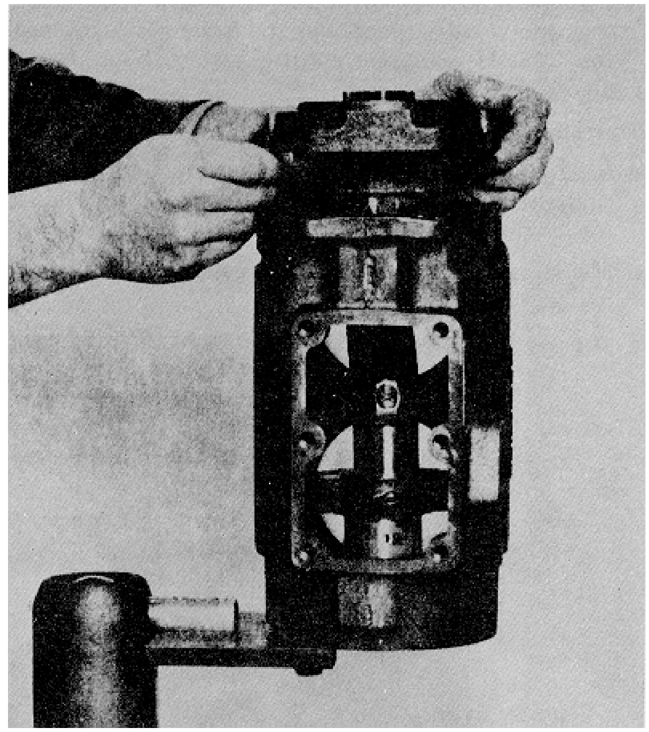


Figure 12B-39. Install Crankshaft and Front Support

6. Assemble the connecting rods and pistons.

A. Install one piston pin snap ring in each piston. Lubricate the piston pin with clean engine oil.

B. Insert the piston pin end of the connecting rod into the piston. Install the piston pin through the piston and connecting rod until it contacts the snap ring, Figure 1 2B40.

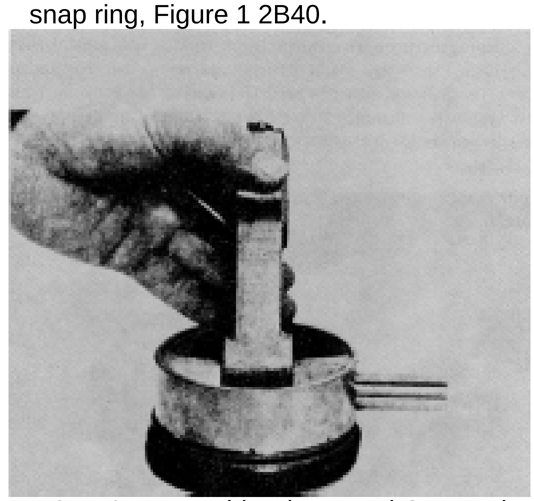


Figure 12B-40. Assemble Piston and Connecting Rod

CAUTION

Do not drive the piston pin into the bore. This may damage the piston. It may be necessary to heat the piston in hot water. This will expand the pin bore and allow the pin to be installed.

C. Install the other piston pin snap rings. Be sure both snap rings are securely seated in the snap ring grooves.

7. Install the piston rings on the pistons.

A. Place the oil ring expander and the oil ring in the bottom piston ring groove. The expander gap and the ring gap should be 180 degrees apart. Be sure that the ends of the expander butt against each other and that they do not overlap under the oil ring.

B. Install the intermediate compression ring in the middle groove. Place the dot on the ring towards the top of the piston, Figure 1 2B41. Install the top compression ring in the top groove. Place the word "Top" on the ring toward the top of the piston, Figure 12B41.

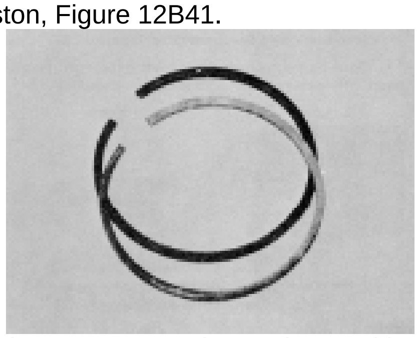


Figure 12B-41. Piston Ring Markings

C. Stagger the compression ring gaps so that they are approximately 180 degrees apart and are not located over the piston pin bore, Figure 12B42.

8. Install the piston and connecting rod assemblies.

A. Rotate the crankshaft in the crankcase until one of the journals is at approximately bottom center.

B. Lubricate the pistons, rings and cylinder bores with clean engine oil. Lubricate the rod bearing surfaces with lubriplate.

C. Use a standard type ring compressor installed on the piston to compress the rings. Insert the piston and rod assembly into the cylinder bore with the numbered side of the rod toward the nameplate side of the crankcase, Figure 12B43.

D. Push the piston from the ring compressor into the cylinder bore. Do not force the piston into the bore. If the

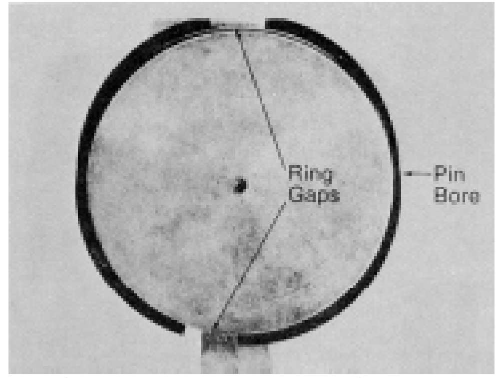


Figure 12B-42. Stagger Ring Gaps

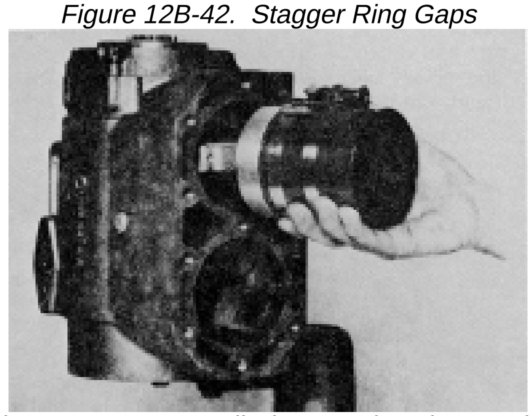


Figure 12B-43. Install Piston and Rod Assembly

piston will not move into the bore smoothly, a ring may be dislodged. Continue to push the assembly through the bore while aligning the connecting rod to the mating crankshaft journal.

E. Install the matching cap to the connecting rod. Be sure that the identification numbers on the rod and cap match to ensure that the rod and cap are installed as they were removed.

F. Install the capscrews with new lockplates to secure the cap to the rod. Tighten the capscrews alternately and evenly as below:

Step 1: 7 to 10 ft-lb (9 to 14 N.m).
Step 2: 15 to 17 ft-lb (20 to 23 N.m).
Step 3: Loosen both completely.
Step 4: 7 to 10 ft-lb (9 to 14 N.m).
Step 5: 15 to 17 ft-lb (20 to 23 N.m).

G. Repeat steps AF for the other connecting rod assembly.

9. Install the crankcase cover plate with a new gasket. Secure the plate to the crankcase with capscrews and wash

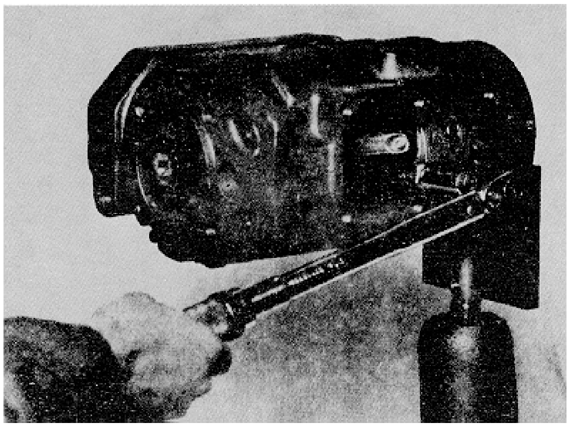


Figure 12B-44. Tighten Connecting Rod Capscrews

ers. Tighten the capscrews to 30 to 35 ft-lb (41 to 47 N.m), Figure 12B-45.

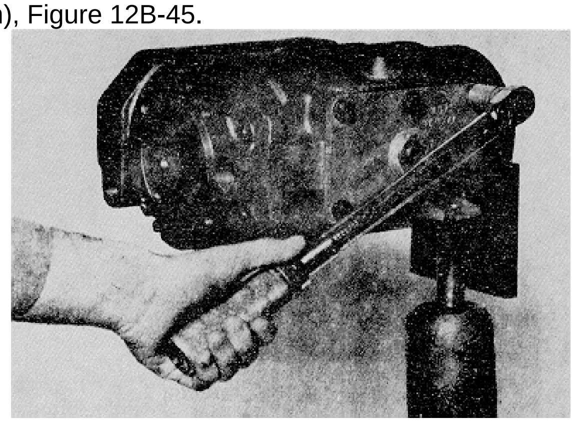


Figure 12B-45. Install Crankcase Cover Plate

10. Assemble and install the cylinder head.

 A. Position a new cylinder head gasket on the crankcase. The part number on the gasket should be up.

 B. Place the exhaust valve on the exhaust valve seat, Figure 12B46.

 C. Install 2 new O-rings on the exhaust valve seat, Figure 1 2B46. Lubricate the O-rings with clean oil.

 D. Install the exhaust valve and seat, spring and wear plate into the cylinder head in the sequence shown in Figure 1 2B46.

 E. Use thumb pressure to snap the exhaust valve assembly into position in the cylinder head. Follow Steps A through E for each of the 2 cylinders.

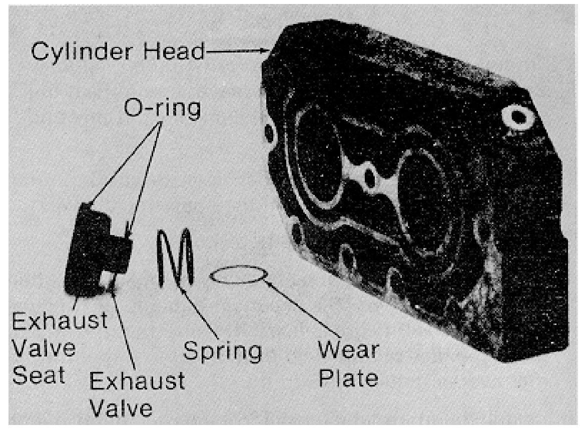


Figure 12B-46. Install Exhaust Valve Assembly

 F. Position the cylinder head containing the exhaust valve assemblies onto the crankcase, Figure 12B47.

11. Place a new cylinder head cover gasket on the cylinder head. The part number on the gasket should be up.

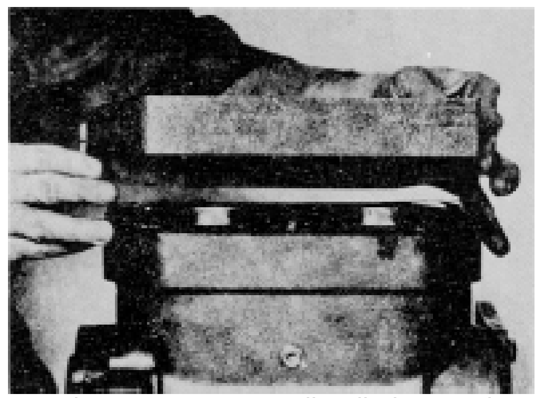


Figure 12B-47. Install Cylinder Head

12. Place the cylinder head cover on the cylinder head. Secure the cover and head with capscrews and lockwashers. Tighten the capscrews to 30 ft-lb (41 N.m), Figure 12B48. Tighten the capscrews in the sequence shown in Figure 12B-49.

13. Install the air unloader assembly.

 A. Install a new seal in the unloader plug, Figure 12B50. Coat the seal and the inside diameter of the plug with antiseize compound.

 B. Install the unloader cap into the unloader plug, Figure 12B51.

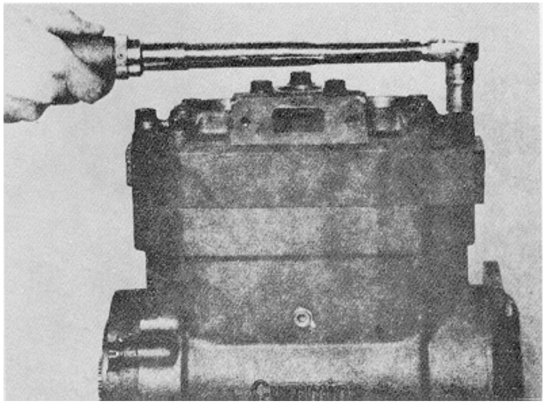


Figure 12B-48. Install Cylinder Head Cover

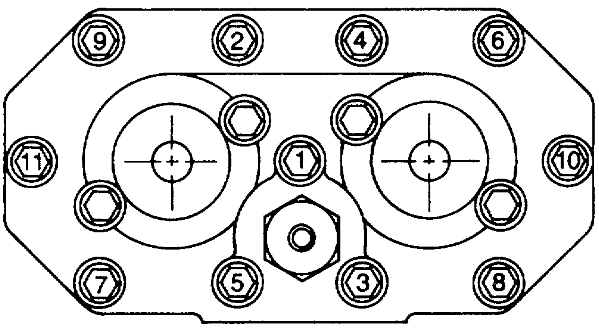


Figure 12B-49. Cylinder Head Capscrew Torque Sequence

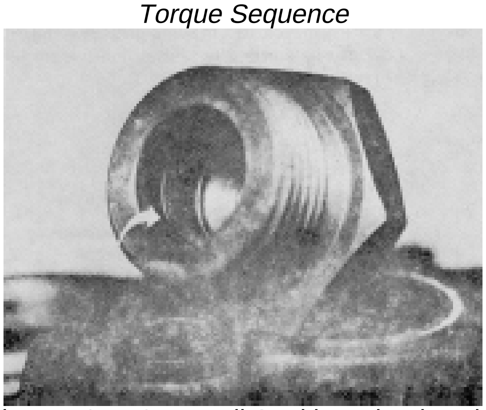


Figure 12B-50. Install Seal in Unloader Plug

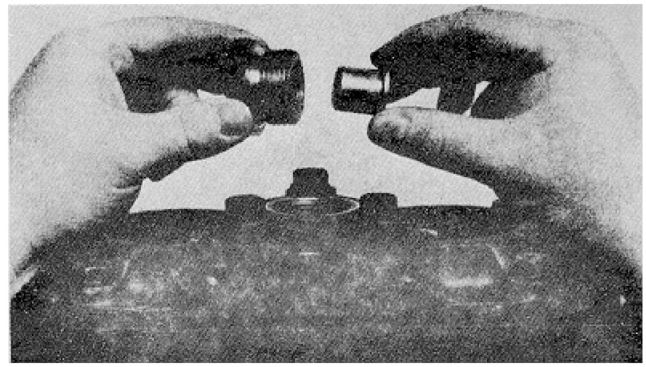


Figure 12B-51. Install Unloader Cap

C. Place a new copper sealing ring on the unloader plug. Insert the unloader spring into the unloader cap. Install the unloader assembly into the cylinder head cover, Figure 12B52.

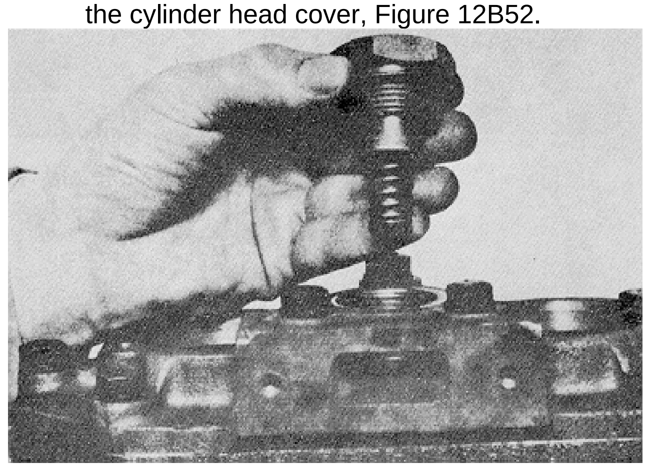


Figure 12B-52. Install Unloader Assembly

14. Install the intake valve assemblies.

A. Place the intake valve seats, intake valves and springs into the cylinder head cover in the sequence shown in Figure 1 2B53.

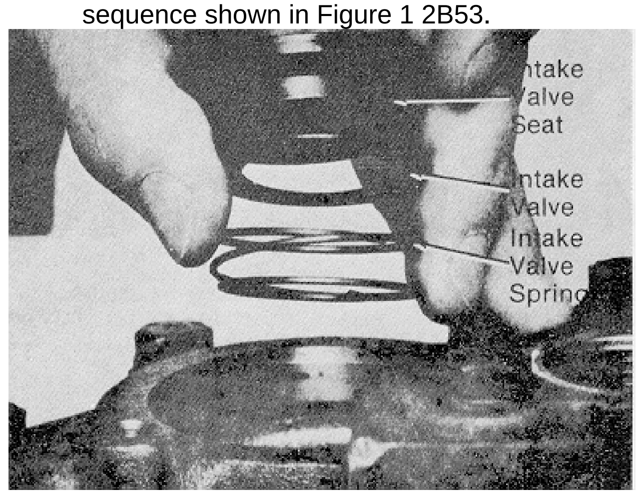


Figure 12B-53. Install Intake Valve Seat, Valve and Spring

B. Install new O-rings and packing seals on the valve assembly retainers, Figure 1 2B54. Coat the packing rings and the inside diameters of the retainers with antiseize compound. Lubricate the O-ring on each retainer with clean engine oil.

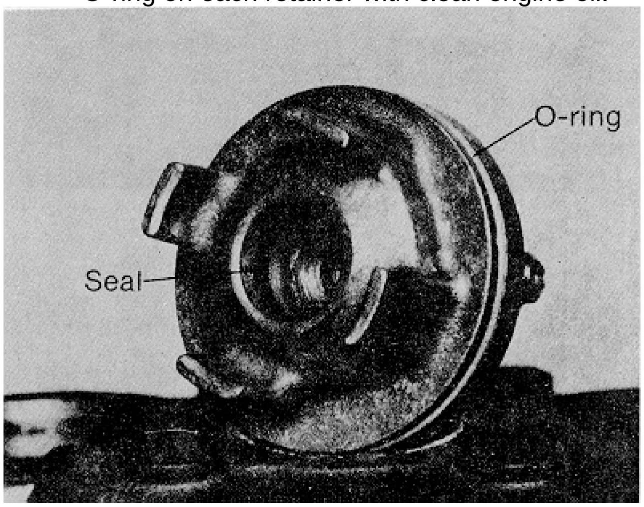


Figure 12B-54. Install O-ring and Packing Seal

C. Install the unloader caps into the valve assembly retainers, Figure 12B-55.

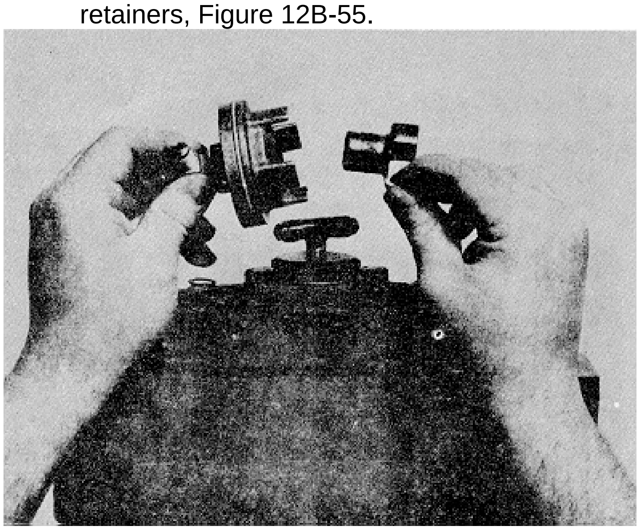


Figure 12B-55. Install Unloader Cap

D. Insert the unloader spring into the unloader cap. Place the entire assembly into the cylinder head cover, Figure 12B56. Align the assemblies and secure with capscrews, lockwashers and flat washers.

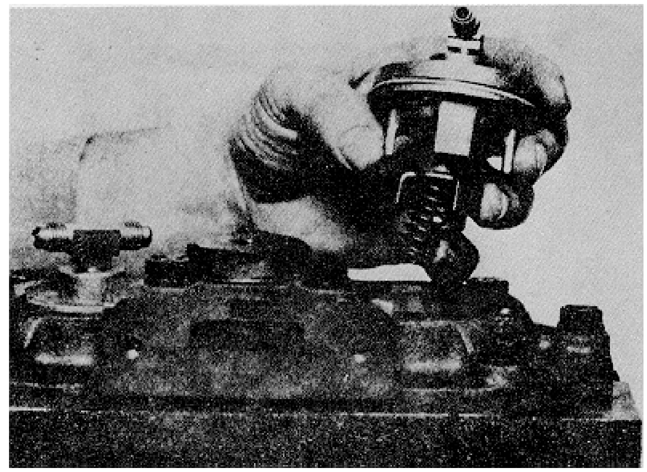


Figure 12B-56. Install Valve Retainer Assembly

E. Tighten the valve assembly retainer capscrews to 8 to 10 ft-lbs (11 to 14 N.m), Figure 12B-57.

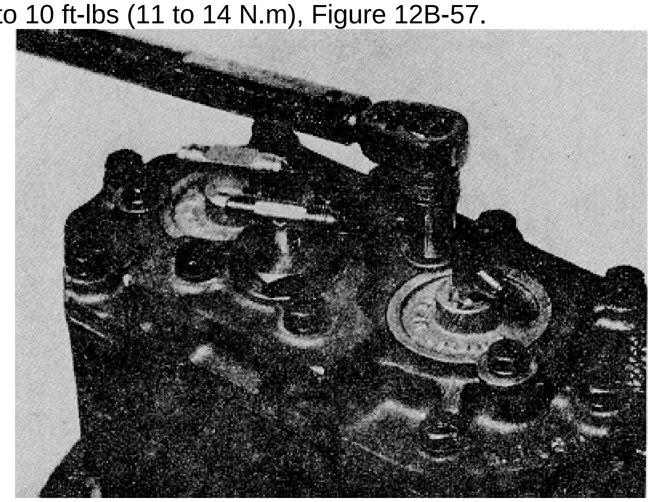


Figure 12B-57. Tighten Valve Retainer Capscrews

15. If they were removed, install the air fittings in the valve retainers and the unloader plug. Install the two air lines shown in Figure 12B-58.

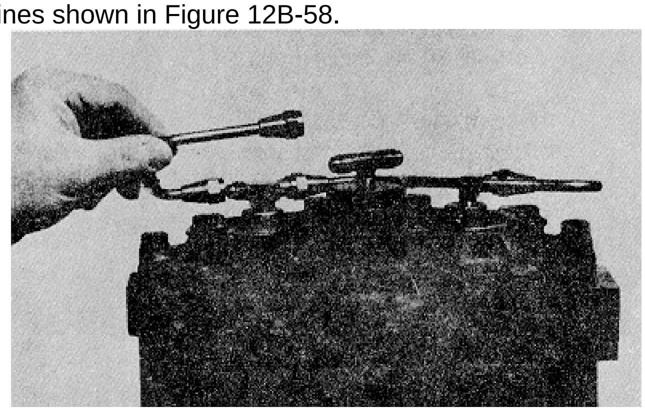


Figure 12B-58. Install Air Lines

BENCH TESTING

Bench test the compressor as follows:

1. Mount the compressor on the proper fixture and connect the oil, water, and air lines. Drain the oil trap.
2. Start the compressor and bring the speed to 800 rpm. Operate the compressor for 30 seconds with the compressor discharging to the atmosphere.

Table 12B-6. Air Compressor Torque Specifications

Part Name	Ft-Lb	Torque (N.m)
Bottom Cover	30-35	(41-47)
Connecting Rod Caps	15-17	(20-23)
Cylinder Head	30	(41)
Front Support	30-35	(41-47)
Unloader Valve Plug	30	(41)
Valve Retainer	8-10	(11-14)
Pipe Plugs		
1/8 Inch	10-15	(14-20)
1/4 Inch	15*20	(20-27)
3/8 Inch	20-25	(27-34)
1/2 Inch	35-40	(47-54)
3/4 Inch	50-55	(68-75)

A. Lubrication-Oil pressure to the compressor is to be maintained at 50 to 60 psi (345 to 414 kPa). Oil temperature is not to exceed 2100F (990C).

B. Cooling-Cooling water is to be supplied to the compressor at the rate of 3 gallon/minute (11 I/min). Temperature is not to exceed 1900F (880C).

3. Inspect the compressor for oil leaks, water leaks, overheated bearings and excessive noise. Reject the compressor if any of these deficiencies are noted.

4. Increase the speed to 2500 rpm and close the air tank discharge valve. Adjust the orifice flow valve which controls the air flow from the tank through a 0.125 inch (3.18 mm) diameter orifice so that the air pressure of 100 psi (689 kPa) is maintained by the compressor. Operate the compressor for two minutes.

5. Air Flow-With all the valves closed, open the orifice flow air control valve to the maximum position. Determine the maximum tank pressure which can be maintained by the compressor at 2500 rpm for 30 seconds and record it.

6. Unloader Valve Operation With the compressor operating at 2500 rpm and all other valves closed, adjust the air tank discharge valve to maintain 90 psi (620 kPa) air pressure in the tank. Open the unloader control valve. This will permit the 90 psi (620 kPa) tank pressure to move the unloader valve down. The compressor will stop delivering air to the tank. The compressor must unload at 90 psi (620 kPa) tank pressure.

Reduce the tank pressure to 45 psi (310 kPa). The compressor must begin pumping at or before a minimum 45 psi (310 kPa) tank pressure is obtained.

The operation of the unloader valve is to be free from chatter and must respond rapidly to pressure changes in the unloader line.

7. Air Flow-Reduce the compressor speed to 1200 rpm. With all the valves closed, open the orifice flow air control valve to the maximum position. Determine the maximum tank pressure which can be maintained by the compressor for 30 seconds and record it.

8. This concludes the test. During shutdown of the compressor, apply a minimum of five milliliters of rust preventive compound, Cummins Material Specification 20,002, into the intake air opening of the cylinder head cover. Stop the compressor immediately after a fog begins to appear from the discarge air outlet. Disconnect the oil, water and air lines and remove the compressor from the test stand.

Table 12B-8. Air Compressor Worn Replacement Limits

Part Name or Location	No Coils	New Dimensions Minimum Inch	(mm)	Maximum Inch	(mm)	Worn Replacement Limits Inch	(mm)
CRANKCASE:							
Out-of-round limits of crankshaft bore						0.0015	(0.038)
Crankcase bore		3.6250	(92.075)	3.6260	(92.100)	3.6285	(92.614)
Rear bushing		1.8745	(47.612)	1.8765	(47.663)	1.8780	(47.701)
PISTONS:							
Piston skirt diameter at 700F (210C)		3.619	(91.92)	3.620	(91.95)	3.6165	(91.859)
Piston pin bore at 700F (210C)		0.6875	(17.462)	0.6880	(17.475)	0.6887	(17.488)
Ring Grooves No.1 Compression		0.126	(3.20)	0.127	(3.23)	0.129	(3.28)
Width No. 2 Compression		0.126	(3.20)	0.127	(3.23)	0.129	(3.28)
Oil ring		0.188	(4.78)	0.189	(4.80)	0.191	(4.85)
Available in 0.010, 0.020 and 0.030 inch (0.25, 0.51 and 0.76) oversize.							
RINGS:							
Ring gap clearance							
No. 1 Compression		0.010	(0.25)	0.020	(0.51)	Replace	
No. 2 Compression		0.010	(0.25)	0.020	(0.51)	New at	
Oil ring		0.015	(0.38)	0.055	(1.40)	Rebuild	
Available in 0.010, 0.020 and 0.030 inch (0.25, 0.51 and 0.76 mm) oversize.							
Teflon compression ring		0.045	(0.11)	0.075	(0.19)		
Available in 0.010, 0.020, 0.030 and 0.040 inch (0.25, 0.51, 0.76 and 1.02 mm) oversize.							
Ring to groove clearance							
No.1 Compression (check with No.2 ring)		0.002	(0.05)	0.0035	(0.089)	0.0045	(0.114)
No.2 Compression		0.002	(0.05)	0.0035	(0.089)	0.0045	(0.114)
Oil ring		0.0015	(0.038)	0.003	(0.076)	0.004	(0.10)
Available in 0.010, 0.020 and 0.030 inch (0.25, 0.51 and 0.76 mm) oversize for oversize pistons.							
PISTON PIN:		0.6875	(1.7462)	0.6876	(1.7465)	0.6872	(1.7455)
CONNECTING ROD:							
Rod bend		0.000	(0.00)	0.002	(0.05)	--	--
Rod twist		0.000	(0.00)	0.004	(0.10)	--	--
Piston pin end		0.6880	(17.475)	0.5885	(17.488)	0.6890	(17.501)
Crankshaft end		1.5645	(39.738)	1.5650	(39.751)	1.5665	(39.789)
Rod length, center to center		3.4740	(88.239)	3.4760	(88.290)		
Rod available with 0.020 inch (00.51 mm) undersize crankshaft bore.							
CRANKSHAFT:							
Connecting rod journal		1.5615	(39.662)	1.5625	(39.687)	1.5600	(39.624)
Support journal, front and rear		1.872	(47.55)	1.873	(47.57)	1.8710	(47.523)
Crankshaft end clearance		0.0015	(0.038)	0.0075	(0.195)	0.0110	(0.279)
Crankshaft end clearance		0.006	(0.15)	0.010	(0.025)	0.020	(0.51)
CRANKCASE SUPPORT FLANGE:							
Bushing bore I.D		1.8745	(45.612)	1.8750	(47.625)	1.8765	(47.663)
Distance between thrust faces		1.217	(30.91)	1.220	(30.99)	1.214	(30.84)
UNLOADING VALVE SPRING:							
Free length (approx.)		1.63	(41.4)	1.65	(41.9)		
Load to compress to 0.98 inch	11.5	32 lbs	(14.5 kg)	38 lbs	(17.2 kg)	30 lbs	(13.6 kg)
(24.9 mm)	10.75	18 lbs	(8.1 kg)	22 lbs	(10.0 kg)		

Table 12B-9. Air Compressor Specifications

Air delivery, CFM (1/mm)	
@1250 rpm	30 (850)
Cylinders	2
Piston displacement cu. In (ml)	41.28 (676)
Bore, inch (mm)	3.625 (92.08)
Stroke, inch (mm)	2.000 (50.80)
Speed	engine speed
Cooling	engine coolant
Lubrication	engine oil
Line sizes	
Water inlet and outlet tubing	1/2 (12.7)
Outside diameter inches (mm)	
Air inlet tubing	7/8 (22.23)
Inside diameter inches (mm)	
Air outlet tubing	5/8 (1 5.8)
Inside diameter inches (mm)*	
Height inch overall (approx.) (m)	13.5 (343.)
Width inch overall (approx.) (m)	7 (178.)
Length inch overall (approx.) (m)	11-1/4 (286.)
Weight, pounds (approx.) (kg)	65 (29.5)

*For duty cycle above 10 percent or operating pressure above 125 psi, use 3/4 inch I.D. minimum.

Table 12B-10. Air Compressor Troubleshooting

Complaint 1
The compressor fails to maintain adequate pressure in the air brake system.
Possible Causes

A. Air governor set improperly, or malfunctioning.
B. Excessive carbon in compressor cylinder head or discharge line.
C. Discharge valve leaking.
D. Excessive wear of components.
E. Intake valve stuck open.
F. Excessive leakage of intake valve.
G. Unloader cap stuck.
H. Leaks in vehicle air system.
I. Check valve inoperative.

Complaint 2
Noisy Operation
Possible Cause
A. Excessive carbon in compressor cylinder head or discharge line.
B. Worn or burned out bearings.
C. Excessive wear of components.
D. Worn gears.

E. Excessive end play.

Complaint 3
Compressor Passes Excessive Oil
Possible Causes

A. Vertical scratches.

B. Taper.
C. Out-of-round.
D. Rings seating.
E. Signs of distress - valve spring breakage - etc.

Complaint 4
Oil Consumption
Possible Causes
A. Excessive wear.
B. Excessive oil pressure.
C. Back pressure from engine crankcase.
D. Piston rings improperly installed or broken.
E. Carbon from head dropping int- bore and scratching cylinder walls.
F. Bent rod.

To correct oil pumping:
1. Make certain that the orifice is not used to limit the lube oil supply to the front support or crankshaft.

Table 12B-10. Air Compressor Troubleshooting (Continued)

2. Check the cylinder bore to determine if it needs honing oversize and resolve what specific oversize dimension should be used for the honing operation. (Pistons are available in 0.010, 0.020 and 0.030 inch (0.25, 0.51 and 0.76 mm) oversize).
3. Hone the cylinder bore with a 150 grit stone, wet, and obtain a 45 degree crosshatch pattern.
4. After honing, note that there is a slight burr left by the hone at the top of the bore, just at the lower edge of the top bore chamfer. Be sure to remove the burr.
5. Wash the crankcase to remove all traces of hone material.
6. Inspect the piston for wear, grooves, etc. Also note the wear pattern on the skirt. If it is uneven below the pin bosses, there may be too much clearance in the front support to crank, or the rod may be bent or twisted. Make sure the piston is the latest style.
7. Install new rings on the piston. Be sure to use the latest ring set.
8. Check the rod for proper pin and crank bore sizes. Check the rod for bend and twist.

Complaint 5

Compressor Does Not Unload

Possible Cause

A. Air governor working improperly.
B. Defective unloader or cap guide seal.
C. Unloading cavity plugged with carbon.
D. Unloading cap binding or stuck to bottom of unloader body.
E. Unloader spring failure.
F. Unloader cap not seating properly on intake valve seat.

Complaint 6

Compressor head leaking water

Possible Causes

A. Capscrews not tight.
B. Excess torque on valve assembly capscrews.
C. Head or head cover porous or cracked.
D. Fittings not properly installed.

Checking Procedures

Is the unit really pumping oil?

How to check:

Bleed the air tanks slowly. If they are block and oily - no good. If they are gray, oil pumping is not too bad, but may still need repair. If all the residue is water with a slight oil film - O.K.

NOTE

Because there is oil in the tanks is not proof that the compressor is presently pumping oil. There have been many cases where corrections have been effected, but the oil in the tanks takes a long time to dissipate.

To check for oil pumping:

1. Warm the engine up to operating temperature.
2. Disconnect the air discharge line at the compressor head.
3. Use shop air at 100 psi (690 kPa) at the unloader valve to unload the compressor.
4. Operate the compressor in an unloaded condition for 10 minutes.
5. Place a white cloth over the air discharge port.
6. Disconnect the shop air from the unloader valve and operate the compressor for 10 minutes.
7. If the compressor is not pumping oil, only a faint trace of gray will show on the white cloth.
8. Another, more time consuming method, is to steam clean the tank and have the customer operate the unit for one or two trips.
9. Remove the unloader valve assembly and check the exhaust valve and air display passage for oil.
10. Remove the cylinder head. Check the cylinder bore.
    a. The majority of oil pumping air compressors inspected have been found to have one or more deep vertical scratches in the bore. Carbon, ring installation, dirt and failed valves or springs will cause scratching of the cylinder bore.

Checking Unloader Valve Spring Action

The following checking and adjusting procedures are for use in troubleshooting air compressors not pumping or with slow pressure buildup. Our investigations shown that these complaints are usually caused by one or more of the following:

1. Improper tension on the unloader valve spring.
2. Air governor is not dumping the air pressure from the compressor unloader valve.
3. Carbon deposits, worn or broken compressor intake and exhaust valves, seats and springs.

Worn or broken (chipped) intake and exhaust valves, valve seats and springs can be determined by simple visual examination.

The air governor is designed to control the air compressor so that air tank pressure is maintained in the range of 90 to 150 psi (620 to 1030 kPa). Proper functioning of the air governor can be checked by installing a pressure gauge in the line between the air compressor and the air governor. In some cases the passages in the governor or connecting lines have become clogged so the pressure necessary to activate the compressor unloader valve is not transmitted to

Table 12B-10. Air Compressor Troubleshooting (Continued)

the compressor. When clogging occurs, cleaning or repair of the air governor is necessary to restore proper operation.

Checking Unloading Valve

The proper functioning of the compressor unloader valve depends upon the spring tension on the unloader cap. The tension must be adjusted so the cap will actuate and unload the air compressor at a lower pressure than will be applied through the air governor.

The cap must retract and allow the compressor to start pumping when the pressure on the unloader cap is more than atmospheric pressure.

The unloader valve should be adjusted so it will function as follows:

1. The unloader valve should actuate to unload or stop the air compressor pumping when the pressure on the cap from the air governor, or as supplied by other means, reaches a minimum of 60 psi (415 kPa).
2. The unloader valve should open or retract and allow the air compressor to pump when the pressure on the cap is reduced to a minimum of 10 psi (69 kPa).

Operation of the unloader valve may be checked by applying shop air pressure to the unloader valve cover at the connection for the line to the air governor.

Some arrangement must be used so the pressure may be varied from zero to approximately 100 psi (690 kPa). A simple arrangement of two valves, a pressure gauge and connections can be used for this check. One of the valves must be arranged to bleed off air; then by adjusting both valves, the pressure applied to the unloader cap can be varied as desired.

With the above arrangement, operation of the unloader valve may be checked as follows:

1. Disconnect the air compressor discharge line at the compressor. With the engine running at rated speed gradually increase the air pressure on the compressor unloader valve until the air compressor unloads or stops pumping. Note the pressure on the gauge at which this occurs.

2. Gradually decrease the pressure on the unloader valve until the air compressor begins to pump. Note the pressure at which this occurs.

NOTE

Pressures on the unloader valve at which the air compressor loads and unloads vary with engine speed and is approximately 20 psi (140 kPa) higher at idle. Therefore, it is important that these checks be made at engine rated speed.

3. If the pressure in Step 2 is less than 10 psi (69 kPa), check the unloader cap to make sure it is free in the body.
On some occasions sharp edges or burrs on the body have caused unloader caps to stick. Correct this by polishing the edges of the body or otherwise making certain the unloader cap works freely in the body.

4. If the unloader cap is working freely, add a sufficient number of shims, Part No. 67990, between the cap and the spring to adjust the spring tension so the unloader valve will retract and load the air compressor at a minimum of 10 psi (69 kPa) pressure on the valve at rated engine speed.

5. Never add more shims than necessary to get the air compressor to load with 10 to 15 psi (69 to 103 kPa) pressure on the unloader valve at rated engine speed. Excessive shimming may prevent the unloader valve from closing to unload the air compressor.

INSTALLATION

Installation of the air compressor is basically the reverse of removal. However, to ensure proper performance of the compressor, the following should be inspected before actually installing the compressor.

1. Clean the oil supply line. Before connecting this line to the compressor, run the engine briefly to be sure oil is flowing freely through the supply line.

2. Clean the oil return line; this line must be unrestricted so oil can return to the engine.

3. Always use a new mounting gasket. Be sure the gasket is properly aligned on the compressor.

NOTE

Be sure splined coupling is on accessory drive gear for the compressor.

4. With new gasket in place, index air compressor gear with splined coupling. Snug tighten capscrews.
5. Install air compressor support bracket to compressor and cylinder block. Tighten air compressor to support capscrews to 4045 ft-lbs (5461 N.m) torque. Tighten mounting bracket to block and air compressor capscrews to 3035 ft-lbs (4147 N.m) torque.
6. Install water inlet and outlet tubes from air compressor to thermostat housing and block; install air supply connection to supply tube (installed in intake manifold). Secure with hose clamps and capscrews.

AIR SYSTEM COMPONENTS

GENERAL

This subsection covers all the valves and devices in the air system, with the exception of the air compressor and the brake chambers.

GOVERNOR (36Z290)

DESCRIPTION. The governor, operating in conjunction with the compressor unloading mechanism, automatically controls the air pressure in the air brake or air supply system between the desired, predetermined maximum and minimum pressures. The compressor runs continually while the engine runs, but the actual compression of air is controlled by the governor which stops or starts compression when the maximum or minimum reservoir pressures are reached.

OPERATING TEST. The operating test is one of the two tests which should be performed to check the operation of the governor when it is suspected that the governor is the cause of an air system malfunction. To perform the operating test, proceed as follows (see Figure 12C1):

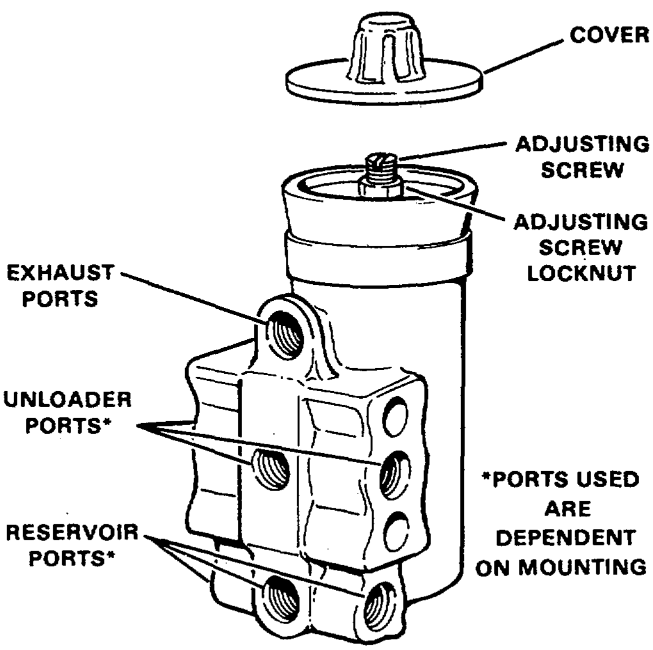


Figure 12C-1. Governor (36Z290)

Start the engine and buildup air pressure in the air system and check the pressure registered by the dash gauge at the time the governor cuts out and stops the compression of air by the compressor. The cutout pressure should be 120 psi (8.27 bars).

With the engine still running, make a series of brake applications to reduce the air pressure and observe at what pressure the governor cuts in the compressor. The cut-in pressure should be 105 psi (7.24 bars).

NOTE

> Never adjust the governor pressure settings unless they are checked with an accurate test gauge or a dash gauge that is known to be registering accurately.

If the pressure settings are incorrect, adjust the governor cutout and cut-in pressure settings as described under the topic, Adjustment.

LEAKAGE TEST. The leakage test will determine whether the air system malfunction is caused by a worn governor.
Perform the leakage test as follows:

With the governor at the cut-in pressure, check for leakage at the inlet valve by applying soap suds at the exhaust port.

If the governor does not function as described, or leakage is excessive, it is recommended that the governor be replaced or repaired to the limits of the repair kit. All necessary parts and instructions are contained in the repair kit.

ADJUSTMENT. To adjust the pressure setting of the governor, first, unscrew the cover at the top of the governor. Next, loosen the adjusting screw locknut. With a screwdriver, turn the adjusting screw counterclockwise to raise the pressure setting or clockwise to lower the pressure setting. After the adjustment is completed, tighten the adjusting screw locknut to lock this adjustment.

REMOVAL. To remove the governor, proceed as follows:

1. Block and hold the carrier by a means other than the carrier brakes.
2. Open the drain cocks at the bottom of each air reservoir to drain the air pressure from the system.
3. Remove the reservoir air line and governor.

INSTALLATION. To install a new or rebuilt governor, proceed as follows:

1. Clean the mounting pad on both the compressor and governor block. Also be sure the connecting line and the compressor unloading port are clean and clear.
2. Position a new mounting gasket on the compressor and install the governor.
3. Connect the air lines to the governor.
4. Test the governor as outlined under the topics, Operating Test and Leakage Test.

AIR RESERVOIR (27Q146)

DESCRIPTION. A reservoir is a storage tank. The function of a reservoir is to provide a place to store compressed air so there will always be an ample supply available for immediate use in air system operation. It also provides storage for sufficient compressed air to permit several brake applications even after the engine has stopped.

A reservoir has no moving parts and could hardly be said to operate. Nevertheless, things do happen inside the reservoir which are not always understood. All compressors must pass a certain amount of oil in order to lubricate the cylinder walls and piston rings; otherwise, rapid wear or even seizing will result. Also, depending on the humidity, the atmosphere entering the compressor contains a certain amount of water. This oil and water normally passes into the reservoir in the form of vapor because of the heat generated during compression. After they reach the reservoir, the vapors cool and condense in the form of an oil and water emulsion and are drained off before entering the air system proper.

This drainage is often referred to as oil but in most cases analysis will show it to be practically all water. An easy method of checking the amount of oil and water in the drainage is to put it in a clear glass sealed container and set the container aside for several days. At the end of this period, the oil and water will separate and a visual inspection will show the percentage of oil and water in the mixture. The next time you drain the reservoir remember that in all probability only a small percentage of the drainage is oil.

ROUTINE INSPECTION. There is probably no other device in the air system requiring simple maintenance and yet more important maintenance than the reservoirs.

Many an efficient reservoir arrangement has been defeated in its normal function through haphazard maintenance. Any collector of unwanted oil and water condensation will fail in its function if it is not properly and regularly drained. The simple routine of draining all the reservoirs daily will pay dividends far beyond what is generally recognized.

Also when we say drained, we do not mean to open the drain cock and let the air out. Satisfactory draining is only accomplished by leaving the drain cock open after the air has escaped and until all drainage stops.

MINOR REPAIRS. Minor repairs to a reservoir consist of examining the reservoir mounting and the inspection of the outside for corrosion or damage. The outside should be kept painted because based on actual experience the possibility of corrosion causing a failure except from the outside is very remote.

MAJOR REPAIRS. Except in unusual cases, major repairs on reservoirs are not economical or practical. If a reservoir has been damaged so as to be unfit for use, it is most economical to replace it with a new one.

In exceptional cases where the inside of the reservoir has become excessively coated with sludge which cannot be drained off, it is sometimes advisable to remove it and clean it out with steam and hot water.

SAFETY VALVE (36Z6) DESCRIPTION.

The safety valve protects the air system against excessive air pressure above 150 psi (10.34 bars).
Should the reservoir pressure below the ball valve rise to a point above the setting of the safety valve, the force developed will overcome the force of the regulating spring holding the ball on its seat, and the ball will lift (see Figure 12C2). This permits air to pass up into the spring cage and exhaust to atmosphere through the exhaust port. As soon as this exhaust process reduces the pressure to the setting of the safety valve, the regulating spring forces the ball back on its seat, stopping the exhaust.

OPERATING TEST. The safety valve may be tested to be sure it is operative by pulling the exposed end of the valve stem. This removes the spring load from the ball and permits the valve to exhaust. If the safety valve does not "blow off" when this is done, the ball must be stuck on its seat. The valve should be removed and disassembled for cleaning.

LEAKAGE TEST. Leakage at the exhaust port should not exceed a three inch soap bubble in three seconds.

PREVENTIVE MAINTENANCE. Every year the safety valve should be removed and cleaned as follows (see Figure 12C2):
Figure 1 2C2.

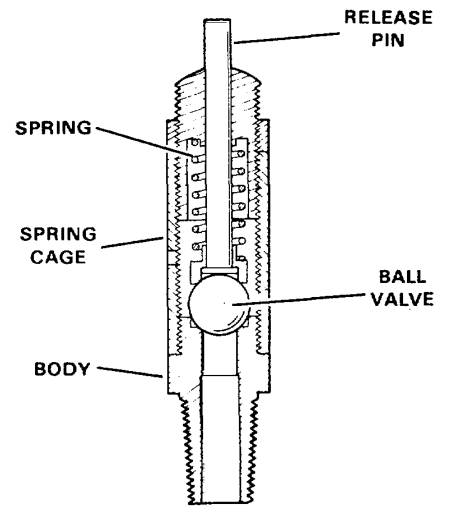


Figure 12C-2. Safety Valve (36Z6)

1. Unscrew the spring cage from the body of the safety valve. Lift the ball valve from the body and remove the spring, spring seat and release pin from the spring cage.
2. Clean all parts in cleaning solvent. Inspect the parts for excessive wear, cracks or damage. If wear or damage is excessive, the complete safety valve should be replaced.
3. Place the ball valve in the body of the safety valve. Place the spring release pin and spring seat in the spring cage with the adjusting screw assembly. Position the spring seat over the ball valve and screw the spring cage to the body.

TEST OF REBUILTSAFETYVALVES. Both the operating and leakage test must be made after repairing the safety valve and the valve must meet the following specifications.
1. Leakage at the exhaust port should not exceed a three inch soap bubble in three seconds.
2. The safety valve should be set to "blow off" at approximately 150 psi (10.34 bars). The pressure setting may be adjusted by loosening the locknut and turning the adjusting screw. Turning the adjusting screw clockwise, raises the pressure setting. Turning the adjusting screw counterclockwise, lowers the pressure setting. The setting of the adjusting screw should be locked by tightening the adjusting screw locknut after each adjustment. An accurate test gauge should be used when adjusting pressure setting of the safety valve.

TREADLE VALVE (36Z976)

DESCRIPTION. The treadle valve is the control unit of the air brake system. It provides the driver with an easily operated and graduated means of applying and releasing the vehicle brakes, and also separates the front and rear service brakes into independent circuits (see Figure 12C3);

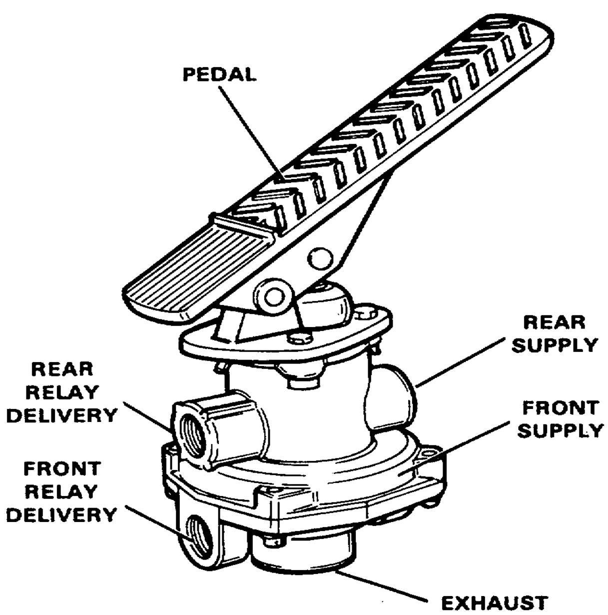


Figure 12C-3. Treadle Valve (36Z976)

OPERATING TEST. Check the delivery pressure of both circuits by attaching test gauges known to be accurate to the fittings on the delivery side of the valve. Depress the treadle to several positions between the fully released and fully applied positions, and check the delivered pressure to see that it varies equally and proportionately with the movement of the treadle. It should be noted that the delivery pressure of circuit number one will be approximately 2 psi (0.14 bars) higher than the pressure in circuit number two.

When the treadle is fully applied the reading on the test gauges should be approximately that of full reservoir pressure. The reading on the test gauges should fall off to zero when the treadle is released.

CAUTION

A change in vehicle braking characteristics or a low pressure warning may indicate a malfunction in one of the brake circuits. Although the vehicle air brake system may continue to function, the vehicle should not be operated until the necessary repairs are made and both braking circuits are operating normally.

LEAKAGE TEST. With the treadle fully released, check the exhaust port for leakage. No leakage is permissible. Make and hold a high pressure application. Coat the exhaust port and the body of the valve with soap suds. Leakage must be limited to a one inch (2.5 cm) bubble in three seconds.

If the treadle valve does not function as described, or leaks excessively, it is recommended that the brake treadle be replaced or repaired to the limits of the repair kit. All necessary parts and instructions are contained in the repair kit.

REMOVAL. To remove the treadle valve, proceed as follows:

1. Block and hold the vehicle by some means other than the carrier brakes.
2. Open the drain cock on each reservoir to exhaust air pressure from the air system.
3. Mark and disconnect all supply and delivery lines at the treadle valve.
4. Remove the treadle valve from the carrier by removing the three capscrews on the outer bolt circle of the mounting plate.

INSTALLATION. To install a new or rebuilt treadle valve, proceed as follows:

1. Clean the air supply lines.
2. Mount the treadle valve on the cab floor and install the mounting bolts.
3. Connect the supply and delivery lines to the treadle valve and plug any unused ports.
4. Test the valve for serviceability by performing the Operating and Leakage Tests.

QUICK RELEASE VALVE (36Z254)

DESCRIPTION. The quick release valve speeds up the release of air pressure from the brake chambers. When a brake valve application is released, the exhaust of the quick release valve opens and the air pressure accumulated in the brake chambers is exhausted through the quick release valve, rather than exhausting back through the brake valve (see Figure 12C4).

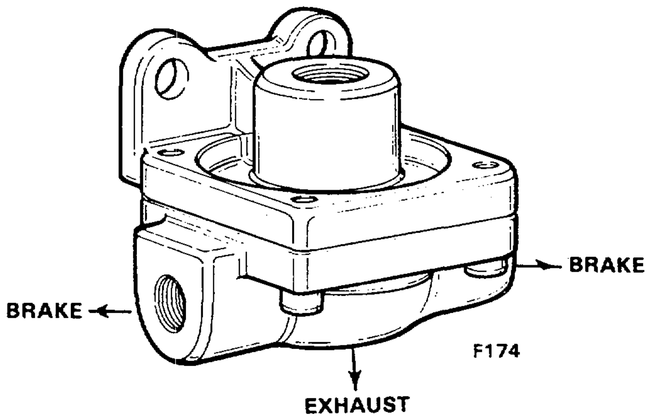


Figure 12C-4. Quick Release Valve (36Z254)

OPERATING TEST. Make a treadle valve application and note that the brake chambers served by the quick release valve apply the brakes. Release the application and observe that the air pressure is quickly exhausted through the exhaust port of the quick release valve.

LEAKAGE TEST. Make and hold a treadle valve application, and then check the exhaust port of the quick release valve for leakage. If the valve does not function as just described, or leaks excessively, the valve must be replaced.

REMOVAL. To remove the quick release valve, proceed as follows:

1. Block or hold the vehicle in position with wheel chocks.
2. Open the drain cocks on each reservoir to drain the air pressure from the air system.
3. Disconnect the air lines connected to the quick release valve.
4. Remove the mounting bolts, and then the valve.

INSTALLATION. Install a new or rebuilt quick release valve as follows:

1. Mount the quick release valve with mounting bolts and lockwashers with the valve's exhaust port pointing down.
2. Connect the treadle valve line to the top port and the brake chamber lines to the side ports of the valve.
3. Be sure the exhaust port of the valve is not restricted.
4. Test the valve for serviceability by performing the Operating and Leakage Tests.

RELAY VALVE (36Z650)

DESCRIPTION. The relay valve serves to speed up the application and release of the service brakes. The valve operates as a remote controlled brake valve, delivering air pressure directly from the reservoir to the brake chambers, at a rate proportional to the pressure delivered to the front brake chambers by the treadle valve (see Figure 12C5).

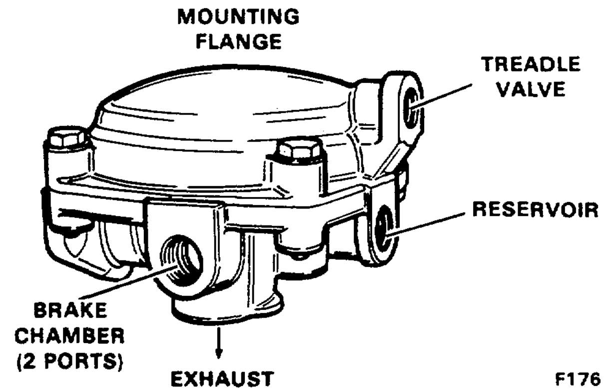


Figure 12C-5. Relay Valve (36Z650)

OPERATING AND LEAKAGE TEST. To determine the serviceability of the relay valve, perform the following test:

1. Fully charge the air system and adjust the brakes.
2. Make several brake applications and check for prompt application and release of all wheel brakes.
3. With the treadle valve in the released position, check the exhaust port of the relay valve for inlet valve and valve guide O-ring leakage. This can be done by applying soap suds to the exhaust valve.
4. Make and hold a brake application, and check the exhaust port for leakage. If excessive leakage is detected, the insert or exhaust valve only should be replaced. If leakage still occurs at the exhaust port, the leakage could be at the relay piston O-ring or possibly at the exhaust valve seat. Continue to hold the brake application and check between the cover and body for cover O-ring leakage.
5. If the valve does not function as described, or leakage is excessive, it is recommended that the valve be replaced or repaired to the limits of the repair kit. All necessary parts and instructions are contained in the repair kit.

REMOVAL. To remove the relay valve, proceed as follows:

1. Block and hold the vehicle with wheel chocks.
2. Open the drain cock on each reservoir to drain the pressure from the air system.
3. Disconnect the air lines attached to the relay valve.
4. Remove the valve mounting bolts and remove the valve.

INSTALLATION. To install a new or rebuilt relay valve, proceed as follows:

1. Clean and inspect the air lines which connect to the relay valve. Replace any air lines which are damaged.
2. Mount the relay valve securely with the mounting bolts.

3. Connect the air lines to the valve.
4. Test the valve for serviceability as outlined under the topic, Operating and Leakage Test. Also check the air line connections for leakage.

MAXIBRAKE CONTROL VALVE (36Z222)

DESCRIPTION. The Maxibrake control valve provides manual driver control as well as automatic application of the Maxibrake safety chambers.

The Maxibrakes are released when the air system is fully charged and the Maxibrake Control Knob is pulled out. Under these conditions, air pressure enters the valve at the inlet port and flows through the drilled passage in the shuttle to the outlet port (see Figure 1 2C-6). The air flowing to the outlet also applies pressure to the bottom of the shuttle, compressing the spring at the top of the shuttle. This holds the valve in the open position as long as the service air pressure is sufficient to hold the spring in the compressed position.

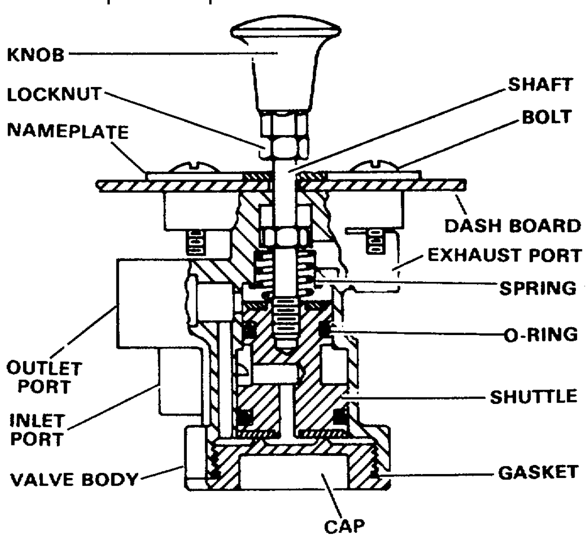


Figure 12C-6. Maxibrake Control Valve (36Z222)

If the service air pressure should drop to approximately 28 psi (1.93 bars), the pressure at the bottom of the shuttle would be insufficient to hold the valve in the open position. When this occurs, the spring at the top of the shuttle will shift the shuttle to the closed position. This will block the inlet port and connect the outlet port to the exhaust port, allowing air pressure in the Maxibrake safety chambers to exhaust.

NOTE

The same sequence of events occurs when the shuttle is shifted to the closed position manually by the operator. This allows the operator to use the Maxibrakes as parking brakes.

OPERATING AND LEAKAGE TEST. To determine the serviceability of the Maxibrake control valve, perform the following test:
1. Block the wheels with wheel chocks to prevent movement of the machine while performing this test.
2. Fully charge the air system.
3. Pull the Maxibrake control knob outward from the dash panel, and check the wheel brakes. The brakes should release when air is applied to the Maxibrake safety chambers.
4. Coat the exhaust port of the Maxibrake control valve with soap suds to determine if leakage exists.
5. Make a series of brake applications and observe the Maxibrake control knob. The knob should automatically move inward, toward the dash panel, when the service air pressure drops to approximately 28 psi (1.93 bars). This pressure can be checked with air gauge on the dash panel.
6. If the valve does not function as described above, or excessive leakage is present, it is recommended that the valve be replaced or overhauled.

REMOVAL. To remove the Maxibrake control valve, proceed as follows:
1. Open the drain cock on each reservoir to drain the air pressure from the system. Check the Maxibrake control knob to be sure that it is pushed in fully. This will vent any air pressure which may be in the Maxibrake safety chambers.
2. Loosen the locknut and remove the knob. After the knob has been removed, remove the locknut.
3. Disconnect the two air lines attached to the valve.
4. Remove the mounting bolts and nameplate, and then remove the valve.

OVERHAUL. Overhaul of this valve is limited to the replacement of two O-rings and a gasket. To replace these parts, proceed as follows (see Figure 12C-6):
1. Using a suitable wrench, unscrew the cap from the bottom of the valve body.
2. Carefully remove the shuttle by pushing it out the bottom of the valve body and the shaft.
3. Remove the gasket from the cap and the two O-rings from the shuttle.
4. Wash all remaining parts in cleaning solvent.
5. Install the two O-rings in their respective grooves.
6. Carefully install the shuttle in the valve body. Be sure the O-rings do not extrude as the shuttle is installed. Install the gasket on the cap, and install the cap in the bottom of the valve body.

INSTALLATION. To install a new or overhauled valve, proceed as follows:

NOTE

If a new valve is being installed, the knob and locknut must be removed from the shaft.

1. Position the valve on the underside of the dash panel. Then install the nameplate on the topside of the dash panel, and secure the valve with the mounting bolts.
2. Install the locknut and knob on the end of the shaft. Secure the knob by tightening the locknut.
3. Connect the two air lines to the inlet and outlet ports of the valve.
4. Test the operation of the newly installed valve by performing the Operating and Leakage Test.

EMERGENCY RELEASE VALVE (36Z362)

DESCRIPTION. The emergency release valve provides a means of transferring stored air from the emergency air tank to the Maxibrake control valve when service air pressure is lost.

When the knob is pulled out, the emergency air inlet is blocked, and the service air inlet is connected to the Maxibrake control valve outlet. In this case, the air at the service air inlet flows through the drilled passages in the plunger to the outlet port (see Figure 1 2C-7).

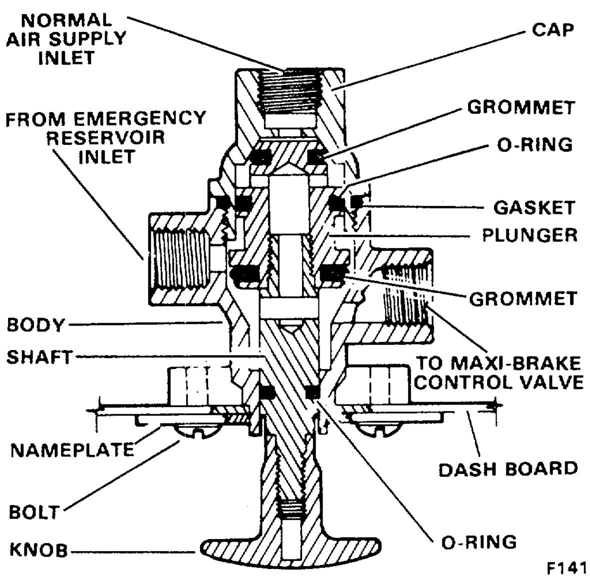


Figure 12C-7. Emergency Release Valve (36Z362)

When the knob is depressed, the service air inlet is blocked and the emergency air inlet is connected to the Maxibrake control valve outlet. Air from the emergency air tank can then flow around the plunger to the outlet port.

LEAKAGE TEST. The only factor that could affect the operation of the emergency release valve would be internal leakage between the service and emergency air inlets. If this leakage is excessive, the air pressure in the emergency air tank could be lost, which would prevent releasing the Maxibrakes. To check for internal leakage, proceed as follows:
1. Depress the emergency release valve knob.
2. Open the drain cock on the wet and dry air tanks to drain the air pressure from the service air system. Do not drain the emergency air tank.
3. Loosen the service air connection at the valve. Coat the connection with a soap solution to determine if any leakage from the emergency air inlet to the service air inlet exists. If leakage is excessive, the valve should be replaced or overhauled.

REMOVAL. To remove the emergency release valve, proceed as follows:
1. Remove the knob from the end of the shaft. if the knob is equipped with a locknut, it will be necessary to loosen the locknut before the knob can be removed. Then remove the locknut.
2. Disconnect the air lines connected to the valve.
3. Remove the mounting bolts and nameplate. Then remove the valve.

OVERHAUL. Overhaul of this valve is limited to the replacement of two grommets, two O-rings and a gasket. To replace these parts, proceed as follows (see Figure 12C-7):
1. Using a suitable wrench, unscrew the cap from the body. Remove the gasket from the cap.
2. Carefully push the plunger out the bottom of the body, by pushing on the knob end of the shaft. Remove the two grommets and two O-rings on the plunger.
3. Wash all the remaining parts in cleaning solvent.
4. Install the grommets and O-rings on the plunger as shown in Figure 12C-7.
5. Carefully install the plunger in the body. Be sure the grommets and O-rings do not extrude when the plunger is installed in the body.
6. Install the gasket on the cap. Then install the cap on the bottom of the body.

INSTALLATION. To install a new or overhauled valve, proceed as follows:

NOTE

If a new valve is being installed, it will be necessary to remove the knob and locknut.

1. Position the valve on the underside of the dash panel. Then install the nameplate and secure the valve to the dash panel with the mounting bolts.
2. Install the locknut and knob. Then connect the air lines to the valve.
3. Check the operation of the valve by performing the Leakage Test.

AIR SHIFT VALVE (1036Z677)

DESCRIPTION. The air shift control valve is used to change gears in the spicer auxiliary transmission (53Z520). It is basically a rotary selector valve which controls two cylinders mounted in the top of the auxiliary transmission.

AIR SYSTEM COMPONENTS

Air pressure is supplied to this valve from the air filter to the "S" port on the valve. When the finger control lever is in the "N" (neutral) position air pressure is supplied to ports "1 ", "2", "3", "4" and the "E" (exhaust) port is blocked by the spool. When the finger control lever is moved to any one of the gear selection positions (1, 2, 3, or 4), that port is exhausted while the other three are supplied pressure. As an example, if the operator selects gear position 1, air is supplied to ports 2, 3 and 4, while port 1 is exhausted. The same thing happens when the lever is moved to any of the other gear selections.

OPERATING TEST. If the auxiliary transmission is shifting slowly there may be several reasons for this. Perform the following checks to determine the cause:

1. Air leaking continually from the exhaust ("E") port with the control selector in a certain gear position. If this is the case the valve should be removed and repaired.
2. There may be a pinched air line or internal leakage of the cylinders in the auxiliary transmission.
3. Air pressure must be 75-80 psi (5.17-5.52 bars).
4. The butterfly nut at the bottom of the air filter is loose if not seated properly.
5. The control valve is dry of O-ring lubrication or there is excessive dirt in the control which adheres to the rotor. The valve should be removed and repaired.
6. There may be worn O-rings in the control valve under the rotor or there may be worn O-rings in the pistons located in the shifter cover of the auxiliary transmission. The valve and/or pistons should be removed or repaired.

REMOVAL. To remove the air shift valve, proceed as follows:

1. Using tape that can be written on, identify each line with the air port involved so that when the valve is reinstalled the lines are attached exactly as they were removed. Disconnect all the lines from the valve.
2. Unscrew the shift knob from the top of the control valve and then unscrew the valve from the auxiliary transmission shift bracket.

DISASSEMBLY. To disassemble the valve, proceed as follows:

1. Remove the three capscrews and lockwashers from the top of the valve and remove the valve top.

NOTE

The valve top is preloaded by a rotor pressure spring.

2. Remove the pressure spring.
3. Note the position of the control lever (whether it is in ("N", "1 ", etc.). With a red pencil, or ink, mark the tab location of the top rotor cam with relation to the main valve body. These rotor tabs are held in solid location to slots in the valve top. The tab location to the main valve body is important when reassembling the whole valve unit and it affects its functioning.
4. Remove the rotor cams and the plastic rotor from the valve body by pulling up on the finger control lever.

NOTE

As the rotor cams and the plastic rotor move out of the valve body, a small plunger will pop out from the side of the rotor. Remove the plunger and preload spring from the plastic rotor.

INSPECTION AND REPAIR. To inspect and repair the valve, proceed as follows:

1. Inspect all O-rings on the plastic rotor and replace if necessary. Also inspect the small plunger for wear, cuts, etc. and replace if necessary.
2. Inspect the plastic rotor for wear, cracks, etc. and replace if necessary.

NOTE

There is a seal kit and an overhaul kit available. See the Replacement Parts Manual.

ASSEMBLY. To assemble the valve, proceed as follows:

1. Insert the side plunger spring and the plunger into the rotor.
2. Insert the rotor into the valve body. Preload the side plunger in the correct location to the body diameter, see Figure 12C-8.

NOTE

The side plunger must be installed as shown in Figure 12C-8, with the lips of the plunger toward the top and bottom of the rotor.

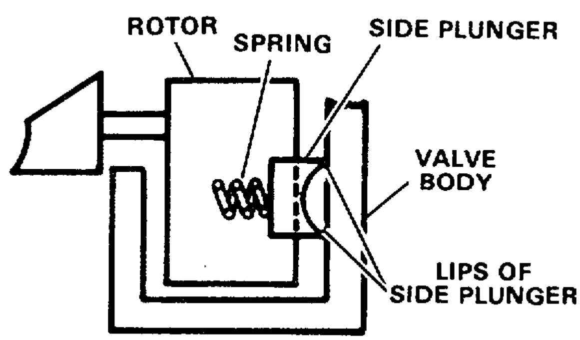


Figure 12C-8. Installing Side Plunger

When installing the rotor and plunger use care not to pinch the seals or plunger.

3. With the rotor fully installed in the valve, place the finger lever in the gear position noted when the valve was disassembled. Place the lower cam in the rotor and place the top cam in line with the red pencil or ink marks put on the valve at disassembly.
4. Place the pressure spring on top of the rotor cams. Place the valve top on the pressure spring and align the capscrew holes.
5. Preload the top of the valve and reassemble the lockwashers and capscrews to the valve top. Tighten the capscrews firmly.

INSTALLATION. To install the valve proceed as follows:

1. Screw the valve onto the auxiliary transmission bracket. Screw the shift knob onto the valve.

2. Connect the air lines to the valve ports in the exact position as they were removed.

3. Check the valve operation by placing the finger control lever in each position on the valve top from neutral through number 4 position and back to neutral. Make sure that the finger locks into each position noted. If the selector finger moves into any position with very little force, it indicates that the top plastic rotor cam is not locating correctly, because it has excessive wear on the cam teeth of the top rotor to the main cam; or the pressure spring is weak or broken.

4. Check that the valve is not exhausting all the time. If so, the side plunger, located in the plastic rotor, may not be installed properly.

BRAKE CHAMBERS

GENERAL

This subsection contains the information necessary to repair the air chambers used to apply and release the front and rear brakes.

MAXIBRAKE CHAMBER (38Q18)

DESCRIPTION. A Maxibrake chamber is a combination service brake chamber and spring brake, which provides two methods of applying the carrier brakes (see Figure 12D-1).

Service air pressure is supplied to the spring chamber air inlet by the Maxibrake control valve. Air pressure at this inlet will compress the power spring, allowing the chamber to function as a basic service brake chamber.

Air pressure entering the service brake air inlet will force the diaphragm against the push rod assembly, extending the push rod from the chamber. Since the push rod is connected to a slack adjuster, outward movement of the push rod will rotate the brake cam and apply the brakes. Venting air pressure from the chamber will retract the push rod, which in turn rotates the brake cam in the opposite direction, releasing the brakes.

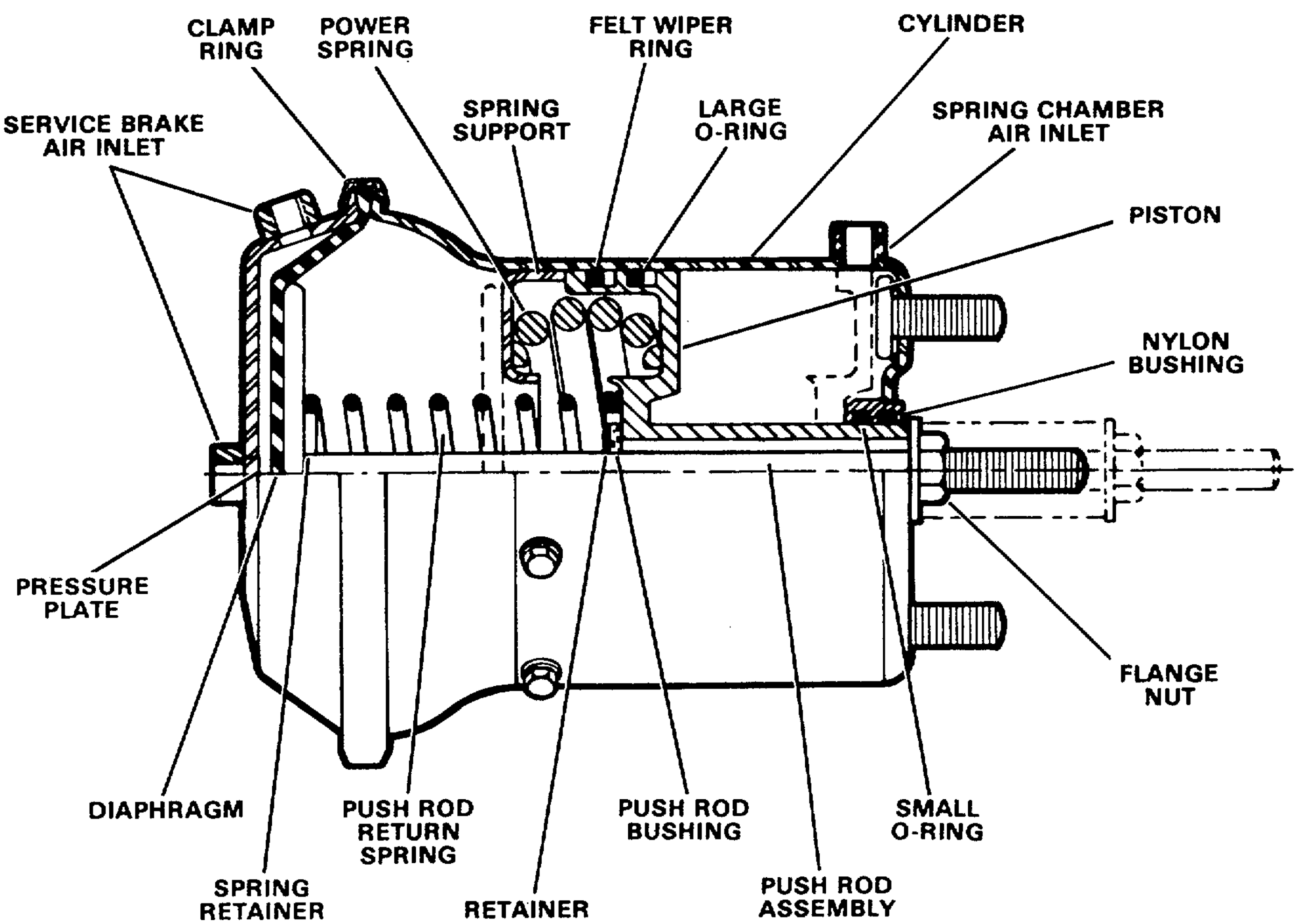


Figure 12D-1. Maxibrake Chamber (38Q18)

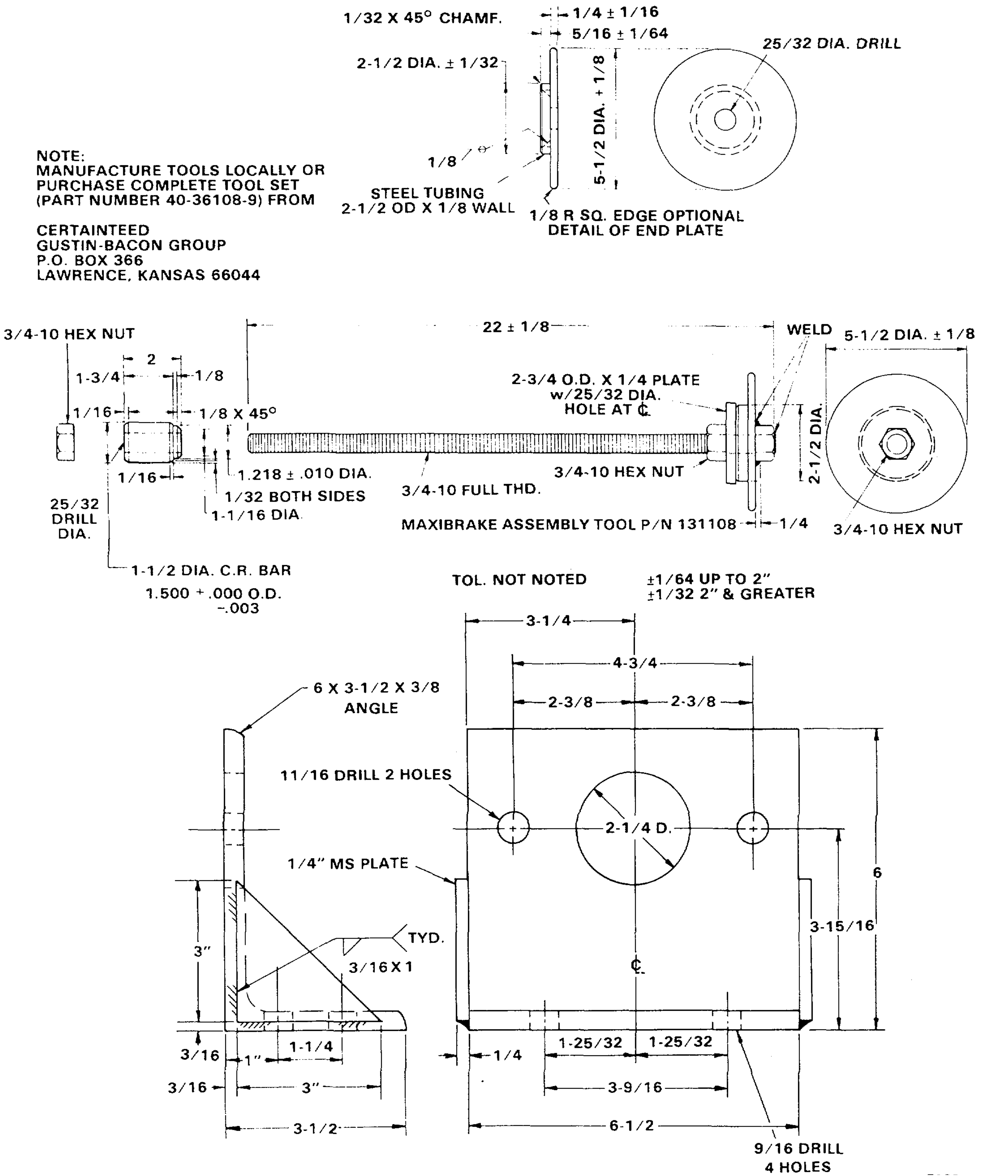


Figure 12D-2. Maxibrake Tools

BRAKE CHAMBERS

If the air pressure is vented from the spring chamber, by shifting the Maxibrake control valve to the vented position either automatically or manually, the power spring will expand, forcing the piston outward. Outward movement of the piston places the neck of the piston against a flange nut on the end of the push rod. This pushes the push rod outward, rotating the brake cam to apply the brakes.

LEAKAGE TEST. The Maxibrake system should be checked periodically to determine that the brakes are suitable for continued service or to determine whether a problem is caused by a faulty Maxibrake chamber. Test the system as follows:

1. Start the engine and build up maximum air pressure. top the engine and depress the Maxibrake control valve knob. Then check the air gauge for a drop in pressure. A drop in pressure indicates that a leak exists in the air supply system.

2. Pull the Maxibrake control valve knob outward from the dash panel, and check the air gauge for a drop in pressure after the Maxibrakes are released. A drop in pressure indicates that a leak exists beyond the control valve.

Coat the pressure plate, clamp ring, and push rod of the Maxibrake chamber with a soap solution to determine if the leakage is within the chamber itself. Maximum permissible leakage at these points is 1 lb-min. with a total volume of 200 cu in./l 00 psi (3278 cm3/6.89 bars) test pressure.

3. Make a full service brake application by depressing and holding the treadle valve. Check the air gauge for a drop in pressure. An air pressure drop of over 3 pounds per minute indicates that excessive leakage beyond the treadle valve exists.

4. If leaks occur at the points indicated above, they should be repaired before the machine is returned to service.

DISASSEMBLY. To disassemble Maxibrake chamber, proceed as follows. Refer to Figure 1 2D-3, unless otherwise directed.

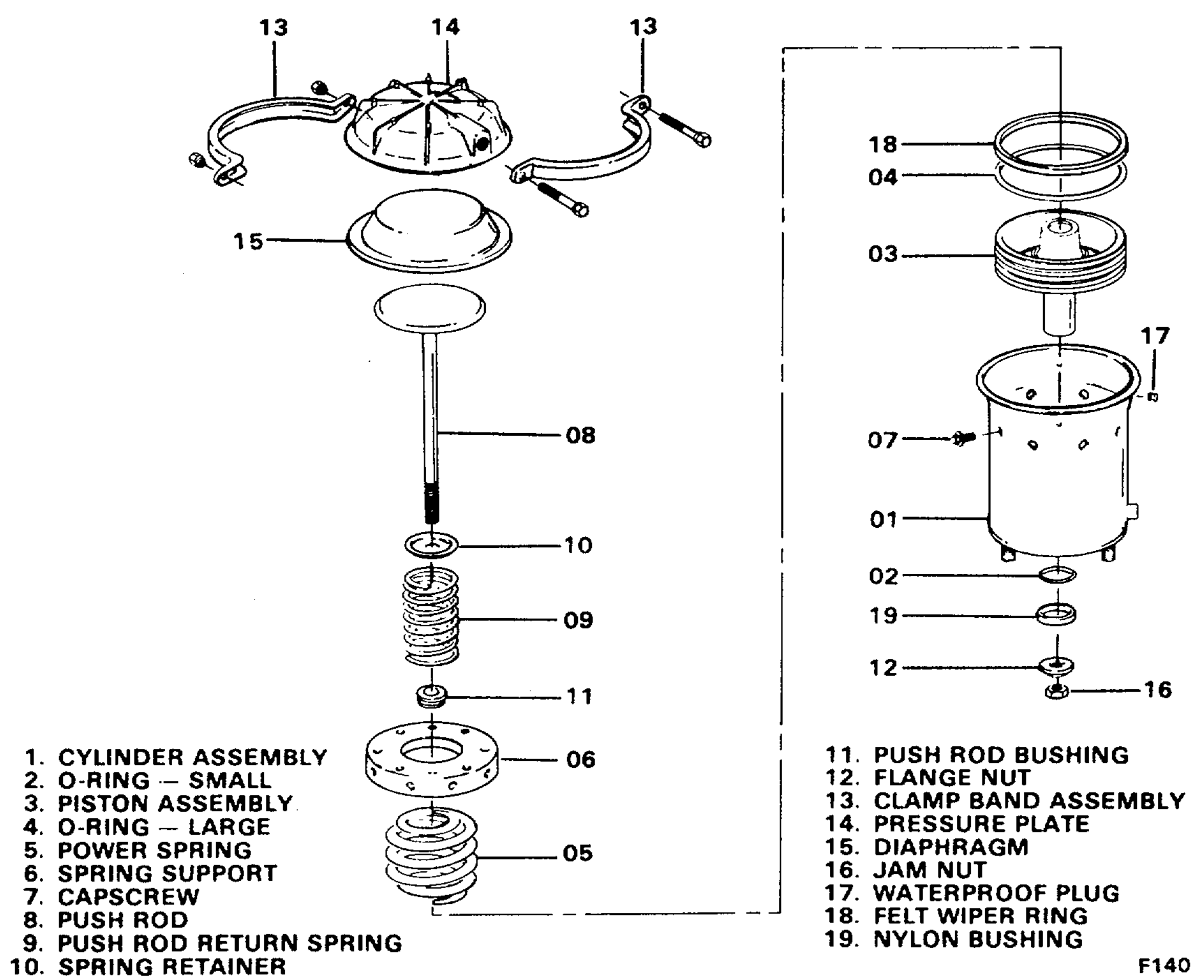


Figure 12D-3. Exploded View- Maxibrake Chamber

NOTE

To ensure that the Maxibrake chamber is serviced quickly and safely, it is recommended that the caging tool and servicing bracket shown in Figure 12D-3 be used. These tools can be manufactured locally or purchased from the chamber manufacturer at the address shown on Figure 12D-2.

1. Mount the Maxibrake chamber on the servicing bracket and secure it with the stud nuts (see Figure 1 2D-4).

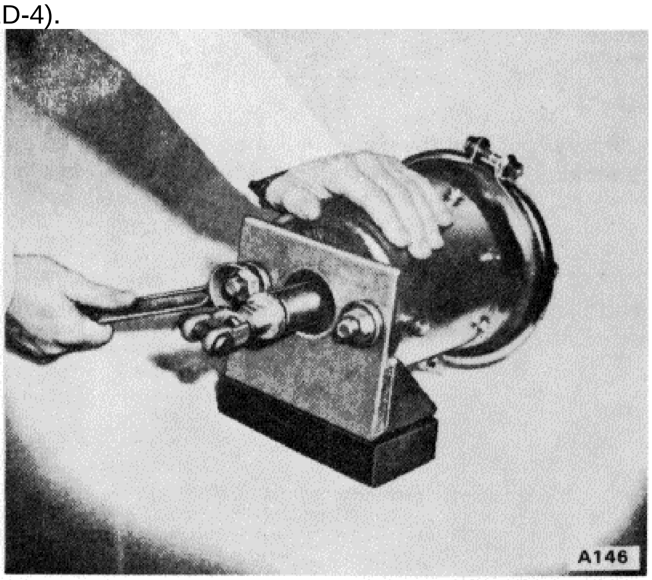


Figure 12D-4. Service Bracket

2. Note the location of the pressure plate inlet port with respect to the cylinder. Loosen the clamp band nuts and bolts, and remove the clamp band halves.
3. Remove the pressure plate and diaphragm.
4. Press down on the push rod face plate to remove the jam nut and flange nut securing the push rod (see Figure 1 2D5).

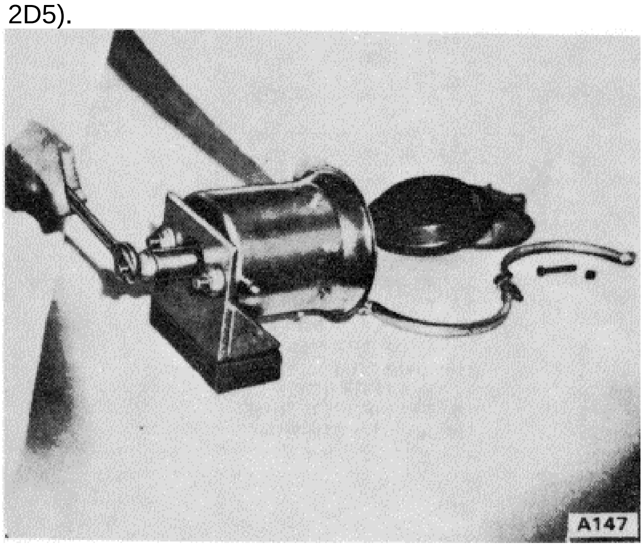


Figure 12D-5. Removing Flange Nut

5. Remove the push rod assembly from the cylinder. The push rod, spring retainer, and push rod return spring will be removed with the assembly.
6. Free the push rod bushing from the piston boss by inserting the caging tool shaft through the piston tube and tapping the tool lightly(see Figure 1 2D-6). Remove the push rod bushing.

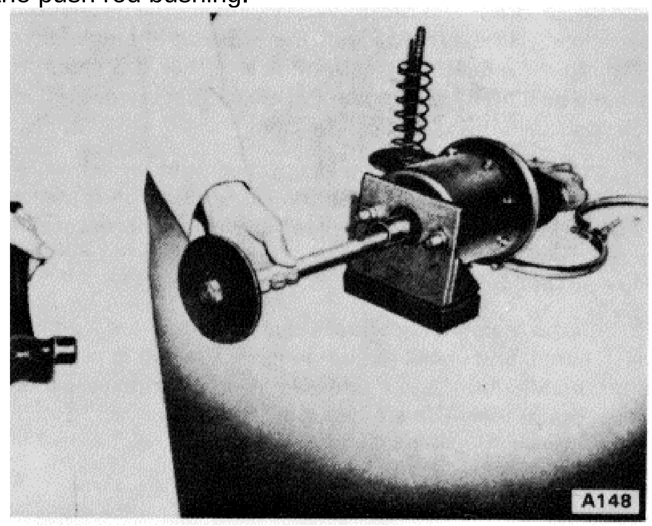


Figure 12D-6. Removing Push Rod Bushing

7. Insert the caging tool, from the back of the chamber, through the piston tube. Install the machined end of the caging tool bushing into the neck of the piston. Install the nut on the caging tool and tighten the nut down until the caging tool is centered and resting firmly against the spring support (see Figure 12D-7).

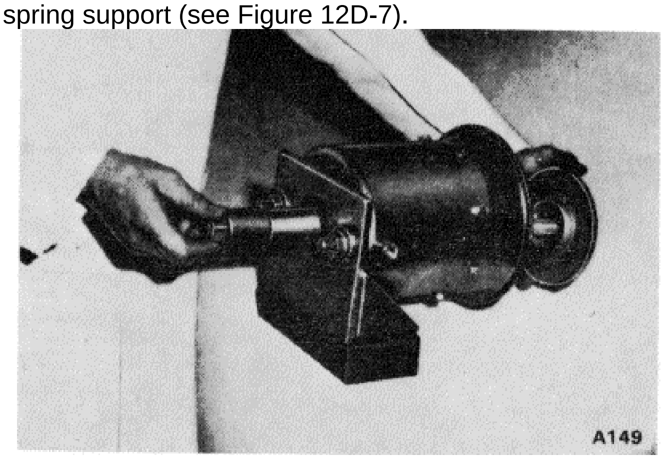


Figure 12D-7. Caging Power Supply

8. Remove the eight capscrews holding the spring support to the cylinder.
9. Gradually back off the nut on the caging tool until all spring pressure is removed. Remove the caging tool, power spring and spring support.
10. Using the caging tool bushing on the piston neck, drive the piston assembly from the cylinder. Remove the piston assembly from the cylinder (see Figure 12D-8).

BRAKE CHAMBERS

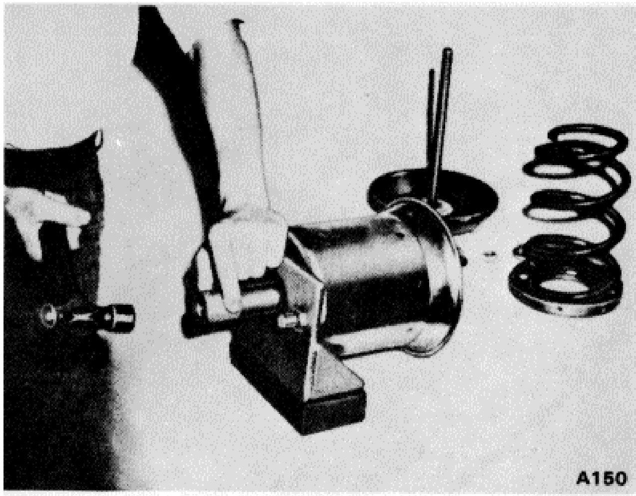


Figure 12D-8. Removing Piston Assembly

11. Remove the felt wiper ring and O-ring from the piston.
12. Remove the O-ring and nylon bushing from the cylinder center boss. Use a sharp pointed instrument to remove the bushing; work clockwise from the cut to pry the bushing out of the groove (see Figure 12D-9).

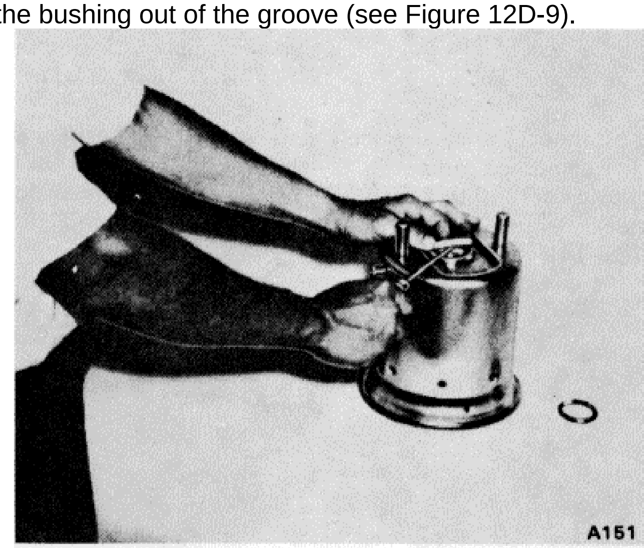


Figure 12D-9. Removing Nylon Bushing

INSPECTION AND REPAIR. After the Maxibrake chamber has been disassembled, wash all the metal parts in cleaning solvent and inspect and repair the following:

1. Check the bore diameter of the cylinder for rust, scoring, or dents. Sandblasting of the cylinder removes the plating and is not recommended. Inspect a cylinder with a suitable bore finish for other defects, such as damaged or worn studs and push rod bushing wear.
2. Remove all nicks and scratches from the piston skirt. The piston neck is chrome plated, and only pistons with necks in good condition should be reused. If the piston neck is corroded, scored, or notched, corrective action should be taken to prevent a reoccurrence. Painting the outside diameter of the piston neck must be avoided.
3. The power spring should be wire brushed and immediately coated with a rust inhibiting compound. It is important that all rust on the inside diameter of the spring be removed.
4. The spring support should be wire brushed and coated with rust inhibiting compound.
5. Inspect the push rod for a loose pressure plate and rod wear. If rust is present, wire brush and coat with rust inhibiting compound.
6. If the push rod return spring is rusty, it should be wire brushed and coated with a rust inhibiting compound.
7. The remaining parts should be inspected in accordance with standard brake service and shop practices.

REASSEMBLY. Reassemble the Maxibrake chamber as follows:

1. Fill inside center boss groove, and lightly coat the cylinder bore, with grease. Install the small O-ring in the inner center boss groove. Then install the nylon bushing in the outer center boss groove with the beveled edge of the bushing toward the inside of the cylinder (see figure 12D-10).

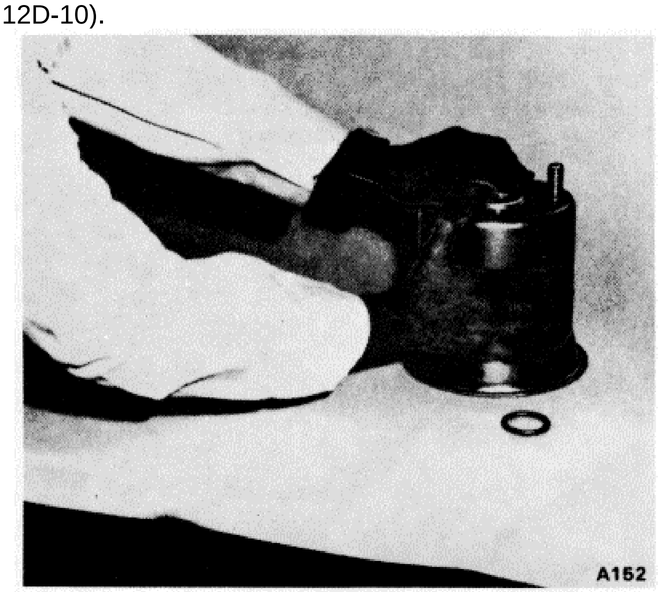


Figure 12D-10. Installing Nylon Bushing

2. Install the large O-ring in the piston groove nearest the neck. Install the saturated felt wiper ring in the remaining groove.
3. Insert the piston assembly all the way into the cylinder, holding the felt wiper ring in place as the piston is inserted (see Figure 12D-11).
4. Assemble the spring support and power spring onto the caging tool, and insert the tool through the piston assembly. Install the caging tool bushing and nut on the end of the tool. Tighten the nut slightly and center the power spring over the piston hub and spring support.
5. Tighten the caging tool nut until the holes in the spring support are aligned with the holes in the cylinder. Install the

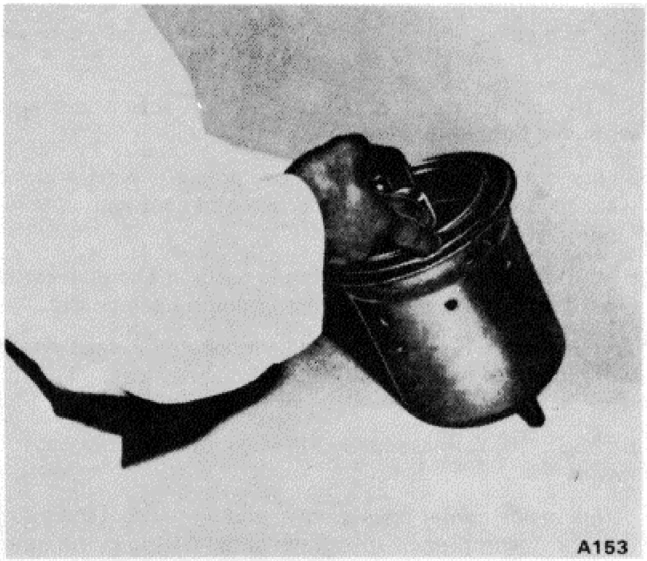


Figure 12D-11. Installing Piston Assembly

eight capscrews used to secure the spring support to the cylinder. Alternately tighten each capscrew.

6. Remove the caging tool. Then install the push rod bushing in the piston (see Figure 12D-12). Tap the bushing lightly to be sure it is seated properly.

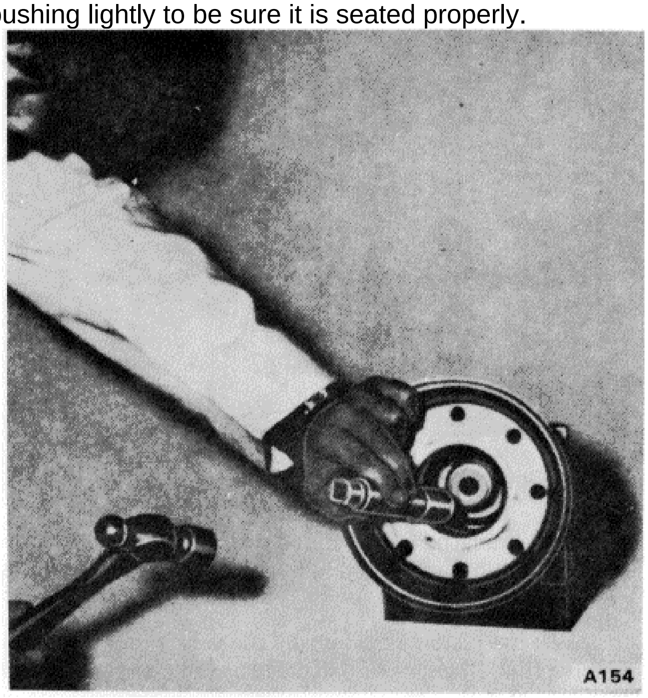


Figure 12D-12. Installing Push Rod Bushing

7. Assemble the spring retainer and push rod return spring on the push rod, and install the assembly through the push rod bushing and piston tube. Install the flange nut on the end of the push rod (see Figure 12D-13).

8. Install the diaphragm with the crown surface in the pressure plate, and center the assembly over the cylinder. Ap

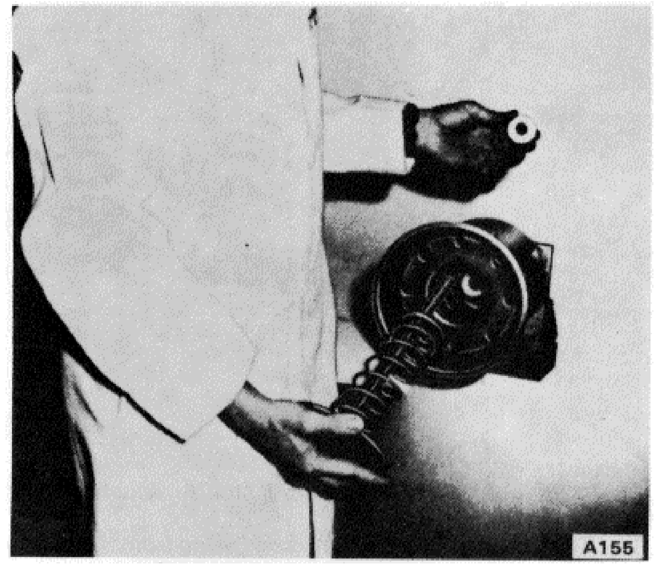


Figure 12D-13. Installing Push Rod

ply pressure to the top of the pressure plate to squeeze the diaphragm in place. Install the clamp band on the pressure plate and cylinder. Be sure the service air inlet is in the position it was before the unit was disassembled. Tighten the clamp band bolts to 100 to 150 in-lbs. (1.15-1.73 kg-m).

9. Connect a shop air supply to the spring chamber air inlet and compress the power spring. Adjust the flange nut to provide a 1/1 6 to 1/8 inch (1.6-3.2 mm) gap at the piston neck. Secure the flang nut with the jam nut (see Figure 12D-14).

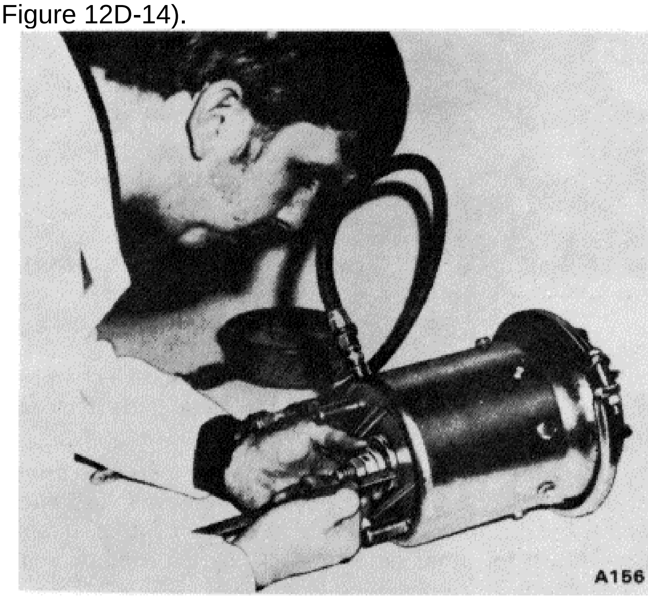


Figure 12D-14. Adjusting Flange Nut

10. Test the chamber for air leaks by applying air pressure to both inlets. Maximum permissible leakage is 1 lb/min. with a total volume of 200 cu in./100 psi (3278 cm3/6.89 bars) test pressure.

BRAKE CHAMBERS

INSTALLATION. Install a new or reconditioned Maxibrake chamber as follows:

1. Position the chamber on the mounting bracket and run on the stud nuts. Torque the nuts to 110 to 1 50ft-lbs(1l 5.220.7 kg-m).

2. Connect a shop air supply to the spring chamber air inlet and compress the power spring. Adjust the slack adjuster so it is perpendicular to the push rod when the push rod is at 50% of its stroke. Connect the push rod yoke to the slack adjuster. Remove the air supply.

3. Connect all service air lines to the chamber, and compress the power spring. Check the clearance between the flange nut and piston neck. The gap should be 1/6 to 1/8 inch (1.6-3.2 mm). Adjust the gap, if necessary and tighten the jam nut.

4. Adjust the service brakes so that push rod travel is as short as possible with no brake shoe drag.

SECTION XIII.

ELECTRICAL SYSTEM

SUBSECTION 13A

ELECTRICAL SYSTEMS

GENERAL

This subsection contains schematics of the power plant (upper and carrier), upper main machinery and lighting systems. These schematics should be helpful in determining the cause of an electrical malfunction.

REPAIRS AND ADJUSTMENTS

Detailed information on maintenance and repair of the specific type of electrical equipment can be found in the Service Manuals and Bulletins issued by the equipment manufacturer. Information regarding equipment manufac tured - by the Delco-Remy Division of General Motors may be obtained from their electrical equipment operation and maintenance manuals. The manuals may be obtained from United Delco Division, or from the Technical Literature Section, Delco-Remy Division of General Motors Corporation, Anderson, Indiana. Information regarding equipment manufactured by the Leece-Neville Co. maybe obtained from their electrical operation and maintenance manuals. The manuals may be obtained from the nearest LeeceNeville distributor or the Service Department of the LeeceNeville Co., 5109 Hamilton Avenue, Cleveland 14, Ohio 44103.

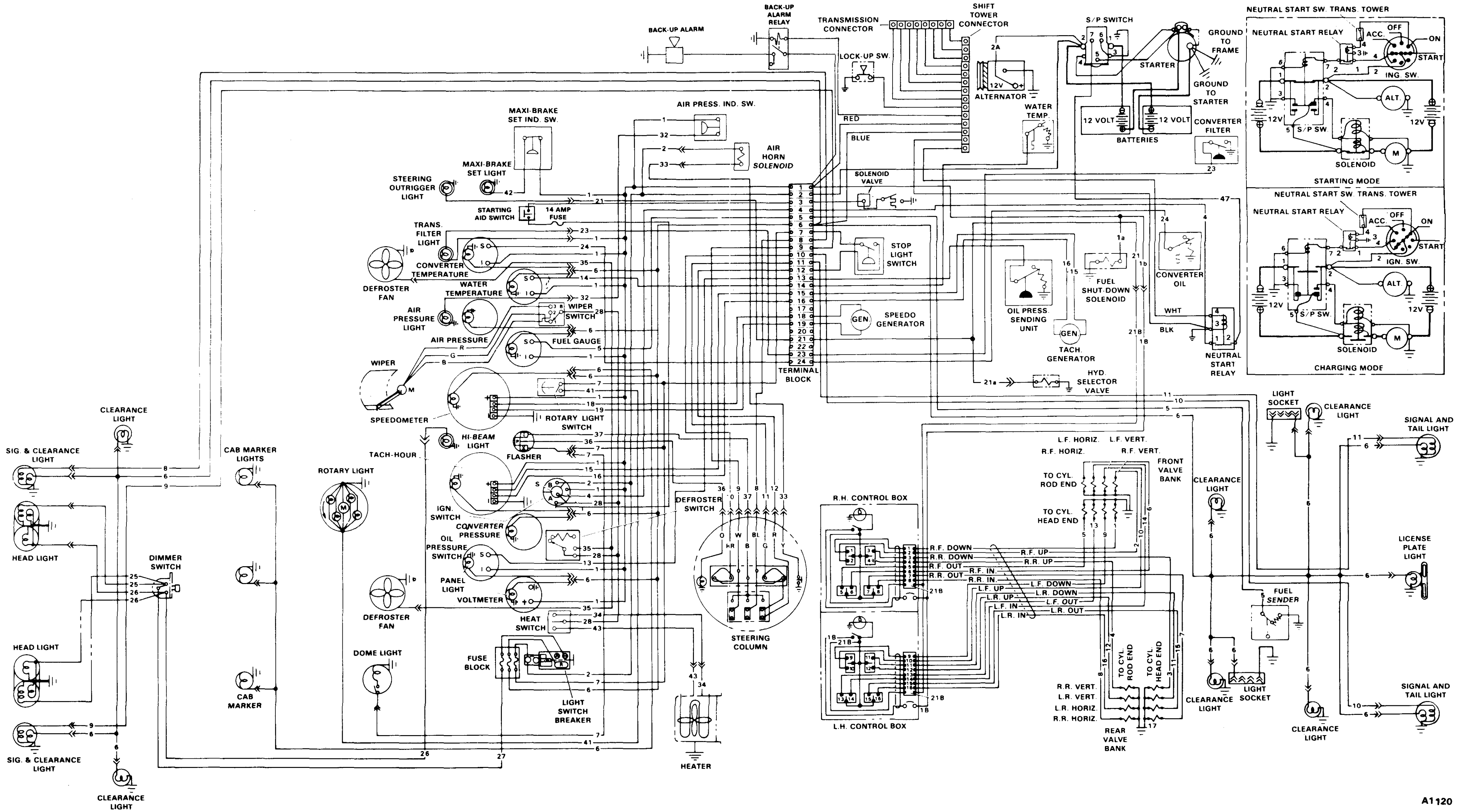
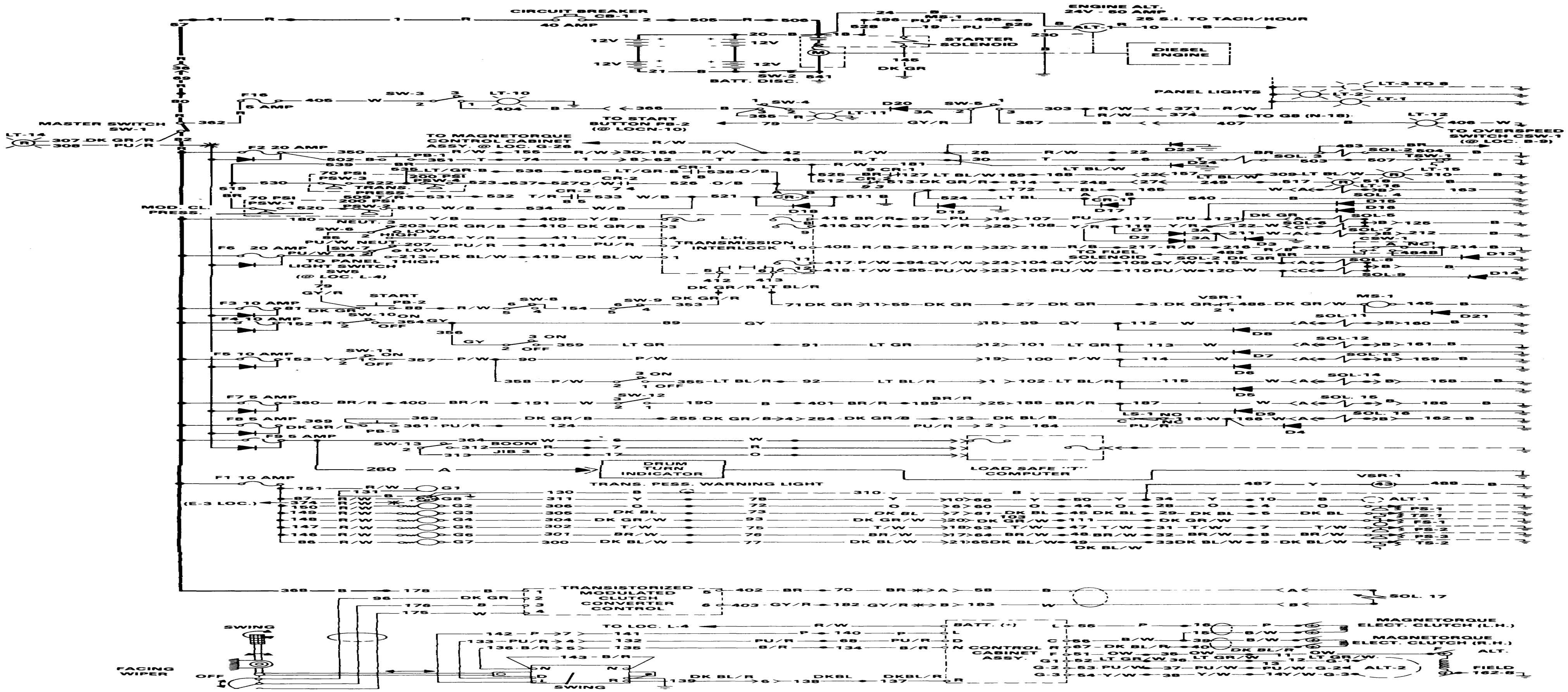


Figure 13A-1. Carrier Electrical Schematic (8105N068) -Electrical Shift Control



NOMENCLATURE

ALT-1: ALTERNATOR, ENGINE, CHG.
ALT-2: ALTERNATOR, MAGNETORQUE

CR-1: CONTROL RELAY
CR-2: CONTROL RELAY

CSW-1: OVERSPEED SWITCH
CB-1: CIRCUIT BREAKER
D1-24: DIODE
FS-1: FUEL LEVEL SENDER

G-1: GAUGE, VOLTMETER
G-2: GAUGE, ENG. OIL PRESS.
G-3: GAUGE, ENG. WATER TEMP.
G-4: GAUGE, FUEL LEVEL
G-5: GAUGE, TRANS. LUBE PRESS.
G-6: GAUGE, CONV. PRESS.
G-7: GAUGE, CONV. TEMP.
G-8: TACHOMETER/HOUR

LT-1: LIGHT, GAUGE 1
LT-2: LIGHT, GAUGE 2
LT-3: LIGHT, GAUGE 3
LT-4: LIGHT, GAUGE 4
LT-5: LIGHT, GAUGE 5
LT-6: LIGHT, GAUGE 6
LT-7: LIGHT, GAUGE 7
LT-10: LIGHT, CAB DOME
LT-11: LIGHT, COURTESY
LT-12: LIGHT, MAP
LT-14: LIGHT, FUSE FAILURE
LT-15: LIGHT, LOW TRANS. PRESS.
LT-16: LIGHT, MOD. CL. PRESS.
LS-1: LIMIT SWITCH, - 80° BOOM

MS-1: MAGNETIC SWITCH

PB-1: PUSHBUTTON, START-AID
PB-2: PUSHBUTTON, START
PB-3: PUSHBUTTON, BOOM HOIST RELEASE

PS-1: PRESS. SENDER, ENG. OIL
PS-2: PRESS. SENDER, LUBE
PS-3: PRESS. SENDER, CONV.

PSW-1: PRESS. SWITCH
PSW-2: PRESS. SWITCH } MOD. CLUTCH RPESS.
PSW-3: PRESS. SWITCH
PSW-4: PRESS. SWITCH } TRANS. PRESS.

SOL-1: SOLENOID, STARTER
SOL-2: SOLENOID, FUEL
SOL-3: SOLENOID, START AID
SOL-4: SOLENOID, SAFETY
SOL-5: SOLENOID, L.H. TRANS. (LOW)
SOL-6: SOLENOID, L.H. TRANS. (HIGH)
SOL-7: SOLENOID, B.H. INTERLOCK
SOL-8: SOLENOID, R.H. TRANS. (LOW)
SOL-9: SOLENOID, R.H. TRANS. (HIGH)
SOL-11: SOLENOID, REAR DRUM PAWL
SOL-12: SOLENOID, REAR DRUM LOCK
SOL-13: SOLENOID, FRONT DRUM PAWL
SOL-14: SOLENOID, FRONT DRUM LOCK
SOL-15: SOLENOID, SWING BRAKE
SOL-16: SOLENOID, BOOM HOIST
SOL-17: SOLENOID, MOD. CLUTCH

SW-1: MASTER SWITCH
SW-2: BATTERY DISCONNECT
SW-3: SWITCH, CAB DOME
SW-4: SWITCH, CAB
SW-5: SWITCH, PANEL & GAUGE
SW-6: SWITCH, L.H. TRANS.
SW-7: SWITCH, R.H. TRANS.
SW-8: SWITCH, REAR DRUM LOCK
SW-9: SWITCH, FRONT DRUM LOCK
SW-10: SWITCH, REAR PAWL
SW-11: SWITCH, FRONT PAWL
SW-12: SWITCH, SWING BRAKE
SW-13: SWITCH, LOAD SAFE-T COMPUTER

TS-1: TEMP. SENDER, ENG. WATER
TS-2: TEMP. SENDER, CONV.

TSW-1: THERMOSTATIC START-AID

VSR-1: VOLTAGE SENSING RELAY

Figure 13A-2. Upper Machinery Electrical Schematic (2101J20)

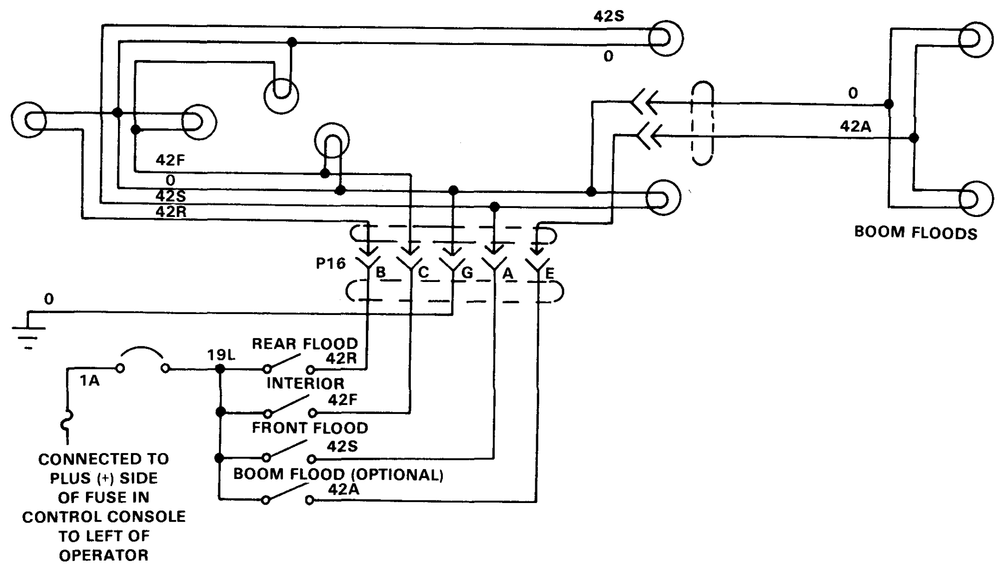


Figure 13A-3. Lighting Schematic - 24 Volt System

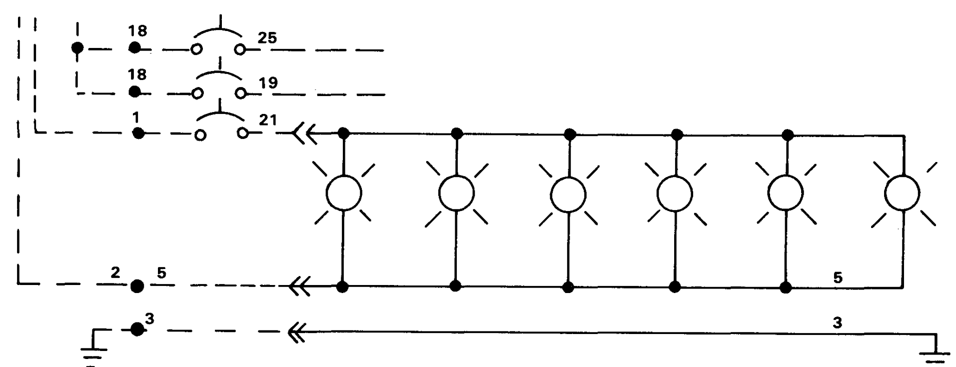


Figure 13A-4. Boom Lighting-110 Volt System.

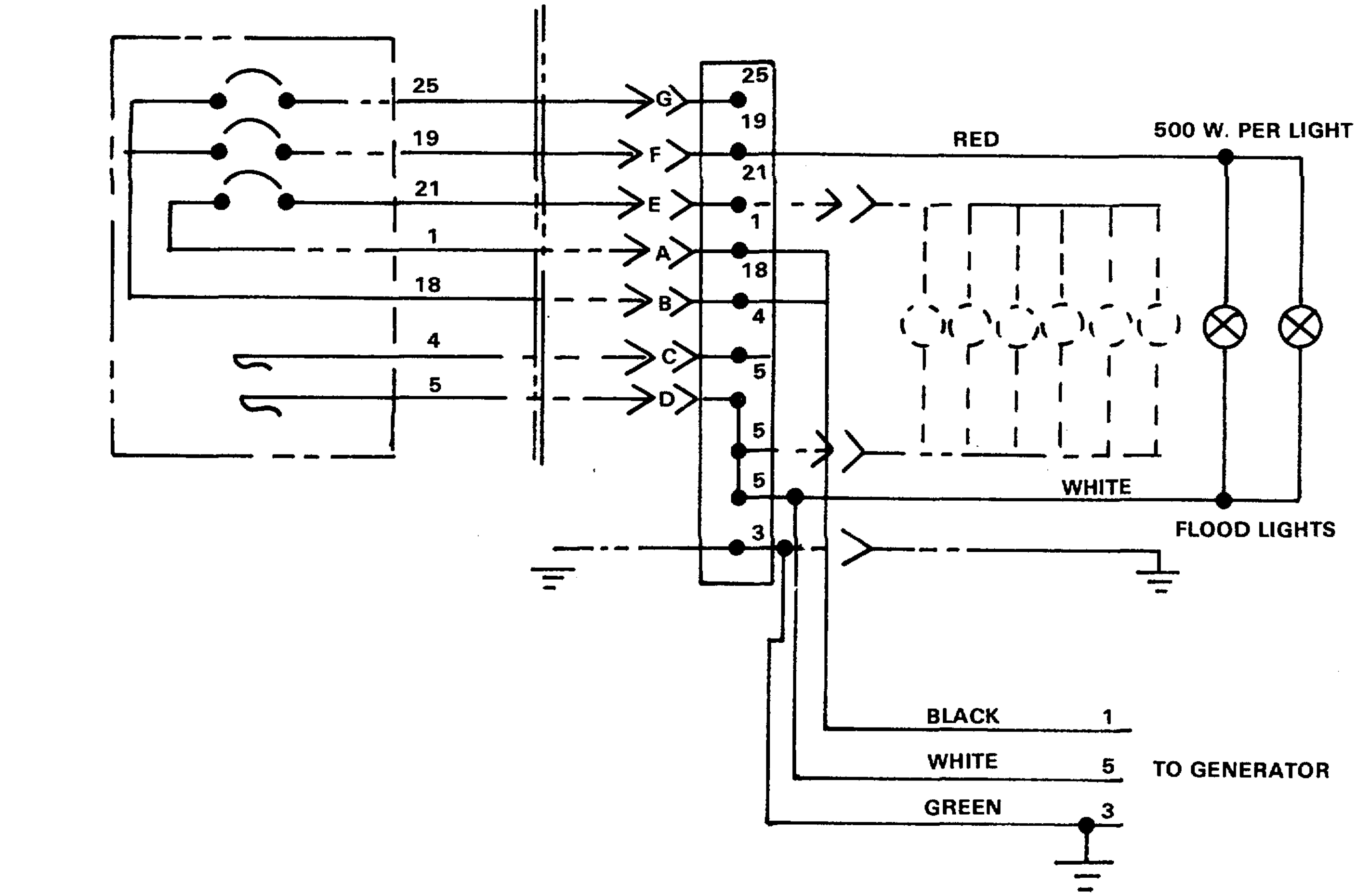


Figure 13A-5. Cab lights - 110 Volt System

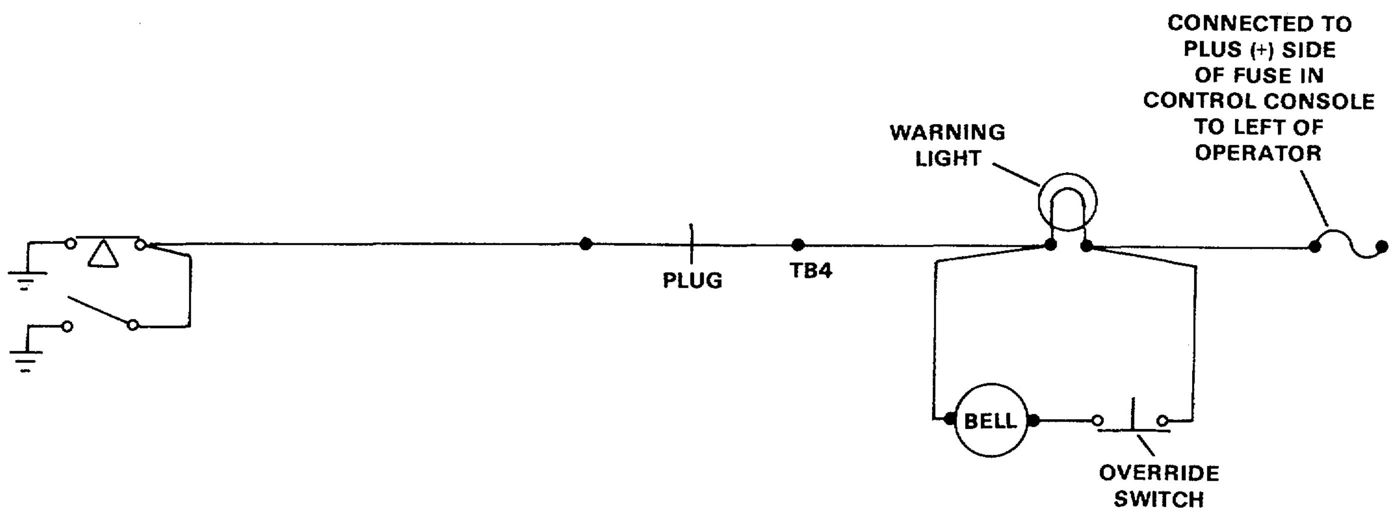


Figure 13A-6. Electrical Schematic - High Water Temperature, Low Oil Pressure in Upper Engine (2100J925)

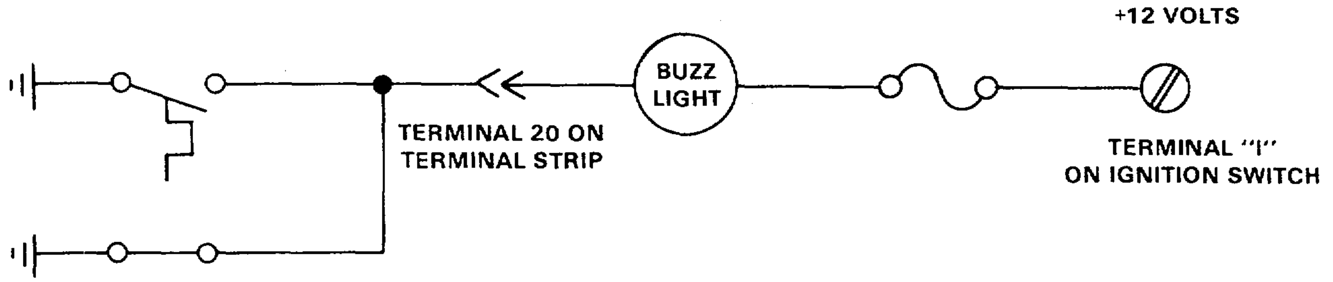


Figure 13A-7. Electrical Schematic - High Water Temperature, Low Oil Pressure - Carrier (8100N06229)

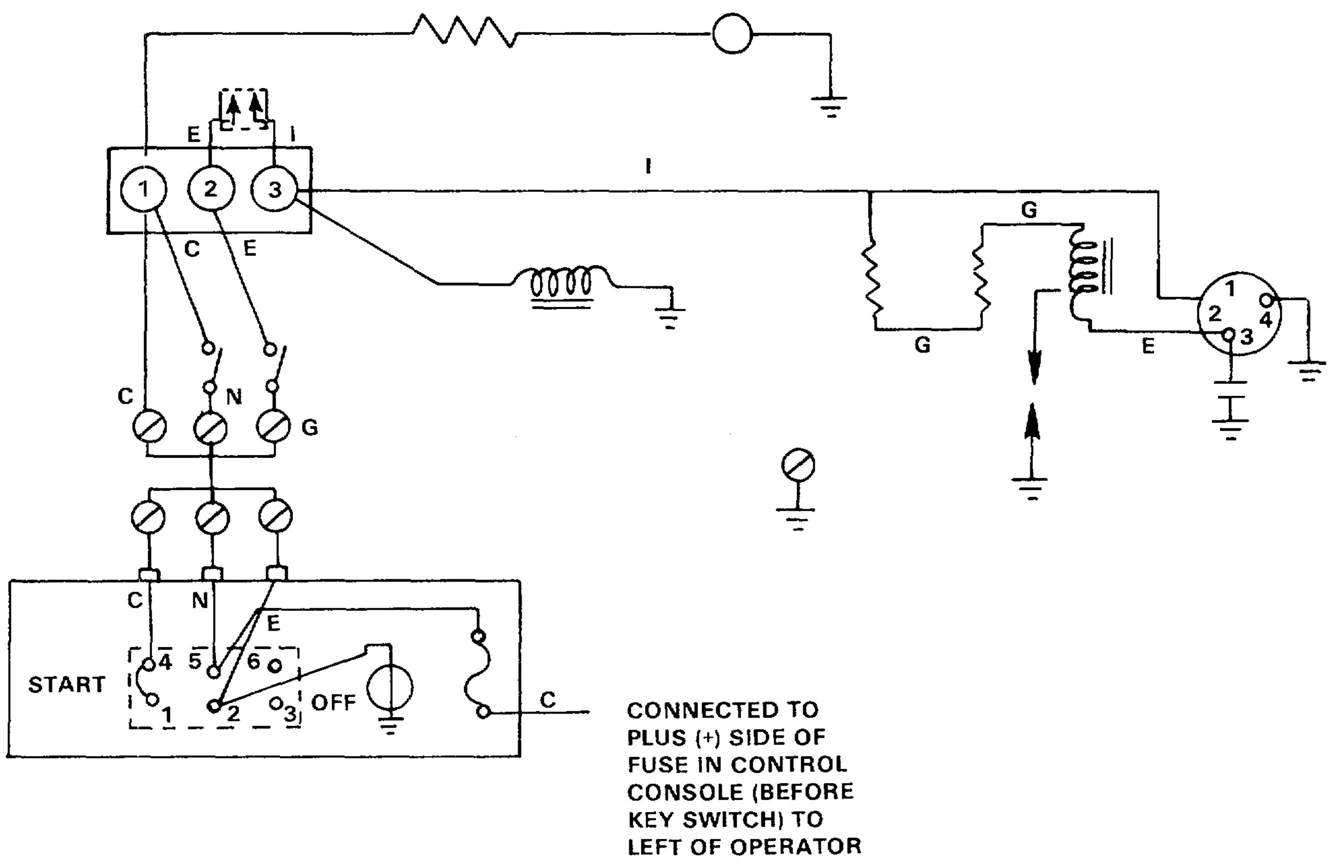


Figure 13A-8. Upper Cab Heater Electrical Schematic

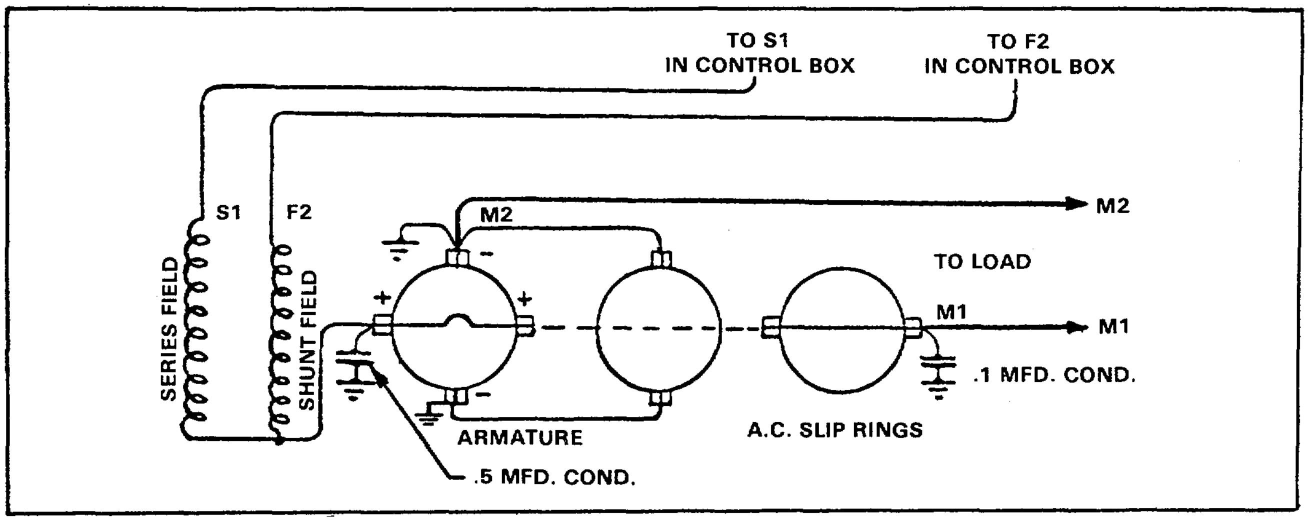


Figure 13A-9. Revolving Armature, 2-Wire, Single Phase - Generator

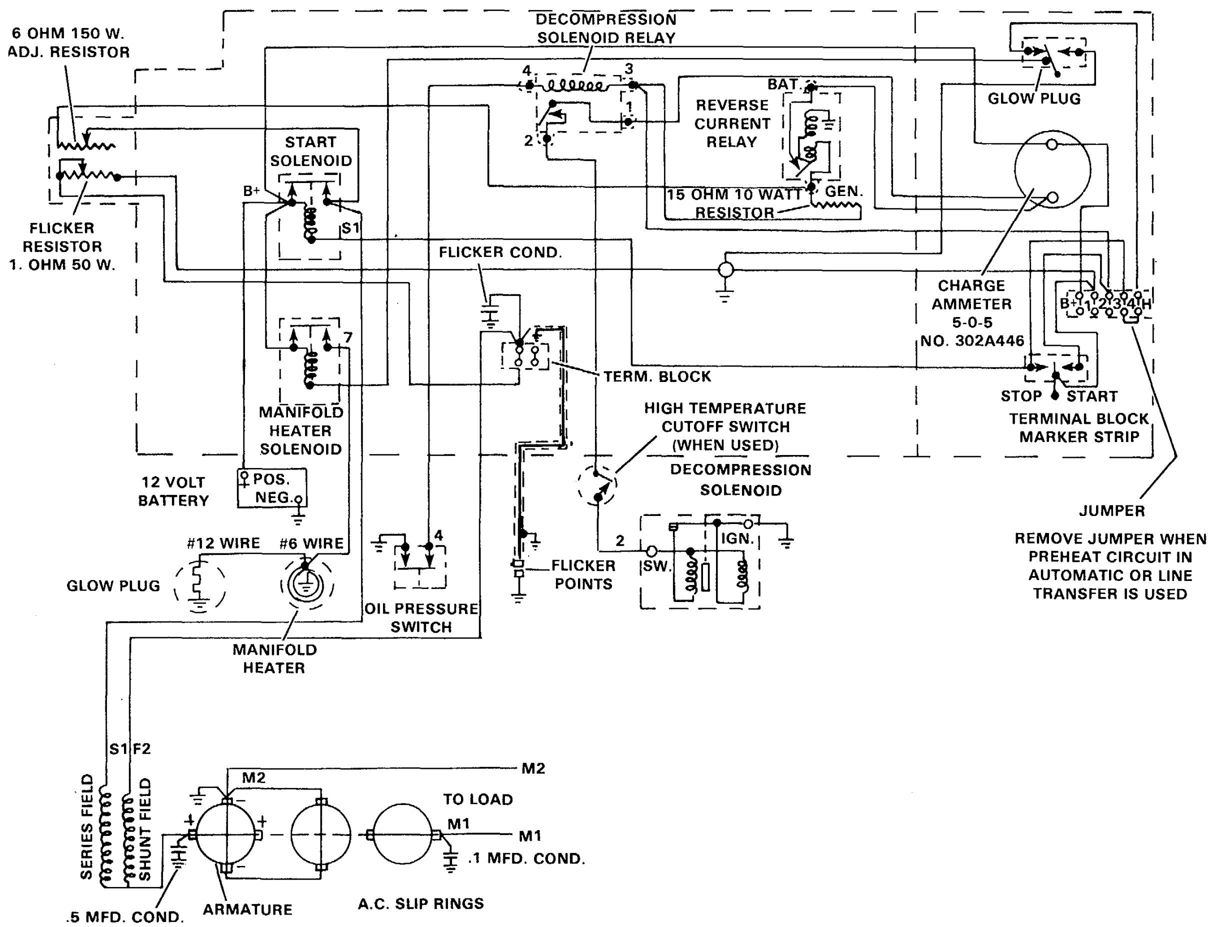


Figure 13A-10. Generator Wiring Diagram

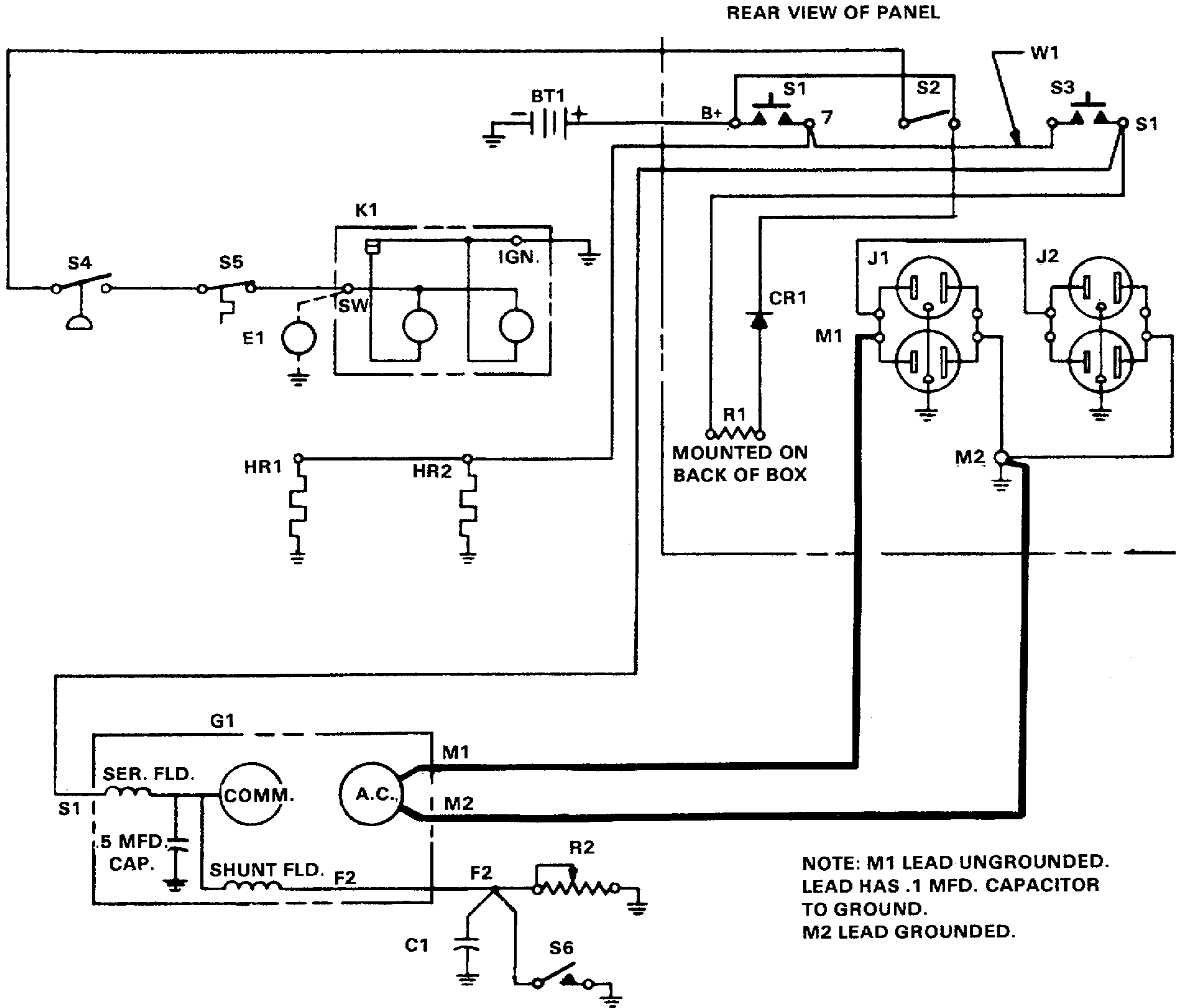


Figure 13A-11. Generator Engine Wiring Diagram

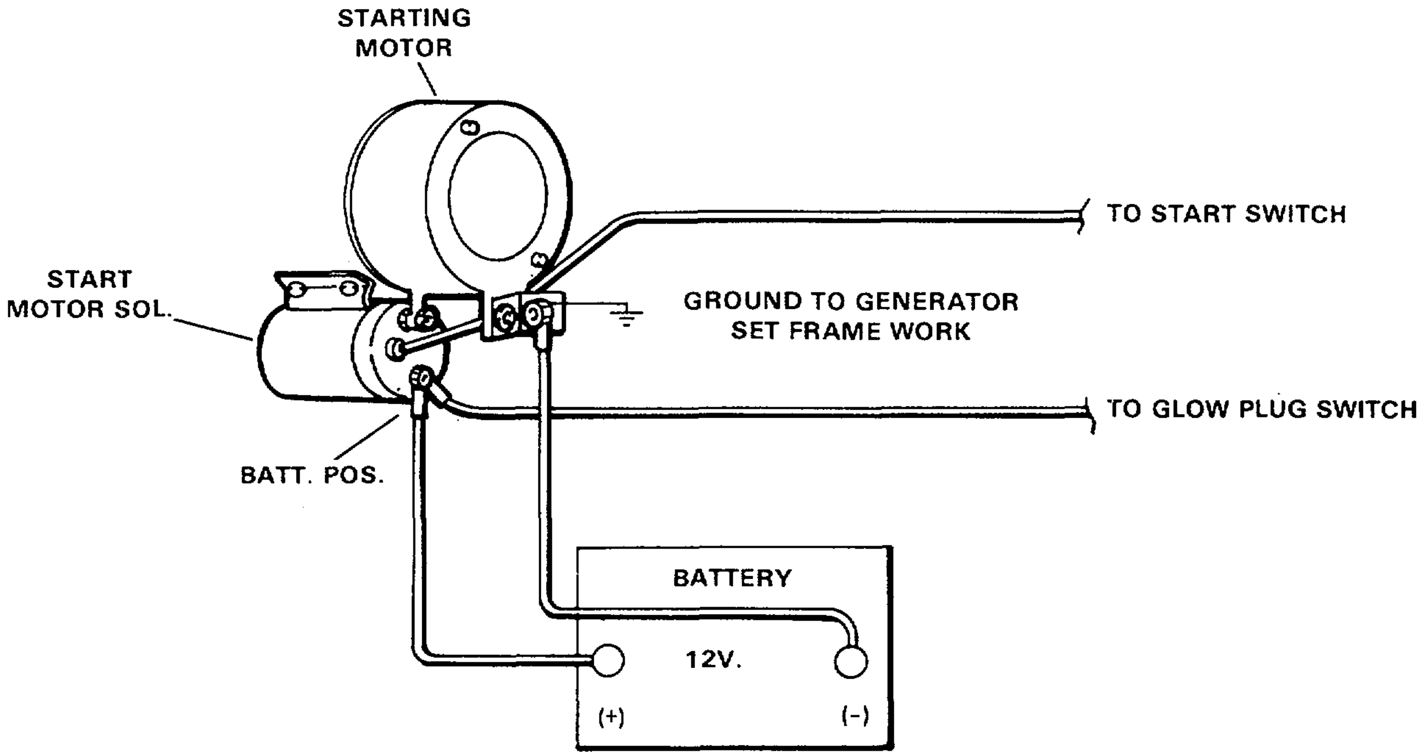


Figure 13A-12. Generator to Switch and Battery Wiring

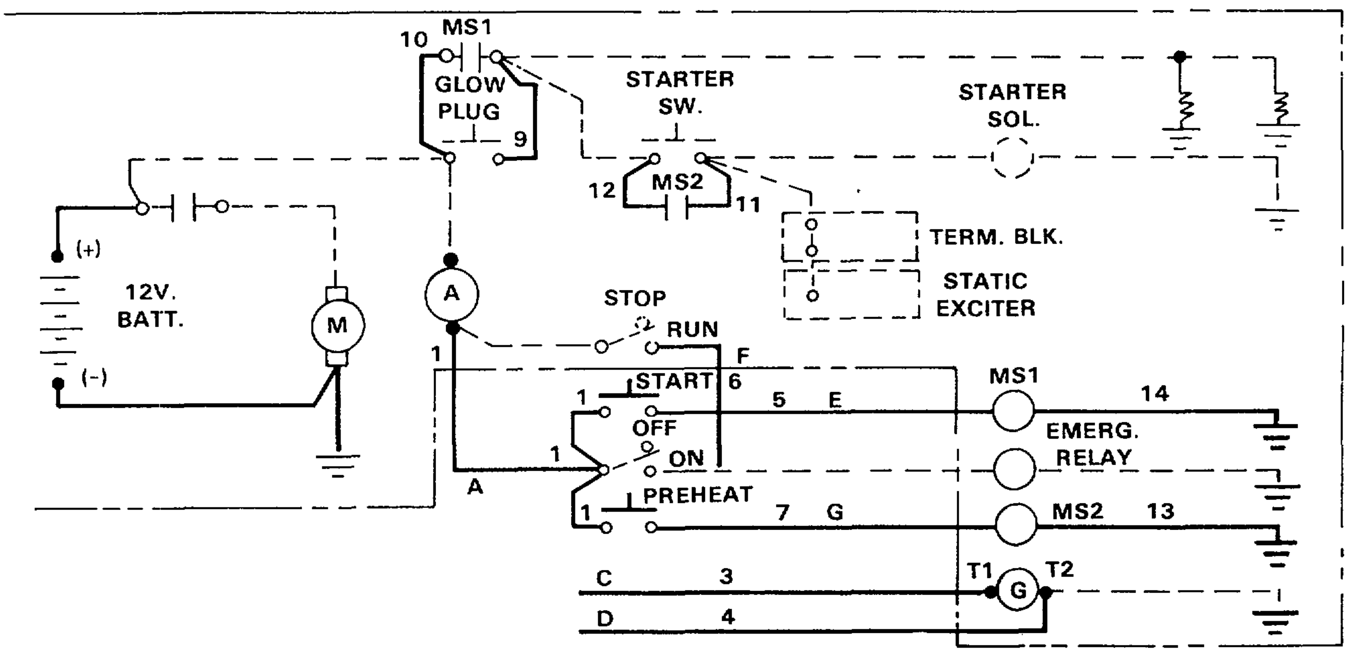


Figure 13A-13. Generator Hook-Up Wiring Diagram

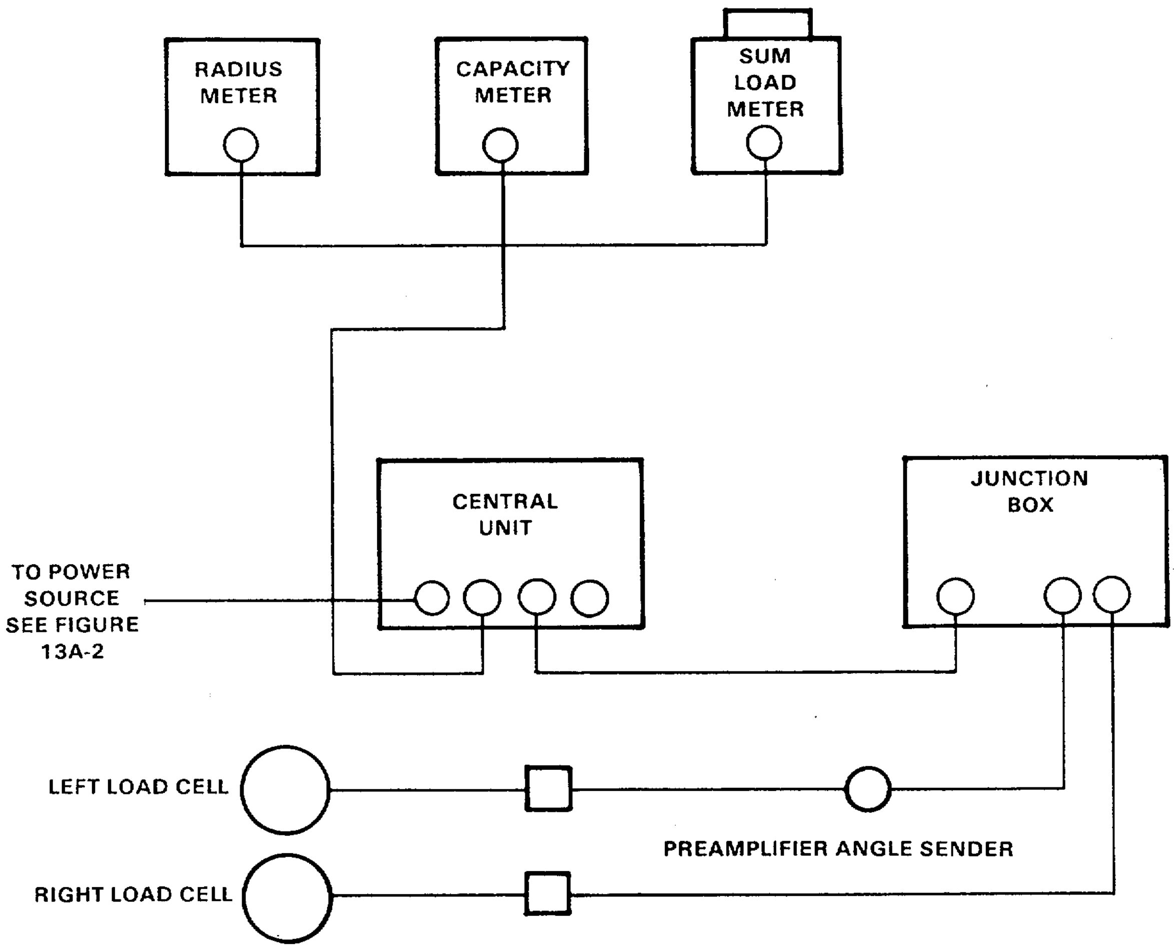


Figure 13A-14. Load Weighing System Diagram

SUBSECTION 13B

SWING CLUTCH ELECTRICAL SYSTEM

GENERAL

This subsection will discuss the various electrical components and the troubleshooting of the Magnetorque® swing clutch system. These items include the alternator, control cabinet, swing controller, and the swing clutch brushes and slip rings.

SYSTEM OPERATION - TRANSISTORIZED REGULATOR

DESCRIPTION

The swing clutch system is designed to provide the operator with a means of revolving the upper of the machine on the lower. Figure 1 3B-1 shows an electrical schematic and the components used in the transistorized system.

The swing clutch system can be broken down into three major parts; the power source, the control system and the swing clutch units. Electrical power for the swing clutch system is supplied by an independent, engine driven alternator. The control system consists of the control cabinet mounted in the right center (below the rear drum shaft) of the main machinery, and the swing controller, mounted inside the front controls console. The swing clutch units consist of the brushes, slip rings, and the inner and outer members mounted on the swing clutch shaft. Using Figure 1 3B-1 2, a description is given of the three major parts of the swing clutch system.

With the engine running at a relatively constant speed and the alternator field strength remaining constant, the alternator output is a relatively constant ac voltage. With constant voltage output, if the main contacts of the swing controller were closed, you would have constant voltage to the clutch coils and if the main contacts of the swing controller were open you would have no voltage to the clutch coils. There would be no variation of output from the alternator. So, there must be some way of controlling the alternator voltage output. The method employed in this system is varying the field strength of the alternator. The alternator field strength is controlled by increasing or decreasing the current which flows through the alternator field. Increasing or decreasing the current flow through the alternator field controls the output of the alternator, and therefore, controls swing speed.

Current flow through the alternator field is varied by the regulator and the swing controller. When the operator moves the swing lever, the swing control bar in the swing controller moves, closing one pair of movable main contacts (at the same time the graphite brush in the controller moves across the resistor contacts). This causes an increase in resistance which in turn will activate the regulator causing an increased current flow through the regulator. Increased current flow through the regulator supplies increased current to the alternator field.

As the operator moves the swing lever further, the graphite brush in the swing controller moves across the contacts of the printed circuit board. This progressively increases the resistance to the regulator, increasing current flow through the regulator. This progressively increases the alternator field strength. Increasing the alternator field strength, increases the output of the alternator and swing speed increases accordingly.

The main rectifiers, located in the control cabinet, convert the ac output of the alternator into dc current required by the remainder of the circuit. When the operator closes one pair of movable main contacts (using the swing control lever) in the swing controller, rectified current from the alternator flows to the clutch coils of the selected inner Magnetorque member, magnetizing the member.

The outer surface of the inner member is composed of many pole pieces which alternate in polarity (N-S-N-S). The strength of the inner member magnetic field (primary field) is determined by the amount of rectified alternator output applied to the inner member clutch coil. This alternator output is controlled by varying the strength of the alternator field, which in turn is controlled by the regulator and the swing controller as explained above.

When the inner member is energized, a primary magnetic flux field is set up between the adjacent poles of unlike polarity. This primary field induces a current in the permeable steel rim of the outer member. The eddy current flow establishes a secondary magnetic field in the outer member of the swing unit.

Eddy current strength is determined by the strength of the primary field (increased alternator output to the coils) and the relative speed between the inner and outer members. In an eddy current coupling, the attraction of the primary and secondary fields cause the inner member to attract the driven outer member. In other words the magnetic fields will try to follow each other in the same direction. Thus in Magnetorque swing clutch operation, the attraction of these two fields cause the inner member to follow the direction of rotation of the driven outer member.

Forces tending to retard the motion of the inner member, such as heavy loads, wind, or long booms, will tend to cause the inner member to lag behind the outer member. This tendency to lag is called SLIP. However, the tendency to slip will increase the speed at which the primary field lines of magnetic force move through the outer member, and this increased magnetic field speed will result in additional swing torque. This additional torque will always be just sufficient to overcome the tendency to slip. This automatic compensation system accounts for the smooth operating characteristics of the Magnetorque clutch swing.

When the swing control lever is returned to neutral, the movable main contacts in the swing controller are opened, and current flow through the inner member coil will stop. This will collapse the magnetic field, and the inner member will no longer be magnetically coupled to the outer member. The outer member will continue to be driven, but the inner member will not follow.

Since a large amount of energy was induced in the coils of the inner member when the swing control lever was moved to swing the machine, there must be some way of dissipating this energy when the swing control lever is returned to neutral. This energy is dissipated through discharge resistors in parallel with the coils. The resistors are located in the control cabinet. Blocking rectifiers, in the control cabinet, prevent reverse current damage to the alternator and the main contacts of the swing controller during field collapse.

RECOGNIZING TROUBLE INDICATIONS. The ability to recognize trouble indications in a specific part of the system is usually acquired with experience. However, a few tests will help you to localize the trouble.

1. Check the alternator drive belts. See Alternator, later in this subsection.

2. Put a dc ammeter (0-1 OOA) in series with the "C" lead from the swing controller.

3. Move the swing control lever to the extreme forward position (swing left). Set the swing regulator, R8 adjuster on the regulator assembly, to read 30 amp (cold). Adjust to this amperage by turning the R8 adjusting screw in small increments.

4. Move the swing lever to the extreme rear position (swing right).

5. Check that the right swing reads 30 amp (±2 amp).

6. Remove the ammeter and reconnect the "C" lead to the swing controller.

SYSTEM TROUBLESHOOTING

GENERAL. The troubleshooting charts and hints that follow are of a general nature, but should provide an intuitive feeling for a specific problem. Probably the greatest aid to troubleshooting is knowing the system. Every component has a purpose in the system. The operating characteristics of each one should be understood. Know how the system works.

DEVELOPING SYSTEMATIC PROCEDURES. Analyze the system and develop a logical sequence of looking for trouble. Ask the operator how the machine performed when it started to malfunction or if there was anything unusual about it. Operate the machine to see if the components are operating smoothly. Check such things as alternator belts, the circuit breaker, and observe the swing motions. Develop a cause and effect troubleshooting guide listing the symptoms, probable causes, and the corrective measures to be taken. As is the case with any such listing, there is always the possibility that improper operation is caused by conditions other than those noted so list all probable causes.

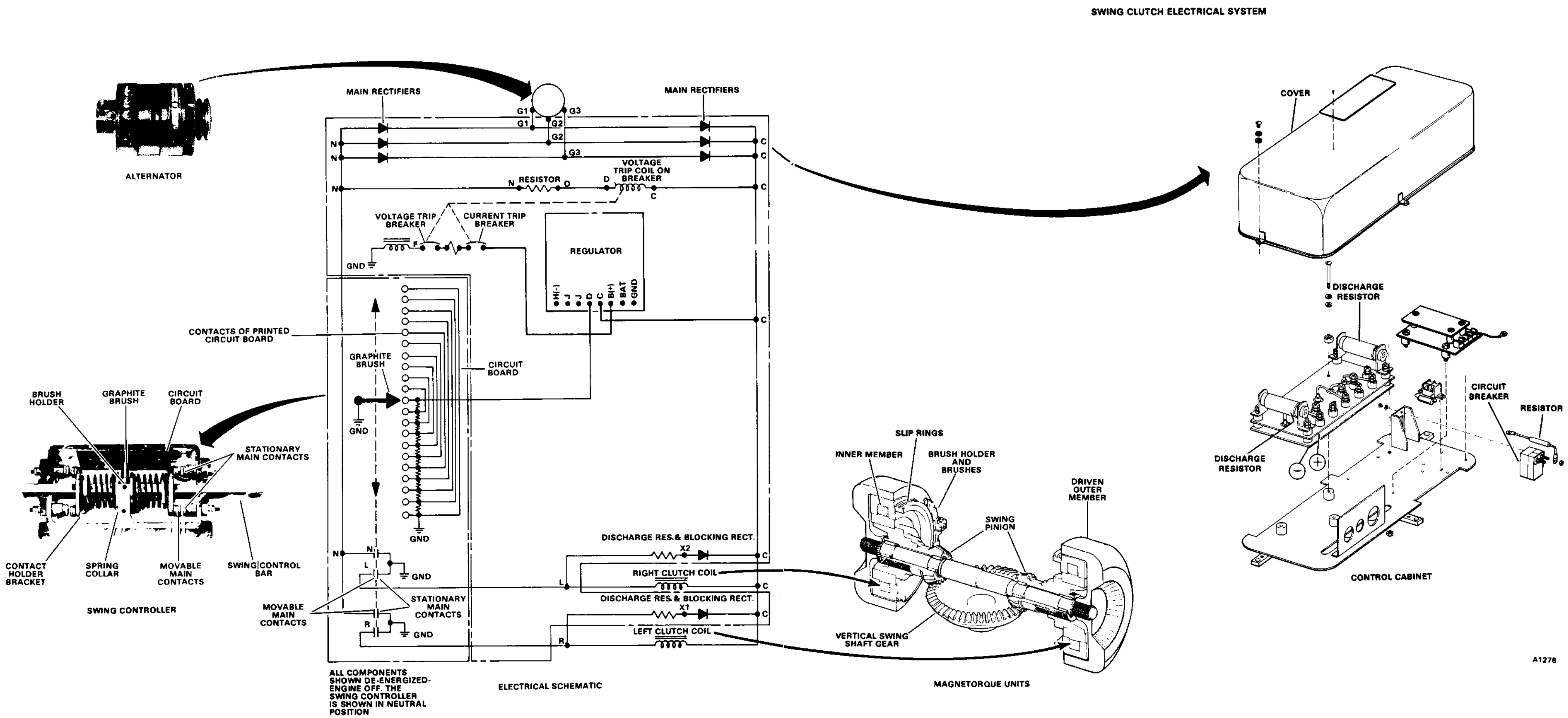


Figure 13B-1. Swing Clutch Electrical System-Transistorized Regulator

Table 13B-1. Troubleshooting Guide

Probable Cause	Check	Remedy
Problem: Machine fails to swing in either direction.		
1. Circuit breaker tripped	Remove the cover from the control cabinet Reset the breaker and operate the machine again as a momentary overload may have tripped the breaker.	Reset the circuit breaker.
2. Alternator field open or shorted	Check the continuity of the alternator field with an ohmmeter. Disconnect the leads at the alternator field terminals. You should get a reading of approx	If the reading is low, replace the brushes, and clean the slip rings. If trouble persists, replace the alternator. 16 to 20 ohms.
3. Alternator belts loose or broken.	Visually inspect the belts. Also check the belt tension	Adjust or replace the belts, if necessary.
4. Alternator AC wiring open or grounded	Check the continuity of leads (G1), (G2), and (G3). Check with an ohmmeter across (G1 -G2), (G2-G3), and (G3-G1) for an open circuit. Also check each individual lead to the frame for a ground.	Replace or repair the leads if they are open or grounded. Replace the alternator if an open circuit appears across the terminals, or if one winding is grounded.
5. Regulator faulty	a. With the engine runnging at idle speed and the engine clutch disengaged, check with a volt-ohmmeter (60 VDC scale) across B to ground. With the swing control lever fully in either position you should get a reading of 10-20 volts depending upon engine speed.	a. If a reading of 10-20 volts is obtained and the machine still does not swing, recheck steps 2 thru 4 above. If there is no reading check for 24V at the battery. Also check for any broken or grounded wires leading into the control box a grounded D lead will allow no output at D, and an open at D or a broken lead will allow B to go to max out-put and will not be controllable with the swing lever.
	b. Check with a volt-ohmmeter (set at 60 VDC) across D to ground. As the swing control lever is moved back and forth from off to full on 5C you should get a reading of from 0 to 4-7 volts depending upon the setting of R8	b. If there is no signal, remove the D wire from the D terminal and proceed to step If you do obtain the re-quired volts recheck the previous steps.
	c. With the engine off and the volt-ohmmeter set on 1000 ohm scale, measure across the D wire to ground. As the swing control lever is moved back and forth from off to full on you should get a reading of 0-700 ohms (some models will give a reading of 0-100 ohms)	c. If there Is no signal check the swing controller contacts, brushes, etc. Also look for a ground in the D lead. If you do not obtain the required ohms the transis-torized regulator is malfunctioning. If it is malfunctioning replace it as a unit.
6. Magnetorque clutch coil may be grounded on the (C) side.	With the brushes lifted, resistance from the slip ring to ground should be infinite Check both Magnetorque units Magnetorque.	Examine the leads between the slip rings and the clutch coil for damage. Repair the leads or replace the

Table 13B-1. Troubleshooting Guide (Cont.)

Probable Cause	Check	Remedy
Problem: The machine fails to swing in one direction but is normal in the other direction.		
1. The movable contacts in the swing controller, (R) or (L), are not making contact with the stationary contact.	Remove the cover from the swing controller box and inspect the main contacts visually.	Replace any badly burned or worn main or stationary contacts.
2. The brushes do not make good contact with the slip rings on the Magnetorque unit.	Inspect the brushes and replace them if they are worn to a point near the top of the brush holder. Check the brush pressure spring to make sure it is exerting enough pressure on the brush.	Replace the Magnetorque slip ring brushes and clean the slip rings to assure good contact.
3. The Magnetorque clutch coil may be open or shorted.	Lift the brushes from the slip rings and check across the slip ring with an ohmmeter. Ohmmeter reading should be approx. equal to the resistance value stamped on the Magnetorque unit.	If the clutch coil is open or shorted, the Magnetorque unit must be replaced.
4. Magnetorque clutch coil may be grounded on the (R) or (L) side.	With the brushes lifted, resistance from the slip rings to ground should be infinite. Check both Magnetorque units. If the machine fails to swing left the left Magnetorque unit winding is grounded, and vice versa for the right Magnetorque.	Examine the leads between the slip rings and the clutch coil for damage. Repair the leads if necessary. If either Magnetorque winding is grounded, the Magnetorque unit affected must be replaced.
5. Cables (R) or (L) open to individual Magnetorque units.	Check the continuity of cables (R) and (L) from the brush holder to the main rectifier assembly and to the swing controller.	If the cables are cut or damaged, they must be replaced.

NOTE

Failure to swing on one direction could be caused by mechanical failure such as damaged or frozen bearings. An indication of mechanical trouble would be that the machine may swing with the controller in the neutral position. When problems occur it may take full-on plugging in the opposite direction to stop the machine.

Probable Cause	Check	Remedy
Problem: The machine swings violently and lacks control.		
1. Voltage regulator not functioning properly.	See Step 5, Regulator Faulty, under the problem "Machine Fails to Swing in Either Direction."	
2. The movable graphite brush contact on the circuit board assembly in the controller fails to make contact with the segments.	Remove the swing control cover and inspect the movable graphite brush for good contact with all segments. Check for an open circuit from terminals (C), on the regulator chassis, to ground in the controller.	Remove and replace any worn parts. Replace any faulty wiring. Clean the circuit board.

Table 1 3B-1. Troubleshooting Guide (Cont.)

Probable Cause	Check	Remedy
Problem: The machine swings too slow in either direction.		
1. Main rectifiers defective.	Disconnect the rectifier flexible leads from the (G1), (G2) and (G3) terminals. Check the rectifier cells with an ohmmeter.	Replace any defective rectifier.
2. Alternator belts loose.	Check the tension of the alternator belts.	Adjust the belt tension.
3. Voltage regu-lator on the wiring grounded on the terminal (D) side of the regulator.	See Step 5a, Regulator Faulty, under problem, "Machine Fails to Swing in Either Direction."	
Problem: The machine swings intermittently and sluggishly.		
Poor connection or poor contact in the swing controller. controller. contact surfaces.	Check the main contacts for extreme wear or a broken contact spring. Check for any oil or dirt inside the swing swing controller, especially the	Replace any worn or broken parts. Thoroughly clean the inside of the
Problem: The machine swings normally in both directions but is rough in one direction with plugging.		
Clutch dis-charge resistor is defective.	Remove the cover from the control cabinet. Remove the leads from terminals (X1) and (X2) on the main rectifier assembly. With an ohmmeter measure the resistance from terminals (X2) to (L) and (X1) to (R). These readings should be approximately 3 ohms.	If the resistors show an open circuit when checked, they should be replaced.
Clutch block-ing rectifier is defective.	Check the rectifier cells connected be-tween (C) and (Xl), and (C) and (X2) with the leads removed as noted above. This reading should be low in the forward direction and infinite in the reverse direction.	If the reading is the same in both directions the blocking rectifier must be replaced.

ALTERNATOR (88Z30) DESCRIPTION. This is a three phase, 12 pole, revolving field alternator. Its only function is to serve as the power source for the swing clutch system.

DRIVE BELTS. The alternator drive belts should be checked several times during the first 50 hours of operation. The initial stretch of the belts will be taken up during this time.

After the first 50 hours of operation the belts should be checked on a monthly basis. To check and adjust these belts, proceed as follows (see Figure 13B-2): 1. Adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will not exceed the deflection shown in the table.

2. To adjust the belt, loosen capscrew (23) and make the necessary adjustments. Repeat step 1 whenever any adjustments are made.

3. Tighten capscrew (23), dry, to 150 ft-lbs (20.7 kg-m).

TESTING. In the event that the machine does not swing properly and it is believed that the alternator is the cause of the problem, the following procedure should be used to test the alternator.

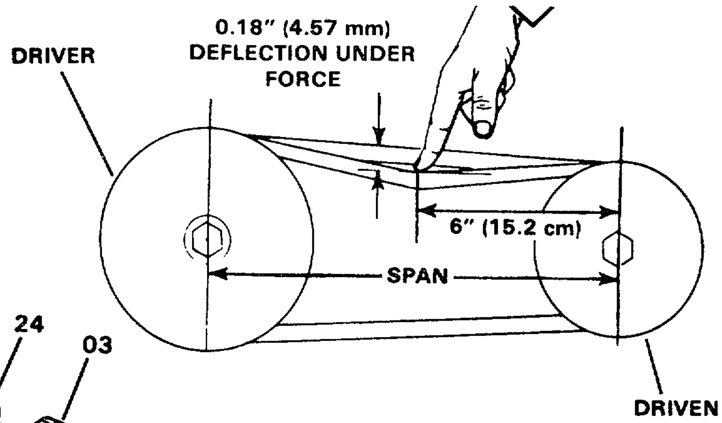
1. Attach one voltmeter lead to the "C" terminal of the swing controller a Rd the other voltmeter lead to the "N" controller terminal.

2. With the engine running, determine the alternator speed by means of a strobe light or a hand tachometer.

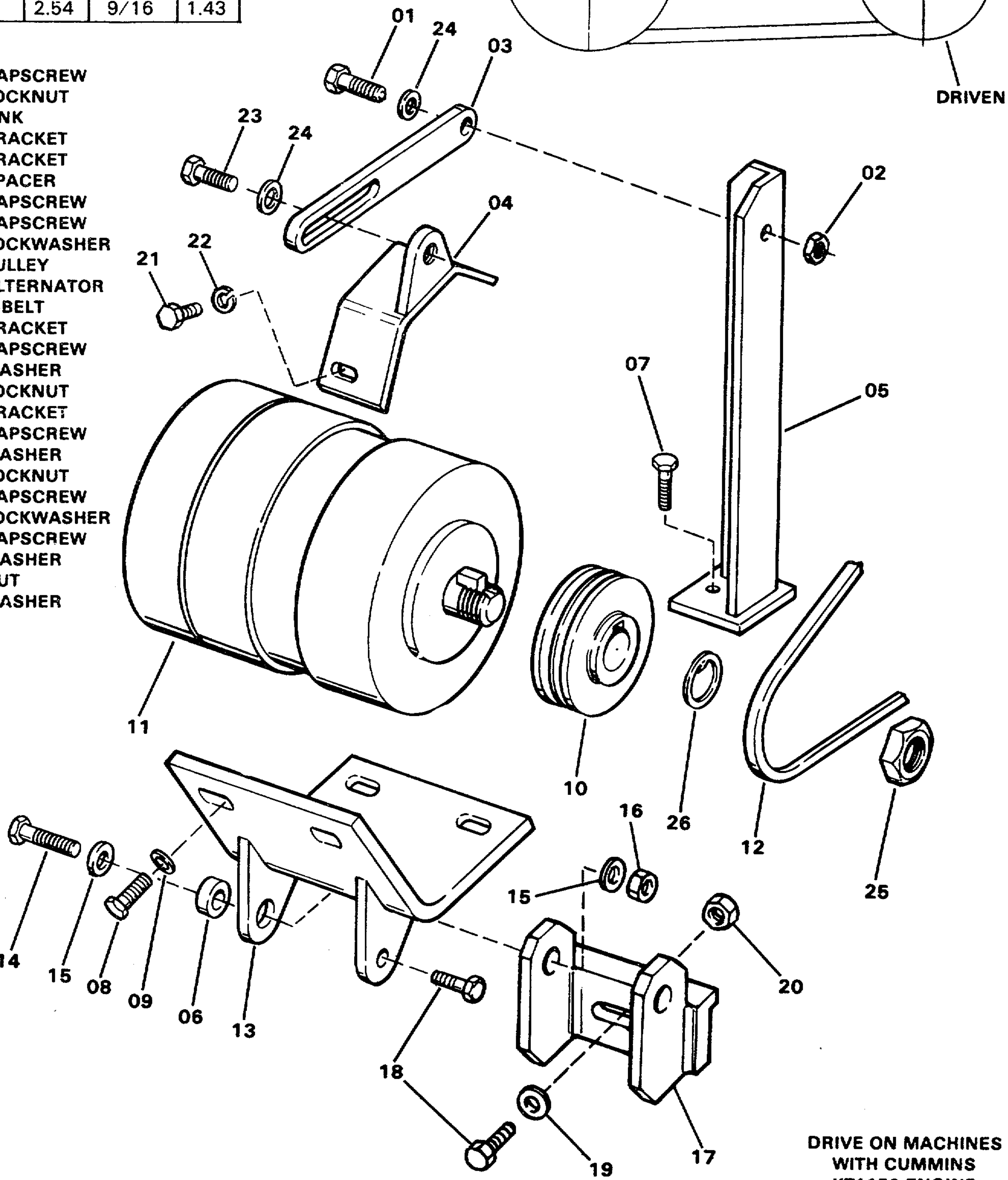
3. Operate the engine such that the alternator speed is 1725 RPM (+50 RPM). If the voltmeter reading is 4.0 VDC or greater, the alternator is electrically acceptable.

4. If the voltage is less than 4.0 VDC, flash the alternator field terminals with 24 volts for several seconds.

Belt Width		Deflection per Foot of Span	
inches	cm	inches	cm
1/2	1.27	13/32	1.03
11/16	1.75	13/32	1.03
3/4	1.91	7/16	1.11
7/8	2.22	1/2	1.27
1	2.54	9/16	1.43



01. CAPSCREW
02. LOCKNUT
03. LINK
04. BRACKET
05. BRACKET
06. SPACER
07. CAPSCREW
08. CAPSCREW
09. LOCKWASHER
10. PULLEY
11. ALTERNATOR
12. V-BELT
13. BRACKET
14. CAPSCREW
15. WASHER
16. LOCKNUT
17. BRACKET
18. CAPSCREW
19. WASHER
20. LOCKNUT
21. CAPSCREW
22. LOCKWASHER
23. CAPSCREW
24. WASHER
25. NUT
26. WASHER



DRIVE ON MACHINES WITH CUMMINS KT1150 ENGINE

Figure 13B-2. Alternator (88Z30)

NOTE

When flashing the field, the positive terminals of the alternator field must be connected to the positive terminal of the battery. Likewise, the negative battery terminal must be connected to the negative field terminal. The engine must be stopped and the machine field leads must be removed when flashing the alternator. Wait two minutes and repeat step 3.

5. At normal engine idle speed, inspect the alternator for any signs of arcing or rotor interference with the stator. If no external defects are apparent, the unit is mechanically acceptable.

6. The alternator will have to be repaired or replaced if the unit is either electrically or mechanically unacceptable.

7. Test the machine swing in both directions.

8. Record the residual voltage and the alternator speed at which the voltage was taken, on a service report.

REMOVAL. If it is necessary to remove the alternator, proceed as follows (see Figure 13B-2):

1. Loosen nut (23) and slide alternator (11)forward enough to slip belts (12) off of pulley (10). Do not pry the belts off of the pulleys with a screwdriver or other sharp tool. This can cause damage to the belts.

2. Remove capscrews (23 and 14) and remove alternator (11) from the machine. Set the alternator on a clean workbench.

3. Remove brackets (04 and 13).

4. To remove pulley (10), remove nut (25) and washers (26) from the alternator driveshaft. Pull pulley (10) straight back.

REPAIRS AND ADJUSTMENTS. Alternator repairs and adjustments are covered by a Service Manual prepared by the alternator manufacturer. These service manuals can be obtained by contacting the nearest alternator dealer or from the manufacturer at the following address:

Leece-Neville Co.
Service Department
5109 Hamilton Avenue
Cleveland, Ohio 44103

INSTALLATION. To install an alternator on the machine, proceed as follows (see Figure 13B-2):

1. Install pulley (10) on alternator (11) and secure with nut (25) and lockwasher (26).

2. Install support brackets (04 and 13) on alternator (11).

CAUTION

Care must be exercised to be sure capscrews (21 and 08) do not penetrate to the windings of alternator (11). Never use a capscrew longer than that originally used for attaching the bracket to the alternator.

3. Place alternator (11) on frame bracket (17) and install capscrews (14). Also install capscrews (23) and lockwasher (24). Do not tighten at this time.

4. Slide the alternator toward the engine sheave and slide belts (12) over pulley (10). Do not pry the belts on the pulleys with a screwdriver or other sharp tool. This can cause damage to the belts.

NOTE

The belts come in a matched set. Always replace both belts at the same time. Replacing just one belt can result in premature belt wear, because of belt length variation.'

5. See Drive Belts, earlier in this subsection, and adjust the belts to the proper tension.

CONTROL CABINETS (21OOJ593-1)

DESCRIPTION

The control cabinet contains the following items (see Figure 13B-3):

1. Main Rectifiers. The main rectifiers convert the ac output of the alternator into dc current required by the remainder of the system.

2. Circuit Breakers. The voltage and current trip breakers are provided for overload protection. The circuit breakers are the first item to check in the event of complete system malfunction.

3. Field Discharge Resistors and Blocking Rectifiers. The field discharge resistors in parallel with the swing coils are provided to dissipate the surge of current generated when the operator returns the swing control lever to the neutral position. The blocking rectifiers prevent this surge of current from backing up into the remainder of the system.

4. Voltage Regulator. This item, working in conjunction with the swing controller, controls the current to the alternator field.

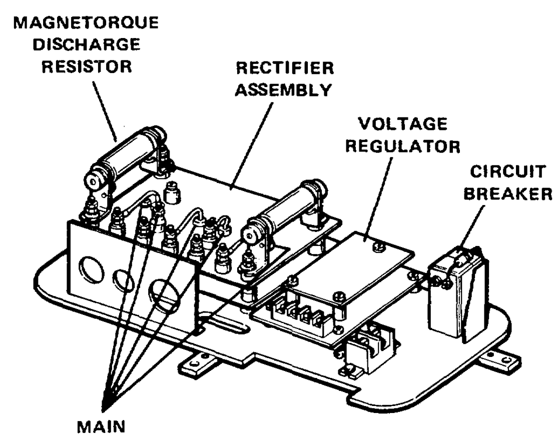


Figure 13B-3. Control Cabinet (2100J593-1)

SWING CLUTCH ELECTRICAL SYSTEM

COMPONENT TESTING

GENERAL. The testing of the individual major components of this system are covered in the Troubleshooting charts given earlier in this section. The following items will describe the testing of the components in the control cabinet which were not covered in the Troubleshooting section.

NOTE

When replacing items in the control cabinet, be sure to test the new items before installing them in the cabinet.

TESTING SILICON RECTIFIERS. Silicon rectifiers of the type used are shown in Figure 13B-4. All are attached to a mounting plate (called a heatsink) by means of a threaded stud. This stud (and the case of the rectifier) is one terminal. The other terminal maybe a standard copper pigtail covered with an insulating sleeve as shown in b, e, or f or it may be a short terminal with a lug as shown in a, c or d. The two terminals are insulated from each other by the potting compound through which the upper terminal extends.

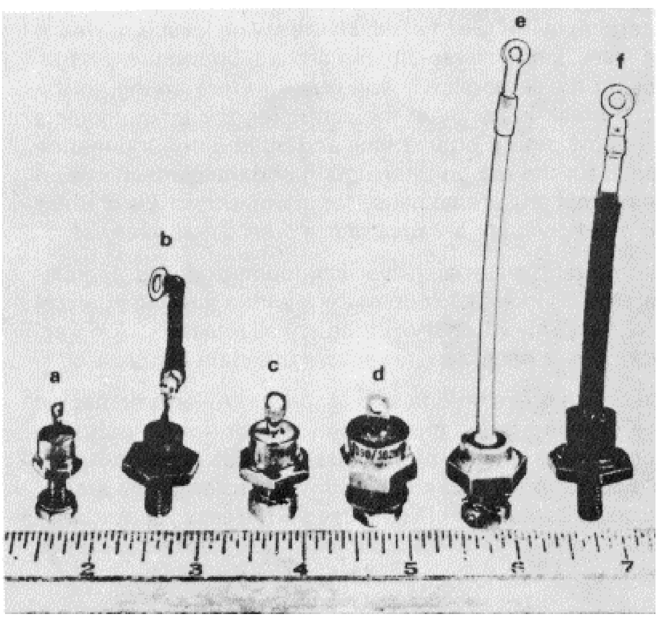


Figure 13B-4. Typical Silicon Rectifiers

Rectifiers act as a very low resistance in one direction (called the forward direction) and as an infinite resistance in the other direction (called reverse). The symbol for a rectifier is shown in Figure 13B-5. The forward (low resistance) direction is the condition when current flows from the anode to cathode in the direction of the arrow. Infinite resistance is presented to any current which tends to flow from the cathode to anode (reverse direction).

The anode terminal may be the stud or the top lead, depending upon the internal connections inside the case. In servicing or replacing silicon rectifiers it is important to determine which terminal is the anode and which the

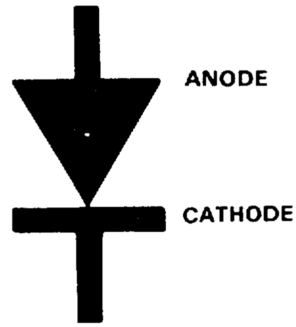


Figure 13B-5. Rectifier Symbol

cathode. On almost all rectifiers the symbol shown is stamped or painted on the outside of the case. If so, identification of terminals is easy. If, however, no symbol is given, the rectifier type number printed on the case must be used for identification and the terminals identified in this manner.

NOTE

It must never be assumed that all rectifiers in a group or assembly are identical just because they look alike at first glance.

Silicon rectifiers usually increase in physical size in proportion to their current carrying capabilities. That is, a larger unit can carry more current than a small size unit. This is only approximate, however, because there are exceptions to the general rule due to difference in manufacturing and packaging techniques employed by various rectifier producers.

The two most important ratings of a silicon rectifier coil are its forward current rating and peak inverse voltage rating. As mentioned above, the physical size usually increases with current ratings, but there is no way to tell by physical appearance what the voltage rating is. It is entirely dependent upon the internal construction of the cell. For this reason, defective cells must be replaced by a cell with exactly the same type number.

A defective silicon rectifier gives no visible appearance of being faulty. Usually they fail by internally shorting, and thereby offer very low resistance to current flow in both forward and reverse directions. Occasionally they fail by opening internally. They then behave as an open circuit to current flow in both directions.

The most simple way of testing a silicon rectifier to determine if it is defective is with an ohmmeter.

CAUTION

Never, under any circumstances, use a megger, bell, buzzer, or other ringing device to check rectifiers. The surge voltages developed by these devices when interrupted will destroy the rectifier cells.

The following procedure should be followed when testing a silicon rectifier cell with an ohmmeter.

1. Touch the two ohmmeter leads together and adjust the ohmmeter scale pointer to read zero.
2. It is not necessary to remove the rectifier from its heatsink mounting to make the test. Be sure, however, that the flexible lead has been disconnected from all external circuits before testing.
3. After disconnecting the rectifier from all external circuits, place one lead on the cathode and one on the anode and observe the meter reading as in Figure 13B-6. Then reverse the leads and observe the meter reading as in Figure 13B-7. One reading should show infinite resistance and the other should read some low value of resistance.

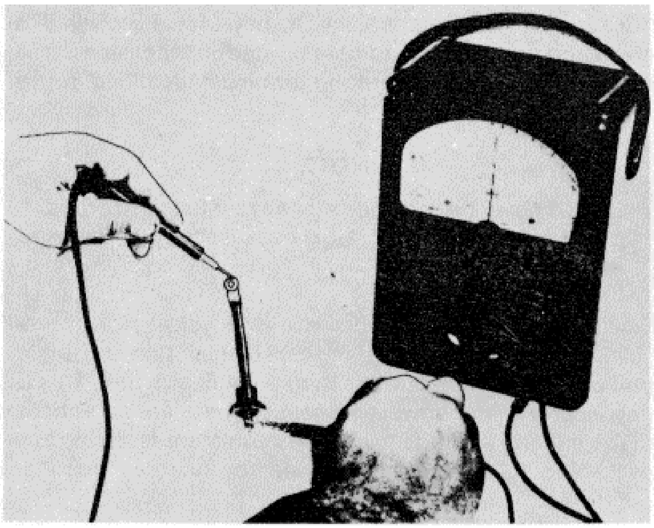


Figure 13B-6. Testing Silicon Rectifier

4. If the rectifier does not check out as indicated above in step 3, it is defective and must be replaced by a new cell of exactly the same type as the defective one. Replacement by a substitute not of the same type may have an adverse effect on the circuit.

REGULATOR TESTING. The regulator testing is covered in the troubleshooting charts given earlier, but it must be noted that the regulator must not be adjusted under any circumstances. The springs, armature, and fingers in the regulator are properly set at the factory and should not be adjusted.

SWING CONTROLLER (100J1755)

GENERAL. The controller, in conjunction with the regulator, varies the output of the alternator. The swing controller should be checked for wear when the alternator brushes are checked. In normal operation of the controller it will be found that the main contacts "R" and "L", located at each end of the controller, will arc considerably as the contacts are interrupted. This is normal with an inductive load such as the Magnetorque units. The amount of the arc will vary

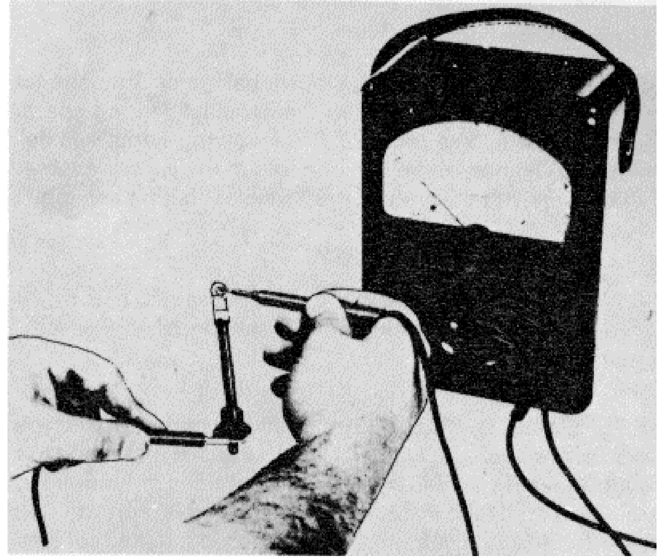


Figure 13B-7. Testing Silicon Rectifier with Reversed Leads

according to the speed at which the swing lever is moved. If the lever is moved rapidly, the arc will be relatively large.

Moving the lever slowly will result in less arcing. In the initial break-in period of the controller, the main contacts will show pitting on one face and build-up on the mating face. Both the arc on interruption and the contact erosion are normal and are no cause for alarm. Do not file or dress the main contacts because of the build-up of material.

The contact material (silver-cadmium oxide) is approximately 1/8 inch (3.175 mm) thick with a backing of nickel steel, and only when the pitting is well into the nickel steel backing is it necessary to replace the main contacts.

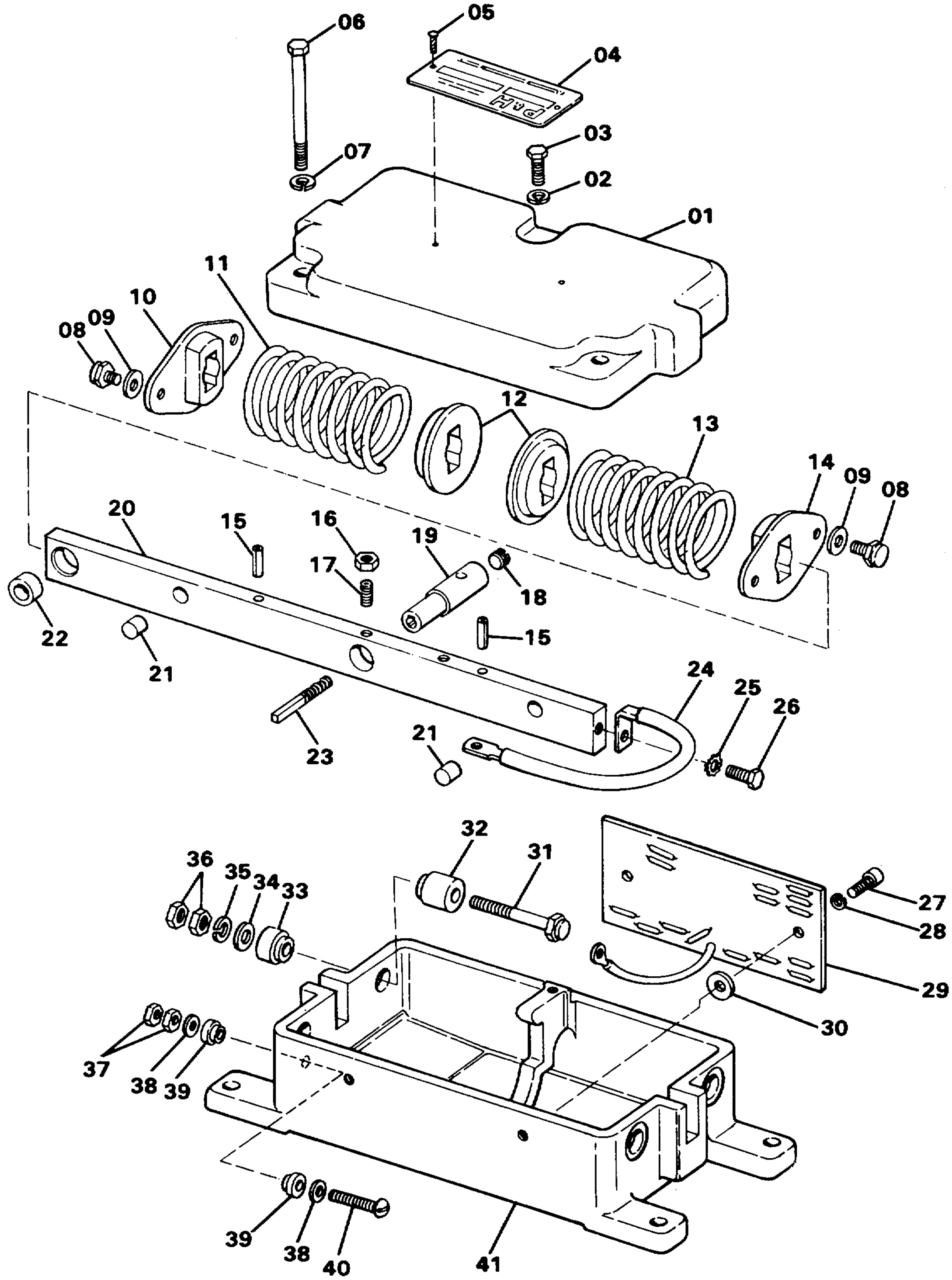
The circuit board on one side of the controller is contacted by a graphite brush mounted on the controller shaft. The brush leaves a track of graphite material. After considerable operation, the circuit board will blacken in the area of the brush contact. To clean it, use a lint-free rag soaked with chlorothene or carbon tetrachloride to remove the carbon deposits.

Caution should be observed in using carbon tetrachloride. It should only be used in a well-ventilated area. Never use sandpaper, emery cloth, or a file on the circuit board surface.

The graphite brush in the controller must be replaced when worn to 1/2 inch (12.7 mm) in length.

REMOVAL. If it is necessary to remove the swing controller
for repair, proceed as follows:

1. Shut off the engine and tag the ignition switch to warn against starting the engine, or remove the ignition key until the controller is reinstalled.
2. Remove the access covers from the front control box.
3. Remove the pin connecting the controller shaft to the swing lever linkage.
4. Disconnect and tag all electrical leads.



01. COVER
02. LOCKWASHER
03. COVER BOLT
04. NAMEPLATE
05. SCREW
06. COVER BOLT
07. LOCKWASHER
08. CONTACT
09. WASHER
10. BRACKET
11. SPRING
12. COLLAR
13. SPRING
14. BRACKET
15. ROLL PIN
16. JAM NUT
17. SCREW
18. CAP
19. BRUSH HOLDER
20. SHAFT
21. INSERT
22. BUSHING
23. BRUSH
24. SHUNT
25. WASHER
26. CAPSCREW
27. CAPSCREW
28. LOCKWASHER
29. CIRCUIT BOARD
30. SPACER
31. CONTACT
32. BUSHING
33. BUSHING
34. WASHER
35. LOCKWASHER
36. JAM NUT
37. NUT
38. WASHER
39. BUSHING
40. SCREW
41. CONTROLLER CASE

Figure 13B-8. Swing Controller

5. Remove the four controller mounting bolts and lift the controller out of the front control box.

DISASSEMBLY. To disassemble the swing controller, proceed as follows (see Figure 13B-9).

1. Remove cover bolts (03 and 06)and lockwashers(02 and 07).
2. Compress springs (11 and 13) and place two nails in the holes provided in shaft (20). See Figure 13B-9.

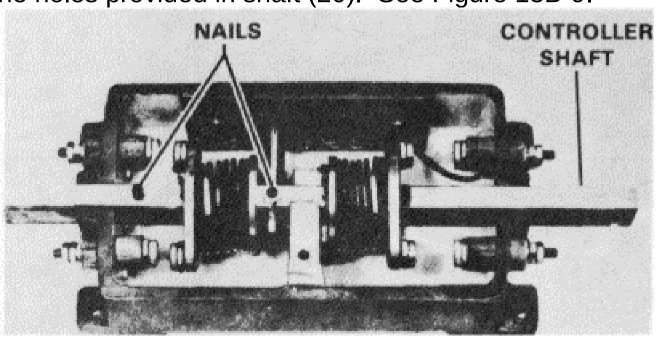


Figure 13B-9. Swing Controller Disassembly

3. Slide shaft (20) to one side (in the direction of spring compression) about 3/4 inch (1 9.05 mm) to allow shaft (20) to be lifted from controller (41).

CAUTION

Care should be used in lifting out the controller shaft assembly to insure no damage is done to the graphite brush. Do not attempt to remove the brush from the front of the brush holder.

4. Remove brush (23) by removing the wax seal and cap (18) from the rear of brush holder (19). Slide the brush through the rear of the holder.
5. To remove circuit board (29), remove capscrews (27) and lockwashers (28). Care should be taken to insure that spacers (30) are not lost during removal.
6. To remove contact brackets (10 and 14), springs (1 1 and 13), and spring collars (12), drive out roll pins(1 5). Contacts (08) can then be unthreaded from contact brackets (10 and 14).
7. Contacts (31)are removed by removing jam nuts (36) and pulling the items out of controller case (41).

ASSEMBLY. To assemble the swing controller, proceed as follows (see Figure 13B-8):

1. Install feed-thru bushing (32) and contact (31) into controller case (41). Install bushing (33), washer (34), lockwasher (35), and jam nuts (36) on contact (31). Fully tighten jam nuts (36).
2. Install contacts (08) on contact brackets (10 and 14).
3. Install spring collars (12), springs (11 and 13), and contact brackets (10 and 14) on shaft (20). Hold these items in place by driving in pins (15).
4. Place spacers (30) on the back side of circuit board (29) and place the circuit board in controller case (41). Secure the board in place with lockwashers (28) and capscrews (27). Do not tighten capscrews (27) to the point of cracking circuit board (29).
5. Install brush (23) into the rear of brush holder (19). Then install cap (18) and seal the end with a small amount of wax.
6. Install the assembled shaft into controller case (41) as shown in Figure 13B-10. Remove the nails used to compress springs (11 and 13).

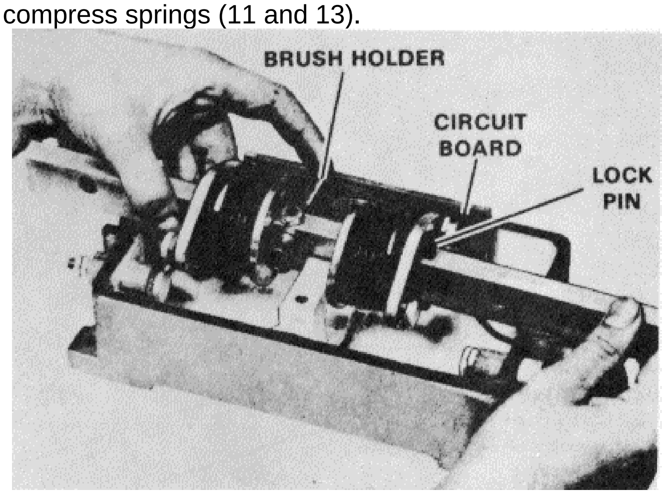


Figure 13B-10. Controller Bar Installation

7. Place cover (01) on controller case (41) and secure in' place with lockwasher (02 and 07) and bolts (03 and 06).

INSTALLATION. To install the swing controller in the lower control box, proceed as follows:

1. Set the controller in the lower control box and secure in place with the mounting bolts, lockwashers, and nuts.
2. Connect all electrical leads to the controller.
3. Attach the swing lever to the swing controller shaft using the pin, washers, and cotter pin.
4. Reinstall the access cover over the lower control box.

SWING BRUSHES AND SLIP RINGS

ADJUSTMENTS. The brushes which contact the Magnetorque slip rings should be checked occasionally to be certain that they are free in the brush holders. If the brushes do not move freely in the brush holder, there will be poor electrical contact between the brushes and the slip rings, resulting in worn slip rings. New brushes should be installed if the old brushes:

1. Are worn down more than 50 percent.
2. Have excessive side clearance, greater than 0.020 inch (0.508 mm).
3. Have corroded, frayed or fractured shunt leads.
4. Are contaminated from oil, chemical, etc.
5. Arched short because of binding in the brush box.

INSTALLING NEW BRUSHES. If new brushes are to be installed use the following procedure (see Figure 13B-11):

1. Check that the brushes slip easily into the brush holder and do not hold up. Check the clearance on the sides; less than, or equal to 0.020 inch (0.508 mm). Carefully sand if required.

2. Check for adequate brush pressure, 1-1/4 lbs +10 percent (0.567 kg +10 percent). Too low or too high brush pressure will wear the brushes excessively. Too low, by arcing and too high by wear. Replace the springs if required.

3. Check that the shunt length is proper for the life of the brush.

4. New brushes should be arced to fit the ring by placing fine sandpaper under the brush with the grit side toward the brush. With the spring pushing down on the brush, slowly slide the sandpaper back and forth until the total length of the brush is contacting the sandpaper. Remove the sandpaper.

5. After repairing and installing the brushes, observe their performance. Initially the brushes will spark while a new film is built up on the bare ring. Observe that the film on the burnished copper is proper, varying from light to medium mahogany color. Watch for foreign contaminants (liquid or gaseous) from the environment.

SLIP RING REPAIRS. If the slip rings become badly discolored or tarnished, they may be cleaned with an arced stone or arced wooden block covered with fine sandpaper.

Do not use emery paper or cloth. Both turning and cleaning can be done by turning over the machine by its own engine, with the brushes removed. Slowly move clean, dry abrasive across the ring surface.

CAUTION

Do not use solvents to clean the slip rings, as they leave a residue and contaminate the brushes. Only clean rings by mechanical methods as explained above.

If the slip ring surface is badly pitted, it may need turning. In this case the rings have to be removed and turned. When maintenance work is performed on the swing shaft, these slip rings may be removed from the clutch assembly and turned down if necessary. See Section VI.

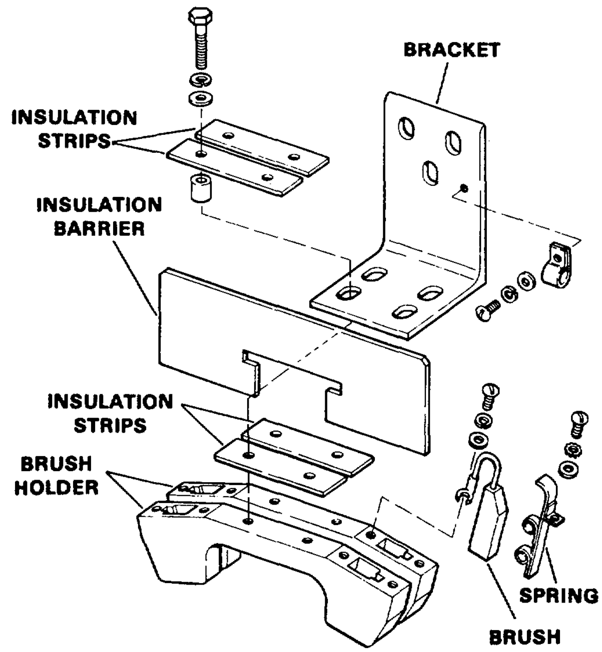


Figure 13B-11. Brush Holder Assemblies

OPERATIONAL AIDS

GENERAL

T his subsection covers any necessary adjustments to the operational aids such as the boom hoist limit device, and Mark Load system.

BOOM HOIST LIMIT DEVICE

DESCRIPTION. The boom hoist limit device is used to set the maximum angle of the boom. When the boom stop, mounted on the boom base, contacts the limit switch it shifts the boom hoist limit solenoid. At this point, pulling the boom hoist control lever back will direct hydraulic oil back to tank and will not release the boom hoist brake or engage the boom hoist clutch to raise the boom.

ADJUSTMENT. Whenever a boom hoist limit switch has been replaced or disturbed the maximum angle that the boom is allowed to reach should be checked. To set the boom stop for the proper maximum angle, proceed as follows (see Figure 13C-1):

1. Elevate the boom to an angle of 800

NOTE

For machines operating with a hammerhead boom, the boom must be elevated to a maximum of 81°.

2. Loosen the locknut and turn the adjusting screw as required to open the contacts in the limit switch. The switch contacts will make a click to indicate when they are open.

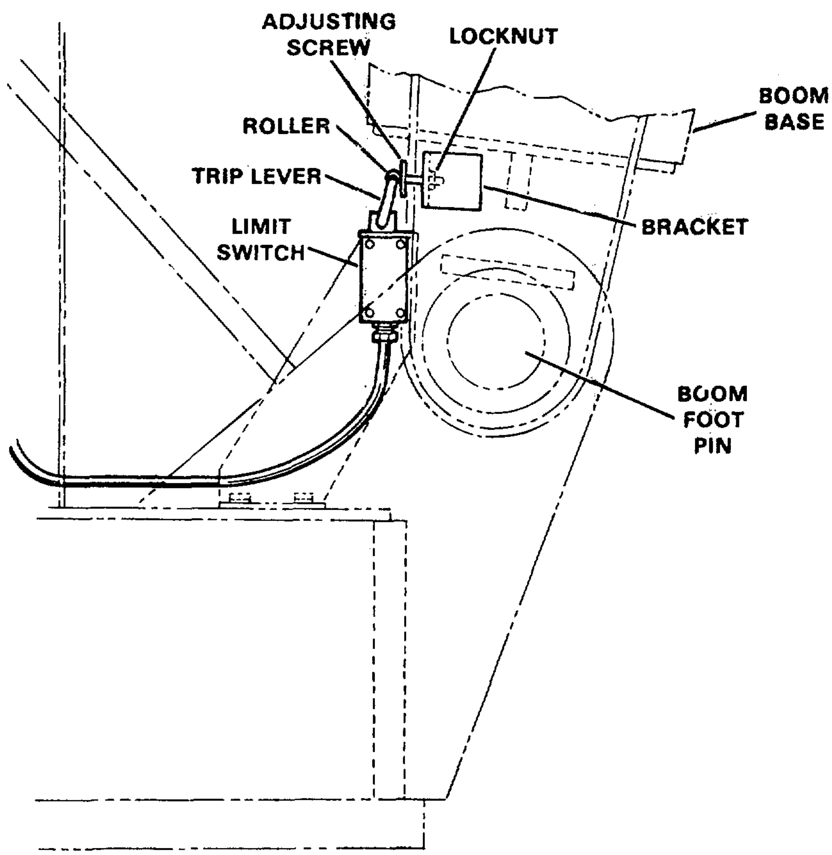


Figure 13C-1. Boom Hoist Limit Device

3. Tighten the locknut on the adjusting screw.

4. Raise and lower the boom slowly several times to check the adjustment. Repeat the procedure as necessary to achieve the proper adjustment.

NOTE

If necessary, a further adjustment can be made by loosening the nut on the trip lever and rotating the trip lever. Retighten the nut after the adjustment is complete.

MARK LOAD SYSTEM

GENERAL

The information below is intended as a calibration and troubleshooting guide for the Mark Load computer system.

The rating of any crane is limited by two factors, namely, the strength of its structural members, and the stability of the crane. The purpose of the load moment system is to give the operator an indication when the load on the machine is approaching or has reached the limits shown on the capacity chart.

When properly calibrated, as described below the load system will give visual and audible indications when the load on the machine reaches 35% and 100% of machine capacity.

A visual and audible indication will be given when the load on the machine has reached crane capacity. A visual and audible indicator will also be given if the operator enters an operating condition for which the crane is not rated and when the crane boom radius is outside the range rated for lifting by the machine.

The system consists of a central unit, remote indicators (meters), angle sender, preamplifier, load cell and connecting cables.

WARNING

This unit is an operating aid and cannot be used as a substitute for the rating plate. The system should be inspected on a weekly basis for pinched, loose or cracked cables. Also check for proper sealing of the central unit and meters to keep out water and dust and to insure proper operation of the unit.

CALIBRATION

INITIAL TESTING. Initially test the units as follows:

1. Recheck all cable routing and check all connections. Also check the load cell mounting(s).

2. Lower the hook block(s) so they are resting on the ground.

3. Move the Power switch to the ON position (central unit).

4. Depress the Test switch and note that the Hook Load meter reads approximately ha If scale, the Capacity meter reads full scale, the load radius meter reads zero and the alarm indications should be operating.

5. With the hook block(s) still on the ground, set the number of lines switch to the total number of lines supporting the hook block(s), including the dead end line.

6. Leave the Power switch in the ON position and place the Test switch in the downward position and observe the hook load meter. Stamp this reading and the number of lines in the space provided on the name plate. This reading represents the weight of lines plus the normal half-scale reading (i.e.: 100,000 pounds, main meter reads 52,000 lbs on four lines with the test switch depressed and the hook block(s) on the ground. Stamp 52,000 x 4).

7. Lift a known load, when available, to check system accuracy. The load cell has been factory calibrated. Any error is usually due to the weight of the hook block(s), slings, wire rope, etc. Approximately 1/4 percent friction will be noted in each sheave in the boom point.

ANGLE CALIBRATION. The ACAL position of the Quadrant switch on the central unit allows the angle sender to be calibrated within 1/20 as follows:

1. Level the boom using an appropriate level.

2. Switch the Quadrant switch on the central unit to the ACAL mode.

3. The Capacity meter will display O to 10° full scale. Loosen the angle sender clamps and rotate the angle sender clockwise slowly. As the angle sender is rotated through zero, the Capacity meter will move from zero up scale in jerky steps (each step equals 1).

4. Rotate the angle sender counterclockwise slowly. The angle sender clamps should be tightened at a point just after the Capacity meter reaches zero.

LOAD ALIGNMENT PROCEDURE. Set the hook load meter using the following procedure:

1. Lower the boom as low as possible and lay the hook block(s) on solid surface with a small amount of slack in the load lines.

2. Turn the Power switch on the central unit to the OFF position. The hook load meter should read zero. Turn the Power switch ON.

3. Adjust the main zero balance control of the central unit for zero indication on the hook load meter.

TROUBLESHOOTING

WARNING

The central unit and meters shall not be opened or adjusted by non-authorized personnel. Opening and adjustment by other than authorized personnel voids the warranty and may result in failure of the warning device.

The troubleshooting material that follows is intended to provide an intuitive feeling for a specific problem. Analyze the system and develop a logical sequence for looking for trouble. A majority of problems stem from loose connections. Tighten all connections with a pliers and recheck the operation of the system.

Many malfunctions of the Markload System can be analyzed without returning the entire system to the factory or requesting the aid of a Field Service Representative. Replacement parts and/or technical advice can be obtained from Markload Systems, Inc. (713) 485-8600, Telex #79-1947. PLEASE COMPLETE THE PROBLEM REPORT FORM BEFORE CALLING MARKLOAD. THIS WILL SAVE YOU BOTH TIME AND MONEY.

RECOMMENDED TEST EQUIPMENT:

1. DC voltmeter that can be used to measure up to 30 VDC with accuracy of 2%.

2. Load-Angle Simulator part number 7774.

3. Load Cell Simulator part number 1329.

Symptom		Test Indicated or Possible Cause	
1.	System does nothing.	A.	Check front panel fuse.
		B.	Check supply voltage, see Test 1.
		C.	Check power supply voltages, see Test 2.
2.	Load Meter reads correctly, Capacity and/or Radius reads incorrectly.	A.	Switch the POWER switch off then back on, this resets the microcomputer.
		B.	Press the EST switch, the Capacity meter should read full scale and the Radius meter should read zero.
		C.	Simulate Load and Angle, see Test 3.
		D.	Select another CONFIGURATION, and BOOM LENGTH and repeat A. and B. If proper operation can be obtained for any combination of acceptable CONFIGURATION, JIB LENGTH, JIB ANGLE, BOOM LENGTH or PARTS OF LINE settings the malfunction is in the I/O board or CPU board in the CENTRAL UNIT. The boards should be returned to the factory for testing. The system will function as a Load Only system with the remaining boards. If proper operation can not be obtained check power supply voltages, see Test 2.
3.	Load meter reads incorrectly, Capacity and Radius read correctly	A.	Simulate Load and Angle, see Test 3.
		B.	Check power supply voltages, see Test 2.
		C.	Test Boom Mounted Equipment, see Test 4.
4.	Load, Capacity and Radius meters read incorrectly.	A.	Simulate Load and Angle, see Test 3.
		B.	Check supply voltage, see Test 1.
		C.	Check power supply voltages, see Test 2.
		D.	Test Boom Mounted Equipment, see Test 4.

TEST 1 - Supply Voltage Test

Disconnect the POWER cable from the CENTRAL UNIT. Turn the crane power on and measure the DC voltage from pin N to pin R of the POWER cable connector. The voltage should be between 10.5 and 1 5.0 volts (21.0 and 30.0) for 12 volt (24) systems respectively. Check the voltage rating on the label on top of the CENTRAL UNIT. Check the supply voltage where the POWER cable connects to the crane while the system is connected and the POWER switch is on. If the supply voltage is below 10.5 volts (21.0) for a 12 volt (24) system, then the reason for the low voltage must be found and corrected. If the supply voltage is above 15.0 volt (30.0) for a 12 volt (24) system, then the reason for the high voltage must be found and corrected. High voltage can damage the power supply, see Test 2.

TEST 2 Power Supply Voltage Test

Disconnect the MAIN cable from the CENTRAL UNIT. Turn the power on and measure the voltage on the MAIN connector of the CENTRAL UNIT. The voltages should be as follows:

Connector Pin	Voltage
L to F	+15 +.05
L to E	-15 +.05

If either voltage is below the specified range disconnect the cable connected to the JIB connector on the CENTRAL UNIT. Remeasure the voltages, if the voltage is now within the specified range there is a short or high load in the circuits connected to the JIB connector, see Test 2B.

If either voltage is above the specified range return the Power Supply Board (in the CENTRAL UNIT) and PREAMP (s) to the factory for repair.

If the voltages are correct, disconnect the cable connected to the JIB connector on the CENTRAL UNIT. Connect the cable removed from the MAIN connector to the JIB connector. Remeasure the voltages, if the voltages are now below the specified ranges there is a short or high load in the circuits connected to the MAIN connector. If the voltages are correct go to A, otherwise, go to B.

A. Internal Power Supply Voltage Test Disconnect all cables from the CENTRAL UNIT. Remove the seal screws that hold the CENTRAL UNIT in the housing. Remove the CENTRAL UNIT. Turn the CENTRAL UNIT over so that the MOTHERBOARD can be seen. Reconnect the POWER cable, turn on the power and measure the voltages indicated on the MOTHERBOARD. +5, -5, +12 or -10 are with respect to DGND. +15 and -15 are with respect to SGND.

Voltage	Acceptable Range
+5	±.25
-5	+.25
+12	+.6
-10	+.5
+15	±.05
-15	+.05

If any voltage is outside the acceptable range the entire CENTRAL UNIT, except the case, should be returned to the factory for repair.

B. External Power Supply Load Test

A short or high load condition has been indicated in Test 2. Connect the cable that has an indicated short or high load to the JIB connector on the CENTRAL UNIT. Monitor the voltage that is below the range specified in Test 2 on the MAIN connector on the CENTRAL UNIT. Start with the LOAD CELL, disconnect one connector at a time moving toward the CENTRAL UNIT. Determine which component is loading (shorting) the supply voltage. Repair or return to the factory all components that are defective.

TEST 3 - Simulate Load and Angle

Connect the LOAD-ANGLE SIMULATOR (7774) to the MAIN connector on the CENTRAL UNIT. Set PARTS OF LINE switches to the maximum allowed for the crane configuration. Set the toggle switch on the simulator to the CU position. Use the ANGLE and LOAD knobs to simulate crane operation.

If a meter responds improperly, disconnect the METER cable from the CENTRAL UNIT and connect it to the connector on the panel of the LOAD-ANGLE SIMULATOR. Set the toggle switch on the simulator to DIR. Use the LOAD knob to check the LOAD meter response. Check all the meters by connecting them to the LOAD connector on the METER cable and using the LOAD knob. Return defective meters to the factory for repair.

If none of the meters respond properly go to the next test called for.

If all of the meters respond properly the problem is in the BOOM mounted equipment, see Test 4.

TEST 4 - Test Boom Mounted Equipment

Connect all cables to the CENTRAL UNIT in the proper positions. Depress the TEST switch, the LOAD meter should read half scale. If the LOAD meter reads half scale the LOAD CELL, LOAD CELL CABLE and PREAMP are probably OK. If the LOAD meter does not read near half scale (no load on the hook), disconnect the LOAD CELL cable from the PREAMP, then press the TEST switch. If the LOAD meter reads half scale the problem is in the LOAD CELL or LOAD CELL CABLE, check the cable. If the LOAD meter does not read half scale go to A.

A. Test Boom Mounted Equipment

If the system is not equipped with an ANGLE meter disconnect the METER cable and monitor the voltage from pin M to pin K. Depress the TEST switch, the voltage should be 5.0 +.5 volts. If no voltage is detected disconnect the BOOM cable from the ANGLE SENDER. Depress the TEST switch, if the voltage is OK, the problem is a short in the BOOM cable or PREAMP, go to Test 2. If no voltage is present the problem is in the ANGLE cable or ANGLE SENDER. Inspect cable for damage. Return malfunctioning equipment for repair.

If the system has an ANGLE meter depress the TEST switch, the ANGLE meter should read half scale. If not disconnect the BOOM cable from the ANGLE SENDER. Depress the TEST switch, If the reading is half scale the problem is in the BOOM cable or PREAMP, go to Test 2. If not the problem is in the ANGLE cable Qr ANGLE SENDER. Inspect the cable for damage. Return malfunctioning equipment for repair.

PROBLEM REPORT

Answer as many of the questions as possible.

1. System Type? ____________________

2. System serial number? (On label)____________________

3. Record all switch settings and meter readings when problem occurs.

Switch Settings	Meter of Display Readings
Parts of Line ____________	Load ____________
Boom Length ____________	Capacity ____________
Jib Length ____________	Angle ____________
Jib Angle ____________	Radius ____________
Jib - Main ____________	Boom Length ____________
Configuration ____________	

4. Record Display or Meter readings when Test switch is depressed.

Main	Jib
Load____________	Load ____________
Capacity____________	Capacity ____________
Angle ____________	Angle ____________
Radius ____________	Radius ____________

5. If the Load display can not be zeroed or goes negative, did the problem occur after a rain storm and/or after the Markload System was reconnected after rigging etc.? Did you check the Load Cell, Load Cell Cable and Preamp connections for moisture or damage?

Contact the Service Department for assistance at:

Markload Systems, Inc.
(713) 485-8600
Telex: #79-1947

BOARD REPLACEMENT

here are four boards in the central unit which are: I/O Board (8016-1), converter board (8019-1), CPU Board (8069-1), and Power supply board (8065-1). To replace the boards, proceed as follows:

1. Disconnect the cables from the central unit. Mark the cables so they can be reinstalled properly.
2. Remove the 14 cover screws (see Figure 1 3C-2). Carefully pull the cover from the central unit. The cover and frame of the central unit will come out as an assembly.

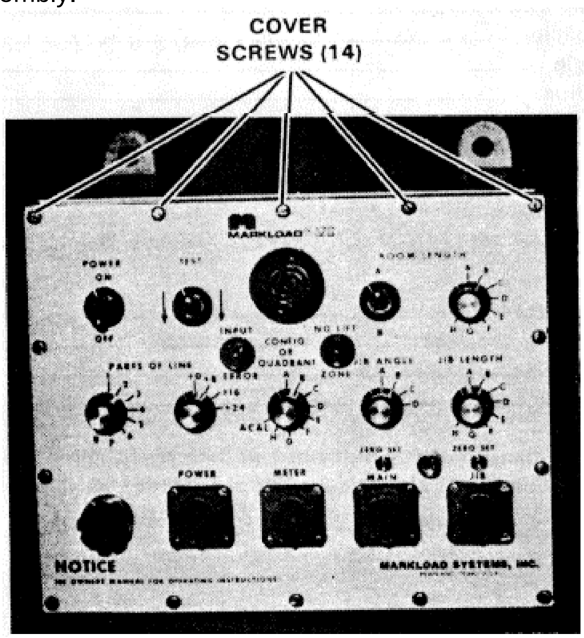


Figure 13C-2. Removing Central Unit Cover

3. From the TOP of the central unit frame, note the position and orientation of the boards (see Figures 1 3C-3 add 1 3C4). The POWER SUPPLY board is the rear most board, then the CPU board (second from rear), then the I/O board (third from rear) and finally the CONVERTER board (fourth from rear or front most board).
4. Pull the boards out of the central unit frame to remove them.

CAUTION

For additional heat sink the POWER SUPPLY board is secured to the central unit frame with eight screws. Remove the screws, then remove the POWER SUPPLY board (see Figure 13C-4).

5. Set the boards in the central unit frame and note that the COMPONENT SIDE of board goes to the REAR of the central unit.

NOTE

Secure the POWER SUPPLY board to the central unit frame with the eight screws.

LOAD WEIGHING SYSTEM TEST UNIT. The system test unit, Model PN-1840 (Figure 13C-5), can be used to either monitor all input signals to the CENTRAL UNIT or simulate MAIN (JIB) LOAD and BOOM ANGLE. There are two rotary switches, one toggle switch, two test points, three adjustable potentiometers and two connectors on the SYSTEM TEST UNIT.

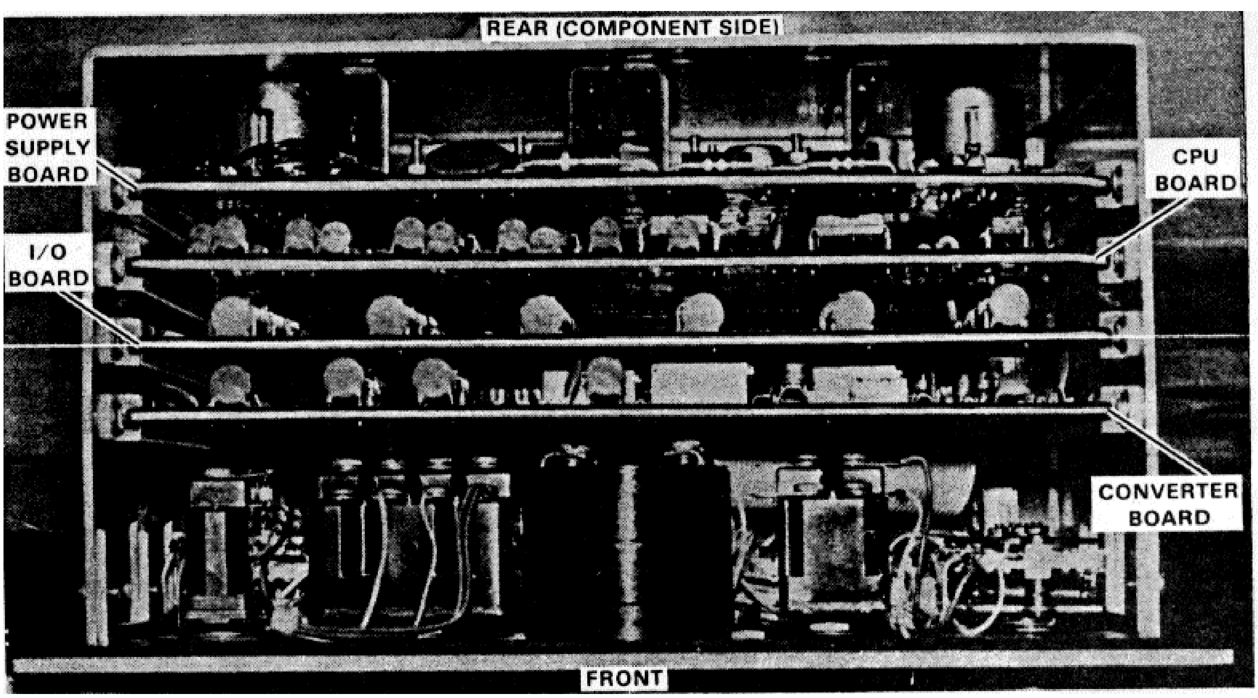


Figure 13C-3. Central Unit Frame and Boards

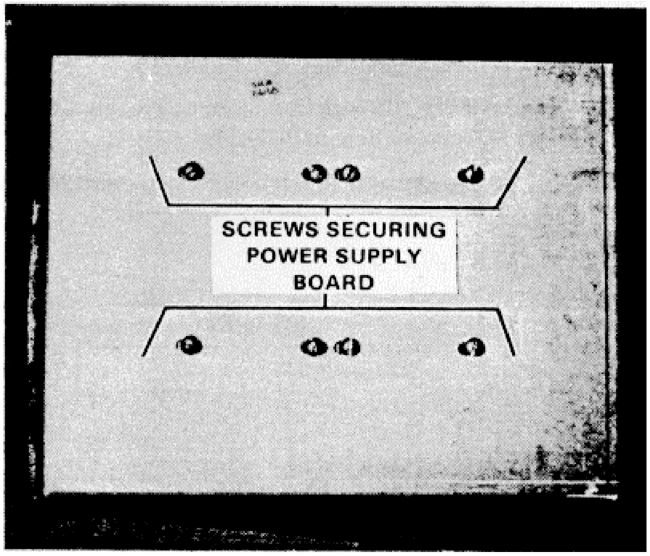


Figure 13C-4. Screws Securing Power Supply Board

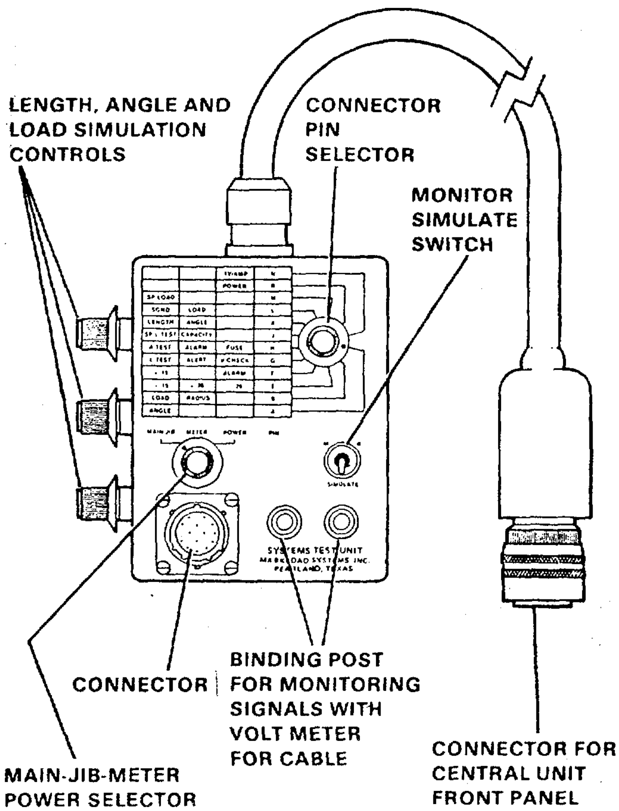


Figure 13C-5. Load Weighing System Test Unit

There are four procedures to follow to simulate conditions or to monitor certain units or power.

1. SIMULATE LOAD AND ANGLE:

A. On the SYSTEM TEST UNIT, set the MAIN-JIB METER POWER selector switch to MAIN-JIB.

B. Set the MONITOR-SIMULATE switch to SIMULATE.

C. Disconnect the MAIN (JIB) cables from the CENTRAL UNIT front panel.

D. Connect the SYSTEM TEST UNIT to the MAIN (JIB) connector on the front panel of the CENTRAL UNIT.

E. Connect the MAIN (JIB) cable to the SYSTEM TEST UNIT.

F. Simulate LOAD LENGTH and ANGLE by turning the knobs on the side of the SYSTEM TEST UNIT clockwise.

1. To observe the input voltage from the SYSTEM TEST UNIT to the CENTRAL UNIT, MAIN (JIB) connector, connect a voltmeter to the black and red binding post.
2. Select the signal to be monitored with the rotary switch (connector pin selector) on the right of the four (4) columns on the front of the SYSTEM TEST UNIT.

2. MONITOR MAIN (JIB) CONNECTOR SIGNALS: A. On the SYSTEM TEST UNIT set the MAIN-JIB METER POWER switch to MAIN-JIB.

B. Set the MONITOR-SIMULATE switch to MONITOR.

C. Disconnect the MAIN (JIB) Cable from the CENTRAL UNIT front panel.

D. Connect the SYSTEM TEST UNIT to the MAIN (JIB) connector on the CENTRAL UNIT.

E. Connect the MAIN (JIB) cable to the connector on the SYSTEM TEST UNIT.

F. Monitor MAIN (JIB) signals on the red and black binding post on the SYSTEM TEST UNIT.

G. Select the signal to be monitored with the CONNECTOR PIN selector on the front of the SYSTEM TEST UNIT. See Table 1 3C1 for values. If the values are not up to specification see the ERROR column of Table 13C-1.

3. MONITOR METER CONNECTION SIGNALS: A. On the SYSTEM TEST UNIT set the MAIN-JIB METER power selector switch on METER.

B. Set the MONITOR-SIMULATE switch on MONITOR.

C. Disconnect the METER cable from the front panel of the CENTRAL UNIT. .

D. Connect the SYSTEM TEST UNIT to the METER connector on the CENTRAL UNIT.

E. Connect the METER cable to the connector on the SYSTEM TEST UNIT.

F. Connect a volt meter to the red and black binding posts on the SYSTEM TEST UNIT.

G. MONITOR THE METER cable signals on the red and black binding posts.

H. Select the signal to be monitored with the CONNECTOR PIN selection on the SYSTEM TEST UNIT.

1. LOAD, CAPACITY and ANGLE are 10VDC for full scale (FS). See Table 13C-2 for values.

2. If the values are not up to specifications see- ERROR column of Table 13C-2

4. MONITOR POWER CONNECTOR SIGNALS: A. On the SYSTEM TEST UNIT, set the MAIN-JIB METER POWER selector switch on POWER.

B. Set the MONITOR-SIMULATE SWITCH on MONITOR.

TABLE 13C-1. MAIN (JIB) CONNECTION SIGNALS

PIN	MAIN-JIB	DESCRIPTION	REMARKS	ERROR*
M	SP Load	Spare Load	Not Applicable	
L	SGND	Signal Ground		
K	Length	Length Voltage	Not Applicable	
J	SP L Test	Spare Load Test Voltage	Not Applicable	
H	A Test	Angle Test Voltage	4.85 to 5.15 VDC	Check power supply voltage (pins F and E). If power supply voltage is not correct, contact MARKLOAD.
G	L Test	Load Test		
F	+15		+ 20 MV	If not correct, contact MARKLOAD.
E	-15		+ 20 MV	If not correct, contact MARKLOAD.
B	Load	Load Voltage	0-10 VDC	Check power supply, preamplifier in boom tip and load cell if not correct.
A	Angle	Angle Voltage	0-10 VDC	Check boom angle sender and all cables.

* Always fill in problem report, page 13C-5, before contacting MARKLOAD SYSTEMS, INC.

TABLE 13C-2. METER CONNECTION SIGNALS

PIN	MAIN-JIB	DESCRIPTION	REMARKS	ERROR*
L	Load	Load Meter Voltage	0-10 VDCFS t	Check meter to see if needle is hanging up. Check for water in meter.
K	Angle	Not Applicable	Not Applicable	
J	Capacity	Capacity Meter Voltage	0-10 VDCFS	Check for leakage between + terminal and meter case and between - terminal and case.
H	Alarm	Red Light Ground	Light Off 22-27 VDC Light On 0 VDC	Indicates central unit components problem, contact MARKLOAD.
G	Alert	Amber Light Ground	Light Off 22-27 VDC Light On 0 VDC	Indicates central unit component problem, contact MARKLOAD.
E	+26	Alarm Voltage	22-27 VDC	Indicates central unit component problem, contact MARKLOAD.
B	Radius	Radius Meter Voltage	0-10 VDCFS	Check meter to see if needle is hanging up. Check for water in meter.**

t FS means full scale.

* Always fill in problem report, page 1 3C-5, before contacting MARKLOAD SYSTEMS, INC.

** Take the measured voltage to the meter, divide by 10 and multiply by full scale (FS) of meter reading and this should you the actual meter reading.

C. Disconnect the POWER cable from the front panel of the CENTRAL UNIT.

D. Connect the SYSTEM TEST UNIT to the power connector on the front panel of the CENTRAL UNIT.

E. Connect the POWER cable to the connector on the SYSTEM TEST UNIT.

F. Monitor the POWER cable signals on the red and black binding posts with a volt meter.

G. Select the signal to be monitored with the CONNECTOR PIN selector switch on the SYSTEM TEST UNIT. See Table 13C-3 for values. If the values are not up to specification see ERROR column of Table 13C-3.

TABLE 13C-3. POWER CONNECTION SIGNALS

PIN	POWER	DESCRIPTION	REMARKS	ERROR*
N	.1V/Amp	Power Consumption	.1V per ampere	Indicates how much current system is drawing. If high it could indicate faulty installation or short to case to central unit.
R	Power	Supply Voltage	12 VDC	Check batteries and cables up to central unit if low.
H	Fuse	Supply Voltage will be on this pin if the internal fuse is ok.	Not Applicable	
G	V Check	Supply Voltage will be on this pin if System is internally connected for 24 VDC	Not Applicable	
F	Alarm	External Alarm Drive	Not Applicable	
E	+26	Alarm Voltage Drive	Not Applicable	

* Always fill in problem report, page 13C-5, before contacting MARKLOAD SYSTEMS, INC.

SUBSECTION 13D

PROPANE HEATER - UPPER

TROUBLESHOOTING
Table 13D-1 is provided to aid in determining the cause of heater malfunctions. Table 13D-1 is at the back of the Subsection.

HEATER HOUSING
The heater is designed for easy service. Disconnect fuel lines, electric wires, and exhaust connections. Remove the mounting bolts and remove the heater. If the heater has been in service for a long time, it may be easier to remove exhaust connector (13, Figure 13D-1) than to disconnect the exhaust piping from the connector.

WARNING

Disconnect electrical power from the heater before removing the covers. Do not run the heater with covers removed except for troubleshooting or adjustment. The ignition pack generates a voltage that is high enough to cause severe injury.

The covers (2, Figure 1 3D-1) are a slide fit. From the sides of the heater, pull outward on the covers to disengage them from the cross bar (01) at top center of the heater.

Three clips hold each of the air deflectors (10) to the case. To remove them, squeeze the ring of the deflector at one of the clips to disengage it from the case.

When reinstalling the heater, the use of an Exhaust Seal Kit will facilitate heater installation.

SOLENOID VALVE
REMOVAL To remove the solenoid valve, proceed as follows (see Figure 13D-2):
1. Turn off the fuel supply to the heater at the propane tank.

2. Disconnect the fuel line (11) from solenoid valve (9).

3. Tag and disconnect the electrical lead, then unscrew and remove the solenoid valve from nipple (8).

4. No service to the solenoid valve is authorized. Replace if defective.

INSTALLATION
Installation of the solenoid valve is the reverse of removal. Check that all lines are tight before restarting the heater.

BURNER HEAD

REMOVAL AND DISASSEMBLY To remove and disassemble the burner head, proceed as follows (see Figure 13D-2):

1. Remove the solenoid valve and disconnect the igniter wire and combustion air hose.
2. Remove five screws around the burner head and remove the burner head and gasket (03).
3. Remove igniter (04) from the burner head (05).

CLEANING AND INSPECTION

1. Clean the igniter with cleaning solvent or diesel fuel.
2. Clean the carbon from the burner head.
3. Inspect the burner head for cracks, dents, damaged threads, or other damage.
4. Inspect the igniter for an eroded or damaged electrode, cracked porcelain, and damaged threads.

REASSEMBLY AND INSTALLATION

Reassembly and installation are the reverse of removal and disassembly. See Figure 13D-2 and note the following:

1. Install the igniter in the burner head before installing the burner head on the heat exchanger. Check that there is a 1/16 to 1/8 inch (1.59 to 3.18 mm) gap between the tip of the igniter electrode and the burner tube. The electrode can usually be bent carefully to obtain this gap, but if it cannot, replace the igniter.
2. Install the burner head on the heat exchanger. Make sure gasket (03) is in place before positioning the burner head.

IGNITION PACK

TESTING Test the igniter and the ignition pack as described in the troubleshooting chart, Table 13D-1.

REMOVAL

To remove the ignition pack, proceed as follows:

1. Disconnect igniter wire (02, Figure 13D-2)from the igniter and the top of the ignition coil. Tag and disconnect the other electrical leads.

01. CROSS BAR
02. COVER
03. CLAMP
04. GROMMET
05. TOP COVER
06. SPEEN NUT
07. UPPER BAFFLE
08. THERMOSTAT (OVERHEAT SWITCH
09. CASE ASSEMBLY
10. AIR DEFLECTOR
11. WASHER
12. EXHAUST GASKET
13. EXHAUST CONNECTOR
14. BRACKET
15. GROMMET
16. HEAT EXCHANGER
17. GROMMET
18. GROUND SCREW NO. 10 INT EXT TOOTH
19. LOCKWASHER, NO. 10 INT. EXT TOOTH
20. CLIP
21. MERCURY SWITCH
22. INSULATOR
23. LOCKWASHER, NO. 10 EXT TOOTH
24. NUT, NO. 10-24
25. MARKER STRIP
26. TERMINAL BLOCK
27. RESISTOR
28. TERMINAL BOARD
29. INSULATOR

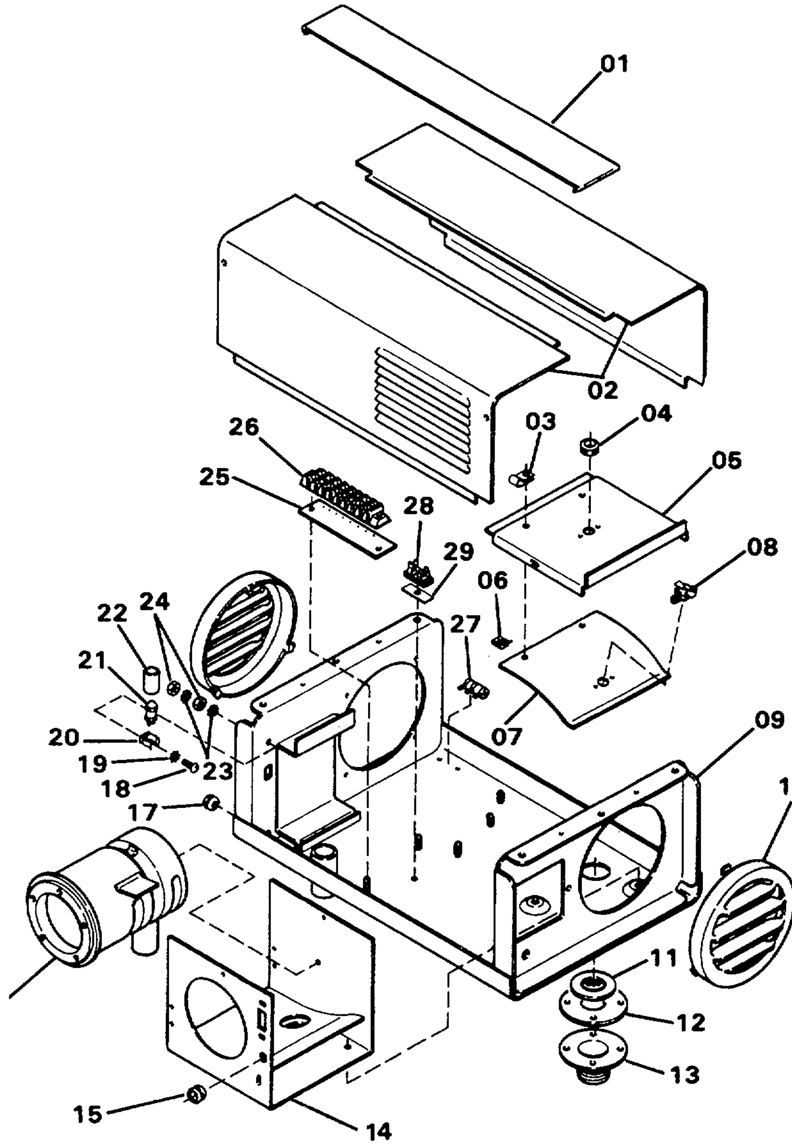


Figure 13D-1. Case and Heat Exchanger

2. Loosen the clamps and pull out ignition coil (01, Figure 13D-3).
3. Remove the two screws and lockwashers which secure the top of the ignition pack to the case assembly. Tilt the ignition pack and lift it from the case.

DISASSEMBLY

To disassemble the ignition pack, proceed as follows (see Figure 13D-3):

NOTE

> 1 2 volt heaters with serial numbers up to 600 used a 6 volt coil (01) and a resistor board (12). Later model heaters use a 12 volt coil and no resistor board.

1. Loosen the vibrator clamp screw. Wiggle the vibrator and pull it out.

2 Capacitor (02) and resistor (08) are accessible after removing vibrator bracket (03). If either part is defective, note the position of the leads, then unsolder and remove the part.

NOTE

> For 1 2 volt heaters supplied with 6 volt coils and resistor boards, if coil is defective, replace with 12 volt coil and discard resistor board.

MOTOR AND BLOWER ASSEMBLY

REMOVAL

To remove the motor and blower assembly, proceed as follows (see Figure 1 3D-4):

1. Carefully note the connection of the motor leads.

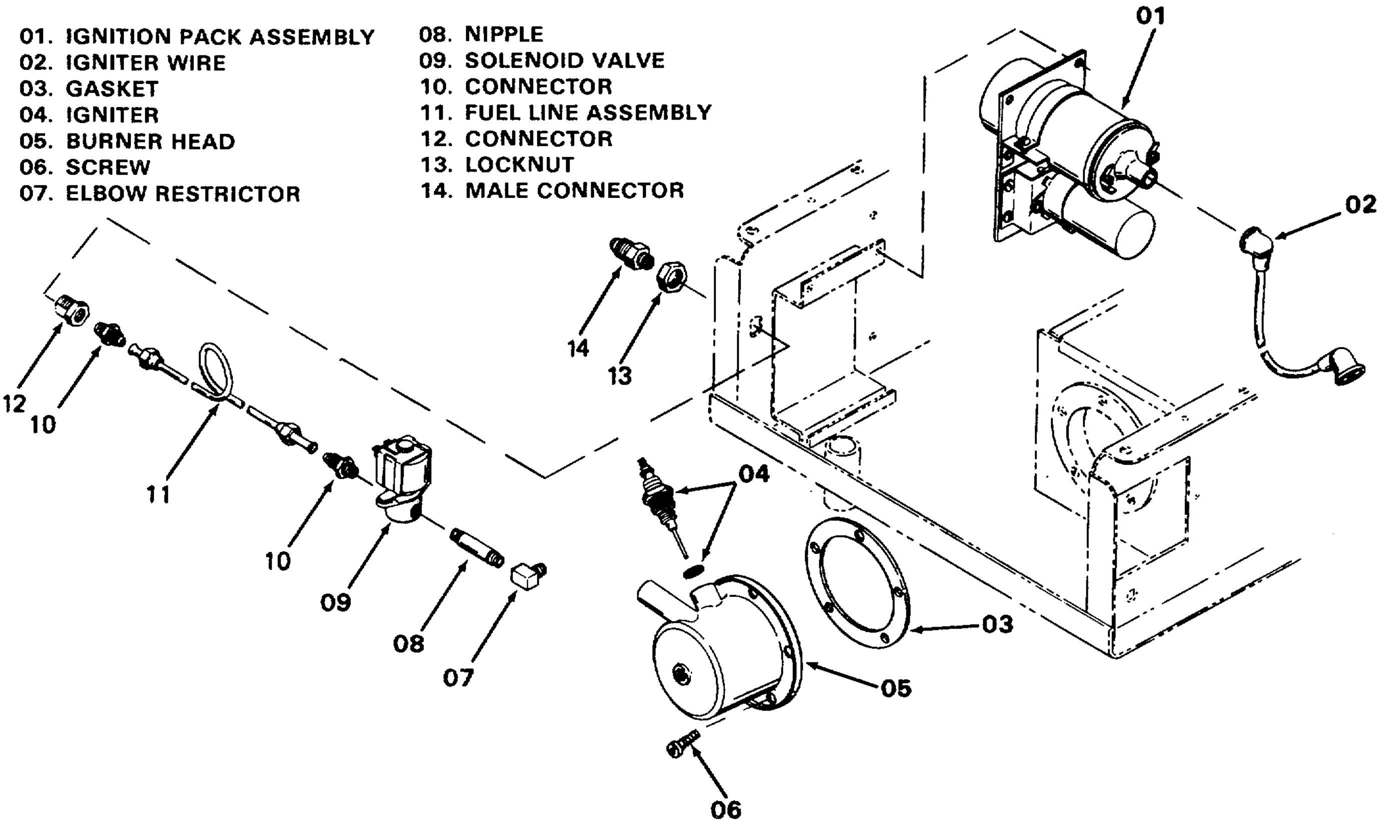


Figure 13D-2. Fuel and Ignition Systems

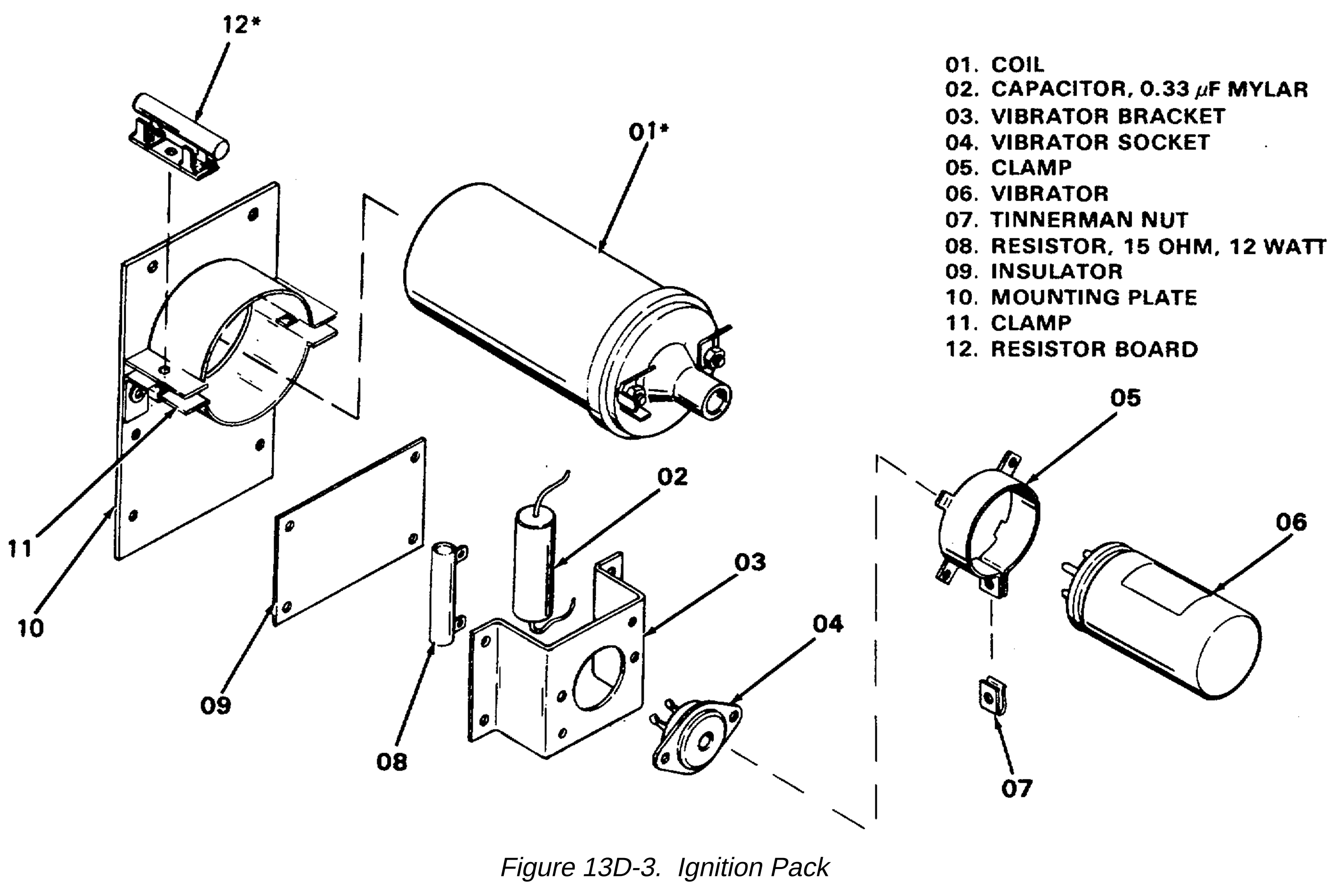


Figure 13D-3. Ignition Pack

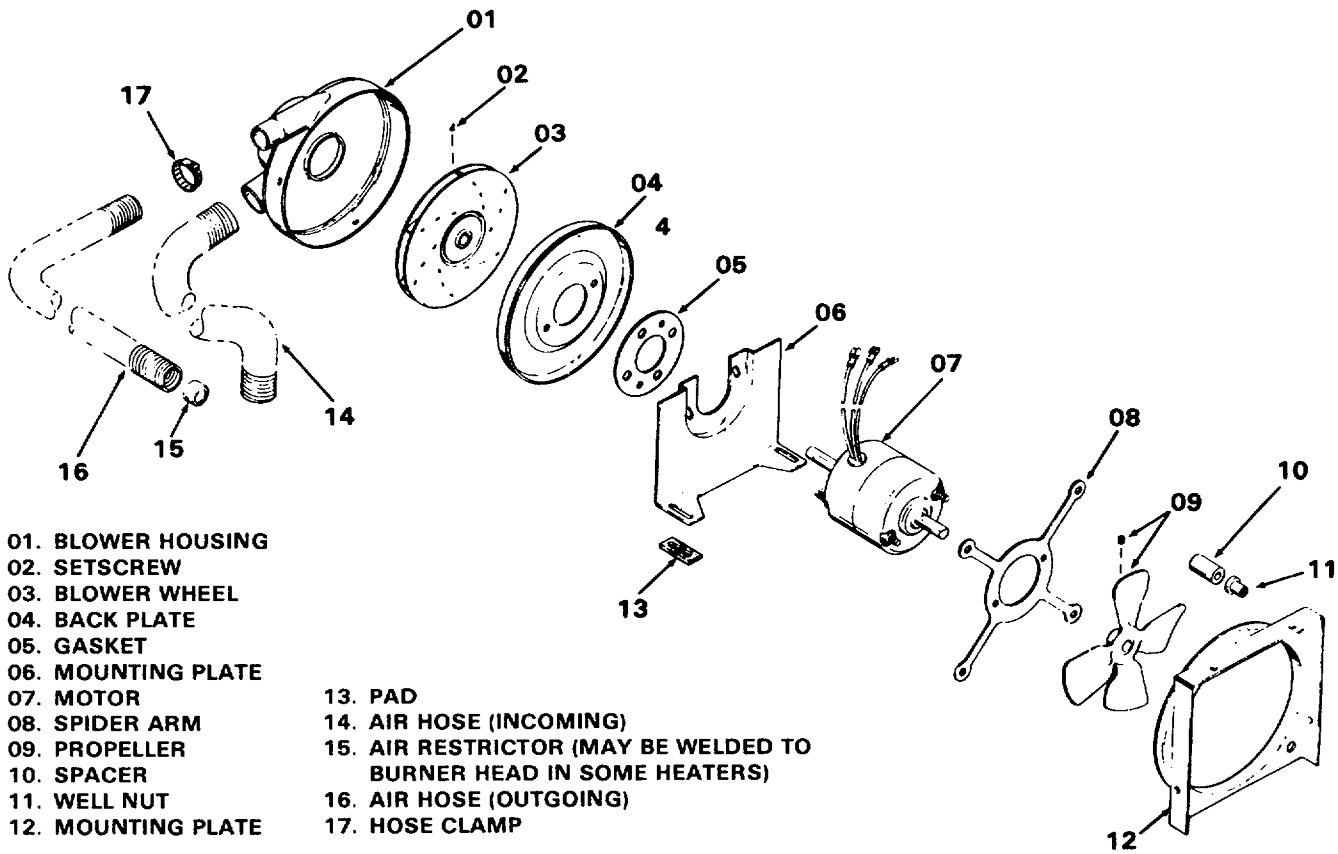


Figure 13D-4. Motor and Blower

2. Remove the ignition pack.
3. Pull off air hoses (14 and 16). Be careful not to lose restrictor (15). On some heaters, this restrictor is welded to the burner head and cannot be removed.
4. Remove spacers (10) and well nuts (11).
5. Remove nuts securing mounting plate (06) to case assembly. Lift out assembled blower and motor.

DISASSEMBLY To disassemble the motor and blower assembly, proceed as follows (see Figure 13D-4): .

1. Remove the tape that seals blower housing (01). Remove the attaching screws and pry off the blower housing.
2. Loosen set screw (02) in blower wheel (03), and pull off the blower wheel.
3. Remove back plate (04), gasket (05), and mounting plate (06) from the end of motor (07).
4. Loosen set screw in propeller (09) and pull off propeller.
5. Remove spider arm (08) from the end of the motor.

CLEANING AND INSPECTION Clean and inspect the motor and blower assembly as follows:

1. Clean the parts with a cloth lightly dampened with diesel fuel. Blow off dirt with compressed air.
2. Inspect the motor for signs of overheating and for rough, catching, or binding operation of the motor shaft. Check the motor using a 24 volt battery. Connect the black lead to battery negative. When the orange lead is connected to battery positive, the motor will run at high speed. The red lead is not used.
3. Inspect the propeller and blower wheel for cracks, distortion, broken vanes, and other damage.
4. Inspect the blower housing for distortion, cracks and dents.
5. Check all non-metallic parts for brittleness, deterioration and damage.
6. Replace all defective parts.

ASSEMBLY

Assembly is the reverse of disassembly. Make sure that all setscrews that secure the propeller and blower wheel to the motor shaft are tightened against the flats of the motor shaft. Be sure to seal the blower housing to the back plate with tape.

INSTALLATION

Installation is the reverse of removal. If necessary, refer to the wiring diagram in Subsection 13A for wire connection information.

HI-LO CONTROL AND MICROSWITCH

ADJUSTMENT

These parts constitute a thermostat assembly which is adjustable to provide the desired heat level for the cab. Adjust as follows:

1. Remove the air deflector adjacent to the control panel. Squeeze the outside diameter of the deflector at one of the clips, and disengage the deflector from the heater case.
2. The V-shaped bi-metal blade (Figure 13D-5) expands to widen the gap at the top of the V when heated. As the bimetal blade expands, it strokes the actuator stop and pushes the actuating rod against the microswitch. This causes the heating circuits to de-energize.

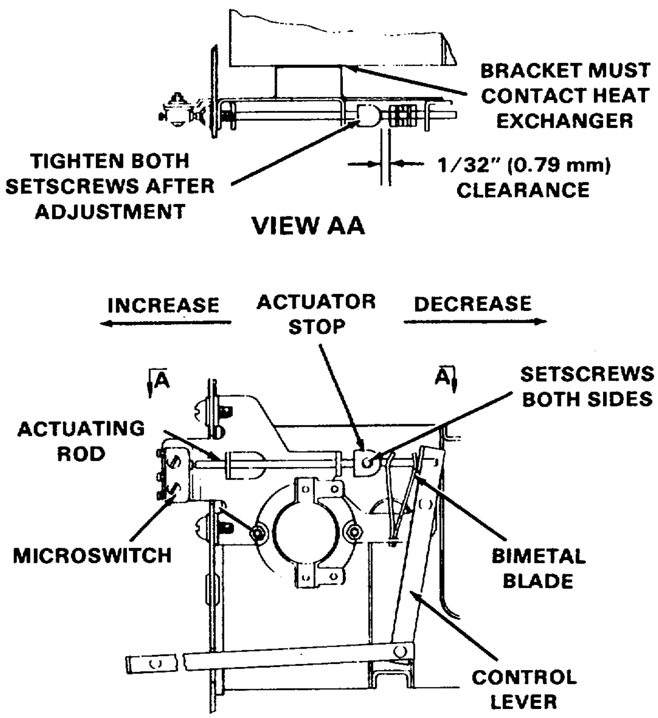


Figure 13D-5. HI-LO Control and Microswitch Adjustment

3. Adjustment is made by changing the position of the actuator stop on the actuating rod. Loosen the two setscrews in the top to permit adjustment. Hold the rod and shift the stop toward the microswitch to increase the temperature within the control range. Shift the stop toward the bi-metal blade to decrease the temperature within the control range. Tighten the setscrews.

NOTE

After adjustment there must be a minimum gap of 1/32 inch (0.79 mm) between the bi-metal blade and the actuator stop when the control knob is in the LO position. Insufficient clearance will result in incorrect operation.

4. Install the air deflector and operate the heater to determine if it provides the required temperature. Readjust if necessary.

REMOVAL AND DISASSEMBLY

To remove and disassemble the control end microswitch, proceed as follows (see Figure 13D-6):

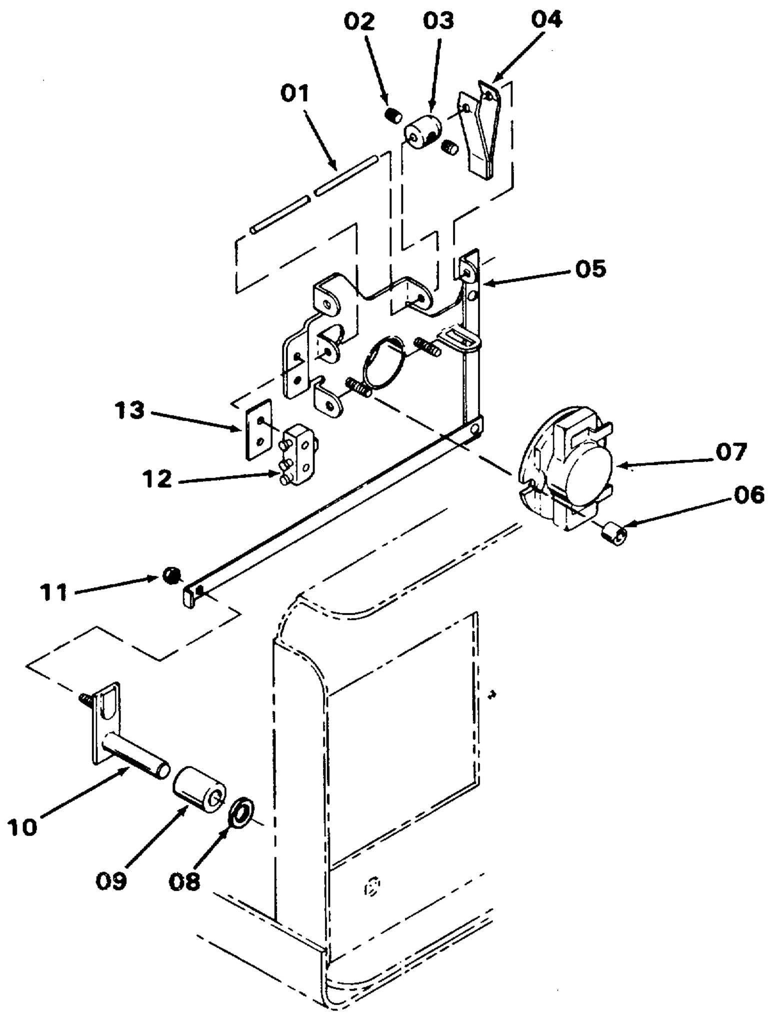
1. Remove the deflector from the heater outlet.
2. Remove the stop nut (11) and disengage pivot arm (10) from the lever on bracket (05).
3. Disconnect the leads from flame switch (07) and remove the switch.
4. Remove bracket (05), if necessary, and pull out the assembly through the heater outlet.
5. Loosen setscrews (02) in actuator stop (03). Pull out actuating rod (01) to release the stop and bi-metal blade (04).
6. Remove two screws through microswitch (12). Pull off the microswitch and insulator (13). These two parts are in a kit as shown in the parts list.

CLEANING AND INSPECTION

Clean and inspect parts as follows:

1. Wipe all parts with a clean cloth. Do not use solvent or diesel fuel.
2. Check continuity of the microswitch (11). Continuity between the two end terminals must break when the switch plunger is depressed. Inspect switch for cracks and for faulty operation.
3. Check continuity of the flame switch (7). At normal temperature it should be open, closing at approximately 120 + 5°F. It must open upon cooling at 105 + 50F. Inspect the switch for cracks and for loose terminals.
4. Inspect all other parts for cracks, burrs, distortion and damage. Replace damaged parts with service kits listed in the parts list.
5. Inspect the bracket and its levers for cracks and damage. The levers must pivot freely. Wipe off the actuating rod. If desired, lubricate all moving parts (except the microswitch) with automotive speedometer cable lubricant, or equivalent.

REASSEMBLY AND INSTALLATION Reassembly and installation are the reverse of removal and disassembly. Refer to the wiring diagram in Subsection 13A for wire connections. After installation, adjust the switch and bi-metal blade as described above. Make sure the flame switch is in contact with the heat exchanger as shown.



01. ACTUATING ROD
02. SETSCREW
03 ACTUATOR STP
04. BI-METAL BLADE
05.BRACKET
06.SPACER
07. FLAME SWITCH
08.SPRING WASHER
09.SPACER
10. PIVOT ARM
11. STOP NUT
12. MICROSWITCH
13. INSULATOR

Figure 13D-6. Control Panel

HEAT EXCHANGER
REMOVAL

To remove heat exchanger, proceed as follows (see Figure 13D-1)

WARNING

The heat exchanger must be inspected annually, or more frequently if heater usage is heavy. A damaged heat exchanger can allow poisonous gases to seep into the heated enclosure causing illness or death to occupants.

1. Remove the two screws that secure cross bar (01) to the case.
2. Disconnect the fuel line at the solenoid. Remove the burner head and elbow restrictor.
3. Remove the heat exchanger top cover (05).
4. Remove the screw that secures the end of heat exchanger (1 6)to mounting bracket(14). Pull straight upto remove the heat exchanger.

CLEANING AND INSPECTION

Clean the exterior of the heat exchanger with a wire brush to remove all dust and dirt.

Inspect the heat exchanger for cracks, holes, broken weldments and other damage. Replace if defective or install Heat Exchanger and Control Subassembly.

CAUTION

Heat exchanger must be installed as shown to prevent exhaust gases from leaking around the burner head.

INSTALLATION

Installation is essentially the reverse of removal. Alignment between the heat exchanger and the bracket is critical to correct sealing of the burner head. Install the heat exchanger in the bracket and carefully align the open end of the heat exchanger with the hole in the bracket as shown in Figure 1 3D-7. At the same time, the exhaust outlet must be aligned with the hole in the bottom of the bracket, and the tapped hole in the back of the heat exchanger must be aligned with the hole for the attaching screw. Make sure all parts are aligned before installing the burner head

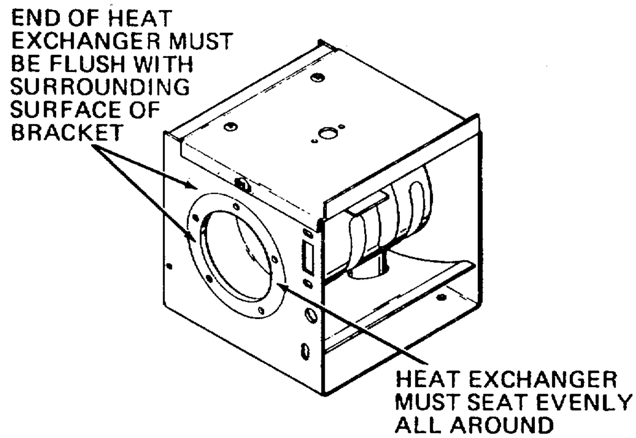


Figure 13D-7. Heat Exchanger Installation

Table 13D-1. Troubleshooting Chart for Propane Heater

Trouble	Cause and/or Remedy
A. Heater fails to start - motor does not run	1. Check fuse 2. Check all electrical connections, including ground 3. Check for power at the heater - at least 22 VDC with heater turned on 4. Check motor. Replace if necessary
B. Motor runs, but there is no combustion.	1. Check fuel supply by loosening the fitting on the outside of the heater and checking for propane odor. If propane odor is present, pull off igniter wire completely and remove igniter. Try to start heater and listen for solenoid click. Check for odor of propane in the burner. If propane odor is present at bulkhead fitting, but not the burner head, the solenoid valve is defective or contaminated with some foreign object. The solenoid valve can become contaminated when a liquid take-off bottle is used instead of the required vapor take-off bottle. If the fuel system is contaminated, clean the lines and solenoid valve with a degreasing solvent. 2. Check HI-LO control and microswitch adjustment. 3. Check for spark by holding an insulated handle screwdriver with the shaft grounded and the tip approximately 1/8 inch away from the high tension lug of the ignition coil. There should be a continuous strong spark. If no spark is produced, check that there is voltage applied to the ignition pack. If input voltage is present and no spark or a weak spark is produced, replace or repair the ignition pack. 4. Check the igniter. To check, shut off the fuel at the tank and depress the start switch until the lines are purged of fuel. Remove the burner head and check the gap between the igniter and the burner tube. It should be 1/16 to 1/8 inch. With the burner head grounded, move the START-RUN-OFF switch to the START position and check the gap for spark. If no spark is produced, the igniter may be dirty or defective. Before removing igniter from burner head, check inside the burner head to determine if any carbon threads or chips are present which could short the plug.

Table 1 3D-1. Troubleshooting Chart for Propane Heater (Cont.)

Trouble	Cause and/or Remedy
B. Motor runs, but there is no combustion (cont.)	5. Check tilt switch. The switch must be secure in its bracket and be in the vertical position with the electrical leads pointing down. Check leads on both side of switch for power. Replace if defective. 6. Check with your propane supplier to be sure your fuel is suitable for the temperatures encountered. Around -100F, propane may not produce enough pressure to pass through the regulator.
C. Excessive backfiring or popping.	1. Check ignition pack as described in B.3. 2. Using voltmeter, check to be sure full voltage is available for heater operation - 22 VDC minimum with heater turned on. 3. Check solenoid valve. When the START-RUN-OFF switch is in the RUN position, the solenoid valve should produce an audible click and remain open until heater cycles off. 4. In extremely cold weather, the regulator may become frosted. As it thaws and freezes, the heater will burn intermittently. 5. Check for clogged or restricted exhaust.
D. Heater remains on burner cycle after heat demands are met.	1. HI-LO control or microswitch out of adjustment. 2. Bi-metal blade broken or linkage out of adjustment. 3. Dirt on fuel solenoid valve lip.
E. Excessive smoking at exhaust port and buildup of carbon in heat exchanger.	1. Check for plugged or blocked air inlet tube. 2. Check for low voltage - at least 22 VDC. 3. Check for defective pressure regulator. There should be 11 inches water pressure in the propane supply line at the connector.

SUBSECTION 1 3E

ELECTRIC GENERATING PLANT

DESCRIPTION

The electric generating plant consists of a diesel engine directly connected to an electric generator.

The engine is a vertical four stroke, overhead valve diesel. It is air cooled and governor equipped to maintain constant speed and output.

The 4-pole, self-excited generator is inherently regulated, and serves also as a starting motor for the diesel engine. The generator also supplies dc current to recharge the starting batteries.

The control system to start and stop the plant is remote mounted in the operator's cab.

Electrical output characteristics of the plant appear on the nameplate with the model designation and serial numbers. The plant model and specification numbers are separated by a diagonal line (/). The plant specification consists of a number, which indicates optional equipment as ordered by the purchaser, and a letter at the end, which is advanced to coincide with production modification by the manufacturer. Any communications to the manufacturer should include the plant model and Spec. number.

When discussing left side and right side in this manual, view the plant from the engine end of the plant, which is designated the front end.

TROUBLE-SHOOTING CHART

STARTING

POSSIBLE CAUSE	REMEDY
ENGINE WILL NOT TURN OVER	
Defective switch.	Replace.
Internal seizure	Turn engine over by hand, check, disassemble and repair.
Loose connections.	Tighten connections.
Engine oil too heavy for low temperature.	Change oil.
Battery discharged.	Recharge.
ENGINE CRANKS TOO STIFFLY	
Oil in crankcase too heavy for low temperature	Check oil specification, change oil.
Load connected.	Disconnect load.
Defective decompression release.	Check and adjust.
ENGINE TURNS BUT WILL NOT START	
Defective glow plug or preheater.	Repair or replace.
Defective fuel system.	See Fuel System-
Air in fuel system.	Bleed fuel system.
Faulty injection caused by dirty fuel or clogged fuel filter.	Replace with clean fuel, clean primary fuel filter and replace secondary fuel filter.
Poor compression.	See poor compression section.
Wrong timing.	Correct timing.
Poor quality fuel.	Drain, fill with fresh fuel.

ENGINE HARD TO START	
Restricted air intake.	Clean air cleaner.
Poor fuel.	Check fuel specification, change if necessary.
Incorrect timing.	Retime.
Worn or damaged fuel transfer pump.	Replace or rebuild pump.
Air leak in fuel lines	Tighten all corrections, check for defects in lines.
Clogged fuel lines.	Clean fuel lines.
Clogged primary or secondary fuel filter.	Clean primary filter, replace secondary filter cartridge.

DEFECTIVE BATTERY	
Hardened plates (sulfation) due to low charge after long period.	
Shorted cells.	Replace battery, check new battery charge condition at frequent intervals.
Loss of active material	
Broken terminals.	

BATTERY DISCHARGED	
Defective starting circuit.	Check starter circuit.
Excessive use of starter.	Adjust starting procedures, check for causes of hard starting.
Dirt and electrolyte on top of battery causing constant drain.	Clean battery top.

OPERATION

POSSIBLE CAUSE	REMEDY
ENGINE MISFIRES AT ALL LOADS	
Poor compression.	See Poor Compression
Broken valve spring.	Replace.
Defective or dirty nozzle. Clean fuel system.	Clean nozzle or replace. !

ENGINE MISFIRES AT LIGHT LOAD	
Faulty injection.	Inspect fuel system.
Poor compression.	See Poor Compression.
Poor fuel.	Replace with correct fuel.

ENGINE MISFIRES AT HEAVY LOAD	
Faulty injection.	Inspect fuel system.
Dirty air cleaner.	Clean.
Dirty fuel filter.	Clean primary filter, replace secondary filter cartridge.

LOW ENGINE POWER	
Restricted air intake.	Clean air cleaner.
High exhaust back pressure.	Inspect exhaust line for restrictions.
[Thin air at high altitude or in hot weather.	Normal under these conditions.
Poor fuel.	Change to correct fuel.
Fuel line leaks.	Inspect fuel system.
!Poor compression.	See Poor Compression.
Incorrect timing.	Adjust injection timing

POSSIBLE CAUSE	REMEDY
DEFECTIVE NOZZLE (Usually Indicated by Defective Spray Pattern)	
Dirt in nozzle.	Clean nozzle.
Externally carboned nozzle.	Clean outside surface.
Worn nozzle or valve.	Replace or repair injection nozzle.
Incorrect nozzle opening pressure.	Using proper equipment. adjust nozzle pressure.
Dribble below opening pressure.	Clean nozzle and recheck. If it still dribbles, replace nozzle.
FUEL KNOCK	
Injection nozzle sticking.	Clean nozzle.
Injection nozzle spring broken.	Replace complete nozzle.
Air leaks in fuel lines.	Repair or replace.
Poor fuel.	Change to proper fuel.
Water in fuel.	Change fuel.
Sticking Nozzle Valve (usually caused by dirt or corrosion from fuel).	Clean nozzle - check filters and fuel quality.

OIL SYSTEM

POSSIBLE CAUSE	REMEDY
DILUTED OIL	
Leaky fuel transfer pump diaphragm.	Rebuild or replace pump.
Faulty cylinder oil control.	Inspect rings and cylinder walls
CRANKCASE SLUDGE	
Dirty oil filter.	Replace oil filter, adjust oil filter service periods.
Run for long idle periods.	Correct running procedures.
Sticking compression ring.	Replace.
LOW OIL PRESSURE	
Worn bearings.	Rebuild engine.
Oil by-pass stuck open. Oil supply low.	Clean by-pass valve. Add oil. Check cause of oil consumption.
Worn oil pump-	Replace pump.
Defective oil gauge.	Replace gauge.
HIGH OIL PRESSURE	
Oil by-pass stuck closed.	Clean.
Oil' too heavy.	Replace with lighter oil.
Clogged oil passages.	Clean all lines and oil passages.
EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST	
Worn or sticking piston rings.	Check compression. Clean or replace rings.
Defective breather valve.	Clean or replace.
Oil too light or diluted.	Replace with proper grade of oil. If diluted, check for cause.
Engine overheating.	See Cooling System.

EXCESSIVE OIL CONSUMPTION, NO CHANGE IN EXHAUST	
Leaking oil seals.	Inspect crankshaft front and rear oil seals.
Leaky oil base gasket	Check for leaks around gasket. Replace if necessary.
Defective breather valve.	Clean the valve or replace it.

GOVERNOR

ENGINE RACES (Stop Engine Immediately by Pushing Throttle Lever)	
Governor incorrectly adjusted.	See Governor System.
Linkage binding.	Clean or replace linkage.

ENGINE SPEED TOO LOW	
Governor incorrectly adjusted.	Adjust for proper speed.
Low engine power (will not reach governed speed).	Check for other causes.

HUNTING CONDITION	
Governor spring sensitivity too great.	Adjust sensitivity.

POOR SENSITIVITY	
Excessive wear in linkage.	Replace governor linkage.
GOVERNOR ACTS SLOWLY	
Binding in linkage.	Clean and lubricate linkage.

NO GOVERNOR CONTROL	
Linkage disconnected.	Reconnect linkage.

FUEL SYSTEM

POSSIBLE CAUSE	REMEDY
BLACK SMOKY EXHAUST, EXCESSIVE FUEL CONSUMPTION	

The brown or black color in the exhaust is minute solid particles of pure carbon. A darker exhaust indicates a higher carbon content. The exhaust color may vary from a very light gray haze to a brown or black, which indicates incomplete combustion. Since combustion is never absolutely complete, the exhaust gases will never be invisible, but an increase may indicate trouble, especially if there is no apparent change in engine conditions.

Engine over-loaded (a normal condition under over-load).	Reduce load.
Poor compression.	See Poor Compression.
Poor grade or dirty fuel.	Replace fuel.
Dirty air cleaner.	Clean.
Faulty injection timing.	Check timing.
Faulty injection pump or nozzle.	Check and rebuild, or replace as necessary.

EXCESSIVE FUEL CONSUMPTION	
Engine overloaded.	Reduce load.
Poor compression.	See Poor Compression.
Defective injection pump or nozzles.	Repair or replace.

MISCELLANEOUS

DULL METALLIC THUD; IF NOT BAD, MAY DISAPPEAR AFTER FEW MINUTES OF OPERATION	
Loose crankcase bearing.	Replace bearing.

SHARP. METALLIC THUD, ESPECIALLY WHEN COLD ENGINE FIRST STARTED	
Low oil supply.	Add oil.
Oil badly diluted.	Replace oil.

POSSIBLE CAUSE	REMEDY
TAPPING SOUND, CLACKING, LIGHT CLICKING	
Valve clearance too great.	Check valve clearance.
Broken valve spring.	Replace valve spring.
METALLIC KNOCK UNDER NO LOAD CONDITIONS AND WHEN STOPPING	
Worn connecting rod bearings.	Replace bearings.
HOLLOW CLICKING SOUND WITH ENGINE COOL AND UNDER LOAD	
Loose piston	Check piston clearance.
LIGHT POUNDING KNOCK	
Loose connecting rod bearing.	Replace bearings.
Low oil supply.	Add oil- check for cause.
Oil badly diluted.	Replace oil - check for cause.
POOR COMPRESSION	
Loose cylinder head.	Tighten.
Sticking rings or worn rings.	Replace rings, check cylinder condition.
Worn cylinder wall and piston.	Refinish cylinder and replace piston.
Leaky head gasket.	Replace head gasket.
Valves sticking.	See Sticking Valves.
Broken valve spring.	Replace spring. check valve condition.
Leaky nozzle gasket.	Replace gasket.
Leaky valves.	Regrind valves.
Burned valves and seats.	Regrind valves and seats. Replace if necessary.
Insufficient valve clear-	Adjust clearance.
STICKING VALVES	
Incorrect valve clearance.	Adjust valve clearance.
Weak or broken springs.	Replace springs.
Dirty, scored or gummy guides.	Clean or replace valves and guides.
Incorrect clearance between valve and guide.	Correct clearance.
VALVE BURNING	
Close valve clearance.	Re-adjust valve clearance.
Weak springs.	Replace springs.
High temperatures, causing valve stretch.	Check for engine overheating.
Valve seat or face off center.	Regrind seat, replace valve.
Loose valve seat inserts.	Replace seats. Rebore and use over size if necessary.
Coked or gummed oil on stem.	Clean or replace valve.
VALVE BREAKAGE	
Weak valve springs.	Replace weak springs.
Excessively strong valve springs.	Replace springs.
Worn guides which set up thrust action.	Replace guides.
Excessive valve clearance.	Adjust valve clearance.
WORN CONNECTING ROD, BUSHINGS AND BEARINGS	
Plant run with low oil.	Add oil, check cause of oil loss.
Badly diluted, dirty or wrong oil.	Change oil. Check cause of dilution. If dirty, check service periods.
Clogged oil passages. drillings.	Clean oil passages and

PISTON, CYLINDER AND RING WEAR	
Operated with dirty air cleaner .	Change air cleaner service periods.
Air leak between the air cleaner and engine.	Repair leaks.
Faulty cylinder oil control	Check rings
Engine run on low or dirty oil.	Add or replace oil. Check cause of loss. If dirty, adjust service periods.
Overheating.	See Cooling System.

GENERATOR

VOLTAGE UNSTEADY, BUT ENGINE NOT MISFIRING	
Speed too low.	Adjust governor to correct speed.
Loose connections.	Tighten connections.
GENERATOR OVERHEATING (Approximately 160°F higher than ambient)	
Overloaded.	Reduce load.
VOLTAGE DROPS UNDER HEAVY LOAD	
Engine lacks power.	See remedies of Engine Misfires At Heavy Load. Inspect, repair as necessary.
Faulty injection.	Clean the fuel system. Clean, adjust or replace parts necessary.
Dirty air cleaner.	Clean.
Restricted exhaust line.	Clean or increase size.

ENGINE RUNS; VOLTAGE WON'T BUILD UP	
Poor brush contact.	Be sure brushes seat well, are free in their holders, are not worn too short, and have good spring tension.
Open circuit, short circuit or ground in generator.	Replace necessary parts.
Residual magnetism lost.	Remagnetize the field.
NOISY AND EXCESSIVE ARCING OF BRUSHES	
Rough commutator.	Turn down. Undercut mica between bars.
Dirty commutator.	Clean.
Brushes not seating properly.	See Poor Brush Contact.
Brush rig out of position.	Line up properly.
UNSTEADY VOLTAGE WITH STEADY-RUNNING ENGINE	
Speed too low.	Adjust governor to correct speed.
Poor brush contact.	See that brushes seat well on commutator, are free in holders, are not worn too short and have good spring tension.
Loose connections.	Tighten connections.
Fluctuating load.	Correct any abnormal load conditions causing trouble.
FLICKERING LIGHTS	
Defective anti-flicker breaker points.	Check point gap and inspect points.
Anti-flicker resistor out of adjustment.	Adjust slider for minimum flicker at average load.

PLANT REBUILDING

GENERAL

When engine disassembly is necessary remove complete assemblies (tear down individual components like fuel pump, breaker mechanism, etc., as bench jobs). *Use special tools available.*

DISASSEMBLY

Common sense will dictate proper order of disassembly. As disassembly progresses, the order may be changed, as will become self-evident.

A suggested procedure would be as follows:

1. Housings, shrouds, blower housing, air cleaner.
2. Flywheel - using puller or pry bar method.
3, Gear Cover - protect oil seal from keyway damage.
4. Crank Gear - use puller and gear puller ring.
5. Loosen accessories such as fuel pumps, oil filter, starter and generator.
6. Control box and generator (lift all generator brushes) tag all wires for identification.
7. Drain oil - discard oil removed.
8. Cylinder head.
9. Valves, springs, rocker arms.
10. Camshaft and gear, rear bearing plate, oil pump.
11. Piston, connecting rod bearings.
1 2. Crankshaft.
13. Try to analyze reasons for any parts failure and necessity of the repair.
14. Cleanliness and neat orderly work area makes the job easier to do.

1 5. Use proper meters and gauges. Observe if cylinder re-quires boring, crankshaft needs grinding, or other major shop work necessary.

16. Check generator and static exciter (if used). Use growler, test light (buzzer), or ohmmeter for armature or field coil shorts, grounds, or opens. Determine if commutator or slip rings need turning by lathe or true them up. Undercut mica if necessary.

ASSEMBLY

Engine assembling procedure is normally the reverse of disassembly observing proper clearances of bearings, connecting rod, proper fitting and sizing of piston, rings, etc.

Follow proper recommended procedure for fit of valves, adjusting clearances, and torque of all special items. Use a torque wrench to assure proper tightness without danger of stripping threads.

As each internal engine part is assembled, use crank (or wrench) and turn over engine, making certain it turns freely. If tightness is noted after any operation you then know your last step is responsible.

As each internal engine part is assembled, coat it heavily with oil (the same grade to be used in the crankcase). During the first few critical moments of operation the engine will depend on this lubrication.

After you have the internal engine parts reassembled, the engine should turn over freely when cranked. If reasonable care and attention has been given, the engine will operate efficiently. At this point, it is a matter of mechanically adding the outside accessory items to the block assembly. *Order of assembly is reverse of disassembly.*

When engine is complete, install generator and plant control. Check the tagged wires. Use wiring diagram to connect generator leads to control, and, from control to engine leads. All wires are marked for correct identification. If plant is to work properly, wires must be connected correctly.

The engine generator is now ready for testing. Follow suggestions given on Testing and Adjusting Plants. Before final test and adjustments, run the plant about 15 minutes under light load to reach normal operating temperature.

ASSEMBLY SUGGESTIONS (Things to keep in mind during engine assembly).

Wet holes in crankcase (holes through crankcase) always use copper (gasket) washers.

Nuts, bolts and screws that do not require exact torque should be tightened snugly, then 1/4 extra turn.

Select proper length of any screw or bolt and position in hole. Make sure they do not bottom.

Gasket kits sometimes cover more than (1) engine. Therefore, select gasket of correct size and shape for part being used. Always use new gaskets.

When disassembling engine, mike bearing plate gasket thickness. Then select proper gasket thickness for correct end play.

When assembling crankshaft, make sure bearing thrust washers are in proper position supported by bearing stop pins. Use cup grease to hold in place.

When adjusting valve lash on J-Series, tap the rocker arm so it is straight when checking with feeler gauge.

When installing gearcase cover, put a dab of grease on roll pin so governor cup can be aligned.

Crank gears are easier to remove and install if heated.

Service manual (for any specific model) should be read carefully for correct timing.

Allow some gear lash (approximately 0.005 in. (0.127 mm) in oil pump). *Do not install gears tightly against each other!*

TESTING AND ADJUSTING PLANTS

Preparation

Check the following:

1. Put proper oil in crankcase.
2. Service the air cleaner.
3. Connect the fuel line.

4. Connect the load.
5. Connect fully charged battery.
6. Check ventilation for proper cooling.

OPERATION

1. Start engine.
2. Check oil pressure, adjust brush rig.
3. Run plant 1 5 minutes to bring up to operating temperature.
4. Check for oil leaks, loose electrical connections, tight fuel lines and tight exhaust connections.

ADJUSTMENTS

1. Adjust governor for speed and sensitivity.
2. Make sure meters are connected.
3. Check the output; volts, amps, watts, frequency.

ENGINE DISASSEMBLY

GENERAL

If engine disassembly is necessary, observe the following order (i.e. Flywheel, Gear Cover, etc.). As disassembly progresses, the order may be changed somewhat as will be self-evident. The engine assembly procedure is the reverse of disassembly. Any special assembly instructions for a particular group are included in the applicable section. When reassembling, check each section for these special assembly instructions or procedures.

FLYWHEEL

Remove the blower housing. The flywheel is a tapered fit on the crankshaft. Improvise a puller, using at least a 7/16 inch bar, and drill two 7/1 6 inch holes 2-7/8 inch between centers. Loosen the flywheel mounting screw a few times. Place bar against the flywheel screw and attach bar, using two 3/8-16 thread screws in the holes provided in flywheel. Alternately tighten the screws until flywheel is free.

Replacement flywheels are supplied without the timing markings because each flywheel must be fitted to its engine. The only accurate method of determining the top dead center (TDC) and port closing points is to measure the piston travel. This is a critical measurement and should be attempted only with accurate, dependable equipment.

With the flywheel mounted, remove the head and install a depth gauge over the piston. Rotate the flywheel to find the TDC position on the compression stroke and mark this point on the flywheel. Next, turn the flywheel counterclockwise until the piston drops exactly.102 inch from TDC. This is the port closing point, 170 BTDC. Mark it on the flywheel.

GEAR COVER

To remove the gear cover, detach the upper governor ball joint. Remove the governor speed adjustment nut and governor spring bracket.

Remove the screws holding the gear cover to the crankcase. To loosen the gear cover, tap it with a soft hammer.

GOVERNOR SHAFT. The governor shaft is supported by two sets of needle bearings. To remove the shaft, remove the yoke and pull the shaft from the gear cover. If the shaft is binding, clean the bearings; if loose, replace the bearings. To remove the larger bearing, drive both bearing and oil seal out from the outside of the gear cover. Remove the smaller bearing with an Easy-Out or similar tool. Press new bearings and oil seal into place.

GEAR COVER OIL SEAL. Replace the oil seal if damaged or worn. Drive the old seal out from inside the gear cover. Lay the cover on a board so the seal boss is supported. Using an oil seal driver, insert the new seal from the inside with rubber lip toward outside of gear cover (open side of seal inward) and drive it flush with the outside surface. During gear cover installation, use the driver to protect the oil seal. See Figure 13E-2.

ASSEMBLY. To assemble the gear cover, proceed as follows:

1. Work the governor shaft to check for binding and see that the governor shaft end thrust ball is in place (Figure 1 3E-1). Later models have larger ball which will not fall out.
2. Turn governor yoke so the smooth side is toward governor cup.

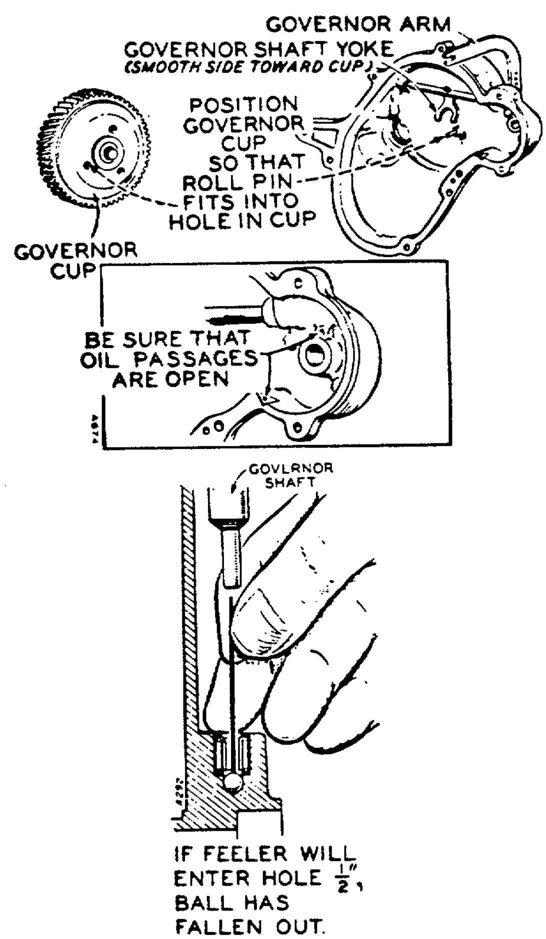


Figure 13E-1. Gear Cover Assembly

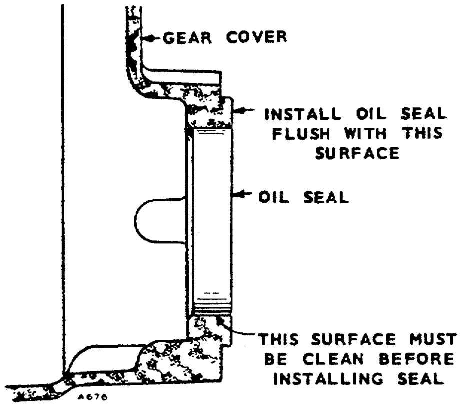


Figure 13E-2. Gear Cover Oil Seal

3. Turn the governor cup so the stop pin in the gear cover will fit into one of the holes in the cup surface (Figure 13E1). Measure the distance from the end of the stop pin to the mounting face of the cover. It should be 25/32 inch (19.84 mm). If it is not, replace the pin. Pin should be positioned with open end facing crankshaft seal.

4. Coat the oil seal lip with oil or grease. Set a piece of shim stock over the crankshaft keyway to protect the seal and install the gear cover. Torque the mounting screws to 1 5 to 20 foot pounds (20.3 to 27.1 N.m). Before tightening screws, be sure the stop pin is in the governor hole.

GOVERNOR CUP

To remove the governor cup, remove the snap ring from the camshaft center pin and slide the cup off.

NOTE

> Be sure to catch the ten flyballs that will fall out when the cup is removed.

Replace any flyballs that have flat spots or grooves. Replace the cup if the race surface is grooved or rough. The governor cup must be a free spinning fit on the camshaft center pin, but should be replaced if excessively loose or wobbly.

Check the distance the center pin extends from the camshaft gear; this distance must be 25/32 inch (19.84 mm) to give the proper travel distance for the cup (Figure 1 3E-3). If it is less, the engine may race; if more, the cup will-not hold the balls properly. If the distance is too great, drive or press the center pin in. If it is too small, replace the pin; it cannot be removed without damaging the surface.

In some cases, if the distance is too small, the head of the governor cup can be ground to give the necessary 7/32 inch (5.56 mm) travel distance.

To install the governor assembly, tip the front of the unit upward. Set the flyballs in their recesses and position the governor cup on its shaft. Finally, brush with heavy grease and install the snap ring on the center pin.

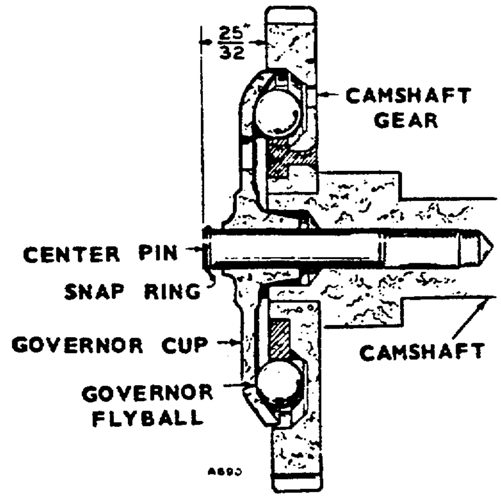


Figure 13E-3. Governor Cup

CAMSHAFT

GENERAL. The camshaft is a one piece machine casting, driven through gears by the crankshaft. It rides on sleeve bearings pressed into the crankcase. In addition to providing a means of opening and closing the valves, the camshaft operates the injection pump and fuel transfer pump.

REMOVAL. To remove the camshaft, proceed as follows:
1. Remove the rocker arms and push rods from the valve chambers.
2. Remove the injection pump and fuel transfer pump from the engine.
3. Remove the crankshaft gear retaining washer by removing the lock ring on the crankshaft.
4. Lay the engine on side to avoid dropping tappets and remove the camshaft assembly as a group. If necessary, pry it out with a screwdriver between the camshaft gear and crankcase.
5. Remove the valve tappets. These can be removed only from the camshaft end of the push rod holes.

REPAIR. If a lobe has become slightly scored, dress it smooth with a fine stone. If the camshaft is badly worn or scored, replace it. After installing a new camshaft, retime the injection pump to the engine.

CAMSHAFT GEAR. This gear is a pressed fit on the camshaft and drives it at 1/2 the crankshaft speed. To remove the gear, use a hollow tool or pipe that will fit inside the gear bore and over the center pin. Press the camshaft out of the gear bore. Be careful not to damage the center pin.

CAMSHAFT BEARINGS. The camshaft bearings should be replaced if the clearance to the camshaft is greater than specified, the bearings show cracks, breaks, burrs, excessive wear, or other defects. The camshaft to bearing clearance should be .0012 inch to .0037 inch. To check the rear bearing, remove the expansion plug at the rear of the crank-case.

Press new bearings into place (Figure 13E-4). Press the rear bearing flush with the bottom of the expansion plug recess. Press the front bearing in flush with the crankcase front surface so the oil passages are aligned. Do not attempt to ream the bearings, as they are a precision type. After the rear bearing is installed, insert a new expansion plug in the recess, using sealing compound, and expand it into place with sharp blows at its center.

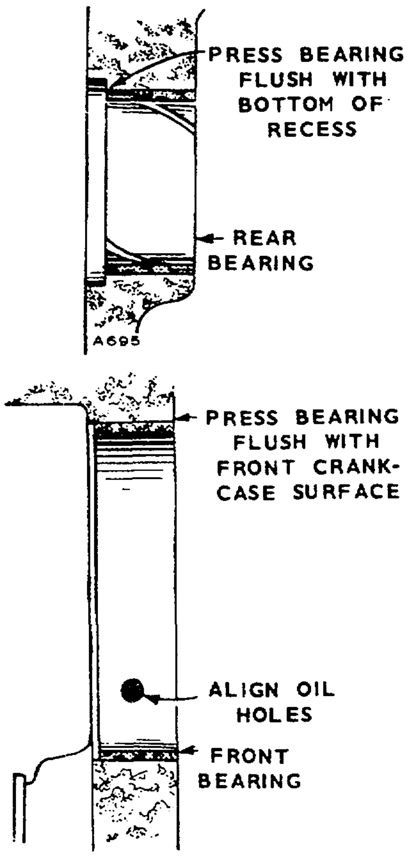


Figure 13E-4. Camshaft Bearings

INSTALLATION. To install the camshaft, proceed as follows:

1. Install the key and press the camshaft gear on its shaft.

2. Install the governor components.

3. Slide the thrust washer onto the shaft. Measure camshaft end play; it should be 0.007 to 0.039 inch (0.178 to 0.991 mm) (Figure 13E-5).

4. Lay the engine on side or end and insert the push rod tappets.
5. Install the camshaft assembly in the engine. Align the timing marks on the camshaft gear and crankshaft gear (Figure 13E-6).
6. Replace the push rods and fuel transfer pump.

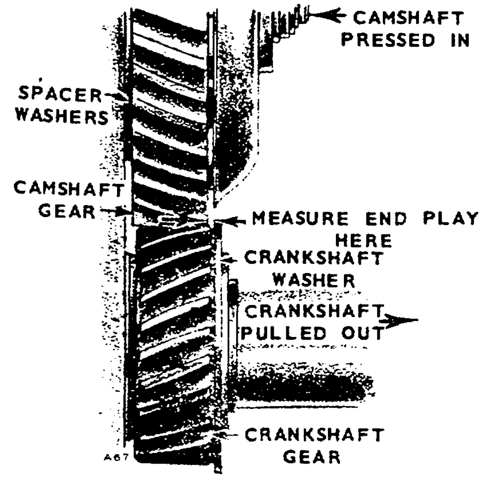


Figure 13E-5. Camshaft End Play

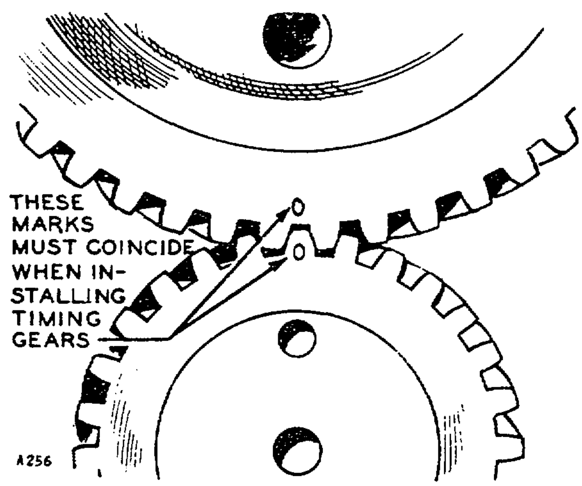


Figure 13E-6. Timing Marks

7. When the engine is reassembled, install the injection pump, following the steps for Injection Pump Installation.
This step is critical.

CRANKSHAFT

GENERAL. These engines use a counterbalanced, ductile iron crankshaft. To increase the shaft fatigue durability, all crankpin fillets are shot peened during manufacture. The crankshaft rides on two lead bronze bearings; the front one housed in the crankcase and the rear one in the bearing plate.

REMOVAL. To remove the crankshaft, proceed as follows:

1. Remove the lock ring and retaining washer in front of the crankshaft gear.

2. Pull off the crankshaft gear. It has 2-1/4-20 UNC tapped holes for attaching a gear pulling ring. Use care not to damage teeth if the gear is to be reused (Figure 1 3E-7).

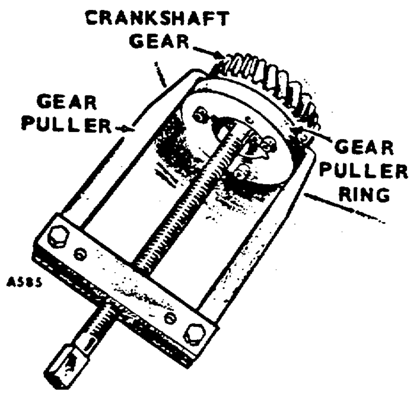


Figure 13E-7. Removing Crankshaft Gear

3. Remove the oil pan, piston and connecting rod.

4. Remove the rear bearing plate from the crankcase.

5. Remove the crankshaft through the rear opening in the crankcase.

INSPECTION. Clean the crankshaft and blow out all oil passages. Check journals for out-of-round, taper, grooving or ridges. Pay particular attention to ridges or grooves on either side of the oil hole areas. Unusual conditions here often point to previous neglect of oil changes. If journal dimensions are not within limits, or if the journals are scored, regrind the crankshaft.

CRANKSHAFT REGRINDING. Crankshaft grinding requires a trained, experienced operator working with precision equipment. Procedures which may be satisfactory for some spark ignition engines may well be unsatisfactory for diesel applications, resulting in expensive failures. On an emphasizes that if facilities or trained personnel are not available, the crankshaft may be sent to the factory.

Special procedures must be observed when reworking diesel crankshafts. In addition to machining, the crankshaft must be shot peened and super finished. Failure to *shot peen* the crankpin fillets is likely to cause early failure. When the shaft is machined, follow this data and Figure 1 3E-8 to shot peen each crankpin fillet.

1. Almen gauge reading, .012-A.
2. Peen with .019 inch diameter cast steel shot.
3. Peen for 15 seconds on each crankpin fillet.
4. Mask off connecting rod bearing areas.

Undersize bearings and connecting rods are available to rework the shaft to .010 inch, .020 inch and .030 inch undersize.

MAIN BEARINGS. Replace main bearings if clearances are greater than limits, or if the bearings are worn, grooved or broken. Precision replacement bearing inserts and thrust washers are available for all main bearings. Do not ream the bearings. Align the oil holes and press the new bearings into the front and rear housings.

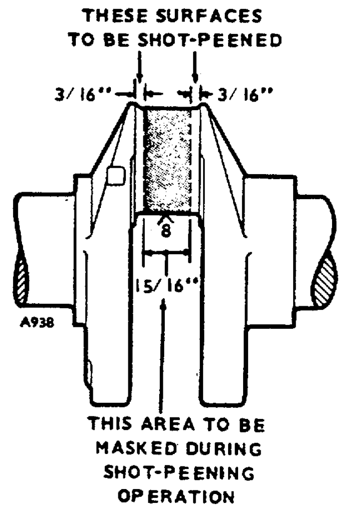


Figure 13E-8. Shot Peening Crankshaft

REAR OILSEAL. The rear oil seal is in the rear bearing plate. If damaged, drive it out from the inside of the plate. Using the oil seal installing tool, install a new seal with the rubber lip facing outward (open side of seal inward) Figure 13E-9. Drive the new seal flush with the rear surface of the bearing plate. Leave the seal installer on during bearing plate installation to protect the oil seal.

INSTALLATION. After each installation step, check the crankshaft to be sure it is not frozen into place. Install the crankshaft as follows:

1. Press the front and rear main bearings into place, aligning the bearing and bearing housing oil holes. Do not attempt to drive a bearing into a cold block or rear bearing plate (Figure 1 3E-9).

2. Install the thrust washers and locking pins.

3. Oil the bearing surfaces and install the crankshaft from the rear of the crankcase through the rear bearing plate hole.

4. Mount and secure the rear bearing plate.

5. Heat the timing gear on an electric burner or oven to about 3500F (1 770C). Install the key on the crankshaft, then drive the gear into place. Install the retaining washer and lock ring.

6. Check the crankshaft end play. Use enough rear bearing plate gaskets or shim and gaskets to provide .010 to .015 inch (0.254 to 0.381 mm) end play. If gaskets of more than .015 inch (0.381 mm) total thickness are required, use a steel shim of proper thickness and a thin gasket on each side of shim. This avoids excessive gasket compression and maintains bolt torque.

7. Install the piston assembly.

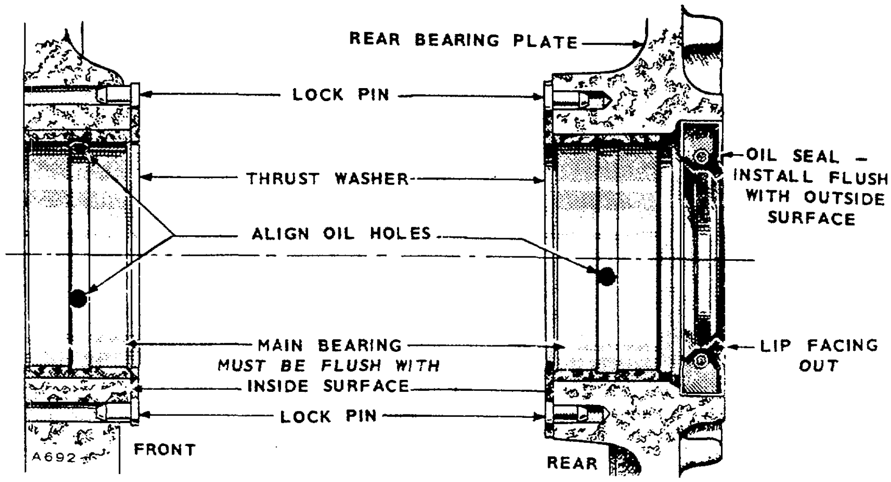


Figure 13E-9. Main Bearing Installation

CRANKCASE

If the crankcase is replaced, a new set of injection pump shims will be furnished with the new crankcase. These must be used and, in addition, the injection pump must be retimed to the engine. See Fuel System.

CYLINDER HEAD, VALVES

GENERAL

The cylinder head assembly has alloy hardened faced valves, release type rotators, alloy hardened inserts, guides, rocker arms, injection nozzle and glow plug. The push rods run through shields. The head assembly contains a decompression mechanism.

MAINTENANCE

Check the valve clearances at regular intervals. In addition, clean the combustion chamber and valve seats at regular intervals. Readjust decompression mechanism after adjusting valves.

TESTING

The cylinder compression test can be used to determine the condition of valves, the piston, piston rings and cylinder.

To check compression, run the engine until thoroughly warm. Stop it and remove the injection nozzle. Insert the compression gauge in the injection nozzle hole, crank the engine and note the reading. To check for piston blow-by, squirt a small amount of SAE 50 oil into the cylinder and repeat the check. An increase in compression with oil in the .cylinder indicates piston blow-by.

Another quick check of valve condition is to listen at the intake manifold (air cleaner removed) and the exhaust outlet while the engine is turned over by hand. A hissing sound indicates a leaking valve. Be careful when using this test because there will always be a slight hissing during the start of each compression stroke as the intake valve finishes closing.

VALVE CLEARANCE

Check valve clearance when the engine is at room temperature (about 700F (210C)). Allow at least two hours for engine to cool after operation.

1. Turn the flywheel until the cylinder is on its compression stroke. Use a socket wrench on the flywheel screw hex head.

To determine if the cylinder is in its compression stroke, observe the action of the push rods as the engine is rotated in a clockwise direction. The exhaust valve push rod will be in its lowest position and the intake valve push rod will be moving downward. As the piston reaches top dead center, the flywheel timing mark should be aligned with the timing pointer and the valve push rods stationary.

2. Now turn the flywheel clockwise an additional 10 to 450°. There is no timing mark for this position, so it must be estimated. With the piston located in this position, it will be in its power stroke with both valves completely closed.

3. To change the setting of valve clearance, adjust the locknut which secures the rocker arm to the cylinder head (see Figure 13E-10). Loosen the locknut to increase clearance and tighten it to reduce clearance.

4. After allowing engine to cool, check the clearance with a feeler gauge between the rocker arm and the valve(see Figure 13E-11). Increase or reduce the clearance until the proper gap is established. Correct valve clearance is .011 inch intake .008 inch (0.203 mm) exhaust.

Compression of early (pre-Spec. P) engines will indicate 300 to 350 psi (2069 to 2413 kPa). Starting with Spec. P, compression tests should indicate 350-400 psi (2413 to 2758 kPa).

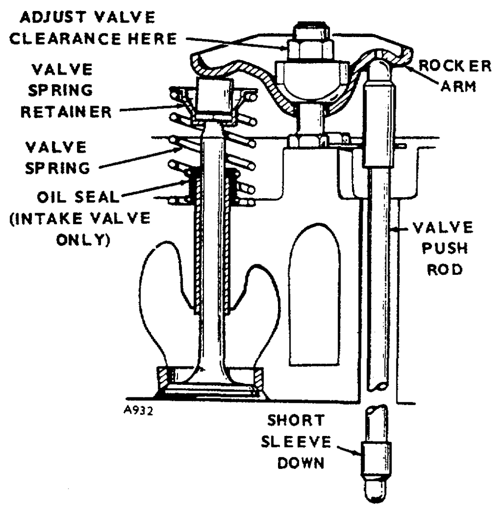


Figure 13E-10. Setting Valve Clearance

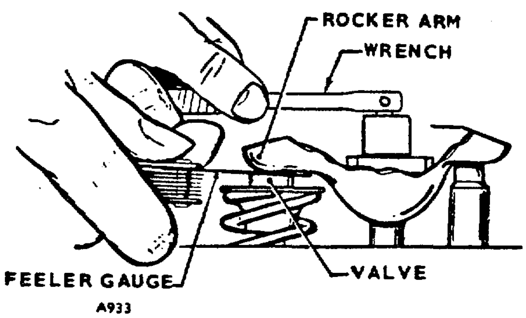


Figure 13E-11. Checking Valve Clearance

Compression reading will deviate from the above readings because of differences in cranking speed, altitude and ambient temperature conditions. Therefore, the specification is given only as a guide.

DISASSEMBLY

Disassemble the cylinder head as follows:

1. Remove the decompression solenoid.

2. Remove the rocker box cover, fuel nozzle and connecting oil lines to the cylinder head.

3. Remove the intake and exhaust manifold.

4. Remove the capscrews holding the cylinder head to the cylinder block.

5. Remove the head. If it sticks, rap it sharply with a soft hammer. Do not use a pry.
6. Remove the rocker arms and push rods.

7. Using a valve spring compressor, disassemble the valve assemblies.

REPAIR

GENERAL. Thoroughly clean all components of the cylinder head assembly. Remove all the carbon deposits from the intake and exhaust ports and clean all gasket surfaces.

VALVES. Remove all carbon and check each valve for burning, pitting or warped stem. Refinish valves that are slightly pitted or burned on an accurate valve grinder. Refinish intake valves to a 420° angle and exhaust valves to a 450° angle. If they are badly pitted or have a thin edge when refacing, replace them.

Check refinished valves for a tight seat to the valve seat with an air pressure type testing tool, or by applying Prussian Blue to the valve face and rotating it against the seat.

VALVE GUIDES. Check valve guide to valve clearance, (see Table of Clearances). If the proper clearances cannot be obtained by replacing the valves, replace the valve guides. Drive the old valve guides into the valve chambers. Drive new guides in until they protrude 11/32 inch (8.73 mm) from the rocker box side of the head. Ream the new valve guide to obtain the proper clearance.

VALVE SEATS. If the valve seats are pitted, refinish them. Using conventional seat grinding equipment, reface each seat to a 450 angle and a seat width of 3/64 inch to 1/16 inch (1.19 to 1.59 mm). You should be able to reface each seat several times before it becomes necessary to replace it. If, however, the valve seats are loose or cannot be refaced, replace them.

Use valve seat remover in a drill press (Figure 13E-12) to remove each valve seat. Adjust the tool to cut 1/64 inch (1.59 mm) from the edge of the seat. Oil the pilot to prevent it from seizing in the valve guide. Cut each seat down to a narrow rind on edges and bottom and break it out with a sharp tool. Be careful not to cut into the counterbore bottom.

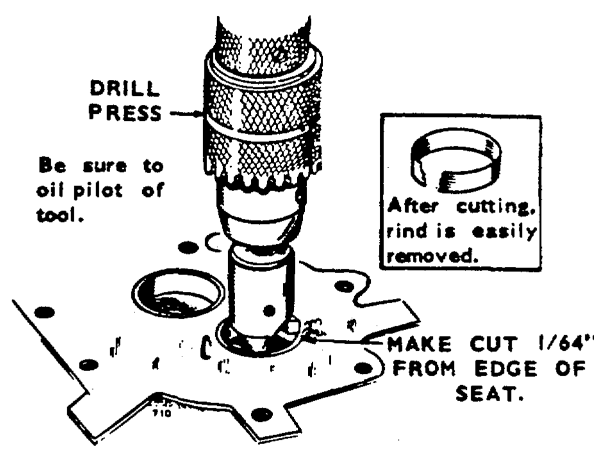


Figure 13E-12. Removing Valve Seats

Thoroughly clean the valve seat counterbore and remove any burrs from the edges. If the counterbore is damaged, it will have to be remachined for an oversize seat. Oversize seats are available in .002 inch, .005 inch, .010 inch and .025 inch. Otherwise, install new standard size seat inserts.

Drive the new valve seat inserts into place. Be certain that each seat rests solidly on the bottom of the counterbore at all points. To make installation easier, heat the cylinder head in an oven at 3250F (1 630C)for about 30 minutes and cool the valve seats in dry ice.

Face each new seat to a 450 angle and width of approximately 3/64 inch (1.19 mm). The finished seat face should contact approximately center of the valve face. Use Prussian Blue on each valve face to check this. Make any corrections on the seat, not the valve face.

When the new seats are installed and faced, insert the valve into each and check the clearance from valve head to the face of the cylinder head. This must be at least .030 inch (0.762 mm). If it is not, regrind the seat.

VALVE SPRINGS. Check the valve springs on an accurate compression scale. The valve spring load should register 45-49 lbs. closed; 83-93 lbs. open. Replace any weak, cracked or pitted spring, or one that has out-of-square ends.

INSTALLATION

Install the valves and cylinder as follows:

1. Push a valve stem oil seal onto the intake valve guide and clamp in place. Then oil the inside surface of the seal.
2. Oil the stem of each valve lightly and insert into its own guide.
3. Check each valve for a tight seat with an air pressure type tester. If a tester is not available, make pencil marks at intervals on the valve face and observe if the marks rub off uniformly when the valve is rotated part of a turn in the seat. If the seat is not tight, regrind the valves.
4. Using a valve spring compressor, compress each valve spring and insert the valve spring retainer and retainer locks.
5. Install the head assembly and gasket to the cylinder block. Tighten the head bolts evenly to 44 to 46 ft-lbs (60-62 N.m). See Figure 13E-13 for proper tightening sequence.
6. Install the exhaust manifold, nozzles, glow plugs and oil lines. Tighten manifold nuts evenly to 13-15 ft-lbs (18-20 N.m).
8. Install the push rods, rocker arms and rocker arm nuts.
9. Set the valve clearance. Intake is .01 1 inch (0.279 mm); exhaust is .008 inch (0.203 mm).
10. Install and adjust the decompression mechanism.
11. Install the rocker cover. Remove the solenoid, dip plunger O-ring in oil and reinstall when cover is on engine.

CAUTION

After the first 50 hours of operation, retighten the generator cylinder head bolts and check valve clearance. See Figure 13E-13.

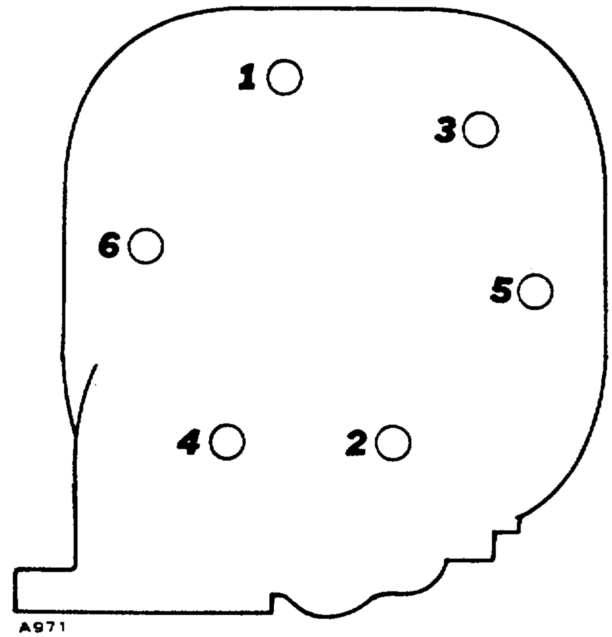


Figure 13E-13. Bolt Tightening Sequence

DECOMPRESSION RELEASE

The decompression release mounts on the cylinder head with a solenoid on the rocker box cover. It holds the exhaust valve open to allow the engine to build up speed during starting before compression occurs, and to stop the plant. The mechanism holds the exhaust valve open when the solenoid is de-energized. If the release is defective, replace any worn parts; otherwise, adjust it, following the instruction below.

NOTE

Before adjusting the decompression mechanism, the valves must be set for the correct clearance.

Figure 13E-14 shows the decompression release in detail. It must operate properly for dependable engine starting and stopping.

1. With the piston 100 to 450 past TDC on the power stroke, hold the arm in the decompression position (tension against spring). Turn the set screw so it just touches the exhaust rocker arm. The release arm must be tight against the snap ring during adjustment. Then turn the screw exactly one revolution clockwise. The original factory setting is marked with white or yellow paint.

NOTE

If the screw is tightened more than one turn, the exhaust valve could hit the piston.

Hold the set screw and lock it into position with the attached nut. Turn the nut hand tight plus 1/4 to 1/2 turn to lock the mechanism.

2. Release the mechanism to allow compression. Check the clearance between the screw and rocker arm. Insert a

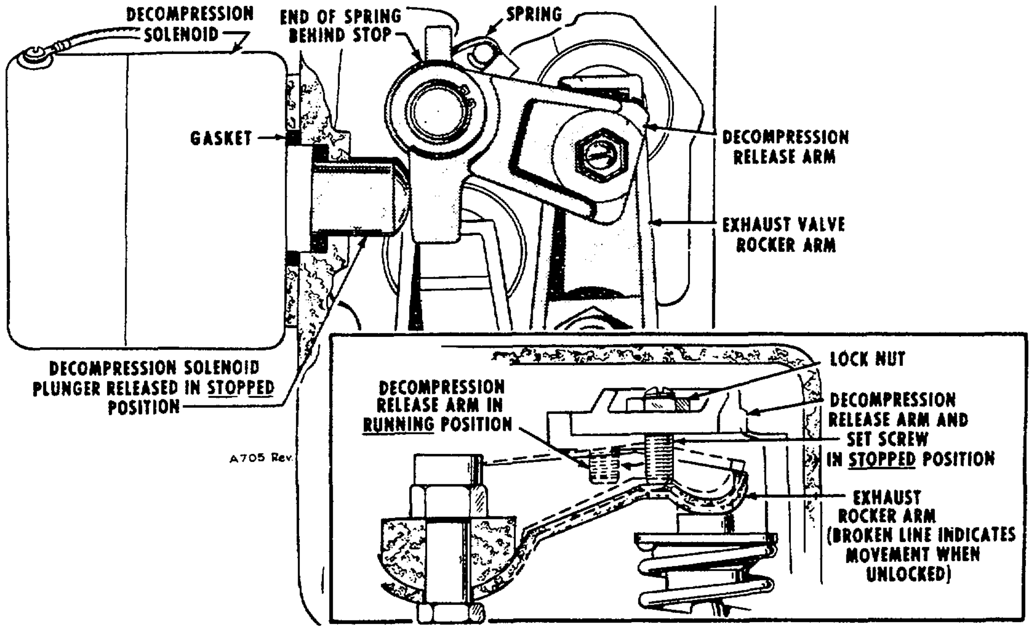


Figure 13E-14. Decompression Release

.008 inch feeler gauge between valve and rocker arm to take up valve clearance for this check. If there is no clearance, back off the sets crew until it just clears the rocker arm.

When reassembling the rocker cover, remove the solenoid, dip the plunger O-ring in oil and reinstall when cover is on the engine. Align solenoid so terminal "SW" is above terminal "IGN."

PISTON, RINGS, CONNECTING ROD

GENERAL

This engine uses a cam ground aluminum piston, tapered and fitted with three compression rings and an oil control ring. A full floating piston pin connects the piston to its connecting rod. The pin is held in place with a snap ring at each end. The lower end of the connecting rod contains half shell, precision bearings, and the upper end, semi-finished bushings.

CAUTION

Some engines are fitted with a .005 inch oversize piston and rings at the factory. These engines are marked with an E following the engine serial number.

REMOVAL AND DISASSEMBLY

Remove and disassemble the components as follows:

1. Drain the crankcase oil and remove the oil base.
2. Remove the cylinder head.
3. Remove the cap from the connecting rod and push the assembly through the top of the cylinder bore. Replace the cap and bearing inserts in the assembly.
4. Using a ring expander, remove the rings from the piston.
5. Remove the two retaining rings and push the piston pin from the piston.

REPAIR

CYLINDER. The cylinder wall should be free of scratches, pitting and scuffing. Check cylinder with an inside reading micrometer for out-of-round and wear. The bore should measure between 3.2495 inch and 3.2505 inch (8.2537 and 8.2563 mm) and be less than .001 inch (0.0254 mm).

If necessary, rebore the cylinder to fit the next available oversize piston. Pistons and rings are available in .005 inch, .010 inch, .020 inch, .030 inch and.040 inch oversize. If the cylinder does not need refinishing, remove any existing ridge from the top of the wall with a fine stone.

PISTON. Clean thoroughly and inspect the piston. Clean the carbon from the ring grooves and be sure all oil holes are open. If the piston is badly scored or burred, loose in the cylinder, has badly worn ring grooves or otherwise is not in good condition, replace it.

Check the clearance 900 from the axis of the piston pin and below the oil control ring. Clearance should be .0055-.0075 inch (0.1399-0.1905 mm), (prior to Spec. P, .0050-.0070 inch). If not, replace the piston and check the cylinder for possible reconditioning.

PISTON PIN. The piston pin should be a thumb push fit into the piston at room temperature. If the pin is excessively loose, install a new one. If the condition is not corrected, install the next oversize pin. If the piston is worn enough that the oversize pin will not fit, replace it. RINGS. Inspect each ring carefully for fit in the piston grooves and seating on the cylinder wall (Figure 1 3E-1 5). Fit each ring to the cylinder wall at the bottom of its travel, using the piston to square the ring in the bore. Check the gap with a feeler gauge. It should be .010 inch to .020 inch (0.254 to 0.508 mm). If the gap is too small, file the butt ends of the rings. Do not use rings that need a lot of filing, as they will not seat right on the cylinder wall. If an oversize piston is used, use the correct oversize rings.

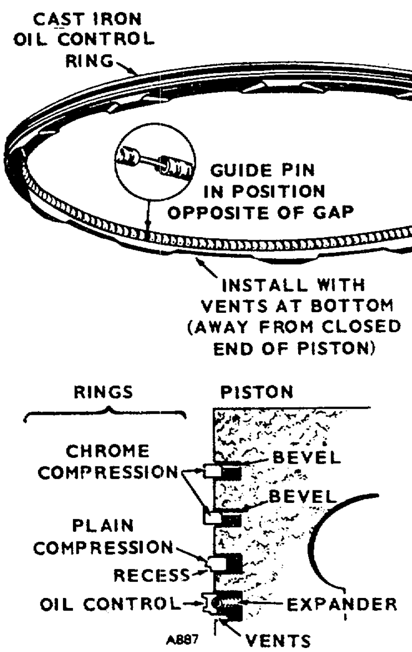


Figure 13E-15. Piston Rings

CONNECTING ROD. Clean the connecting rod and check for defects. Check the connecting rod bushings for proper clearance with the piston pin. Clearance should be .0002 inch to .0007 inch (0.0508 to 0.0179 mm).

If the bushings are excessively worn, press them out and install one new bushing from each side of the bushing bore. Press the new bushings only until flush with the sides of the rod to leave 1/1 6 inch to 7/64 inch (1.588 to 2.778 mm)oil groove in the center (Figure 13E-16).

CONNECTING ROD BEARINGS. Inspect the connecting rod bearings for burrs, breaks, pits and wear. Measure the clearance between bearings and the crankshaft journal. The clearance should be .001 inch to .0033 inch (0.025 to 0.0838 mm). If necessary, replace with new standard or oversize precision bearings

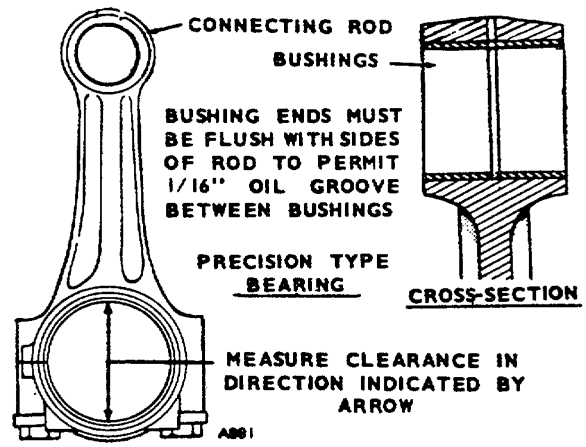


Figure 13E-16. Connecting Rod Bushings

For information about the crankpin journals, see Engine Disassembly.

ASSEMBLY AND INSTALLATION

To assemble and install the components, proceed as follows:

1. Install the connecting rod on the piston, with the pin and retaining rings. If new bushings were installed, make certain the ends are flush with the connecting rod to provide for the oil recess in the center.
2. Install the rings on the piston. Rings will be marked top, or identified in some other manner. Place this mark toward the closed end of the piston. Space the ring gaps one fourth of the way around the piston from one another. No gap should be in line with the piston pin. Oil the rings and piston. Gap in oil ring expander must be approximately 1800 from gap in oil ring.
3. Position a bearing half in the connecting rod. Be sure there is no dirt under the bearing. This could cause high spots and early bearing failure.
4. Oil the cylinder wall. Install the piston in the cylinder using a suitable installer. The assembly should be installed with the stamp on the piston facing in the same direction as when removed. The notch on the piston should be on the front of the engine.
5. Position the connecting rod on the crankshaft, oil the journal and install its rod cap with bearing half. When installing the rod cap, position so the raised witness mark on the forging matches the mark on the connecting rod.
6. Tighten the capscrews to the specified torque.
7. Crank the engine over by hand to see that the bearings are free.
8. Install the oil base with a new gasket.
9. Install the cylinder head using an even bolt tightening sequence and specified torque.

10. Replace oil.

BREAK-IN PERIOD

Whenever a new piston or rings are installed or the cylinder refinished, the engine must be run-in before regular operation can be resumed. Run the engine for 15-20 minutes at no load, about 30 minutes at 1/3 load and 2 to 3 hours at 2/3 load. Regular operation can then be resumed. Avoid light load operation during the following several hours for best ring seating to control oil.

COOLING SYSTEM

GENERAL

To remove the heat produced during operation, the generating plant uses a pressure air cooling system. Blades on the engine flywheel draw air into the front of the engine housing and force the air past the cylinder and out the right side of the engine. A separate blower on the generator rotor draws air into the rear of the generator and forces it out through openings near the engine.

For the engine outlet, air can be ducted out of the area. An optional shutter assembly can be installed on the air outlet to improve engine temperature control.

MAINTENANCE

With a properly installed engine, maintenance should consist of cleaning the engine cooling area (fins on cylinder head) at regular intervals, normally every 1,000 hours but more often under dirty operating conditions.

OVERHEATING

The first sign is usually a dark exhaust smoke and loss of engine power, which results in a speed loss. This happens before the engine seizes, and results in a seized piston, or worse. At the first sign of speed or power loss the plant should be stopped, if possible, and the cause found.

The most probable causes of overheating are dirty cooling surfaces, operating without the engine air housing, poor air circulation, improper lubrication, wrong injection timing or engine overloaded.

Piston rings and nozzles will generally stick before the piston seizes.

CAUTION

The air housing, including the door, must be on when operating the engine. Overheating and permanent damage can result from as little as one minute of operation without it.

FUEL SYSTEM

GENERAL

The diesel fuel system provides a means of filtering, transporting and delivering fuel in a fine spray to the engine cylinder at the correct time for ignition. The system consists of a primary fuel filter, fuel transfer pump, secondary fuel filter, injection pump and an injection nozzle. Figure 13E-17 shows the fuel system.

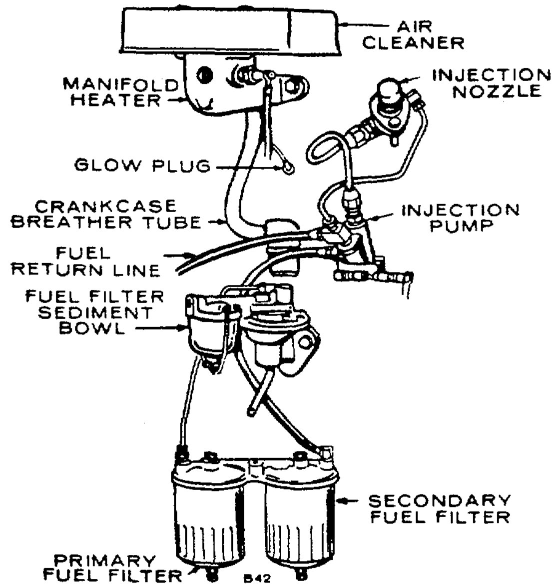


Figure 13E-17. Diesel Fuel System

The diaphragm fuel transfer pump which operates directly off the engine camshaft, draws fuel from a supply tank and delivers it through two filters to the injection pump. The injection pump meters fuel and delivers it at high pressure to the injection nozzle at the correct time for ignition.

The injection nozzle opens at a set pressure delivering fuel in a fine spray to the precombustion chamber for ignition.

Excess fuel is returned to the tank after each injection cycle by a fuel return line from the nozzle. An adapter combines the leak off fuel with the flow through fuel from the injection pump. A return line connected at this point returns the combined fuel back to the fuel supply tank.

CAUTION

A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.

FUEL FILTERS

Fuel filters are required for protection of the fuel injection system, even though good fuel handling practices are followed. It is absolutely necessary to use filters capable of removing micron size particles from the fuel.

Two stage filtration is supplied. The first stage of filtration is a 10 micron filter which has a replaceable cartridge, air bleed and drain valve. This filter is installed on the suction side of the fuel transfer pump and provides protection for the pump as well as the injection system when extremely adverse conditions are encountered, such as mobile installations or construction sites.

Fuel transfer pumps have a glass sediment bowl which traps water and sediment. If water or sediment are seen at this point (in continuing amounts), an additional filter and water trap should be installed at the supply outlet.

The final stage of filtration is accomplished with a 2 to 5 micron filter (particle sizes from 0.00080to0.000200 inch). Particles larger in size would eventually damage the injec-. tion equipment.

AIR CLEANER

Check the air cleaner after each 50 hours of operation. Wash the filter element.

Starting with Spec. S, a new fuel filtration system accommodates both primary and secondary fuel filters on a common mounting casting which is bolted to a newly designed oil fill tube. The engine cannot be run with either filter loose or missing, thus ensuring proper lubrication at all times.

The drains are located on the bottom of each filter housing. A damaged fitting may cause fuel leakage. To avoid damage, use two wrenches on each fitting when draining the filters. This will avoid the possibility of the upper drain fitting nut twisting away from the sheet metal housing.

In addition to regular service periods, change the secondary fuel filter cartridge if the engine shows signs of starving from lack of fuel. Remove the secondary filter by removing the large screw in the center of the filter cover. Use care when replacing the filter cartridge to avoid getting dirt into the injection pump passages.

When replacing or cleaning filters, bleed the fuel system. Do this by opening the air bleed screw located on top of the secondary filter removal capscrew. Operate the hand priming lever on the transfer pump until no air bubbles flow from the bleed screw hole, then tighten the bleed screw. Return the priming lever to its original position (Figure 13E-18).

NOTE

> If the transfer pump cam lobe is on the high side, the priming lever will not operate the pump. Turn the engine one revolution before operating the priming lever.

FUEL TRANSFER PUMP

GENERAL. Fuel transfer pumps are automotive type, incorporating a diaphragm and check valves. These pumps are operated by a rocker arm which rides on an eccentric camshaft lobe. The diaphragm spring maintains required fuel pressure to the injection pump. Fuel pressure should be 31/4 to 4-1/2 psi (22.4 to 31.0 kPa).

If fuel does not reach the secondary filter, make the following checks before removing the pump.

1. Check the fuel tank and see that the shut-off valve is open.

2. Remove the fuel line from the transfer pump outlet and work the priming lever on the pump. Fuel should spurt out of the pump. If not, remove the pump for repair or replacement.

TESTING. If the transfer pump delivers fuel, test it with a pressure gauge or manometer. Perform these tests before removing the pump from the engine. Remove the pump outlet and install the pressure gauge (Figure 13E-19).

Run engine at governed speed with fuel supplied by gravity feed. The pressure gauge should show 3-1/4 to 4-1/2 psi (22.4 to 31.0 kPa), with the gauge 16 inches above the fuel pump. A low pressure reading indicates extreme wear in

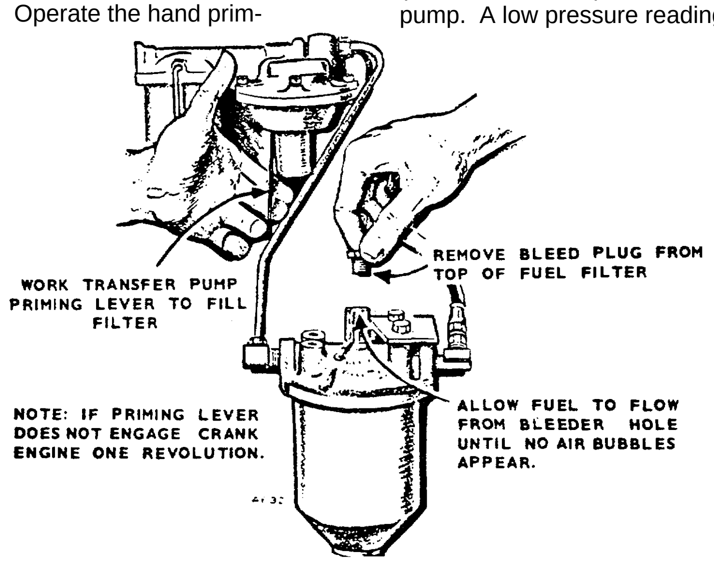


Figure 13E-18. Bleeding Fuel System

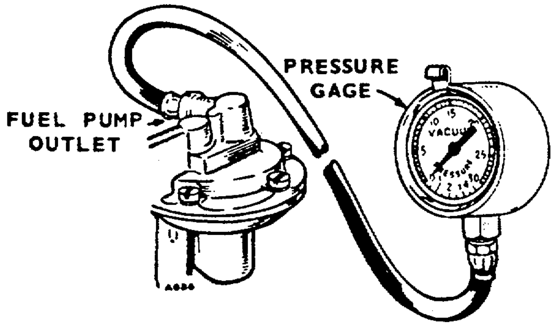


Figure 13E-19. Fuel Pressure Gauge

one part or some wear in all parts, and the pump should be overhauled or replaced. If the reading is above maximum, the diaphragm is probably too tight or the diaphragm spring too strong. This can also be caused by fuel seeping under the diaphragm retainer nut and between the diaphragm layers, causing a bulge in the diaphragm. Overhaul the pump and replace the defective parts. Low pressure, with little or no pressure leak after pumping stops, indicate a weak or broken spring or worn linkage, and in most cases the pump should be replaced. Figure 1 3E-20 shows the fuel transfer pump. Refer to it for disassembly/assembly.

FUEL PUMP REMOVAL AND DISASSEMBLY. To remove and disassemble the fuel pump, proceed as follows:

1. Remove the pump inlet and outlet lines. Remove the two capscrews holding the pump to the engine and lift it off.

2. Notch the pump cover and body with a file so they can be reassembled in the same relative positions and remove the six screws holding them together.

3. Tap the body with a screwdriver to separate the two parts. Do not pry them apart; this would damage the diaphragm.

4. Lift out the diaphragm assembly and diaphragm spring.

REPAIR. Transfer pump failure is usually due to a leaking diaphragm, valve or valve gasket. A kit is available for replacement of these parts. Because the extent of wear cannot be detected by the eye, replace all parts in the kit. If the diaphragm is broken or leaks fuel, check for diluted crankcase oil and replace.

Occasionally, failure is due to a broken or weak spring or wear in the linkage. In this case, replace the worn part or install a new pump. Obtain replacement parts other than the repair kit from an original equipment parts distributor.

ASSEMBLY. To assemble the fuel pump, proceed as follows:

1. When installing a new diaphragm, soak it in fuel before assembling. Insert the diaphragm spring and soaked diaphragm into the pump body.

2. Insert the link and rocker arm into the body and hook it over the diaphragm pull rod. Align the rocker arm with the rocker arm pin hole and drive in the pin. The priming lever must be in its lowest position, as shown in Figure 13E-20, when installing the rocker arm.

3. Compress the rocker spring and install between the body and rocker arm.

4. Insert the valve cages, gaskets and valve cover plate. Position the inlet valve with spring showing and the outlet valve with spring in the cover recess (if valves were removed).

5. Assemble the cover to the body with notch marks lined up. Install the screws but do not tighten.

6. Push the rocker arm in full stroke and hold in this position to flex the diaphragm. The diaphragm must be flexed or it will deliver too much fuel pressure.

7. Tighten the cover screws alternately and securely, then release the rocker arm.

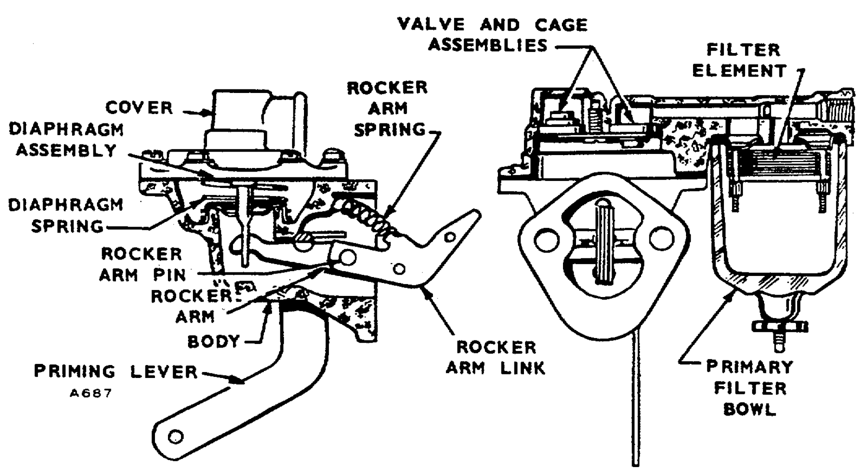


Figure 13E-20. Fuel Transfer Pump

8. Install the pump on the engine and repeat the pressure test.

NOZZLE

GENERAL. The American Bosch injection nozzle is the conventional inward opening, hydraulically operated pintle type with adjustable opening pressure. It is factory adjusted to open at 1,900 to 1,950 psi (13 100 to 13 445 kPa). After several hundred hours of operation the nozzle pressure will decrease to approximately 1,750 psi (1 2 066 kPa). Do not disassemble the nozzle or adjust nozzle pressure without proper test equipment. A nozzle pressure tester is essential to do this work.

OPERATING PRINCIPLE. Figure 13E-21 shows the parts of the injection nozzle. Nozzle operation is as follows:

1. High pressure fuel from the injection pump enters the fuel inlet stud (05), flows down the drilled passage in the body of the nozzle holder (04).

2. Fuel enters the fuel duct and pressure chamber of the nozzle assembly. When the fuel pressure overcomes the preset pressure of the adjusting spring (06), the pintle is forced upward off its seat and a fine mist of fuel is injected into the precombustion chamber.

NOTE

Do not disturb the pressure adjusting spring (06) as it cannot be reset without proper equipment.

TROUBLESHOOTING. If the cylinder is misfiring, it is reasonable to suspect that its nozzle is not operating properly. To inspect the nozzle spray pattern, remove the nozzle from the cylinder head. Crank the engine, let the nozzle spray into the air and watch the pattern. The spray should be cone shaped, with a solid appearing center surrounded by cloud like fog in which the spray is evenly atomized (Figure 13E22). An apparent chattering of the nozzle is normal

If streamers are visible, the pattern is badly distorted or the nozzle drips before it reaches opening pressure, it is defective, and must be cleaned or replaced.

WARNING

Do not let the nozzle spray against your skin. The fuel can penetrate flesh and cause a serious infection.

If the spray pattern of the nozzle appears to be satisfactory, other areas should be explored, such as compression pressure, etc.

INJECTION NOZZLE TESTING AND ADJUSTMENT. Testing adjustment can be performed only with a nozzle tester such as shown in Figure 13E-23. Clean procedure is extremely important when disassembling injection equipment. Always rinse in clean fuel before reassembling.

Opening pressure, leakage and spray pattern can be checked using this tester. If, when checking nozzles, any of the above malfunctions appear (except opening pressure), the nozzle valve and seat can be inspected with a magnifying glass for erosion, scoring, etc. If these conditions are present, and cleaning with solvent does not correct them, a new nozzle tip will be required. The opening pressure can then be set and spray pattern checked (see Figure 13E-22).

The nozzle opening pressure on a used nozzle should be set at 1,750 psi (12 066 kPa).

The nozzle tester and nozzle assembly cleaning kit are shown in Figure 13E-23.

Never use hard or sharp tools, emery paper, grinding powder or abrasives of any kind.

01. PROTECTION COVER
02. PRESSURE ADJUSTING SCREW
03. GASKET
04. NOZZLE HOLDER
05. FUEL INLET STUD
06. PRESSURE ADJUSTING SPRING
07. LOCKNUT
08. SPINDLE ASSEMBLY
09. NOZZLE CAP NUT

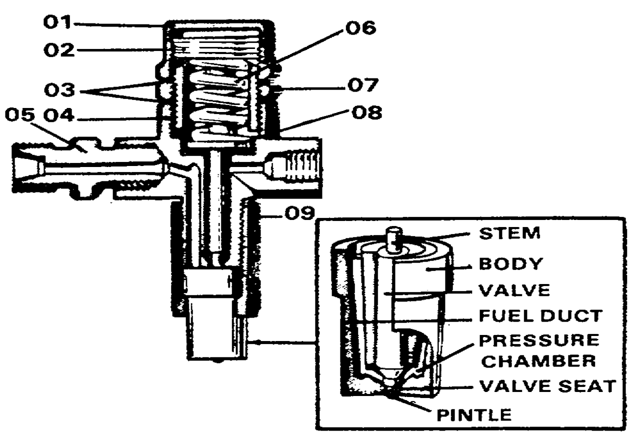


Figure 13E-21. Injection Nozzle

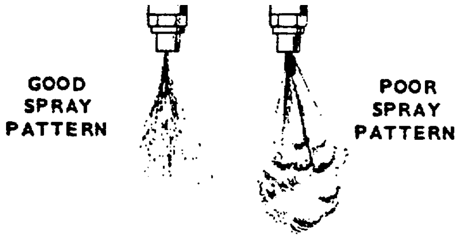


Figure 13E-22. Nozzle Spray Pattern

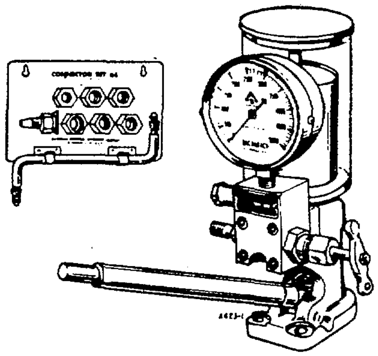


Figure 13E-23. Nozzle Tester and Cleaning Kit

Soak each nozzle in fuel to loosen dirt. Then clean the inside with a small strip of wood soaked in oil and the spray hole with a wood splinter. If necessary, clean the outer surfaces of the nozzle body with a brass brush, but do not attempt to scrape carbon from the nozzle surfaces. This can severely damage the spray hole. Use a soft oil soaked rag or mutton tallow and felt to clean the nozzle valve.

To adjust the opening pressure, remove the nozzle from the engine. Remove the cap nut over the adjusting screw of the nozzle and install the nozzle on a static fuel nozzle testing fixture (it may be purchased from Onan). Following the tester instructions, adjust the opening pressure to 1,750 psi (12 066 kPa) by turning the adjusting screw (Figure 13E24). Turning it clockwise increases the pressure and turning counterclockwise decreases it. Do not try to adjust the pressure without a testing fixture.

DISASSEMBLY. When removing and disassembling nozzles, separate and label all nozzle components. Never interchange components between nozzles.

1. Remove nozzle assembly from the engine and remove the fuel inlet and return lines.

2. Clamp the nozzle holder body in a vise and remove the nozzle cap nut and nozzle.

3. Install the nozzle cap nut loosely to protect the lapped surface for the holder body.

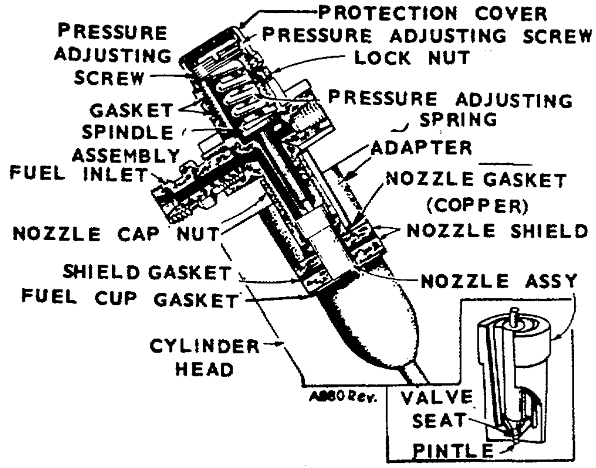


Figure 13E-24. Nozzle Assembly

4. If necessary to further disassemble the nozzle, reverse the pressure adjusting screw and lift out the spring and spindle assembly.

CLEANING. Cleanliness is essential in cleaning nozzles. Work only in a clean room, on a clean work bench. Keep a pan of clean diesel fuel handy and have a supply of clean, lint free wiping rags available.

REPAIR. If cleaning will not eliminate a nozzle defect, replace the nozzle or take it to an authorized service station. Do not attempt to replace nozzle parts, except for the nozzle and pintle assembly.

ASSEMBLY. Rinse both the valve and nozzle thoroughly before assembly and coat with oil. The valve must be free in the nozzle. Lift it about 1/3 out of the body. It should slide back to its seat without aid when the assembly is held at a450 angle. If necessary, work the valve into its body with clean mutton tallow.

1. Remove all pressure on the nozzle spring by adjusting the pressure adjusting screw.
2. Clamp the nozzle holder body in a vise.
3. Set the valve in the body and set the nozzle over it.
4. Install the nozzle cap nut loosely.
5. Place the centering sleeve over the nozzle (Figure 13E-25) for initial tightening. Then remove the centering sleeve to prevent it from binding between nozzle and cap nut and tighten the nozzle cap nut to specified torque.

INSTALLATION. Before installing the injection nozzle in the engine, thoroughly clean the mounting recess.

A dirty mounting surface could permit blow by, causing nozzle failure and a resulting power loss.

1. Install a new heat shield to head gasket in the cylinder head recess.

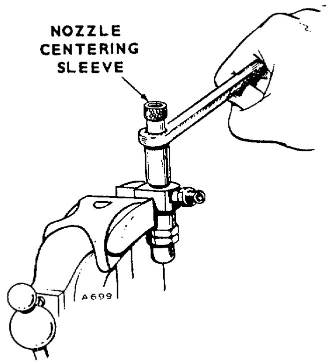


Figure 13E-25. Tightening Nozzle Cap Nut

2. Install the heat shield, a new nozzle gasket and the nozzle adapter.

3. Insert the nozzle assembly into the recess. Do not strike the tip against any hard surface.

4. Install the nozzle flange and two capscrews. Tighten the capscrews alternately to avoid cocking the nozzle assembly. Tighten each capscrew to 20-21 ft-lbs (27-28 N.m).

INJECTION PUMP

GENERAL. The American Bosch Model PLB single outlet pump is mounted on the left side of the engine crankcase. The camshaft operates the pump plunger, producing pressure to deliver fuel and open the injection nozzle. A control sleeve in the pump meters fuel by controlling the length of time the plunger port is closed in each stroke.

Model PLB, Figure 13E-26 illustrates the injection pump cross section. When the piston is nearing the end of the compression stroke, the plunger has moved upward (lower line, Figure 1 3E-26)closing the ports trapping fuel and forcing the delivery valve off its seat. The fuel flow is up past the

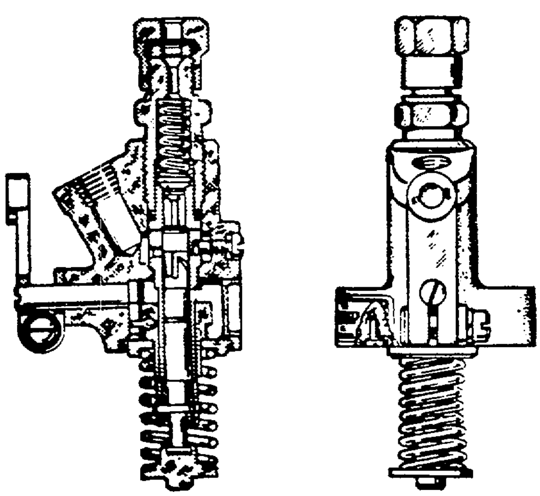


Figure 13E-26. PLB. Injection Pump

delivery valve and delivery valve spring to the high pressure line leading to the injection nozzle. Injection continues until the helix passes and spills, which drops the pressure rapidly. Delivery valve action is to aid in dropping line pressure and keep fuel from draining out of the line, allowing a void between the injection pump and nozzle which would cause the nozzle not to open on the next firing cycle.

Figure 13E-27 shows the helix on the plunger.

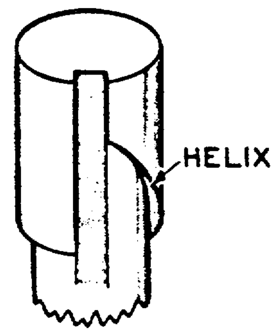


Figure 13E-27. Plunger Helix

The amount of fuel delivered is controlled by rotating the plunger, thus changing the length of its effective pumping stroke. The distance the plunger travels is always the same because the cam lift never varies.

Field repair of the injection pump is discouraged because of the exceptionally close tolerances between parts, and the specialized equipment necessary for repair. The injection pump is an expensive part of the unit and even a particle of dirt as fine as talcum powder could score its working surfaces. If the rest of the fuel system is in working order and fuel delivery is abnormal, remove the pump for replacement or repair. American Bosch maintains a world-wide repair service for these pumps.

REMOVAL. Remove the pump inlet and outlet lines. Remove the two capscrews holding the pump to the engine and lift it off. Don't lose the shims. They time the injection pump to the engine. Cap all openings in the pump and fuel lines to keep dirt out of the fuel system.

REPAIR. Most fuel system troubles are not due to a faulty injection pump. Test the rest of the fuel system before condemning the injection pump.

TIMING. Pump timing procedures determine the correct thickness of shims between pump and engine so port closing occurs at 17° BTC (before top center), and is marked PC on the flywheel. The control sleeve position controls port opening and is, in turn, controlled by the throttle setting.

The most accurate method of injection pump timing is with a depth micrometer (Method 1). However, if a depth micrometer isn't available, time it by Flowing the pump (Method 2).

NOTE

The injection pump must be timed on the compression stroke, not the exhaust stroke.

METHOD 1. DEPTH MICROMETER METHOD

1. Install pump tappet in its recess and position flywheel on the port closing mark (PC) of the compression stroke.
2. Using a depth micrometer, measure the distance from the pump mounting pad on the crankcase to the tappet center (Figure 1 3E-28).

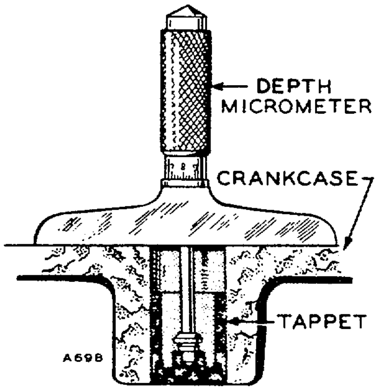


Figure 13E-28. Depth Micrometer

3. Subtract from the port closing dimension of the pump (1.670 inch) the depth obtained in Step 2. The result is the thickness of shims necessary to correctly time the pump.

NOTE

Shims thickness may vary from .006 inch to .052 inch. If it does not fall within these limits, check camshaft and tappet for excess wear or improper assembly.

4. Select the correct shims for the required thickness.

5. Install the pump.

METHOD 2. FOLLOW THE PUMP

1. Install pump with .006 inch shims between pump and pad.
2. Loosen the delivery valve holder to relieve pressure on spring (Figure 13E-29).
3. Rotate the flywheel to about 1 50 before the port closing (PC) point. Blow in the pump inlet and rotate the flywheel slowly clockwise until air stops coming out of the pump outlet. This is the port closing point.
4. Measure the distance from the point where port closing occurs to the PC mark on the flywheel. The Shim Thickness Chart shows the thickness of shims to be added.
5. Install the pump.

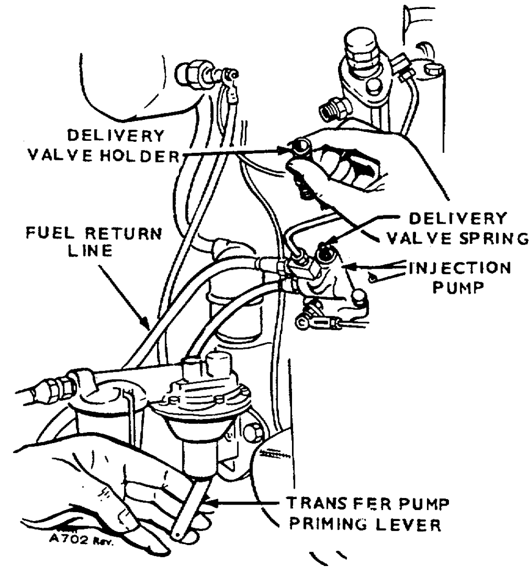


Figure 13E-29. Loosening Delivery Valve Holder

Method 2. Shim Thickness Chart

Distance Measured Step 4	Add These Shims	Distance Measured Step 4	Add These Shims
.1"	.004	.8"	.032
.2"	.008	.9",	.036
3"	.012	1.0"	.040
.4"	.016	1.1"	.044
.5"	.020	1.2"	.048
.6"	.024	1.3"	.052
.7" .	028		

INSTALLATION. Prior to mounting the injection pump to the cylinder block, follow steps 1 through 3.

1. Slide the shim or shims (using proper thickness of shims for correct timing) over the pilot until they are flat on the pump flange (Figure 13E-30).
2. Dip the seal (O-ring) in engine lubricating oil.

3. Slide the seal over the pilot until tight against the shim or shims.
4. With shims and seal in place insert the pump into cylinder block mounting pad, and insert mounting screws. Torque the mounting screws (tighten alternately) to 18-21 ft-lbs (24-28 N.m).
5. Install the fuel inlet line and governor linkage. Bleed the pump and then install the fuel outlet line.

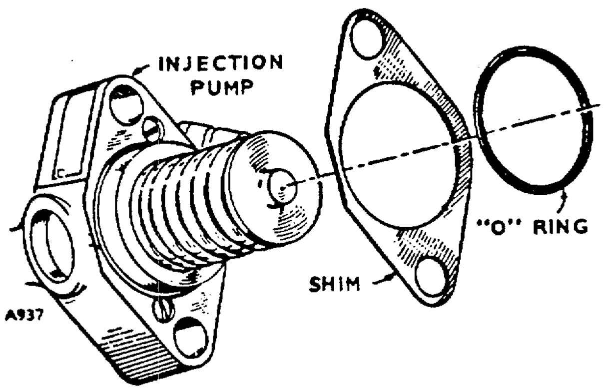


Figure 13E-30. Shimming the Pilot

OIL SYSTEM

GENERAL

These engines have pressure lubrication to all working parts. The oil system includes oil intake cup, gear type oil pump, bypass valve, oil pressure gauge, full flow oil filter, and block passages and drillings to deliver oil throughout the engine (Figure 13E-31). Oil is held in the oil base, drawn by the pump and delivered through the oil filter. Lines leading to the rocker housing, drillings through the block to crankshaft bearings and to front camshaft bearing, crankshaft passages to connecting rod bearings, and connecting rod passages to piston pin bushings complete the oil system plumbing.

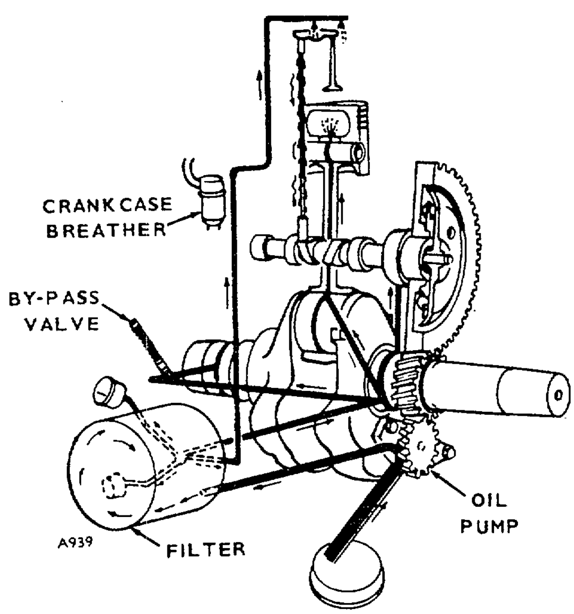


Figure 13E-31. Pressure Oil System

The crankcase breather is included in this system because it aids oil consumption control.

Oil pressure should be 25 psi (721 kPa) or higher when the engine is at normal operating temperature. If pressure drops below 20 psi (138 kPa) at governed speed, inspect the oil system for faulty components.

MAINTENANCE
Periodic oil system maintenance should include changing crankcase oil, cleaning the crankcase breather, cleaning rocker box oil lines, and replacing the oil filter. Consult the periodic service chart for service periods.

OIL PUMP
The oil pump is mounted on the front of the crankcase behind the gear cover and is driven by the crankshaft gear.

REMOVAL. To remove the oil pump, proceed as follows:
1. Remove the gear cover and oil base. (See Engine Disassembly.)

2. Unscrew the intake cup from the pump.
3. Remove the crankshaft lock ring and gear retaining washer.
4. Loosen the two capscrews holding the pump and remove pump.

REPAIR. Except for the gaskets, component parts of the pump are not individually available. If the pump is defective or excessively worn, replace it. Disassemble the pump by removing the two capscrews holding the pump cover to the body. Inspect for excessive wear in gears and shafts. To improve pump performance, adjust the gear end clearance by changing the gasket thickness between the pump body and cover. Use the thinnest gasket that permits free movement of the pump shaft. Oil all parts when assembling the pump.

INSTALLATION. Before installing, fill the pump intake and outlet with oil to be sure it is primed. Mount the pump on the engine and adjust for .005" (0.127 mm) lash between the pump gear and crankshaft gear. Mount the intake cup on the pump so it is parallel to the bottom of the crankcase.

BYPASS VALVE
Located on the outside of the rear bearing plate, the bypass valve (Figure 13E-32) controls oil pressure by allowing excess oil to flow directly back to the crankcase. Normally the valve begins to open at about 25 psi (172 kPa). It is not adjustable and normally requires no maintenance.
To determine if high oil pressure is caused by the plunger sticking closed or low oil pressure by the plunger sticking open, clean and inspect the valve.
To remove the valve, unscrew the recessed plug in the rear bearing plate and lift out the spring and plunger assembly. Determine proper valve operation by checking the spring and plunger against the values given below:

Plunger diameter ... . 3365 to .3380 inch
Spring free length . ... 2-5/16-1/16 inch
2.25 lb + .11 lb at 1-3/16 inch (compressed)

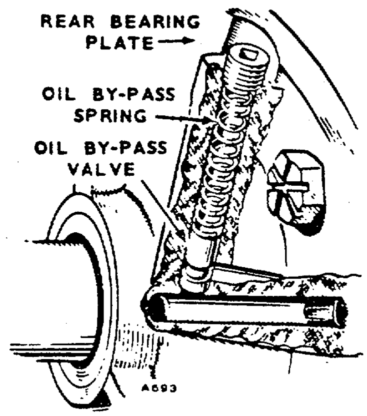


Figure 13E-32. Bypass Valve

OIL LINES

At overhaul time the rocker box oil line should be flushed with fuel and a fine wire used to clean the small holes (Figure 13E-33). Clean out all other oil lines and drillings with compressed air whenever the engine is disassembled or overhauled. Reach the oil gauge passage by removing the oil filter mounting plate.

oil lines, the rocker box oil line and the internal oil line to the rear bearing are replaceable, if damaged.

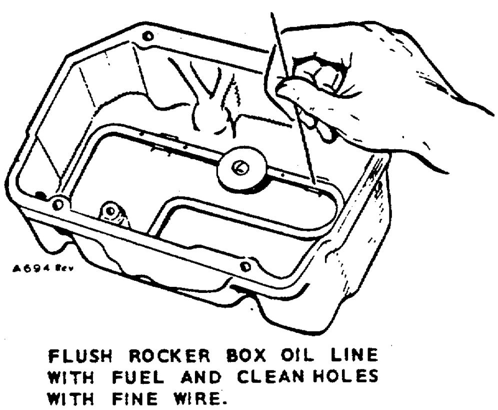


Figure 13E-33. Cleaning Rocker Box Oil Line

GAUGE

The oil pressure gauge is located on the lower front corner of the cylinder block. Remove it with a wrench and screw in a new gauge if it is faulty. Before replacing, check for clogged oil passage behind the gauge.

OIL PRESSURE SWITCH

GENERAL. The non-adjustable oil pressure switch controls the decompression solenoid in the starting system, allowing it to energize only when the switch closes. This allows the engine to build up speed during starting before compression occurs. The switch closes at about 5 psi under increasing oil pressure.

NOTE

This switch is not designed to be used as low oil pressure protection. It will not protect the engine against slowly decreasing oil pressure. The engine can be equipped with low oil pressure protection. See Low Oil Pressure Circuit. If the decompression solenoid won't energize, check switch operation by shorting oil pressure switch terminal to ground when engine has built up speed during starting. The solenoid should energize immediately and the engine should start.

CAUTION

If the engine starts, check immediately for oil pressure and shut the engine down if oil pressure doesn't build up within a few6econds. In this case it is lack of oil pressure that is causing faulty operation, not the switch.

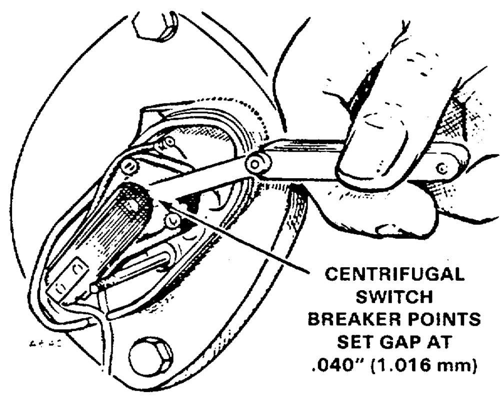


Figure 13E-34. Breaker Points

CENTRIFUGAL SWITCH. For plants with standard low oil pressure cut-off, this switch is mounted on the gear cover back plate and operates directly off the camshaft gear. Normally open, the switch closes when engine speed builds up to about 900 rpm. This allows engine to build up sufficient oil pressure and unit can be started.

For correct operation maintain the switch gap at .020 inch (0.508 mm). See Figure 13E-35.

DISASSEMBLY. To disassemble the pressure switch, proceed as follows (see Figure 13E-35):

1. Disconnect the battery to prevent accidental shorts.

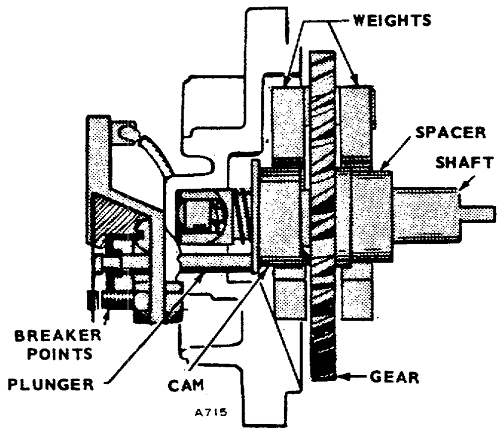


Figure 13E-35. Centrifugal Switch Assembly

2. Remove the switch cover, revealing the point set.
3. Remove the point set assembly by removing the screws holding it to the plate. Pull out the plunger and plunger diaphragm.
4. Remove the centrifugal switch plate, revealing the cam and weight assembly.
5. Pull out the cam and weight assembly.

CAUTION

Be careful not to lose the spacer mounted on the gear shaft behind the gear.

REPAIR. Thoroughly clean the gear and cam assembly, the bearing surfaces in the gear case and breaker plate, and oil trickle holes to these bearings. Check the oil spray hole in the gear case to be sure it is open.

Check for wear in the spacer, fiber plunger and the spring loaded shaft plunger. The spacer must be at least .35 inch (8.89 mm) long. If not, replace it immediately. Push the weights outward; they should move freely. If they don't, or if any part of the assembly is sticking or worn, replace the cam and weight assembly. If the cam is loose on the gear shaft, replace the assembly.

If the breaker gap cannot be maintained at .040 inch (1.016 mm), check the fiber plunger and spacer for wear.

ASSEMBLY. To assemble the pressure switch, proceed as follows:

1. Install the spacer on the shaft and install the shaft assembly into the gear case. Match it with the cam gear.

2. Install the spring and plunger into the end of the shaft.

3. Install the breaker plate.

4. Install the plunger and diaphragm.

5. Install the breaker points on the breaker plate and set the gap at .040 inch (1.016 mm).

6. Install switch cover and reconnect battery.

CRANKCASE BREATHER

crankcase breather is located in the left rear corner of the crankcase, and maintains a partial vacuum in the crankcase during engine operation. Its purpose is to ventilate the crankcase and control oil loss. It consists of a metal filter packed into the tube on the crankcase, a rubber cap with flipper valve, and a hose connecting it to the engine air horn.

To disassemble, remove the rubber cap from the crankcase tube and pry the valve out of the cap. Wash the valve in fuel at regular intervals and, if defective, replace it. At the same time, pull the baffle out of the breather tube and clean it. Install the valve with the perforated disk toward the engine. Figure 1 3E-36 shows the crankcase breather.

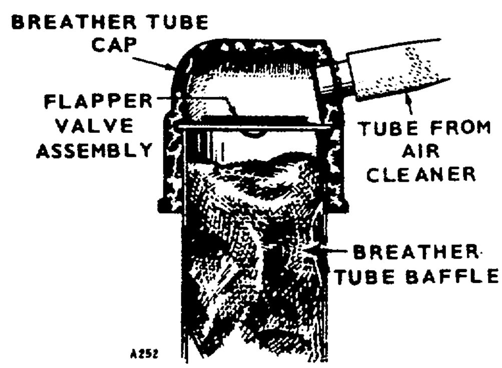


Figure 13E-36. Crankcase Breather

CRANKCASE BREATHER VALVE. This valve requires cleaning only. To clean, remove hose clamp, breather hose, breather cap clamp, and insulator valves (air cooled units only) to release breather cap and valve assembly. Wash the baffle in fuel, and reinstall. Figure 13E-37 shows the breather valve assembly. (Used on Spec. "R" and later models.)

GOVERNOR SYSTEM

GENERAL

The purpose of a governor is to maintain a nearly constant engine speed during changes in power demands. A governor responds to these power demand changes by varying the throttle position.

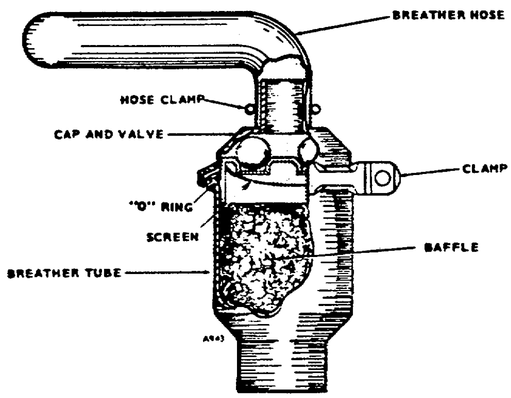


Figure 13E-37. Breather Valve Assembly

GOVERNORS

The constant speed governor(Figure 1 3E-38) maintains engine speed up to 1800 rpm, The speed sensing device is a ball and cup mechanism on the camshaft gear. A yoke, resting on the cup, is connected to the governor arm which, in turn, is connected to the throttle lever. Any change in engine speed is transmitted from the cup to the yoke and on to the throttle.

Tension on the governor spring determines the speed at which the engine is governed. A stud screwed into the spring is used to vary the number of effective coils for getting the desired sensitivity - the speed drop from no load to full load (prior to Spec. "R").

MAINTENANCE

Periodically lubricate the governor linkage with lubricating graphite or light non-gumming oil. During servicing, inspect the governor linkage for binding, or excessive slack or wear.

GOVERNOR ADJUSTMENT

SPEED ADJUSTMENT. To change the governor speed, change the spring tension by turning the governor spring nut (Figure 13E-39). Turn the nut clockwise (more spring tension) to increase rpm and counterclockwise to reduce governed speed. Hold a tachometer against flywheel capscrew.

SENSITIVITY ADJUSTMENT. To adjust governor sensitivity (no load to full load speed droop) turn the sensitivity adjusting ratchet accessible through a covered access hole on the side of the blower housing. Counterclockwise gives more sensitivity (less speed droop when full load is applied), clockwise gives less sensitivity (more speed droop). If the governor is too sensitive, a rapid hunting condition occurs (alternate increasing and decreasing speed). Adjust for maximum sensitivity without hunting. After sensitivity adjustment, the speed will require readjustment. After adjusting the governor, replace the knockout plug in the blower housing and secure speed stud locknut.

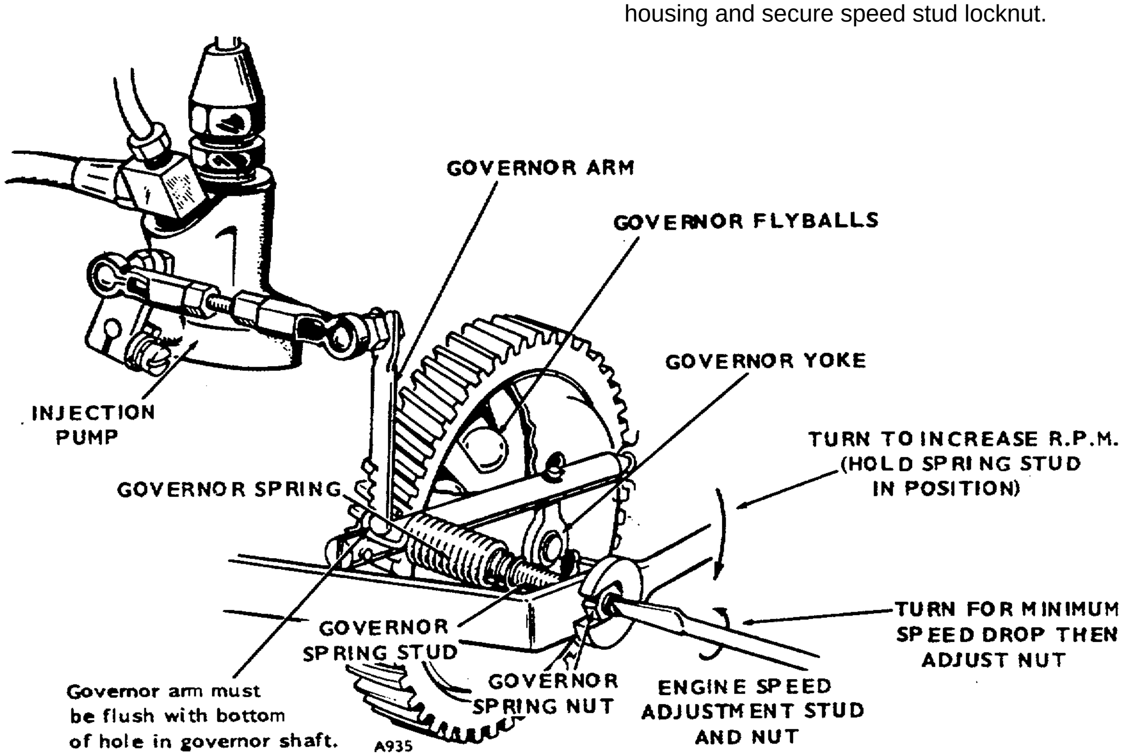


Figure 13E-38. Governor Assembly

Excessive droop may be caused by engine misfiring. Correct this condition before adjusting governor.

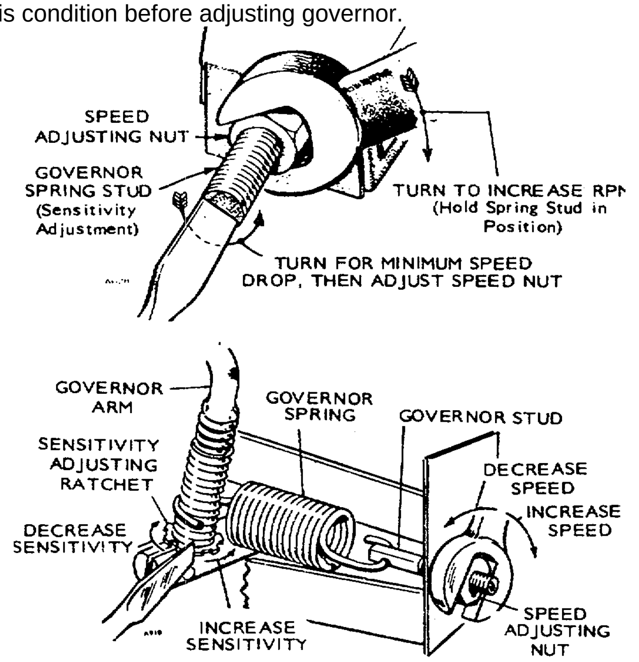


Figure 13E-39. Governor Adjustment

GENERATOR, REVOLVING ARMATURE

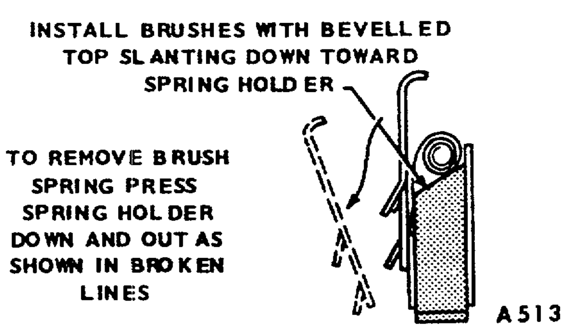
GENERAL

The revolving armature generator is used on DJA generating plants. It is a 4 pole, self-excited generator with inherent regulation. The generator serves as a starting motor and furnishes dc current to recharge the batteries during operation. This section covers ac plants and serves as a guide for dc battery charging plants.

MAINTENANCE

GENERAL. Normal maintenance procedures include periodic inspection of the armature, ball bearing, collector rings and commutator and the brushes, normally every 400 hours.

BRUSHES. To examine the brushes, remove the end bell band and cover (Figure 13E-40). Replace the brushes when they wear to the Onan name and part number. At this point there is about 5/8 inch (15.875 mm) of brush remaining. If the brush is not replaced, the slip rings or commutator will be damaged. All brushes must have at least a 50 percent seat. If they don't, sand as illustrated in Figure 1 3E-41.



13E-28

Figure 13E-40. Brush Installation

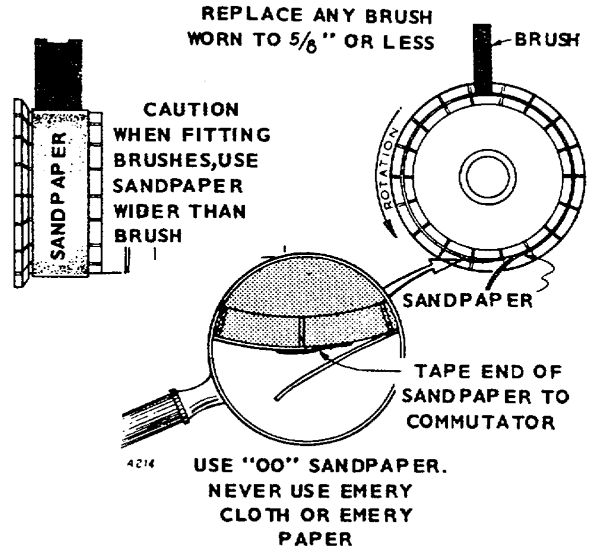


Figure 13E-41. Seating Brushes

GENERATOR BEARING. The generator bearing is prelubricated for its life and sealed. It requires no servicing.

COMMUTATOR AND COLLECTOR RINGS. The commutator must be clean and in good condition. If it is dirty, clean with paper or cloth. Do not use a cleaning solvent because it will destroy the film. Check the mica between the commutator bars. If it is above the level of the bars, undercut it.

ANTI-FLICKER POINTS AND RESISTOR. The anti-flicker breaker points are located on the left rear corner of the engine crankcase. The camshaft opens these points on every power stroke to add a resistor in series with the generator field windings. To adjust the points, crank the engine until the points are at full separation. Adjust the stationary contact to .025 inch (0.635 mm) gap. Retighten and check the gap. When breaker plunger guide and O-ring are removed, dip O-ring in oil before reinstalling. Tighten guide to 25 to 28 ft-lbs (33.9 to 38 N.m). Figure 13E-42 shows breaker point adjustment.

The adjustable flicker resistor is located on the right side of the control box. If flicker becomes excessive, adjust the resistor by moving its slider. Adjust resistor for minimum flicker with the average load on the plant.

TESTING AND REPAIR

GENERAL. Most of the following tests can be performed without disassembling the generator. Clearly mark all leads disconnected, together with the point taken from.

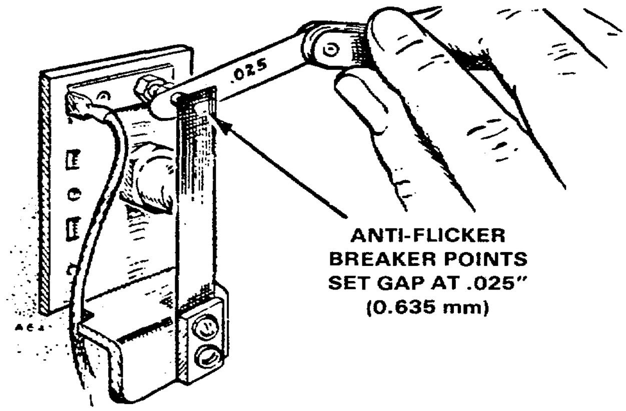


Figure 13E-42. Setting Breaker Points

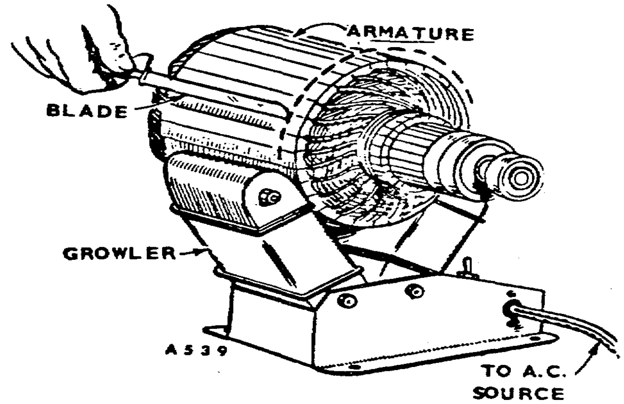


Figure 13E-43. Testing with Growler

ARMATURE TESTING. Before testing, remove all brushes from their holders.

1. Using a test lamp or ohmmeter, check the ac winding for an open circuit between the slip rings. If an open circuit is found, replace the armature.

2. Test both the slip rings and commutator for grounding to the shaft.

3. To test the armature for an open circuit in the dc windings, check continuity between all adjacent bars of the commutator. Open circuit problems can be seen, because they cause bar burring, arcing and poor cranking. Touch the probes to two adjacent bars and check for continuity. Move each probe over one bar and check again. Continue around the commutator. Any adjacent bars that don't show continuity indicate an open armature winding.

4. This test can only be performed with the generator disassembled and requires a growler. To test for shorts in the dc winding, place the armature in the growler. Operate the growler and pass a steel strip back and forth over and above the armature windings (Figure 13E-43). If the strip is magnetically attracted to the armature at any point, a short is indicated. After testing in one position, rotate the armature slightly and repeat the test. Do this for one complete revolution.

If the test indicates a short circuit in the dc windings, be sure the commutator is clean. Carbon dust, dirt or grease between the bars or slip rings can cause a short.
If the tests show that the armature is defective, replace it.

FIELD WINDING TESTS. The following tests can be performed without disassembling the generator, but the field coil leads must all be disconnected from their terminal points; brush rig, control box and external connections. If a defective coil is found, disassemble the generator and re-place the defective coil.

1. With an ohmmeter or continuity lamp, check for grounding to the generator frame. Touch one prod to the coil terminals and the other to a clean, paint free part of the frame. If grounding is indicated, separate the windings and check each.

2. Check the field winding resistance from F2 in the control box to the F+ connection on the generator (F+ is connected to the positive brushes). Resistance should be 1.46 ohms on standard ac models. Other models will have the following resistances:

2.06 ohms for 24 volt cranking
3.80 ohms for 32 volt cranking
0.80 ohms for transistor flicker
5.14 ohms for 24 volt battery charger
8.8 ohms for 32 volt battery charger

If the windings are warm from running, the resistance will be slightly higher. If the resistance is high, check for an open circuit in one of the parallel windings, step 3, other-wise go to step 4.

3. Separate the parallel field windings (at F+) and check each for open circuit.

4. Check for open circuit in the series winding with ohmmeter. Touch probes to lead S1 and connection F+. If there is an open circuit, isolate each coil and check it.

5. Test for short circuit between the starter windings and the shunt windings. Before doing this, separate all windings at F+.

COMMUTATOR REPAIR. The commutator bars wear down with use, so eventually the mica between them extends over the tops of the bars and causes sparking and noisy brushes. When the mica on any part of the commutator is touching the brushes, it must be undercut. A suitable undercutting tool can be made from a hacksaw blade (Figure 13E-44). Be careful not to injure the bars. After undercutting, remove any burrs formed on the bars. Cut the mica to about 1/32" (0.79 mm) under the bars.

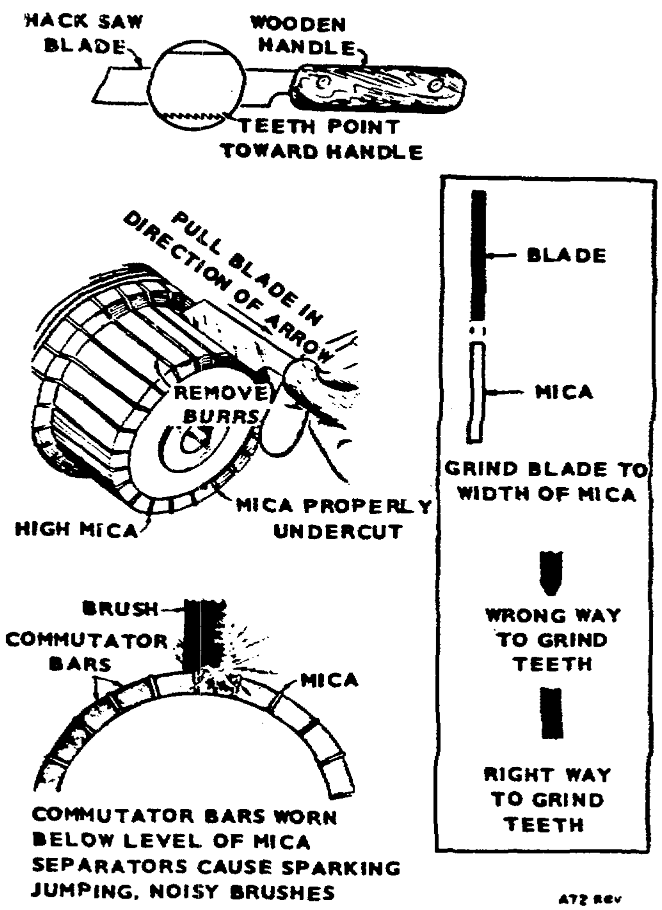


Figure 13E-44. Undercutting Commutator Mica

If the commutator is grooved, out-of-round, or otherwise damaged, refinish it. Turn it in a lathe and then undercut the mica as described above. Shield the ball bearing during refinishing. Do not use turning centers on shaft because they probably have been damaged and are no longer true centers. Commutator and slip ring run-out should be less than .002 inch (0.051 mm).

COLLECTOR RINGS. If the collector rings are grooved, out-of-round or rough, so good brush seating can't be maintained, remove the armature and refinish the rings in a lathe. Shield the ball bearing during refinishing. BALL BEARING. If the ball bearing becomes noisy, worn or otherwise defective, replace it. Remove the old ball bearing with a gear puller and drive or press a new one into place.

BRUSH RIG ALIGNMENT. The brush rig must be aligned in the neutral position. If it isn't sparking will occur. Normally the neutral position is identified by a yellow mark extend-ing from the brush rig tot he end bell. If the mark is lost, or a new brush rig installed, follow these instructions o find the neutral position:

1. With the end cover and band removed to allow access to the rig,

2. Start the unit.

3. Apply full rated load.

4. Allow unit to reach full operating temperature.

5. Inspect brushes; they must be seated across the brush face if we are to have an accurate setting.

6. Connect a voltmeter across the dc terminals.

7. Loosen the brush rig mounting screws and rotate the rig to get the highest voltage with full load.

8. Rotate the rig in one direction until the voltmeter reading starts to decrease. Mark this point See Figure 13E-45.

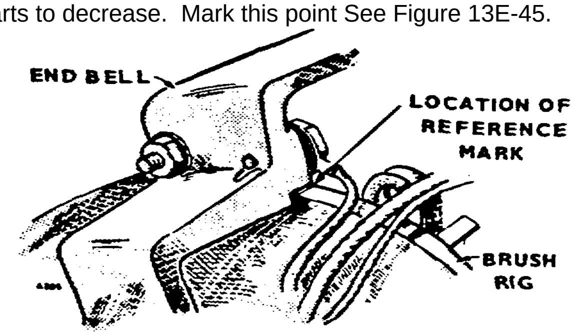


Figure 13E-45. Brush Rig Alignment

9. Repeat Step 8 in the other direction.

10. Half the distance between the two marked points is the neutral position.

NOTE

If a voltmeter is not available, use the above procedure, but mark the point where arcing begins in each direction and set it at one half the distance. (This procedure is not as accurate as the procedure above.)

NOTE

DO NOT tighten the armature or rotor through stud before mounting the frame and bearing support. If this procedure is not followed, misalignment may occur, shortening the life of the rear main and outboard bearings. Also, cranking torque requirements could be doubled, resulting in damage to the commutator and dc brushes on revolving armature units.

DISASSEMBLY

To disassemble the generator, proceed as follows:

1. The first step is to remove generator band and end bell cover. Remove all brush springs and lift the brushes from their holders.

2. Remove generator through stud nuts. Hold both the end bell and frame assembly, since they are separate parts, and remove them as one assembly from the adapter. Screw-

driver slots in the adapter provide for prying the frame loose. Be careful not to let the frame assembly rest or drag on the armature.

3. Remove baffle ring from adapter. Turn armature through stud nut out to the end of the through stud. While pulling the armature outward with one hand, strike a sharp end wise blow on the nut with a heavy soft faced hammer to loosen the armature. If the armature does not come loose, strike the armature with a sharp downward blow in the center of the lamination stack with a lead or plastic hammer. Rotate the armature and repeat. Be careful not to hit the collector rings, commutator, bearing or windings.

4. Upon disassembly, all parts should be wiped clean and visually inspected.

ASSEMBLY

To assemble the generator, proceed as follows:

1. Clean and inspect all mating surfaces. Surfaces should be free of nicks and dirt.

2. Clean mating area between the generator shaft and the engine crank shaft with a thin film of lubricating oil moly-coat, or equal.

3. Assemble the armature through stud to the engine crankshaft with required torque.

4. Check to see that the key is in the crankshaft.

5. Slide armature over the through stud and onto the crank-shaft, being careful not to let the weight of the armature rest on the through stud.

6. Install baffle ring, when used.

7. Assemble generator through studs to the adapter with required torque.

8. Install the frame and bearing support. Tighten frame to required torque. On "J" series with battery charging, make certain the B lead is run through the grommet in baffle ring and out the air discharge opening in the adapter.

9. NOW torque down the armature through stud nut. Be-cause you have tightened the frame and bearing support before tightening the armature, you have the armature and frame in alignment.

10. Tap the bearing support in the horizontal and vertical plane with a lead hammer to relieve stresses on the com-ponents and then recheck the torque.

11. Reconnect the decompression solenoid and other leads to the engine.

12. Reinstall the battery cables.

13. Align the brush rig.

CONTROL SYSTEM

MAINTENANCE

Reliable operation of the electric plant depends heavily upon the performance of the controls, as they are the "brains" of the plant, and must function properly to give dependable service. Connections should be periodically checked for tightness, as a loose connection can cause erratic performance.

The plant control system functions to control starting, stopping and battery recharging. It also provides emergency automatic stopping and engine preheating. The con-trol system and control system defects can best be analyzed with the aid of the proper wiring diagram.

When using wiring diagrams, remember these points. The views shown are modified pictorials. Components are shown in their actual positions, and normally the top view of each component is shown for terminal location. Dotted lines show the edges of the control box and indicate the direction from which it is being viewed, for example, "Top View". All relays are shown in the de-energized position. This section covers ac plants and serves as a guide for dc battery charging plants.

The generating plant uses the generator as a starting motor and a decompression solenoid on the engine rocker box to control the engine. The control system includes the start-ing circuit, a battery charging circuit with a reverse current relay, a preheating circuit, and the optional high air temperature cutoff. Figure 13E-46 shows the starting cycle in pictorial form.

The oil pressure switch on this model is used as part of the starting system.

If any component of the control circuit fails, replace it. Normally, it isn’t worthwhile to attempt repairs on individual relays, etc.

CONTROL COMPONENTS

STARTING AND STOPPING SYSTEM. The starting system includes the start solenoid, decompression solenoid and oil pressure switch: To stop the engine, the switch grounds the decompression solenoid relay, releasing the decompression solenoid which holds the exhaust valve open.

DECOMPRESSION SOLENOID. Mounted on the engine rocker box, the decompression solenoid controls a lever that holds the exhaust valve open. The solenoid contains 2 windings. Both are used to pull the plunger into the solenoid body. When the plunger hits bottom, it opens a set of contacts, de-energizing one coil while the other coil holds it in the energized position.

To test the solenoid operation, check plunger operation and current draw with 12 volt input to the solenoid. Current draw should be about 1 amp with the plunger fully in the solenoid body.

DECOMPRESSION SOLENOID RELAY. This single pole normally open relay controls the decompression solenoid. It energizes during the engine starting cycle when the oil pressure switch closes, and is de-energized by pushing the stop switch. This is not a 12 volt relay, and is wired in series with a 15 ohm resistor.

To test the relay, check the contact operation with a lamp or ohmmeter as indicator and check the coil continuity. The relay should energize with 5 volts input.

OIL PRESSURE SWITCH. The non-adjustable oil pressure switch controls the decompression solenoid, allowing it to energize only when the switch closes. This allows the engine to build up speed during starting before compression

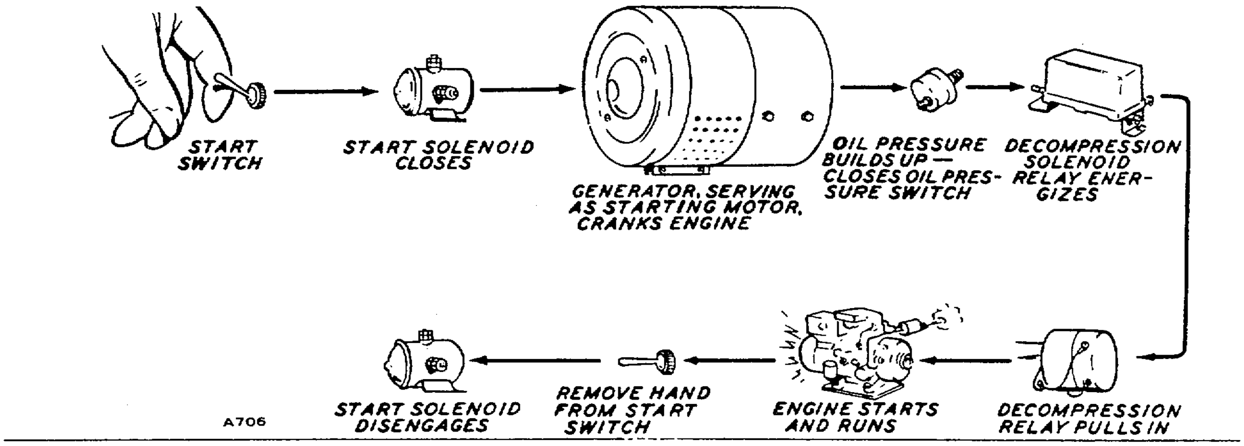


Figure 13E-46. DJA Starting Cycle

occurs. The switch closes at about 5 psi under increasing oil pressure.

NOTE

The is switch is not designed to be used as low oil pres-sure protection. It will not protect the engine against slowly decreasing oil pressure.

To check oil pressure switch operation, if the decompression solenoid won't energize, short to ground when engine has built up speed during starting. The solenoid should energize immediately and the engine should start.

CAUTION

If the engine starts, check immediately for oil pres-sure and shut the engine down if oil pressure doesn't build up within a few seconds. In this case it is lack of oil pressure that is causing faulty operation, not the switch.

STARTING SOLENOID. The starting solenoid controls the heavy currents required by the exciter starting motor. Test this solenoid for welded contacts across the main terminal or an open circuit in the coil.

IMPROPER USE. If the start switch is released when an engine slows at the peak of the first compression stroke, the very large current passing through the solenoid may burn or weld the contacts. Be sure the engine is revolving when the START switch is released. Momentary flips of the START switch in an attempt to "jar" the engine over compression will only result in damage to the starting solenoid.

BATTERY CHARGING CIRCUITS. Adjust the charge rate between 2 to 5 amps by moving the slider on the charge resis-tor.

The generator dc winding supplies current for the battery charging circuit. The current flows through the charge rate resistor, reverse current relay and charge ammeter to the battery.

REVERSE CURRENT RELAY. This relay allows current flow only from the generator to the battery, and opens when cur-rent attempts to flow in the other direction. To test the relay, isolate it by removing the generator connection (GEN). Check for continuity between the battery and generator terminals. Continuity here indicates that the relay contacts are welded together. Measure the resistance from the generator terminal to ground. This should be approximately 112 ohms.

PREHEATING CIRCUIT. This circuit consists of a manifold heater to heat the engine intake air in the intake manifold and a glow plug to heat the precombustion chamber. Used for engine starting, the manifold heater and glow plug are wired in parallel and controlled by a preheat switch.

Check the heater by removing its lead, operating the pre-heat switch, and touching the lead to its terminal. If it sparks, there is continuity and the heater is working. If any components of this circuit fail, replace them. Do not at-tempt repairs on individual components. If there is still a question, check the component for heating.

SPECIAL TOOLS

These tools are available from ONAN to aid service and repair work.

Crankshaft gear pulling ring	420A248
Diesel nozzle tester	420P184
Diesel pintle, nozzle cleaning tool set	
(includes injection nozzle centering tool)	420P208
Driver, front camshaft bearing	420A252
Driver, rear camshaft bearing	420B250
Driver, rear camshaft bearing (JA)	420B264
Driver, main bearing front and rear......................	420B269
Driver, valve seat..	420B270
Oil seal guide and driver.......................................	420B250
Valve seat remover..	420B272
Replacement blades for 420B272..................	420B274
Wrench, oil filter (for purolator	
full flow filter)	420B268

DIMENSIONS AND CLEARANCES

All clearances given at room temperature of 70°F.
All dimensions in Inches (metrics In parentheses) unless otherwise specified.

	Minimum	Maximum
CAMSHAFT		
Bearing Journal Diameter, Front	2.500 (63.5 mm)	2.505 (63.63 mm)
Bearing Journal Diameter, Rear	1.1875 (47.63 mm)	1.1880 (30.18 mm)
Bearing Clearance Limit	0.0012 (.031 mm)	0.0037 (.094 mm)
End Play, Camshaft	0.007 (.18 mm)	0.039 (.99 mm)
Cam Tappet Hole Diameter	0.7505 (19.06 mm)	0.7515 (19.09 mm)
Cam Tappet Diameter	0.7475 (18.99 mm)	0.7480 (19.00 mm)
CONNECTING RODS		
Large Bearing Bore Diameter	2.1871 (55.55 mm)	2.1876 (55.57 mm)
Small Bushing Bore Diameter	1.044 (26.52 mm)	1.045 (26.54 mm)
Distance Center Large Bearing Bore to Small Bushing Bore	5.998 (152.35 mm)	6.002 (152.45 mm)
Clearance, Large Bearing to Crankshaft	0.001 (.03 mm)	0.003 (.08 mm)
CYLINDER		
Cylinder, Bore	3-1/4 (82.55 mm)	
Cylinder Diameter Limits	3 2495 (82.54 mm)	3.2505 (82.56 mm)
CRANKSHAFT		
Main Bearing Journal Diameter	2.2437 (56.99 mm)	2.2445 (57.01 mm)
Crankshaft Main Bearing Clearance	0.0014 (.036 mm)	0.0052 (.132 mm.)
Connecting Rod Journal Diameter	2.0597 (52.32 mm)	2.0605 (52.34 mm)
End Play Crankshaft	010 (.25 mm)	0.015 (.38 mm)
PISTON		
Piston Clearance to Cylinder Wall	0.0055 (.140 mm)	0.0075 (191 mm)
Piston Pin Hole Diameter	0.9900 (25.146 mm)	0.9903 (25.153 mm)
Ring Groove Width, Top	0.097 (2.46 mm)	0.098 (2 49 mm)
2nd	0.0965 (2.45 mm)	0.0975 (2.48 mm)
3rd	0.0965 (2.45 mm)	0.0975 (2.48 mm)
4th	0.1880 (4.78 mm)	0.1895 (4.81 mm)
PISTON PIN		
Length	2.738 (69.55 mm)	2.753 (69.93 mm)
Diameter	0.9899 (25 14 mm)	0 9901 (25.15 mm,)
Piston Clearance	Thumb Push Fit	
Connecting Rod Bushing Clearance	0 0002 (.005 mm)	0.0007 (.018 mm,
PISTON RINGS		
Ring Type		
Top	Compression	
2nd	Compression	
3rd	Compression	
4th	Oil Control	
Ring Width		
Top	0.0925 (2.35 mm)	0.0935 (2 37 mm)
2nd	0.0925 (2.35 mm)	0.0935 (2 37 mm)
3rd	0.0925 (2.35 mm)	0.0935 (2.37 mm)
VALVE INTAKE (Hardened Chrome Alloy Faced)		
Stem Diameter	0.3381 (8.59 mm)	0.3420 (8 69 mm)
Clearance in Guide	0.0005 (.013 mm)	0.0025 (064 mm)
Seat Angle	42-degrees	
Valve Clearance	0.011 (.28 mm)	

VALVE, EXHAUST (Hardened Chrome Alloy)

Stem Diameter	0.3405 (8.65 mm)	0.3415 (8.67 mm)
Clearance in Guide	0.0025 (.063 mm)	0.0045 (114 mm)
Seat Angle	45-degrees	
Valve Clearance	0.008 (.20 mm)	

VALVE GUIDE

Length	1-25/32 (45.24 mm)	
Outside Diameter	0.4690 (11.91 mm)	0.4695 (11 93 mm)
Cylinder Block Bore Diameter	0.467 (11.86 mm)	0.468 (11.89 mm)
Inside Diameter (after reaming)		
Exhaust	0.344 (8.74 mm)	0.345 (8 76 mm)
Intake	0.342 (8.69 mm)	0.343 (8 71 mm)

VALVE SEATS (Hardened Chrome Alloy Faced)

Valve Seat Bore		
Diameter	1.361 (34.57 mm)	1.362 (34.59 mm)
Depth (from cylinder head face)	0.433 (11.00 mm)	0.439 (11.15 mm)
Seat Outside Diameter	1.364 (34.65 mm)	1.365 (34.67 mm)
Seat Width	3/64 (1.19 mm)	1/16 (1.59 mm)
Seat Angle	45-degrees	
Available Oversizes	0.002 (.05 mm); 0.005 (.13 mm); 0.010 (.25 mm); 0.025 (.64 mm)	

VALVE SPRINGS

Free Length	1-7/8 (22.23 mm)	
Length, Valve Closed	1.528 (38.81 mm)	
Load, Valve Closed	45 lbs. (20.41 kg)	49 lbs (22 23 kg)
Length, Valve Open	1.214 (30.84 mm)	
Load, Valve Open	83 lbs. (37.65 kg)	93 lbs. (42.18 kg)

SECTION XIV

BOOM SECTION REPAIR

BOOM SECTION REPAIR

GENERAL

Harnischfeger Corporation provides a worldwide boom repair service using certified Harnischfeger welders. We recommend that Harnischfeger welders do boom repairs whenever possible. Contact your local Harnischfeger Dealer to arrange for the services of a welder.

This procedure is provided as a guide to aid users in the proper repair of boom sections when our welders are not available.

IMPORTANT

Repairs made by other than a certified Harnischfeger welder are the responsibility of the person performing the repair. Harnischfeger Corporation assumes no liability for claims resulting from failures traceable to such repairs.

These instructions pertain to repair of laced bases, boom tips, inserts, masts, and tower crane head sections. Instructions apply to both tubular and angle chord booms. For repairs other than replacing lacing, as covered herein, contact the Harnischfeger Corporation Service Department.

BOOM MATERIALS

P&H booms are made of various high quality materials. To insure that replacement material is of the proper strength and size, it should be obtained from authorized Harnischfeger Corporation dealers.

Bulk lacing material may be obtained from any Harnischfeger Corporation dealer by giving the part number and serial number of the boom section to be repaired, along with the machine model and serial number.

Individually coped lacings can be obtained from any Harnischfeger Corporation dealer by giving the part number and serial number of the boom section to be repaired, identifying the physical location of the lacings to be re-placed on boom drawings available from all Harnischfeger dealers, along with the machine model and serial number.

NOTE

Typical boom identification plates showing the boom part number and serial number are shown in Figure 14-1.

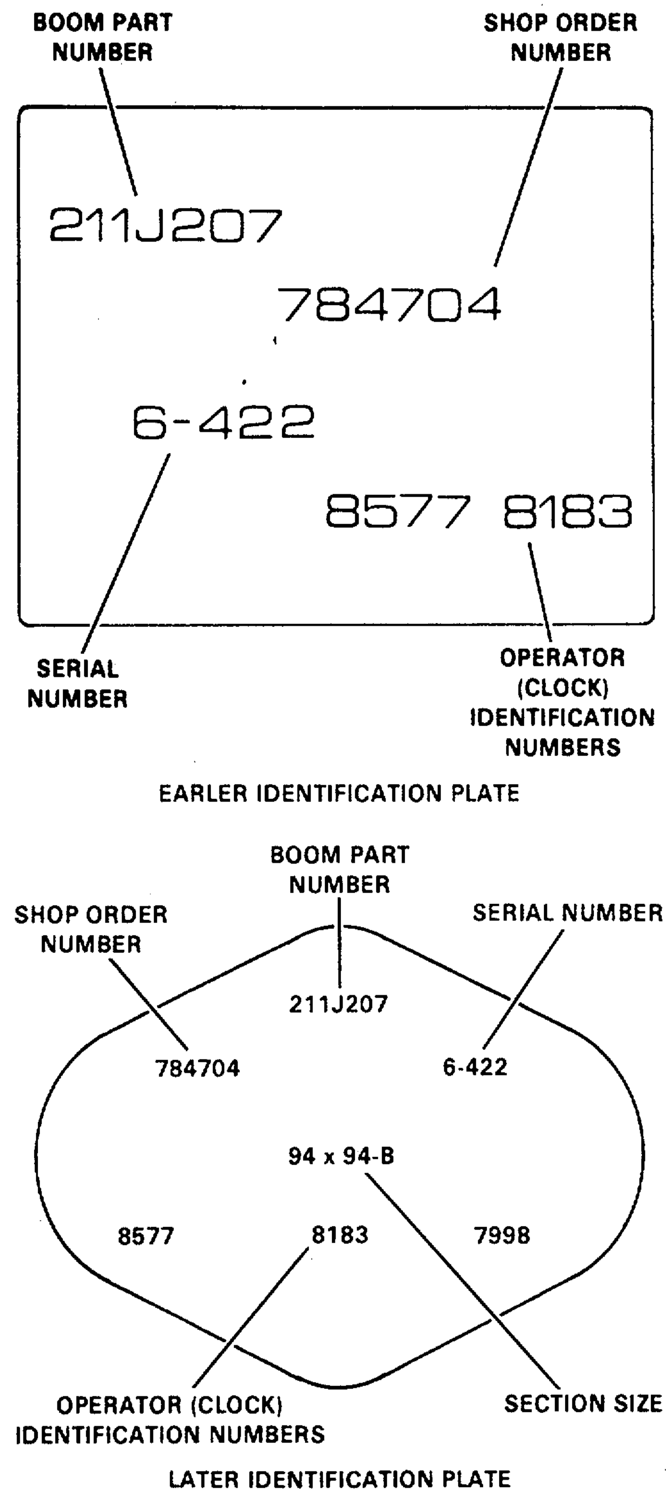


Figure 14-1. Boom Identification Plate

WELDING MATERIALS

Welding electrodes to be used must be high quality dry low-hydrogen type AWS-E-7018. Recommended sizes are 3/32" (2.4 mm) diameter or 1/8" (3.2 mm) diameter.

NOTE

> Do not use electrodes larger than 1/8" (3.2 mm) diameter, as the thin lacing walls make it extremely difficult to prevent burn through when using larger electrodes.

Electrodes must be purchased in hermetically sealed containers and maintained in their "as manufactured" condition until used. Once opened, these electrodes must be kept in a weld rod holding oven above 250°F (120°C) until used. No more than a two hour supply shall be exposed to the atmosphere at any one time.

All welding shall be done with direct current (D.C.) reversed polarity. This must be supplied by a D.C. rectifier or generator of sufficient capacity to deliver a minimum of 250 amps at 40 volts.

WELDER QUALIFICATION

Boom sections on a mobile crane are constructed from special alloy and heat treated steels requiring exacting fit-up and welding skills.

Only an experienced, skilled, and fully qualified welder may repair booms.

Practice before boom welding is very desirable. Since lac-ing material is, for the most part, thin wall, medium strength material, a very delicate touch and a high degree of skill is required to produce the weld joint between the heavier chord member walls and the thin wall lacing material. It is recommended that damaged lacing material removed from the boom section to be repaired be used to practice welding to 1/4" (6 mm) thick plate to obtain "feel" for the welding and proper welding machine settings. See Figure 14-2.

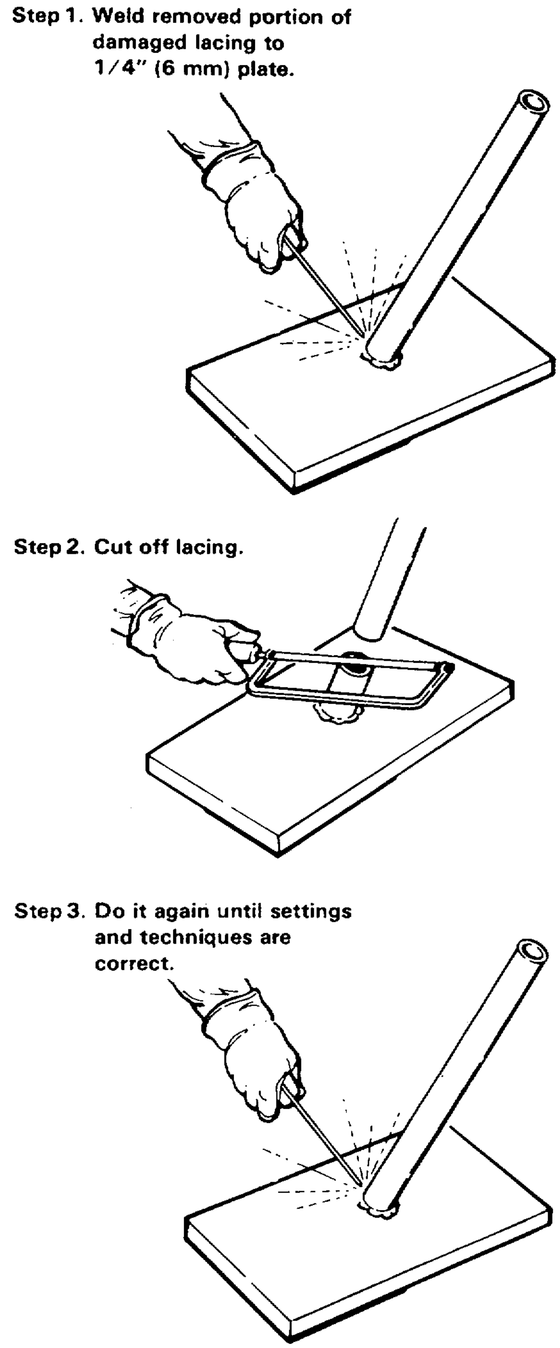


Figure 14-2. Practicing Welding Technique

EXTENT OF REPAIR

No welding shall be done on the corner structural members (referred to as chords) except to attach lacing members. No chord shall be replaced in whole or in part.

Heat shall not be used to straighten chords or lacings.

No more than 1/3 of the lacings on any side of the boom section should be replaced in one repair operation.

To insure structural integrity of the boom section, after repair, the chords shall meet the overall straightness requirements of Table 14-1. In addition, the individual chords and lacings shall meet the requirements of Table 14-2 measured between any two adjoining panel points (see Figure 14-3). These dimensions can be checked with a tight-line or straightedge, and shall be checked in two directions, 90 degrees apart.

All bent lacings must be replaced, since they pull the chords out of true alignment and can cause deflections in the chords which can contribute to failure of the boom section. Smooth sweep bends in lacings may be straightened by jacking back into alignment, with extreme care being taken not to kink or further damage bent lacings. If a lacing cannot be straightened within the 1/16 of an inch (1.6 mm) tolerance, it must be removed and replaced.

Angular distortion (twist), dl, shall be no more than 1/16 inch (1.6 mm) for a 10 foot (3048 mm) section or 1/8 inch (3.2 mm) for longer sections. See Figure 14-4.

Dents or dimples in chords or lacings shall not exceed those dimensions shown in Figure 14-5 and Table 14-3. There shall be no more than 2 dents between panel points (see Figure 14-3) and defects shall be at least 6 inches(1 50 mm) apart.

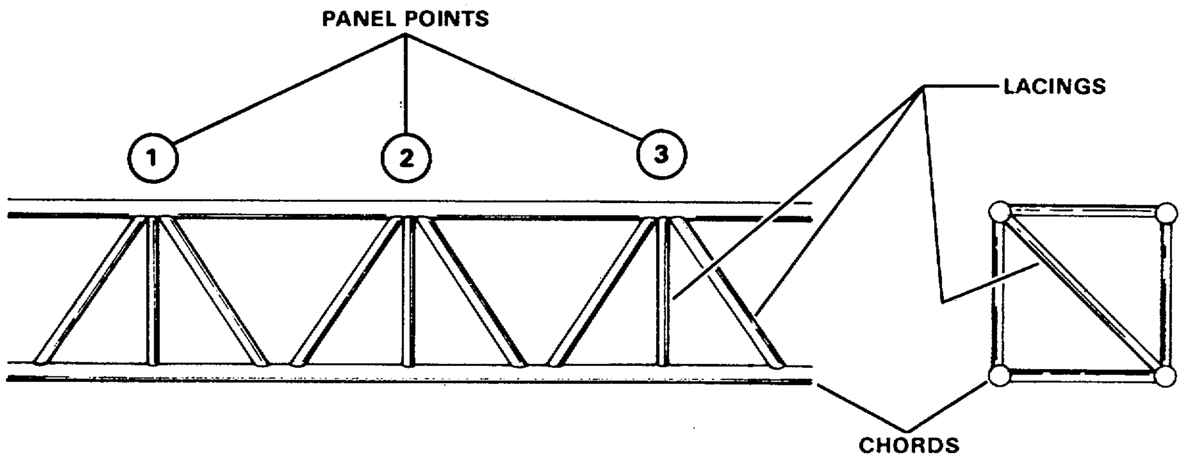


Figure 14-3. Nomenclature

Table 14-1. Overall Chord Straightness

Maximum Deviation Chord Length	Over Length of Chord
10 ft. or less (3048 mm or less)	.12 inches (3.2 mm)
Over 10 ft. to and including 30 ft. (Over 3048 mm to and including 9144 mm)	.19 inches (4.8 mm)
Over 30 ft. to and including 50 ft. (Over 9144 mm to and including 15,240 mm)	.25 inches (6.4 mm)

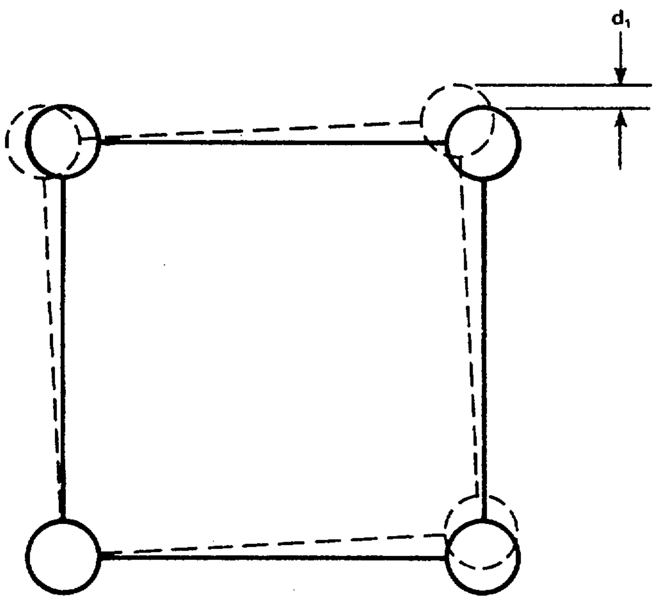


Figure 14-4. Angular Distortion

Table 14-2. Tube Straightness Between Panel Points

Tube Diameter		Maximum Deviation Between Panel Points	
inches	(mm)	inches	(mm)
Less Than 2	(51)	.062	(1.6)
2	(51)	.062	(1.6)
2.25	(57)	.068	(1.7)
2.5	(64)	.074	(1.9)
2.75	(70)	.080	(2.0)
3	(76)	.086	(2.2)
3.25	(83)	.092	(2.3)
3.5	(89)	.098	(2.5)
3.75	(95)	.10	(2.6)
4	(102)	.11	(2.8)
4.25	(108)	.12	(2.9)
4.5	(114)	.12	(3.1)
4.75	(121)	.13	(3.2)
5	(127)	.13	(3.4)
5.5	(140)	.14	(3.7)
6	(152)	.16	(4.0)
6.5	(165)	.17	(4.3)
7	(178)	.18	(4.6)
7.5	(191)	.19	(4.9)
8	(203)	.20	(5.2)
8.5	(216)	.21	(5.5)
9	(229)	.23	(5.8)
9.5	(241)	.24	(6.1)
10	(254)	.25	(6.4)

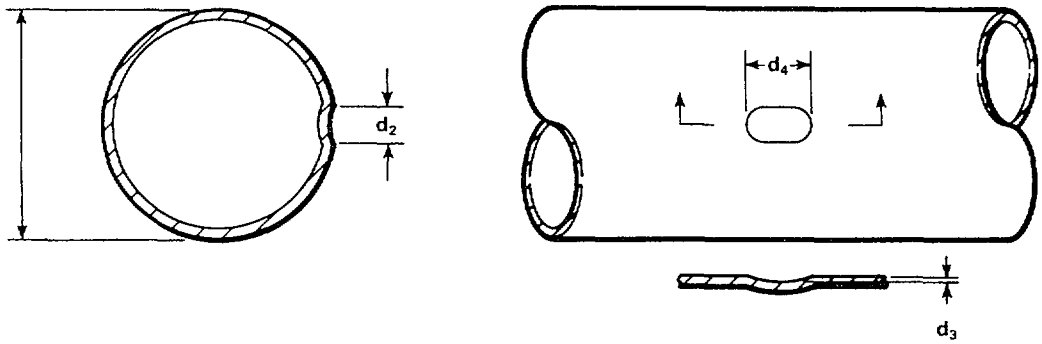


Figure 14-5. Dents or Dimples

Table 14-3. Dents or Dimples

D Tube Diameter inches	D Tube Diameter (mm)	d_2 Dent Width inches	d_2 Dent Width (mm)	d_3 Dent Depth inches	d_3 Dent Depth (mm)	d_4 Dent Length inches	d_4 Dent Length (mm)
1	(25)	.111	(2.8)	.025	(0.6)	.182	(4.6)
1.25	(32)	.139	(3.5)	.031	(0.8)	.227	(5.8)
1.5	(38)	.167	(4.2)	.038	(1.0)	.273	(6.9)
1.75	(44)	.194	(4.9)	.044	(1.1)	.318	(8.1)
2	(51)	.222	(5.6)	.050	(1.3)	.364	(9.2)
2.25	(57)	.250	(6.4)	.056	(1.4)	.409	(10)
2.5	(64)	.278	(7.1)	.063	(1.6)	.455	(12)
2.75	(70)	.306	(7.8)	.069	(1.7)	.500	(13)
3	(76)	.333	(8.5)	.075	(1.9)	.545	(14)
3.25	(83)	.361	(9.2)	.081	(2.1)	.591	(15)
3.5	(89)	.389	(9.9)	.088	(2.2)	.636	(16)
3.75	(95)	.417	(11)	.094	(2.4)	.682	(17)
4	(102)	.444	(11)	.100	(2.5)	.727	(18)
4.25	(108)	.472	(12)	.106	(2.7)	.773	(20)
4.5	(114)	.500	(13)	.113	(2.9)	.818	(21)
4.75	(121)	.528	(13)	.119	(3.0)	.864	(22)
5	(127)	.556	(14)	.125	(3.2)	.909	(23)
5.5	(140)	.611	(16)	.138	(3.5)	1.00	(25)
6	(152)	.667	(17)	.150	(3.8)	1.09	(28)
6.5	(165)	.722	(18)	.163	(4.1)	1.18	(30)
7	(178)	.778	(20)	.175	(4.4)	1.27	(32)
7.5	(191)	.833	(21)	.188	(4.8)	1.36	(35)
8	(203)	.889	(23)	.200	(5.1)	1.45	(37)
8.5	(216)	.944	(24)	.213	(5.4)	1.55	(39)
9	(229)	1.00	(25)	.225	(5.7)	1.64	(42)
9.5	(241)	1.06	(27)	.238	(6.0)	1.73	(44)
10	(254)	1.11	(28)	.250	(6.4)	1.82	(46)

Corrosion or abrasion damage to chords or lacings shall not exceed depths shown in Table 14-4 and illustrated as dimension d_6 in Figure 14-6. Corrosion or abrasion which is not deeper than the values of the last column of Table 14-4 can be disregarded.

The sum of the greatest dimensions of all corrosion or abrasion defects between panel points (see, Figure 14-3) shall not exceed those values shown in Table 14-3. An example of this dimension is shown as d5 in Figure 14-6.

TUBULAR BOOM LACING REPAIR PROCEDURE

Once a full and detailed inspection of the entire boom has been performed, and those lacing members that need to be replaced or straightened have been identified, the lacing replacement procedure for tubular chord booms is as follows:

1. If at all possible, replace only one lacing at a time and complete the repair before removing another so as to maintain the original chord alignment. If there is extensive damage and more than one lacing must be replaced at onetime, extreme care must be used to hold the chord In alignment, both vertically and horizontally, during replacement. All damaged lacings must be replaced with tubing of equivalent material and properties, size and wall thickness.

2. Tubular lacings to be replaced should be cut off mechanically, preferably with a hacksaw directly above the fillet weld attaching it to the chord, leaving the original weld on the chord member. Grind or file the remaining weld bead flush with the chord, using extreme care not to notch the chord or nick it in anyway. See Figure 14-7. Lacings maybe removed from the heavier booms by careful use of the arc air torch, slightly above the attaching fillet weld, again using extreme care not to damage the chord member in anyway.

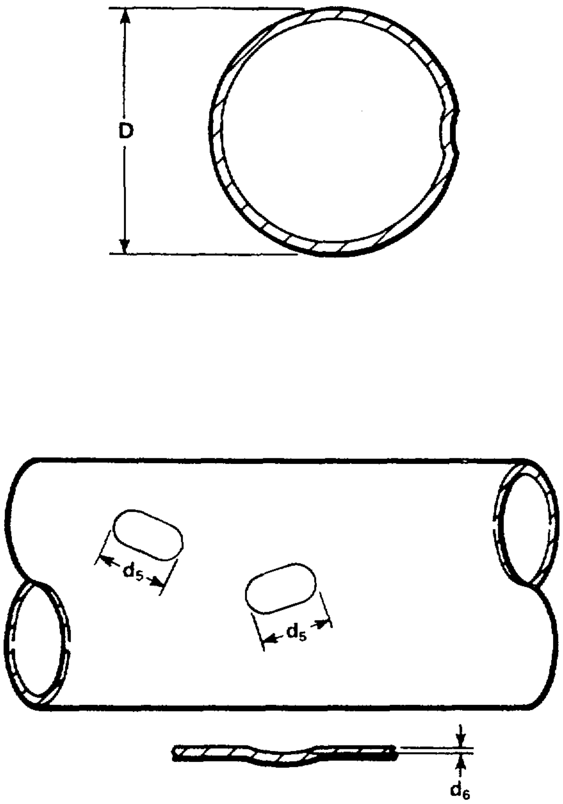


Figure 14-6. Corrosion or Abrasion

Table 14-4. Corrosion or Abrasion

D Tube Diameter		d_5 Sum of Greatest Dimensions Between Panel Points		d_6 Maximum Depth Allowable		Disregard Unless Deeper Than	
inches	(mm)	inches	(mm)	inches	(mm)	inches	(mm)
1	(25)	.25	(6.4)	.008	(.2)	.003	(.08)
1.25	(32)	.31	(7.9)	.009	(.2)	.004	(.10)
1.5	(38)	.38	(9.5)	.011	(.3)	.005	(.11)
1.75	(44)	.44	(11)	.013	(.3)	.005	(.13)
2	(51)	.5	(13)	.015	(.4)	.006	(.15)
2.25	(57)	.56	(14)	.017	(.4)	.007	(.17)
2.5	(64)	.62	(16)	.019	(.5)	.008	(.19)
2.75	(70)	.69	(17)	.021	(.5)	.008	(.21)
3	(76)	.75	(19)	.023	(.6)	.009	(.23)
3.25	(83)	.81	(21)	.024	(.6)	.010	(.25)
3.5	(89)	.88	(22)	.026	(.7)	.011	(.27)
3.75	(95)	.94	(24)	.028	(.7)	.011	(.29)
4	(102)	1	(25)	.030	(.8)	.012	(.30)
4.25	(108)	1.06	(27)	.032	(.8)	.013	(.32)
4.5	(114)	1.12	(29)	.034	(.9)	.014	(.34)
4.75	(121)	1.19	(30)	.036	(.9)	.014	(.36)
5	(127)	1.25	(32)	.038	(1.0)	.015	(.38)
5.5	(140)	1.38	(35)	.041	(1.0)	.017	(.42)
6	(152)	1.5	(38)	.045	(1.1)	.018	(.46)
6.5	(165)	1.62	(41)	.049	(1.2)	.020	(.50)
7	(178)	1.75	(44)	.053	(1.3)	.021	(.53)
7.5	(191)	1.88	(48)	.056	(1.4)	.023	(.57)
8	(203)	2	(51)	.060	(1.5)	.024	(.61)
8.5	(216)	2.12	(54)	.064	(1.6)	.026	(.65)
9	(229)	2.25	(57)	.068	(1.7)	.027	(.69)
9.5	(241)	2.38	(60)	.071	(1.8)	.029	(.72)
10	(254)	2.5	(64)	.075	(1.9)	.030	(.76)

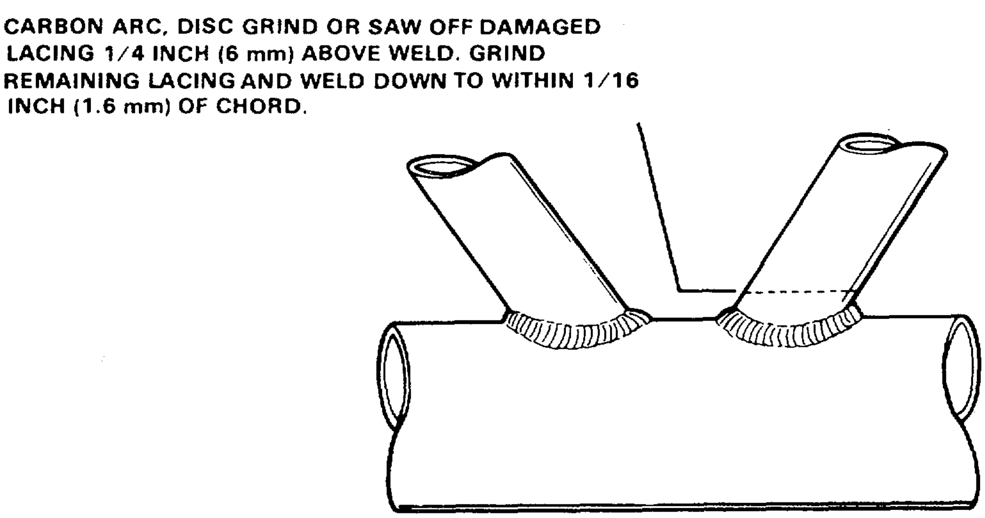


Figure 14-7. Cutting Off Damaged Tubular Lacings

3. Remove the remaining material. Grind marks should be parallel to the chord to minimize the possibility of damaging the chord. See Figure 14-8.

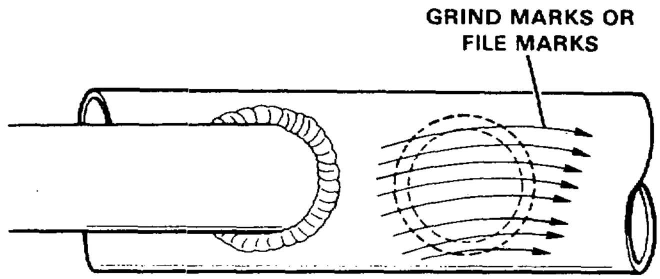


Figure 14-8. Removing Remaining Material

NOTE

Due to the location of the lacing being removed in Figure 14-8 disc grinding the remaining 1/16 inch (1.6 mm) of weld is difficult, if grind marks are to be kept longitudinal to the chord. Therefore, a large file should be used to remove the remaining 1/16 inch (1.6 mm) of weld. If no other member interferes with grinding, a fine grit disc grinder should be used. Note the direction of the grind marks in Figure 14-8.

NOTE

A smooth gouge free surface is required on the chord before a replacement lacing is fitted into place. Use emery cloth to polish the chord after grinding or filing.

4. When using bulk replacement lacings, cut the lacing to the proper length, which will be about 1/2 inch (12 mm) longer than is actually required so as to leave sufficient material for contour fitting. See Figure 14-9.

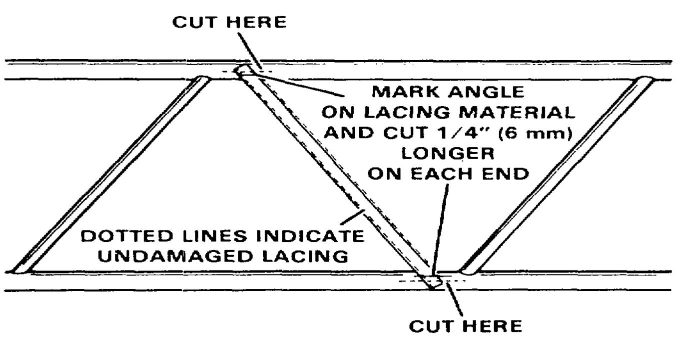


Figure 14-9. Cutting Replacement Lacings

A. Hold a length of bulk lacing in proper alignment with another undamaged lacing of the same length as the lacing to be replaced.

B. Cut at the points and at the angle shown in Figure 14-9.

5. Cope the lacing as shown in Figure 14-10. Carefully contour fit the ends of the replacement lacing so that it fits within 1/16 inch (1.6 mm) all around the joint and a slight drive fit is required to align the lacing in its proper location. See Figure14-10. This fitting is very important as excessive openings will result in greater weld metal deposit, excessive heat buildup which can materially weaken the joint and also result in very undesirable distortion and locked up stresses. Weld sizes required to attach the lacings to the chords can be determined by looking at the previous welds on the other unaffected joints on the boom. These will usually be from 1/8 to 3/16 inch (3.2 to 4.8 mm) leg size. It is extremely important that this fit and weld size be maintained so as not to induce an unbalance of weld shrinkage and locked up stresses.

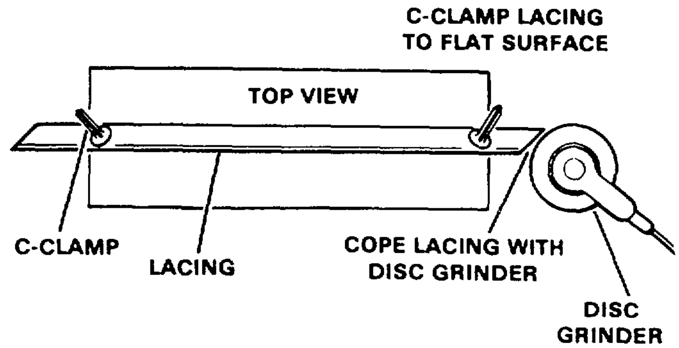


Figure 14-10. Coping Lacing with Disc Grinder

NOTE

It is very important that the centerlines of the copes on each end of the replacement lacing be in the same plane (not twisted), to assure a good fit on both chords.

6. New lacings shall be installed in alignment with adjacent lacings. Accomplish this alignment by placing two straightedges on existing lacings, one on each side of the lacing being replaced. Clamp the straightedges firmly against the existing lacings, bring the replacement lacing against the straightedges, and hold in this position while welding is performed. See Figure 14-11.

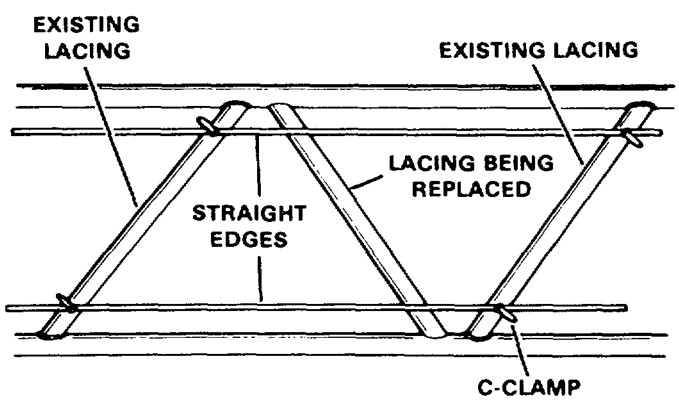


Figure 14-11. Aligning Replacement Lacing

7. All welding should be done in the flat or down-hand position. The boom section should be rolled or turned to allow the welding to be done in this position.

Keep welding heat as low as possible and weld in two distinct steps. Complete the other half of the weld after the joint has cooled to 70°F to 200°F (21°C to 93°C).

All welding should be performed within a material temperature range of 700F to 4000F (21 °C to 2040C). No welding shall be done on material under 700F (210C). Bring the boom section into a building where it can be warmed to this temperature, if necessary.

Material may be preheated to a maximum of 200°F (93°C). A temperature measuring device shall be used to determine maximum temperatures.

No welding shall be done in rain, snow, or other climatic conditions in which the weld can be chilled extremely fast. If it is necessary to perform the weld outside a building, a proper wind-break and enclosure must be constructed over the area to be repaired. Heat must be applied to the area very cautiously to bring the material within the recommended temperature range. Extreme care and skill is required for the proper overlap at the start and stop of the weld joints, or weld passes so as not to leave any unfilled craters which are subject to crater cracks and weakening of the joint. See Figure 14-12.

WELD START & STOP

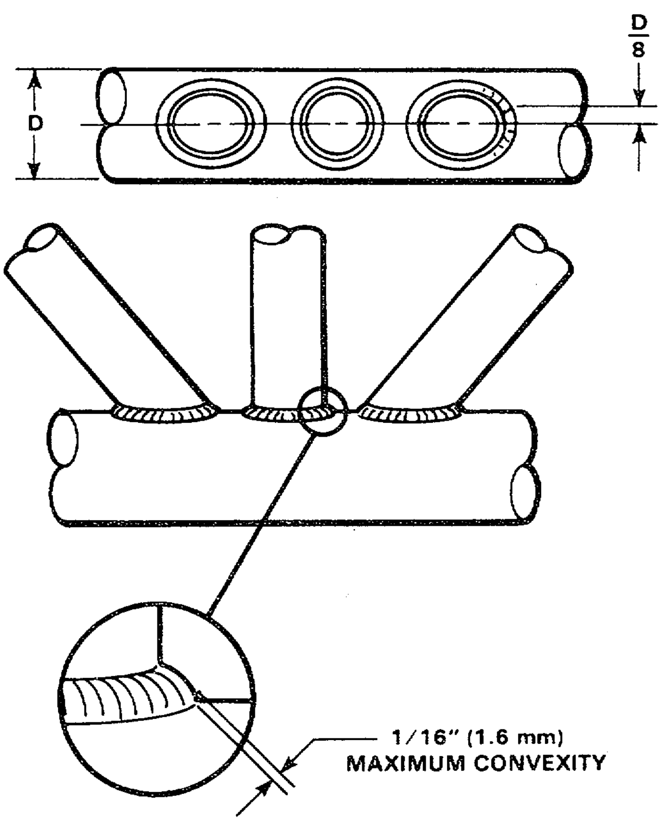


Figure 14-12. Welding Lacings to Tubular Chord

Be sure that all grease, oil, water, and other contaminants are removed from the weld area and welding is performed in a dry, still atmosphere away from wind, rain, and other adverse elements.

Inspect welds as specified under the topic inspection later in this manual.

ANGLE CHORD BOOM LACING REPAIR PROCEDURE

Replacement of a lacing in an angle chord boom section is similar in most respects to the procedure for lacing replacement in tubular chord boom sections. Only the differences will be discussed here. Therefore, be sure to read the procedure for replacement of tubular boom lacings as well as this procedure. The major difference in the procedures is that the ends of the lacings must be crimped or flattened to permit proper fitup with the edge of the angle chords. See Figure 14-13. Proceed in the following sequence.

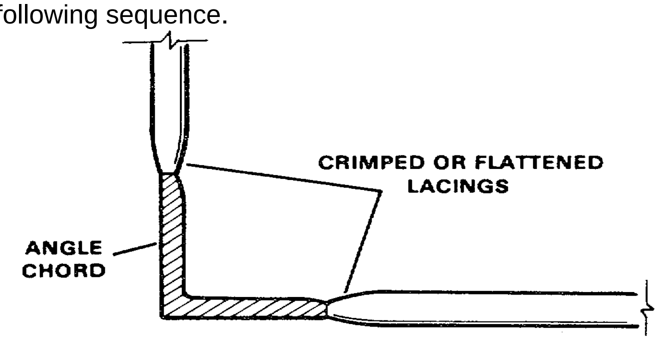


Figure 14-13. Fit-Up of Lacings to Chords

1. Cut the lacing to be replaced off about 1/4 inch (6 mm) above the weld, using a hacksaw, carbon arc torch, or disc grinder. See Figure 14-7 and 14-14.

2. Disc grind the remaining lacing and weld material away until the angle is returned to its original shape. See Figures 14-8 and 14-14.

CUT LACING OFF 1/4" (6 mm) ABOVE WELD WITH SAW, CARBON ARC OR DISC GRINDER

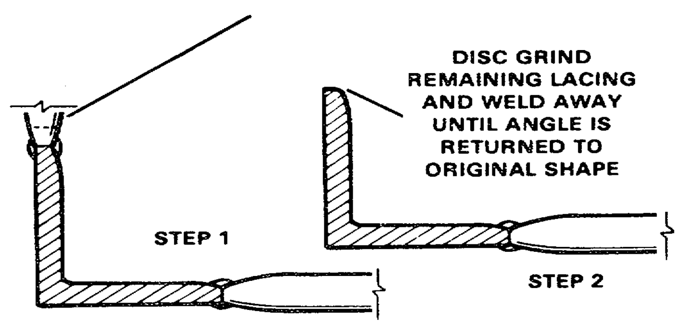


Figure 14-14. Removing Damaged Lacing

3. Lacing ends must be flattened by pounding into the approximate shape shown in Figure 14-15.

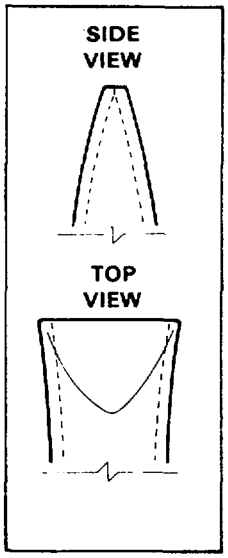


Figure 14-15. Approximate Shape of Lacing Ends

4. When forming lacing ends with a hammer, the lacing will have a tendency to move backward. A holding device similar to the ones shown in Figure 14-16 should be used to hold the lacing in place. This will make it easier to obtain the desired shape of the lacing end. Be sure that both ends of the lacing are flattened in the same plane (not twisted).

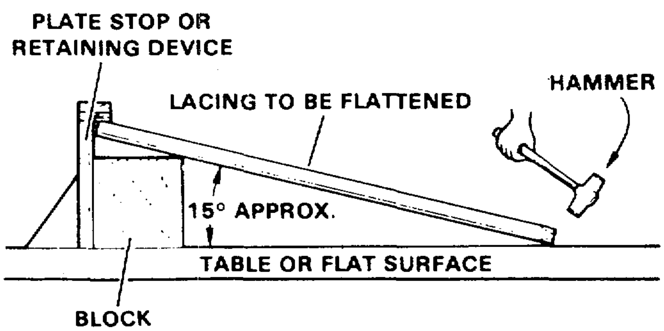


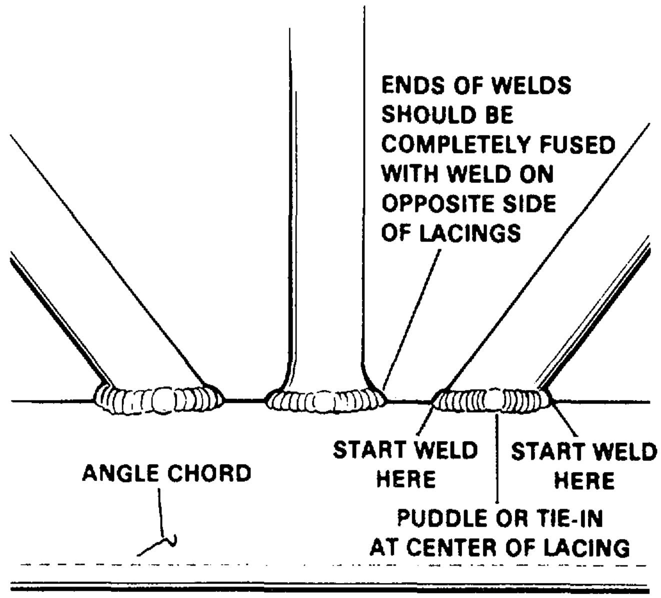
Figure 14-16. Shaping Lacing Ends

5. Determine the length of replacement lacings and the correct angle at which they should be cut by placing a length of lacing material against a lacing of identical construction in the boom section to be repaired. Mark the correct length and angle of cut needed and saw cut the lacing approximately 1/8 inch (3.2 mm) longer than required.

6. Flatten the lacing ends as previously described, and check for correct fit in the position it will occupy in the boom section to be repaired. If necessary, grind the lacing end to the correct length and reshape the end which was ground off.

7. Make sure the lacing is placed in the exact position from which the damaged lacing was removed. Then tack weld the lacing to the chord angle on each side.

8. Weld the lacing in place, using the materials and techniques previously described in this catalog. See Figure 14-17.



CAUTION

THE "PUDDLE" OR "TIE-IN" SHOULD NOT BE CONCAVE. IT MUST EQUAL OR EXCEEDTHE CONTOUR OF THE REST OF THE WELD.

Figure 14-17. Welding Lacings to Angle Chord

INSPECTION

After all welding repairs have been completed, a full visual shall be made to assure that all craters are full, that there is no undercut around any of the weld, and that proper con-tours have been accomplished.

In addition, magnetic particle inspection should be made. Suggested procedures are outlined in American Society of Testing and Materials Specification E109 or American Society of Non-Destructive Testing Specification TC-1A.

Any defective weld shall be ground out and rewelded.

A full detailed record shall be made of the repair, its location, the date, the welder, and the circumstances under which the repair was made.

SECTION XV

MAIN TRANSMISSION

Page

SECTION XV.

MAIN TRANSMISSION

GENERAL INFORMATION

GENERAL

This section describes the operation, maintenance and overhaul procedures for the main transmission. Figure 15-1 illustrates the main transmission. A description of the major components of the transmission, the function and operation of the hydraulic system, wear limits, and inspection procedures are included. Torque specifications are given with each assembly step and on the exploded view Foldouts at the back of the section.

Overhaul procedures are illustrated mainly by photo-graphs. Line drawings are used to supplement detailed as-sembly procedures; cross sections show torque paths and the relationship of assembled parts. Cross sections, color-coded hydraulic schematics, and parts exploded views are on Foldouts at the back of this section. The Foldouts maybe opened for reference while studying the text.

The nameplate (Figure 15-2) is located on the lower rear side of the end cover. The nameplate shows the transmission serial number, part number (assembly number) and Figure 15-1. Main Transmission with the Electric Control Valve Body

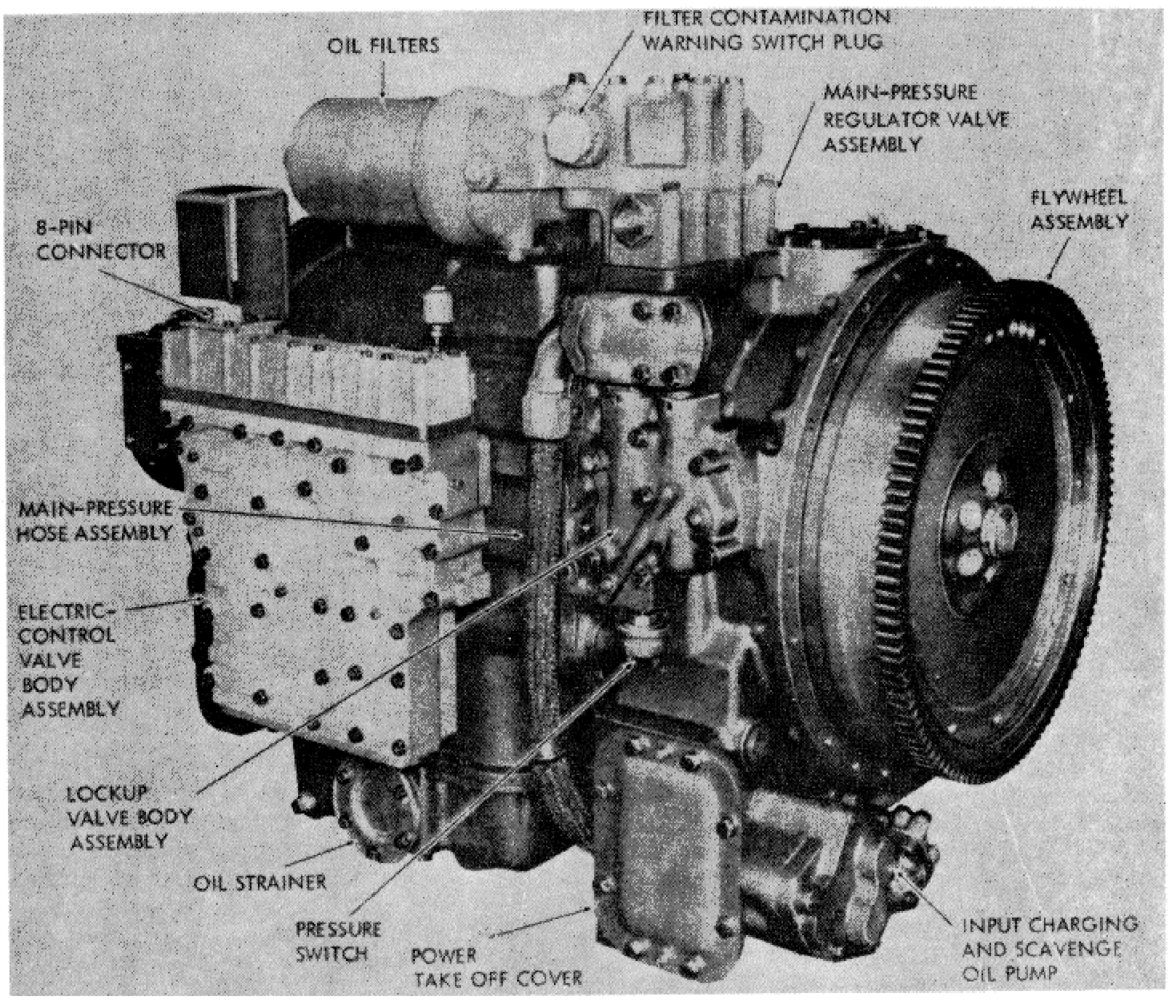


Figure 15-1. Main Transmission with the Electric Control Valve Body

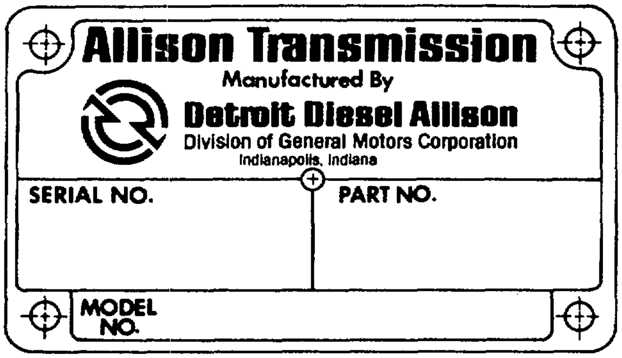


Figure 15-2. Transmission Nameplate

model number, all of which must be supplied when order-ing replacement parts or requesting service information.

Do *not* order by illustration item numbers on exploded views in this section. All replacement parts should be ordered through the replacement parts catalog.

DESIGN FEATURES

The transmission is mounted directly to the engine. The direct-mounted transmission has a modified SAE 1 mount-ing face on converter housing 3 (Foldout 1) which is bolted to the engine flywheel housing. Flexible flywheel disk as-sembly 40 connects the engine crankshaft to the transmission input.

The fixed capacity torque converter is a single-stage, poly-phase, three-element unit, consisting of pump 6 (Foldout 1) stator 5, and turbine 4. The converter provides maximum torque when load conditions demand. Oil for converter charging pressure comes from the sump and is supplied by the pump.

The planetary gear train includes constant mesh, straight spur gear planetary sets 15, 17, 26 and 30. The forward set is arranged for overdrive or direct drive (Foldout 1) and is called the splitter planetary. The remaining sets are the in-termediate planetary, the low planetary, and the reverse planetary. By the engagement of the clutches in various combinations, the planetary sets act singly or together to provide six speeds forward and one speed reverse.

Clutches 12, 13, 16, 18, 19 and 20 (Foldout 1) direct the flow of torque through the transmission in accordance with the gear selected by the operator. All clutches are hydraulically applied and oil cooled. All clutches, except the lockup clutch, are spring released. The lockup clutch is released by converter oil pressure. The external-splined clutch plates are polished steel. Wear is automatically compensated and no adjustment is necessary.

A common hydraulic system (manual electric shift) serves the torque converter, the hydraulic retarder, and the trans-mission (Foldout 2). Oil for all hydraulic operations, lubrication, and cooling comes from the sump and is supplied by the same oil pump.

SHIFT CONTROL SYSTEM

The manual-electric system includes an electrically controlled valve body assembly on the transmission (Figure 15-1), a manual-electric shift tower in the vehicle cab (Figure 15-3) and wiring harness 81 (B, Foldout 9). Also included is pressure switch 20 (A, Foldout 6) which activates a down-shift inhibitor.

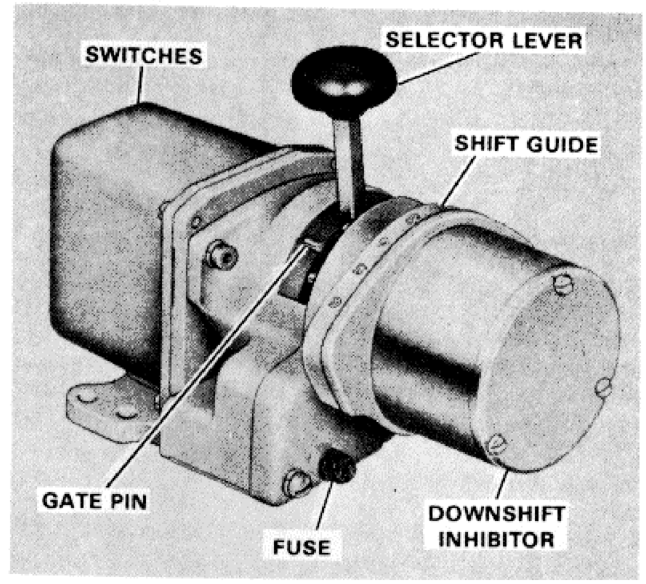


Figure 15-3. Manual-Electric Selector Assembly

Seven solenoid (electro-magnetic) valves control hydraulic circuits that shift the range control valves. Six forward speeds, neutral, and reverse are selected manually by the operator. The electrical circuit, established by each position of the operator's shift control, establishes a hydraulic circuit in the transmission valve body that produces neutral or drive in the gear selected.

Electrical power for actuation of the control system is sup-plied by the vehicle electrical system. Electrical components to match the vehicle system voltage are provided in the control system. An integral SFE 9A fuse is provided in the selector assembly (Figure 15-3).

If electrical power fails at one solenoid, or fails completely, the transmission will continue to operate in the forward gear in which it was operating at the time of the electrical failure. If the electrical failure occurs in neutral, the transmission will remain in neutral. If an electrical failure occurs in reverse, the transmission will go into neutral.

NOTE

The conditions resulting from power or solenoid failure cited above apply only if the failure occurs dur-ing operation in the selector position given, and when the selector is neither moved nor the engine stopped after the failure. If the selector is moved or the engine is stopped after power or solenoid failure, new shift situations result. Refer to troubleshooting later in this section.

LOCKUP CLUTCH

The clutch assembly (Foldout 1) includes a single clutch plate, a piston, and a backplate. The internal-splined clutch plate is splined to the hub of the converter turbine. When the clutch is applied, the converter turbine and the converter pump are locked together and rotate as a unit. Engine power is transmitted to the transmission gearing at a 1: ratio. Lockup occurs in all gear ranges and neutral.

HYDRAULIC RETARDER

Hydraulic retarder consists of rotor (Foldout 1), fixed state vanes, and an operator controlled valve. The rotor turn continuously at turbine output shaft speed. However, the retarder functions only when the cavity around the rotor i filled with oil. The rotor vanes force oil into the pockets be- tween the fixed vanes in the rotor cavity. This makes it harder for the rotor to turn. This slows the transmission out-put shaft and slows the vehicle.

POWER TAKEOFF

1. The side-mounted power takeoff is located on the lower-right side of the torque converter housing. It is driven by gear 36 (Foldout 1), which rotates at 1.00 times engine speed. The 8-bolt mounting flange is SAE heavy-duty.

SPECIFICATIONS AND DATA

Transmission type	Torque converter and planetary gear
Rating (truck)	5960
Max. input speed (rpm)	2500
Max. input torque, net (lb-ft)	1350
Max. input power, gross (hp)	525
Rotation:	
Input	Clockwise (when viewed from input end)
Output (forward operation)	Clockwise (when viewed from input end)
Mounting:	
Direct	Flywheel housing, SAE size 1 (wet); two mounting pads at rear
Remote	Trunnion at front; two SAE 1 mounting pads at rear
Torque converter:	
Type	Single-stage, three-element, polyphase
Multiplication ratio	2.6:1
Lockup clutch	Automatic in all gears
Gear data:	
Range and splitter	Constant mesh, spur-type, planetary
Gear ratios:	
First gear	4.00:1
Second gear	2.68:1
Third gear	2.01:1
Fourth gear	1.35:1
Fifth gear	1.00:1
Sixth gear	0.67:1
Reverse gear	5.12:1
Range clutches	Multiplate, hydraulic-actuated, spring-released, oil-cooled, self-adjusting
Power takeoff (top and side):	
Mounting flange	One, SAE 8-bolt, heavy-duty
Rating	Intermittent - 200 hp (149 kW) Continuous - 125 hp (93 kW)
Ratio	Side mounted 1.00 X engine speed
Gear data	Side mounted - 25 degree pressure angle, 6-pitch, 38 teeth
Parking brake:	
Type	Internal expanding shoe
Rating	90,000 lb in. (10 168 N.m) at 517 lb (2300 N) lever pull - manufacturer's rating for run-in (burnished) condition.
Size	12 x 5 in. (305 x 127 mm)

SPECIFICATIONS AND DATA (Continued)

Oil system:
- Sump
- Input pressure and scavenge oil pump

Flanges:
- Output

Dry weight (approx.)

MANUAL-ELECTRIC CONTROL SYSTEM

Type

Gear ranges, selector positions

Manual selector assembly:
- Location
- Selector sequece (rear to front)
- Light (connected to vehicle light system)
- Downshift inhibitor

Electrical system:
- Power source
- Voltage
- Current draw:
  - 12-volt system
- Number of solenoids

Solenoids energized:
- Neutral
- Reverse
- Forward gears

Wiring harness:
- Number of conductors
- Side branches
- Connectors

Downshift inhibitor:
- Type and location
- Activated by

Oil
- Fluid viscosity and grade
- 30
- 15W-40
- 10W, 10-10W
- 5W-20
- Capacity (excluding external circuits)
- Filters

Pressures:
- Stator control pressure (variable torque converter models)

Main oil pressure

Converter-out pressure:
- Rev, 1, 2, 3, 4, 5, 6

Integral
Positive displacement, spur-gear type

Spicer 1800, 1850; Mechanics 8C, 9C, 10C
2265 lb (1028 kg)

Manual-electric hydraulic (manual selection of operating mode energizes solenoids; solenoids control hydraulic pressures to shift valves; valves control hydraulic clutches)
Neutral, six forward speeds, reverse

Vehicle cab
R, N, 1, 2, 3, 4, 5, 6 (each position gated)

Integral
Integral

Vehicle electrical system
12 volts dc

0.6 amp per solenoid
7

2
3
2

14
6
16-pin at selector; 8-pin at valve body; push-in, thread-tighten type

Solenoind, in manual selector assembly
Pressure switch on transmission, closed by lockup clutch pressure
Type C3
Ambient temperatures below which preheat is required
32°F (0°C)
5°F (-15°C)
-10°F (-23°C)
-30°F (-34°C)
18.5 U.S. gal. (70 liters) initial fill, plus external circuits
Full flow, replaceable elements, remote or direct mount with filter contamination signal warning switch

140 to 170 psi (965 to 1172 kPa) at 1500 rpm, output stalled
Refer to page 15-24.

Full throttle, normal operating output speed range: 30-65 psi (207 to 448 kPa)

SPECIFICATIONS AND DATA (Continued)

	No pressure check point provided
	Same as main pressure (see page 15-24)
Lubrication pressure:	
Models with retarder	See page 15-24
Lockup clutch pressure	
First-and-second-gear clutch	See page 15-24
(electric-shift models)	
Third-and-fourth-gear clutch	See page 15-24
(electric-shift models)	
Fifth-and-sixth-gear clutch	
(electric-shift models)	600 hp (447 kW)
Hydraulic retarder:	Vaned rotor between fixed vanes
Estimated absorption capacity at	
2100 rpm	
Type	

DESCRIPTION AND OPERATION

GENERAL

This material describes and explains the operation of all components and systems of the transmission.

STRAIGHT-THROUGH CONFIGURATION

The transmission is a straight-through configuration. The output at the rear is in line with the input (Figure 15-1).

CONTROL SYSTEM

Refer to page 15-9 for description of the manual-electric shift system.

DIRECT MOUNTING

Flywheel assembly 12 (A, Foldout 3) is bolted to the front of converter pump 20 (A, Foldout 4), and retains the oil in the torque converter. Starter ring gear 13 (A, Foldout 3) is shrunk onto the front of the flywheel. The outer bolt circle of flex disk assembly 2 is bolted to the fly wheel. The hub of the disk assembly is bolted to the engine crankshaft. Converter housing 9 (B, Foldout 4) is bolted to the engine flywheel housing, and supports the front of the transmission.

The rear end of the transmission is supported at mounting pads at each side of the rear cover.

LOCKUP CLUTCH

The lockup clutch includes piston 4 (B, Foldout 3), plate 5, and backplate 7. Teflon seal rings 1 and 2, seal piston 4 in flywheel 15 (A, Foldout 3).

When oil pressure is applied (automatically) against the front of piston 4 (B, Foldout 3), the piston compresses clutch plate 5 against backplate 7. Clutch plate 5 then is forced to rotate with the piston and backplate These parts are attached to, and rotate with, torque converter pump 20 (A, Foldout 4). The internal splines of clutch plate 5 (B, Foldout 3) are meshed with external splines of turbine 6 (A, Foldout 4). Thus, when the lockup clutch is engaed, the torque con-verter turbine and pump are locked together. This provides direct drive from the engine to the transmission gearing.

TORQUE CONVERTER

DESCRIPTION (A, Foldout 4). The torque converter consists mainly of three elements: converter pump 20, stator 10, and turbine 6. These paned elements are cast aluminum. Pump 20 is the input member and is driven by the engine. Turbine 6 is splined to turbine shaft assembly 5 (B, Foldout 6). Stator 10 (A, Foldout 4) is the reaction (torque multiplying) element. The stator is supported on freewheel roller race 9, which is splined to ground sleeve 31 (B, Foldout 4). This stator arrangement provides an over-running clutch which permits the stator to rotate freely in one direction but lock up in the opposite direction.

OPERATION. The torque converter assembly is continuously filled with oil, which flows through the converter to cool and lubricate it. When the converter is driven by the engine, the pump vanes throw oil against the turbine vanes. The impact of the oil against the turbine vanes tend to rotate the turbine.

The turbine, splined to the turbine shaft, transmits torque to the transmission gearing. At engine idle speed, the impact of oil against the turbine vanes is not great. At high engine speed, the impact is much greater than at idle, and high torque is produced by the turbine.

Oil thrown into the turbine flows to the stator vanes. The stator vanes change the direction of oil flow (when the stator is locked against rotation), and direct the oil to the pump in a direction that assists the rotation of the pump. It is the redirection of the oil that enables the torque converter to multiply the input torque.

Greatest torque multiplication occurs when the turbine is stalled and the pump is rotating at its highest speed. Torque multiplication decreases as the turbine rotates and gains speed.

When turbine speed approaches the speed of the pump, oil flowing to the stator begins to strike the backs of the stator vanes. This rotates the stator in the same direction as the turbine and pump. At this point, torque multiplication stops and the converter becomes, in effect, a fluid coupling.

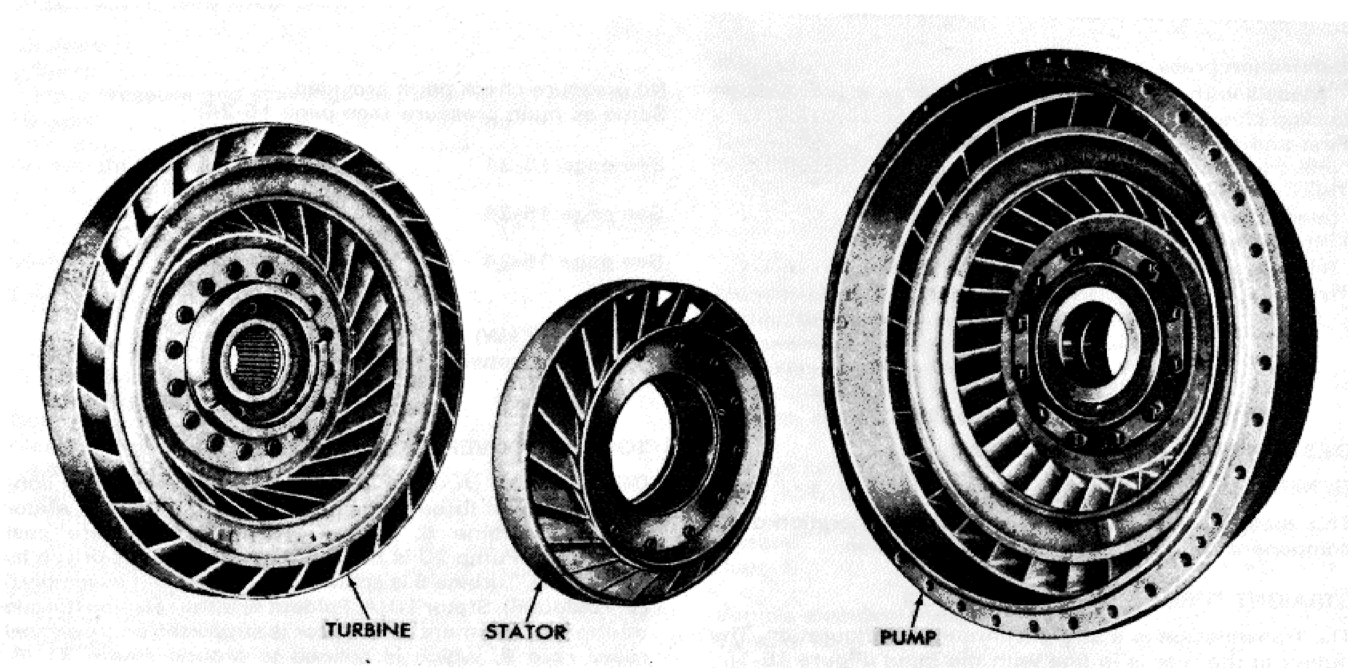


Figure 15-4. Three-Element Torque Converter S3725

Thus, the torque converter accomplishes three functions. It acts as a disconnect clutch, because little torque is transmitted at engine idle speed. It multiplies torque at low turbine/high pump speed to give greater starting or driving effort when needed. It acts as a fluid coupling to efficiently transmit engine torque to the transmission gearing while in a drive range.

HYDRAULIC RETARDER

DESCRIPTION (B, Foldout 6). Rotor 12 is the only moving part of the hydraulic retarder. The rotor is splined to and ro-tates with turbine shaft 5. The vaned rotor is enclosed in retarder housing 19. Converter housing 9 (B, Foldout 4) and retarder housing 19 (B, Foldout 6) both include vanes.

OPERATION. The rotor turns continuously at turbine output shaft speed. However, the retarder functions only when the cavity around the rotor is filled with oil. A manual valve directs oil which fills the cavity when retarder operation is desired. The churning of the oil by the rotor resists the rotation of the rotor. Part of this energy is used to circulate the oil through a cooler to dissipate the heat generated. When the control valve is released, the retarder cavity is evacuated.

The retarder is used to slow the vehicle on curves or on downgrades. Maximum retarder effect occurs in the lowest gear range. The throttle should be closed when the retarder is used. Long continuous use will raise the oil temperature. Short periods of full-release, to interrupt continuous application, will prevent overheating.

POWER TAKEOFF DRIVE

DESCRIPTION (B, Foldout 4). This transmission has no top power takeoff provided, items 4 through 7 cover the top opening in the converter housing.

This transmission has a machined pad for a power takeoff at the lower-right side of the torque converter housing, and provides items 22 through 25 to cover the power takeoff mounting pad.

The power takeoff pads are eight-bolt, heavy-duty SAE mountings.

OPERATION. The power takeoff gear meshes with oil pump drive gear 68 (B, Foldout 4). Drive gear 68 is driven by idler gear 64 which, in turn, is driven by accessory drive gear 23 (A, Foldout 4). Gear 64 on side-mounted power takeoff drives, rotates at 1.00 times engine speed and in the direction of the engine output.

SPLITTER CLUTCHES, GEARING

TWO CLUTCHES, ONE PLANETARY. The splitter system includes the splitter-direct clutch (low-splitter) (B, Foldout 7), splitter-overdrive clutch (high-splitter) (A, Foldout 8), and splitter planetary (A, Foldout 8).

The splitter-direct clutch includes mainly: clutch drum 5 (B, Foldout 7), piston 10, one external-splined plate 14, two internal-splined plates 13, backplate 15, and clutch hub and sun gear assembly.

The splitter-overdrive clutch includes mainly: backplate 16 (A, Foldout 8), three external-splined plates 18, three internal-splined plates 17, clutch anchor 19, piston 22, and piston housing 26.

The splitter planetary includes mainly: carrier assembly 1 (A, Foldout 8), ring gear 11, and hub 13.

OPERATION. The two splitter clutches and one splitter planetary are interconnected to provide either direct drive (1.00:1 ratio), or overdrive (0.67:1 ratio)between the torque converter turbine and the transmission range gearing.

When the splitter-direct clutch is engaged, the splitter planetary sun gear and carrier are locked together. This causes ring gear 11 (A, Foldout 8) and splitter shaft 3 (A, Foldout 11) to be driven at the same speed as the torque converter turbine. This is direct drive, which occurs in first-, third-, fifth-, and reverse-gear operation.

When the splitter-overdrive clutch is engaged, splitter sun gear 22 (B, Foldout 7) is held stationary, while carrier assembly 1 (A, Foldout 8) rotates around the sun gear. This overdrives ring gear 11, hub 13, and splitter shaft 2 (A, Foldout 11). Overdrive (0.67:1 ratio) occurs in second-, fourth-, and sixth-gear operation.

FIFTH-AND-SIXTH-GEAR CLUTCH

DESCRIPTION. The fifth-and-sixth-gear clutch includes mainly: clutch drum 4 (A, Foldout 9), piston assembly7, two external-splined plates 1 3, three internal-splined plates 12, and backplate 14.

There is no gearing that is controlled directly by the fifth-and-sixth-gear clutch. The clutch transmits the rotation of splitter shaft 2, (A, Foldout 11) to third-and-fourth-gear ring gear 13 (B, Foldout 10) at a 1.00:1 ratio.

OPERATION. When the fifth-and-sixth-gear clutch is applied, piston 7 (A, Foldout 9) compresses clutch plates 12 and 13 against backplate 14. This locks clutch drum 2 to third-and-fourth-gear ring gear 13 (B, Foldout 10). Be-cause clutch drum 2 (A, Foldout 9) and third-and-fourth-gear sun gear 1 (B, Foldout 10) are both splined to splitter shaft 2 (A, Foldout 11), the third-and-fourth-, and first-and-second-gear systems are locked together and must rotate at the same speed as the splitter shaft.

When the splitter-direct clutch is engaged, while the fifth-and-sixth-gear clutch is also engaged, the transmission output shaft rotates at the same speed as the torque con-verter turbine (direct drive - 1.00:1 ratio). This is fifth gear.

When the splitter-overdrive clutch is engaged, while the fifth-and-sixth-gear clutch is also engaged, the overdrive ratio (0.67:1) produced in the splitter planetary is transmitted to the first-and-second-gear planetary ring gear. Turbine speed is transmitted through the splitter shaft to the first-and-second-gear planetary. Thus, the splitter and first-and-second-gear planetary sets are compounded. This results in the transmission output being driven at a higher speed than the torque converter turbine. This is sixth gear.

THIRD-AND-FOURTH-GEAR CLUTCH, PLANETARY

DESCRIPTION. The third-and-fourth-gear clutch includes mainly: backplate 15 (B, Foldout 10), anchor 17, internal-splined plates 19, external-splined plates 20, piston 22 and piston housing assembly 24.

Anchor 17 (B, Foldout 10) is stationary. Clutch plates 20 are splined to the anchor. Clutch plates 1 9 are splined to third-and-fourth-gear ring gear 13.

The third-and-fourth-gear planetary includes sun gear 1 (B, Foldout 10) carrier assembly2, and ring gear 13. Sun gear 1 is splined to splitter shaft 2 (A, Foldout 11). Carrier assembly 2 (B, Foldout 10) is splined to first-and-second-gear ring gear 17 (A, Foldout 11). Third-and-fourth-gear ring gear 13 (B, Foldout 10) is splined to fifth-and-sixth-gear clutch plates 1 2 (A, Foldout 9) and to third-and-fourth-gear clutch plates 19.

OPERATION. When the third-and-fourth-gear clutch is ap-plied, piston 22 (B, Foldout 10) compresses clutch plates 19 and 20 against backplate 15 (B, Foldout 10). This holds ring gear 13 (B, Foldout 10) stationary.

Driven by sun gear 1, carrier assembly 2 rotates within stationary ring gear 13 and drives first-and-second-gear ring gear 17 (A, Foldout 11) at reduced speed. In the first-and-second gear planetary, a further reduction in speed occurs because its ring gear is rotating slower than its sun gear (splitter shaft).

In third gear, the splitter-direct clutch is applied. Thus, the third-and-fourth-gear sun gear and the first-and-second-gear sun gear (splitter shaft) rotate at equal speeds (at turbine speed). Speed reduction is accomplished in the two planetaries as explained earlier. The reduction ratio is 2.01:1.

In fourth gear, the splitter-overdrive clutch is applied resulting in a speed increase of the third-and-fourth-gear sun gear. The same reduction occurs in the two com-pounded planetaries as explained earlier, but the resulting speed is higher because of the higher speed of the third-and-fourth-gear sun gear. The reduction ratio is 1.35:1.

FIRST-AND-SECOND-GEAR CLUTCH, PLANETARY

DESCRIPTION. The first-and-second-gear clutch includes mainly: anchor 18 (A, Foldout 11), four internal-splined plates 21, four external-splined plates 22, piston 24, and piston housing assembly 26. The first-and-second-gear clutch plates compress against third-and-fourth-gear clutch piston housing 24 (B, Foldout 10).

The first-and-second-gear planetary includes a sun gear that is integral with splitter shaft 2 (A, Foldout 11), carrier assembly 8, and first-and-second-gear ring gear 1 7.

OPERATION. When the first-and-second-gear clutch is applied, piston 24 (A, Foldout 11) compresses plates 21 and 22 against housing assembly 26 and holds ring gear 17 stationary.

Driven by splitter shaft 2, carrier assembly 8 rotates within stationary ring gear 17.

In first gear, the splitter-direct clutch is applied. Thus the first-and-second-gear sun gear (splitter shaft) is rotating at turbine speed and drives planetary carrier assembly 8 at reduced speed. This produces a ratio of 4.00:1.

In second gear, the splitter-overdrive clutch is applied resulting in a speed increase of the first-and-second-gear sun gear (splitter shaft). The same reduction occurs as explained above, but the resulting speed is higher because of the higher speed of the first-and-second-gear sun gear. The reduction ratio is 2.68:1.

REVERSE-GEAR CLUTCH, PLANETARY

DESCRIPTION. The reverse-gear clutch includes mainly: anchor 15 (B, Foldout 11) five internal-splined plates 18, five external-splined plates 19 and piston 21. Plates 18 and 19 compress against piston housing 26 (A, Foldout 11). Piston 21 (B, Foldout 11) uses the rear cover assembly as its housing.

The reverse-gear planetary includes sun gear assembly 1 (B, Foldout 11), reverse-gear ring gear 5, and carrier assembly 6.

OPERATION. When the reverse-gear clutch is applied, piston 21 (B, Foldout 11) compresses plates 18 and 19 against first-and-second-gear piston housing 26 (A, Foldout 11). This holds ring gear 5 (B, Foldout 11) stationary. Reverse-gear sun gear assembly 1 is attached to first-and-second-gear ring gear 17 (A, Foldout 11). The first-and-second reverse-gear planetaries are com-pounded to provide reverse rotation in the first-and-second-gear planetary, and further speed reduction in the reverse-gear planetary.

First-and-second-gear sun gear 2 drives the pinions of carrier assembly 8. The pinions, in turn, drive ring gear 1 7 in a reverse direction. Ring gear 17, being splined to reverse-gear sun gear 1 (B, Foldout 11), drives carrier assembly 6 in the reverse direction within stationary ring gear 17.

Reverse carrier assembly 6 (B, Foldout 11) is splined to the transmission output shaft and drives it in the reverse direction also. All of the transmission torque is carried by the transmission main shaft assembly 15. The splitter-direct clutch is engaged but transmits no torque. The reverse gear reduction ratio is 5.12:1.

SPEEDOMETER DRIVE

DESCRIPTION (A, Foldout 12). The speedometer drive consists of drive gear 25 and bushing 6.

OPERATION (A, Foldout 12). When the transmission shaft rotates, drive gear 25 rotates. Bushing 6 supports the driven gear (vehicle furnished) within the rear cover. The driven gear rotates clockwise (as viewed at the cable connection in the rear cover) during forward operation.

OIL PAN, STRAINER

DESCRIPTION. The straight-through configuration includes oil pan assembly 2 (A, Foldout 10) and strainer 6. The oil pan is bolted to the lower opening of the transmission main housing.

OPERATION. All oil returns to the sump and is drawn by the oil pump through strainer 6 (A, Foldout 10) before delivery to the hydraulic system. Debris which may be in the sump remains outside the strainer. A magnet inside the strainer also helps to collect the debris.

OIL PUMP

DESCRIPTION. The oil pump has two two-gear sections within a common assembly 10 (A, Foldout 5). The pressure section has one inlet and one outlet port. The scavenge sec-tion has one inlet and one outlet port.

The oil pump is driven by coupling 32, which is splined to gear 23. Various external tubes and internal passages direct oil to and from the pump.

OPERATION. When the vehicle engine is running, the pressure section draws oil from the transmission sump. The outlet from the pressure section directs oil to the hydraulic system (refer to Foldout 2).

The scavenge section of the pump draws excess oil that drains to the bottom of the torque converter housing, and returns it to the transmission sump. Screen 30 (A, Foldout 5) prevents debris from entering the suction side of the scavenge pump.

HOUSING, COVERS

TORQUE CONVERTER HOUSING. Converter housing 9 (B, Foldout 4) provides an enclosure for the torque converter, power takeoff gearing and oil pump gearing. It provides mountings for oil pump, power takeoffs, and lockup shift valve. The front flange provides a means to support the front of the transmission. The rear of the housing provides vanes for use with the hydraulic retarder rotor.

MAIN HOUSING. Housing 10 (B, Foldout 8) is the main structural member of the transmission. It houses the splitter and range gearing and clutches. The front surface provides a mounting surface for the torque converter housing or retarder housing. The rear surface provides a mounting surface for the rear cover assembly. The lower surface provides a mounting surface for the oil pan. The right side provides a mounting surface for the main control valve components.

HYDRAULIC SYSTEM

NOTE

References to up, down, left or right refer to positions or movements of components on Foldout 2.

SYSTEM FUNCTIONS. The hydraulic system generates, directs and controls the pressure and flow of hydraulic fluid within the transmission. Hydraulic fluid (transmission oil) is the power transmitting medium in the torque converter. Its velocity drives the converter turbine. Its flow cools and lubricates the transmission. Its pressure operates the various control valves and applies the clutches.

SYSTEM SCHEMATICS (Foldout 2). A color-coded Foldout of the hydraulic system is presented at the back of this sec-tion. The illustration represents each system as it functions in neutral with the engine idling.

OIL FILTER, PRESSURE REGULATOR (B, Foldout 5). The oil passes through two disposable cartridge-type oil filter elements. The filters are arranged for full-flow operation.

On some filters, an oil pressure signal switch 26, located in filter base 32, warns that the oil filters are becoming clogged. This switch is activated by differential oil pressure in the filter base when oil pressure going into the filter elements exceeds the pressure coming out by 15 psi (103 kPa). When filter elements are badly clogged, and the differential oil pressure in the filter base is 20 psi (138 kPa), filter bypass valve 31 opens and allows the oil to bypass the filter elements.

Main pressure in the hydraulic circuit is regulated by a spring-loaded, spool-type valve 15, located in the main pressure regulator valve body 14. Its movement opens or closes ports which determines the volume of oil flow and main pressure. Function and movement are fully automatic. The pressure is regulated to the required value for various requirements of pressure and flow.

MAIN-PRESSURE REGULATOR BOOSTER PLUG. The transmission includes a main-pressure regulator booster plug 19 (B, Foldout 5), located in the main-pressure regulator valve bore of valve body 14. The type of booster plug used determines the main oil pressure schedule applicable to the transmission.

This modulation causes main-pressure to decrease as turbine output shaft speed increases.

This transmission has a booster plug that is longer and cannot move lengthwise in its bore. Thus, booster signal pressure in first gear and reverse cannot influence main pressure. This booster plug is identified by a bore depth of 0.740 inch (18.80 mm) at the spring end.

LOCKUP SHIFT VALVE. Flow of oil to and from the lockup clutch piston cavity is controlled by the lockup shift valve. The shift valve is a spool-type valve. Movement of the valve in its bore opens or closes ports which determine whether the lockup clutch is engaged or disengaged. This valve is located in lockup valve body 7 (A, Foldout 6).

Automatic lockup operation occurs as a result of pilot oil pressure acting upon lockup shift valve 8 (A, Foldout 6) at high turbine output shaft speeds. Lockup operation occurs in all ranges. This is accomplished by using different lockup valve body assemblies.

FLOW VALVE. Working in conjunction with the lockup shift valve is the spool type flow valve, located in the lockup valve body. This valve momentarily interrupts the flow of main pressure to the lockup clutch when shifts occur from one gear to another. When the manual selector valve is moved (except to neutral), a rapid flow of oil is required to engage different clutches. This oil must pass through the flowvalve bore. During the initial part of this flow, the valve moves to the left, cutting off main pressure to the lockup clutch and exhausting the lockup clutch line. When the oncoming clutch is filled, the valve returns to the right and restores pressure to the lockup clutch. Thus, full-power shifts are cushioned by the torque converter.

HYDRAULIC RETARDER VALVE. Located at the left-front side of the transmission is hydraulic retarder control valve 4 (A, Foldout 7). It is a spool-type valve, mounted in a vertical position. It is connected by linkage with an operator-con-trolled foot pedal.

The retarder is applied when the valve is pushed downward in the body, and released in its upward position (Foldout 2). Oil supply for the retarder, having passed through the torque converter to the oil cooler (heat ex-changer), is directed to the retarder when retarder operation is desired. Oil flow from the retarder is directed through the oil cooler (heat exchanger).

CONVERTER PRESSURE RELIEF VALVE. This valve is an umbrella-type valve located in the transmission housing. The function of this valve is to limit converter-in oil pressure to 80 psi (552 kPa). The valve protects the torque converter from excessive oil pressure such as during cold starts, by dumping the excess oil directly to sump. Refer to items 1 through 4 (B, Foldout 8).

CONVERTER PRESSURE REGULATOR VALVE. This valve is located in the main transmission housing. The valve works against spring pressure and will exhaust to sump any oil in excess of 22.5 psi (155 kPa) coming from the torque converter, through the oil cooler. Therefore, converter oil pressure is regulated by this valve, plus any restriction in the oil cooler and converter-out oil line. Refer to items 57 through 61 (B, Foldout 4).

CHECK VALVES. Lockup includes a check valve with an orifice located in the lockup valve body. The purpose of this valve is to permit the rapid exhaust of oil from the left end of the flow valve during shifts and a gradual return (through the orifice) of the oil.

A check valve, used only with the retarder, is located in the transmission converter housing. This valve will not allow converter-in oil pressure to drop lower than 20.5 psi (141 kPa). Oil pressure on one side of the valve, regulated at 22.5 psi (155 kPa) by the converter pressure regulator valve, is opposed by converter-in oil pressure and a 2 psi (14 kPa) valve spring pressure on the other side. If converter-in oil pressure should drop below 20.5 psi (141 kPa), oil from the oil cooler, regulated at 22.5 (155 kPa) by the converter regulator valve, opens the valve and maintains a minimum con-verter-in oil pressure of 20.5 psi (141 kPa). Thus, oil is allowed to recirculate to the converter from the cooler and the system is referred to as an "auto-flow" oil circuit.

MANUAL-ELECTRIC CONTROL SYSTEM
(Foldout 2)

NOTE

References to up, down, left or right refer to positions or movements of components on Foldout 2.

SYSTEM FUNCTIONS. The hydraulic system generates, directs and controls the pressure and flow of hydraulic fluid within the transmission. Hydraulic fluid (transmission oil)is the power transmitting medium in the torque converter. Its velocity drives the converter turbine. Its flow cools and lubricates the transmission. Its pressure operates the various control valves and applies the clutches.

SYSTEM SCHEMATICS (Foldout 2). A color-coded Foldout of the hydraulic system is presented at the back of this sec-tion. The illustration represents the system as it functions in neutral with the engine idling.

REVERSE SHIFT VALVE. The reverse shift valve is a spool-type valve which can move lengthwise in its bore. A spring pushes the valve upward when solenoid B is energized. Hydraulic pressure pushes the valve downward when solenoid B is de-energized and its valve closes. In its upward position, the reverse shift valve directs hydraulic pressure to the reverse clutch. In its downward position, the clutch is exhausted.

FIRST-AND-SECOND-GEAR SHIFT VALVE. The second-gear shift valve is a spool-type valve which can move lengthwise in its bore. A spring pushes the valve upward when solenoid C is energized. Hydraulic pressure pushes the valve downward when solenoid C is de-energized and its valve closes.

In its upward position, the valve directs hydraulic pressure to the first-and-second-gear clutch. In its downward position, the valve is exhausted.

THIRD-AND-FOURTH-GEAR SHIFT VALVE. The third-and-fourth-gear shift valve is a spool-type valve which can move lengthwise in its bore. A spring pushes the valve upward when solenoid D is energized. Hydraulic pressure pushes the valve downward when solenoid D is de-energized and its valve closes.

In its upward position, the valve directs hydraulic pressure to the third-and-fourth-gear clutch. In its downward position, the valve exhausts the third-and-fourth-gear clutch.

FIFTH-AND-SIXTH-GEAR SHIFT VALVE. The fifth-and-sixth-gear shift valve is a spool-type valve which can move lengthwise in its bore. A spring pushes the valve upward when solenoid E is energized. Hydraulic pressure pushes the valve downward when solenoid E is de-energized and its valve closes.

In its upward position, the valve directs hydraulic pressure to the fifth-and-sixth-gear clutch. In its downward position, the clutch is exhausted.

PRIORITY VALVE The priority valve is so named because it gives the upper ends of the shift valves priority on main pressure when the vehicle engine is first started. This is necessary to ensure that the shift valves are all positioned (in neutral) so that no apply pressure is directed to a drive clutch until a gear is selected.

The valve is held downward by spring pressure until main pressure, reaching the step on the valve through an orifice, is sufficient to raise the valve against its two springs. When the valve is upward, main pressure enters the bore at a second point (below the orifice) and flows to the remainder of the circuit. By the time the valve is fully upward, main pressure (regulated to a lower pressure in the solenoid pressure regulator valve) has pushed all of the shift valves downward, except for the splitter shift valve, at which solenoid F is energized and its valve is open.

When the priority valve is fully upward, main pressure is exerted on its lower end as well as on its step area. Thus, the valve cannot move downward until main pressure falls below that required to raise it initially.

SPLITTER SHIFT VALVE. The splitter shift valve is a spool-type valve which can move lengthwise in its bore. A spring pushes the valve upward when solenoid F is energized. Hydraulic pressure pushes the valve downward when solenoid F is deenergized and its valve closes.

When the valve is upward, hydraulic pressure is directed to the splitter direct clutch. When the valve is downward, hydraulic pressure is directed to the splitter-overdrive clutch. When the splitter-overdrive clutch is applied, the splitter-direct clutch exhausts through a port at the side of the valve bore. When the splitter-direct clutch is applied, the splitter-overdrive clutch exhausts through the bore of the splitter-direct trimmer.

Solenoid G is de-energized (valve closed) during splitter-direct operation. This retains splitter-direct clutch pressure at the bottom of the valve during splitter-direct operation. Solenoid G provides the means (when energized) to exhaust splitter-direct pressure at this point when it is de-sired to shift to splitter-overdrive operation.

SOLENOID PRESSURE REGULATOR VALVE. The solenoid pressure regulator valve is a spool-type valve that can move lengthwise in its bore. Spring pressure pushes downward on the valve, allowing main pressure to flow into the area at the middle of the valve, then to the upper ends of the shift valves and through an orifice, to the lower end of the valve.

When pressure at the lower end of the valve exceeds the force of the valve spring, main pressure is blocked, pre-venting solenoid pressure from increasing. When solenoid pressure falls, the valve moves downward, again admitting main. When a balanced condition is reached (solenoid pressure equals spring force) a uniform pressure, lower than main pressure, is established.

FAILURE PROTECTION (All Shift Valves). The shift valves (except for the splitter shift valve) are arranged in a cascade system. This arrangement ensures that only one drive clutch can be applied at a given time because the apply pressure of each depends upon the released position of the preceding valve. Thus, if two valves should be in the apply position, only the one that is first in line can receive apply pressure.

Each of the forward operation shift valves directs its clutch apply pressure to the spring cavity beneath the valve at the same time the clutch is charged. This ensures that the valve will remain in its upward position (clutch applied) even though the solenoid at the upper end of the valve is deenergized (by electrical failure). This hydraulic "hold" can be re-lieved only by the upward movement of an adjacent shift valve, or in the case of the first- and second-gear shift valves, by energizing solenoids I and A respectively. The splitter shift valve, in splitter-direct position, is unlocked by energizing solenoid G to exhaust the pressure from beneath the valve.

These features are referred to as "lock-in-range" because the operating range is retained even though an electrical failure occurs during operation.

NOTE

Loss of hydraulic pressure, as caused by stopping the engine, will relieve all hydraulic holds and only neutral will be obtained when the engine is restarted.

The reverse-gear shift valve has no such failure protection, and will always go to neutral (exhaust position) in the event of electrical failure during reverse operation.

TRIMMER SYSTEM. The trimmer system includes four valve groups in the lower section of the control valve as-sembly. These are: reverse-gear trimmer, first-and-second-gear trimmer, third-and-fourth-gear trimmer, and splitter-direct trimmer.

The functions of the four trimmers are similar. Each trimmer regulates the application of the clutch indicated by its designation. Basically, each trimmer limits the apply pressure of its clutch initially and then permits full apply pressure. The purpose of trimming is to prevent shift shock resulting from abrupt clutch engagement.

A secondary function of the first-and-second-gear, third-and-fourth-gear and splitter-direct trimmers is a regulation of the exhaust of preceding clutches. This prevents both clutch slippage and excessive clutch overlap during shifting.

Individual trimmer system valve groups are described below.

REVERSE-GEAR TRIMMER. This valve group includes a valve stop and two springs in the lower end of the valve bore, a valve or valve plug near the middle point in the bore, and a spring and valve at the upper end of the bore. A reverse clutch pressure passage is connected to the upper end of the bore. An exhaust port is provided just below the reverse clutch pressure passage.

When the reverse clutch is applied, apply pressure is sent to the top end of the valve. Initially, the plug and valve are forced downward against the spring until oil escapes at the exhaust port. The escape of oil, as long as it continues, reduces clutch-apply pressure. However, oil flows through an orifice in the trimmer valve to the cavity between the trimmer valve and the trimmer valve plug. Pressure in this cavity forces the plug farther downward to the stop. The plug stops, but the flow through the orifice continues. The pressure below the trimmer valve, because it is acting upon a greater surface area than at the upper end, pushes the trimmer valve to the upper end of the valve bore. This throttles, then stops the escape of oil to exhaust. When the escape of oil is throttled, clutch pressure rises. When the escape of oil stops, clutch pressure is at maximum. The plug remains downward until the clutch is released.

Upon release of the clutch, the spring pushes all the trimmer components to the top of the valve bore. In this position, the trimmer is reset and ready for the next clutch application.

FIRST-AND-SECOND-GEAR TRIMMER. This valve group includes a valve stop and two springs at the lower end of the trimmer valve bore, a valve near the middle of the bore, and a trimmer valve and spring at the upper end of the bore. A first-and-second-gear clutch pressure passage is con-nected to the upper end of the bore. An exhaust port is provided just below the first-and-second-gear clutch pressure passage. The lower cavity of the trimmer bore is exhausted to sump.

In addition, exhaust passages from the first-and-second-gear and fifth-and-sixth-gear shift valve bores connect to the trimmer bore near the middle of the bore. These passages, in conjunction with the position of the trimmer lower valve, control the exhaust rates of preceding clutches.

The trimming function of the first-and-second-gear trimmer is similar to that of the reverse-gear trimmer.

THIRD-AND-FOURTH-GEAR TRIMMER. This valve group includes a valve stop and two springs at the lower end of the trimmer valve bore, a valve near the middle of the bore, and a trimmer valve and spring at the upper end of the bore. A third-and-fourth-gear clutch pressure passage is con-nected to the upper end of the bore. An exhaust port is provided just below the third-and-fourth-gear clutch pressure passage. The lower cavity of the trimmer bore is exhausted to sump.

In addition, exhaust passages from the third-and-fourth-gear shift valve and to the exhaust regulator valve are provided. These passages, in conjunction with the position of the trimmer valve plug, control the exhaust rate of the first-and-second-gear clutch.

The trimming function of the third-and-fourth-gear trimmer is similar to that of the reverse-gear trimmer.

SPLITTER-DIRECT TRIMMER. This valve group includes two springs and a valve stop in the lower end of the trimmer valve bore, a trimmer lower valve at the middle of the bore, and a spring and trimmer upper valve at the upper end of the valve bore. A splitter-direct clutch pressure passage is connected to the upper end of the trimmer valve bore. An exhaust port is provided just below the splitter-direct clutch pressure passage. An exhaust passage from the splitter shift valve bore is connected to the middle of the trimmer valve bore. An exhaust port is provided just below the splitter exhaust passage and another at the lower end of the trimmer valve bore.

The trimming function of the splitter-direct trimmer valve is similar to that of the reverse-gear trimmer.

A secondary function of the splitter-direct trimmer is the regulation of splitter-overdrive clutch exhaust. The position of the splitter lower valve, in relation to the exhaust passages near the middle of the trimmer valve bore, deter-mines the exhaust rate of the splitter-overdrive clutch exhaust.

EXHAUST CHECK VALVE. This valve group includes a valve guide pin, a spring, and a mushroom-shaped valve. The valve seats in an opening in the separator plate adjacent to the control valve body. The spring maintains a slight pressure to hold the valve in its seat (closed).

The exhaust check valve is a common point through which several exhaust passages lead. The purpose of the ar-rangement is to provide an exhaust system which will dissipate almost all pressure, but will retain fluid in the system. When the system is filled with fluid, response to control is quicker.

DOWNSHIFT INHIBITOR PRESSURE SWITCH. A pressure switch (Figure 15-1), closed by lockup clutch pressure, energizes a solenoid in the shift selector assembly. The switch is installed into a tapped opening in the bottom of the lockup shift valve body. A conductor in the wiring harness connects the switch to the selector assembly.

SOLENOIDS. The system includes seven solenoids. These are identified as A, B, C, D, E, F and G in illustrations and explanations. These are identical components, and are not marked for identification when the control system is built. Electrical leads which connect to the solenoids are marked.

Solenoids are electrically energized devices which produce a magnetic pulling force when energized. In this application the magnetic force opens spring-loaded needle valves. The open needle valves bleed off pressure at the ends of shift valves faster than the pressure can be sustained by oil coming into the area through an orifice. This permits the shift valve spring to push the valve toward the solenoid (or relieves pressure at the spring ends of valves).

The manual-electric control has solenoids that match the voltage rating of the vehicle electrical system.

SHIFT SELECTOR ASSEMBLY. The shift selector assembly (shift tower) is manually operated and has eight selector positions. These are (from rear to front): reverse, neutral, first gear, second gear, third gear, fourth gear, fifth gear, and sixth gear. The shift indicator is correspondingly marked R, N, 1, 2, 3, 4, 5 and 6. Each shift position is gated, and the selector lever must be pushed right or left, alternately, to clear the gate separting each shift position from the adjoining position.

Eight microswitches are operated by a cam attached to the manual selector lever. Each position of the lever opens and closes the proper combination of switches required to energize or de-energize the proper combination of solenoids for that selector position.

A solenoid which has its axis on a line with the axis of the switch-operating cam acts as downshift inhibitor. It is energized when the transmission lockup clutch engages. Lockup clutch pressure closes a pressure-actuated switch which in turn energizes the inhibitor solenoid. The inhibitor solenoid engages a dog clutch arrangement which prevents the selector lever from being moved to a lower gear position. It may be upshifted.

NOTE

> The inhibitor solenoid is not to be confused with the nine solenoids used in the valve body assembly.

A lamp, which illuminates a translucent shift guide, is included in the selector assembly. It is connected to the ve-hicle dash lamp circuit.

FUSING AND OVERLOAD PROTECTION. In the shift tower, an SFE 9A fuse is installed. This fuse protects the neutral start switch.

The 12/24 volt converter unit is equipped with an SFE 7-1/2A fuse. This fuse protects the shift system from transient or steady high current from the vehicle system.
Replace fuses only with fuses of the prescribed amperage.

WIRING HARNESS. A wiring harness of the length required to connect the selector assembly to the valve body assembly transmits the electrical signals that cause the transmission to respond to the movements of the shift selector.

Fourteen wires are in the harness at the point where it leaves the selector assembly. Six wires branch off from the harness to attach to various parts of the circuit. The remaining eight wires attach to the main control valve body.

A sixteen-pin, female connector is attached to the selector end of the wiring harness. An eight-pin female connector is attached to the control valve body end of the harness. These connectors push onto mating connectors on the selector assembly and valve bodies. A nut at each connector is tightened to secure the harness ends.

MANUAL-ELECTRIC CONTROL SYSTEM CIRCUITS (Foldout 2)

NOTE

> Refrences to up, down, left or right refer to positions or movements of components on Foldout 2.

SYSTEM FUNCTIONS. The hydraulic system generates, directs and controls the pressure and flow of hydraulic fluid within the transmission. Hydraulic fluid(transmission oil) is the power transmitting medium in the torque converter. Its velocity drives the converter turbine. Its flow cools and lubricates the transmission. Its pressure operates the various control valves and applies the clutches.

SYSTEM SCHEMATICS (Foldout 2). A color-coded Foldout of the hydraulic system are presented at the back of this section. The illustrations represent the system as it functions in neutral with the engine idling. The lockup clutch is not engaged.

NEUTRAL. Main pressure (red), leaving the flow valve, is directed to the solenoid pressure regulator valve and to the priority valve. At the solenoid pressure regulator valve, a regulated pressure for controlling the shift valves is produced, and directed to each shift valve. At each shift valve, the oil must pass through an orifice. At the priority valve, oil passes through an orifice and exerts upward pressure on the step diameter of the valve. In a parallel branch, oil flows beneath the lower end of the priority valve and is directed to the splitter shift valve, two points on the fifth-and-sixth-gear shift valve, and the first-and-second-gear shift valve.

At the reverse shift valve, solenoid B is de-energized and its valve closed. This retains solenoid pressure, and the valve is pushed downward against its spring. The reverse clutch is exhausted through the spring-loaded check valve.

At the first-and-second-gear shift valve, solenoid C is de-energized and its valve is closed. Solenoid A is energized and its valve is open. Solenoid pressure at the upper end of the valve holds it downward against its spring. The first-and-second-gear clutch is exhausted through the bore of the third-and-fourth-gear shift valve and the spring-loaded check valve.

At the third-and-fourth-gear shift valve, solenoid D is de-energized, and its valve is closed. Solenoid pressure, retained at the upper end of the valve, forces the valve downward against its spring. The third-and-fourth-gear clutch is exhausted through the fifth-and-sixth-gear shift valve bore (valve downward), the first-and-second-gear trimmer valve bore, and then through the spring-loaded check valve.

At the fifth-and-sixth-gear shift valve, solenoid E is de-energized and its valve is closed. Solenoid pressure retained at the upper end of the shift valve forces the valve downward against its spring. The fifth-and-sixth-gear clutch is exhausted directly through a port at the right side of the valve.

At the splitter shift valve, solenoid F is energized and its valve is open. No pressure is retained at the upper end of the valve, and the spring at the valve lower end pushes the valve upward. In its upward position, pressure is directed to the splitter-direct clutch. This clutch apply pressure also is directed through an orifice to the lower end of the splitter shift valve and is retained by the valve of solenoid G (de-energized). Thus, the splitter shift valve will remain upward until solenoid G is energized. Splitter-direct clutch pressure is directed also to the splitter-direct trimmer valve.

NEUTRAL FAIL PROTECTION. Fail protection as covered herein concerns only the design of the system to provide certain safeguards in the event of loss of electrical power to solenoids.

If total electrical power fails while the transmission is in neutral, the transmission will remain in neutral (engine running) regardless of any position which might be manually selected after the failure. Partial electrical failure (one solenoid loses power) while in neutral will permit continued operation in neutral if the selector lever is not moved.
If individual solenoids A or F lose power while the trans-mission is in neutral, erratic shifting can be expected if other selector positions are selected. Refer to trouble-shooting later in this section.

FIRST GEAR OPERATION. When the vehicle selector lever is moved from neutral (N) to first gear (1), solenoid A is de-energized and its valve closes. Solenoid C remains energized. Solenoid F is energized, and its valve opens.

When solenoid A is de-energized, no change occurs except to prepare the hydraulic circuit for a shift to second gear operation. Its valve closes to retain first-and-second-gear clutch pressure when the first-and-second-gear shift valve moves upward.

When solenoid C is energized, its valve opens and releases solenoid pressure (yellow/white) from the upper end of the first-and-second-gear shift valve. Spring pressure pushes the shift valve upward, and main pressure is directed to the first-and-second-gear range clutch and to the lower end of the shift valve. The first-and-second-gear range clutch is applied. Pressure at the lower end of the shift valve equals that at the upper end. Thus, if electrical power fails, the valve will remain upward (transmission will remain in first-gear).

Solenoid F is energized as it was in neutral operation. Thus, the splitter-direct clutch is still applied.

When the first-and-second-gear shift valve moves up-ward, main pressure (red) is directed to two locations. These are: bottom of the shift valve to assist the spring in retaining the valve in an upward position and the first-and-second-gear clutch piston via the first-and-second-gear trimmer valve. With the first-and-second-gear shift valve in an upward position, main pressure to the reverse shift valve and the trimmer regulator valve is cut off. Pressure at these two points is exhausted to sump. In later models, the trimmer regulator valve and components are omitted.

When the first-and-second-gear clutch is charged initially, the first-and-second-gear trimmer, functions as described earlier.

All other valve components remain in the position they were in during neutral operation.

FIRST GEAR FAIL PROTECTION. If electrical power is lost completely during operation in first gear, the transmission will continue operation in first gear if the vehicle engine is not stopped.

If the manual selector is moved, first gear will be maintained in all selector lever positions. If the engine is stopped, the transmission will go to neutral when it is restarted.

If individual solenoids (C or F) lose power, the transmission will continue in first gear operation until shifted out of first gear or the engine stopped. Thereafter, shifting will be erratic in other selector positions. (Refer to troubleshooting later in this section.)

SECOND-GEAR OPERATION. When the vehicle selector lever is moved from first gear (1) position to second gear (2) position, solenoid F is de-energized and solenoid G is energized. Solenoid C remains energized.

When solenoid F is de-energized its valve closes and solenoid pressure is exerted on the upper end of the splitter shift valve. This pressure exerts a downward force on the shift valve.

When solenoid G is energized, and its valve opens, splitter-direct pressure (red/white) is released from the lower end of the shift valve. Solenoid pressure pushes the shift valve downward, and the splitter-overdrive clutch is applied and splitter-direct clutch exhausted. Solenoid C remains energized to retain first-and-second-gear clutch engagement.

The splitter-direct clutch exhausts through a port at the left side of the valve bore when the shift valve is downward.
SECOND-GEAR FAIL PROTECTION. If electrical power is lost completely during operation in second gear, the transmission will continue in second-gear operation if the vehicle engine is not stopped.

If the manual selector lever is moved, second gear will be maintained in all selector positions. If the engine is stopped, the transmission will go to neutral when it is restarted.

If individual solenoids (C or G) lose power, the transmission will continue in second-gear operation until the manual selector lever is moved or the engine stopped. Thereafter, shifting will be erratic in other selector positions. (Refer to troubleshooting later in this section.

THIRD-GEAR OPERATION. When the selector lever is moved from second gear (2) to third gear (3) position, solenoids C and G are de-energized and solenoids D and F re-energized.

When solenoid D is energized and its valve opens, solenoid pressure (yellow/white) is released from the upper end of the third-and-fourth-gear shift valve. The shift valve is pushed upward by its spring. When upward, the first-and-second-gear clutch can begin to exhaust through its main pressure feed line, through the third-and-fourth gear shift valve bore, through a check valve ball, through the third-and-fourth-gear trimmer valve bore, and to the exhaust check valve. When partially exhausted, the first-and-second-gear shift valve moves downward due to solenoid pressure (yellow/white) at its upper end (solenoid C de-energized). When part way down, the shift valve can complete the exhaust of the first-and-second-gear clutch through another passage which bypasses the ball check valve.

When solenoid G is de-energized, and solenoid F energized, spring pressure pushes the splitter shift valve upward. The splitter-overdrive clutch is released, and the splitter-direct clutch is applied. Splitter-direct clutch pressure also is directed to the lower end of the shift valve and to the upper end of the splitter-direct trimmer.

At the lower end of the splitter shift valve, splitter-direct clutch pressure can hold the valve upward in case of solenoid F power failure. At the splitter-direct trimmer, the trimmer functions as explained earlier.

When the third-and-fourth-gear clutch is charged, clutch pressure is also directed to the third-and-fourth-gear trimmer. All other valves remain in the position they were in during second-gear operation.

THIRD-GEAR FAIL PROTECTION. If electrical power is lost completely during operation in third gear, the transmission will continue in third gear operation if the vehicle engine is not stopped.

If the vehicle selector lever is moved, third gear will be maintained in all selector positions. If the engine is stopped, the transmission will go to neutral when it is restarted.

If individual solenoids (D or F) lose power, the transmission will continue in third-gear operation until the selector lever is moved or the engine stopped. Thereafter, shifting will be erratic in other selector positions. Refer to troubleshooting later in this section.

FOURTH-GEAR OPERATION. When the vehicle selector lever is moved from third gear (3) position to fourth gear (4) position, solenoid F is de-energized and solenoid G is energized. Solenoid D remains energized.

When solenoid F is de-energized its valve closes and permits solenoid pressure to push downward on the splitter shift valve. The valve can move downward because solenoid G was energized and its valve opened to relieve splitter-direct pressure at the lower end of the splitter shift valve. When the splitter shift valve moves downward, main pressure is directed to the splitter-overdrive clutch. The splitter-direct clutch exhausts through a port at the left side of the valve bore. Solenoid D remains energized to retain the third-and-fourth-gear shift valve in its upward position.

FOURTH-GEAR FAIL PROTECTION. If electrical power is lost completely during operation in fourth gear, the transmission will continue in fourth gear if the vehicle engine is not stopped.

If the selector lever is moved, fourth gear will be maintained in all selector positions. If the engine is stopped, the transmission will go to neutral when it is restarted.

If individual solenoids (D or G) lose power, the transmission will continue in fourth gear until the selector lever is moved or the engine is stopped. Thereafter, shifting will be erratic in other selector positions. Refer to troubleshooting later in this section.

FIFTH-GEAR OPERATION. When the selector lever is moved from fourth gear (4) position to fifth gear (5) position, solenoids D and G are de-energized, and solenoids E and F are energized.

When solenoid G is de-energized, and solenoid F is energized, solenoid pressure is released from the upper end of the splitter shift valve. Spring pressure pushes the shift valve upward, and the valve directs splitter-direct clutch pressure (red/white) to the splitter-direct clutch. The splitter-overdrive clutch exhausts through the splitter direct trimmer valve bore. This exhaust is regulated by the downward movement of the trimmer lower valve. The splitter-direct clutch is trimmed by the splitter-direct trimmer, as explained earlier.

When solenoid E is energized, solenoid pressure (yellow/white) is released from the upper end of the fifth-and-sixth-gear shift valve, and the valve moves upward. This directs main pressure to the fifth-and-sixth-gear clutch. At the same time, the fifth-and-sixth-gear shift valve (upward) opens a passage through which the cavity at the lower end of the third-and-fourth-gear shift valve can exhaust. This permits the third-and-fourth-gear shift valve to move downward, due to solenoid pressure (yellow/white) retained when solenoid D was de-energized.

The third-and-fourth-gear clutch exhausts through a passage to the fifth-and-sixth-gear shift valve bore, then to the splitter shift valve bore, and then to the splitter-direct trimmer valve bore. At the trimmer valve bore, exhaust is initially regulated through an orifice. Then, when the splitter-direct trimmer acts, the exhaust is direct (bypassing the orifice).

FIFTH-GEAR FAIL PROTECTION. If electrical power fails completely during operation in fifth gear, the transmission will continue in fifth-gear operation if the engine is not stopped.

If the vehicle selector lever is moved, fifth gear will be maintained in all selector positions. If the engine is stopped, the transmission will go to neutral when it is restarted.

If individual solenoids (E or F) lose power, the transmission will continue in fifth gear until the selector lever is moved or the engine is stopped. Thereafter, shifting will be erratic in other selector positions. Refer to troubleshooting later in this section.

SIXTH-GEAR OPERATION. When the selector lever is moved from fifth-gear (5) position to sixth-gear (6) position, solenoid F is de-energized, solenoid G is energized, and solenoid E remains energized.

When solenoid F is de-energized, its valve closes and solenoid pressure is exerted upon the upper end of the splitter shift valve. When solenoid G is energized, its valve opens and relieves splitter-direct clutch pressure at the lower end of the splitter shift valve. The valve moves downward and exhausts the splitter-direct clutch, and applies the splitter-overdrive clutch.

Solenoid E remains energized, and the fifth-and-sixth-gear shift valve remains upward to retain engagement of the fifth-and-sixth-gear clutch.

SIXTH-GEAR FAIL PROTECTION. If electrical power fails completely during operation in sixth gear, the transmission will continue in sixth gear if the engine is not stopped.

If the selector lever is moved, sixth gear will be maintained in all selector positions. If the engine is stopped, the transmission will go to neutral when it is restarted.

If individual solenoids (E or G) lose power, the transmission will continue in sixth-gear operation until the selector lever is moved or the engine is stopped. Thereafter, shifting will be erratic in other selector positions. Refer to troubleshooting later in this section.

REVERSE OPERATION. Regardless of which forward gear is selected, the manual control must pass through neutral (N) before reverse is selected. In neutral, solenoids A and F are energized.

When the selector lever is moved from neutral (N) position to reverse (R) position, solenoid B is energized. Solenoids A and F remain energized.

When solenoid B is energized, its valve opens and solenoid pressure is relieved at the upper end of the reverse shift valve. The spring at the lower end of the reverse shift valve pushes the valve upward. In its upward position, the valve directs main pressure to the reverse clutch, and it engages.

Reverse clutch pressure is directed also to the reverse trimmer valve. The reverse trimmer functions as described. Solenoid F remains energized to retain splitter-direct operation. Solenoid A remains energized to prevent trapping first-and-second-gear clutch pressure at the lower end of the first-and-second-gear shift valve in the event of a quick shift from first or second gear to reverse (selector would not be in neutral a sufficient length of time to permit the first-and-second-gear shift valve to bottom, and exhaust the first-and-second-gear clutch).

REVERSE FAIL PROTECTION. If electrical power fails completely during reverse operation, the transmission will go to neutral and remain in neutral regardless of where the shift selector is placed.

If only solenoid B loses power, the transmission will go to neutral and remain there until the selector lever is moved to another position. Shifting to any forward range will be normal. If solenoids A or F lose power during operation in reverse, the transmission will remain in reverse until the selector lever is moved or the vehicle engine is stopped. Thereafter, shifting will be erratic when the engine is restarted and the shift selector moved to other positions. Refer to troubleshooting.

TORQUE PATHS THROUGH THE TRANSMISSION

NOTE

In all power flows discussed, it is assumed that the engine is operating at its normal output torque and speed. Even though two clutches are applied, the vehicle should not move (except possibly to creep) if the engine is idling. The torque converter will not transmit sufficient torque at low-idle speed to move the vehicle at more than a creep. The direction of rotation is determined by viewing the transmission from the front (input) end.

TORQUE CONVERTER OPERATION. Power is transmitted hydraulically through the torque converter. The engine drives the torque converter pump. The pump throws oil against the turbine vanes to impart torque to the turbine shaft. From the turbine, oil flows between the vanes of the stator and re-enters the pump where the cycle begins again. When the engine is idling, impact of the oil upon the turbine blades is negligible. When the engine is accelerated, the impact is increased and the torque directed through the turbine shaft can exceed the engine torque (by an amount equal to the torque ratio of the converter).

LOCKUP OPERATION. Power is transmitted mechanically through the lockup clutch. Application of the lockup clutch occurs automatically as a function of front governor (pilot) pressure. When the lockup clutch is applied, the converter elements rotate as a unit at engine speed. This provides a direct drive from the engine to the turbine shaft.

NEUTRAL - TORQUE PATH (Figure 15-5). The shift tower lever is in neutral (N) position. The torque from the engine passes, by hydraulic action, through the converter to the splitter-direct clutch drum and the splitter planetary carrier. The splitter-direct clutch is applied, transmitting torque to the splitter sun gear. All other clutches are released.

With two elements (sun gear and carrier) of the splitter planetary thus locked together, the third member (ring gear) must rotate when the other two rotate. The intermediate-and low-range sun gears are attached to the splitter ring gear and rotate with it. Torque is not transmitted to the transmission output because the range clutches are released and allow free rotation of all range planetary gears.

FIRST GEAR - TORQUE PATH (Figure 15-6). The shift tower lever is in first-gear (1) position. The torque from the engine passes, by hydraulic action, through the converter to the splitter-direct clutch drum and the splitter planetary carrier. The splitter-direct clutch is applied. Thus, rotation and torque is transmitted to the intermediate- and low-range sun gears. Refer to Neutral Torque Path.

In addition to the splitter-direct clutch, the first-and-second-gear clutch is applied. This holds the low-range ring gear stationary. The rotating low-range sun gear forces the pinions on the low-range planetary carrier to rotate within the stationary ring gear. Rotation of the pinions causes the carrier to rotate in the same direction as the sun gear. The

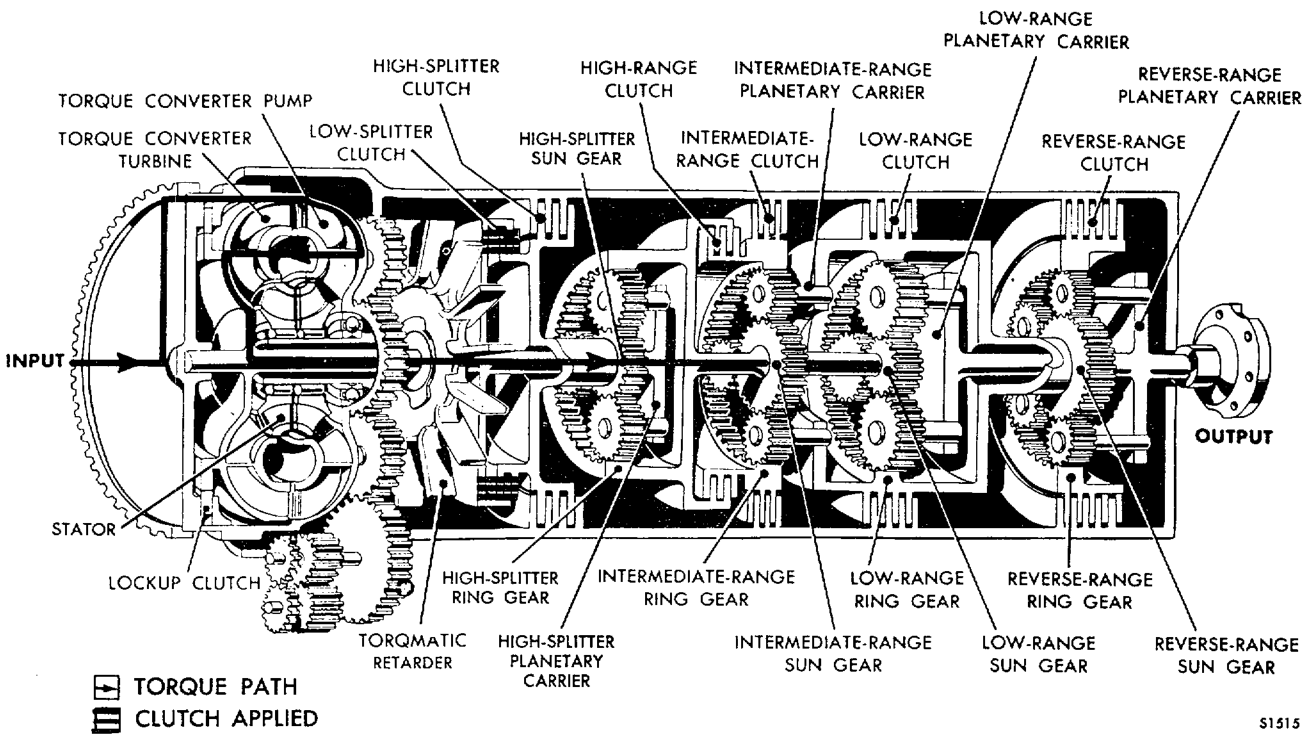


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Figure 15-5. Neutral --Torque Path

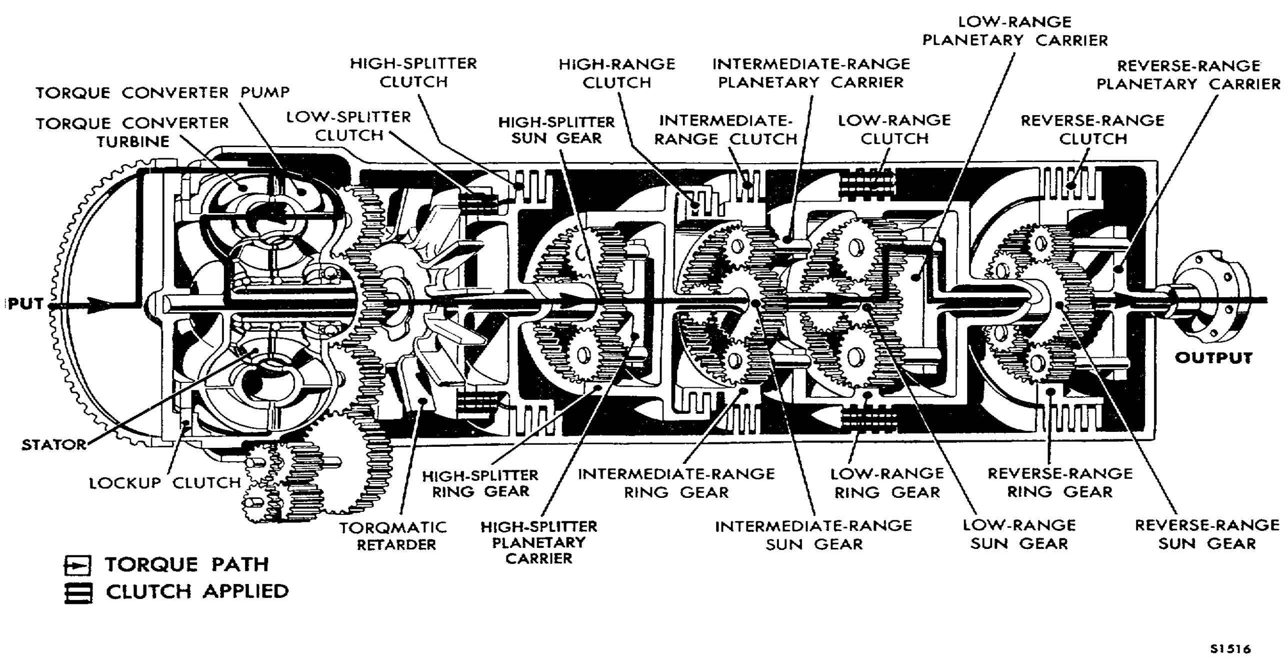

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Figure 15-6. First Gear - Torque Path

low-range planetary carrier, being integral with the transmission output shaft, causes it to rotate.

The transmission output shaft rotates in a clockwise direction. A speed reduction ratio of 4 to 1 is obtained, entirely within the low-range planetary.

SECOND GEAR - TORQUE PATH (Figure 15-7). The shift tower lever is in the second-gear (2) position. The torque from the engine passes, through the applied lockup clutch, to the splitter-direct clutch drum and splitter planetary carrier. The splitter-overdrive clutch is applied. This holds the splitter sun gear stationary. This forces the pinions on the splitter planetary carrier to rotate around the stationary sun gear. The pinions overdrive the splitter ring gear, to which is attached the intermediate- and low-range sun gears.

In addition to the splitter-overdrive clutch, the first-and-second-gear clutch is engaged. Refer to First Gear Torque Path, for explanation of power flow from the low-range sun gear to the transmission output shaft.

The transmission output shaft rotates in a clockwise direction. A speed increase ratio of 0.67 to 1 in the high splitter, coupled with a speed reduction ratio of 4 to 1 in the low-range planetary, gives an overall speed reduction of 2.68 to 1.

THIRD GEAR - TORQUE PATH (Figure 15-8). The shift tower lever is in the third-gear (3) position. The torque from the engine passes, by hydraulic action, through the converter to the splitter-planetary carrier. The splitter-direct clutch is applied. Thus, torque and rotation is transmitted to the intermediate-range and low-range sun gears.

In addition to the splitter-direct clutch, the third-and-fourth-gear clutch is applied. This holds the intermediate-range ring gear stationary. The rotating intermediate-range sun gear forces the pinions on the intermediate-range planetary carrier to rotate within the stationary ring gear. This causes the carrier and the low-range ring gear, to which it is attached, to rotate. Thus, both the sun gear and ring gear of the low-range planetary are rotating in the same direction, but at different speeds. The ring gear has the slower rotation.

The low-range pinions, being meshed with both the sun gear and ring gear, rotate at another speed and drive the low-range planetary carrier. The carrier, integral with the output shaft, drives it. This arrangement of two planetary, interconnected, is called compounding.

The transmission output rotates in a clockwise direction at an overall speed reduction ratio of 2.01 to 1. This ratio is the result of the 1 to 1 ratio in the splitter, and the 2.01 to 1 ratio in the compounded intermediate- and low-range planetary.

FOURTH GEAR - TORQUE PATH (Figure 15-9). The shift tower lever is at the fourth-gear (4) position. The torque from the engine passes through the applied lockup clutch to

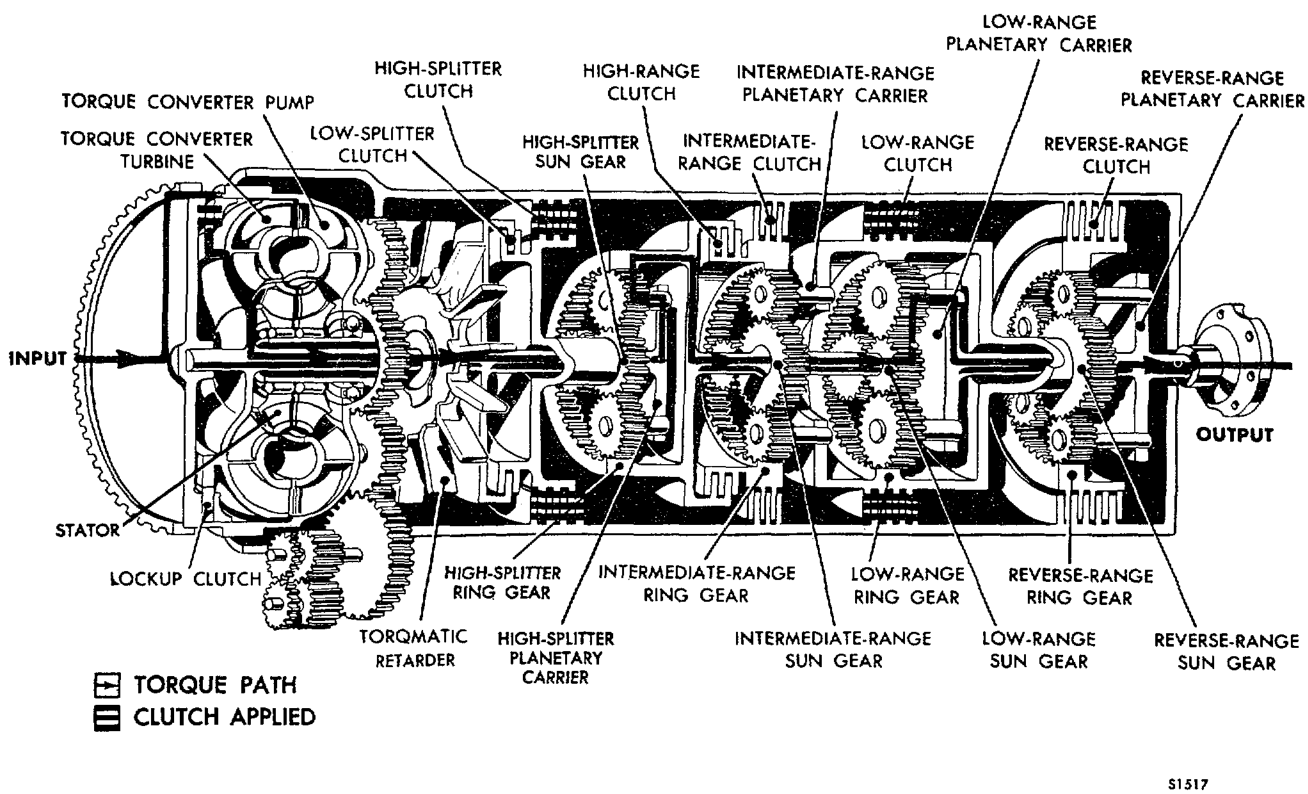

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Figure 15-7. Second Gear - Torque Path

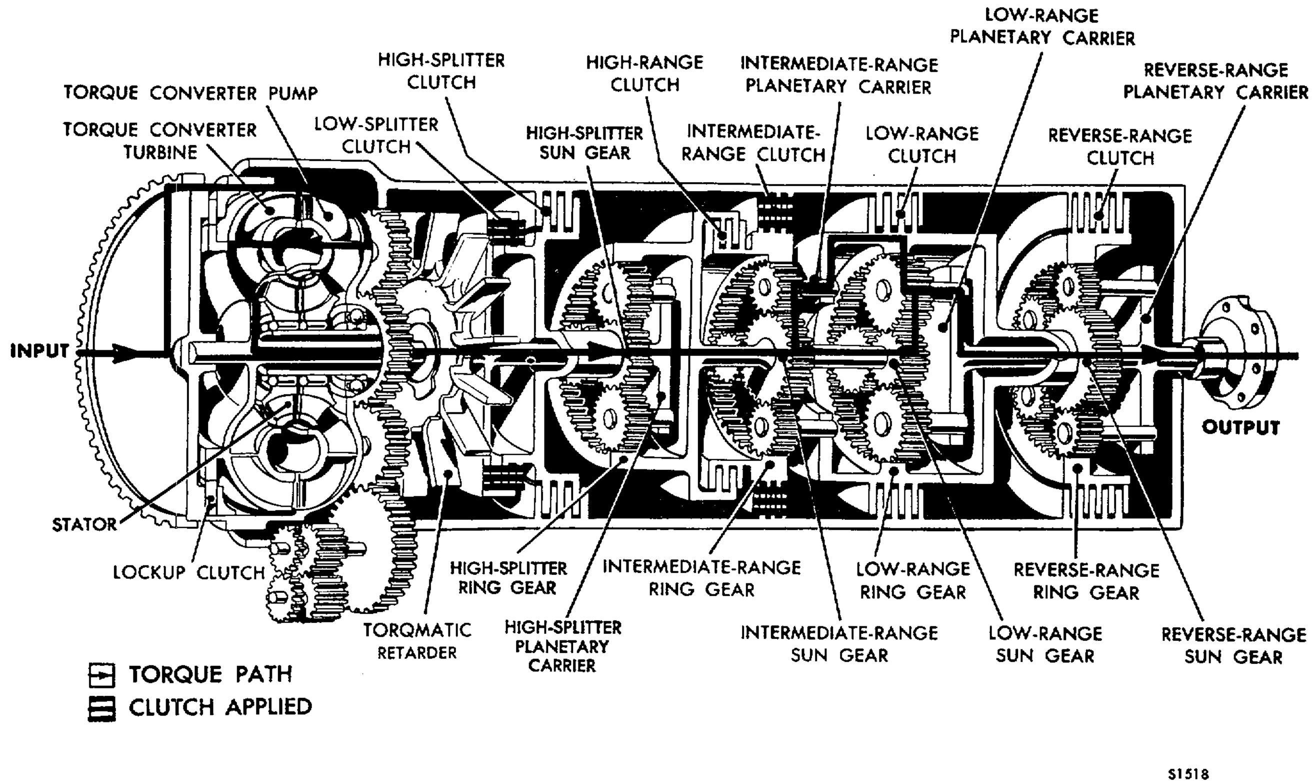

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Figure 15-8. Third Gear - Torque Path

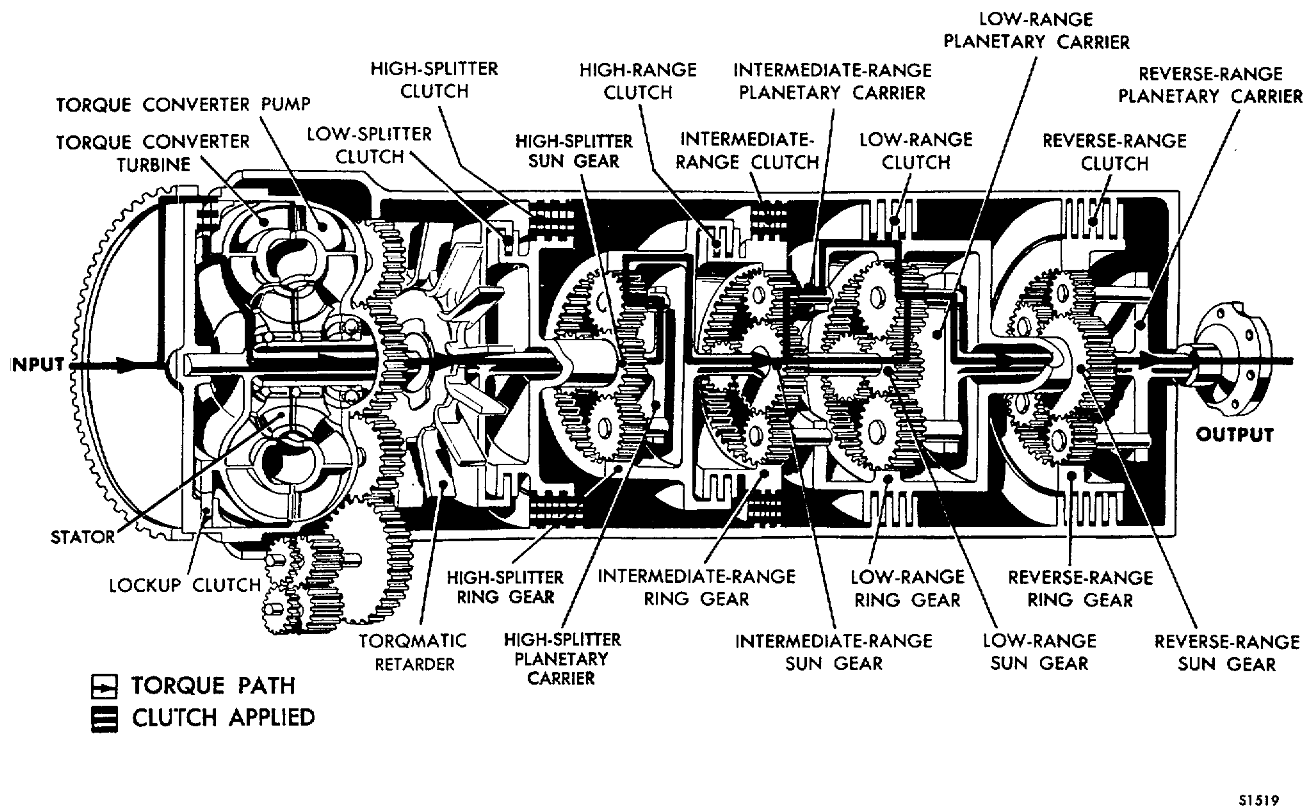

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Figure 15-9. Fourth Gear - Torque Path the splitter-direct clutch drum and the splitter planetary, carrier. The splitter-overdrive clutch is applied. Refer to Second Gear Torque Path for explanation of delivery of power to the low- and intermediate-range sun gears.

In addition to the splitter-overdrive clutch, the third-and-fourth-gear clutch is applied. Refer to Third Gear Torque Path for explanation of action in the intermediate- and low-range planetary.

The transmission output rotates in a clockwise direction at an overall speed reduction of 1.35 to 1 .This is a result of the 0.67 to 1 overdrive in the splitter planetary, coupled with the 2.01 to 1 speed reduction in the compounded low- and intermediate-range planetary.

FIFTH GEAR - TORQUE PATH (Figure 15-10). The shift tower lever is in fifth-gear (5) position. The torque from the engine passes through the applied lockup clutch to the splitter-direct clutch drum and to the splitter planetary carrier. The splitter-direct clutch is applied. Refer to Neutral Torque Path for explanation of delivery of power to the low-and intermediate-range sun gears.

In addition to the splitter-direct clutch, the fifth-and-sixth-gear clutch is applied. This causes the intermediate-range ring gear to rotate at the same speed as the intermediate-range sun gear. Thus, the intermediate-range planetary carrier must rotate at the same speed as the sun and ring gears. In turn, the low-range ring gear, being connected to the intermediate-range planetary carrier, also rotates at the same speed. The low-range sun gear also is rotating at the same speed. The result is that the entire range planetary group is locked together and rotating at the same speed as the turbine output shaft.

The transmission output rotates in a clockwise direction at 1 to 1 ratio. This is a result of direct drive in the splitter-direct clutch, and direct drive through the locked planetary sets. There is no relative rotation of any planetary gears. They are rotating as a unit.

SIXTH GEAR - TORQUE PATH (Figure 15-11). The shift tower lever is in the sixth-gear (6) position. The torque from the engine passes through the applied lockup clutch to the splitter-direct clutch drum and to the splitter planetary carrier. The splitter-overdrive clutch is applied. Refer to Second Gear Torque Path for explanation of the delivery of power to the intermediate- and low-range sun gears.

In addition to the splitter-overdrive clutch, the fifth-and-sixth-gear clutch is applied. Refer to Fifth Gear Torque Path for explanation of delivery of power to the transmission output.

The transmission output rotates in a clockwise direction at a speed increase of 0.67 to 1. This is a result of the overdrive ratio of 0.67 to 1 in the splitter planetary, coupled with the locked up range planetary group rotating as a unit.

REVERSE GEAR - TORQUE PATH (Figure 15-12). The shift tower lever is in the reverse (R) position. The torque from the engine passes, by hydraulic action, through the converter to the splitter-direct clutch drum and to the splitter planetary carrier. The splitter-direct clutch is applied. Refer

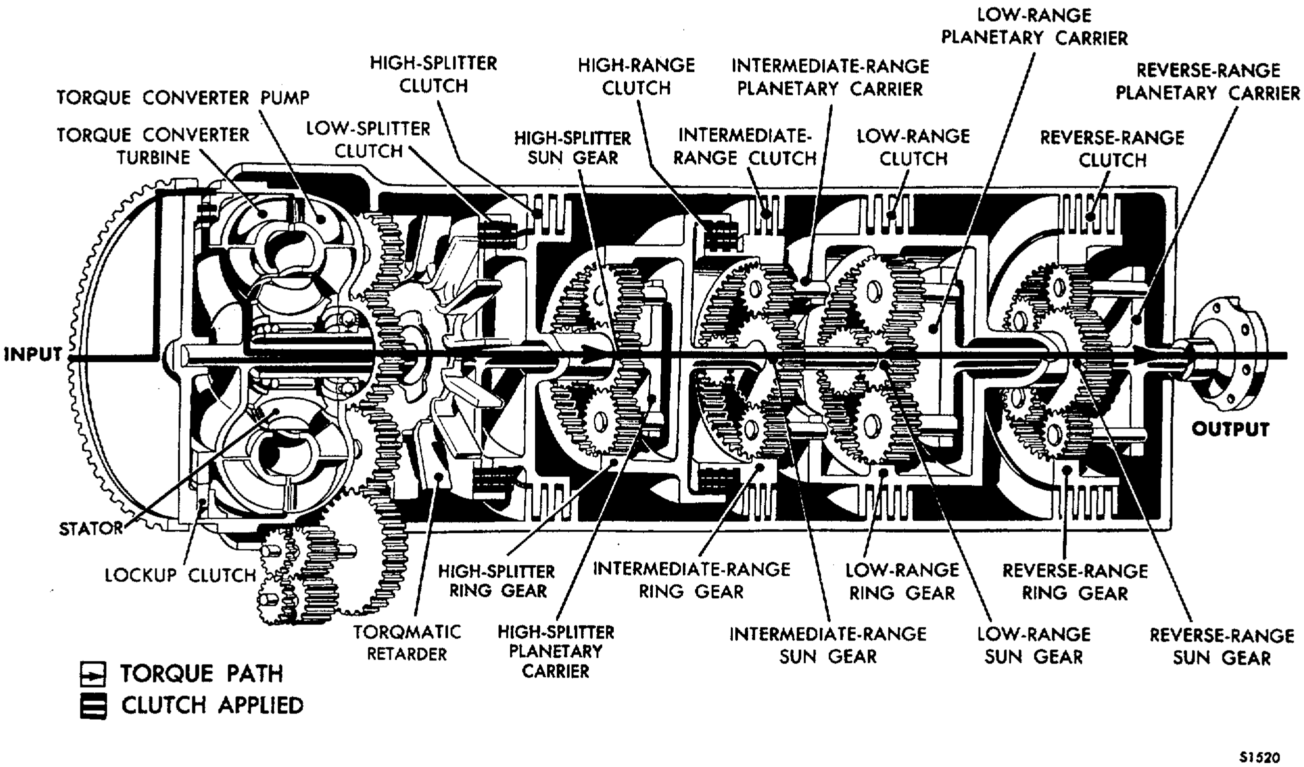

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Figure 15-10. Fifth Gear - Torque Path

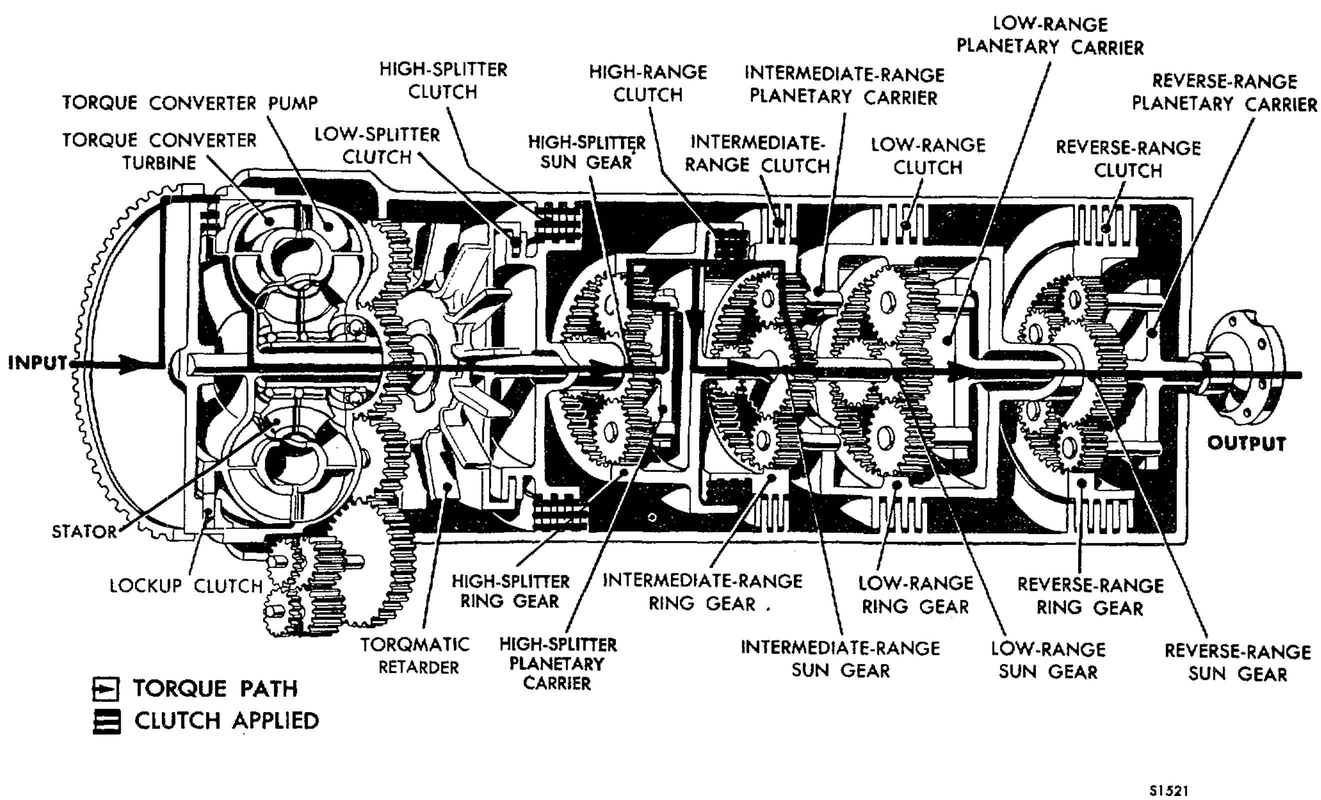

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Figure 15-11. Sixth Gear - Torque Path

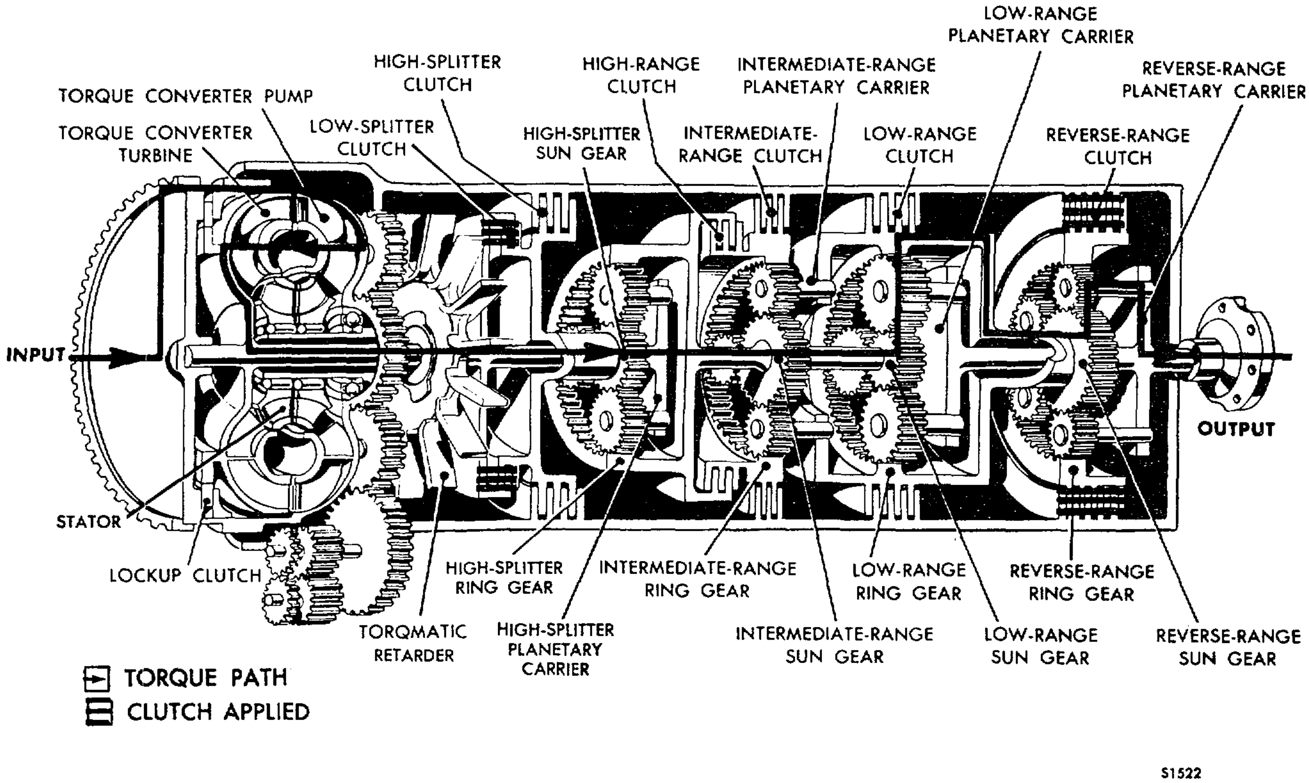

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Figure 15-12. Reverse Gear - Torque Path to Neutral Torque Path for explanation of the flow of power to the low- and intermediate-range sun gears.

In addition to the splitter-direct clutch the reverse clutch is applied. This holds the reverse ring gear stationary. The reverse planetary is coupled with the low-range planetary (compounded) to obtain opposite rotation and the desired ratio. The two planetary's are interconnected so that rotation is reversed in the low-range planetary, and further speed reduction is obtained in the reverse planetary.

The low-range sun gear rotates clockwise, driving the low-range planetary pinions counterclockwise. The low-range ring gear is driven counterclockwise by the pinions. The reverse sun gear, being connected to the low-range ring gear, also rotates counterclockwise. The sun gear forces the reverse-range planetary pinions to rotate clockwise within the stationary ring gear, driving the reverse carrier counterclockwise.

The low-range carrier being connected to the reverse-range planetary carrier, thus acts as a reaction member although it is moving slowly at output shaft speed. The overall speed reduction ratio is 5.12 to 1. This is the result of direct drive(1 to 1 ratio) in the splitter-direct clutch and a 5.12 to 1 speed reduction ratio in the compounded low-range and reverse planetarys.

PREVENTIVE MAINTENANCE

GENERAL

This material describes routine procedures to maintain the transmission in good operating condition. Included are instructions for care of the oil system, minor adjustments of the transmission and control linkage, tests to determine condition, instructions for extended storage and a troubleshooting chart.

INSPECTION AND CARE

The transmission should be kept clean to make inspection easier. Check for loose bolts, loose oil lines, oil leakage, and condition of control linkage and cables. Check the transmission oil level at intervals specified in the vehicle operator's manual.

OIL LEVEL CHECKS

IMPORTANCE OF PROPER OIL LEVEL. Maintaining the proper oil level is very important. The transmission oil is used to apply clutches and lubricate and cool the components. Transmission performance will be affected when the oil aerates. The primary causes of aeration are low oil in the sump or too much oil in the sump.

A low oil level will not completely envelop the oil filter. Therefore, oil and air are drawn by the input pump and are directed to the clutches and converter, causing converter cavitational noises and irregular shifting. The aeration also changes the viscosity and color of the oil to a thin milky liquid.

Too much oil in the sump can introduce oil into the gearing and clutches during severe up or down grade operation of the vehicle. This can cause aeration which can overheat the transmission or cause irregular shift patterns.

COLD CHECK. The cold oil check (engine not running) is made only to determine if there is sufficient oil to permit safe starting of the engine. Check plugs (Figure 15-13) are provided. The oil level must be at or above the ADD plug level before the engine is started.

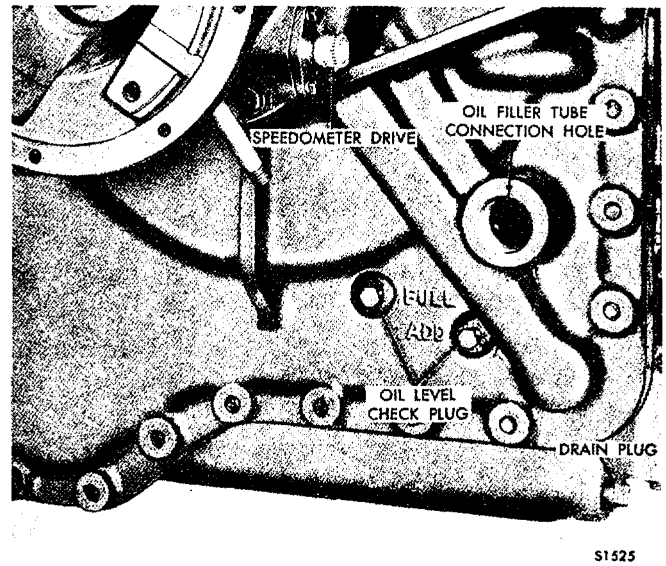

Figure 15-13. Fill, Drain, and Oil Level Locations at Rear of Transmission Housing

HOT CHECK. The hot oil check is made to determine if there is sufficient oil for working operation of the transmission. This check is made, while the engine is running, after a few minutes operation at 1 000 rpm, the vehicle standing level, and the transmission at a normal operating temperature of 180-2000F (82-930C). The hydraulic retard control must be in the OFF position.

Oil level plugs are located at the rear of the transmission (Figure 15-13). Remove the FULL plug. Under the conditions stated in the previous paragraph the oil level should be at the FULL plug level. If the oil is below this level add sufficient oil to bring it to the FULL plug level. Drain excess oil until oil is at the FULL plug level.

CHANGING OIL AND FILTERS

CLEANLINESS. Oil must be handled in clean containers to prevent foreign material from entering the transmission.

CAUTION

Containers or fillers that have been used for anti-freeze or engine coolant solution must not be used for transmission oil.

OIL CAPACITY. Straight-through configuration transmissions require approximately 18 U.S. gallons (68 liters) for initial filling, plus the additional amount needed in the external system (cooler, filter, external lines).

OIL TYPE. Use Type C3 transmission oil as specified below.

Fluid Viscosity and Grade	Ambient Temperature below Which Preheat is Required
30	320F (0°C)
15W-40	15°F (-90°C)
10W, 10-10W	-10°F (-23°C)
5W-20	-300F (-34°C)

INTERVALS. The oil and oil filters should be changed every 1200 hours or sooner depending on type of duty and environment.

PROCEDURES. The transmission should be at operating temperature (after about one hour operation).

Remove the oil drain plug (Figure 15-13 or 15-14)and drain the oil. Replace the plug.

The transmission has a cylindrical oil strainer located in the oil sump (Figure 15-14). A new gasket should be used when replacing the cover after each cleaning. Clean the strainer assembly thoroughly.

Filter elements should be replaced whenever the oil is changed, and at 600 hour intervals between oil changes.

The filter shells should be thoroughly cleaned. New gaskets (or seal rings) should be used when new filter elements are installed.

Before starting the engine refill the transmission with clean transmission oil. The oil filler arrangement varies among installations.

When filling the system, pour enough oil into the transmission until the correct level is indicated on the ADD check plug. Start the engine, and let it idle for two or three minutes. If the main oil pressure fluctuates and will not stabilize during this period, more oil should be added. After enough oil is added to stabilize the pressure, operate the vehicle through all ranges until the temperature reaches 180°F (820C). Stop the vehicle and check the oil. Add oil, if required, while the engine is running.

Carefully inspect the filter components and cover for oil leakage while the vehicle engine is running.

OIL CONTAMINATION

EXAMINE AT OIL CHANGE. At each oil change, examine the oil which is drained for evidence of dirt or water. A normal amount of condensation will emulsify in the oil during operation of the transmission. However, if there is evidence of water, check the cooler (heat exchanger) for leakage between the water and oil areas. Oil in the water side of the cooler (or vehicle radiator) is another sign of leakage. This, however, may indicate leakage from the engine oil system.

METAL PARTICLES. Metal particles in the oil (except for the minute particles normally trapped in the oil filter and strainer) indicate damage has occurred in the transmission. When these particles are found in the sump, the transmission must be disassembled and closely inspected to find the source. Metal contamination will require complete disassembly of the transmission and cleaning of all internal and external circuits, cooler and all other areas where the particles could lodge. During the repair of a major internal failure of a transmission, it should be dismantled into as many serviceable detail parts as possible and thoroughly

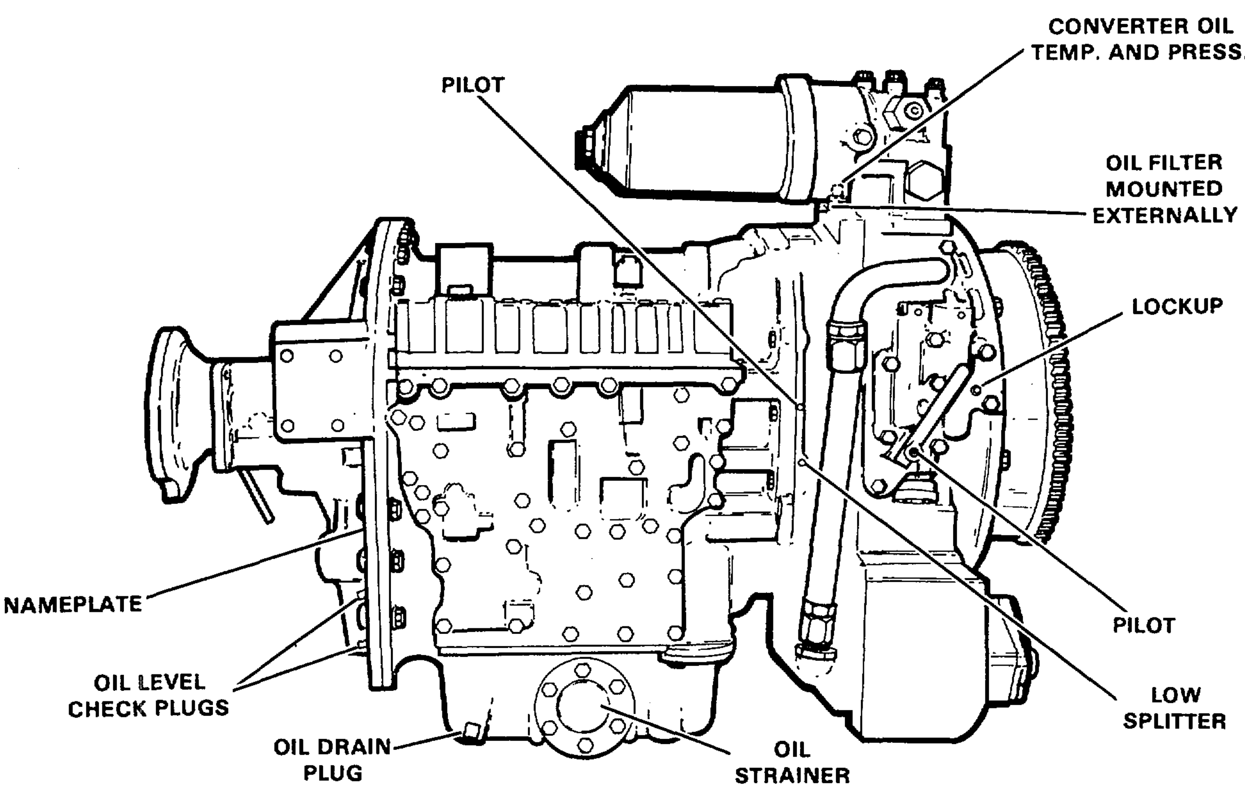

Figure 15-14. Oil System Check Points - Right Rear View

cleaned. Do not disassemble the unit just to the problem area.

COOLANT LEAKAGE. If engine coolant leaks into the transmission oil system, immediate action must be taken to prevent malfunction and possible serious damage. Glycol will attack friction-faced clutch plates. The transmission must be completely disassembled, inspected and cleaned. If glycol is present, all friction-faced clutch plates (including lockup clutch) must be replaced. All traces of the coolant, and varnish deposits, resulting from coolant contamination, must be removed. The cooler should be repaired or replaced prior to installation of the new or rebuilt transmission.

NOTE

A Gly-Tek test kit to detect glycol in transmission oil can be obtained from Nelco Company, 1047 McKnight Road South, Saint Paul, Minnesota 55119. (Some C3 fluids may produce a positive reading due to "additives" that are not actually glycol. When test results are questionable, a test of an unused sample of the oil type or brand should be made to confirm test results.)

BREATHER

The breather is located at the top of the transmission housing. The breather prevents pressure build-up within the transmission. The breather must be kept clean and the passage open. The prevalence of dust and dirt will determine how often the breather requires cleaning.

CHECKING OIL TEMPERATURE, PRESSURES

OIL TEMPERATURE GAUGE. An oil temperature gauge is installed on the vehicle instrument panel to indicate converter-out (to cooler) oil temperature. The gauge sending unit is installed in a tapped hole at the top of the retard control valve (Figure 15-15).

The gauge is marked with a range of 150-330°F (65-165°C). The 150-275°F (65-135°C) segment has a green band: the 275-330°F (135-165°C) segment is red. The safe operating range is green. The red indicates overheating. The only exception of this limit is during retarder operation. For intermittent retarder operation only, the converter-out oil temperature may exceed 275°F (135°C) but under no condition is the converter-out oil temperature to exceed

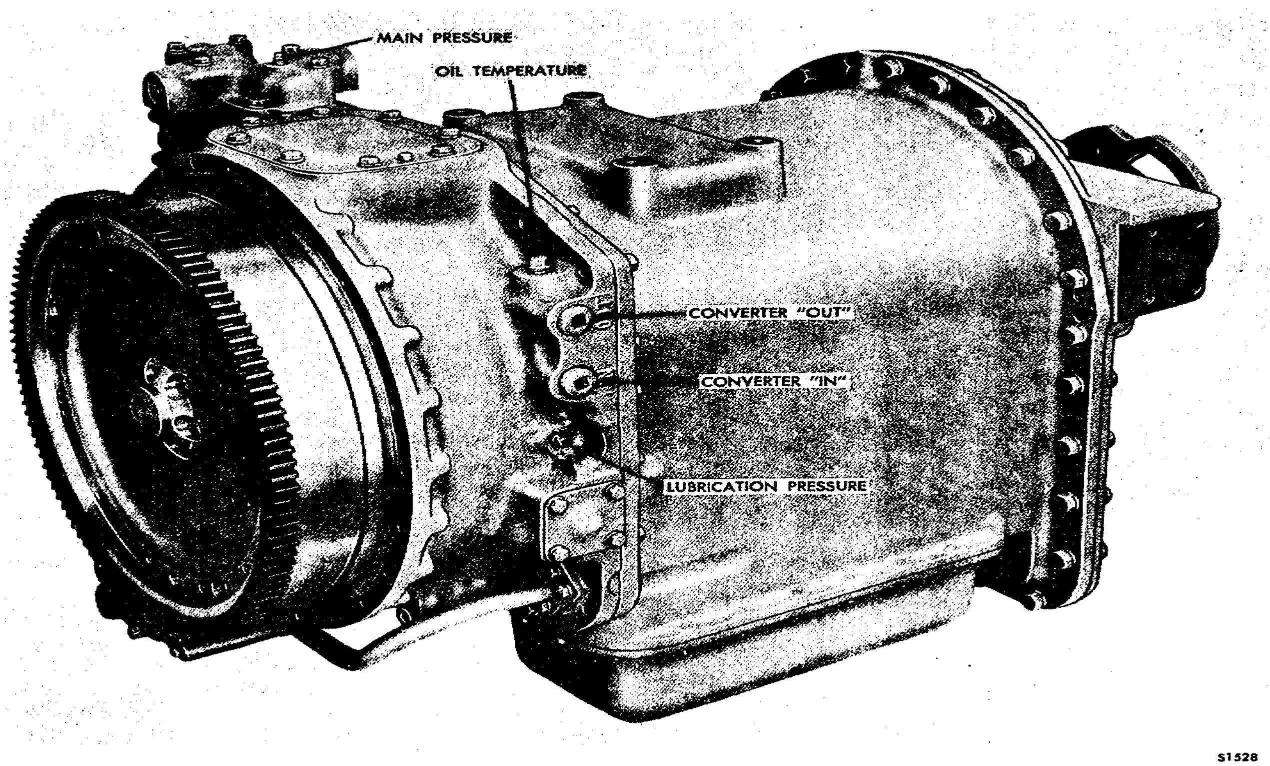

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Figure 15-15. Transmission Showing Pressure and Temperature Check Points

330°F (165°C). The normal operating temperature of the transmission is 180-200°F (82-93°C).

If the maximum converter-out oil temperature is reached, stop the vehicle and shift the transmission into neutral. Operate the engine at 1500 rpm to reduce the transmission oil temperature. If the transmission oil does not cool in approximately 30 seconds, or if it continues to overheat after operation is continued, stop the engine and locate the problem.

CHECKING MAIN OIL PRESSURE

NOTE

Pressures should be checked with the engine running at 1500 rpm and the transmission oil temperature at 180-200°F (82-93°C). Apply the service and parking brakes securely to prevent the vehicle from moving during stalled output testing.

A pressure gauge is installed in the instrument panel to indicate the oil pressure. The gauge is calibrated from 50-300 psi (345-2067 kPa). The 50-140 psi (345-965 kPa) segment is solid red, the 140-230 psi (965-1584 kPa) segment is solid green. The 230-300 psi (1585-2067 kPa) segment is solid red.

Main pressure is checked by the gauge on the instrument panel or by connecting a gauge to the 1/4 NPTF tapped opening on the front side of the main-pressure regulator body. Refer to Table 15-1 for main-pressure data.

The gauge continuously registers the pressure in the main pressure circuit and the applied clutches. Refer to Table 15-1.

Table 15-1. Main Pressure Schedule

Pressures are taken with the engine running at 1500 rpm normal 180-200°F (82-93°C) temperature and the output stalled.

Selector	Main Pressure	
Position	psi	kPa
6	180 to 190	1241 to 1310
5	180 to 190	1241 to 1310
4	180 to 190	1241 to 1310
3	180 to 190	1241 to 1310
2	180 to 190	1241 to 1310
1	180 to 190	1241 to 1310
N	———	———
R	180 to 190	1241 to 1310

If the operating pressures do not fall within limits, main pressure requires adjustment. Main-pressure can be raised or lowered by adding or removing shims at the booster signal plug end of the main-pressure regulator valve spring. To add or remove shims, remove the main-pressure regulator valve booster plug 19 (B, Fold-out 5), gasket 20 and plug 21. The shims are located in the bore of the booster plug. Add or remove shims to obtain the proper main oil pressure readings. Shims are available in thickness' of 0.0289 and 0.0528 in. (0.734 and 1.341 mm)

CHECKING LUBRICATION PRESSURE. The lubrication pressure may be checked by connecting a pressure gauge into the check point on the left side of the converter housing (Figure 15-15). The lubrication oil pressure should be approximately 20 psi (138 kPa) when the transmission is in first gear, with the output stalled, the transmission at a normal operating temperature of 1 80-200°F (82-93°C) and the engine running at 1000 rpm.

CHECKING CONVERTER-OUT PRESSURE. Converter-out pressure may be checked at the point provided for attaching the temperature gauge sending unit (1/2 NPTF tapped opening, Figure 15-15). With transmission at a normal operating temperature of 180-200°F (82-93°C) maximum converter-out pressure at full throttle stall is 65 psi (448 kPa); minimum is 30 psi (207 kPa).

CHECKING FLUID VELOCITY GOVERNOR (PILOT) PRESSURE. Install a pressure gauge at the lower plug on the lockup valve body or the upper plug on the right side of the retard housing (Figure 15-14). Pilot pressure depends upon the rotation of the splitter-direct clutch drum. Therefore, no reading can be had with the vehicle standing except when the shift control is in neutral position. In neutral, with engine running at 1000 rpm, the reading will be proportional to the speed of the turbine output shaft and will vary from 0 to approximately 30 psi (0 to approximately 207 kPa).

With the vehicle in motion, readings in each range will be proportional to the speed of the vehicle in that range. While the vehicle is being driven, there will be a momentary sudden drop in governor pressure as shifts are made from one range to another.

When up-shifting, the pressure will quickly return after the shift is made but the pressure will be lower than before shifting. It will climb as vehicle speed increases. In down-shift, the pressure will return and be higher than before shifting. It will fall as vehicle speed decreases. Under differing operating conditions, governor pressure will vary from 0-120 psi (0-827 kPa).

CHECKING RANGE AND SPLITTER CLUTCH PRESSURES. Refer to Figure 15-16 for location of pressure taps for range and splitter clutches.

Clutch apply pressure at all range and splitter clutch pressure taps should equal main-pressure. See Checking Main Pressure this page.

LINKAGE

RETARD VALVE LINKAGE. Clean, inspect, and lubricate all linkage. The retard is not applied when the valve is downward (into the valve body). Therefore, it is important, for normal operation with the retard off, that the linkage be adjusted so that the valve is held firmly downward to its stop. If the linkage allows the retard to be partially applied, excessive drag and overheating will result and fuel consumption will be excessive. When the retard is applied, make sure that the valve is all the way up. Inspect the control linkage for binding, wear or breaks. Air cylinder retard control systems should include a stop to prevent battering the valve against its internal stop.

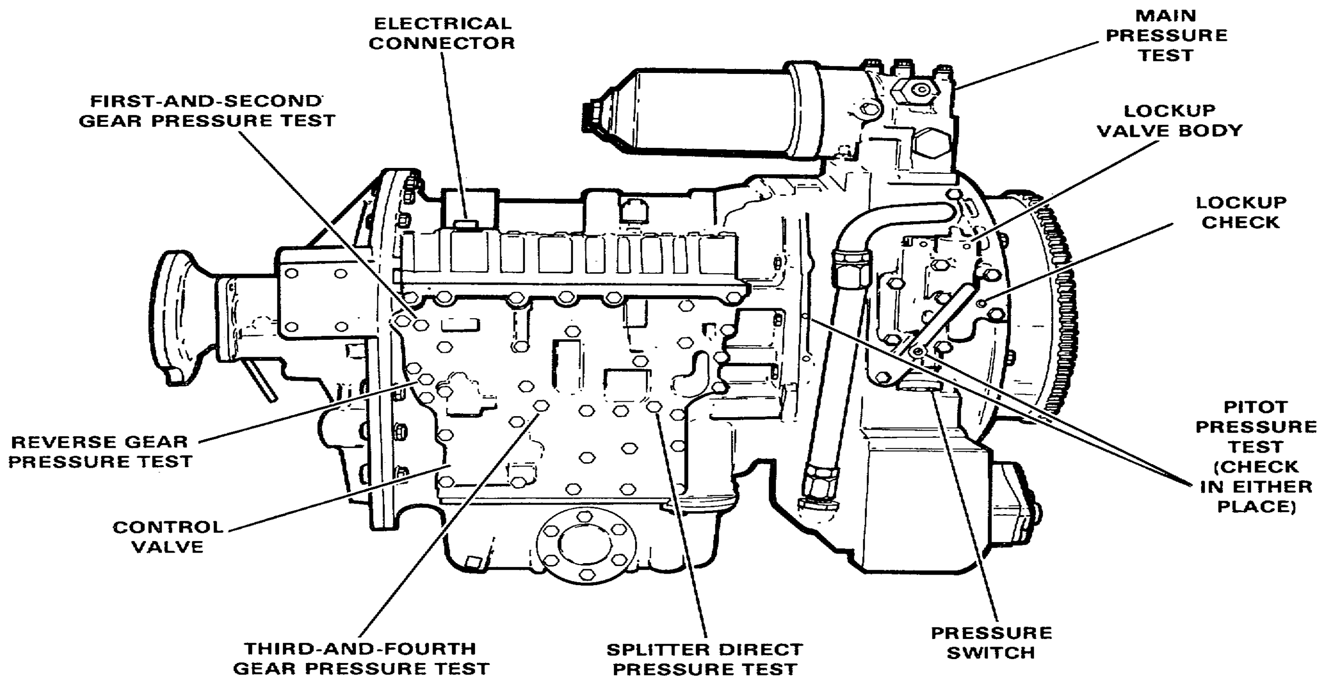

Figure 15-16. Pressure Check Points on Electric Control Valve Body and Transmission

EXTERNAL OIL LINES AND OIL COOLER

EXTERNAL LINES. Inspect for loose or leaking connections and worn or damaged hoses.

OIL COOLER. Examine the radiator coolant for traces of transmission oil. This condition indicates a faulty heat exchanger.

Abnormally high operating temperatures can cause clogging of the oil cooler as well as transmission failure. The oil cooler system should be thoroughly cleaned after each rebuild. Failure to do so may cause poor performance, overheating and transmission damage. For recommendations for cleaning or flushing the oil cooler, see the vehicle service manual.

ADJUSTING LOCKUP SPEED

LOCKUP SPEED IN THE VEHICLE. Lockup speed should be checked with the transmission in fifth gear at the point of lockup disengagement (release). The lockup pressure check point is shown in Figure 15-16. The "out-of-lockup" should be as close as possible to the vehicle manufacturer's recommendations.

Attach a tachometer of known accuracy to the engine. Increase the vehicle speed until it is operating in lockup. At this point, apply the hydraulic retard until the lockup clutch releases and the transmission operates in converter operation. Note the engine speed at the moment the lockup clutch releases and compare it to the lockup release speed recommended by the vehicle manufacturer for the transmission.

NOTE

Although transmissions may have the same model designation, the engine speed at which the lockup clutch release occurs may vary between them due to the vehicle application and the engine governed speed. Therefore, be sure that the lockup release speed is the one specifically recommended for the vehicle and transmission being checked and adjusted.

LOCKUP SPEED AND SHIFT POINTS - USING A TEST STAND. The electric control valve body incorporates a hydraulic "overlap" system which functions during some up-shifts and downshifts. Therefore, when checking on a test stand at engine idle with no load, the transmission output shaft will visibly stop turning momentarily during some shifts. This is normal and will not harm the transmission. At top engine speed, the output shaft should not visibly stop during range shifts. When the transmission is installed in a vehicle and shifted properly, the unit will operate and perform satisfactorily.

NOTE

Although transmissions may have the same model designation, the engine speed at which the lockup clutch release occurs may vary between them due to the vehicle application and the engine governed speed. Therefore, be sure that the lockup release speed is the one specifically recommended for the vehicle and transmission being checked and adjusted.

LOCKUP SPEED ADJUSTMENT. If the lockup release rpm requires adjustment, the speed can be changed by adding or removing shims 9 (A, Fold-out 6). These shims are located between lockup shift valve 8 and lockup valve spring 11. Adding a shim will raise and lockup speed approximately 20 rpm; removing a shim will lower the lockup speed approximately 20 rpm.

CONVERTER STALL TEST

PURPOSE. A stall test should be conducted when the power package (engine and transmission) is not performing satisfactorily. The purpose of the test is to determine if the transmission is the malfunctioning component.

WARNING

When conducting a stall test, the vehicle must be positively prevented from moving. Both the parking and service brakes must be applied, and the vehicle should be blocked to prevent movement forward or reverse. *Keep people safely away from the vehicle path.*

CAUTION

Do not maintain the stalled condition longer than thirty seconds due to rapid heating of the transmission oil. With the transmission in neutral, run the engine at 1200 to 1500 rpm for two minutes to cool the oil between tests. Do not allow the converter-out temperature to exceed 275°F(135°C). Keep a close check to prevent overheating of the engine cooling system.

PROCEDURES. Proceed as follows to perform converter stall test:

1. A tachometer of known accuracy must be used.
2. To perform a stall test, first lock the transmission output.
3. Move the selector control to fifth gear.
4. Accelerate the engine to full throttle, and note the maximum rpm the engine will attain. Converter-out pressure should be 30 psi (207 kPa) minimum. Compare the speed attained to the speed specified by the vehicle manufacturer as normal for those conditions. An engine speed above or below the specified range by more than 150 rpm may indicate a malfunction in the engine or transmission.

NOTE

Engine power will decrease with an increase in elevation (altitude), becoming more pronounced at greater elevation. This will result in a lower engine speed under converter stall conditions.

5. After making allowances for elevation, a low engine speed may indicate the engine is not delivering full power. Refer to the engine service manual for engine repair information.
6. If low engine speed persists after the engine is tuned, refer to the troubleshooting procedures in Table 15-2.
7. If high engine speed is noted, refer to the Troubleshooting Table 15-2

PRESERVATION AND STORAGE STORAGE, NEW TRANSMISSIONS. New transmissions are tested with preservative oil and drained prior to shipment. The residual oil remaining in the transmission provides adequate protection to safely store the transmission for six weeks without further treatment.

PRESERVATION METHODS. When the transmission is to be stored or remain inactive for an extended period (up to one year), specific preservation methods are recommended to prevent damage due to rust, corrosion, and growth of biologicals. Preservation methods are presented for storage with and without oil.

STORAGE, ONE YEAR - WITHOUT OIL. Proceed as follows to store transmission:

1. Drain the oil and replace the oil filter element(s).
2. Seal all openings with moisture-proof tape.
3. Coat all exposed, unpainted surfaces with preservative grease, such as petrolatum (MIL-C-11796), Class 2.
4. If the breather can be easily removed, spray one ounce (30 milliliters) of Motorstor * (or equivalent) into the transmission through the breather hole. Also, spray one ounce (30 milliliters) through the fill tube hole. If the breather cannot be removed, spray two ounces (60 milliliters) of Motorstor (or equivalent) into the transmission through the fill tube hole.
5. If additional storage time is required, repeat 3 and 4 at yearly intervals.

STORAGE, ONE YEAR - WITH OIL. Proceed as follows to store transmission with oil:

1. Drain the oil and replace the filter element(s).
2. Fill the transmission to operating level with a mixture of 30 parts Type C3 oil to one part Motorstor rust preventative (or equivalent). Add 1/4 tsp of Biobor JF** (or equivalent) for each 3 gallons (11 liters) of oil in the system.

NOTE

When calculating the amount of Biobor JF required, use the total volume of the system including external lines, filters, and cooler; not just the quantity required to fill the transmission.

* Motorstor ® is the registered trademark for a vapor phase rust preventative manufactured by the Daubert Chemical Company, Chicago, Illinois. Motorstor is covered by Military Specifications MIL-L-46002 (ORD) and MIL-I-23310 (WEP) under the designation of "Nucle Oil".

** Biobor JF® is the registered trademark for a biological inhibitor manufactured by U.S. Borax and Chemical Corporation.

3. Shift to sixth gear (1-6) and operate the vehicle for approximately five minutes at a sufficient speed to cause sixth-gear lockup operation. Operate the vehicle for approximately five minutes at a sufficient speed to cause lockup operation. Then stop the vehicle and stall the transmission output until an oil temperature of 2250F (1 070C) is obtained.

CAUTION

Do not allow the temperature to exceed 225°F (107°C).

4. Stop the engine. As soon as the unit is cool enough to touch, seal all openings and breather with moisture-proof tape.
5. Coat all exposed, unpainted surfaces with preservative grease, such as petrolatum (MIL-C-11796), Class 2.
6. If additional storage time is required, just add the prescribed mixture (Item 3, above) of Motorstor and Biobor JF, or equivalents, and repeat 3 through 5 above, at yearly intervals. It is not necessary to drain the transmission each year.

RESTORING UNITS TO SERVICE. Proceed as follows to restore transmission:
1. Remove the tape from openings and breather.
2. Wash off all the external grease with mineral spirits.
3. If the transmission is new, drain the residual preservative oil. Refill the transmission to the proper level with Type C3 oil.
4. If the transmission was prepared for storage without oil, refill the transmission to the proper level with Type C3 oil.
5. If the transmission was prepared for storage with oil, check for proper oil level. Add or drain transmission oil as required to obtain the proper level.

NOTE

It is not necessary to drain and refill the transmission with new oil.

LUBRICATION OF SHIFT TOWER

CAUTION

Do not over lubricate. Do not apply any lubricant to any point on or near the switches or switch assembly.

TIME INTERVALS. Shift towers should be lubricated after the first 500 hours of operation and after each 2500 hours of operation thereafter.

The 2500 hour intervals may be shortened if operating conditions are extremely dusty or dirty.

CLEAN BEFORE LUBRICATING. Using compressor air, thoroughly clean the area to be lubricated. Work the shift handle from side to side while applying the air blast.

LUBRICATION POINTS. Refer to Figure 1 5-106 for the area to be lubricated. The shift handle 16 (B, Fold-out 12), where it swivels in rotary key 39 and at its point of contact with leveler 4, should be lubricated with Lubriplate No. 107 (or equivalent). Also, lubricate the right end of leveler 4, where it reciprocates in rotary key 39. Lubricate the cams of switch assembly 24 with Aircraft Shaft and Instrument Grease. Lubricate bushing 12 with Bentone 508.

The lubrication points may be reached by a pump-type applicator (Eagle No. 33F or equivalent). Access to the parts to be lubricated is available from the top of the shift tower, through the opening in which the shift handle moves, as well as through an opening at the bottom of the tower (Figure 15-101). Use both access points to ensure complete lubrication. Some disassembly is necessary to lubricate other points.

Apply lubricant sparingly. Excess lubricant tends to retain dust and dirt, or may seep into areas where it would be harmful.

CHECKING, ADJUSTING MANUAL - ELECTRIC CONTROL SYSTEM (Figure 15-17)

WARNING

Be sure to shut off the engine, set the vehicle brakes and lock the wheels before any troubleshooting of the electric-shift solenoids. It is important that electricity never, under any circumstance, be applied to any electric valve body component while the vehicle engine is running and while the mechanic is under the vehicle. Failure to shut off the engine and set the brakes could cause the vehicle to run away when the solenoids were activated by an external power supply. Removal of the power supply would not stop the run away vehicle because of the fail protection system. The vehicle could only be stopped by applying the vehicle brakes or shutting down the engine.

IMPROPER SHIFTING (ELECTRICAL TROUBLE). Check the battery for voltage. When the voltage of a 12-volt system falls below 9 volts, proper solenoid action cannot be guaranteed. Check the fuse. Selector assemblies have an integral fuse (Figure 15-3).

Check the wiring harness for breaks, signs of chafing, fraying, or deterioration.

Check all connections for tightness and freedom from corrosion. Disconnect, clean and reconnect any connections that may be defective.

Firm, complete connection of each connector is important. The pins must not be bent or otherwise damaged. Align the

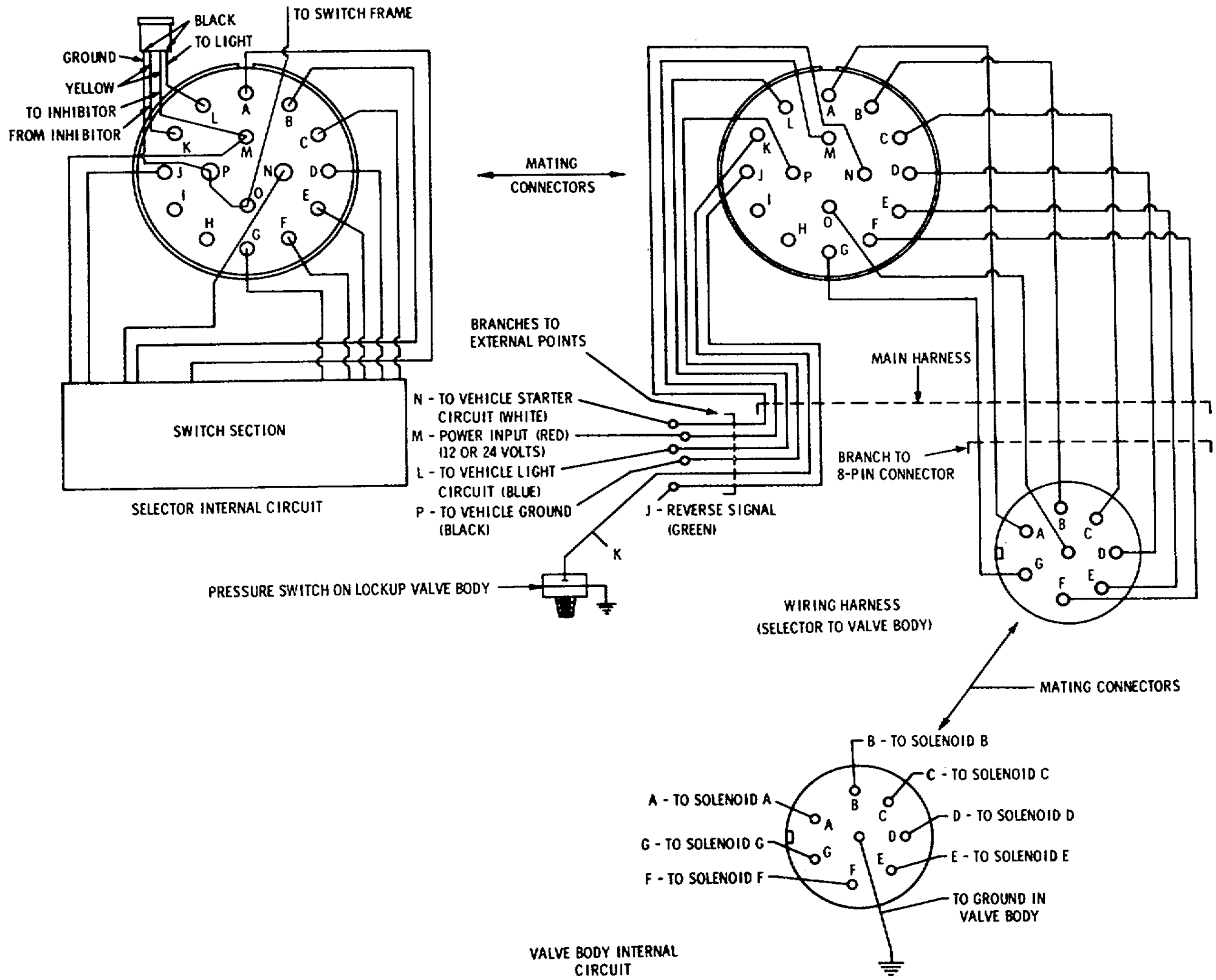

Figure 15-17. Manual-Electric Control System Wiring Diagram

index key and slot, and push the cable end of the connector firmly into its socket. Tighten the retaining nut as tightly as possible, by hand. (Do not use any tool to retain the connect-ors.) Then push again on the cable end while working it slightly from side to side. Retighten the nut. Continue push-ing the cable end and tightening the nut until the connection is firm and the nut will not tighten further. Check multi-pin connectors at the shift tower and valve body assembly. Be sure that all pins and their receptacles are clean, undamaged and tightly reconnected.

FIELD TEST KIT. See WARNING above.

A field test kit* is available for checking the shift tower, wiring harness and valve body solenoid circuits. Complete operating and test instructions accompany each test kit.

* Manual-Electric Field Test Kit N1920 can be purchased from Noel-Symser Engineering Corp., 5230 West Tenth Street, Indianapolis, Indiana 46224.

TROUBLESHOOTING WITHOUT TEST KIT. See WARNING above.

To determine if the proper electrical signals are being trans-mitted to the valve body, disconnect the eight-pin connector from the valve body.

Use a test lamp of the proper voltage (1 2 V)to match the sys-tem voltage. Ground one test lamp lead.

Check each female pin receptacle of the wiring harness for delivery of electrical signals at the proper time by positioning the shift tower control in each selector position and checking each female pin receptacle. Touch each female pin receptacle with the ungrounded lead of the test lamp.

The pin receptacles which should be energized in each range are as follows:

Selector Position	Pin Receptacle
R	A, B
N	A, F
1	C, F
2	C, G
3	F, D
4	G, D
5	F, E
6	G, E

Only the pin receptacles listed above should be energized in the selector positions shown. If any others are energized, or if those listed are not all energized, a malfunction of either the shift tower or wiring harness is indicated.

If the terminals do not check out as listed above, the shift tower (selector assembly) should be checked separately (refer to page 1 5-30). If the shift tower is faulty, it may be rebuilt. If the shift tower tests satisfactorily (wiring harness disconnected) but trouble is evident in tests above, the wiring harness is faulty and must be replaced.

NOTE

If the wiring harness is cut or worn, reroute the new harness to avoid recurrence of the fault.

Check the valve body internal circuits as outlined below, with an ohmmeter.

Disconnect the eight-pin connector of the wiring harness from the control valve body. Check between the center pin of the eight-pin connector on the valve body, and the ground. The center pin is grounded to the valve body by an internal lead, and the meter reading should be zero. A resistance reading here indicates a poor or broken connection.

Check each of the solenoid pins (A through G) with the ohmmeter connected between each pin and ground. The readings should be 15-30 ohms for each solenoid.

If resistance measurements are not within the range prescribed above, replace the solenoid module shown in Figure 15-109. If a spare module is not available, replace the defective solenoid, or repair or replace the internal wiring as required.

DOWNSHIFT INHIBITOR DOES NOT ENGAGE. The malfunction maybe due to a disconnected or broken wiring harness lead to the pressure switch (Figure 15-1), a failed pressure switch, a faulty shift tower, or faulty wiring harness. Make the following checks:

1. Inspect the wiring harness lead and ground lead (or terminal if no ground lead is used) for corrosion, loose connections, and condition.
2. With vehicle power on, ground the inhibitor wiring harness lead to the body of the pressure switch. If the inhibitor then engages, the pressure switch is faulty (will not close) and should be replaced.
3. If grounding the lead does not actuate the inhibitor, check the shift tower (page 15-30).
4. If checks 1, 2 and 3 above, do not locate the malfunction, a faulty wiring harness is indicated.

DOWNSHIFT INHIBITOR DOES NOT DISENGAGE. Malfunction may be due to a grounded wiring harness lead to the pressure switch, a failed pressure switch, a faulty shift tower, or faulty wiring harness. Make the following checks:

1. Check the pressure switch lead for a ground. Check that the lead is connected to the pressure switch terminal insulated with a fiber washer (not to the terminal having a star washer).
2. If disconnecting the pressure switch lead from the switch terminal disengages the inhibitor, the pressure switch is faulty, and must be replaced.
3. Check the shift tower (page 15-30).The inhibitor should engage when the lead to the pressure switch (K, Figure 15-17) is grounded (while vehicle power to the tower is on).
4. If checks 1, 2 and 3, above, do not locate the malfunction, a faulty wiring harness is indicated.

STARTER OPERATES IN ALL GEARS. The neutral start switch in the shift tower is faulty. Check the shift tower (page 15-30).

STARTER WILL NOT OPERATE IN NEUTRAL. The malfunction may be due to a faulty starter, starter solenoid, disconnected or broken wire or terminal in the vehicle system, or to a faulty shift tower. Make the following checks:

1. Using a test light or voltmeter, check for power at the starter solenoid input when the starter switch is activated. If power is present, the starter or solenoid is defective.
2. If no power is present, check the vehicle wiring system. Refer to Section 13.
3. Check the shift tower (page 15-30).

SHIFT QUADRANT NOT ILLUMINATED. The malfunction may be due to a failed light bulb, defective vehicle wiring or connections, defective wiring harness, or to a faulty shift tower. Make the following checks:

1. Replace the light bulb.
2. Check the vehicle wiring and terminals. Refer to the vehicle wiring diagram.
3. Check the shift tower (page 15-30).

REVERSE SIGNAL NOT ENERGIZED. When the reverse signal lead is not energized during reverse operation, make the following checks:

1. Check the reverse indicator device. Check for power to the indicator.
2. Check the vehicle wiring system for loose or broken wires and connectors.
3. Check the shift tower (page 15-30).
4. If checks 1, 2 and 3, above, do not locate the malfunction, a faulty wiring harness is indicated.

CHECKING HYDRAULIC CIRCUITS. If electrical checks do not indicate electrical system malfunction, the hydraulic circuit may be at fault. Hydraulic troubles may be in either the control valve assembly or in the related hydraulic components in the transmission. The check outlined in 1 through 4, below, will locate an inoperative shift valve. Further checks, involving disassembly steps, will determine the reason the valve is inoperative:

1. A shift valve can be inoperative or erratic in operation for the following reasons:
   Sticking in its bore
   Dirt in a solenoid
   Dirt in valve body or separator plate orifices
2. If a specific forward shift valve remains in the "down" position (refer to Fold-out 3 or 4), the transmission will shift normally below that range but not into that range. However, if it is shifted to a higher range it will not downshift except to the range immediately above the range controlled by the inoperative valve.
3. If a specific forward shift valve remains in the "up" position (refer to Fold-out 2), the operation in that range and above will be normal, but no lower ranges, neutral, or reverse can be obtained. The range controlled by the inoperative valve will be retained in all lower selector lever positions.
4. If the splitter shift valve remains in either the "up" or "down" position (refer to Fold-out 2), the transmission will operate in all forward gears and reverse, but the gear ratio will depend upon which splitter clutch may be engaged. The splitter-direct clutch may be engaged when the splitter-overdrive clutch should be engaged and vice versa.
5. To check for sticking shift valves (except first gear), remove the main solenoid module from the top of the control valve assembly. To check for sticking first gear shift valve, remove the first gear shift module from the side of the control valve assembly and disassemble it.
6. An individual solenoid may be removed and a new one installed when it is determined that a particular solenoid is causing the existing condition. One method of checking the physical operation of solenoids is to invert the solenoid module, fill the pressure cavities with transmission oil and, with the module connected to the wiring harness, shift through all selector positions. Oil should drain out of all cavities at the same rate as solenoids are energized.
7. The remaining valve body fault that could cause improper shifting is dirt in solenoid, valve body, or separator plate orifices. The control valve assembly must be removed, disassembled, and thoroughly cleaned to correct the problem. Particular attention should be given to clogged orifices in the solenoids, valve bodies and separator plates. The condition of the transmission oil filters should be checked at this time. Clogged filters will bypass dirty oil, and permit dirt to be carried into the valve body.

TESTING SHIFT TOWER ASSEMBLY MANUAL-ELECTRIC TEST EQUIPMENT. The shift tower may be checked with a test lamp as outlined earlier. This method requires that the wiring harness be connected to the shift tower assembly. Detailed knowledge of the system circuit and multiple tests are necessary when conventional equipment is used.

The test kit described earlier may be employed for any test of the shift tower assembly. However, detailed knowledge of the system circuit and multiple tests are necessary.

SHOP-CONSTRUCTED TEST LAMP BANK. A test lamp bank may be constructed to test the shift tower assembly. This lamp bank will check any manual electric 12 volt system.

Figure 15-18 illustrates the circuit of the test lamp bank. Listed below are the components required to construct the bank. All components are available from Allied Electronics or any similar source.

Lamp ....G.E. No. 1815(11)
  Lamp holders .... Dialco (11)
  Red ....No. 95-9110-0931-102
  Green ....No. 95-9110-0932-102
  Amber..No. 95-9110-0933-102
  White ....No. 95-9110-0935-102
Switch, DPDT .... Cutler-Hammer No. 8373K21 D (1)
Connector, 16-pin .... MS 3106E24-7S (1)
Wire .... AWG No. 18 stranded copper, PVC covered (AR)
Cable covering ....PVC
Binding posts (to attach
  battery) ....Superior Electric Co.
  5-way:
  No. DF 30RC (red) (1)
  No. DF 3OBC (black) (1)
Box ....Bud No. CU2110A (1)
Fuse holder .... Allison No. 6839335 (1)
Fuse ....SFE 9 (1)

NOTE

Sufficient wire, and cable covering, should be obtained to allow a five foot minimum length from the 1 6-pin connector to the box.

Construct the test lamp bank and label each lamp as shown in Figure 15-18.

TESTING MANUAL ELECTRIC SHIFT TOWER

NOTE

The field test kit described earlier may be used for all tests. However, detailed knowledge of the shift tower circuit and multiple tests are necessary.

The lamp bank described above is preferred for testing the shift tower assembly.

Throw switches to positions shown in Figure 15-18 (X to off; Y to manual). Connect the 12 volt battery to the lamp bank, observing the polarity indicated in Figure 15-18.

Couple the lamp bank connector to the connector on the shift tower assembly.

Check the SFE9 fuses in both the shift tower assembly and the lamp bank. If either is blown, replace it. If the new fuse

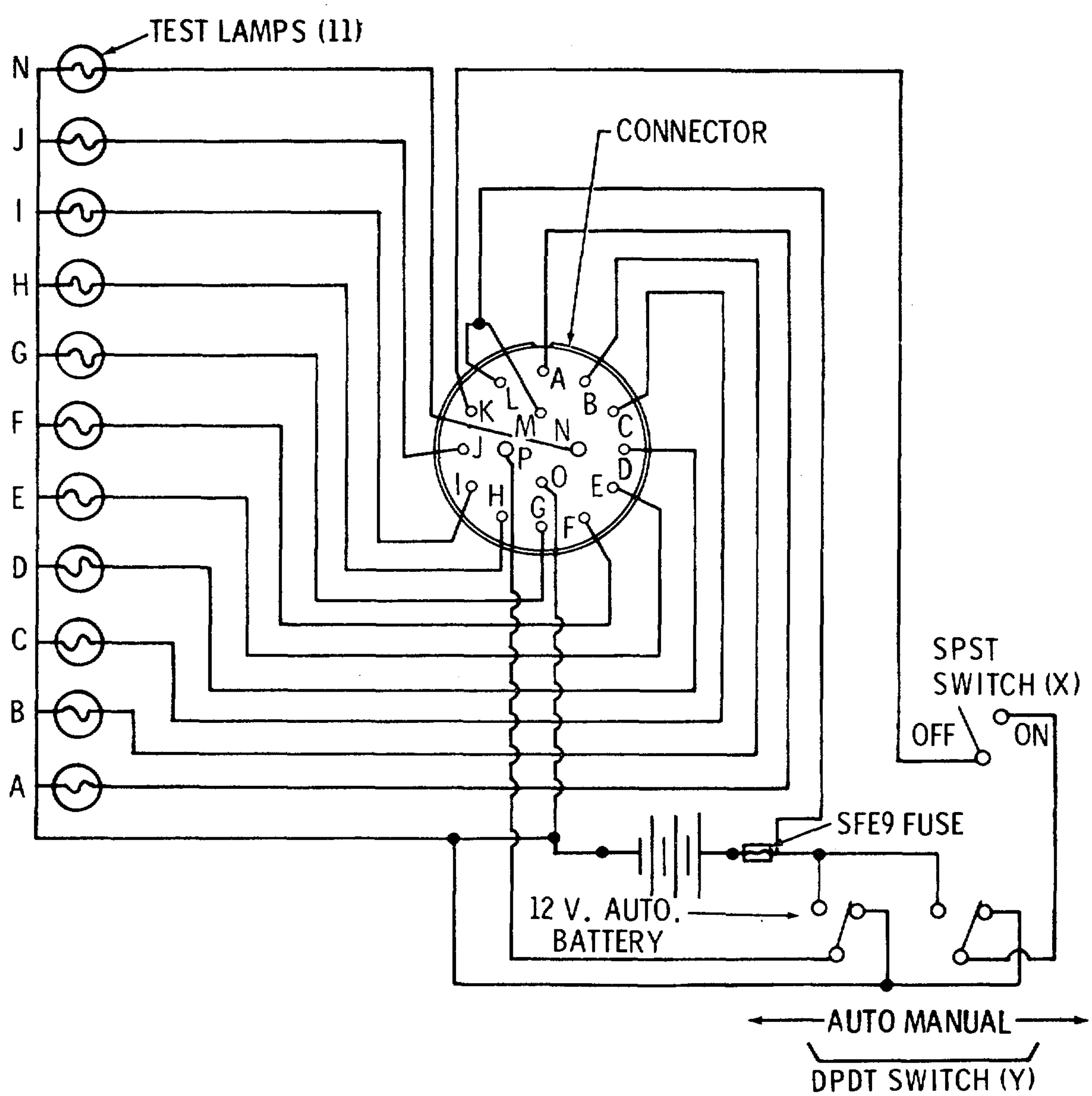

Figure 15-18. Test Lamp Bank Circuit

blows, there is a ground or short circuit in the shift tower assembly that must be corrected before proceeding.

NOTE

Earlier shift tower assemblies had no integral fuse. The fuse was in the power input lead(between the vehicle power circuit and wiring harness conductor M). The fuse in the lamp bank will protect both the shift tower assembly circuit and the lamp bank if there is a short circuit.

Check the shift tower lamp. Note that the lamp circuit is independent of the fuse in the tower assembly. If the lamp fails to light, a failed bulb, defective socket or open circuit is indicated.

Throw switch X (Figure 15-18) to the ON position. This should energize the downshift inhibitor. There should be a "click" when the switch is thrown. When the inhibitor is energized, manual up-shifts are possible but downshifts can not be made. If the "click" does not occur, and downshifts can be made, electrical trouble is indicated. Either the solenoid coil or its connecting circuit is faulty. If the "click" does occur, but downshifts can be made, mechanical trouble is indicated.

Mechanical trouble in the downshift inhibitor is usually due to failure of inner clutch member 2 (B, Fold-out 12) or angular maladjustment of solenoid housing 63. Check failure of the clutch member at disassembly. Check adjustment of the solenoid housing as outlined on page 15-80.

Electrical trouble in the downshift inhibitor may be either a faulty solenoid coil or its connecting wire. The solenoid coil can be checked, when removed, by connecting it directly to a battery to determine if it will energize. The wiring and terminals may be checked when the shift tower is disassembled (page 15-79).

Throw the inhibitor switch (X) to the OFF position. This should release the inhibitor solenoid and permit the selector lever to move either direction. Failure to release when the switch is OFF could be due to a ground in the conductor leading to contact M in the shift tower connector. A mechanical fault not permitting release could be the failure of outer clutch 78 (B, Fold-out 1 2)to retract from inner clutch 2. Disassembly and inspection (page 15-76) will reveal the fault.

Check each position of the selector lever to determine if the selector switches are operating (making and breaking) satisfactorily. This can be determined by noting which lamps are lit and not lit in each selector position. The following chart shows the desired light pattern.

Selector Position	Lamps Lighted
R	A, B, F
N	A, F, N
1	C, F
2	C, G
3	D, F
4	D, G
5	E, F
6	E, G

If the light pattern in the preceding table is obtained, the switches are functioning satisfactorily. If any other pattern is obtained, either the switch assembly is faulty, or the wiring is faulty or connected improperly to the switches.

A further check, using the lamp bank, is necessary to determine if the switch assembly is angularity aligned with the selector lever. Any clockwise or counter-clockwise location of the switch assembly in relation to the selector lever shift positions will affect the sequence and timing of the switches.

Place switch sequence gauge J-24710 on the selector lever (Figure 15-19). The tool holds the shift lever at the midpoint between two shift positions, but provides a tolerance of movement sufficient for complete transition from one shift position to the next. All changes in the light pattern should occur within the movement tolerance. The chart below indicates the light patterns at each test position.

Midpoint Test Position	Lamps Lighted When Selector Lever is Pushed Toward Up-shift Direction	Lamps Lighted When Selector Lever is Pushed Toward Down-shift Direction
5-6	E, G	E, F
4-5	E, F	D, G
3-4	D, G	D, F
2-3	D, F	C, G
1-2	C, G	F, H
N-1	C, F	A, F, N
R-N	A, F, N	A, B, F, J

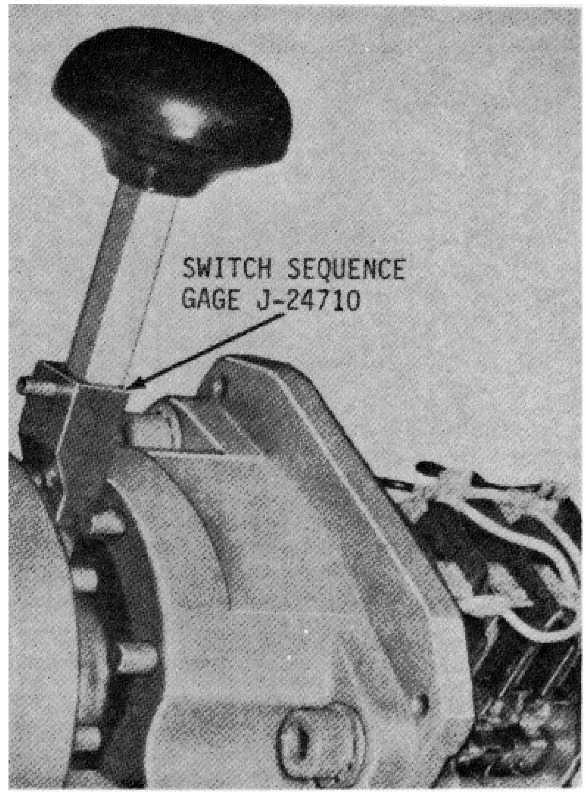

Figure 15-19. Switch Sequence Gauge J-2471 0 Positioned for Test

If the light pattern shown above is not obtained but a satisfactory pattern was obtained above, angular misalignment of the switch assembly is indicated.

To check for the direction (clockwise or counterclockwise) of misalignment of the switch assembly, place the selector lever at the midpoint between N and 1. Install switch sequence gauge J-24710 and push the selector lever toward N. If lamp C lights, the switch assembly requires clockwise adjustment (as viewed from switch end of shift tower). Next, push the selector lever toward 1. If lamps A or N light, the switch assembly requires counterclockwise adjustment.

Make any adjustment required for switch alignment by tapping the switch frame with a hardwood dowel and hammer at the points indicated in Figure 15-20.

TROUBLESHOOTING

BEFORE REMOVAL OR OPERATION. Do not operate the vehicle prior to completing the procedures described in this paragraph. Inspect for oil leakage. Visually inspect all split lines plugs, and hose and tube connections at the transmission and cooler. Oil leakage at split lines may be caused by loose mounting bolts or defective gaskets. Tighten all bolts, plugs and connections where leakage is found. Check the shift linkage for proper operation.

The engine and transmission must be regarded as a single package during troubleshooting. A thorough study of the

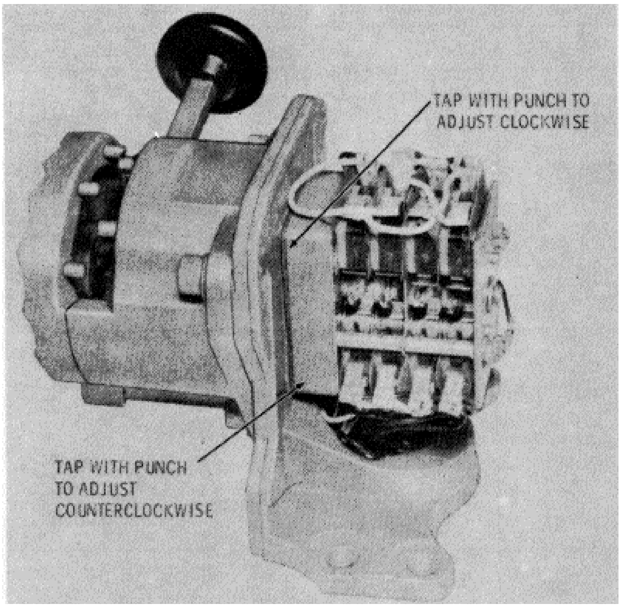

Figure 15-20. Angular Adjustment of Switch

description and operation of the components and hydraulic system will be helpful in determining the cause of trouble.

DURING OPERATION. If inspection does not reveal the cause of trouble, and the vehicle is operational, further troubleshooting is necessary. Do not remove the transmission from the vehicle until the causes of trouble are checked against the Troubleshooting Table 15-2.

To make. a thorough test of the vehicle-mounted transmission, be sure the engine is properly tuned and the oil level in the transmission is correct.

AFTER REMOVAL FROM VEHICLE. When the malfunction of the transmission is not ascertained by tests or inspections before removal from the vehicle, the transmission may be mounted in a test stand and checked (if a test stand is available). Particular attention should be given to proper oil level and to correct linkage adjustment in every transmission test.

Table 15-2. Main Transmission Troubleshooting Chart

TROUBLE	CAUSE	REMEDY
1. Low converter-out pressure	A. Low oil level	A. Add oil
	B. Oil line leakage (remove-mounted cooler or filter)	B. Check for oil leaks; correct leaks
	C. Plugged oil strainer	C. Clean strainer
	D. Defective oil pump	D. Rebuild or replace oil pump assembly
	E. High oil temperature	E. Refer to 2. below
	F. Foaming oil	F. Refer to 5F, below
	G. Converter pressure regulator valve stuck open, or spring failed	G. Repair valve
2. High oil temperature	A. Low oil level	A. Add oil
	B. High oil level	B. Drain oil to the Full mark
	C. Low water level in cooling system	C. Add water, check for leaks
	D. Low main pressure	D. Refer to 7, below
	E. Low converter out pressure	E. Refer to 1, above
	F. Clogged or dirty oil cooler	F. Clean or replace as necessary
	G. Stator locked checking	G. Refer to manufacturer's manual for
	H. Operating too slow in the gear selected	H. Downshift at a higher speed
	I. Stator installed without rollers	I. Refer to 4C, below
	J. Vehicle brakes dragging	J. Check parking and service brakes
	K. Clutch slipping	K. Refer to 3D, below
	L. Restricted oil lines (remote filter or cooler)	L. Clean or replace lines and necessary
	M. Retarder partially applied	M. Check retarder linkage

Table 15-2. Main Transmission Troubleshooting Chart (Continued)

TROUBLE	CAUSE	REMEDY
3. High engine speed at converter stall	A. Low oil level B. Low converter-out pressure C. High oil temperature (above 250°F) (121°C) D. Clutch slipping, main pressure normal E. Foaming oil	A. Add oil B. Refer to 1, above C. Refer to 2, above D. Replace clutch piston seal rings or-clutch plates E. Refer to 5F, below
4. Low engine speed at converter stall	A. Low engine output torque B. Converter element interference C. Stator installed without rollers D. Transmission oil not up to operating	A. Tune engine and check output B. Check for noise at stall; overhaul converter, if necessary C. Install rollers D. Warm up-transmission to 180°to200°F (82° to 93°C)
5. Loss of power	A. Low engine speed at converter stall B. High engine speed at converter stall C. Manual selector valve not positioned properly D. Hydraulic retarder partially applied E. Vehicle brakes dragging F. Foaming oil G. Defective variable capacity converter	A. Refer to 4, above B. Refer to 3, above C. Check linkage D. Check linkage E. Check parking and service brakes F. 1. Check for low oil level; add oil 2. Check for worn input oil pump; rebuild or replace pump assembly 3. Check for air leaks at input oil pump; correct leaks 4. Check for water in oil; correct cause, clean system 5. Check for high oil level; drain to proper level G. Overhaul converter
6. No power transmitted in any range	A. Drive line failure B. Range selector valve not positioned properly C. Low oil level D. Low main pressure E. Failed piston seals F. Electric shift malfunction. on electric shifting.	A. Check input and output of transmission B. Check linkage; correct defects C. Add oil D. Refer to 7, below E. Overhaul transmission F. See manufacturers manual
7. Low main pressure	A. Low oil level B. Leaks in hydraulic system C. Failure in pressure regulator D. Worn input oil pump assembly E. Clogged oil strainer F. Air leaks at suction side of, input pump	A. Fill to proper level B. Check all external points for leaks; check each range for localizing internal leaks C. Overhaul valve assembly D. Rebuild or replace pump assembly E. Clean strainer F. Check input pump; correct leaks

Table 15-2. Main Transmission Troubleshooting Chart (Continued)

TROUBLE	CAUSE	REMEDY
8. No power transmitted in one range	A. Manual selector linkage out of adjustment B. Low main pressure in one range C. Clutch slipping	A. Adjust linkage B. Check for worn piston seals or broken housing C. Replace clutch piston seal rings or clutch plates
9. Slow clutch engagement	A. Low oil level B. Foaming oil C. Worn piston seals D. Low main pressure	A. Fill to proper level B. Refer to 5F, above C. Overhaul transmission D. Refer to 7, above
10. Failure to push start (transmissions without rear pump cannot be push started)	A. Engine does not turn when vehicle is pushed	A. 1. Low oil level; fill to proper level 2. Range selector valve in neutral; shift to second gear 3. Check to determine if engine is locked 4. Check for clogged hydraulic passages 5. Check for worn output oil pump 6. Check for drive line failure; determine if transmission output flange turns during pushing operation 7. Check for slippage of either the overdrive or low-range clutch by shifting to third gear 8. Check for slipping of low-range clutch only by shifting to first gear (continued slipping indicates low-range clutch at fault)
11. Transmission locked in all gears	A. Failed transmission parts	A. Overhaul is required
12. Vehicle drives in first and second gears and moves forward in neutral when engine is accelerated but stalls in every other gear when engine is accelerated	A. Low-range clutch has failed (won't release)	A. Transmission must be overhauled
13. Vehicle drives in third and fourth gears and moves forward in neutral when engine is accelerated, but stalls in every other gear when engine is accelerated	A. Intermediate-range clutch has failed (won't release)	A. Transmission must be overhauled

Table 15-2. Main Transmission Troubleshooting Chart

TROUBLE	CAUSE	REMEDY
14. Vehicle drives in fifth and sixth gears and(won't release) moves forward in neutral when engine is accelerated, but stalls in all other gears when engine is accelerated	A. The high-range clutch has failed	A. Transmission must be overhauled
15. Vehicle drives in reverse and moves backward in neutral when engine is accelerated, but stalls in all other gears when engine is accelerated	A. Reverse clutch has failed (won't release)	A. Transmission must be overhauled
16. Vehicle will operate in second, fourth and sixth gears but will not operate in all other gears	A. High-splitter clutch has failed (won't release), or there is oil leakage at the low-splitter clutch seals	A. Transmission must be overhauled
17. Vehicle will not operate in first, third and fifth gears but will not operate in all other gears	A. The low-splitter clutch will not release or there is oil leakage at the high-splitter clutch piston seals	A. Overhaul transmission

GENERAL OVERHAUL INFORMATION

GENERAL

This material provides general information for overhaul, cleaning, and inspection of the transmission. Tables include special tools and recommended replacement of parts. Good shop practices together with the recommended procedures will aid in restoring high quality performance.

REMOVAL OF WIRING HARNESSES

WARNING

Be sure that the power supply from the vehicle electrical system is switched off. This will prevent any unexpected shift during removal of the wiring harnesses.

Loosen and remove the nut which retains wiring harness 81 (B, Fold-out 9) at the bottom of selector assembly 80 in the vehicle cab.

Pull the socket-type connector off the valve body pin connector.

Remove the wire from pressure switch 20 (A, Fold-out 6).

Loosen and remove the nut which retains wiring harness 81 (B, Fold-out 9) at the bottom of selector assembly 80 in the vehicle cab.

Pull the sixteen-pin socket off the shift tower assembly connector.

Remove the five conductors (or as many as are used) from the vehicle power source, ground, light system, starter circuit, and reverse signal circuit.

NOTE

These conductors are identified in Figure 15-21 as J, L, M, N and P. For convenience in reconnecting these leads, they and the points from which they are removed should be tagged with the same letters.

Remove any fastenings which may retain these leads between their points of connection and the main body of the wiring harness.

Remove any vehicle components which prevent access to the wiring harness fasteners, or which would prevent removal of the harness.

Remove any fasteners which may retain the wiring harness. Remove the harness. If defective, do not attempt to repair it. Replace it with a new harness.

REMOVAL OF REMOTE COMPONENTS

The shift tower assembly (B, Fold-out 12) may be removed, if necessary, by removing the bolts in its base. However, the shift tower may be checked without removing it. If defective, it may be either rebuilt, or replaced as a unit.

INSTALLATION OF EXTERIOR COMPONENTS

Refer to Figure 15-21. Install the wiring harness onto the vehicle.

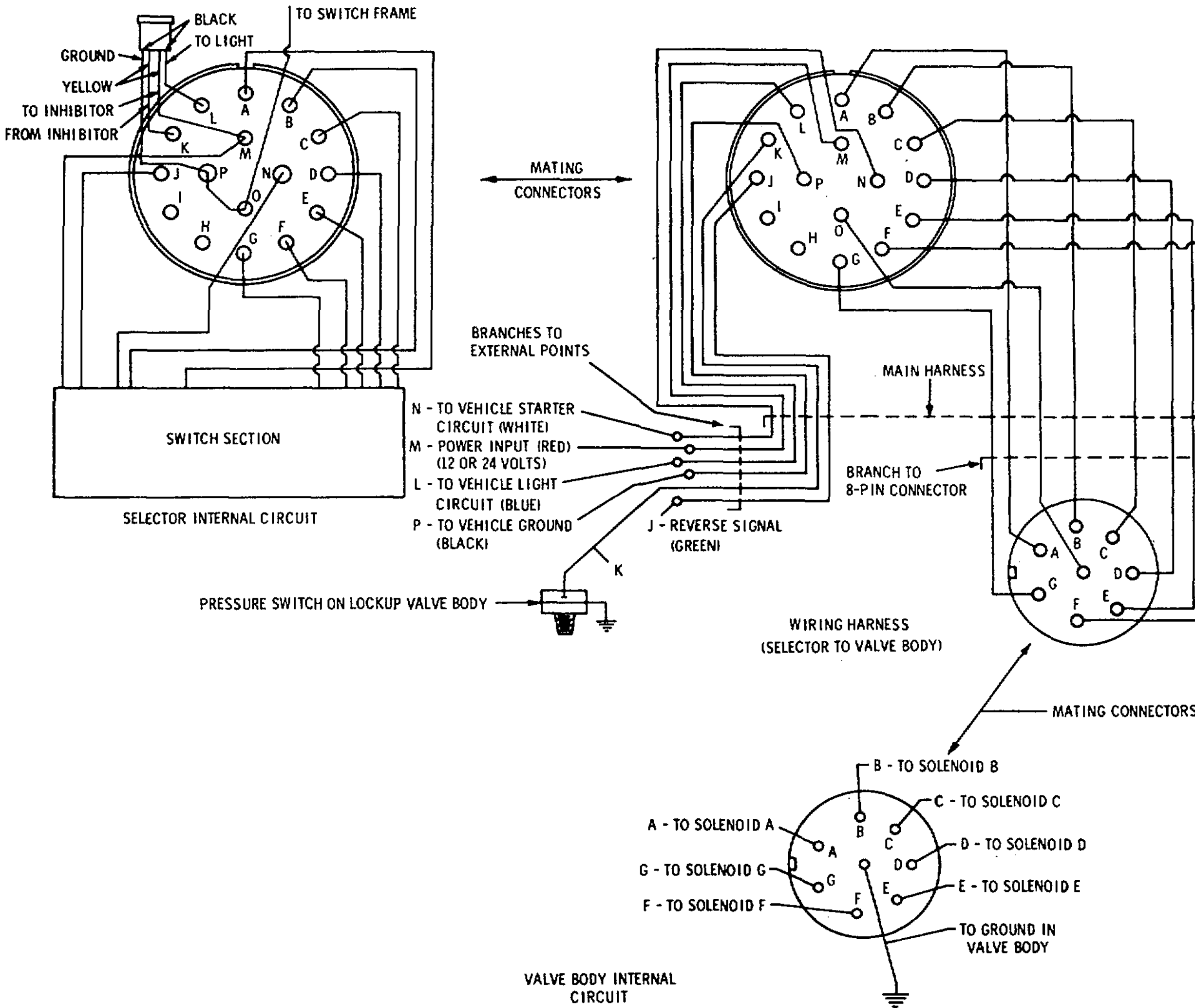

Figure 15-21. Manual-Electric Control System

Replace all supports and fasteners.

Replace all vehicle components removed for access to the wiring harness.

Refer to Figure 15-21 for identification of branches (J, K, L, M, N, P) if not marked at removal.

Connect the branches to the vehicle leads.

Align the index keys and push the 1 6-pin socket onto the 16-pin connector at bottom of shift tower assembly.

Tighten the connector nut, and tight, to retain the socket.

Align the index keys and push the eight-pin socket onto the eight-pin connector on the valve body.

Tighten the nut, hand tight, to retain the eight-pin socket.

If removed, the switch tower assembly may be installed by replacing the bolts which attached it in the vehicle cab.

TOOLS, EQUIPMENT

SPECIAL TOOLS (Figure 1 5-22). A minimum of special and improvised tools are required for overhaul procedures. The following special tools can be purchased from the Kent-Moore Tool Division, 29784 Little Mack, Roseville, Michigan 48066:

J-6534-02	Torque Converter Spanner Wrench
J-7441	Belville Assembly Spring Compressor
J-23552	Stator Assembly Installing Tool
J-23556	Support Legs
J-24710	Switch Sequence Gauge
J-24711	Shift Inhibitor Clutch Drilling Fixture
J-24712	Harness Adapter (provides fifth-gear hold for performance of converter stall check)

These tools are referenced in Disassembly, Rebuild of Sub-assemblies and Assembly.

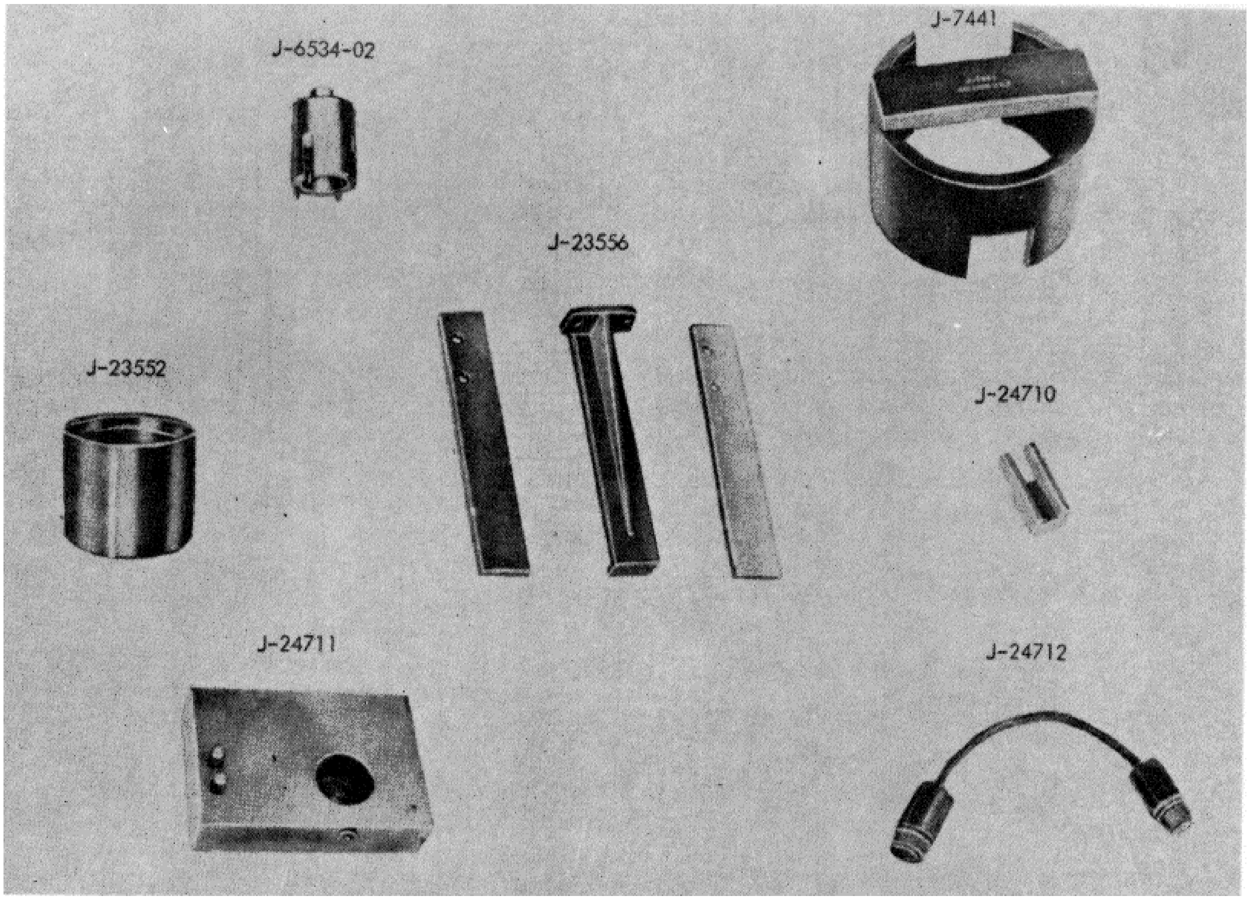

Figure 15-22. Kent Moore Tools

IMPROVISED TOOLS

— Puller — for removing interference-fit flanges (Figure 15-23).

— Sleeve — for seating shaft components (Figure 15-24).

— Table — for disassembly and assembly (Figure 15-25).

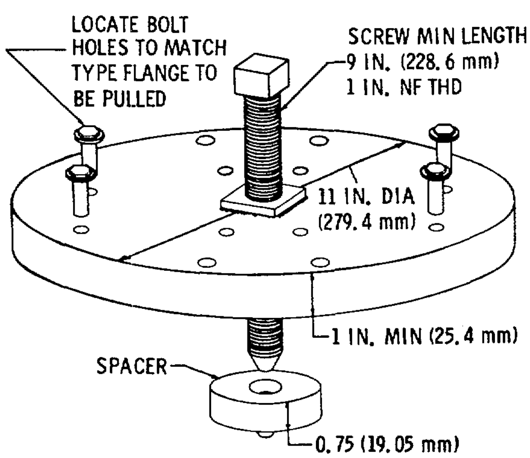

Figure 15-23. Puller for Removing Interference-Fit Flanges

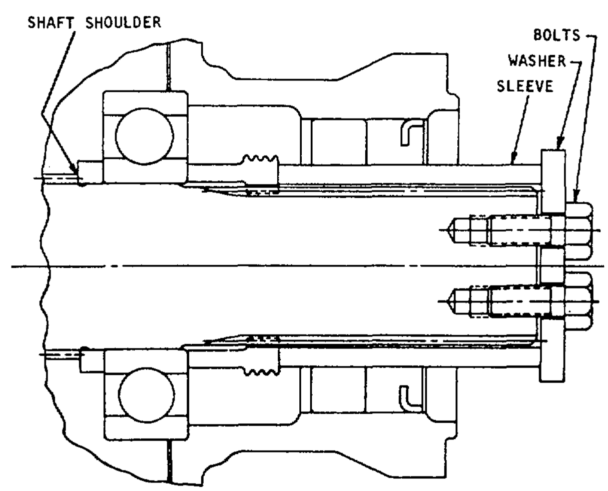

Figure 15-24. Sleeve for Seating Shaft Components

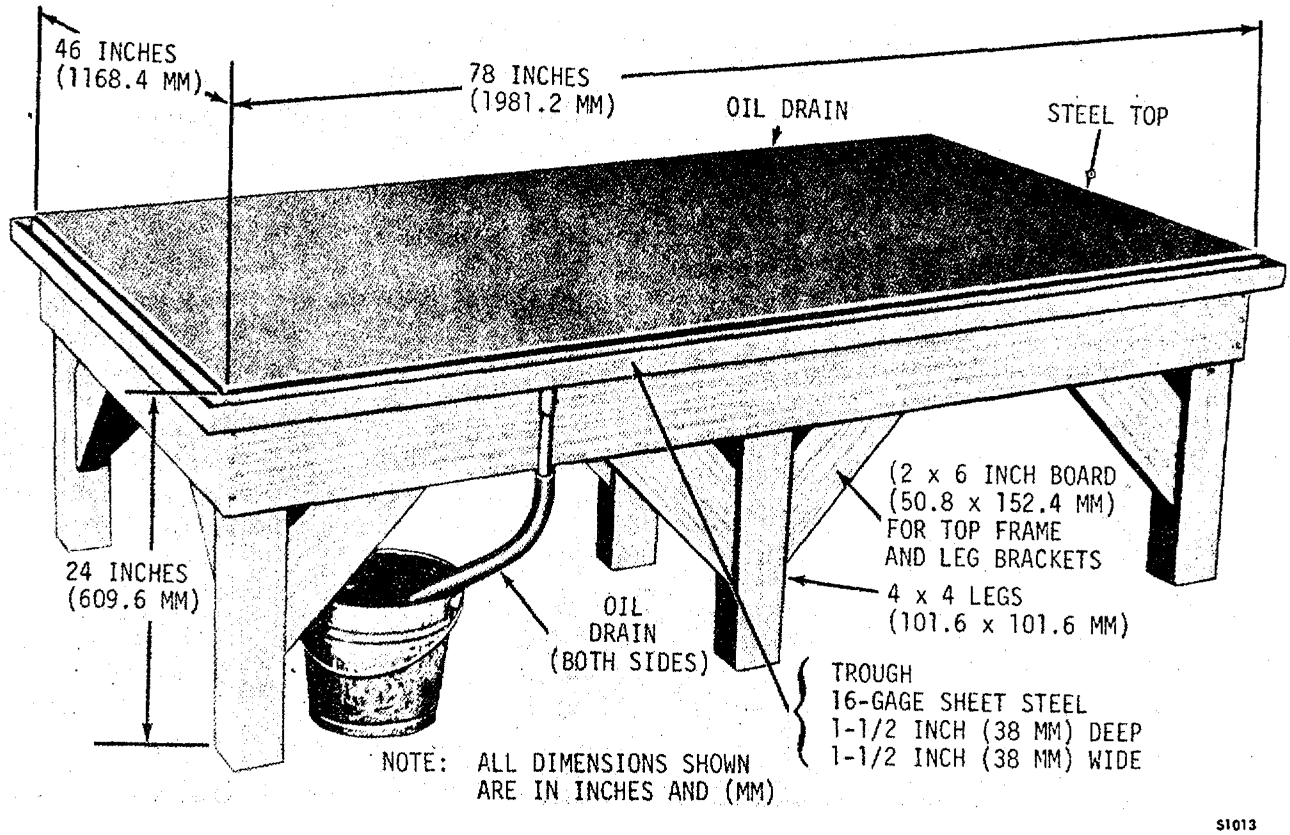

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Figure 15-25. Work Table

MECHANIC'S TOOLS, SHOP EQUIPMENT. The following tools, in addition to common tools, should be available:

- Snap ring pliers
- Micrometer
- 3-leg lifting slings (two required) - 2 ton (1814 kg) capacity - 900 angle attaching plates.
- 2 ton (1814 kg) hoist (two required).

CAUTION

Caustic cleaning compounds will damage some transmission parts. Use only mineral spirits or cleaning solvents such as PD 680-2 (or equivalent).

- Container of mineral spirits for cleaning parts.
- 100 inch-pound (11 N•m) torque wrench.
- 100 foot-pound (136 N•m) torque wrench.
- 1000 foot-pound (1356 N•m) torque wrench.
- Hot plate or heating equipment (for heating bearings or other interference-fit parts).
- Press for disassembly and assembly of spring-loaded clutches, valves and interference-fit parts.
- Clean, lint-free shop cloths (do not use waste).
- Boxes, receptacles for parts.
- Supply of wood blocks.
- Oil-soluble grease (petrolatum).
- Non-hardening sealer, Permatex No. 2, or equivalent (for plugs, seals that are not pre-coated).

REPLACEMENT PARTS

ORDERING INFORMATION. Refer to the current Parts Catalog.

PARTS NORMALLY REPLACED. The following parts are normally replaced at each transmission overhaul:

- Gaskets
- Lockstrips
- Washers or snap rings damaged by removal.
- Oil seals, piston seal rings.

WARNING

Do not burn discarded Teflon seals; *toxic gases are produced by burning.*

OTHER RECOMMENDED PARTS REPLACEMENT. These parts replacement recommendations apply to parts that probably should be replaced because of stress or accumulated operating hours. The replacement parts guide listed in Table 15-3 is provided to assist in determining whether a part should be used or if it should be replaced. Parts without visible damage which may have been subjected to adverse stress or load should be replaced. Other parts may be replaced to ensure maximum intervals between overhauls.

Table 15-3. Recommended Parts Replacement

REPLACE THESE PARTS IF OVER THESE OPERATING HOURS

Part Name	3,000	5,000	8,000	12,000	16,000	20,000
Clutch Plates*		X	X	X	X	X
Planetary Pinion Set & Sun Gears						
Splitter				X	X	X
Intermediate Range			X	X	X	X
Low Range		X	X	X	X	X
Reverse					X	X
PTO Gears					X	X
Planetary Pinion Bearings & Spindles						
Splitter		X	X	X	X	X
Intermediate Range			X	X	X	X
Low Range		X	X	X	X	X
Reverse				X	X	X
Bearings (Ball & Roller Assy)		X	X	X	X	X
Oil Pumps			X	X	X	X
Springs (Clutch Return)		X	X	X	X	X
Shafts						
Turbine				X	X	X
Splitter				X	X	X
Output		X	X	X	X	X
Turbine		X	X	X	X	X
Retarder Rotor				X	X	X

* Careful consideration and interpretation must be given to the wear of the friction plates. The life of these plates is not a straight line function with wear, but the life decreases more rapidly in the second half of the allowable wear. Therefore, good judgment must be used for optimum clutch life, performance and economy.

Parts replacement recommendations apply to transmissions already disassembled and in the process of being overhauled. The parts replacement chart is not intended to establish a definite number of hours a transmission maybe operated before tear-down for overhaul. It merely specifies what parts should be replaced to restore the transmission to a like-new condition.

Determine the number of hours of operation on your transmission since last overhaul. Locate the column on Table 15-3 which coincides with this number of hours. This column represents a transmission having a normal duty operation. If the operation of a transmission can be considered as light duty, use the column immediately to the left. If the operation can be considered as heavy duty, use the column immediately to the right. Parts to be replaced are suggested in addition to obviously damaged or worn parts.

CAREFUL HANDLING

Parts and subassemblies must be handled carefully to prevent nicking, scratching and denting. Close fitting parts may have proper clearance but can bind if they are nicked, scratched, or dented. Parts which depend upon smooth surfaces for sealing may leak if scratched. This is very important for parts of the control valve body assembly. Valves, when dry, must move freely in their bores by their own weight. Such parts should be carefully handled and protected during removal, cleaning, inspection, and installation as well as kept clean while in containers.

CLEANING, INSPECTION

DIRT-FREE ASSEMBLY. All parts must be clean to permit effective inspection. It is very important that no dirt or foreign matter enters the transmission. Even minute particles can cause the malfunction of close-fitting parts, such as valves.

CLEANING PARTS. Use only mineral spirits on friction-faced clutch plates and bearings. All other metallic parts should be cleaned thoroughly with mineral spirits or by steam-cleaning. Do not use caustic soda solution for steam cleaning.

Parts (except bearings) should be dried with compressed air. Steam-cleaned parts should be oiled immediately after drying.

Clean oil passages by working a piece of soft wire back and forth through the passages and flushing with mineral spirits. Dry the passages with compressed air.

After cleaning, examine parts and especially oil passages to make certain they are entirely clean. Re-clean them, if necessary.

Use only petroleum base solvents for cleaning oil seals. Solvents such as tri-chloroethylene, Benzol, Acetone and all aromatics are harmful to oil seals using poly-acrylate rubber.

CLEANING BEARINGS.

WARNING

Never dry bearings by spinning them with compressed air. A spinning bearing can disintegrate, allowing balls or rollers to become lethal flying projectiles. Also, spinning while they are not lubricated can damage the bearing.

Bearings that have been in service should be thoroughly washed in mineral spirits.

If the bearings are particularly dirty or filled with hardened grease, soak them in mineral spirits before trying to clean them.

Before inspection, oil the bearings with the same type of oil that will be used in the transmission.

INSPECTING BEARINGS. Inspect bearings for roughness of rotation. Replace a bearing if its rotation is still rough after cleaning and oiling.

Inspect bearings for scored, pitted, scratched, cracked, or chipped races, and for excessive wear of rollers or balls. If one of these defects is found, replace the bearing.

Inspect bearing housing and shaft for grooved, burred, or galled conditions that would indicate that the bearing had been turning in the bore or on the shaft. If the damage cannot be repaired with crocus cloth, replace the defective part.

CAUTION

Any bearing that has been subjected to metal contamination must be closely inspected for metal particles. Metal particles will cause failure of the bearing.

KEEPING BEARING CLEAN. Since the presence of dirt or grit in bearings is usually responsible for bearing failures, it is important to keep bearings clean during removal and installation. Observance of the following rules will do much to ensure maximum bearing life.

— Do not remove the wrapper from new bearings until ready to install them.
— Do not remove the grease in which new bearings are packed.
— Do not lay bearings on a dirty bench; place them on clean, lint-free paper.
— If assembly is not to be completed at once, wrap or cover the exposed bearings with clean paper or lint-free cloth to keep out dust.

INSPECTING CAST PARTS, MACHINED SURFACES. Inspect bores for wear, scratches, grooves, and dirt. Remove scratches and burrs with crocus cloth. Remove foreign matter. Replace parts that are deeply scratched or grooved.

Inspect all oil passages for obstructions. If an obstruction is found, remove it with compressed air, or by working a soft wire back and forth through the passage and flushing it with cleaning solvent.

Inspect mounting faces for nicks, burrs, scratches, and foreign matter. Remove such defects with crocus cloth or a soft stone. If scratches are deep, replace the defective part.

Inspect threaded openings for damaged threads. Chase damaged threads with the correct size used tap (a new tap can cut oversize).

Replace housings or other cast parts that are cracked. Magnaflux and rinse planetary carriers using approximately 8000 ampere-turns (8 amperes in 1000 turn coil) to determine if fractured. Replace the carrier if cracked.

NOTE

Some torque converter turbines have casting irregularities near the outer edge of the turbine vanes. These "shut" marks are not cracks and are not detrimental to the operation of the transmission.

Inspect all machined surfaces for damage that could cause oil leakage or other malfunction of the part. Rework or replace the defective parts.

Some parts (especially planetary carriers) may be discolored (straw colored up to blue). If only the part itself is discolored (e.g. a carrier but not the spindles) the color is from manufacturing and does not indicate a problem. But, if the parts in the area are all discolored (e.g. both a carrier and spindles), it indicates excessive heat has occurred and the parts must be replaced.

INSPECTING BUSHINGS, THRUST WASHERS. Inspect bushings for scores, burrs, roundness, sharp edges, and evidence of overheating. Remove scores with crocus cloth. Remove burrs and sharp edges with a scraper or knife blade. If bushing is out-of-round, deeply scored, or excessively worn, replace it, using the proper size replacement tool. Whenever it is necessary to cut out a defective bushing, *do not damage* the bore into which the bushing fits.

Inspect thrust washers for distortion, scores, burrs, and wear. Replace if defective or worn.

INSPECTING OIL SEALS, GASKETS. Replace all seal rings (except hook-type), oil seals and composition gaskets.

Inspect hook-type seal rings for wear, broken hooks, and distortion.

Install a new hook-type seal ring if the ring shows any wear on the outside circumference, or if there is excessive side wear. The sides of the seal ring must be smooth within 0.005 inch (0.13 mm) maximum side wear. The sides of the shaft groove (or the bore) into which the seal ring fits should be smooth within 50 micro-inches (1.27 micrometers) equivalent and square with the axis of rotation within 0.002 inch (0.05 mm). If the sides of the grooves have to be reworked, install a new seal ring.

INSPECTING GEARS. Inspect gears for scuffed, nicked, burred, or broken teeth. If the defect cannot be removed with a soft honing stone, replace the gear.

Inspect gear teeth for wear that may have destroyed the original tooth shape. If this condition is found, replace the gear.

Inspect the thrust face of gears for scores, scratches, and burrs. If the defect cannot be removed with a soft honing stone, replace the gear.

INSPECTING SPLINED PARTS. Inspect for stripped, twisted, chipped, or burred splines. Remove burrs with a soft stone.

Replace the part if other defects are found. Spline wear is not considered detrimental except where it affects tightness of fit of the splined parts.

INSPECTING THREADED PARTS. Inspect parts for burred or damaged threads. Remove burrs with a soft honing stone or fine file. Replace damaged parts.

0INSPECTING SNAP RINGS. Inspect all snap rings for nicks, distortion, and excessive wear. Replace the snap ring if any of these defects is found. The snap ring must snap tight in its groove for proper functioning.

INSPECTING SPRINGS. Inspect springs for signs of over-heating, permanent set, or wear due to rubbing adjacent parts. Replace the spring if any of these defects is found. Refer to the spring chart at the end of Section 15-107/109.

INSPECTING CLUTCH PLATES. Inspect friction-faced steel plates (internal-splined plates) for burrs, imbedded metal particles, severely pitted faces, excessive wear, cone, cracks, distortion, and damaged spline teeth. Remove burrs using a soft honing stone. Replace plates which have other defects.

Inspect steel plates (external-splined plates) for burrs, scoring, excessive wear, cone, distortion, imbedded metal, galling, cracks, breaks, and damaged spline teeth. Remove burrs and minor surface irregularities, using a soft honing stone. Replace plates which have other defects.

The amount of cone in clutch plates is determined by measuring the distance between the inside diameter of the plate and a level surface (Figure 15-26). Discard plates having excessive cone (refer to Wear Limits, later in this Section).

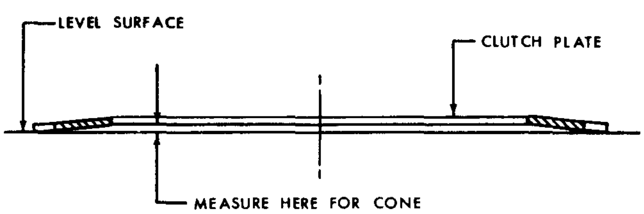


Figure 15-26. Measuring Clutch Plate Cone

INSPECTING SWAGED, INTERFERENCE-FIT PARTS. If there is evidence of looseness due to relative motion, the assembly should be replaced.

INSPECTING BALLS IN CLUTCH PISTONS. Inspect all balls in clutch pistons for free movement. Any restriction could prevent the ball from seating during clutch application.

INSPECTING SEAL CONTACT SURFACES. Inspect the surfaces that contact the sealing area or lip of any seal. Roughness, scoring, pitting, or wear that will permit oil leakage or cause damage to the seal must be corrected. The affected part must be replaced if defects cannot be corrected.

INSPECTING PUMP GEARS. Inspect pump gears for end clearance (Figure 15-27) and diametral clearance (Figure 1 5-28). End clearance between gears and pump cover is determined by measuring the distance between the gear and a steel straightedge placed across the gear and housing as illustrated in Figure 15-27. Diametral clearance between gears and housing is determined by measuring the distance between the gear teeth and housing (in several places) using a narrow feeler gauge as illustrated in Figure 15-28. Replace gears with excessive clearance (refer to Wear Limits, later in this section).

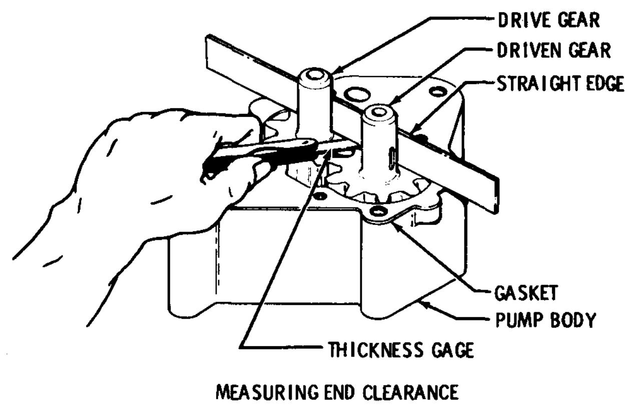


Figure 15-27. Measuring Pump Gear End Clearance

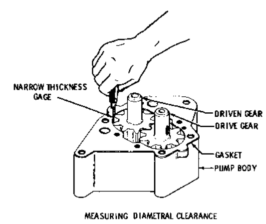


Figure 15-28. Measuring Pump Gear Diametral Clearance

ASSEMBLY PROCEDURES

CLUTCHES, PISTONS. When assembling a clutch pack, soak friction-faced clutch plates in transmission fluid for at least two minutes and install each plate so that any cone is in the same direction as the cone of the adjacent plates.

Apply a generous amount of transmission fluid to the piston cavity prior to final assembly.

PARTS LUBRICATION. During final assembly, lubricate all moving parts with transmission fluid. The lubricant will help protect the friction surfaces and ferrous metals until the unit is in service.

THREADED PLUGS, HYDRAULIC FITTINGS. Prior to installation, apply a small amount of pipe sealant with Teflon onto the threads of the part. Tighten the plug or fitting sufficiently to prevent leakage.

CAUTION

Do *not* use Teflon tape on threaded parts. Slivers can cause the transmission to malfunction.

OIL-SOLUBLE GREASE. Use oil-soluble grease with a low melting point (petrolatum) to temporarily retain parts, step-joint seal rings, scarf-cut seal rings, and hook-type seal rings during assembly with mating parts.

CAUTION

Do not use petrolatum to retain cork gaskets.

SEALING COMPOUNDS, NONSOLUBLE GREASES. Do not use gasket-type sealing compounds, fibrous greases, or nonsoluble, vegetable-base cooking compounds any place inside the transmission. Do not use them any place where they could be flushed into the transmission hydraulic system. However, if adhesives or sealers are required for the oil pan gasket, they may be applied on the pan mounting flange, but only in the area outside of the flange bead.

INTERFERENCE-FIT PARTS. Assembly of interference-fit parts may be accomplished by heating and chilling the respective parts. The female part can be heated in an oven or oil bath to 300°F(149°C), and the male part can be chilled in dry ice. Either one or both parts may require a thermal process. However, if the chill process is used for a ferrous alloy part, coat the components with transmission fluid to inhibit rust due to frost and moisture.

SLEEVE-TYPE BEARINGS. The use of a locking compound such as Loctite Sleeve Retainer 601 or equivalent is recommended to retain bushings and sleeve-type bearings that have press-fit tolerances.

BEARINGS (BALL OR ROLLER). When installing a bearing on a shaft, heat the bearing to 200°F (93°C) in an oil bath (approximately 30 minutes). Use the proper size installation sleeve and a press to seat the bearing.

If a bearing must be removed or installed without a sleeve, *press only on the race which is adjacent to the mounting surface.* If a press is not available, seat the bearing with a drift and hammer, driving against the supported race.

WEAR LIMITS Refer to back of section for information about parts specifications, clearances, and wear limits.

SPRING SPECIFICATIONS
Refer to the spring chart in back of section for spring identification and specifications.

RETAINING OUTPUT FLANGE

REMOVAL OF FLANGES. The flanges are retained by a self-locking nut. Before removing the nut, check to see how many notches have been cut into the wrenching flats. If there are five notches, remove the nut and throw it away.

If there are less than five notches, or none at all, remove all dirt and any burrs from the exposed shaft threads. Then, only loosen the nut until there is approximately 1/16 inch (1.59 mm) gap between the nut and flange.

Check the running torque while removing the nut. The nut can be reused only if it meets the following requirements.

- The first time (no notches) the nut is removed the running torque must be at least 400 lb in. (45 N.m).
- Each additional time (one to four notches) the nut is removed the running torque must be at least 300 lb in. (34 N.m).

Each time the nut is reused, deeply scribe one of the wrenching flats. This method of marking the nut will indicate how many times the nut has been reused. The nut must not be reused more than five times.

CAUTION

A puller placed on the outside diameter of the flange may deform the pilot diameter and mounting face.

Install a suitable heavy-duty puller to the face of the flange.

Atypical puller is illustrated in Figure 15-23.

In order to protect the tapped holes in the end of the shaft, install a soft metal spacer between the puller jackscrew point and the end of the shaft.

Provide a means for preventing flange rotation.

CAUTION

Do not use a pry bar or hammer to force the flange at disassembly.

Remove the flange by tightening the puller screw against the spacer and shaft.

INSTALLATION OF FLANGES. Make sure the output shaft is in its most outward position and the bearing between the shaft shoulder and the flange is tight against the shaft shoulder. A typical method is to insert a sleeve over the shaft and pull tight with washer and bolts as illustrated in Figure 15-24.

Coat the shaft splines and the lip of the oil seal with a thin layer of bearing grease.

Heat the flange to approximately 300°F (149°C) prior to assembly. Either heat in a controlled temperature furnace for at least 45 minutes or submerge the flange in a container of oil and heat the oil. (If acetylene torch is used, heat the container of oil for 15 minutes.)

CAUTION

Do not let the flange cool prior to installation. If the flange cools and seizes to the shaft prior to its final assembly, it will be necessary to remove the flange and repeat the assembly procedure. Do not attempt to force the flange with a hammer.

Immediately after heating, install the flange on the shaft, making sure that the flange is tight against its locating shoulder. The flange should slide freely to its assembled position.

If an output nut is used, coat the threads of the nut with molybdenum disulfide grease and install the flange retaining washer and nut. (Do not reuse nut with five notches; refer to page 15-43). tighten the nut to 700-1000 lb ft (949-1335 N.m) (Figure 15-29).

After the assembly has cooled, it is good practice to check the nut torque and, if necessary, retighten it to 700-1000 lb ft (949-1355 N.m). Or, if washer and bolts were used, retighten the bolts to 96-115 lb ft (131-155 N.m).

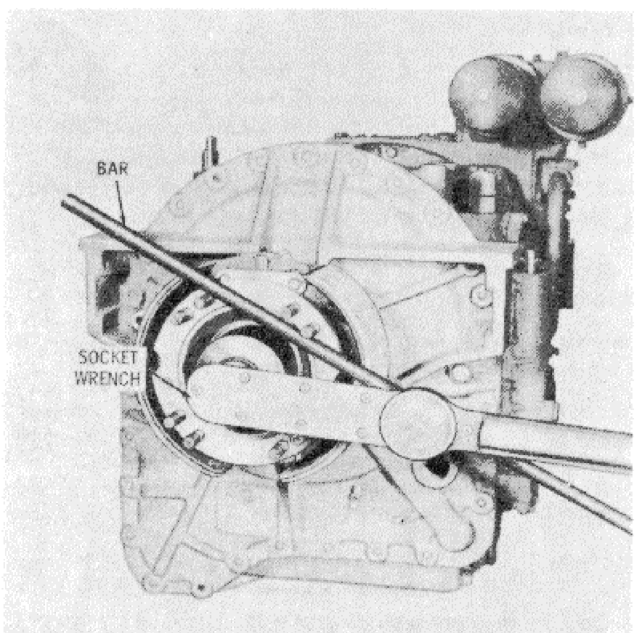


Figure 15-29. Tightening Output Flange Retaining Nut

TEFLON SEAL RINGS

APPLIES TO ALL TEFLON SEAL RINGS. These instructions apply to the installation of both lip-type Teflon seal rings and Teflon seal rings that require expanders.

Some earlier models have seal and expander type seal rings in the pistons of the splitter-direct, splitter-overdrive, first-and-second-gear, third-and-fourth-gear, and fifth-and-sixth-gear ranges. These have been replaced with lip-type seal rings.

REMOVAL

WARNING

Do not burn discarded Teflon seals; toxic gases are produced by burning.

Insert a thin, bladed tool into the seal ring groove, and work one edge of the seal ring out, where it can be grasped with the fingers. It is recommended that all seal rings be replaced.

If present, remove the seal ring expander.

Clean the groove thoroughly, and make sure there are no burrs or rough spots in the groove sides or bottom.

NOTE

Earlier type (polyacrylate) seals may be replaced with Teflon seals. Teflon seals must be replaced with identical items.

INSTALLATION (SEAL RINGS WITH EXPANDERS). Lightly coat the piston housing and the piston hub seal surface with Type C3 oil or oil-soluble grease, but do *not* pack the seal ring groove with grease.

Coil the expanders as shown in Figure 15-30. Inspect the ends for curvature toward the bottom of the groove (inward for external grooves; outward for internal grooves).

Install the expander into the groove.

NOTE

For ease of installation, Teflon seal rings can be heated in an oil bath to 150-2000F (65-930C) for approximately fifteen minutes immediately before installation.

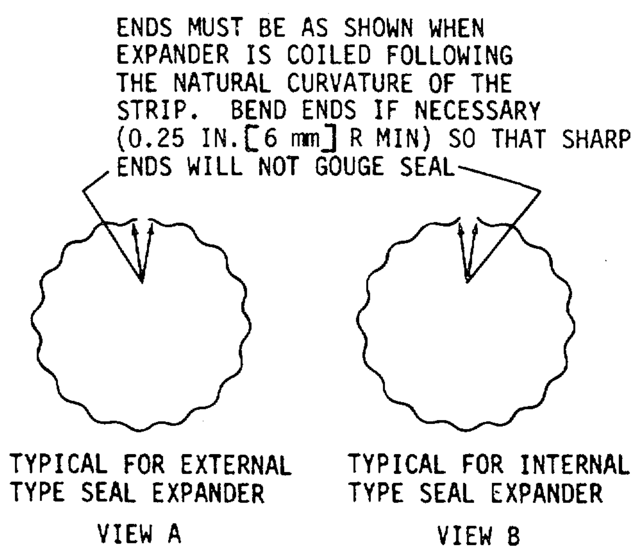


Figure 15-30. Typical Expanders for Teflon Seal Rings

Starting at a point opposite the open ends of the expander, install the Teflon seal ring. Do not stretch or deform the seal ring more than absolutely necessary for installation. Work both directions from the starting point until the seal ring is completely installed. Do not use tools to force the seal ring use fingers only.

Lubricate the seal ring, and center it radially in respect to the piston or part on which it is installed. This will aid installation of the part into its bore.

INSTALLATION (LIP-TYPE SEAL RINGS). Lightly coat the piston housing and the piston hub seal surface with Type C3 oil or oil-soluble grease, but do *not* pack the seal ring groove with grease.

NOTE

For ease of installation, Teflon seal rings can be heated in an oil bath to 150-2000F (65-930C) for approximately fifteen minutes immediately before installation.

Use a nonhardening sealing compound on the outside circumference of the seal (if it is not precoated) to help prevent oil leaks. (Precoated seals do not require sealing compound.) Coat the inside lip of the seal with high-temperature grease to protect the seal during shaft installation and to provide lubrication during initial operation.

CAUTION

If lip-type seal rings are installed incorrectly, the clutches will not operate properly.

All lip-type seal rings must be installed so that the lip faces in the direction of the incoming clutch apply oil pressure. The foldouts at the back of this manual show the direction of each lip-type oil seal installation.

DETERMINING PTO BACKLASH LIMITS

CAUTION

The backlash in power takeoff (PTO) installations should be carefully checked. Excessive or insufficient backlash can result in damage to the transmission and the PTO assembly.

DETERMINING BACKLASH BETWEEN DRIVE AND DRIVEN GEAR (QUANTITY A) (Figure 15-31). When instructions are not immediately available from the vehicle manufacturer, the following method is suggested for determining the proper backlash.

1. Hold gear 1 (transmission drive gear) by holding the input flywheel.

2. Move gear 2 (transmission driven gear) in both directions. Measure the backlash with an indicator as shown in Figure 15-31. This is quantity A.

DETERMINING BACKLASH BETWEEN DRIVE AND DRIVEN GEAR (QUANTITY B)(Figure 15-32). Hold the output shaft of PTO 4 stationary.

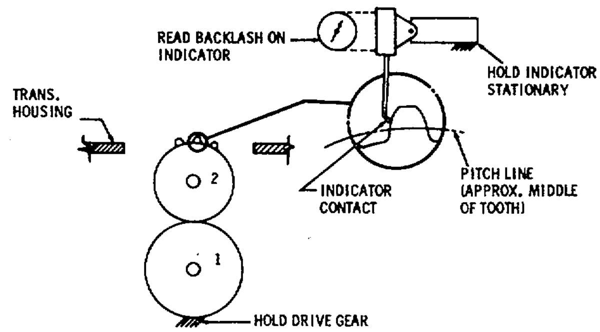


Figure 15-31. Determining PTO Drive-Gear Backlash

Move gear 3 (PTO drive gear) in both directions. Measure the backlash with an indicator as shown in Figure 15-32. This is quantity B.

DETERMINING THE TOTAL BACKLASH IN THE GEAR TRAIN (QUANTITY C) (Figure 15-32a). Hold gear 1 (transmission drive gear) by holding the input flywheel.

Attach a steel strap to the PTO output shaft with a C clamp.

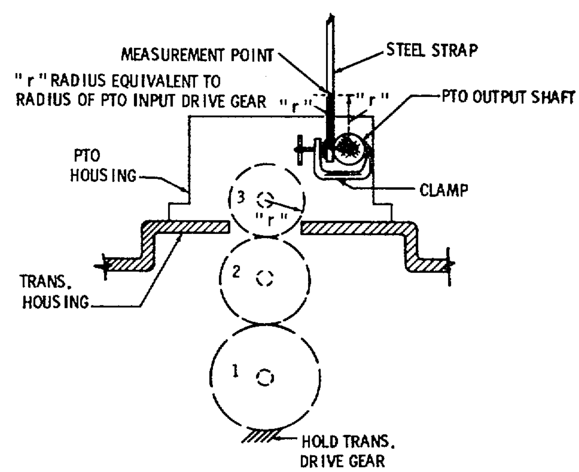


Figure 15-32. Determining PTO Driven-Gear Backlash

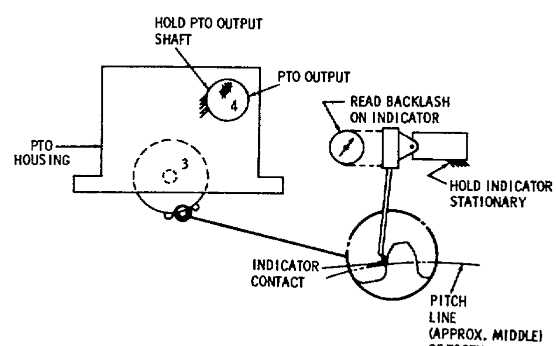


Figure 15-32a. Determining PTO Drive-to-Driven-Gear Backlash

Mark off radius "r" on the strap. Radius "r" is equivalent to the radius of the PTO input drive gear 3. Take the backlash measurement at this point on the strap.

Move the output shaft in both directions and measure the backlash using an indicator as shown in Figures 15-31 and 15-32. This is quantity C.

Add quantity A to quantity B, then subtract this sum from quantity C. The remainder will be the backlash between the transmission gear and the PTO gear. Call this quantity D.

For safe PTO operation, the value of quantity D should be 0.005-0.025 inch (0.12-0.63 mm). The formula is stated: D = C (A + B).

TORQUE SPECIFICATIONS Torque specifications are given with each assembly procedure. Also the exploded view foldouts state torque specifications for all bolts.

REMOVAL

If the main transmission is to be removed at the time the engine is removed, refer to Section 16. The main transmission can be removed from the carrier without removing the engine by following this procedure.

1. Remove the sheet metal over the transmission.
2. Disconnect the shift and retarder cables from the main transmission.
3. Drain the transmission oil and disconnect the lube lines at the transmission leading to the filters.
4. Disconnect the hydraulic, air and electrical lines at the transmission.
5. Disconnect the propeller shaft at the rear of the transmission. Disconnect the universal joint by bending the lock straps away from the capscrews, and remove the capscrews, lock straps, and the bearing and retaining cap subassemblies. Allow the propeller shaft to hinge at the auxiliary transmission.
6. Fully support the transmission from the bottom with a jack at the center of gravity. Remove all hardware that attaches the transmission to the engine braces. Remove the bolts that hold the transmission to the engine.
7. Slide the transmission back from the engine to disengage the flywheel assembly from the carrier engine.
8. Lower the transmission out from under the carrier.
9. Clean the exterior of the transmission. If the transmission should be steam cleaned, it should be disassembled and dried immediately as condensation of the steam will rust the ferrous parts in the transmission.

DISASSEMBLY OF TRANSMISSION

GENERAL

The following procedures describe the disassembly of the transmission into subassemblies. Disassembly of the subassemblies is described later. Refer to the cross section (Foldout 1) for the functional location of parts. Refer to the exploded views (Foldouts 3 through 1 2) for parts identification.

PREPARATION FOR DISASSEMBLY

TOOLS. Refer to Tools, earlier, for tools and equipment needed before beginning disassembly.

LIFTING, HANDLING. The transmission is provided with four 5/8-1 1 lifter holes in the top of the transmission main housing. Position the transmission horizontally on wood blocks as necessary. For vertical support, support legs J23556 may be used. (See Figure 15-22.)

TRANSMISSION DISASSEMBLY

REMOVAL OF EXTERIOR COMPONENTS. Remove exterior components as follows:

1. Refer to Retaining Output Flange, and remove the output flanges. Use a 3-1/8 inch socket wrench to remove the nut (Figure 15-33). Using a suitable puller, remove the flange (Figure 15-34).

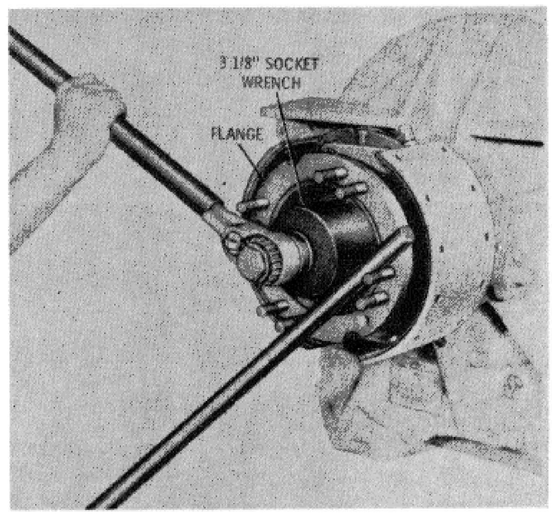


Figure 15-33. Removing Output Flange Nut

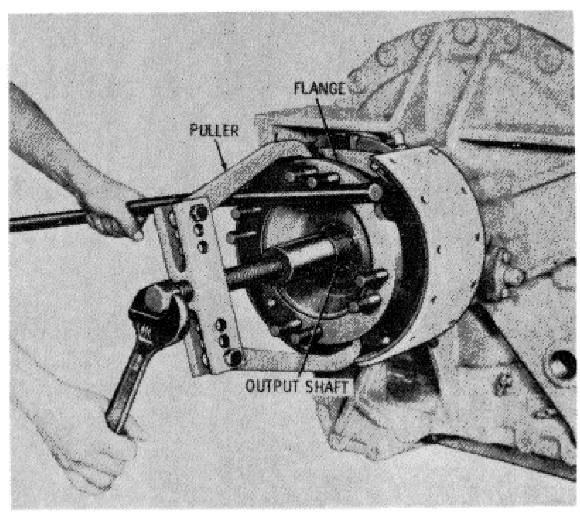


Figure 15-34. Removing Output Flange

2. Remove the two bolts and lockwashers that retain the speedometer cover and gasket.

3. Remove magnetic pickup 18 (A, Foldout 12).

4. Before removing the filter assembly (B, Foldout 5), remove two drain plugs 33 and drain the filters. Remove bolts 2 and 4 and lockwashers 3 and 5. Remove the filter gasket and base assembly (Figure 15-35).

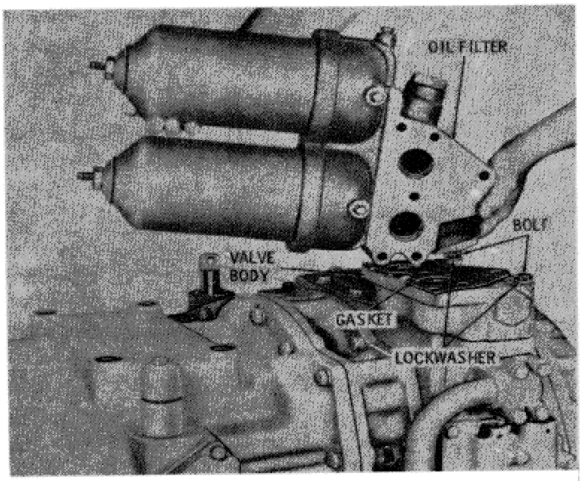


Figure 15-35. Removing Oil Filter Assembly

5. Remove bolts 10 (B, Foldout 5) and lockwashers 11. Remove the main-pressure regulator valve body assembly (Figure 15-36). Remove and discard gasket 24.

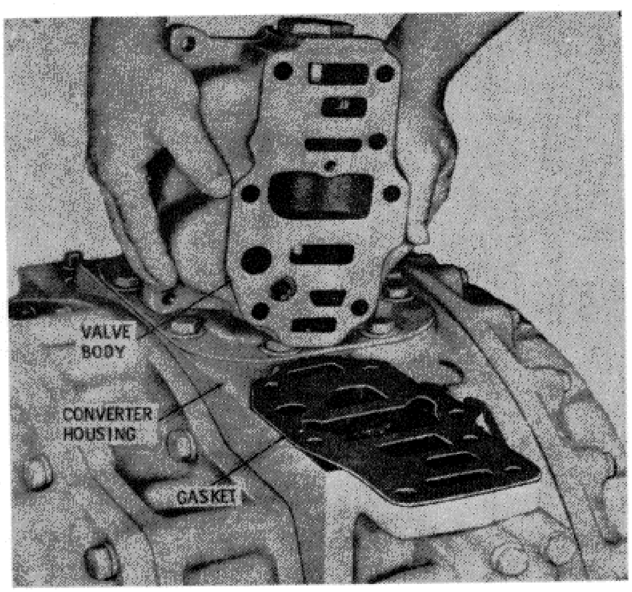


Figure 15-36. Removing Main Pressure Regulator Valve Body

6. Remove bolts 7 (B, Foldout 4), washers 6 and PTO cover

5. Remove and discard gasket 4.

7. Remove the wire from pressure switch 20(A, Foldout 6). Remove bolts 1 and 4 with lockwashers 2 and 5.

8. Remove lockup valve body assembly 6. Remove and discard the gasket (Figure 15-37).

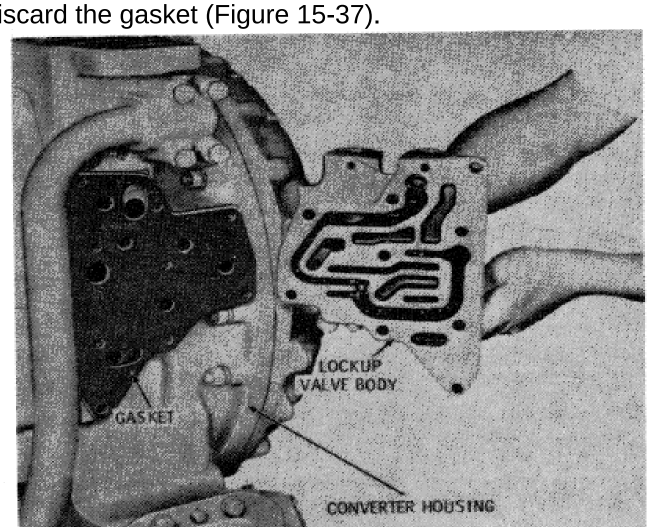


Figure 15-37. Removing Lockup Valve Body Assembly

9. Remove three oil jumper tubes from locations shown in Figure 15-38 by installing a bolt into the tube and catching the threads on the end of the tube (Figure 15-39). Be sure the hoses are removed with the tubes.

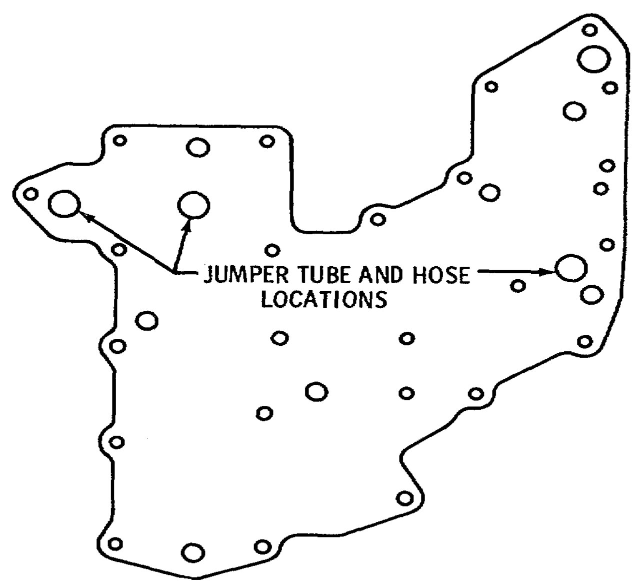


Figure 15-38. Jumper Tube and Hose Locations

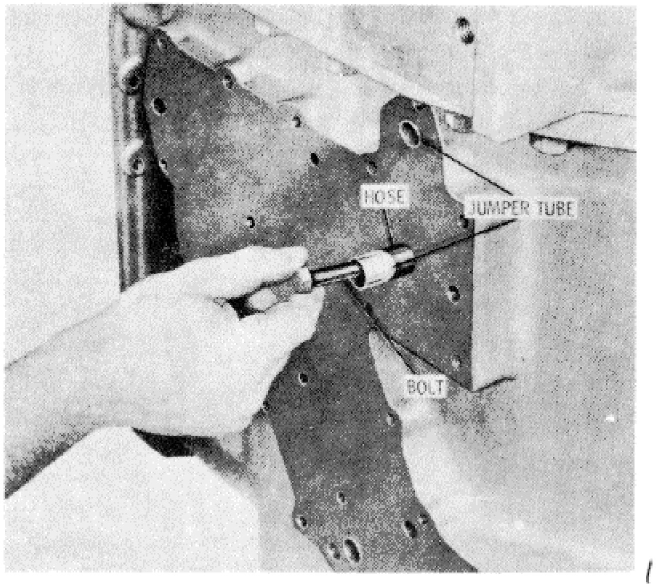


Figure 15-39. Removing Jumper Tubes and Hoses

10. Remove seven bolts 1 (A, Foldout 7) and lockwashers 2 from hydraulic retarder valve body assembly 4. Remove the valve body (Figure 15-40). Remove gasket 18 (A, Foldout 7), and plate 17 and gasket 3 (if present). Discard the gasket(s).

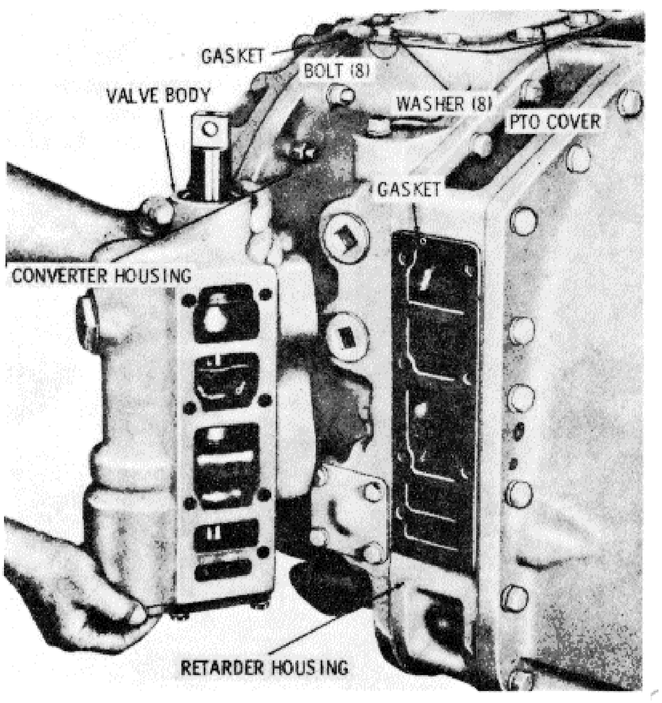


Figure 15-40. Removing Hydraulic Retarder Control Valve Body Assembly

11. Attach a two-strand lifting sling to the top of the transmission and raise it slightly (Figure 15-41). Remove six bolts 7 (A, Foldout 10) and lockwashers 8 from oil strainer 6. Remove strainer 6 and gasket 5.

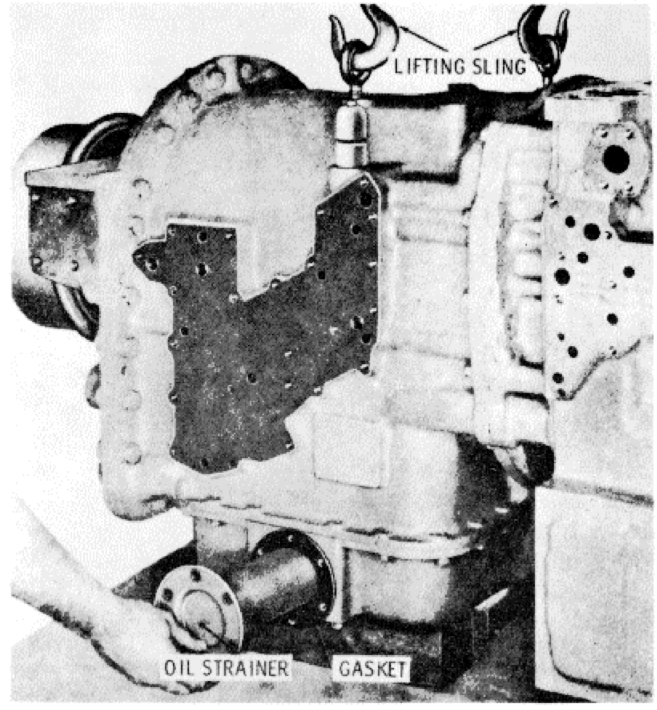


Figure 15-41. Removing Oil Strainer

12. Remove twenty-eight bolts 11 and 13, and washers 10 and 12, from the transmission oil pan. Remove the pan and gasket (Figure 1 5-42).

13. Remove the two hidden bolts and lockwashers that become accessible when the oil pan is removed (Figure 15-42).

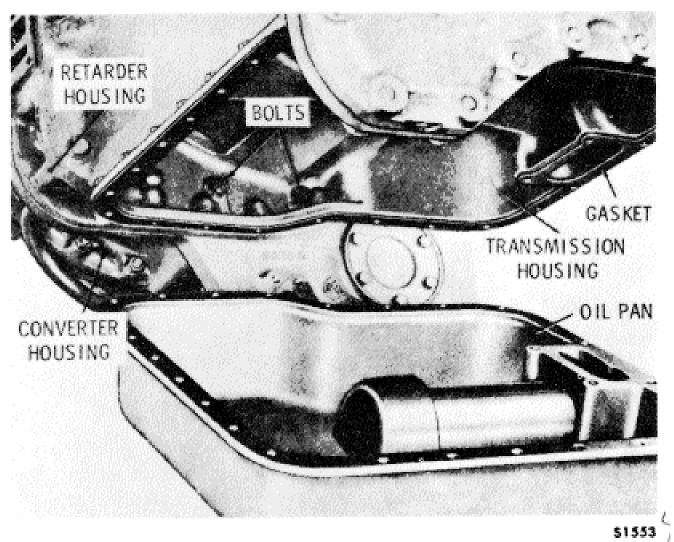


Figure 15-42. Removing Transmission Oil Pan

14. Lower the transmission (Figure 15-43) onto wood blocks.

15. Remove four bolts 45 (B, Foldout 4), four lockwashers 46, and split flanges 43 from each end of main-pressure

transfer tube 42. Remove the tube assembly and seal rings 44. Remove two bolts 48 and two bolts 49 and lockwashers 50 from hose connecting block47. Remove the connecting block and seal ring.

16. Remove Power Take-off and hydraulic pump from side PTO. See Section 11B.

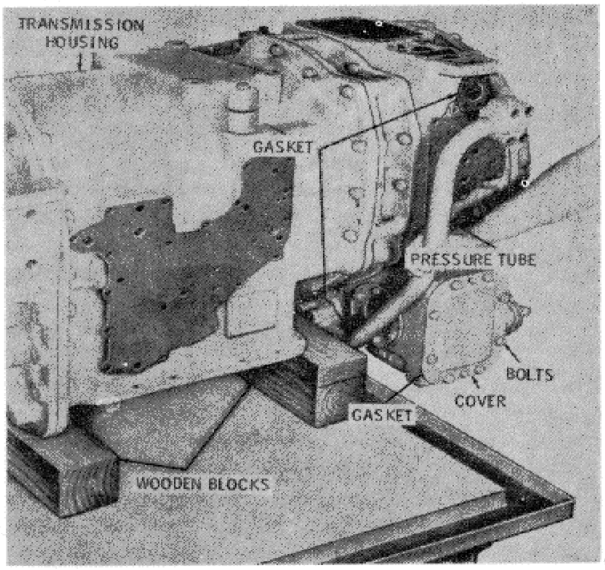


Figure 15-43. Removing Input Oil Pressure Tube.

REMOVAL-OF CONVERTER HOUSING, RETARDER HOUSING AND RELATED COMPONENTS. Remove converter housing and retarder as follows:

1. Attach a two-strand lifting sling to the top of the torque converter housing, adjusting the sling to support the housing. Remove the seventeen remaining bolts and lockwashers which fasten the transmission main housing to the retarder housing. Remove, as a unit, the torque converter and housing assembly, the retarder and housing assembly and attached parts from the transmission main housing (Figure 15-44). Remove and discard the gasket.

2. Position the converter housing and attached parts vertically. If gasket 17 (A, Foldout 3) is present, remove and discard it. Remove thirty-six bolts (accessible through top PTO opening) and flat washers which secure the flywheel to the converter pump (Figure 15-45).

WARNING

When removing the flywheel assembly, lockup parts may drop from the flywheel cavity.

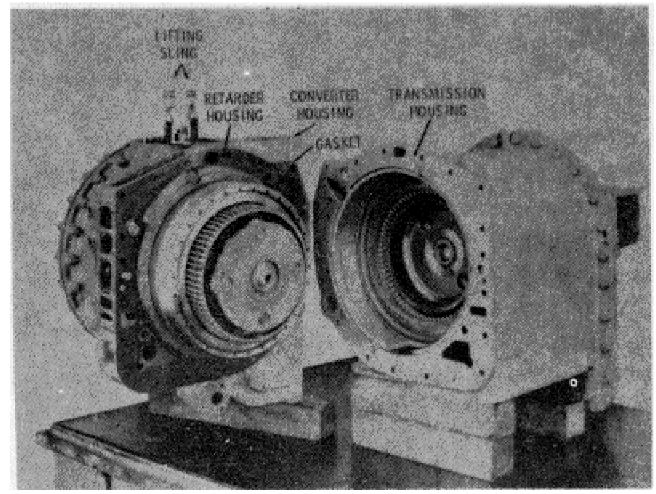


Figure 15-44. Removing Torque Converter, Converter Housing and Retarder Housing

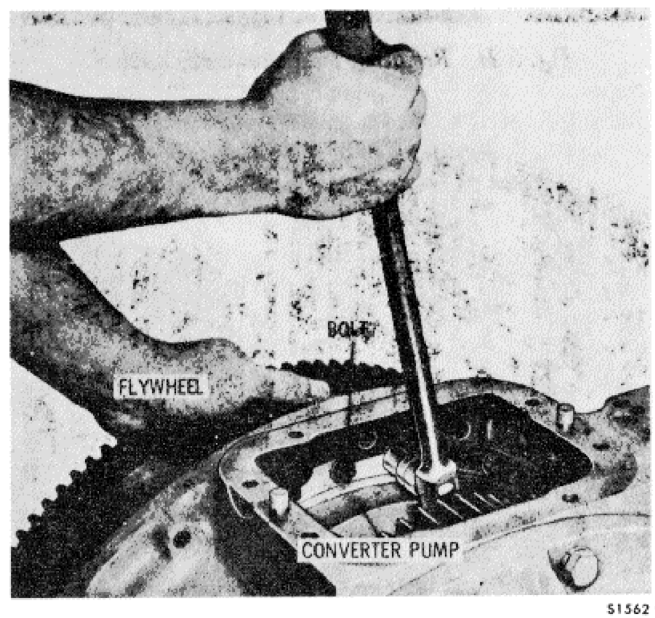


Figure 15-45. Removing Flywheel Bolts

3. Using the flywheel lifting hook (Figure 15-46), remove the flywheel assembly and position the assembly on the work table, front side downward.

4. Remove the hook-type seal ring from the turbine shaft. Install two lifting bolts (Figure 15-47) into the lockup clutch backplate and remove the plate from the flywheel. If present, remove two anchor keys. Remove the lockup clutch plate.

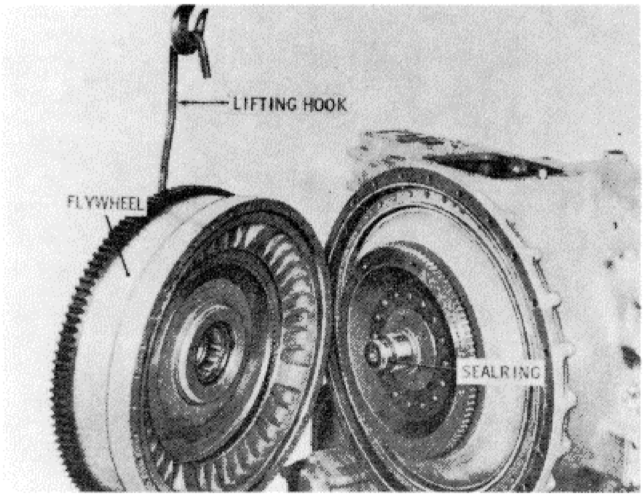


Figure 15-46. Removing Flywheel Assembly

5. Remove the lockup clutch piston, using the two lift out holes provided. Remove the snap ring and bearing. Remove the seal rings from the outside diameter of the piston and from the flywheel hub.

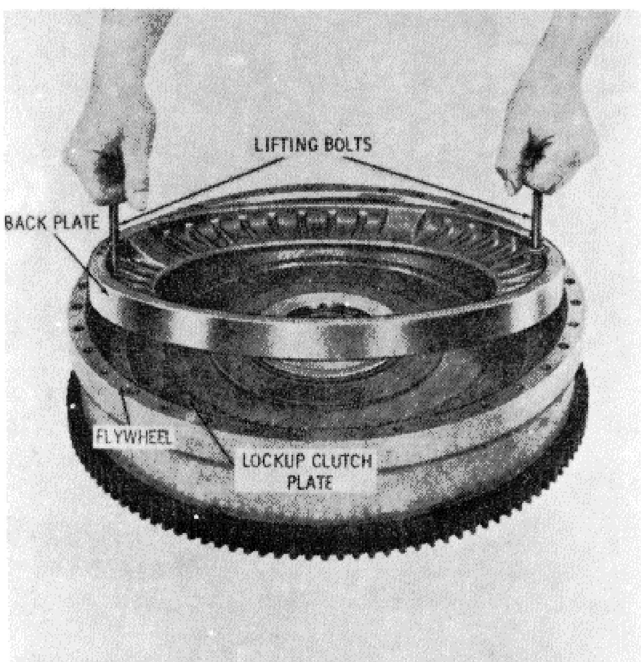


Figure 15-47. Removing Lockup Clutch Backplate

REMOVING TORQMATIC CONVERTER ELEMENTS. Disassemble torque converter as follows:

1. Remove the snap ring from the turbine shaft (Figure 15-48).

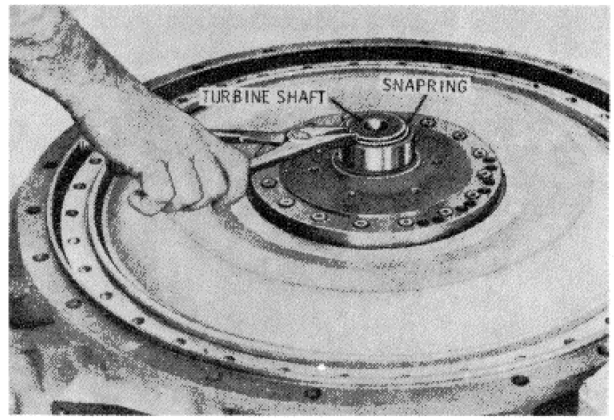


Figure 15-48. Removing Snap Ring from Turbine Shaft

2. Using a turbine puller, remove the converter turbine and the inner race of the front cover bearing (Figure 15-49).

3. Remove spacer 4 (A, Foldout 4) if present.

4. Using a chisel, straighten the staking in the spanner nut. Using spanner wrench J-6534-02 (see Tools earlier) remove the spanner nut which secures the freewheel roller race to the converter ground sleeve (Figure 15-50).

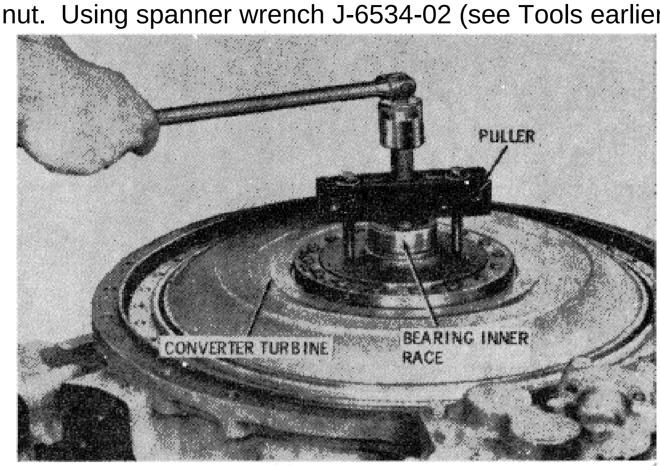


Figure 15-49. Removing Torque Converter Turbine

CAUTION

The stator rollers may drop out when the stator assemblies are removed if the roller race does not lift with the stators.

5. Remove, as an assembly, the stator assembly, with its springs, rollers, cups and pins (needle rollers) and the race. Remove the stator backplate.

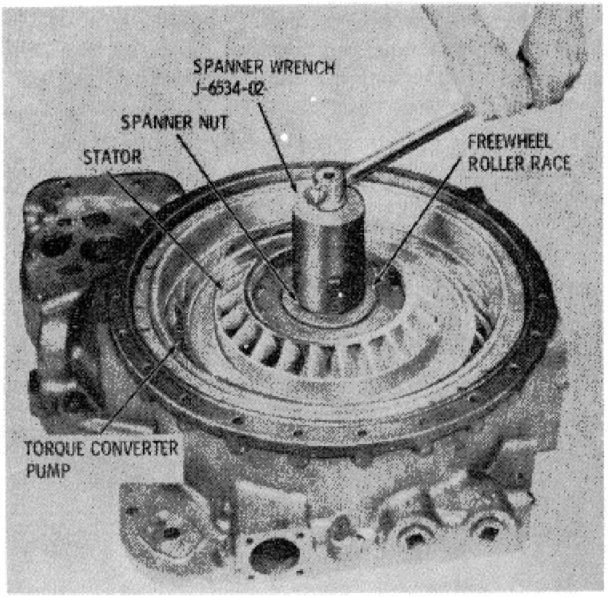


Figure 15-50. Removing Freewheel Roller Race Retaining Nut

6. Attach a lifting sling to the converter pump and remove the pump from the converter ground sleeve (Figure 15-51).

7. Remove the step-joint seal ring from the ground sleeve (Figure 15-51).

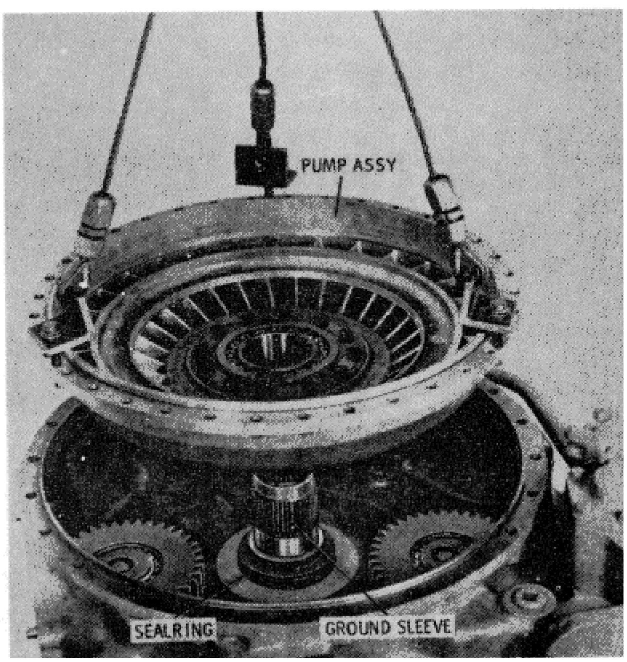


Figure 15-51. Removing Torque Converter Pump Assembly

REMOVING OIL PUMP, PTO AND OIL PUMP IDLER GEARS.

Remove pump components as follows:

1. Remove the eight bolts and lockwashers retaining the scavenge oil discharge tube to the pump and converter housing assemblies (Figure 15-52). Remove the tube and two gaskets.

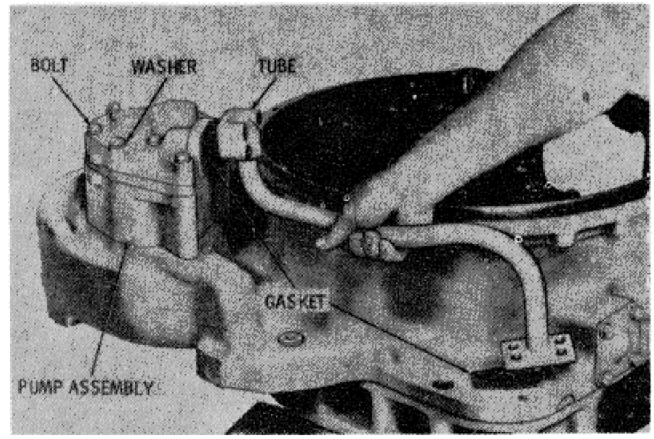


Figure 15-52. Removing Scavenge Oil Discharge Tube

2. Remove six outer bolts and lockwashers from the oil pump assembly (Figure 15-53). Remove the pump assembly. Remove and discard the gasket. Remove the pump drive coupling. Remove the oil screen, if present, from the oil pump.

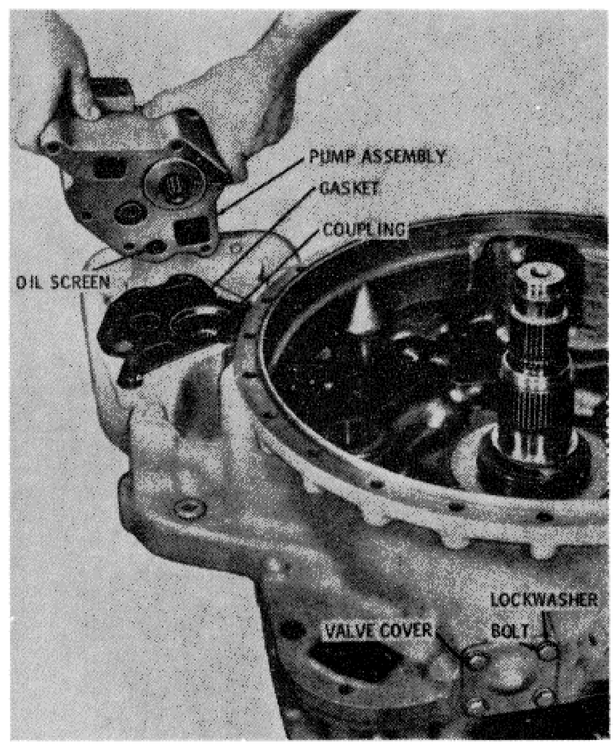


Figure 15-53. Removing Oil Pump Assembly

3. If present, remove the bolt and lockwasher from the power takeoff idler gear spindle (Figure 15-54). Using a slide hammer, remove the spindle from the converter housing. Remove the gear and bearing. Remove the snap ring from the gear. Remove the oil pump idler gear and bearing in the same manner.

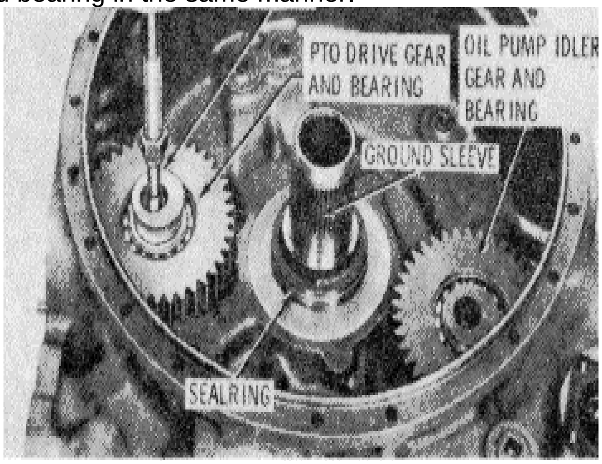


Figure 15-54. Removing PTO Drive Gear Spindle

SEPARATING CONVERTER HOUSING AND RETARDER HOUSING AND REMOVING RELATED PARTS. Separate housings as follows:

1. Remove seven bolts and lockwashers which secure the converter housing to the retarder housing. Attach a 3

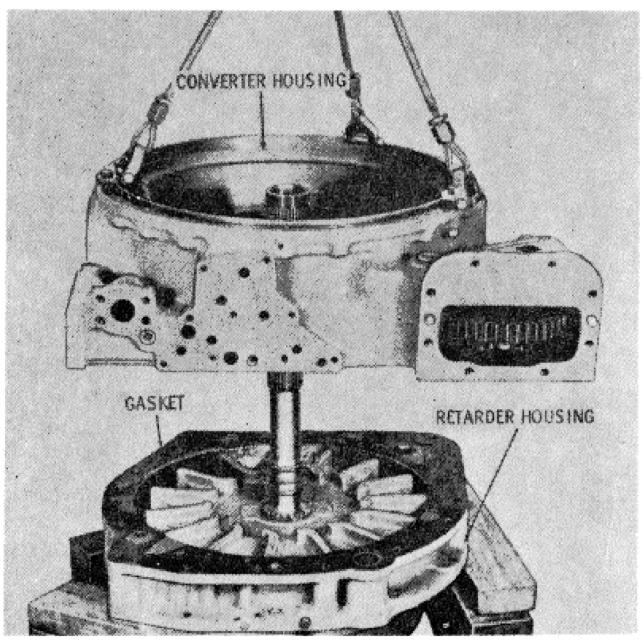


Figure 15-55. Removing Converter Housing from Retarder Housing

strand lifting sling to the converter housing (Figure 15-55) and lift the converter housing from the retarder housing. Position the converter housing vertically on wood blocks. Remove and discard the gasket.

2. Remove six bolts and lockwashers from the oil pump drive gear hub cover. Remove the cover and gasket. Remove the snap ring from the converter housing (Figure 1556).

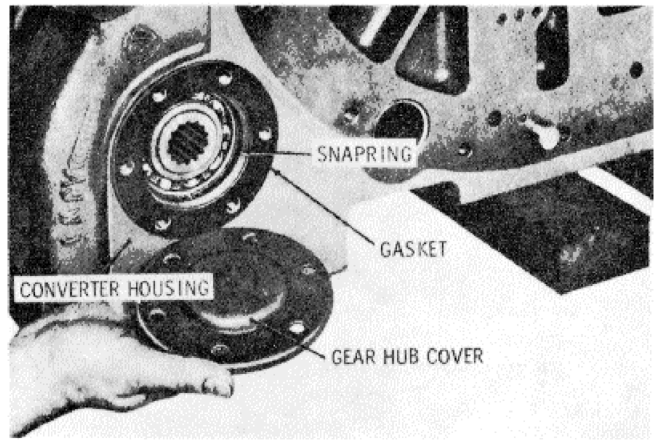


Figure 15-56. Removing Pump Drive Gear Hub Cover

3. Using a hammer and a soft drift, tap on the oil pump drive gear hub and remove the hub and bearing (Figure 15-57). Press the hub from the bearing.

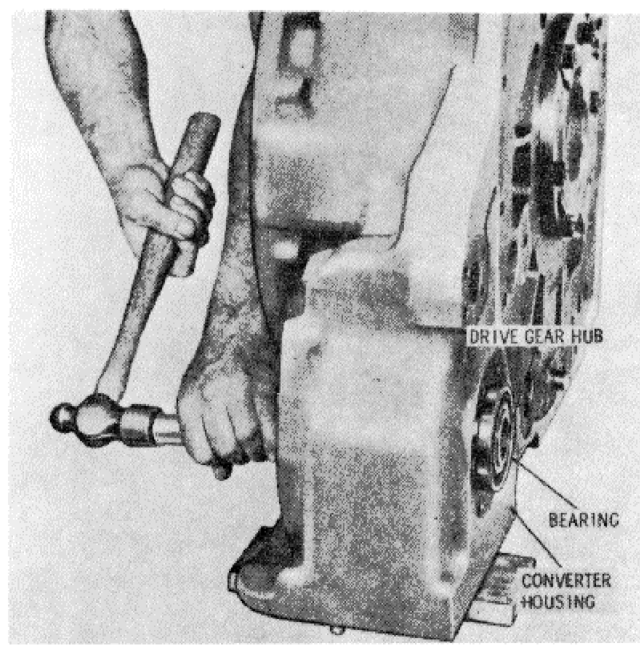


Figure 15-57. Removing Oil Pump Drive Gear Hub and Bearing

4. Remove the oil pump drive gear from the converter housing (Figure 15-58).

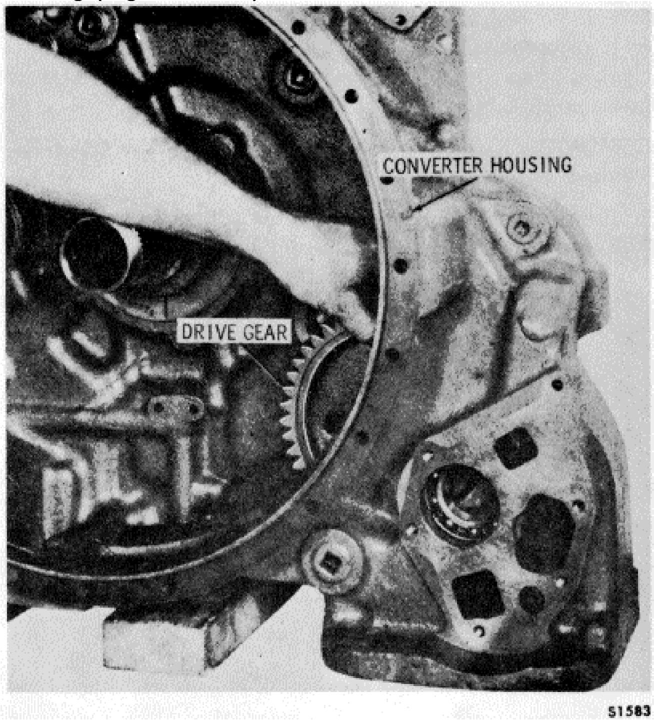


Figure 15-58. Removing Oil Pump Drive Gear

5. Remove the oil pump drive gear spacer and bearing from the converter housing (Figure 15-59).

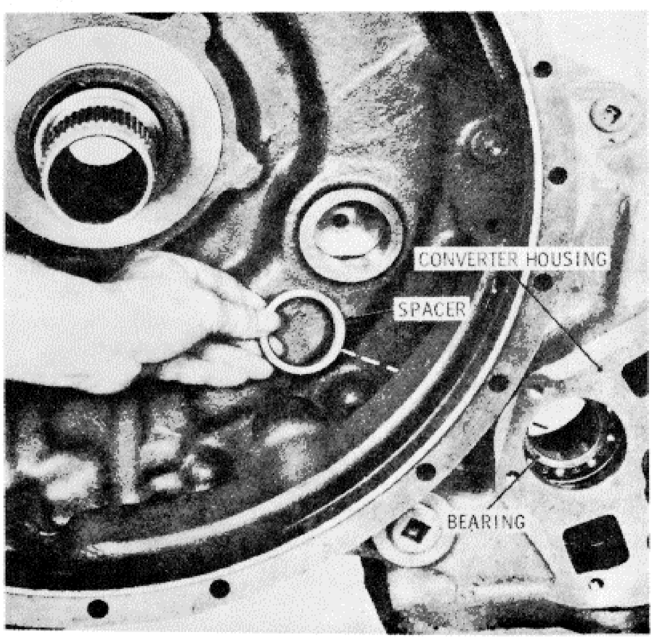


Figure 15-59. Removing Oil Pump Drive Gear Spacer

DISASSEMBLY OF RETARDER HOUSING, TURBINE SHAFT AND RELATED PARTS. Disassemble retarder components as follows:

1. Remove three hook-type seal rings from the turbine output shaft (Figure 15-60). The rotor is press fit onto the turbine output shaft.

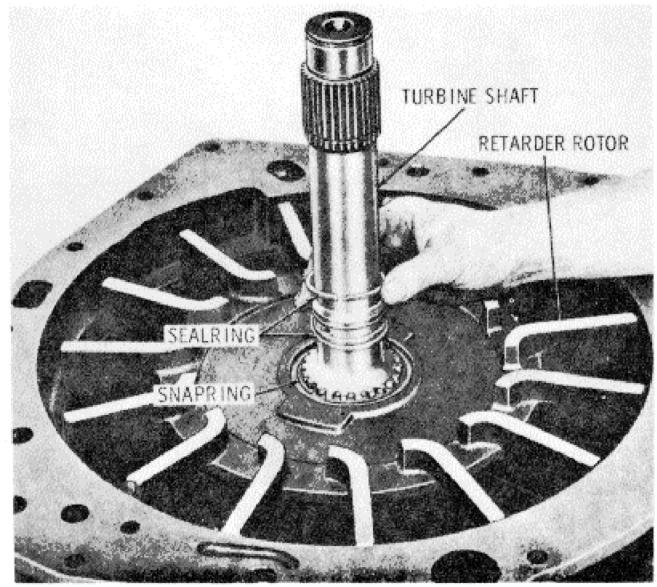


Figure 15-60. Removing Turbine Shaft Seal Ring

2. Through the access hole in the retarder rotor, flatten the end of lockstrip 15 (B, Foldout 6) and remove two bolts 14 and lockstrip 1 5 which secure pitot tube 23. The pitot tube will drop into the pitot collector ring.
3. Turn the retarder housing so that the assembly rests on the front of the turbine output shaft (Figure 15-61). Remove the hook-type seal ring from the turbine output shaft. Remove the snap ring. Remove, as a unit, the splitter planetary carrier assembly and splitter-direct clutch hub.

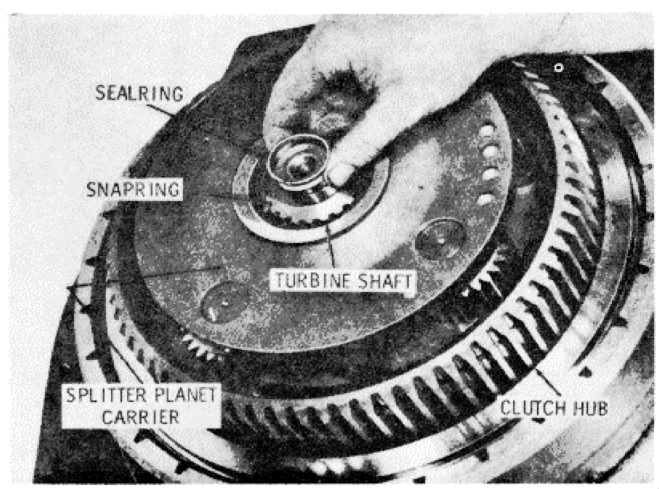


Figure 15-61. Removing Hook-Type Seal Ring from Rear of Turbine Shaft

4. Place the planetary and hub assembly so the hub rests on wood blocks (Figure 15-62). Place the pressing tool against the hub of the carrier assembly. Press the carrier out of the splitter sun gear bearing.

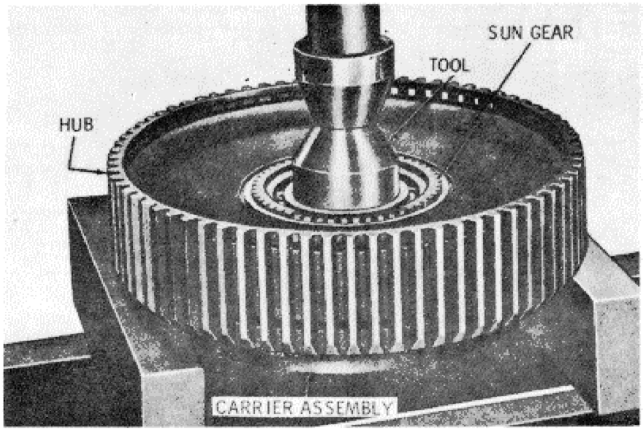


Figure 15-62. Pressing Splitter Carrier Assembly from Splitter Sun Gear Bearings

5. Attach one strand of the lifting sling to the retarder housing (Figure 15-63). Support the housing in a vertical position and remove the splitter-direct clutch and drum assembly from the turbine output shaft. Take the loose pitot tube from the oil collector ring.

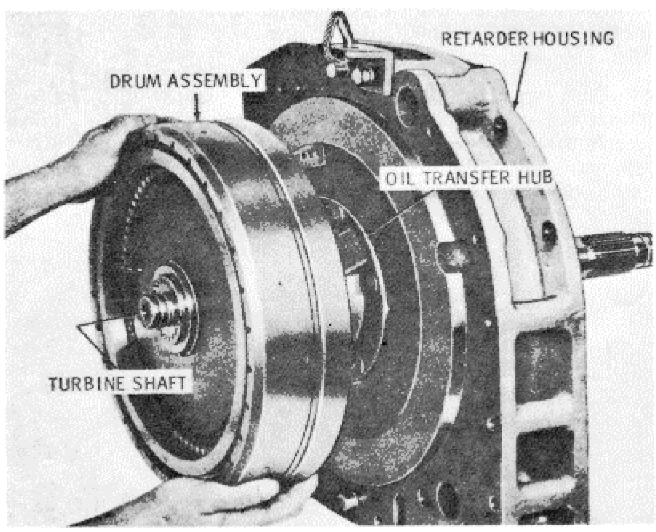


Figure 15-63. Removing Splitter-Direct Clutch and Drum Assembly

6. Support the front of retarder housing assembly 18 (B, Foldout 6) and press shaft 5 and retarder rotor 12, as an assembly, out of bearing 25. Remove splined washer 13.

7. Turn housing assembly 18 over and remove five bolts 28 and lockwashers 27. Remove oil transfer hub 26. Remove bearing 25. If present, remove seal ring 3 from the output shaft.

8. If retarder rotor 12, or shaft 5 requires replacement, remove snap ring 11, support the rear of rotor 12 hub and press shaft 5 out.

REMOVAL OF TRANSMISSION OUTPUT COMPONENTS. Remove output components as follows:

1. Remove the snap ring which retains the splitter ring gear hub to the splitter output shaft (Figure 15-64).

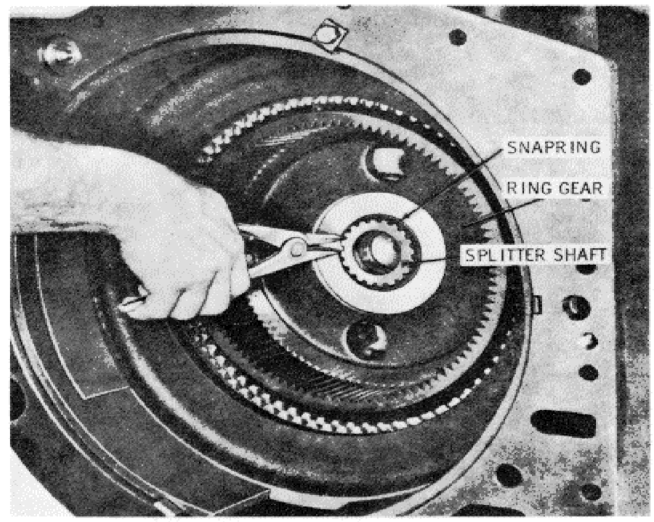


Figure 15-64. Removing Spliter Output Shaft Snap Ring

2. Attach a two-strand lifting sling to the output drive housing (Figure 15-65).

3. Remove bolts 12 (A, Foldout 12) and lockwashers 11 from bearing retainer assembly 13 and remove the bearing retainer. Remove and discard gasket 7. Using a bearing puller, remove bearing 10 (Figure 15-66). Remove speedometer cover 31, gasket 28 and speedometer drive gear 24. If necessary, press gear 26 from gear 25.

4. Remove twenty-seven bolts and lockwashers that secure the output drive housing to the transmission main housing. Remove bolts 9 and 20 (A, Foldout 12) and lockwashers 8 and 19. Using a lifting sling (Figure 15-67), remove output housing 2 and attached parts. If the reverse planetary starts to raise with the housing, pry the ring gear away from the housing. Remove and discard gasket 1.

REMOVAL OF RANGE PLANETARIES, CLUTCHES AND RELATED PARTS FROM TRANSMISSION MAIN-HOUSING OUTPUT END. Remove range planetaries as follows:

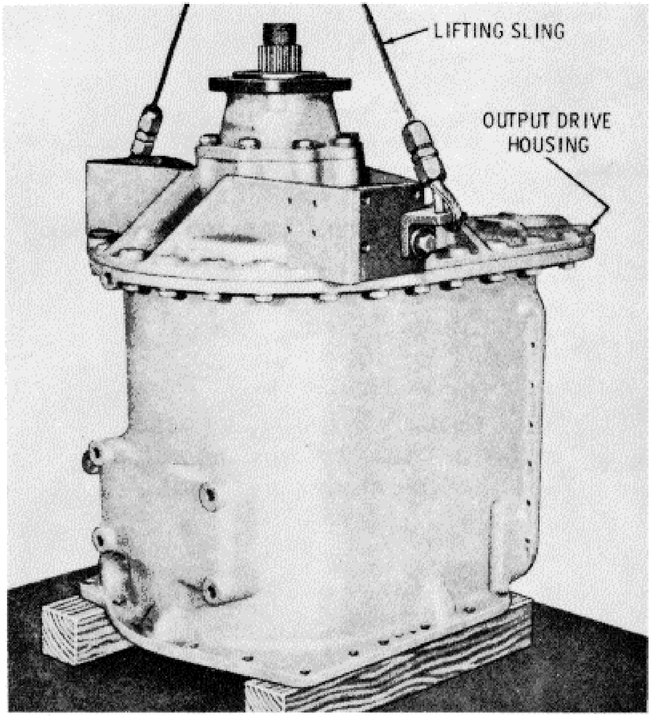


Figure 15-65. Positioning Transmission for Removal of Rear Components

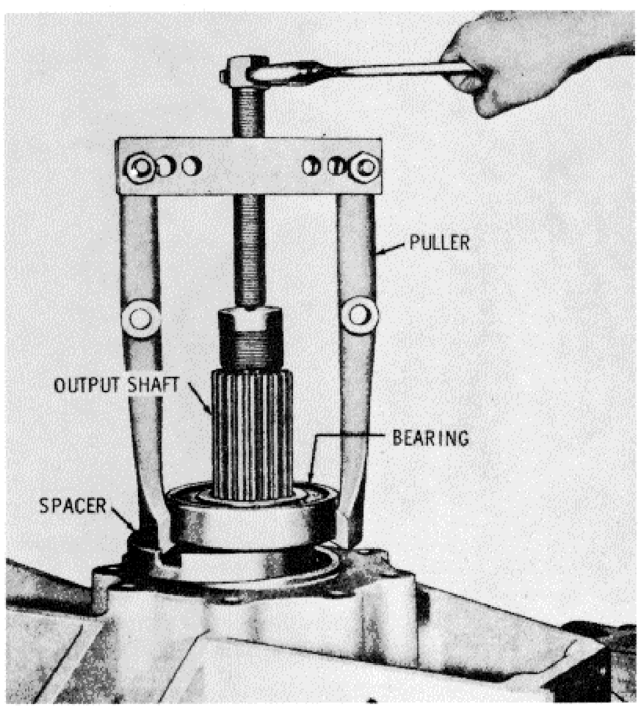


Figure 15-66. Removing Bearing from Output Shaft

1. Remove the reverse-clutch piston return springs from the transmission (Figure 15-67).

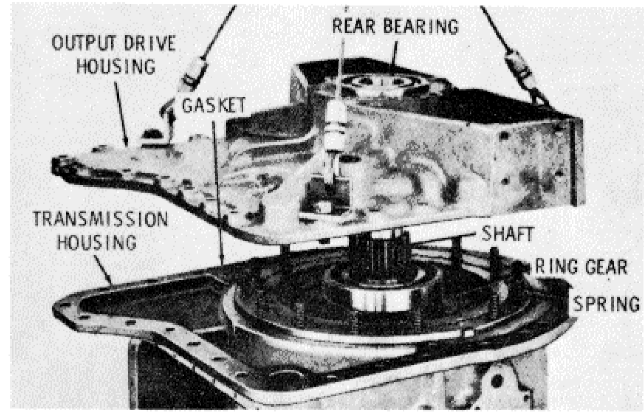


Figure 15-67. Removing Output Drive Housing from Transmission Housing

2. Grasp the reverse planetary carrier bearing and remove the bearing and the reverse planetary carrier and ring gear, as a unit, from the output shaft (Figure 15-68). Remove the bronze thrust washer from the reverse sun gear (or from the underside of the carrier assembly).

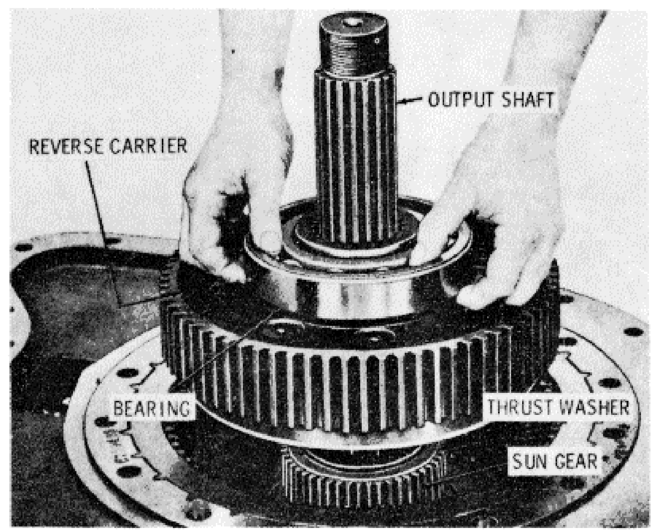


Figure 15-68. Removing Reverse-Gear Planetary Carrier and Bearing

3. Remove five external and five internal-splined, reverse gear clutch plates from the reverse-clutch anchor (Figure 15-69). Remove the reverse-gear clutch anchor. Remove two keys from the transmission housing.

4. Remove the reverse-gear sun gear from the hub of the low-range planetary carrier (Figure 15-70). Remove the bronze thrust washer.

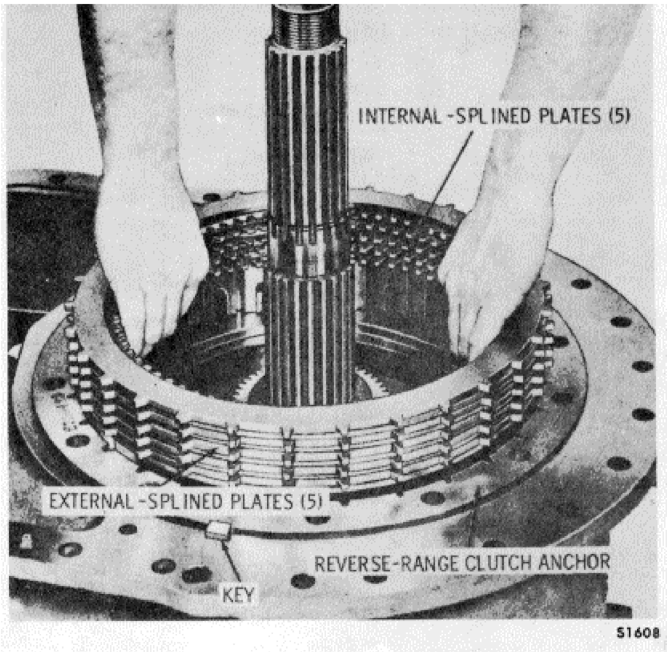


Figure 15-69. Removing Reverse-Gear Clutch Plates

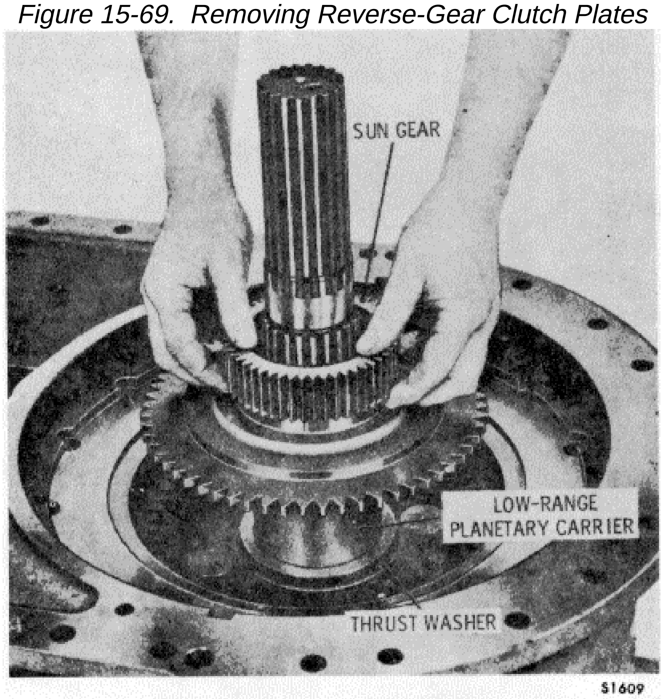


Figure 15-70. Removing Reverse-Gear Sun Gear

5. Remove the low-range planetary carrier assembly and transmission output shaft, as a unit, from the transmission (Figure 15-71). Remove the output shaft from the carrier assembly.

6. If present, flatten the ends of each of the four lockstrips (Figure 15-72). Remove eight self-locking bolts. Remove

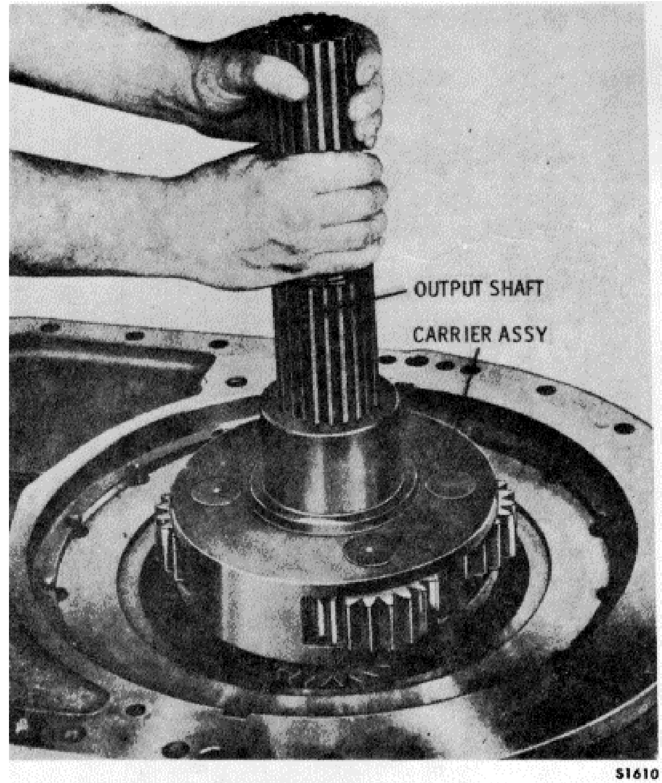


Figure 15-71. Removing Output Shaft and Low-Range Planetary Carrier Assembly

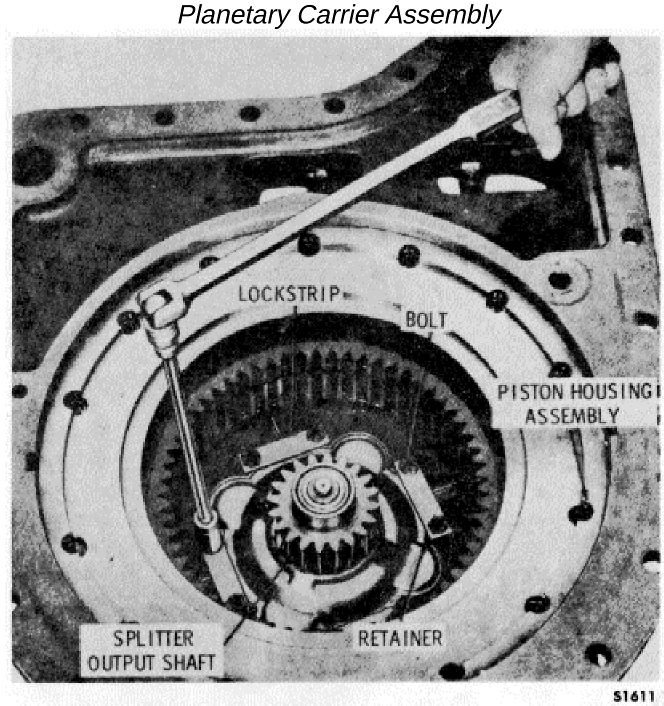


Figure 15-72. Removing Splitter Output Shaft Retainer Bolts

four lockstrips (if present) and discard them. (Lockstrips should not be used at this location at rebuild.) Remove four retainers. Remove the first-and-second-gear clutch piston and piston housing assembly. Remove piston 24 (A, Foldout 11) from housing assembly 26. Remove seal rings 23 and 25. Remove pins 28 from housing 27 only if replacement is necessary.

7. Remove fourteen first-and-second-gear clutch piston return springs (Figure 15-73). Remove the low-range ring gear. Remove the eight first-and-second-gear clutch plates. Remove the first-and-second-gear clutch anchor.

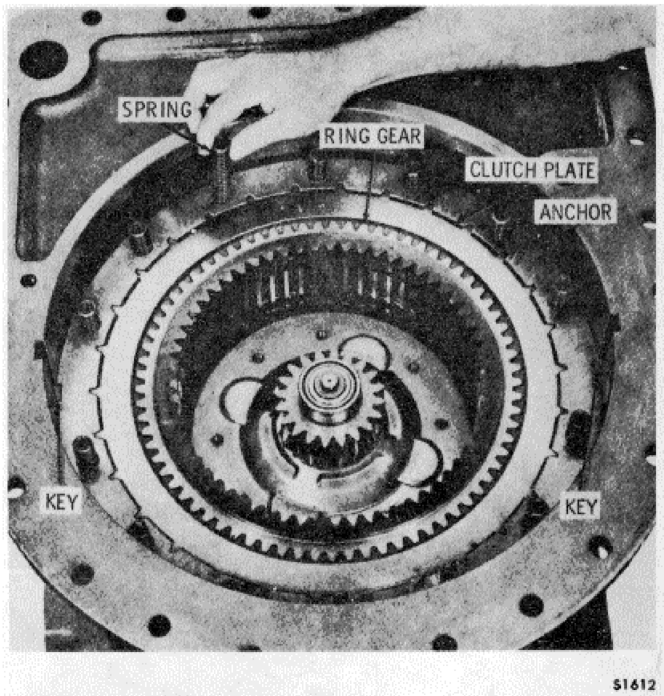


Figure 15-73. Removing First-and-Second-Gear Clutch Piston Return Springs.

8. Remove the third-and-fourth-gear clutch piston and piston housing assembly (Figure 15-74) and two anchor keys. Remove piston 22 (B, Foldout 10) from housing assembly 24. Remove seal rings 21 and 23. Remove pins 26 from housing only if replacement is necessary. Remove fourteen third-and-fourth-gear piston return springs. Remove the third-and-fourth-gear clutch anchor.

9. Remove third-and-fourth-gear clutch plates (Figure 15-75).

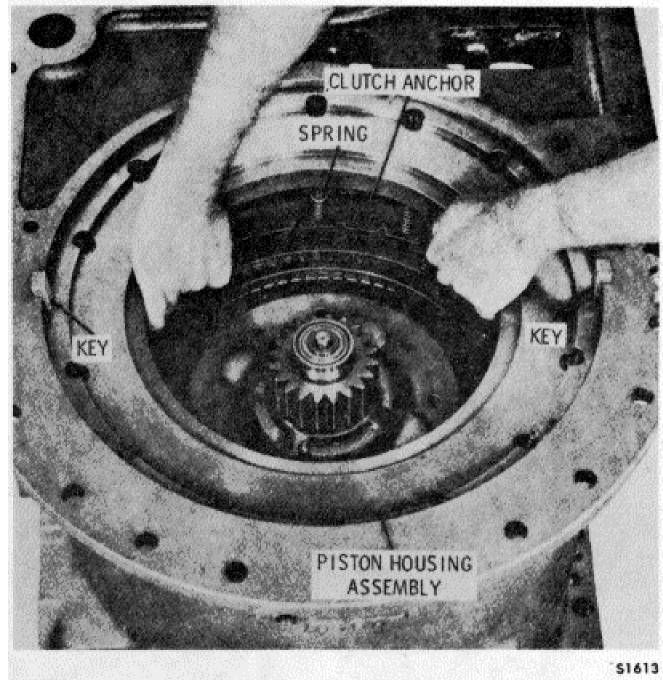


Figure 15-74. Removing Third-and-Fourth-Gear Clutch Piston Housing and Piston

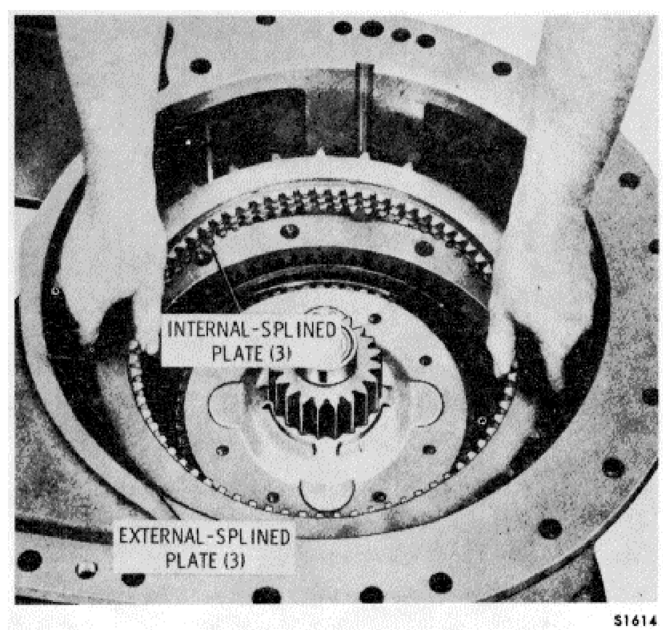


Figure 15-75. Removing Third-and-Fourth-Gear Clutch Plates.

10. Remove the intermediate-range ring gear (Figure 15-76).

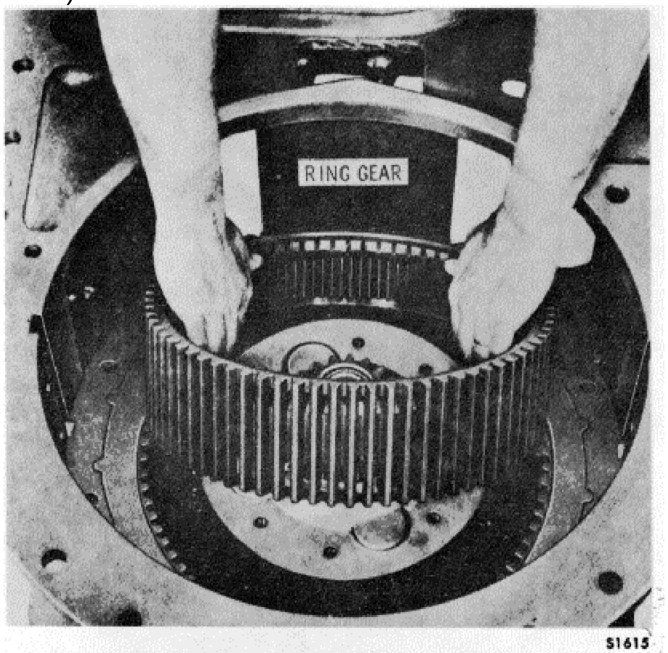


Figure 15-76. Removing Intermediate-Range Ring Gear

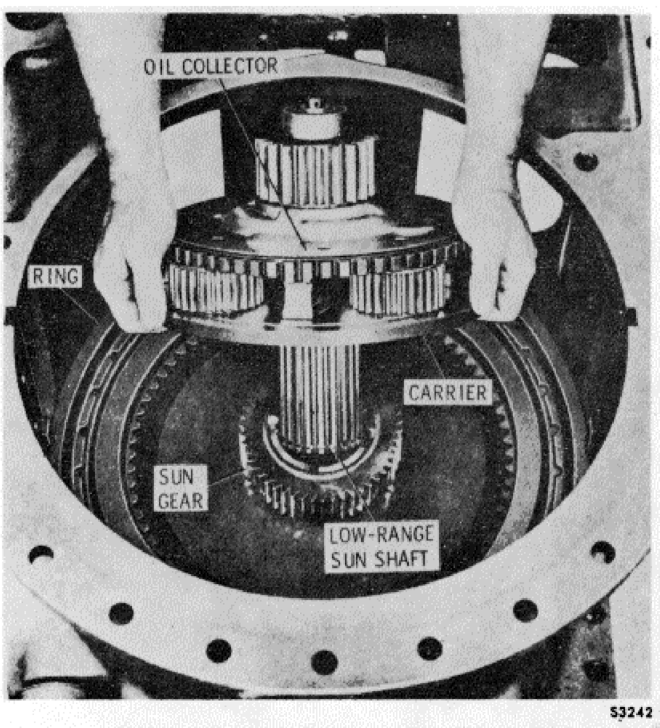


Figure 15-77. Removing Intermediate-Range Carrier Assembly and Components

11. Remove as a unit, intermediate-range carrier assembly, two splitter shaft bearings, oil collector ring and splitter shaft (Figure 15-77). Remove the shaft as shown in Figure 15-78. Remove the seal ring from the intermediate-range carrier assembly.

12. Remove the intermediate-range sun gear. Remove the third-and-fourth-gear clutch backplate.

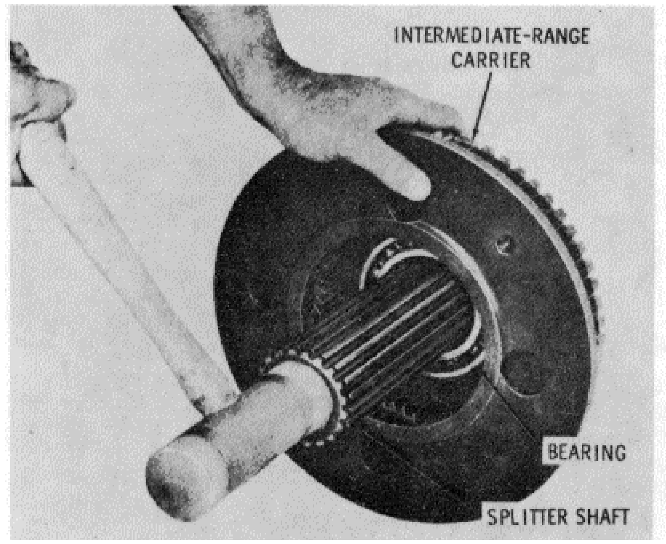


Figure 15-78. Removing Splitter Output Shaft Assembly from Intermediate Range Carrier

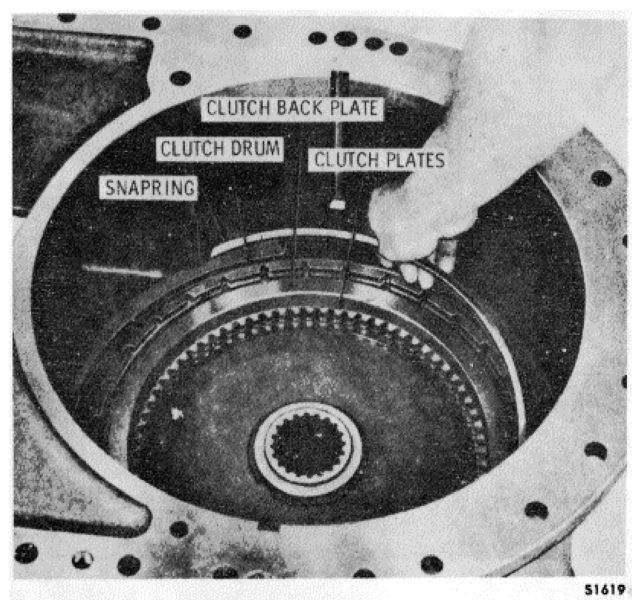


Figure 15-79. Removing Fifth-and-Sixth-Gear Clutch Backplate Snap Ring

13. Remove the large internal snap ring from the fifth- and sixth-gear clutch drum (Figure 15-79). Remove the fifth and-sixth-gear clutch backplate and five clutch plates from the clutch drum.

14. Reinstall the fifth-and-sixth-gear clutch backplate (Figure 15-80) and snap ring into the fifth-and-sixth-gear clutch drum. Lift out the drum and related parts by shouldering the backplate against the snap ring. Remove the snap ring and backplate.

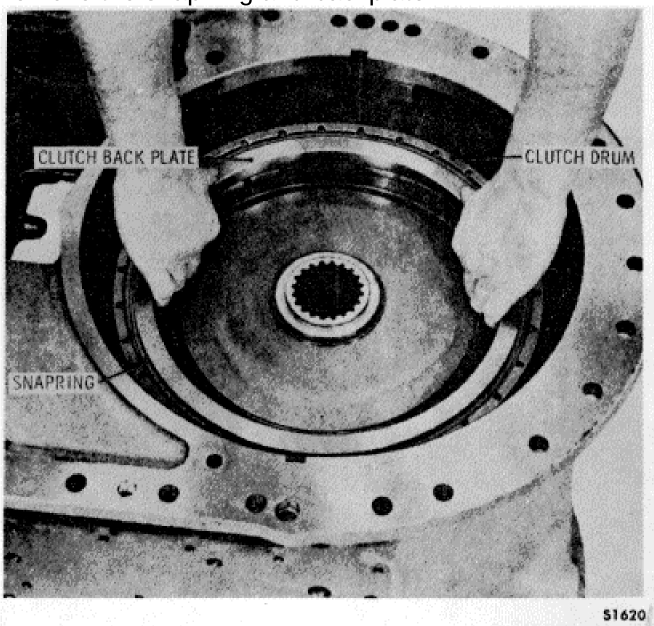


Figure 15-80. Removing Fifth-and-Sixth-Gear Clutch and Drum Assembly

15. Remove two clutch anchor keys from the transmission housing key guides (Figure 15-81).

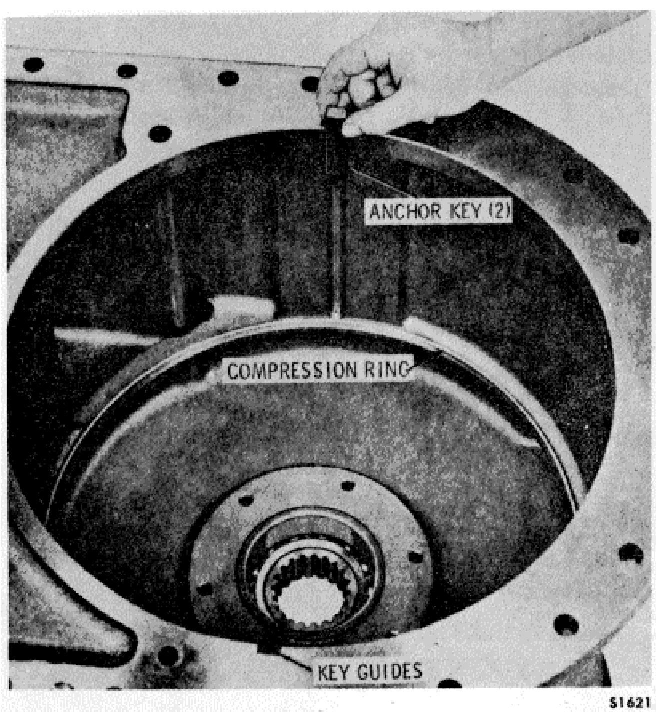


Figure 15-81. Removing Clutch Anchor Keys

REMOVAL OF SPLITTER CLUTCH AND RELATED PARTS. Remove splitter clutch as follows:

1. Turn the transmission housing assembly over, front end up, and rest it on wood blocks. Remove two bolts and retainers that secure the splitter-overdrive clutch backplate spacer (Figure 15-82). Remove the spacer and the splitter overdrive clutch backplate.

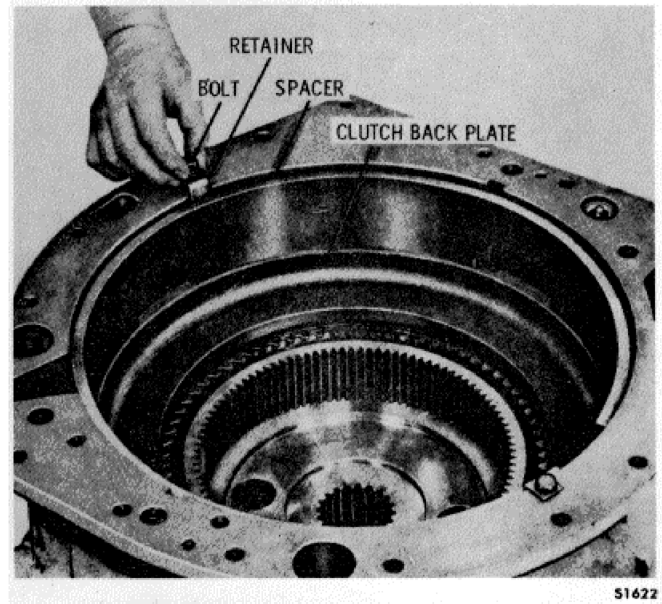


Figure 15-82. Removing Splitter-Overdrive Clutch Backplate Spacer Retainers

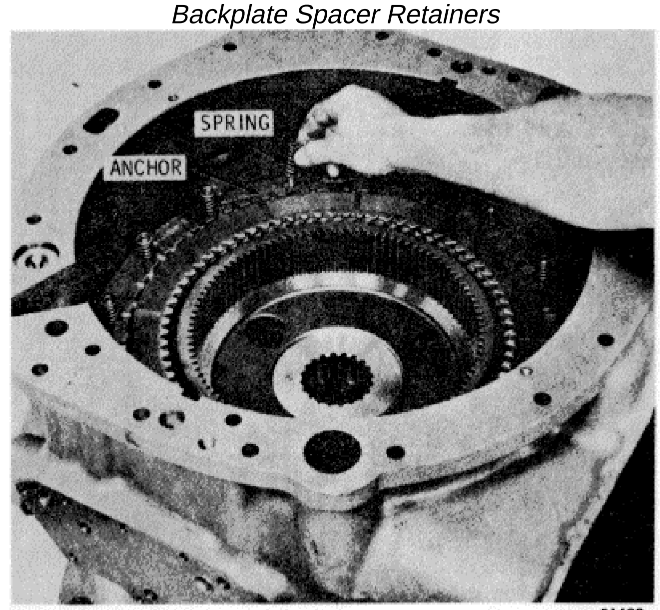


Figure 15-83. Removing Splitter-Overdrive Clutch Piston Return Springs

2. Remove fourteen splitter-overdrive clutch piston return springs (Figure 15-83) from the splitter-overdrive clutch anchor.

3. Remove the splitter-overdrive clutch anchor (Figure 1584) from the housing.

4. Remove four splitter-overdrive clutch plates.

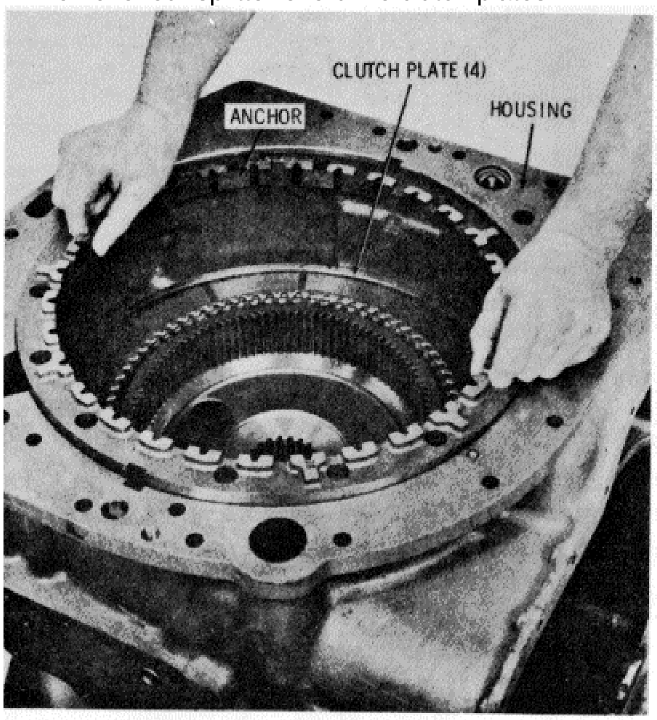


Figure 15-84. Removing Splitter-Overdrive Clutch Anchor

5. Through access holes provided in the splitter ring gear hub, remove six bolts and lockwashers that secure the ring gear hub bearing retainer to the transmission housing (Figure 15-85).

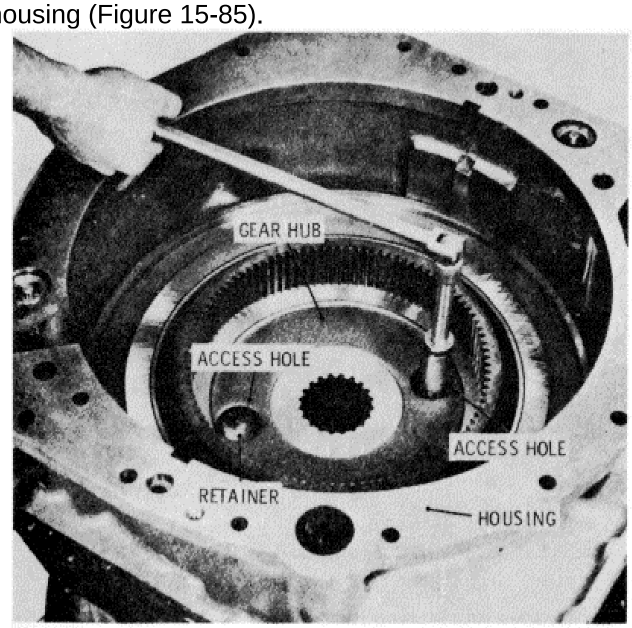


Figure 15-85. Removing Splitter Ring Gear Hub Bearing Retainer Bolts

6. Remove, as a unit, the splitter ring gear, hub, bearing, and bearing retainer (Figure 15-86). Remove snap ring 14 (A, Foldout 8) to separate ring gear 11 from hub 13. Remove retainer 27 (B, Foldout 8), and bearing 26 from hub 13 (A, Foldout 8).

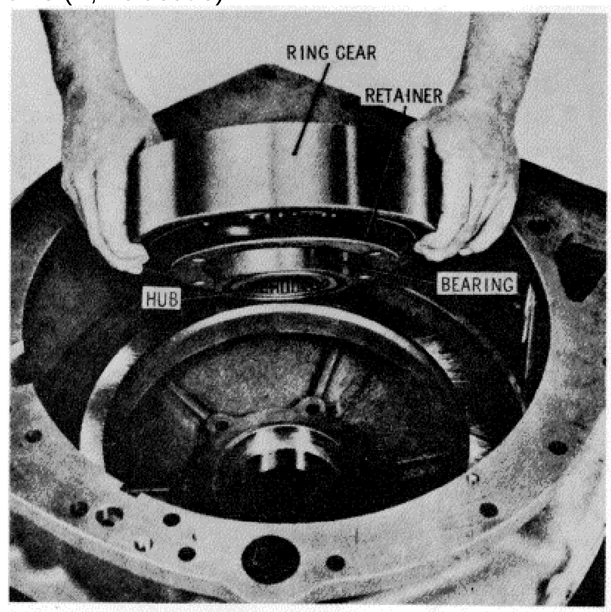


Figure 15-86. Removing Splitter Ring Gear and Attached Parts

7. Remove two clutch anchor keys. Remove, as a unit, the splitter-overdrive clutch piston and housing. Turn splitter overdrive piston housing 26 (A, Foldout 8) with the piston downward and bump the housing on the work table to remove splitter-overdrive piston 22. Remove seal rings 23 and 24. Refer to page 15-74 for rebuild instructions for the transmission main housing assembly.

REMOVAL OF VALVE BODY

Main Control Valve Body Assembly (Figure 15-87). Remove valve body assembly as follows:

1. Remove eleven bolts A and lockwashers.
2. Remove nine bolts B and lockwashers.
3. Remove twelve bolts C and lockwashers.
4. Remove two bolts D and lockwashers while supporting the valve body.
5. Remove valve body G, gasket H, separator plate I, and gasket J. Discard the gaskets.

Oil Transfer Plate (Figure 15-87). Remove oil transfer plate as follows:
1. Remove three bolts F and lockwashers.
2. Remove two bolts E and flat washers.
3. Remove oil transfer plate K and gasket L Discard the gasket.

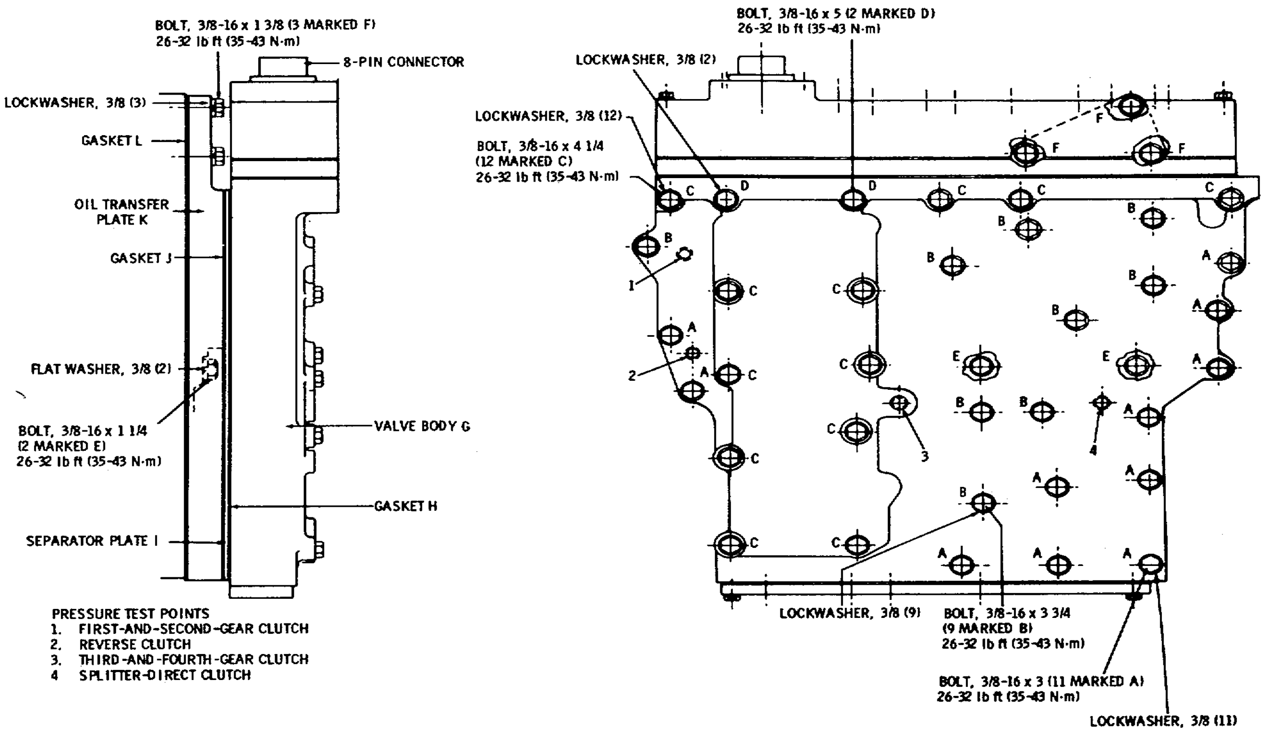


Figure 15-87. Electric Valve Body Components and Mounting Bolts

REBUILD OF SUBASSEMBLIES
GENERAL
This material describes the disassembly and assembly of the subassemblies which were removed. The rebuild procedures refer to photographs and to exploded-view foldouts in the back of this manual.

HYDRAULIC RETARDER CONTROL
VALVE BODY ASSEMBLY

DISASSEMBLY. Disassemble the retarder control valve assembly as follows (see A, Foldout 7):

1. Remove six bolts 15 and lockwashers 14 from the end of valve body 7. Remove cover 13. Remove and discard gasket 13. Remove spring 10.
2. Remove retarder-control valve 9.
3. Remove snap ring 11, and oil transfer tube 8. If a spring and valve are present, they may be removed and discarded. They are not needed.
4. If necessary for parts replacement, remove oil seal and scraper assembly 5 by collapsing it. Remove snap ring 6.
5. If present, remove plug 16.

ASSEMBLY. Assemble the retarder control valve body as follows (see A, Foldout 7):

1. If oil seal and scraper assembly 5 was removed, install snap ring 6 into valve body 7. Assembly 5 consists of two parts-oil seal and scraper. The oil seal is installed first, followed by the scraper.
2. Install the oil seal part of assembly 5, spring-loaded lip first. When it is seated, install the scraper, flat side first, and press it against the oil seal.
3. Install retarder control valve 9, linkage end first, into the bottom of valve body 7. Work the linkage end of the valve carefully through the oil seal and scraper assembly 5. Install spring 10.
4. Install oil transfer tube 8. Retain tube 8 with snap ring 11.
5. Install a new gasket 12 and cover 13 onto valve body 7. Secure the cover with six 3/8-16 x 1 inch bolts 15 and lockwashers 14. Tighten the bolts to 26-32 lb ft (36-43 N.m).
6. Install plug 16. Tighten the plug sufficiently to prevent leakage.

OIL FILTERS, BASE ASSEMBLY

DISASSEMBLY. Disassemble oil filter base as follows (see B, Foldout 5):

1. Remove plug 28 from filter base 32. Remove and discard gasket 29.

2. Remove spring 30 and filter bypass valve 31 from filter base 32.
3. Remove oil signal switch plug 26, gasket 37, and seal ring 36 from filter base 32. Remove plugs 33 and 35.
4. Loosen, but do not remove, center studs 48 from shells 46.
5. Remove shells 46 and related parts from filter base 32. Remove seal rings 39.
6. Remove and discard filter elements 38 from shells 46.
7. Remove snap rings 41 from studs 48.
8. Remove retainers 42, seals 43, washers 44, and springs 45.
9. Remove studs 48. Remove and discard gaskets 47.
10. Do not remove base plates 34 with screws. Do not remove plugs 49.

ASSEMBLY. Assemble the oil filter base as follows (see B, Foldout 5):
1. Install new gasket 47 onto studs 48 and install the studs into shells 46.
2. Install springs 45, washers 44, seals 43, and retainers 42 onto studs 48.
3. Install snap rings 41 onto studs 48. Slide the snap rings down the studs until they engage in the snap ring grooves.
4. Install new filter elements 38 into shells 46. Install seal rings 39 into filter base 32.
5. Install shell assemblies 40 with filter elements 38 onto filter base 32. Tighten studs 48 to 45-55 lb ft (61-74 N.m).
6. Install seal ring 36, a new gasket 37 and oil signal switch 26 into filter base 32.
7. Install filter bypass valve 31, (large diameter end first) into filter base 32. Install spring 30 onto the stem of valve 31.
8. Install a new gasket 29 and plug 28 into filter base 32.
9. Install plugs 33 and 35.
10. Tighten all plugs sufficiently to prevent leakage.

MAIN-PRESSURE REGULATOR
VALVE BODY ASSEMBLY

DISASSEMBLY. Disassemble main-pressure regulator body as follows (see B, Foldout 5):
1. Remove plug 21, from valve body 14. Remove and discard gasket 20.
2. Remove booster plug 19, shims 18 and spring 17.
3. Remove setscrew 22.
4. Remove stop 16 and valve 15 from valve body 14.
5. Remove plug 13, if replacement is necessary.
6. Inspect check valve 23 for leakage by pouring solvent into the valve bore in body 14, on the valve. If there is evidence of leakage after 15 seconds, remove the valve and discard it.

ASSEMBLY. Assemble main-pressure regulator body as follows (see B, Foldout 5):
1. If check valve 23 was removed, install a new valve, spring side first, into body 14.
2. Install plug 13.
3. Install main-pressure regulator valve 15 (smaller diameter end first) into valve body 14.
4. Install stop 16, the drilled hole in the stop toward the outer end of the valve bore. Align the hole in the stop with the hole in valve body 14 for installation of setscrew 22.
5. Install setscrew 22 and tighten it to 36-60 lb in. (4.076.78 N.m).
6. Install spring 17, shims 18, and booster plug 19 (open end first) into valve body 14. Adjust main-pressure as explained on page 15-24.
7. Install a new gasket 20 and plug 21.
8. Tighten all plugs sufficiently to prevent leakage.

LOCKUP CLUTCH CONTROL VALVE ASSEMBLY

DISASSEMBLY. Disassemble clutch control valve as follows (see A, Foldout 6):

1. Clean the area around pressure switch 20. Remove the switch by rotating it counterclockwise.
2. Using a drift, remove two spring pins 17 from valve body 7.
3. Remove lockup shift valve plug 12, and spring 11. (If two springs are present, discard one.) Remove washer 10 (if present), shim(s) 9, and lockup shift valve 8.
4. Remove seal ring 13 from plug 12.
5. Remove plug 15 and flow valve 16. Remove seal ring 14 from plug 15.
6. Pry out check valve 18 if replacement is necessary.
7. Remove plugs 19 (if present).

ASSEMBLY. Assemble clutch control valve as follows (see A, Foldout 6):

1. Install lockup shift valve 8 (larger diameter end first) into valve body 7. Install shim(s) 9, washer 10 (if required), and spring 11.

NOTE

Adding a shim will raise the lockup speed approximately 20 rpm; removing a shim will lower the lockup speed the same amount.

2. Install seal ring 13 onto plug 1 2 and install the plug into valve body 7.
3. Compress spring 11 and install a pin 17 into body 7. Position the end of the pin 0.03-0.06 in. (0.76-1.52 mm) below the machined surface of the valve body.
4. Install flow valve 16 (longer land first) into body 7.
5. Install seal ring 14 onto plug 15 and install the plug (smooth end out) into body 7.

6. Install a pin 17 into body 7. Position the end of the pin 0.03-0.06 in. (0.76-1.52 mm) below the machined surface of the valve body.
7. If removed, press a new check valve 18 (flatter side first) into body 7, seating it lightly in its bore.
8. If removed, install plugs 1 9.
9. Tighten all plugs sufficiently to prevent leakage.
10. If removed, install pressure switch 20.

CONTROL VALVE BODY ASSEMBLY

DISASSEMBLY. Disassemble control valve body as follows (see B, Foldout 9):

NOTE

Cover and plate assembly 10 is spring loaded and must be restrained while the bolts are being removed.

1. Remove four bolts 75, lockwashers 76, and guard 77 if present. Remove fourteen bolts 74 and lockwashers 73.
2. Remove solenoid cover and plate assembly 10. Remove and discard gasket 18.
3. Remove two screws 14 and carefully lift cover 13 until the solenoid leads and ground wire are accessible.
4. Remove one bolt 17, washer 16, and the ground wire terminal. Remove seven wiring harness leads from the solenoid leads. Remove the cover and gasket 11.
5. Do not remove wiring harness 12 from cover 13 unless necessary.
6. Remove the remaining thirteen bolts 17, lockwashers 16, seven solenoids 78.

CAUTION

The valve body assembly contains springs and other parts, some of which are similar and can be mistakenly interchanged. If parts are not reinstalled in the same locations from which they were removed, the calibration of valve body functions will be lost. Tag each part, at removal with its item number in B, Foldout 9, to simplify correct reassembly of valve body components.

7. From the bores in valve body 36, remove steel balls 33, regulator valve spring 19, regulator valve 20, splitter shift valve 21, shift valve spring 22, outer spring 25, inner spring 24, priority valve 23, fifth-and-sixth-gear shift valve 26, shift valve spring 27, third-and-fourth-gear shift valve 29, shift valve spring 34, first-and-second-gear shift valve 30, shift valve spring 31, reverse-gear shift valve 32, and shift valve spring 34.

NOTE

Cover 52 is spring-loaded and must be restrained while the bolts are being removed.

8. Position the valve body, top downward, and remove fourteen bolts 54 and lockwashers 53.

9. Remove cover 52. Remove and discard gasket 51.

10. From the bores in valve body 36, remove stop 50, outer spring 49, inner spring 48, splitter-direct trimmer lower valve 47, spring 46, and splitter-direct trimmer upper valve 45; stop 60, outer spring 59, inner spring 58, third-and fourth-gear trimmer lower valve 57, spring 56, and third and-fourth-gear trimmer upper valve 55; stop 61, outer spring 62, inner spring 63, first-and-second-gear trimmer lower valve 64, spring 65, and first-and-second-gear trimmer upper valve 66; stop 72, outer spring 71, inner spring 70, reverse trimmer lower valve 69, spring 68, and reverse trimmer upper valve 67.

11. Remove four plugs 37 from valve body 36. Remove plug 40 and screen assembly 41. Do not attempt to remove five orifice plugs 38.

12. Remove pin 44, check valve 43 or spring 42 from valve body 36.

13. To ensure the complete removal of dirt and debris from internal oil passages, remove plug 39 from valve body 36. Direct air under pressure into the plug hole to clean the passageway thoroughly.

ASSEMBLY. Assemble the control valve body as follows (see B, Foldout 9):

NOTE

A repair kit with instructions, is available for repair of wiring in the control valve assembly.

1. Inspect the solenoid plate and control valve body for wear at the passages shown in Figure 15-88. If battering or distortion is found, the solenoid plate should be replaced. The replacement plate should conform to the configuration in Figure 15-88. Any extrusion of metal at the valve body should be honed flat, using a flat stone. Remove any honing debris.

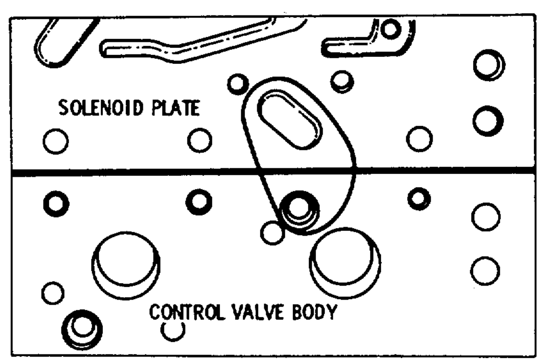


Figure 15-88. Inspection for Battering of the Solenoid Plate and Control Valve Body.

2. Install a new 1/8 inch pipe plug 39 (B, Foldout 9).

3. Solenoid E (Figure 15-89) should always be mounted as shown. Turning this solenoid end-for-end may partially close the passageway under the solenoid and increase the time required to exhaust solenoid regulated pressure from the top of the shift valve, giving erratic shift quality.

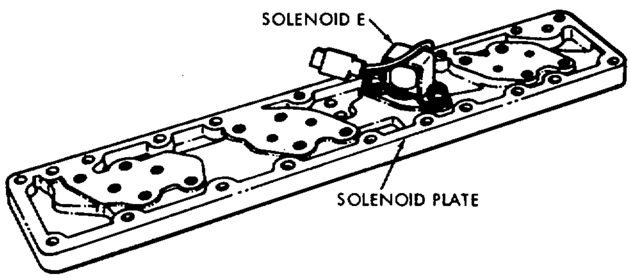


Figure 15-89. Location of Solenoid "E"

4. Install seven solenoids 78(B, Foldout 9), and retain them with thirteen bolts 17 and lockwashers 16. Leave one bolt 17 and lockwasher 16 out of solenoid A(Figure 15-90) until the ground wire terminal is installed. Refer to step 9.

5. Tighten the bolts in six solenoids and one bolt in solenoid A to 9-11 lb ft (12.2-14.9 N.m). Leave the remaining bolt (in solenoid A) untightened.

6. Install gasket 11 (B, Foldout 9) onto plate 15.

7. If wiring harness 12 was removed, install it into cover 13. Index its pin in the hole in the cover and tighten the retaining nut to 30-35 lb ft (41-47 N.m).

8. Place cover 13 into position near plate 15 and connect the wiring harness ground terminal by installing the remaining bolt 1 7 and lockwasher 16 into solenoid A (Figure 15-90). Tighten the bolt to 9-11 lb ft (12.2-14.9 N.m).

9. Connect the seven wiring harness leads to the seven solenoid leads as shown in Figure 15-90. Recheck the lead connections to ensure they are correct. Bind each of the seven leads to the solenoids, using elastic rings (B, Foldout 9).

10. Install cover 13 onto gasket 11 and plate 15. Be certain no leads are pinched between the cover and plate. The weight of the cover should close the gap between the gasket and cover *no force is required.* Retain the cover with two 10-24 x 1 inch flathead screws 14. Tighten the screws to 24-36 lb in (2.71-4.07 N.m).

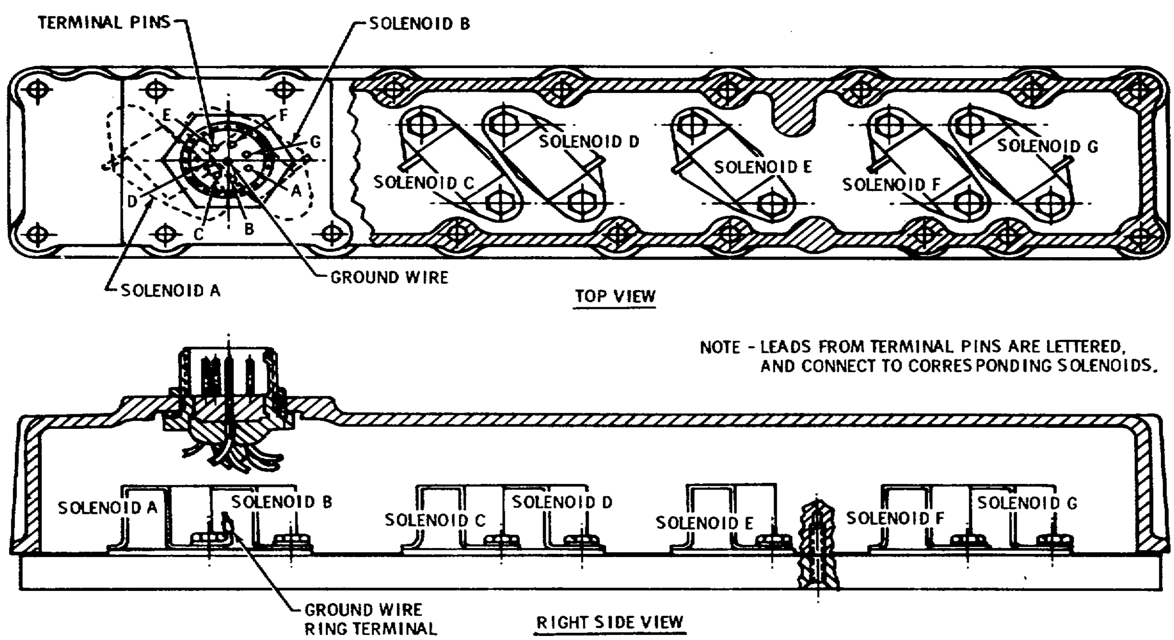


Figure 15-90. Main Valve body Solenoid electrical Connections-Cutaway View

NOTE

Check the position of all components, configuration of all valves and plugs, and identification of all springs before installation. Refer to B, Foldout 9, and to the spring chart later in this Section. All valves, when dry, should move freely by their own weight in their bores.

11. Position valve body 36 (B, Foldout 9) upright.

12. Install reverse-shift valve spring 34 and valve 32 into bore A (Figure 15-91).

13. Install first-and-second-gear shift valve spring 31 (B, Foldout 9) and valve 30 into bore B (Figure 15-91).

14. Install third-and-fourth-gear shift valve spring 28 (B, Foldout 9) and valve 29 into bore C (Figure 15-91).

15. Install fifth-and-sixth-gear shift valve spring 27 (B, Foldout 9) and valve 26 into bore D (Figure 15-91).

16. Install priority valve 23, outer spring 25, and inner spring 24 into bore E (Figure 15-91).

17. Install splitter shift valve spring 22 and valve 21 into bore F (Figure 15-91).

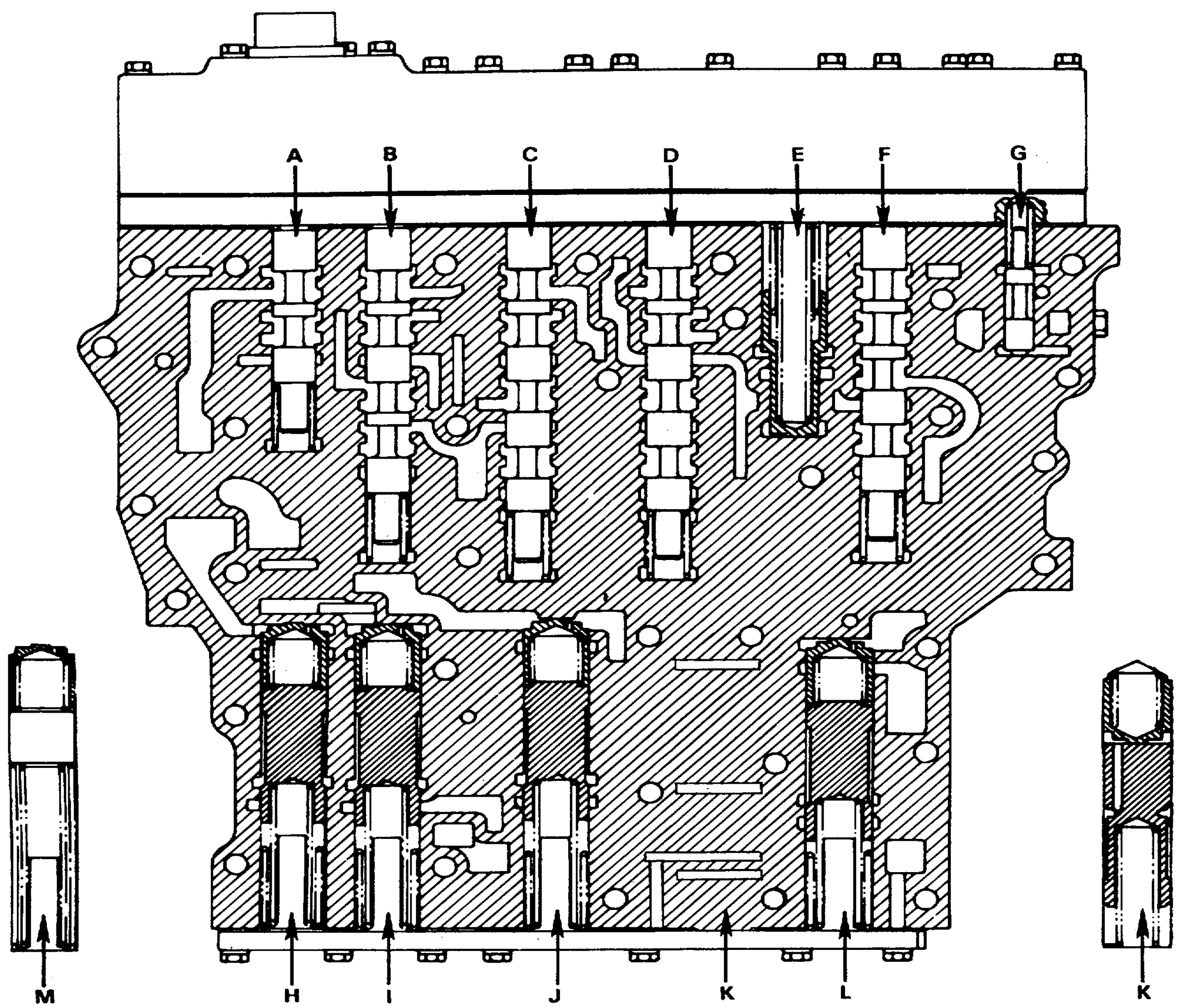


Figure 15-91. Valve Body, with Components Installed in Each Bore

18. Install solenoid pressure regulator valve 20 and spring 19 into bore G (Figure 15-91).

19. Install two steel balls 36 (B, Foldout 9), gasket 18, and cover and plate assembly 10. Headless 1/4-20 guide bolts installed into valve body 36 will aid in this assembly.

CAUTION

Do not damage the threads and contact pins of the electrical connector.

20. Install guard 77 and four 1/4-20 x 4-1/4 inch bolts 75 and lock-washers 76. Install fourteen 1/4-20 x 3-1 /4 inch bolts 74 and lockwashers 73. Tighten the eighteen bolts evenly to 9-11 lb ft (12.2-14.9 N.m).

21. Place the valve body in an inverted position.

22. Install reverse trimmer upper valve 67 (B, Foldout 9) into bore H (Figure 15-91). Into the same bore, install spring 68, reverse trimmer lower valve 69, outer spring 71, inner spring 70, and stop 72.

23. Install first-and-second-gear trimmer upper valve 66 into bore I (Figure 15-91). Into the same bore, install spring 65 (B, Foldout 9), first-and-second-gear trimmer lower valve 64, outer spring 62, inner spring 63, and stop 61.

24. Install third-and-fourth-gear trimmer upper valve 55 into bore J (Figure 15-91). Into the same bore, install spring 56 (B, Foldout 9), third-and-fourth-gear trimmer lower valve 57, outer spring 59, inner spring 58, and stop 60.

25. Install splitter-direct trimmer upper valve 45 into bore L (Figure 15-91). Into the same bore, install spring 46 (B, Foldout 9) splitter-direct trimmer lower valve 47, outer spring 49, inner spring 48, and stop 50.

26. Install gasket 51 and cover 52. Headless 1/4-20guide bolts installed into valve body 36 will aid in this assembly.

27. Install fourteen 1/4-20 x 1 inch bolts 54 and lockwashers 53. Tighten the bolts evenly to 9-11 Ib. ft.(1 2.2-14.9 N.m).

28. Install four plugs 37 into valve body 36.

NOTE

Check the spring chart later in this section to determine the proper spring 42 to be installed.

29. Place valve 43, convex side first, onto pin 44. Install spring 42 onto the pin, against the concave side of valve 43.

30. Press pin 44, with valve and spring, into the pin bore in valve body 36. Press on the pin until the head of the pin is 0.340 inch (8.63 mm) above the mounting surface of the valve body.

31. Install screen assembly 41, open end first, into valve body 36. Retain it with plug 40.

32. Tighten all pipe plugs and orifice plugs sufficiently to prevent leakage.

INPUT PRESSURE, SCAVENGE OIL PUMP ASSEMBLY

DISASSEMBLY. Disassemble pump as follows (see A, Foldout 5).

1. Remove four bolts 12 and lockwashers 11. Remove scavenge pump body assembly 13. If needle bearings 15 require replacement, collapse the failed bearings and remove them from the pump body.

2. Remove scavenge pump gears 17 and remove and discard gasket 18. Remove needle roller 16 which serves as a drive key.

3. Remove plate assembly 19 and gasket 25 from the pump body. Remove dowel pins 20 and 22 if necessary. Discard the gasket. Check for end clearance and diametrical clearance of the pump gears, see page 15-42. Remove pump gears 23 and 24 (A, Foldout 5) from pump body assembly 26.

4. If necessary for parts replacement, press needle bearings 27 from pump body 28.

5. Remove six star tolerance rings 29 from pump body 28.

6. Be sure to remove all burrs and drill debris.

ASSEMBLY. Assemble pump as follows (see A, Foldout 5):

1. Install six star tolerance rings 29 into pump body 28.

2. If bearings 27 were removed, install new ones into the gear cavity side of pump body 28. Press against the numbered side of the bearing cage and press the bearings into their bores until they are 0.06-0.10 inch (1.52-2.54 mm) below surface.

3. Install oil pump drive gear 24 with the splined shaft toward the rear of the pump body. Install oil screen 30(large diameter first) into pump body 28.

4. Install driven gear 23 (splined shaft first) into pump body 28. Install a new gasket 25.

5. If dowel pins 20 and 22 were removed, press new pins 20 and 22 into plate 21. The pins should protrude 0.0180.020 inch (0.46-0.50 mm) on each side of the plate.

6. Install oil pump separator plate assembly 19 onto the pump body assembly 26.

7. Using oil-soluble grease, install needle bearing roller 16 into the groove in pump drive shaft 23.

8. Install scavenge pump gears 17 onto the shafts of gears 23 and 24. Install a new gasket 18 onto the plate assembly and install the plate assembly.

9. If bearings 15 were removed, press against the numbered side of the bearing cage and press new bearings into pump body 14 until theyareO.06-0.1 0 inch (1.52-2.54 mm) below surface.

10. Install scavenge pump body assembly 13 onto plate assembly 19 and secure it with four 3/8-16 x 2-1/4 inch bolts 1 2 and lockwashers 11. Tighten the bolts to 26-32 Ib. ft.(3543 N.m).

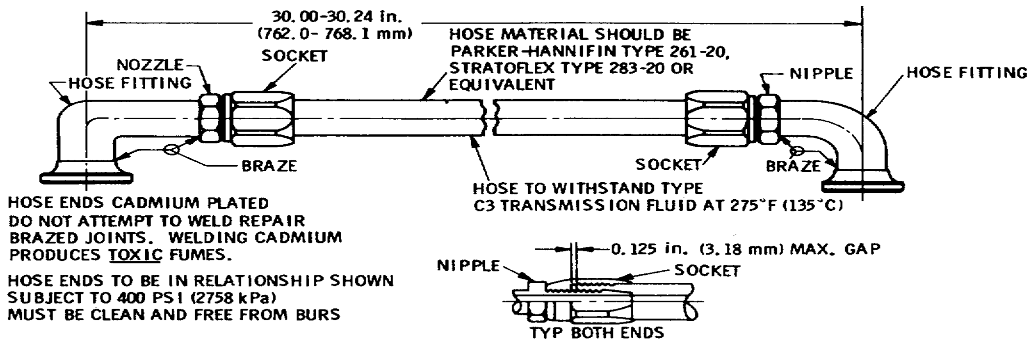


Figure 15-92. Main-Pressure Transfer Tube Assembly.

MAIN-PRESSURE TRANSFER TUBE ASSEMBLY

DISASSEMBLY. Remove the hose fittings at the ends of transfer tube 42 (B, Foldout 4) for replacement only.

ASSEMBLY. Assemble transfer tube as follows:

WARNING

Do NOT attempt to weld repair the brazed joints of the hose fittings (Figure 15-92). Welding the cadmium plated material produces toxic yellow-brown fumes which are extremely hazardous and can be fatal.

1. Cut the customer-supplied hose to 23.65 inch (600.7 mm).

2. Clamp the socket in a vise.

NOTE

Do not lubricate the OD of the hose.

3. Thread the hose counterclockwise into the socket until it bottoms. Back off 1/4 to 1/2 turn.

4. Grease nipple threads and the ID of the hose with oil soluble grease. Thread the nipple clockwise into the socket until it bottoms against the socket.

5. Repeat steps 2 through 4 for the other end of the hose.

6. Either end fitting may be backed out of the socket up to 1/2 turn to properly align the ends. For best results, *each* end fitting should be backed off one half the total required amount.

STATOR ASSEMBLY DISASSEMBLY (See A, Foldout 4). Place the stator and race assembly on its side on the work table. If not previously removed, turn the stator clockwise to free the roller race and remove the stator from the race. Remove twelve rollers 14, twelve cups 11, twelve springs 13, twelve needle rollers 12, and the remaining twelve cups 11 from the stator.

ASSEMBLY. Assemble stator as follows (see A, Foldout 4):

1. Place stator 10 on the work table with the leading edge (thicker part of vane) of the stator vane upward.

2. Install a spring 13 and needle roller 12 into a cup 11 and install a cup 11 onto the opposite end of the spring. Install these assembled parts into a bore in the side of a cam pocket (Figure 15-93). Repeat this procedure to install the remaining eleven roller spring assemblies.

3. Using tool J-23552 or a ring of steel stock which has a 1 1/4 inch (31.75 mm) slot, install twelve rollers 14 (A, Foldout 4) into the cam pockets (Figure 15-93). Use a screwdriver to compress the spring assembly during roller installation. Rotate the steel stock so the slot is opposite each cam pocket as the roller is installed. Leave the steel stock assembly tool and assembled stator in this position until ready for installation into the converter.

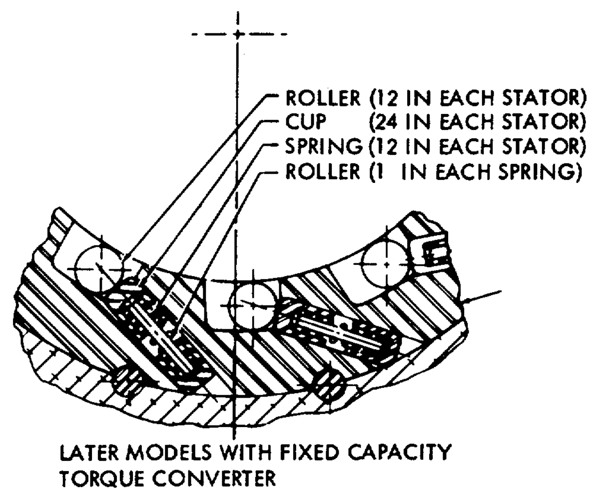


Figure 15-93. Arrangement of Stator Freewheel Components

4. Do not install race 9 at this time. The race will be installed at reassembly of the transmission.

CONVERTER PUMP ASSEMBLY

DISASSEMBLY. Disassemble the converter pump as follows (see A, Foldout 4):

1. Flatten the ends of lockstrips 17 and remove twelve bolts 16, six lockstrips 17, and retainer 18 from converter pum)p 20.

2. Tap ball bearing assembly 19 toward the front of pump 20, removing it from the pump and drive gear 23.

ASSEMBLY. Assemble the converter pump as follows (see A, Foldout 4):

1. Position drive gear 23, tapped holes upward, on the assembly table. Position converter pump 20 on the gear, and align their bolt holes.

2. Install bearing assembly 1 9, grooved end of outer race upward, into the pump bore. Tap the bearing assembly outer race until the bearing groove meets the hub surface of pump 20.

3. Install retainer 18, six lockstrips 17, and twelve bolts 16. Tighten the bolts to 33-40 lb ft (45-54 N.m). Bend the corners of the lockstrips against the bolt heads.

TORQUE CONVERTER HOUSING ASSEMBLY

DIASSEMBLY. Disassemble the torque converter as follows (see B, Foldout 4):

1. If converter ground sleeve 31 must be removed, place housing 9 on its rear surface and remove five bolts 32 and press the ground sleeve from its bore. Remove seal ring(s) 30 from the ground sleeve.

2. Remove four bolts 53 and lockwashers 54. Remove cover 55. Remove and discard gasket 56. Remove converter-in check valve, pin, spring, and seat (Figure 15-94). Remove the pin from the valve if replacement is necessary.

3. Remove oil pump suction tube 28. Remove seal rings 27 and 29 from the tube.

4. Remove plugs 10, 11, 14, 16,17, 18, 19 or 20, if necessary, for replacement or cleaning of oil passages. Remove dowel pins 12, 13 or 21 if replacement is necessary.

5. Do not remove bolt 1 (if present), but check it for tightness.

6. Orifice plug 51 replaces the output pump check valve components. Remove the plug only if necessary. Remove seal ring 52.

ASSEMBLY. Assemble torque converter as follows (see B, Foldout 4):

1. Place seal ring 52 in the housing bore, retaining it with oil-soluble grease. If dowel pins 12 were removed, press the new ones into their bores until they protrude 0.49-0.51 inch (12.44-12.95 mm) from the split line. If dowel pins 13 or 21 were removed, press the new ones into their bores until they protrude 0.43-0.45 inch (10.92-11.43 mm) above the split lines. Install pipe plugs 10, 11,14,16,17,18,19 or 20flush to below the surface of the housing and tighten them sufficiently to prevent leakage.

2. Install the converter-in check valve, pin, spring, and seat (Figure 15-94).

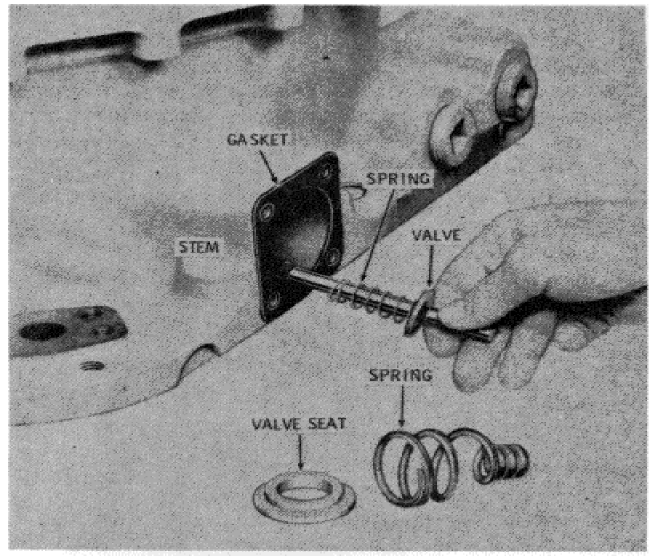


Figure 15-94. Removing Converter-In Check Valve

3. Install gasket 56, cover 55 and four 3/8-16 x 3/4 inch bolts 53 with lockwashers 54. Tighten the bolts evenly to 26-32 lb ft (36-43 N.m).

4. Install seal rings 27 and 29 onto tube 28. Install tube 28 into housing 9.

5. If converter ground sleeve 31 was removed, chill the ground sleeve in dry ice for at least an hour. Install two headless guide bolts into the rear of converter housing 9.

6. Using gloves, install the ground sleeve into the converter housing, using the guide bolts to index the bolt holes. Install seal ring(s) 30.

7. Install five 1/2-13 x 1-1/8 inch bolts 32 to retain the ground sleeve. Tighten the bolts to 81-97 lb ft (110-131 N.m).

HYDRAULIC RETARDER HOUSING ASSEMBLY

DISASSEMBLY. Disassemble hydraulic retarder as follows (see B, Foldout 6):

1. Remove plugs 20 and 21.

2. Remove dowel pins 22 only if replacement is necessary.

Remove seal ring 29.

ASSEMBLY. Assemble hydraulic retarder as follows (see B, Foldout 6):

1. If dowel pins 22 were removed, install two new pins, letting them project 0.49-0.51 inch (12.44-12.95 mm)from the rear of housing 19.

2. Install plugs 20 and 21 and tighten them sufficiently to prevent leakage.

3. Install seal ring 29. Retain the seal ring with oil-soluble grease.

SPLITTER PLANETARY CARRIER ASSEMBLY

DISASSEMBLY. Disassemble splitter planetary carrier as follows (see A, Foldout 8):

NOTE

The pinions in this planetary carrier assembly are a matched set. Therefore, failure of one pinion requires replacement of the complete set.

1. Remove snap ring 7 from carrier.

2. Position carrier 5 on its snap ring side and press out four spindles 9. Removal of the spindles will allow four balls 8to fall free. Place the spindles and balls in a container.

3. Remove four pinions 3, bearings4, and thrust washers 2 from carrier 5. Remove bearings 4 from pinions 3.

4. Remove oil shield 6.

ASSEMBLY. Assemble splitter planetary carrier as follows (see A, Foldout 8):

1. Install oil shield 6.

2. Chill spindles 9 in dry ice for one hour prior to assembly or heat carrier 5 in an oil bath or oven to 300-3500F (1491760C). Handle the parts with gloves.

3. Make a pinion aligning tool by grinding a used spindle 9 to 0.005 inch (0.127 mm) undersize. The aligning tool should have a slight chamfer at one end.

4. Install a washer 2 onto the pinion aligning tool.

5. Install a pinion 3 onto the aligning tool.

6. Install a bearing 4 and another washer 2 onto the aligning tool.

7. Grasp the assembled pinion group to hold it together. Remove the aligning tool and install the pinion group into carrier assembly 5 (snap ring groove of carrier upward).

8. Repeat the procedures in 3 through 7 for the remaining pinion groups. Place carrier assembly 5 (snap ring groove upward) in a press.

9. Align a pinion group by inserting the pinion aligning tool through each spindle bore in carrier assembly 5. Leave the aligning tool in place and allow the spindle to displace the tool during installation.

10. Start a chilled spindle 9 into carrier assembly 5, aligning its recess for ball 8 with the recess in carrier assembly 5.

11. Install ball 8 into the recess in spindle 9, retaining it with oil-soluble grease.

12. Press spindle 9 into carrier assembly 5 until it bottoms firmly.

13. Repeat procedures 9 through 12 for installation of the remaining three spindles 9 and balls 8.

14. Install internal snap ring 7 to retain spindles 9 in carrier 5.

NOTE

Chilling of spindles results in "frost" initially which ultimately is moisture. If a rebuilt carrier assembly is not being installed in a transmission in the near future, apply a coating of oil around spindle locations to avoid rust oxidation.

SPLITTER-DIRECT CLUTCH AND DRUM ASSEMBLY

DISASSEMBLY. Disassemble splitter-direct clutch as follows (see B, Foldout 7):

1. Remove snap ring 16, backplate 15, two clutch plates 13, and clutch plate 14.

2. Install compressor tool J-7441 or other suitable compressor as shown in (Figure 15-94a).

3. Tighten the nut on the tool to compress the piston spring and remove the snap ring and piston spring. Remove the compression tool.

4. Remove piston assembly 8. Do not remove check ball 9 from piston 10.

5. Remove lip-type seal ring 7 from drum 5. Remove piston inner seal ring 6 from drum 5. See page 15-44.

6. Remove two step-joint seal rings 1 from the hub of drum 5.

7. Do not remove dowel pins4. Do not remove collector ring 3 unless parts replacement is necessary.

ASSEMBLY. Assemble the splitter-direct clutch as follows (see B, Foldout 7):

1. If collector ring 3 was removed, install a new ring (Figure 15-95).

2. To secure collector ring 3 (B, Foldout 7) to drum 5, the ring must be depressed into the groove in the drum. For a forming tool, use a 1/8 inch (3.175 mm) steel rod, flat against the ring, aligned with the groove, 0.415 inch (10.541 mm) from shoulder on the drum. Hammer on the rod and force the ring into the groove at four points around the circumference. Then complete the forming operation by forcing the ring metal into the groove around the entire circumference. The depression must be uniform, and should not exceed 0.070 inch (7.78 mm) in depth.

3. Install two step-joint seal rings 1 into grooves in the front hub of drum 5. New seal rings may require forming by wrapping them, for a few seconds, around an object about 2/3 the diameter of the groove. Use oil-soluble grease in the grooves to retain the seal rings.

4. Install piston inner seal ring 6 into the groove in drum 5. See page 15-44. Install into the outer groove of piston housing 5, lip-type seal ring 7. Make sure the lip of seal ring 7 is facing the piston (away from housing cavity).

5. Install piston assembly 8 into drum assembly 2.

6. Install return spring 11, cupped side first, onto the piston.

7. Install compressor tool J-7441 or other suitable compressor as shown in Figure 15-94a.

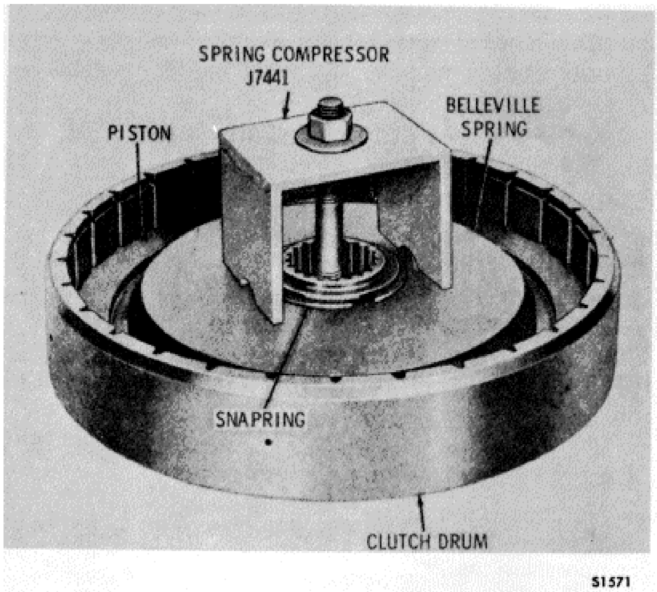


Figure 15-94a. Compressing Splitter-Direct Clutch Spring

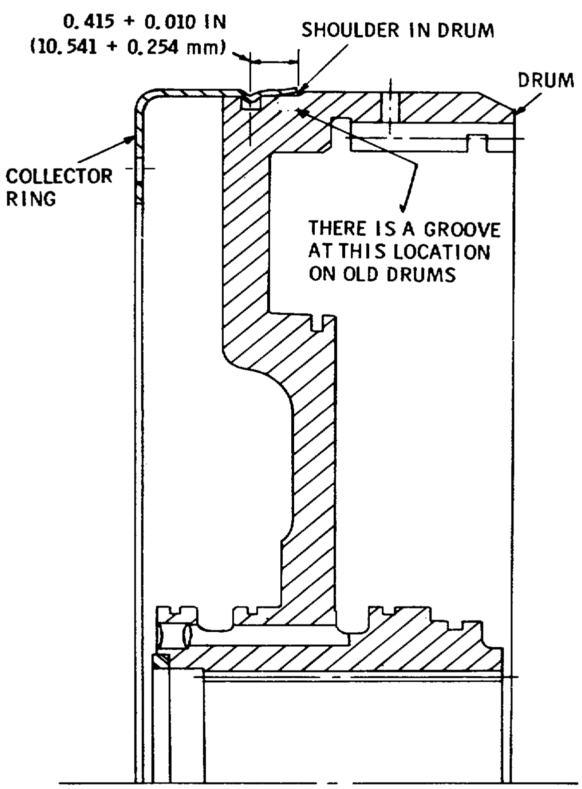


Figure 15-95. Assembly of Oil Collector Ring to Clutch Drum

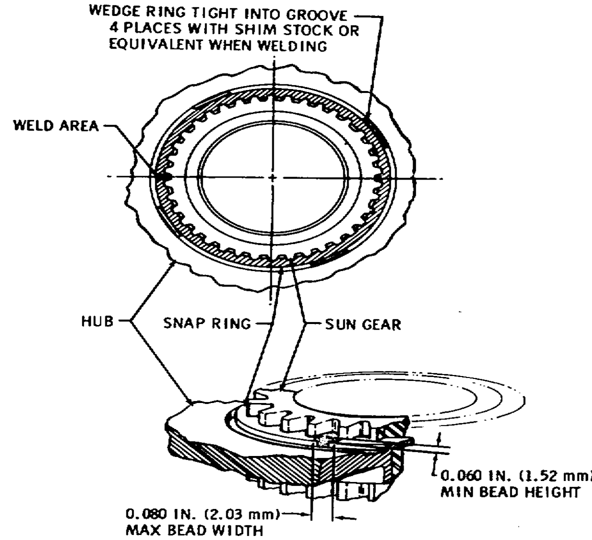


Figure 15-96. Welding Instructions for Splitter Sun Gear Assembly

8. Tighten the nut on the tool to compress the piston spring and install the snap ring. Remove the compression tool.

9. Do not install items 13-16 (B, Foldout 7) at this time.

SPLITTER SUN GEAR ASSEMBLY

DISASSEMBLY. Disassemble splitter sun gear as follows (see B, Foldout 7):

1. Remove snap ring 17 from sun gear 22 and remove bearing 18 from the sun gear.

2. Remove sun gear 22 from hub 21 if part replacement is necessary. If necessary, use a chisel and break the weld joint in snap ring 20.

3. Remove snap ring 20 from sun gear 22, and press the sun gear from hub 21. Discard the snap ring.

ASSEMBLY. Assemble splitter sun gear as follows (see B, Foldout 7):

1. Install sun gear 22 (snap ring groove first) into the deeper (rear) side of hub 21. Press the sun gear until the snap ring groove on its outside diameter is even with the snap ring counterbore in the hub inside diameter.

2. Install a new snap ring 20 and weld it in accordance with the instructions in Figure 15-96. Use Oxweld No. 65* electrode, or equivalent 0.062 inch (1.57 mm) diameter wire.

3. Install bearing 18 (B, Foldout 7) into sun gear 22, and press it firmly against the sun gear shoulder. Install snap ring 17 to retain the bearing in the sun gear.

*Manufactured by Linde Division, Union Carbide

REVERSE-GEAR PLANETARY CARRIER ASSEMBLY DISASSEMBLY. Disassemble reverse-gear planetary carrier as follows (see B, Foldout 11):

NOTE

The pinions in this planetary carrier are a matched set. Therefore, failure of one pinion requires replacement of the complete set.

1. Remove six bolts 2 that attach retainer 3 to carrier 6. Remove the retainer. Remove ring gear 5.

NOTE

Place each pinion group in a separate container, identified with its location in the carrier.

2. Position the carrier, hub upward, and press out six spindles 13. Removal of the spindles will allow six lockballs 12 to fall free. Place the spindles and lockballs in a container.
3. Remove six pinions 10, spacers 9, bearing rollers 11, and thrust washers 8.
4. Remove ball bearing 14 only if replacement is necessary.

ASSEMBLY. Assemble the reverse-gear planetary carrier as follows (see B, Foldout 11):

1. Chill spindles 13 in dry ice for one hour prior to assembly or heat carrier 7 in an oil bath or oven to 300-350°F (149-1760C). Handle the parts with gloves.
2. Grease a pinion thrust washer 8 and pinion spacer 9 and install them at one end of a pinion 10.
3. Grease the bore of a pinion 10 and install twenty-four rollers 11 into the bore. An aligning tool placed in the bore of the gear will facilitate this installation. An aligning tool can be made by grinding a used spindle 13 to 0.005 inch (0.127 mm) undersize. The aligning tool should have a slight chamfer at one end.
4. Install another spacer 9 and thrust washer 8 onto pinion 10.
5. Assemble the remaining pinions 10, rollers 11, spacers 9, and thrust washers 8, as outlined in 2 through 4. Leave the aligning tool in place and allow the spindle to displace the tool during installation.
6. Position carrier 7, hub downward, in a press. Support the carrier at the spindle bore locations.
7. Install an assembled pinion group into the carrier. Align a pinion group with the spindle bores in the carrier by inserting the pinion aligning tool.
8. Start a chilled spindle 13 into carrier assembly 7, aligning its recess for ball 13 with the recess in carrier assembly 7.
9. Install ball 12 into the recess in spindle 13, retaining it with oil-soluble grease.
10. Press spindle 13 into carrier assembly7 until it bottoms firmly.
11. Repeat procedures 7 through 10 for installation of the remaining five spindles 13 and balls 12.

NOTE

Chilling of spindles results in "frost" initially which ultimately is moisture. If a rebuilt carrier assembly is not being installed in a transmission in the near future, apply a coating of oil around spindle locations to avoid rust oxidation.

12. Install ring gear 5, counterbored end first, onto carrier assembly 6.
13. Install retainer 3 onto carrier assembly 6, aligning the internal tangs of the retainer with spindles 13, and the bolt holes with the tapped holes in the carrier.
14. Install six 3/8-24 x 5/8 self-locking bolts 2. Tighten the bolts 41-49 lb ft (56-66 N.m).
15. If bearing assembly 14 was removed, install the bearing assembly. Press on the inner race until the bearing assembly is seated against the shoulder on the hub of carrier assembly 6.

LOW-RANGE PLANETARY CARRIER ASSEMBLY DISASSEMBLY. Disassemble the low-range planetary carrier as follows (see A, Foldout 11):

NOTE

The pinions in this planetary carrier are a matched set. Therefore, failure of one pinion requires replacement of the complete set.

1. Remove snap ring 14 from carrier 15.
2. Position carrier 15, shaft upward, and press out four spindles 12. Removal of the spindle assemblies will allow lockballs 13 to fall free. Place the spindles and lockballs in a container.
3. Remove pinions 10 with bearings 11, and thrust washers 9. Remove bearings 11 from pinions 10.

ASSEMBLY. Assemble the low range planetary carrier as follows (see A, Foldout 11):

1. Chill spindles 12 in dry ice for one hour prior to assembly or heat carrier assembly 15 in an oil bath or oven to 3003500F (149-1760C). Handle the parts with gloves.
2. Make a pinion aligning tool by grinding a used spindle 12 to 0.005 inch (0.127 mm) undersize. The aligning tool should have a slight chamfer at one end.
3. Install one washer 9 onto the pinion aligning tool.
4. Install pinion 10 onto the aligning tool.
5. Install bearing 11 and another washer 9 onto the aligning tool.
6. Grasp the assembled pinion group to hold it together. Remove the aligning tool and install the pinion group into carrier assembly 15 (shaft downward).
7. Repeat the procedures in 2 through 6 for the remaining pinion groups. Place carrier assembly 15 (shaft downward) in a press.

8. Align a pinion group by inserting the pinion aligning tool through each spindle bore in carrier assembly 15. Leave the aligning tool in place and allow the spindle to displace the tool during installation.
9. Start a chilled spindle 12 into carrier assembly 15, aligning its recess for ball 13 with the recess in the carrier assembly.
10. Install ball 13 into the recess in spindle 12, retaining it with oil-soluble grease.
11. Press spindle 12 into the carrier assembly until it bottoms firmly.
12. Repeat procedures 8 through 11 for installation of the remaining three or four spindles 12 and balls 13.
13. Install internal snap ring 20to retain spindles 12 in carrier 15.

NOTE

Chilling of spindles results in "frost" initially which ultimately is moisture. If a rebuilt carrier assembly is not being installed in a transmission in the near future, apply a coating of oil around spindle locations to avoid rust oxidation.

INTERMEDIATE-RANGE PLANETARY CARRIER ASSEMBLY

DISASSEMBLY. Disassemble intermediate-range planetary carrier as follows (see B, Foldout 10):

NOTE

The pinions in this planetary carrier are a matched set. Therefore, failure of one pinion requires replacement of the complete set.

1. Position carrier 3, splined end downward, and press out four spindles 4. Removal of the spindles will allow four lockballs 5 to fall free. Place the spindles and lockballs in a container.

2. Remove four pinions 7 with bearings 27 and thrust washers 6. Remove bearings 27 from pinions 7.

ASSEMBLY. Assemble intermediate-range planetary carrier as follows (see B, Foldout 10):
1. Chill spindles 4 in dry ice for one hour prior to assembly or heat carrier 3 in an oil bath or oven to 300-3500F (1491760C). Handle the parts with gloves.
2. Make a pinion aligning tool by grinding a used spindle 4 to 0.005 inch (0.127 mm) undersize. The aligning tool should have a slight chamfer at one side.
3. Install one washer 6 onto the pinion aligning tool.
4. Install pinion 7 onto the aligning tool.
5. Install bearing 27, and another washer 6 onto the aligning tool.
6. Grasp the assembled pinion group to hold it together. Remove the aligning tool and install the pinion group into carrier assembly 6 (splined end upward).
7. Repeat the procedures in 2 through 6 for the remaining pinion groups. Place carrier assembly 3 (splined end upward) in a press.

8. Align a pinion group by inserting the pinion aligning tool through each spindle bore in carrier assembly 3. Leave the aligning tool in place and allow the spindle to displace the tool during installation.

9. Start a chilled spindle 4 into carrier assembly 3, aligning its recess for ball 5 with the recess in carrier assembly 3.

10. Install ball 5 into the recess in spindle 4 and retain it with oil-soluble grease.

11. Press spindle 4 into carrier assembly 3 until it bottoms firmly.

12. Repeat procedures 8 through 11 for installation of the remaining three spindles 4 and balls 5.

NOTE

Chilling of spindles results in "frost" initially which ultimately is moisture. If a rebuilt carrier assembly is not being installed in a transmission in the near future, apply a coating of oil around spindle locations to avoid rust oxidation.

FIFTH-AND-SIXTH-GEAR CLUTCH ASSEMBLY

DISASSEMBLY. Disassemble fifth-and-sixth-gear clutch as follows (see A, Foldout 9):
1. Remove snap ring 15, backplate 14, three clutch plates 12, and two clutch plates 13.
2. Install compressor tool J-7441 or other suitable compressor as shown in Figure 15-97.

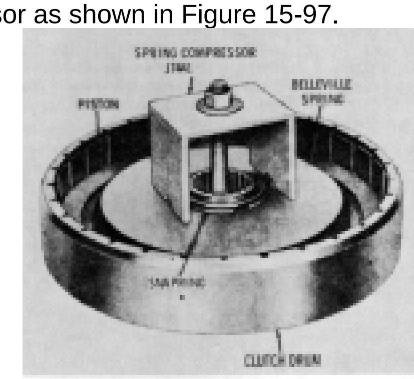


Figure 15-97. Compressing Fifth-and Sixth-Gear Clutch Spring

3. Tighten the nut on the tool to compress the piston spring and remove the snap ring and piston spring.

4. Remove piston assembly 7. Do not remove check ball 8 from piston 9.
5. Remove lip-type seal ring 6.
6. Remove piston inner seal ring 5 from the rear hub of drum 4.

7. Remove two step-joint seal rings from the hub of drum 4.

8. Do not remove dowel pins 3 from drum 4.

ASSEMBLY. Assemble fifth-and-sixth-gear clutch as follows (see A, Foldout 9):

1. Install piston inner seal ring 5 onto the rear hub of drum 4.

2. Install lip-type seal ring 6 (see page 15-44)onto drum 4. Make sure the lip of seal 6 is facing the piston (rearward).

3. Install piston assembly 7 into clutch drum assembly 2. The flatter side of the piston must be toward the drum.

4. Install piston return spring 10, concave side first, onto piston 9.

5. Install compressor tool J-7441 or other suitable compressor as shown in Figure 15-97.

6. Tighten the nut on the tool to compress the piston spring and install the snap ring. Remove the compression tool.

7. Install two step-joint seal rings 1 (A, Foldout 9) into grooves in the front hub of drum 4. New seal rings may require performing by wrapping them, for a few seconds, around a circular object about two-thirds the diameter of the seal ring groove. Retain the seal rings with oil-soluble grease.

8. Do not install items 12 through 15 at this time.

SPLITTER OUTPUT SHAFT AND OIL TRANSFER PLATE ASSEMBLY

DISASSEMBLY. Disassemble splitter output shaft as follows:

1. Remove snap ring and bearing assembly 8 (B, Foldout 10) from the splitter output shaft. Remove oil collector ring 10.

2. Remove bearing 5 (A, Foldout 11) from shaft 3 only if replacement is necessary.

3. Remove orifice plug 4 only if replacement is necessary.

INSPECTION AND REPAIR. Inspect and repair splitter output shaft as follows:

1. Inspect the bore at the front end of shaft 3 (A, Foldout 11) for wear and scoring. The bore of the shaft must be 1.5001.502 inch (38.10-38.15 mm), to a depth of 0.800 inch (20.32 mm).

2. If the front bore of shaft 3 is worn or scored, rework the bore to dimensions shown in Figure 15-98.

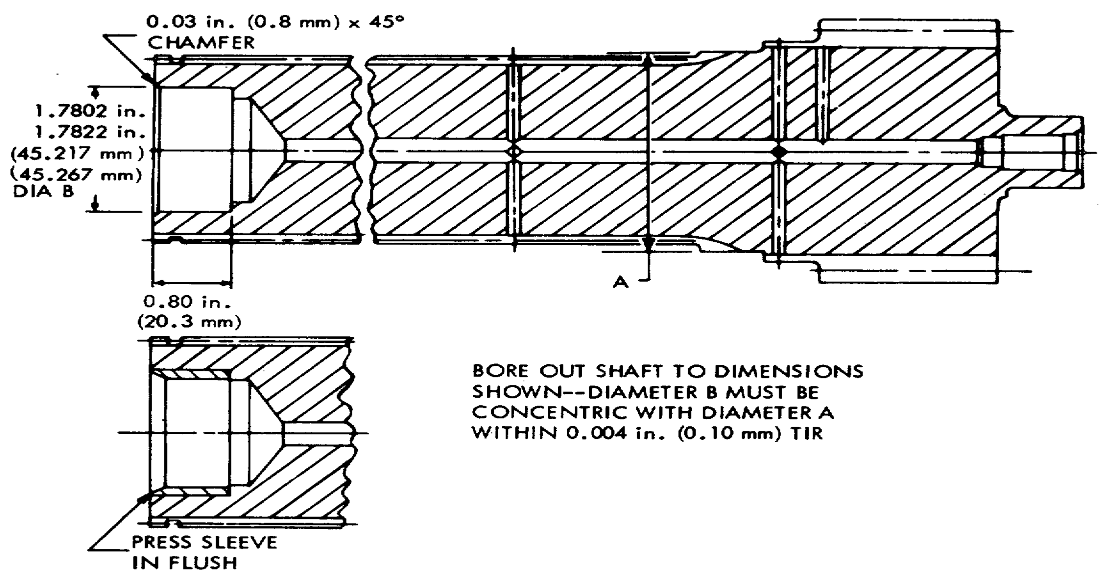


Figure 15-98. Rework of Splitter Output Shaft Bore

3. Chill sleeve 1 (A, Foldout 11) in dry ice. Install it, internal chamfer out, and press it flush with the front of shaft 3.

ASSEMBLY. Assemble splitter output shaft as follows:

1. If orifice plug 4 (A, Foldout 11) was removed, install a new plug. Press it, open-end first, into the rear bore of shaft 3 until it projects 0.22-0.28 inch (5.6-7.1 mm) from the end of the shaft.
2. Install oil collector ring 10 (B, Foldout 10), convex side first, onto the front of shaft assembly 2 (A, Foldout 11).
3. Install bearing and snap ring assembly 10 (B, Foldout 10), with snap ring installed, snap ring first, onto the front of shaft assembly 2 (A, Foldout 11). Press the inner race of the bearing assembly to a seat against the shoulder on the shaft.
4. Press bearing 5 onto the rear of shaft 3.

TRANSMISSION MAIN HOUSING ASSEMBLY

DISASSEMBLY. Disassemble main housing as follows (see B, Foldout 8):

1. Remove snap ring 1 from the front face of transmission housing 10.
2. Remove converter pressure relief valve seat 2, valve 3 and spring 4. If present, remove snap ring 25, converter pressure regulator valve seat 24, valve 23 and spring 22. Remove pins 9 if replacement is necessary.
3. Remove breather 12 and reducer 11 from housing 10.
4. Remove tube 8 if replacement is necessary.
5. Remove oil transfer hub 19 only if replacement is necessary. Press or drive it toward the rear of housing 10 to remove it.
6. Remove washers 31 and plug 30.

ASSEMBLY. Assemble main housing as follows (see B, Foldout 8):

1. If oil transfer hub 19 was removed, chill hub 19 in dry ice. Use two 1/2-20 x 3 inch headless guide bolts, screwed into opposite holes in the hub to aid in installation. Align the bolt holes in the hub with those in housing 10, and press or drive the hub into the rear side of the partition in the housing.
2. If tube 8 was removed, install a new tube (small diameter first) into the front of housing 10. Press the tube 0.01-0.05 inch (0.25-1.27 mm) below the surface.
3. Install reducer 11 and breather 12 into housing 10. Tighten them sufficiently to prevent leakage.
4. If pins 9 were removed, install new pins into the transmission main housing. Press the pins into the bores until they are 0.08-0.12 inch (2.03-3.04 mm) below the splitline face. Install spring 4, valve 3 (concave side first), and converter pressure relief valve seat 2 onto the upper right pin 9. The edge of the bore of seat 2 should be sharp and square. If the same seat is being reused, it may be reversed when installing it to make use of the unworn edge. Compress the spring and install snap ring 1 to retain the valve components.
5. Install spring, valve (concave side first), and converter pressure regulator valve seat 24 onto the upper left pin 9. The edge of the bore of seat 24 should be sharp and square. If the same seat is being reused, it may be reversed when installing it to make use of the unworn edge. Compress the spring and install snap ring 25 to retain the valve components.
6. Install washer 31 and plug 30, if removed. Tighten the threaded fasteners sufficiently to prevent leakage.

FLYWHEEL ASSEMBLY

DISASSEMBLY. Disassemble flywheel as follows (see A, Foldout 3):

1. The flywheel assembly should be disassembled only if parts replacement is necessary.
2. Remove dowel pin 14 from the front of flywheel 15.
3. Remove four dowel pins 16, if present, from the rear of flywheel 15.
4. Note whether the chamfered teeth face forward or rearward and remove starter ring gear 1 3.

REWORK OF FLYWHEEL CENTER BORE. Rework flywheel center bore as follows:

1. If the seal ring surface of the flywheel bore is worn enough to impair sealing, bore it to the dimensions shown in Figure 15-99.
2. Cool sleeve 18 (A, Foldout 3) in dry ice for at least 30 minutes. Then install the sleeve, being careful that it is aligned with the bore and is not damaged during installation. The inside chamfer must be toward the rear.

ASSEMBLY. Assemble flywheel as follows (see A, Foldout 3):

1. Heat starter ring gear 1 3 to 4000F (2040C) maximum. Be sure the chamfer of the teeth is facing the proper direction for starter pinion engagement and install the ring gear onto the flywheel. Gear 13 must fit firmly against the shoulder on flywheel 15.
2. If removed, install four dowel pins 16, pressing them in until they project 0.31 inch (7.9 mm) at the inside of flywheel 15.
3. Install dowel pin 14, pressing it in until it projects 0.120.14 inch (3.1-3.5 mm) at the front of flywheel 15.

BEARING RETAINER ASSEMBLY

DISASSEMBLY. Disassemble bearing retainer as follows (see A, Foldout 12):

1. Remove only items requiring replacement.
2. Remove baffle 16 from retainer 14.
3. Remove oil seal 15 from retainer 14.
4. Remove pipe nipple 17 from retainer 14.

ASSEMBLY. Assemble bearing retainer as follows (see A, Foldout 12):

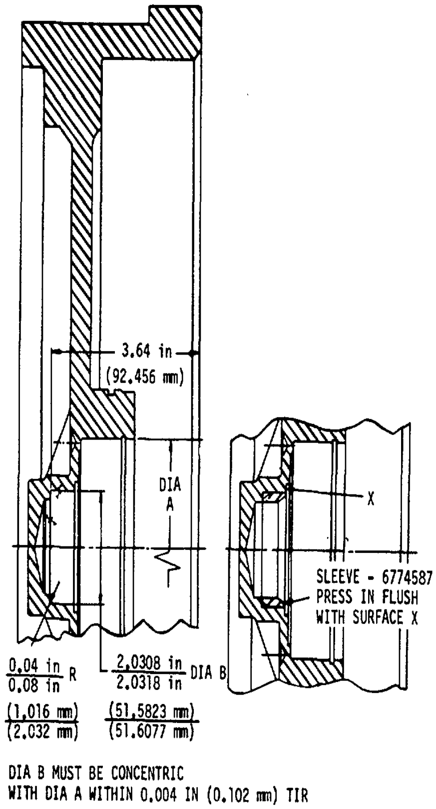


Figure 15-99. Rework of Flywheel

1. Press seal 15, spring-loaded lip first, into the rear of the retainer to the dimension shown in Figure 15-100.
2. Install baffle, smaller inner diameter first, into the rear of the retainer to the dimension shown in Figure 15-100.
3. Install pipe nipple 17 into retainer 14.

OUTPUT DRIVE HOUSING ASSEMBLY (A, Foldout 12) DISASSEMBLY. Disassemble output drive housing as follows:

1. Remove piston 21 (B, Foldout 11) with seal ring 20 from the output drive housing.
2. Remove the seal ring from the piston (see page 15-44).
3. Remove seal ring 22 from the front of the output drive housing (see page 15-44).
4. Remove bushing 6 (A, Foldout 12), dowel pins 4, or plug 3 only if parts replacement is necessary.
5. Remove plugs 23 if necessary for cleaning.

ASSEMBLY. Assemble output drive housing as follows:

1. Install plugs 23 (A, Foldout 12) and plug 3 into housing 5. Tighten the plugs sufficiently to prevent leakage.
2. If removed, press a new bushing 6 into the end of the speedometer drive bore in housing 5.
3. If removed, install two dowel pins 4 into housing 5, letting them project 0.49-0.51 inch (12.5-12.9 mm) at the front of the housing.
4. Install seal ring 22 (B, Foldout 11) into the groove at the front of the output drive housing. Be sure the lip of seal 22 is facing rearward. See page 15-44.

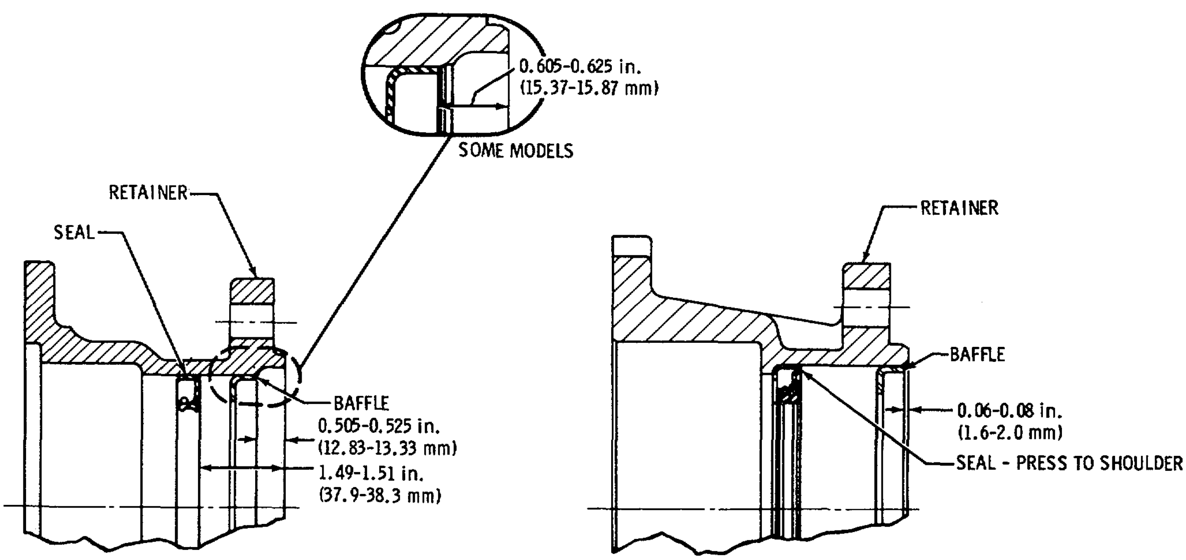


Figure 15-100. Bearing Retainer Configurations

5. Install seal ring 20 into the outside diameter groove of reverse piston 21. See page 15-44.

6. Install piston 21 with seal ring into the front of the output drive housing.

SHIFT TOWER

DISASSEMBLY. Disassemble shift tower as follows (see B, Foldout 12):

CAUTION

Do not use liquid or vapor cleaning methods on any electrical components.

1. Remove four screws that retain the light socket plate assembly (Figure 15-101).

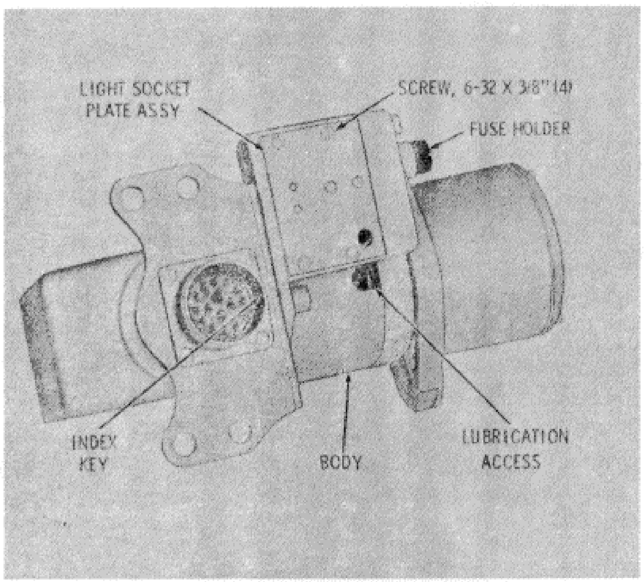


Figure 15-101. Shift Tower Assembly -Bottom View

2. Carefully pull the plate assembly from the shift tower body (Figure 15-102). If necessary, remove the light bulb and O-ring from the socket.

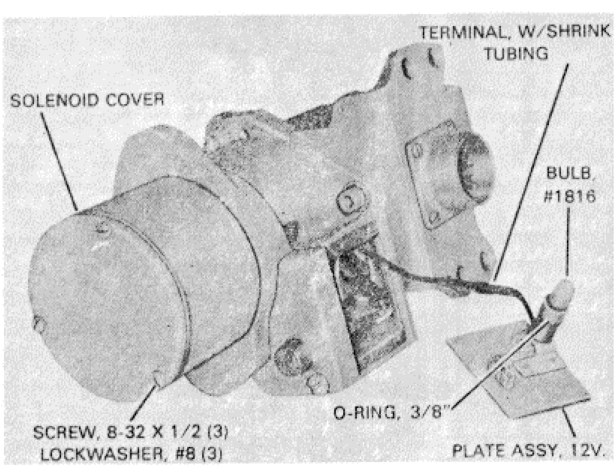


Figure 15-102. Shift Tower Assembly

3. If the light socket plate assembly or wiring is to be replaced, cut the heat-shrink tubing from the wire terminals and disconnect the plate assembly.

4. Remove three screws and lockwashers that retain the inhibitor solenoid cover (Figure 15-102).

5. Remove the solenoid cover and gasket (Figure 1 5-103). Remove the plunger and washer from the solenoid.

6. Remove the heat-shrink tubing from the solenoid and wiring harness leads (Figure 15-103). Disconnect the leads.

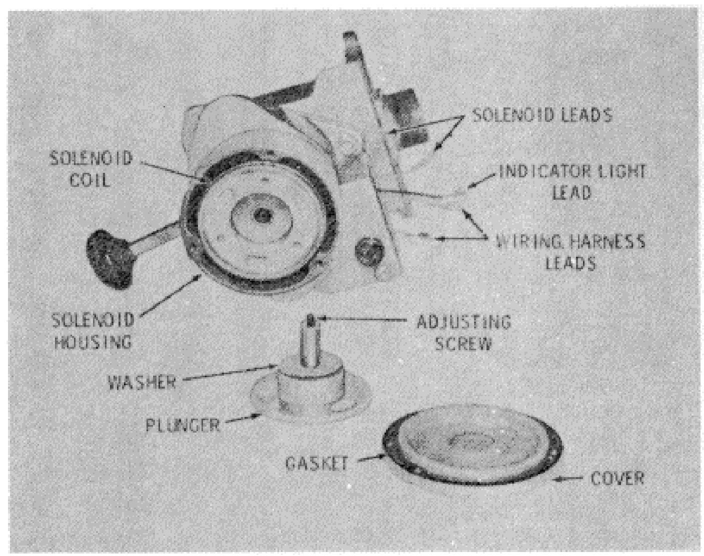


Figure 15-103. Downshift Inhibitor Components

7. Remove the solenoid coil, working the leads through the holes in the shift tower body and solenoid housing (Figure 15-104). Remove O-ring 58 (B, Foldout 12), retainer ring 59, spring seat 60, and spring 61 from the solenoid housing.

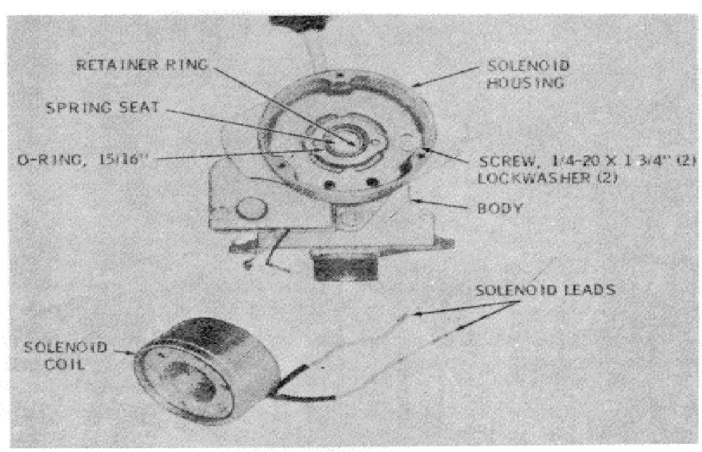


Figure 15-104. Shift Tower Assembly with Solenoid Removed

8. Remove two socket-head screws and lockwashers that retain the solenoid housing (Figure 15-104). Remove the housing.

9. Remove the outer clutch from the solenoid housing (Figure 15-105). Remove the O-ring. Remove the guide pins from the solenoid housing if new pins are required.
10. Remove the clutch spring (Figure 15-105). Remove the indicator support.
11. Remove the screw and lockwasher that retain the cover (Figure 15-105).

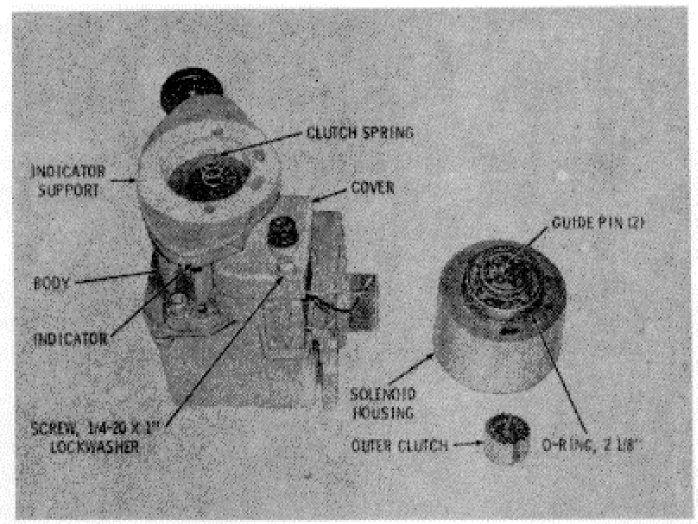


Figure 15-105. Shift Tower Assembly with Solenoid Housing Removed

12. Pull the cover from the body (Figure 15-106). Remove the heat-shrink tubing from the power lead terminals. Disconnect the terminals. Disconnect the fuse lead.

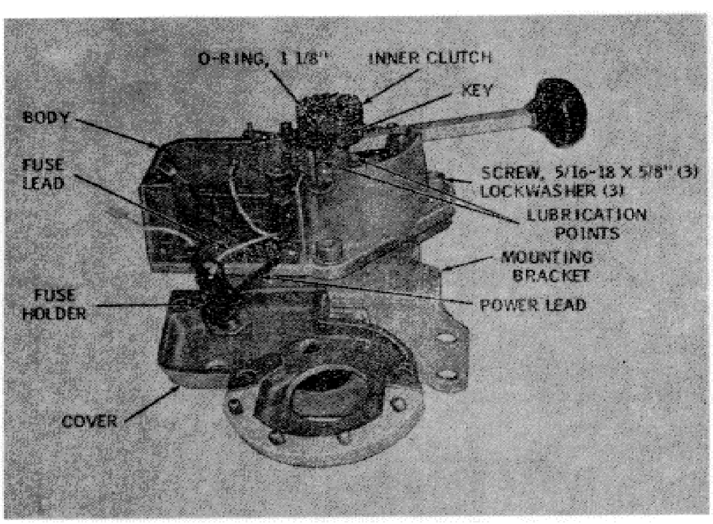


Figure 15-106. Shift Tower Assembly with Inner Clutch Exposed

13. Remove the fuse holder from the cover if replacement is necessary (Figure 15-106).
14. Remove three socket-heat screws and lockwashers that retain the body (Figure 15-106). Remove the body, and its attached parts, from the mounting bracket.
15. Remove O-ring 20 (B, Foldout 1 2) from the mounting bracket. Remove four-pin connector 35 from the body if replacement is necessary.
16. Remove 0-ring 3 from inner clutch 2. Remove pin 46 from inner clutch 2. Remove inner clutch 2 from rotary key 39.

17. Remove nut 13 from pin 38. Remove pin 38from rotary key 39. Remove handle 16 and knob 17 from rotary key 39. Remove leveler 4 and spring 5.
18. Push rotary key 39 from body 8. Remove O-ring 14 from rotary key 39.
19. If bushing 12 requires replacement, press the bushing from body 8.
20. Remove four screws and washers that retain the switch cover (Figure 15-107). Remove the cover and cover seal.

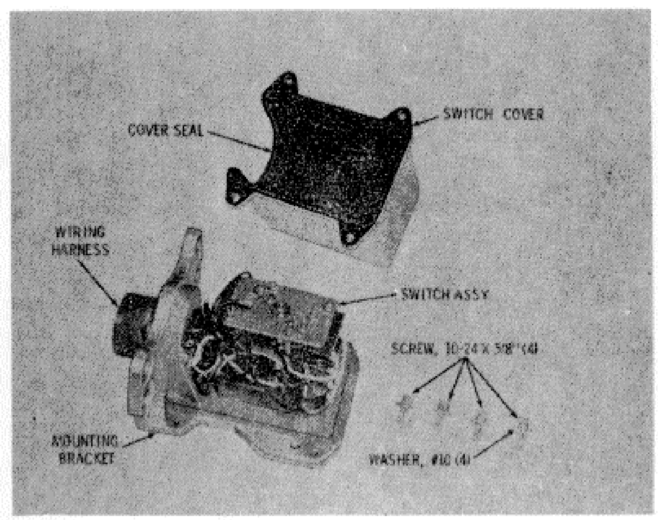


Figure 15-107. Mounting Bracket, Switch Assembly and Cover

21. Loosen the setscrew that retains the drive adapter on the switch shaft (Figure 15-108). Remove the drive adapter. Remove the shim(s) from the switch shaft.
22. Disconnect all of the wiring harness leads from the switch assembly (Figure 15-108). Remove two screws and washers that retain the switch assembly. Remove the switch assembly. The switch assembly is not a serviceable assembly.
23. Remove the four-pin socket if replacement is necessary (Figure 15-108).

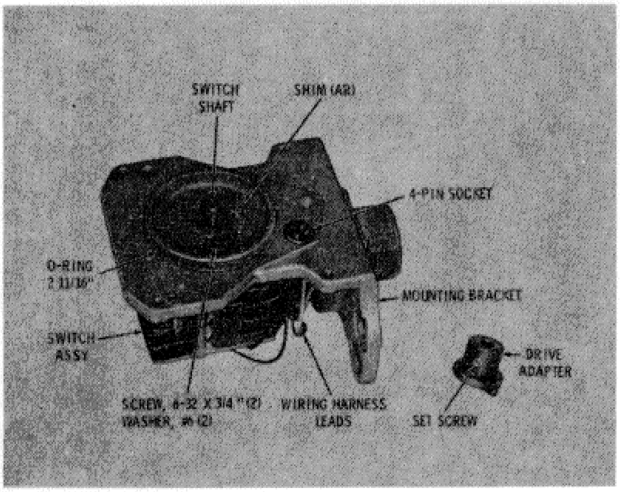


Figure 15-108. Mounting Bracket and Shaft-End of Switch

24. Remove the four screws that retain the wiring harness (Figure 15-109). Remove the wiring harness from the mounting bracket.
25. Remove O-ring 29 (B, Foldout 12) from the wiring harness connector body.

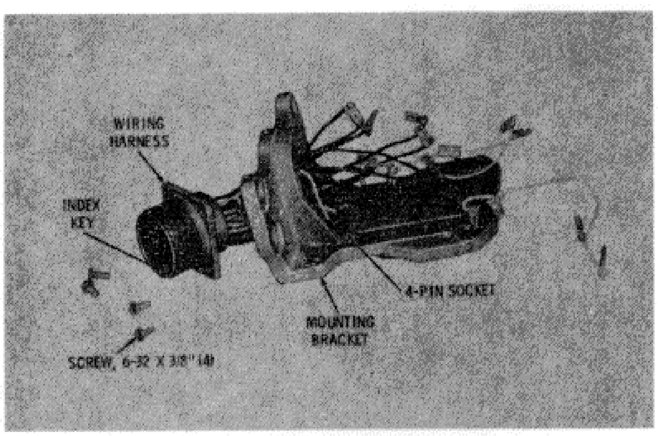


Figure 15-109. Mounting Bracket and Switch Wiring Harness

ASSEMBLY. Assemble shift tower as follows (see B, Foldout 12):

CAUTION

Do not use acid, or acid core solder. Use only rosin core solder.

1. If the four-pin socket (female) was removed from the mounting bracket install a new socket 36 (B, Foldout 12). Refer to Figure 15-109. Push the socket into the flat side of the mounting bracket until it is flush with the adjacent area. Note the projection on the socket body that indexes with a notch in the mounting bracket.

CAUTION

Hand tighten all mating connectors. Use of tools will damage the components.

2. Install a 1-1/2 inch (38.1 mm) O-ring 29 (B, Foldout 12) over the wires and onto the shoulder of the main wiring harness 32. Insert the wires through the bottom of the mounting bracket (Figure 15-109). Push the sixteen-pin connector into the mounting bracket, with the index key toward the flat side of the mounting bracket (Figure 15-101). Retain the connector with four 6-32 x 3/8 inch screws.

NOTE

Refer to Figure 15-110 to confirm the locations, but note the view in the wiring diagram is at the front (mating side) of the socket and the order of installation is counterclockwise.

3. Locate the lead coming from pin K in the sixteen-pin connector. Push its free end through the hole nearest the index projection of the four-pin socket. Crimp and solder a socket terminal to the lead, and push the lead and terminal into the socket body. Attach the lead from pin M to the four-pin socket, directly opposite from lead K, in the same manner. Attach the lead from pin L to the four-pin socket at the hole farthest from the mounting bracket base. Attach the separate lead, having two push-on terminals attached, to the four-pin socket at the remaining hole.

4. Recheck the connections to make sure they are correct. Looking at the back of the socket (where wires enter), the light-colored lead from pin K should be nearest the index lug on the socket. Moving clockwise, the separate lead with four connectors is next; then another light-colored lead to pin M; and last, a dark lead to pin L.
5. Install the switch assembly onto the mounting bracket (Figure 15-111). Position the switch assembly on the mounting bracket so the switch numbers (1 through 8) are not inverted. Retain the assembly with two 6-32 x 3/4 inch screws 21 (B, Foldout 12) and lockwashers 22. The screw holes in the switch assembly should be approximately midway in the elongated holes in the mounting bracket when the screws are tightened.

6. Follow the wiring diagram (Figure 15-110) to connect the wiring harness leads to the switch assembly. Also connect the three jumper leads (from terminal 1 of switch 1, to common terminal of switch 4; from terminal 1 of switch 6, to common terminal of switch 7; and from common terminal of switch 3, to terminal 2 of switch 5, and to common terminal of switch 6). Note also that three switch terminals have no leads connected to them.
7. Install one shim 19 (B, Foldout 12) (darker side first) onto the switch shaft (Figure 15-108).

NOTE

More shims may be required. This will be determined in step 10, below.

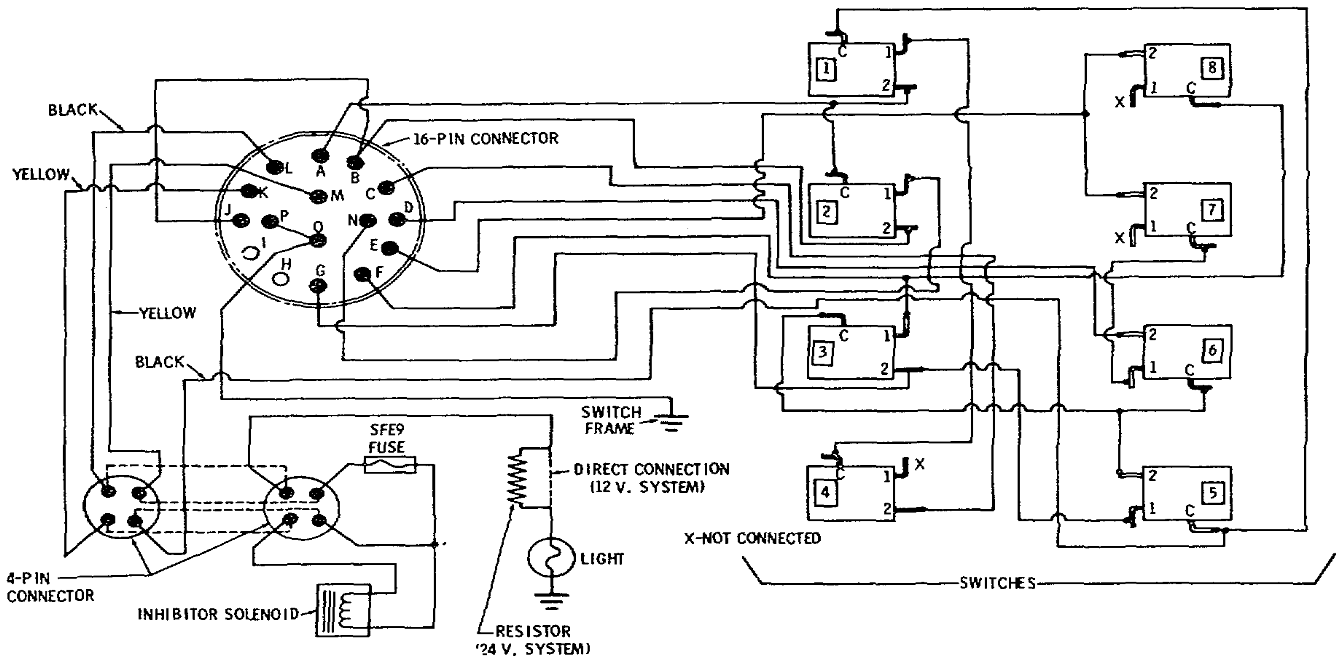


Figure 15-110. Shift Tower Assembly - Manual-Electric

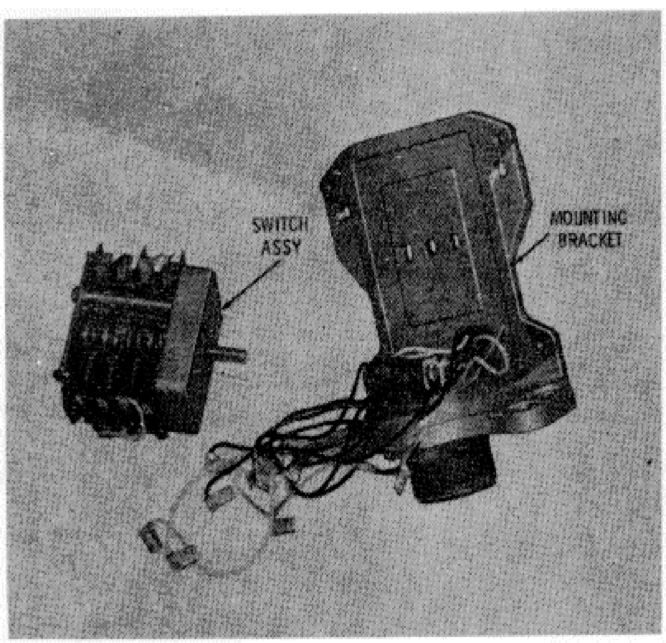


Figure 15-111. Switch Assembly Removed from Mounting Bracket

8. Install the drive adapter (Figure 15-108). Position the adapter lightly against the mounting bracket, and tighten the setscrew against the flat on the switch shaft.

9. If bushing 12 (B, Foldout 12) was removed from the selector body, press a new bushing into the body until it is flush with the hub of the body. Hone or ream the bushing bore until rotary key 39 will fit the bore and can be rotated with finger torque only. Install the rotary key (without 0-ring 14). Install selector body 8 onto mounting bracket 23, engaging the tongue of drive adapter 1 8 with the slot in rotary key 39. Retain body 8 with three 5/16-18 x 5/8 inch socket-head screws 10 and lockwashers 11.

10. Using a dial indicator, depth micrometer, or vernier depth gauge, determine the end play of rotary key 39. If the end play exceeds the thickness of one shim 19, remove selector body 8 and drive adapter 18, and install an additional shim 19 (or more, if required).

NOTE

Shims must not bind the rotary key and switch to hinder rotary actuation.

11. When shim adjustment is completed, remove selector body 8 to complete its assembly.

12. Install 9/16 inch (14.3 mm) O-ring 14 into the groove of rotary key 39. Lubricate the rotary key and O-ring lightly with grease (Texaco Marfak No. 2, or equivalent). Put a small quantity of grease into the spring recess of rotary key 39. Coat spring 5 and leveler 4 lightly with Marfak No. 2, or equivalent grease, and install them into the rotary key. Install handle 16 (and spacer 15, if used) into the slot of the rotary key. Push threaded pin 38 through the holes in the rotary key and handle 16 (and spacer 15, if used). Secure the pin with nut 13. Tighten the nut only enough to eliminate end play of the pin. Do not bind the movement of handle 16 in rotary key 39.

13. If either a new rotary key 39 or a new inner clutch 2, or both, are installed, a drilling guide is required. Install inner clutch 2 onto rotary key 39 until the rotary key bottoms in the clutch. Install the 1-1/8 inch (28.5 mm) O-ring onto the inner clutch (Figure 15-106).

14. Using Shift Inhibitor Clutch Drilling Fixture, J-24711 (see page 15-37), push the inner clutch, of the assembly built thus far, into the large hole in the drilling guide. Position the body dowel pins in the two smaller holes, and the selector handle between the two dowel pins of the guide. Hold the rotary key and inner clutch firmly against the guide stop screw, and drill a 3/32 inch (4.9 mm) hole through the clutch and/or rotary key. Install rotary pin key 46 (B, Fold-out 12). Remove the assembly from the drill guide.

15. Install the four-pin connector into the shift tower (Figure 15-112). Push the connector into the mounting face of the body until it is flush with the adjacent area. Note there is a projection on the connector body that indexes with a notch in the shift tower body for angular alignment of the connector.

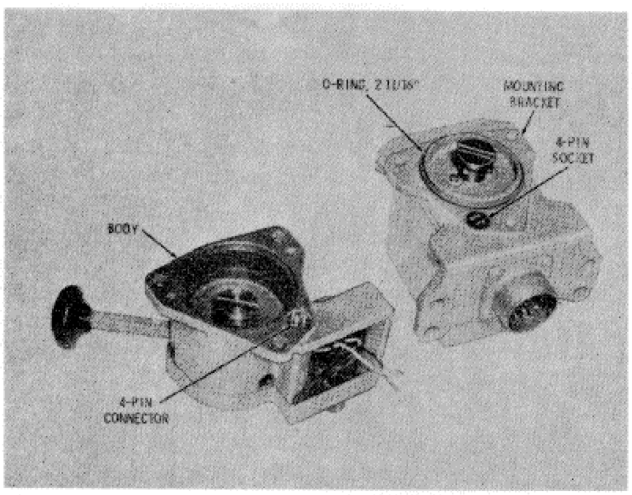


Figure 15-112. Shift Tower Body Section and Switch Section Separated

16. Install the 2-11/16 inch (68.25 mm) O-ring onto the mounting bracket (Figure 15-108).

17. Install the assembled body section of the shiftower assembly onto the assembled switch section (Figure 15-106). Install three 5/16-18 x 5/8-inch socket-head screws and lockwashers to retain the two sections.

18. Install the fuse holder into the body cover (Figure 15-106). Retain it with nut 69 (B, Foldout 12). Connect the fuse lead (coming from M in the sixteen-pin connector, through the four-pin connector) to the single lead of the fuse holder (refer to Figure 15-110). Connect the power lead (coming from the lead in the four-pin socket that connects to the common terminals of switches 3, 5, 6 and 8) to the black lead of the fuse holder. Lightly lubricate the O-ring on the inner clutch with grease (Texaco Marfak No. 2, or equivalent).

19. Install the cover onto the body (Figure 15-105). Retain the cover with one 1/4-20 x 1 inch screw and lockwasher.

20. If necessary, install a new indicator onto the indicator support (Figure 15-105). Install the indicator support onto the body cover. Apply a small quantity of grease (Texaco Marfak No. 2, or equivalent) to the teeth of the inner clutch. Position the clutch spring in the center recess of the inner clutch.

21. If the guide pins were removed from the solenoid housing, install new pins (Figure 15-105). Press the pins until they are flush with the surface of the housing inner hub.

22. Install the 2-1/8 inch (53.9 mm) O-ring onto the solenoid housing (Figure 15-105). Coat the outer surface of the outer clutch lightly with grease (Marfak No. 2, or equivalent). Install the outer clutch, flat end first, into the solenoid housing. The clutch must move freely, endways, when engaged with the guide pins.

23. Install the assembled solenoid housing onto the indicator support (Figure 15-105).

24. Install two 1/4-20 x 1-3/4 inch screws and lock-washers to retain the solenoid housing (Figure 15-104).

25. Install override spring 61 (B, Foldout 12) into the center bore of the solenoid housing.

26. Install the spring seat and retainer ring (Figure 15-104). Install the 15/16 inch (23.79 mm) O-ring into the housing counterbore.

27. Check the angular position of the solenoid housing (Figure 15-113). Push the spring seat downward. While holding the seat downward, push the shift handle, in the upshift direction against a gate pin and then in the opposite direction. The inhibitor clutch should engage, but should allow the shift handle to move away from the gauge pin contacted a maximum of 0.060 inch (1.52 mm) and a minimum of 0.040 inch (1.01 mm) when pull force on the handle knob does not exceed 15 lb (67 N). This 0.060 inch (1.52 mm) maximum movement applies to the gate pin where the least movement is found when all positions are checked. As a result of tolerances in manufacturing, clearance at some gate pins can exceed 0.060 inch (1.52 mm) when the clearance is correctly adjusted at the position where least movement occurs. Check the movement at all gate pins.

28. Too great a clearance requires a counterclockwise adjustment of the solenoid housing to reduce the clearance; too little requires clockwise adjustment. To adjust the solenoid housing, loosen the two screws, rotate the housing, and retighten the screws.

NOTE

When clearance is greatly excessive, a clockwise adjustment may be necessary to engage the inhibitor properly.

29. Install the solenoid coil into the solenoid housing (Figure 1 5-104). Thread the solenoid leads through two holes in the solenoid housing, indicator support, and body cover until they can be pulled out of the bottom opening in the body (Figure 15-103).

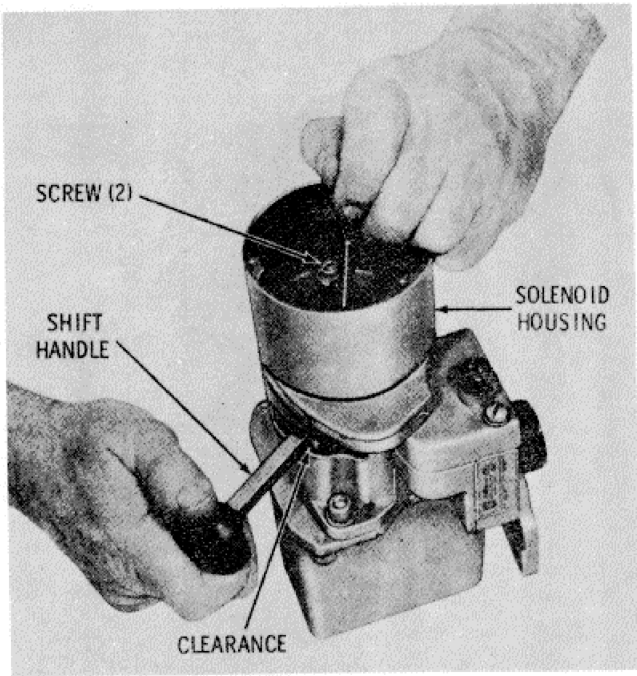


Figure 15-113. Checking Solenoid Housing Angular Adjustment

30. Install the solenoid plunger and washer into the solenoid coil (Figure 15-103). Install the solenoid housing gasket and cover. Retain the cover with three 8-32 x 1/2 inch screws and lockwashers (Figure 15-102).

31. With the solenoid and cover installed, check the shift handle for freedom of movement in both upshift and downshift directions. Any tendency to catch during downshift movement indicates interference between the inner and outer clutch teeth. This may be corrected by removing the cover, gasket, solenoid plunger, and washer, and by rotating the adjusting screw (Figure 15-103) clockwise (inward) until there is no interference. Adjust the screw one turn at a time and recheck for clutch interference after each adjustment.

32. At this stage of assembly, there are five unconnected leads at the bottom of the selector assembly. Four are light color; one is black (Figure 15-103). Attach the two solenoid leads to the proper two wiring harness leads, insulating each connection with a short length of heat-shrink tubing.

33. Replace the bulb, O-ring, or resistor in the light socket plate assembly (Figure 15-102). Connect the lead on the plate assembly with the remaining free lead (black) in the shift tower assembly, insulating the connection with heatshrink tubing.

34. Install the light socket plate assembly, being careful that wires do not touch the light bulb (Figure 15-101). Retain the plate assembly with four 6-32 x 3/8 inch screws.

35. Install a SFE 9 fuse into the fuse holder.

36. Check the circuitry and operation of the shift tower assembly as explained on page 15-30.

37. Install the switch cover and cover seal (Figure 15-107). Retain the cover with four 10-24 x 5/8 inch screws and washers.

ASSEMBLY OF TRANSMISSION

GENERAL

The assembly procedures in this section describe the assembly of the transmission from subassemblies. Refer to the cross sections of the transmission (Foldout 1) for functional location of parts. Refer to parts exploded views (Foldouts 3 through 12) for parts identification.

TRANSMISSION ASSEMBLY

INSTALLING SPLITTER RING GEAR, INTERMEDIATERANGE CARRIER ASSEMBLY, FIFTH-AND-SIXTH-GEAR CLUTCH, AND THIRD-AND-FOURTH-GEAR CLUTCH. Install gears and carrier assemblies as follows:

1. Install hub 13 (A, Foldout 8) into ring gear 11 and install snap ring 14 into the ring gear. Install retainer 27 (B, Foldout 8) and press bearing 26 into place on hub 13 (A, Foldout 8).

2. Position the transmission main housing front end upward. Install, as a unit, the splitter ring gear, gear hub, bearing and bearing retainer (Figure 15-114). Align the bolt holes in the retainer with the bolt holes in the transmission housing. Using care not to damage the bearing, tap the hub to seat the bearing in its bore.

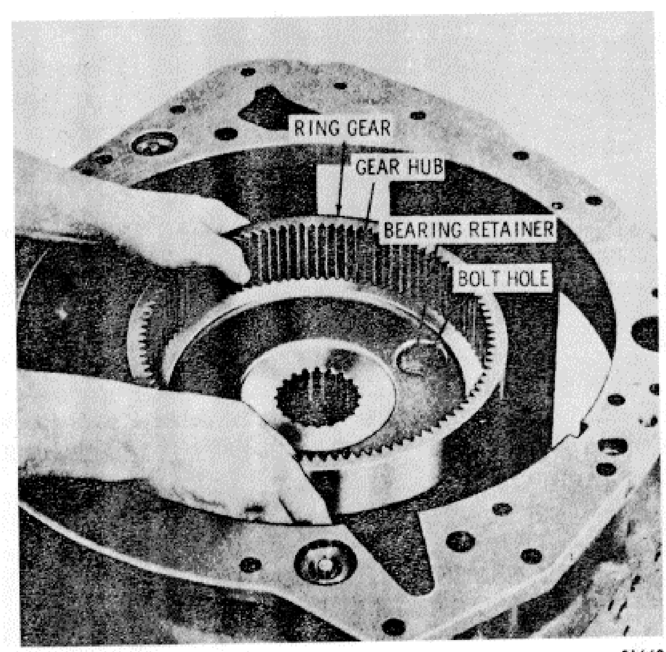
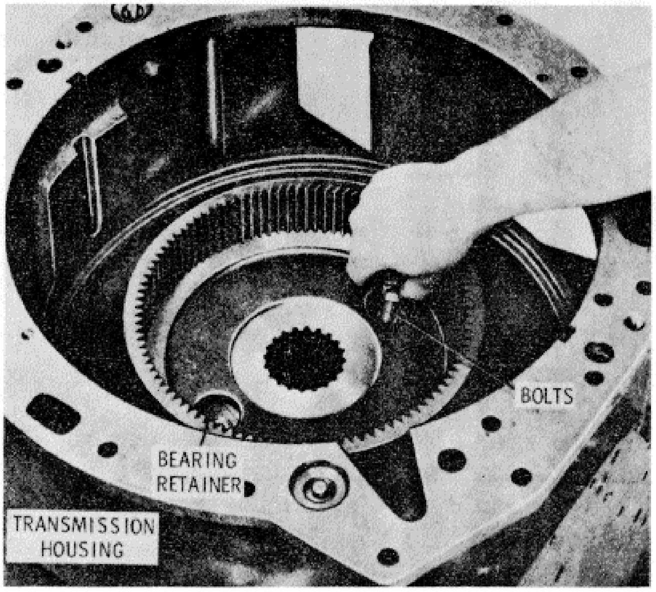


Figure 15-114. Installing Splitter Ring Gear and Hub

3. Install six 1/2-20 x 1-7/8 inch self-locking bolts and toothed lockwashers which secure the bearing retainer to the transmission housing (Figure 15-11 5). Tighten the bolts to 96-115 lb ft (131-155 N.m).



S1649

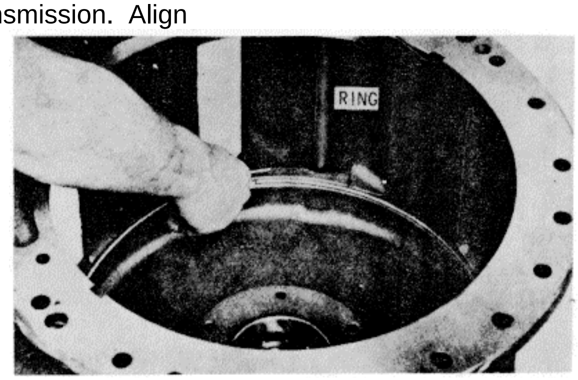
Figure 15-115. Installing Splitter Ring Gear and Bearing Retainer Bolts

4. Turn the transmission housing assembly over and position it on wood blocks, front end downward. (Block the transmission at least six inches above the work table to allow for space to reach under and rotate the splitter ring gear hub in step 8, below). Install two (one at each side) anchor keys 16(B, Foldout 1) or 1 7(B, Foldout 1)(approximately 2.7 inch long). Install the compression ring (Figure 15-116).

CAUTION

Center the clutch and drum assembly with extreme care during installation to avoid damaging the seal rings on the fifth-and-sixth-gear clutch drum hub.

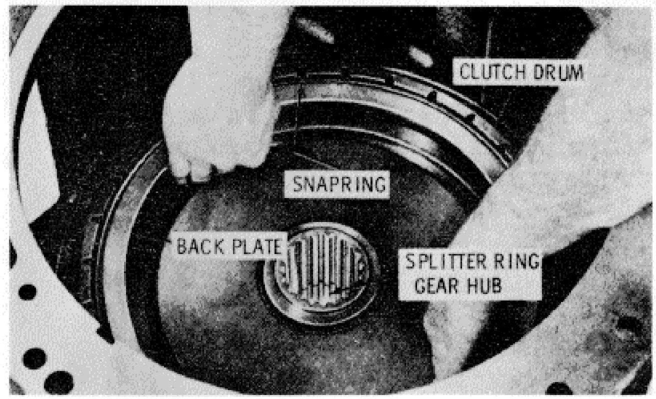
5. To aid in lifting the fifth-and-sixth-gear clutch and drum assembly, install the backplate and snap ring into the fifth and-sixth-gear clutch drum. Grasp the backplate and lower the clutch and drum assembly into the transmission. Align



S1650

Figure 15-116. Installing Compression Ring

the splines of the fifth-and-sixth-gear clutch drum hub with the splines in the splitter ring gear hub (Figure 15-117).



S1651

Figure 15-117. Installing Fifth-and-Sixth-Gear Clutch Drum

6. Install the intermediate-range sun gear(Figure 15-118). Align the sun gear splines with fifth-and-sixth-gear clutch drum splines.

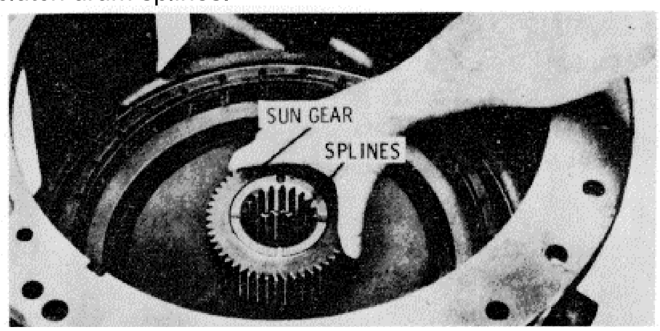


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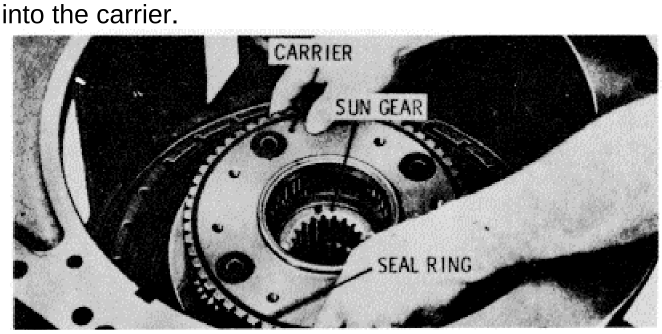
Figure 15-118. Installing Intermediate-Range Sun Gear

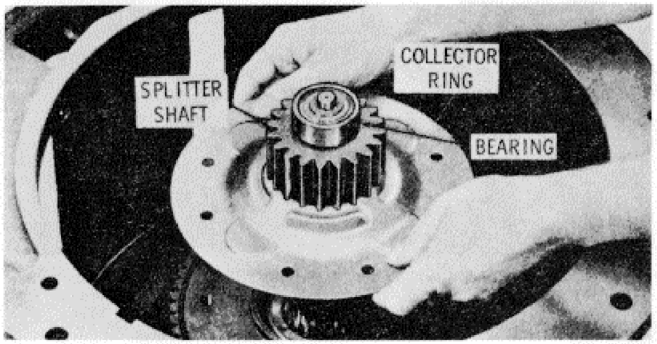
7. Install the intermediate-range planet carrier assembly onto the sun gear (Figure 15-11with9). Align each of four pinion gears with the sun gear. Install the seal ring into the carrier.



S1653

Figure 15-119. Installing Intermediate-Range Planetary Carrier Assembly

8. Install, as a unit, the splitter output shaft, oil collector ring, and splitter shaft bearings (Figure 15-120). If necessary, reach up under the transmission and rotate the splitter ring gear hub in order to align all splines.

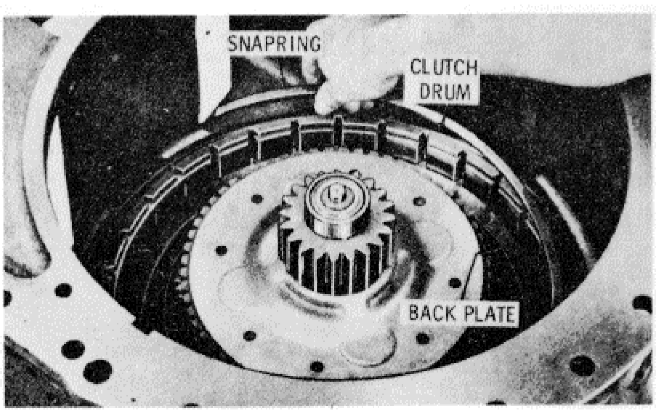


S1654

Figure 15-120. Installing Spliter Output Shaft

9. If the area is accessible, install the splitter output shaft snap ring from inside the front end of the transmission main housing.

10. Remove the large fifth-and-sixth-gear clutch drum snap ring from the clutch drum. Remove the clutch backplate (Figure 15-121).



S1655

Figure 15-121. Removing Fifth-and-Sixth-Gear Clutch Snap Ring and Backplate

11. Install the intermediate-range ring gear, with the shorter counterbore upward (toward the rear of the transmission), onto the intermediate-range planetary carrier assembly (Figure 15-122).

12. Beginning with an internal-splined plate, alternately install one internal and one external-splined fifth-and sixth-gear clutch plate (Figure 15-123). Continue in this manner until all five fifth-and-sixth-gear clutch plates are installed.

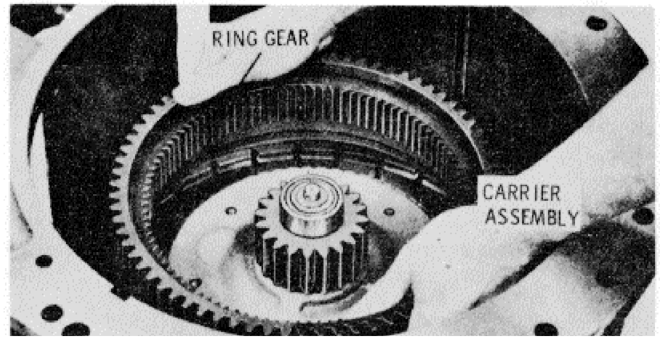


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Figure 15-122. Installing Intermediate-Range Ring Gear

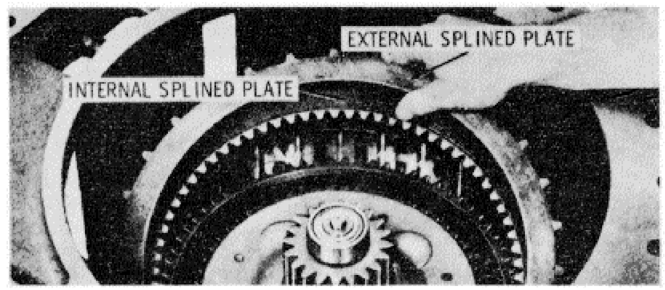

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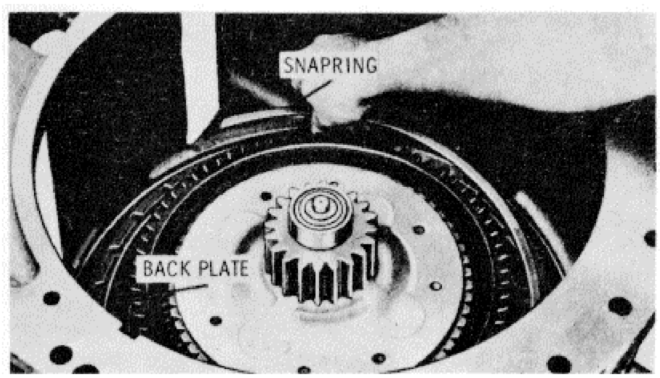
Figure 15-123. Installing Fifth-and-Sixth-Gear Clutch Plates

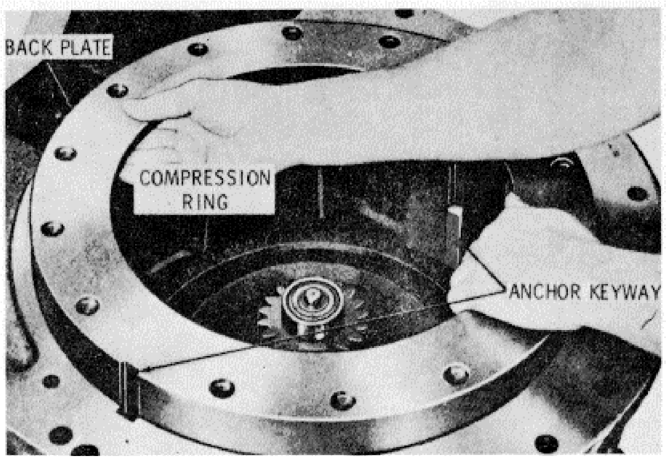
13. Reinstall the fifth-and-sixth-gear clutch backplate. Reinstall the fifth-and-sixth-gear clutch internal snap ring (Figure 15-124).



S1658

Figure 15-124. Installing Fifth-and-Sixth-Gear Clutch Backplate Snap Ring

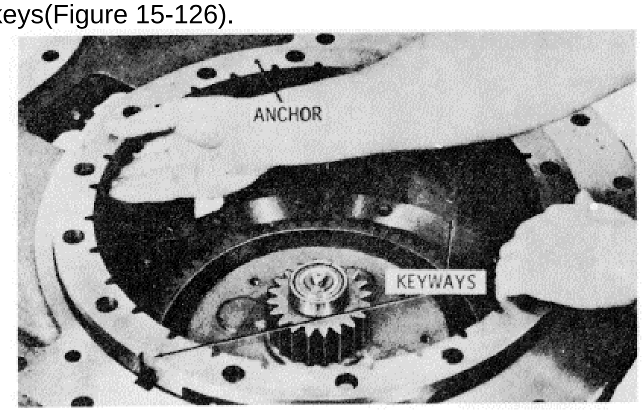
14. Install the third-and-fourth-gear clutch backplate, aligning the keyways with the anchor keys (Figure 15-125). Be certain the compression ring is positioned against the surface of the main housing where the backplate seats.



S1659

Figure 15-125. Installing Third-and-Fourth-Gear Clutch Backplate

15. Install third-and-fourth-gear clutch anchor 17 (B, Foldout 10), aligning the keyways with the anchor keys(Figure 15-126).



S1660

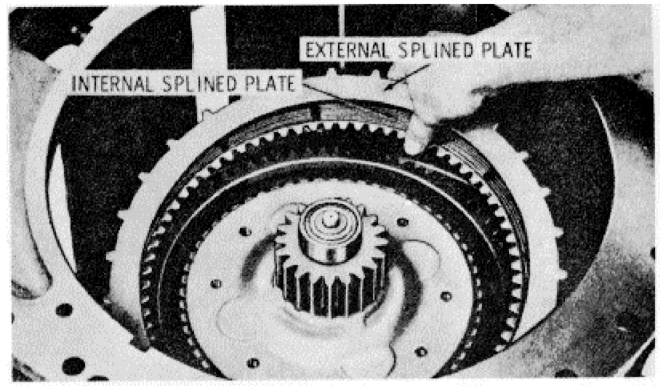
Figure 15-126. Installing Third-and-Fourth-Gear Clutch Anchor

16. Beginning with an internal-splined plate, alternately install one internal and one external-splined, third-and fourth-gear clutch plate (Figure 15-127). Continue in this manner until all six third-and-fourth-gear clutch plates are installed.

17. Install fourteen third-and-fourth-gear clutch piston return springs into the clutch anchor (Figure 15-128).

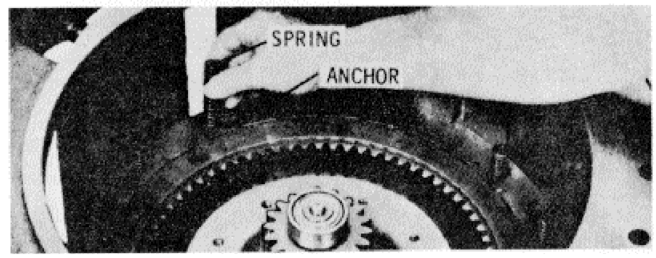
18. Refer to page 15-44 and install seal ring 21 (B, Foldout 10) and seal ring 23 onto piston 22. Be sure the lips of the seal rings face the piston housing (rearward).

19. If removed, install pin 26 (B, Foldout 10) into piston housing 25. Press in the pin until the head of the pin is flush against the surface of the piston housing. Install piston 22, with seal rings into piston housing assembly 24.



S1661

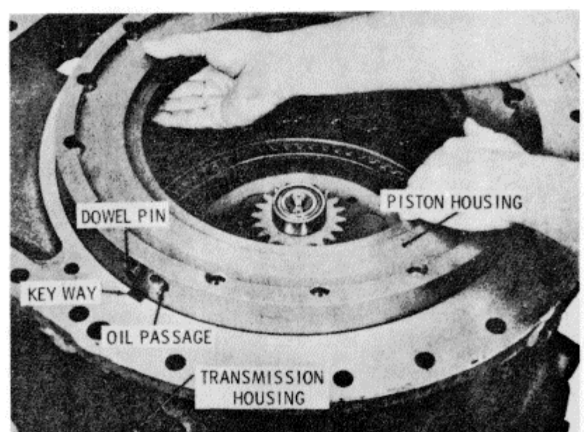
Figure 15-127. Installing Third-and-Fourth-Gear Clutch Plates



S1662

Figure 15-128. Installing Third-and-Fourth-Gear Clutch Piston Return Spring

20. Install, as a unit, the third-and-fourth-gear clutch piston and piston housing (Figure 15-129). Align the dowel pin with the keyway in the transmission housing. Align the oil passage with the oil passage in the transmission housing.

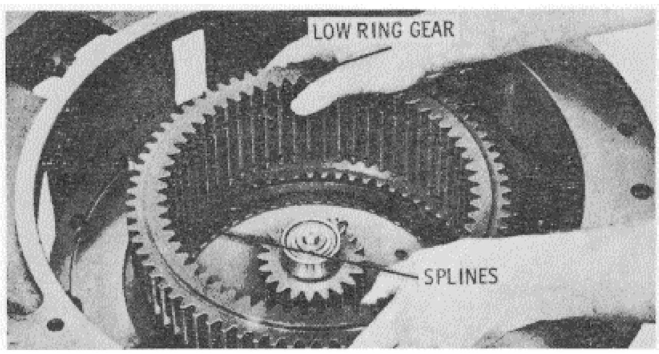


S1663

Figure 15-129. Installing Third-and-Fourth-Gear Clutch Piston Housing and Piston

INSTALLING LOW-RANGE PLANETARY AND FIRST-ANDSECOND-GEAR CLUTCH. Install low-range planetary and clutch as follows:

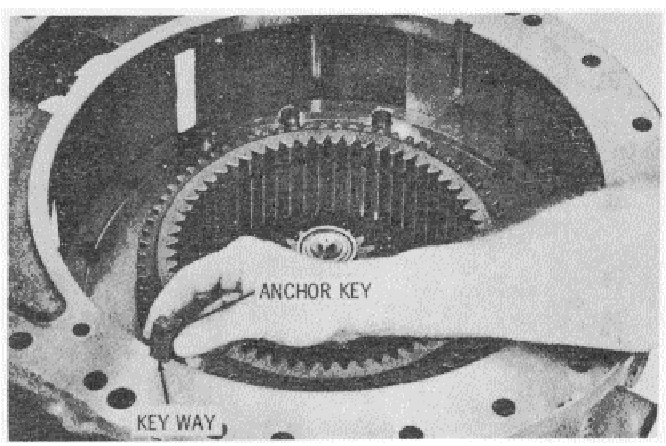
1. Install the low-range ring gear with the longer, outer shoulder downward. Engage the internal splines of the ring gear with the intermediate-range carrier splines (Figure 15130).



S1664

Figure 15-130. Installing Low-Range Ring Gear

2. Install two (one at each side) anchor keys (approximately 1.25 inches long) into the keyways in the transmission housing (Figure 15-131).

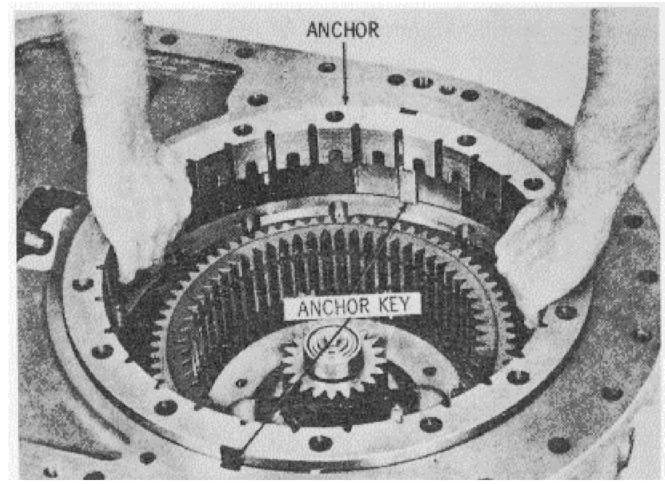


S1665

Figure 15-131. Installing Anchor Key

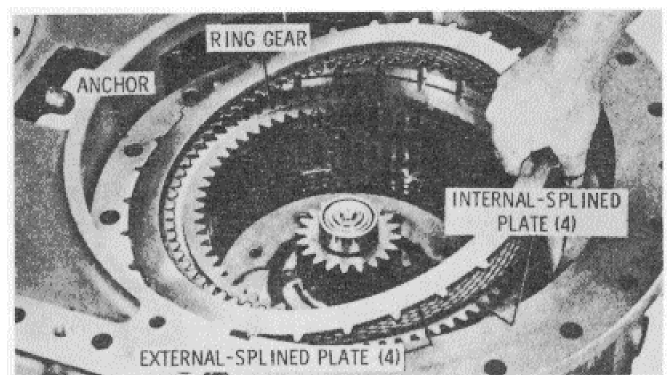
3. Install the first-and-second-gear clutch anchor, flat side upward aligning the keyways in the anchor with the anchor keys (Figure 15-132).

4. Beginning with an internal-splined plate, alternately install one internal and one external-splined, first-and second-gear clutch plate. The external-splined plate indexes with the first-and-second-gear clutch anchor, and the internal-splined plate indexes with the low-range ring gear (Figure .15-1 33). Continue in this manner until all eight first-and-second-gear clutch plates are installed.



S1666

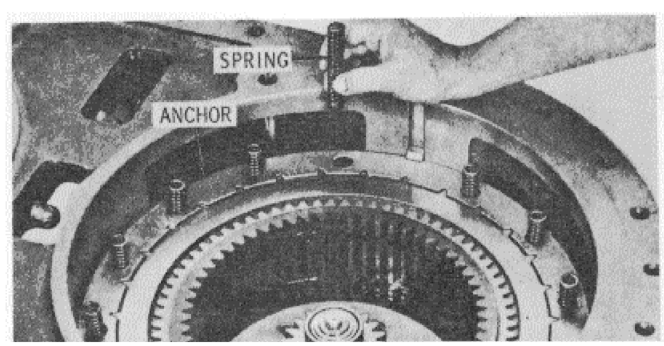
Figure 15-132. Installing First-and-Second-Gear Clutch Anchor



S1667

Figure 15-133. Installing First-and-Second-Gear Clutch Plates

5. Install fourteen first-and-second-gear clutch piston return springs into the first-and-second-gear clutch anchor (Figure 15-134).



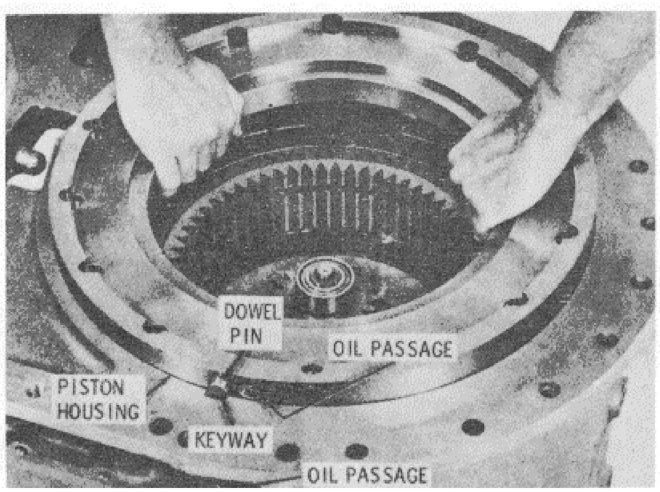
S1668

Figure 15-134. Installing First-and-Second Gear Clutch Piston Return Springs

6. Refer to page 15-44, and install seal ring 23 (A, Foldout 11) and seal ring 25 into piston 24. Be sure the lips of the seal rings face the piston housing (rearward).

7. If removed, install pin 28 into piston housing 27. Press in the pin until the head of the pin is flush against the surface of the piston housing. Install piston 24, with seal rings into piston housing assembly 26.

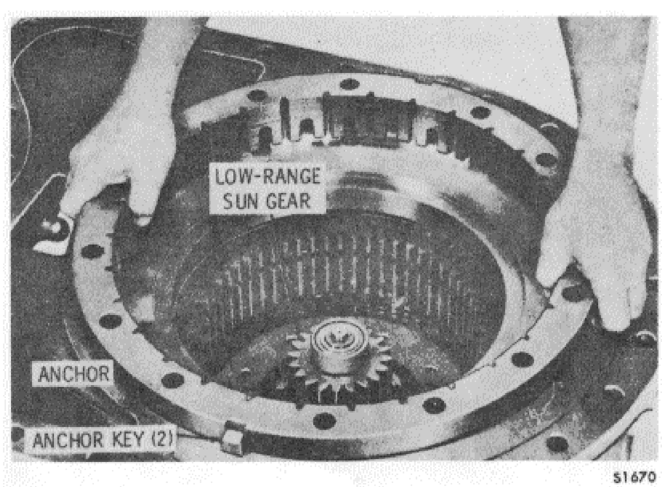
8. Install, as a unit, the first-and-second-gear clutch piston housing and piston. Align the dowel pin with the keyway. Align the oil passage with the oil passage in the transmission housing (Figure 15-135).



S1669

Figure 15-135. Installing First-and-Second- Gear Clutch Piston Housing and Piston

9. Install two (one at each side) anchor keys (approximately 1.7 inches long) into the keyways. Install flat side upward, the reverse clutch anchor, aligning the keyways with the anchor keys (Figure 15-136).



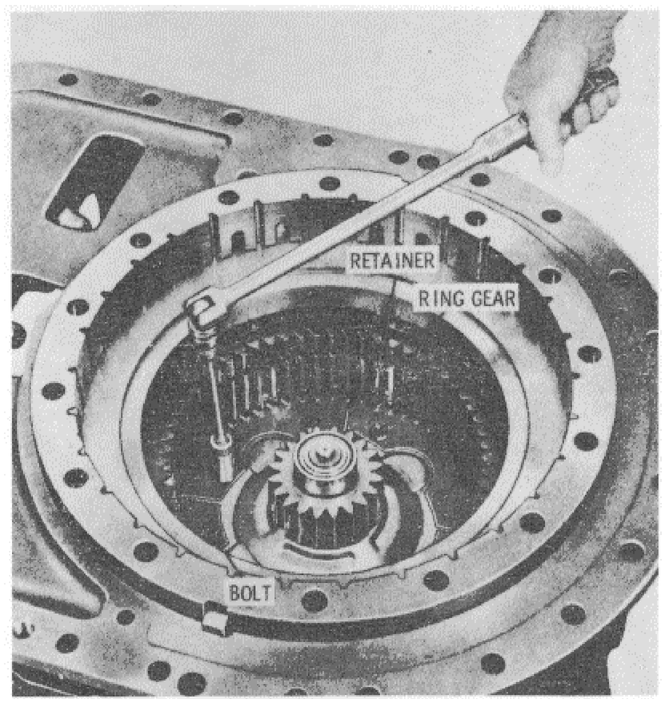
S1670

Figure 15-136. Installing Reverse-Gear Clutch Anchor

10. Install four retainers into a groove in the low-range ring gear. (It may be necessary to compess the clutch piston return springs to align the groove in the gear with the retainers.) Secure the retainers with eight 3/8-24 x 5/8 inch, self-locking bolts (Figure 15-137). Tighten the bolts to 41 49 lb ft (56-66 N.m). Be sure the splines of the intermediate-range carrier and the low-range ring gear are aligned.

CAUTION

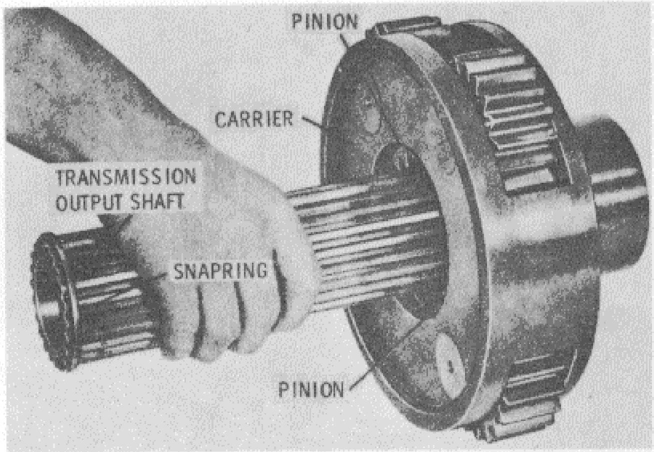
Rotate each pinion so the snap ring is cleared as the output shaft is installed in step 11. The snap ring must seat against the carrier.



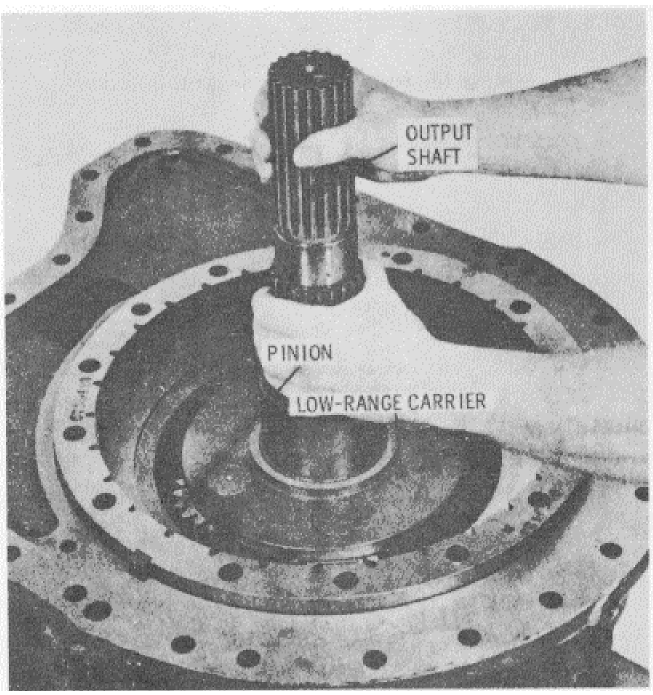
S1671

Figure 15-137. Installing Low-Range Ring Gear Retainer Bolts

11. Install the transmission output shaft with the snap ring into the low-range planetary carrier (Figure 15-138).
12. Install the low-range carrier assembly and transmission output shaft (Figure 15-139). Engage the carrier pinions with the splitter output shaft (low-range sun gear).
13. Install the bronze thrust washer onto the low-range carrier hub. Install the reverse-gear sun gear over the hub of the carrier. Engage the sun gear splines with the teeth of the low-range ring gear (Figure 15-140).
INSTALLING REVERSE-GEAR PLANETARY CARRIER AND CLUTCH. Install reverse-gear planetary carrier and clutch as follows: 1. Install the bronze thrust washer onto the reverse-gear sun gear. Install the reverse-gear planetary carrier assembly and bearing onto the reverse-gear sun gear (Figure 15141).



S1672
Figure 15-138. Installing Transmission Output Shaft



S1673
Figure 15-139. Installing Low-Range Carrier Assembly

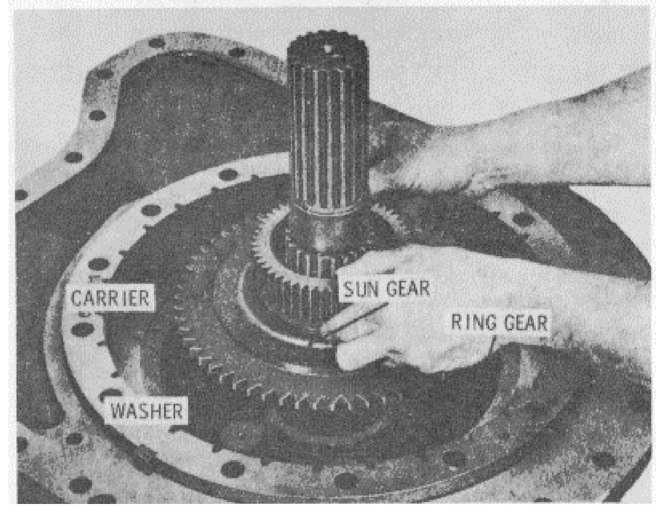


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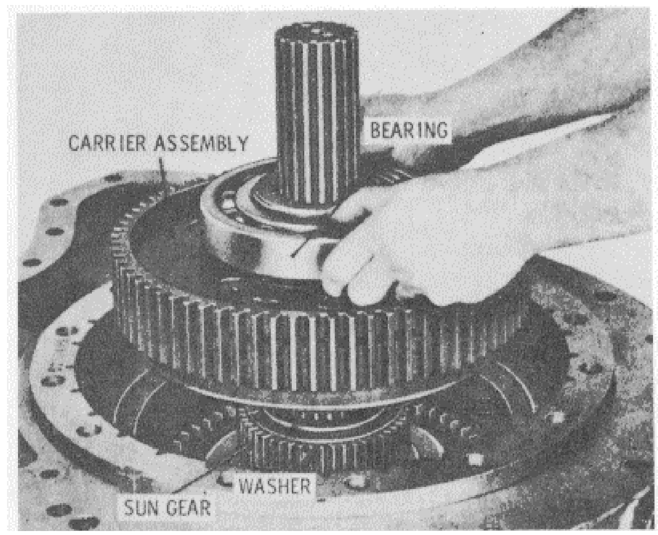
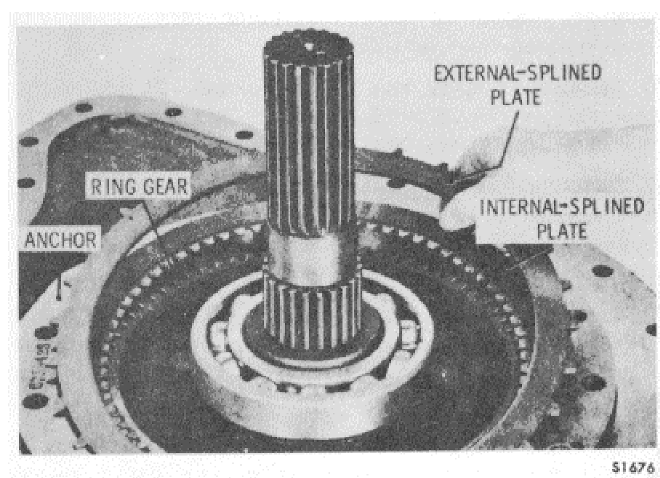
Figure 15-140. Installing Reverse-Range Sun Gear



S1675
Figure 15-141. Installing Reverse-Gear Planetary Carrier Assembly



S1676
Figure 15-142. Installing Reverse-Gear Clutch Plates

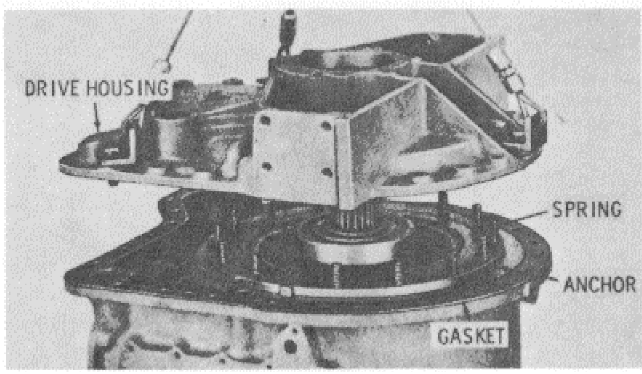
2. Beginning with an internal-splined plate, alternately install one internal and one external-splined, reverse-gear clutch plate (Figure 15-142). The internal-splined plate engages the reverse-gear ring gear, and the external-splined plate engages the reverse-gear clutch anchor. Continue in this manner until all ten reverse-gear clutch plates are installed.

3. Install fourteen reverse-gear clutch piston return springs into holes in the clutch anchor (Figure 15-143).

INSTALLING OUTPUT DRIVE HOUSING COMPONENTS. Install output drive housing components as follows:

1. Install the gasket onto the transmission housing (Figure 5-143).

2. Install the output drive housing (Figure 15-143). Retain it with twenty-seven 5/8-11 x 1-3/4 inch bolts and lockwashers (installed from the front of the main housing rear flange), and two 5/8-11 x 3-3/4 inch bolts and lockwashers, installed at the rear of the housing. Tighten the bolts to 117-140 lb ft (159-189 N.m).

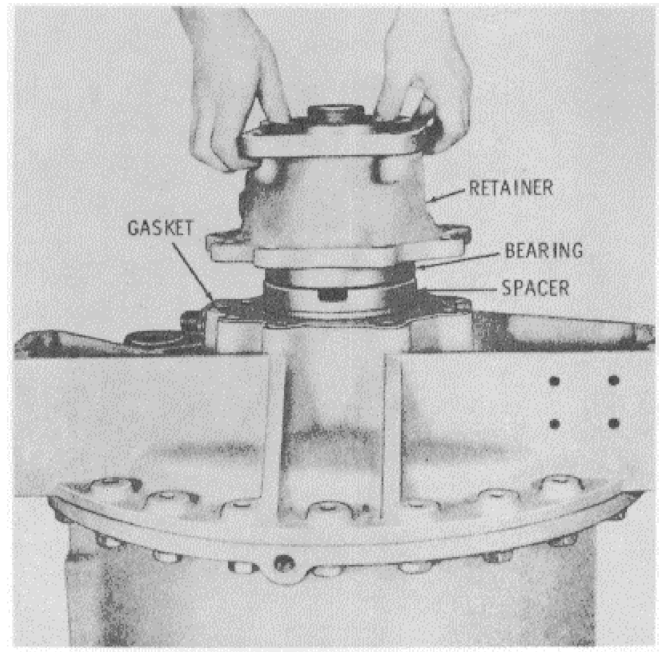


S1677

Figure 15-143. Installing Output Drive Housing

3. Using housing assembly 2 (A, Foldout 12), press gear 26 (if removed) onto gear 25 and install gear assembly 24, spur-tooth gear last, onto the shaft.
4. If gear assembly 24 is used, install spacer 27. Position the spacer gap (approximately 5 o'clock) to accept magnetic pickup 18.
5. Heat bearing 10 to 2000F (930C) in an oil bath (approximately 30 minutes). Install the bearing so the outer race is against spacer 27 and the inner race is against speedometer drive gear 25.
6. Install the gasket, cover 31 (A, Foldout 12). Secure the assembly with two 5/16-18 x 7/8 inch bolts and lockwashers. Tighten the bolts to 13-16 lb ft (18-21 N.m).
7. Install gasket 7 and rear bearing retainer assembly 13, and secure the retainer with eight 5/8-11 x 1-3/4 inch bolts and lockwashers (Figure 15-144). Tighten the bolts to 117-140 lb ft (159-189 N.m).
8. Coat the theads of magnetic pickup 18 with pipe sealant with teflon (not teflon tape) and screw in the pickup until it touches the OD of gear 26. Back it off 3/4 turn and tighten the nut to 13-16 lb ft (18-21 N.m).

INSTALLING SPLITTER OUTPUT SHAFT SNAP RING, SPLITTER-OVERDRIVE CLUTCH. Install splitter components as follows:



S1680

Figure 15-144. Installing Rear Bearing Retainer

1. Attach a two-strand lifting sling to the transmission rear mounting pads and raise the transmission until the front end clears the work table.

CAUTION

Keep the transmission rear higher than the transmission front. If the transmission should be lowered to a horizontal position, or the transmission rear be lowered below the transmission front, some parts within the housing could shift, preventing the snap ring from being installed on the splitter output shaft.

2. Rearrange the wood blocks and lower the transmission with the forward edge of the oil pan split line resting on the block (Figure 15-145).
3. If not previously installed, install the splitter shaft snap ring (Figure 15-145). Then lower the rear of the transmission onto wood blocks, and remove the sling.

NOTE

Transmission support legs J-23556 (Figure 15-146) may be installed at this time to support the transmission, rear downward.

4. Install two anchor keys (approximately 3.91 inch long), stepped ends first, longer sides inward, into keyways at the front of the transmission housing (Figure 15-147). Refer to page 15-44 and install seal rings 23 and 24 onto piston 22. Be sure the lips of the lip-type seal rings face the piston housing (rearward). Install the piston, with seal rings, into housing 26. Install, piston upward, the splitter-overdrive

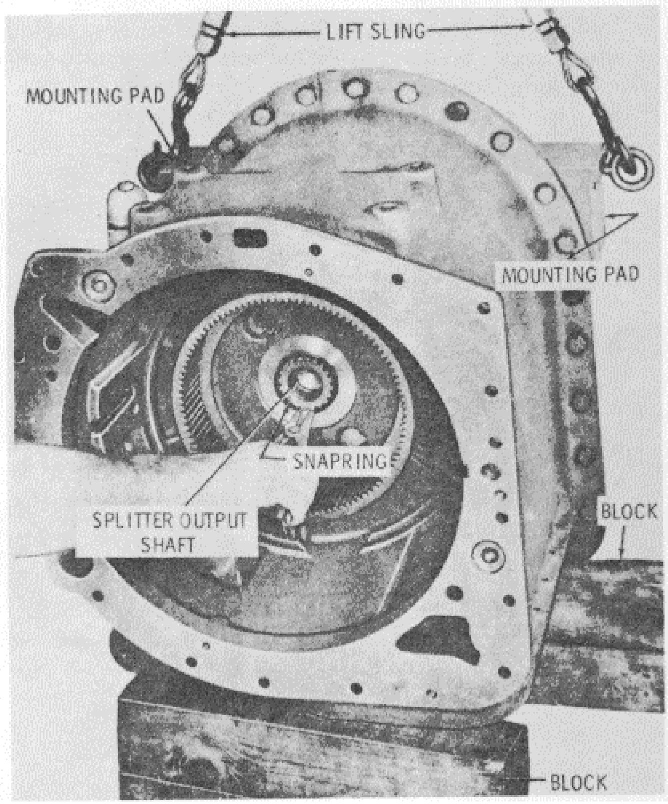


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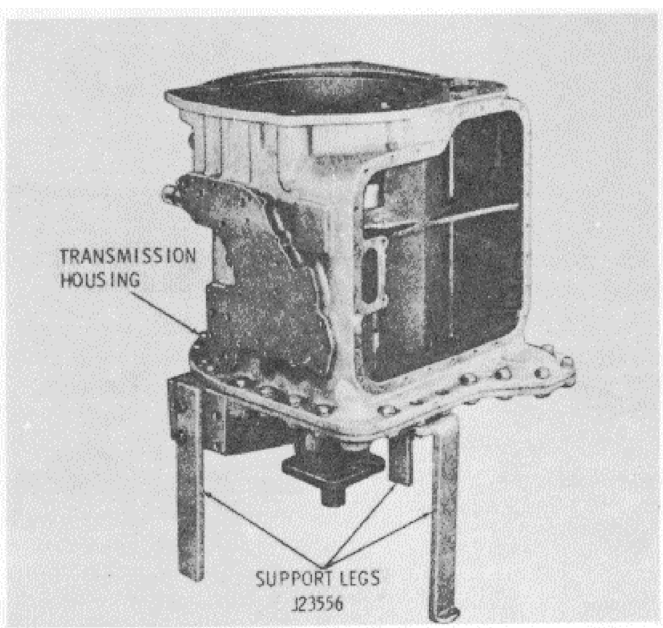
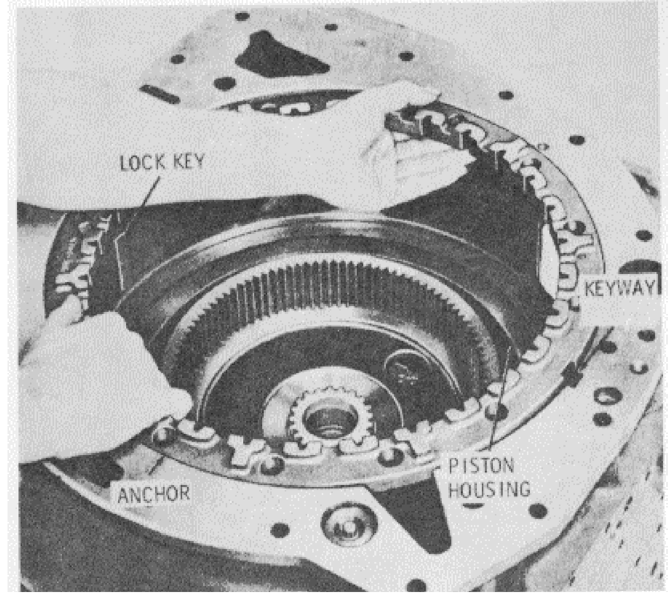
Figure 15-145. Installing Splitter Shaft Snap Ring



S3236

Figure 15-146. Transmission Housing with 3 Support Legs Attached

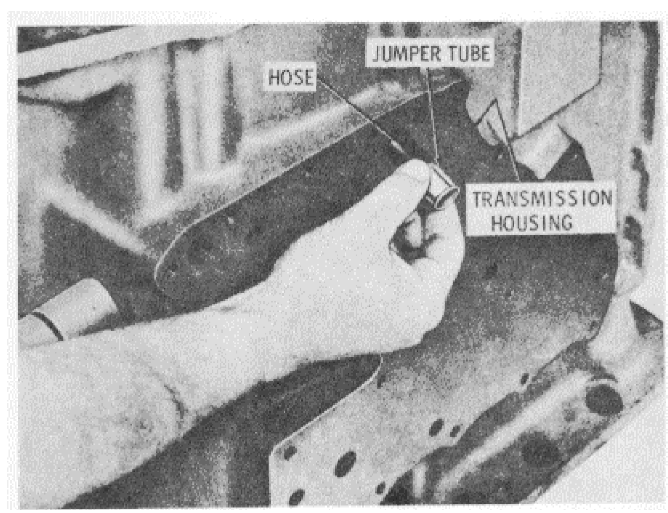


S1682

Figure 15-147. Installing Splitter-Overdrive Clutch Anchor

clutch piston and housing assembly, being sure to index oil passages. Install, flat side first, the splitter-overdrive clutch anchor. Align the keyways in the anchor with the anchor keys.

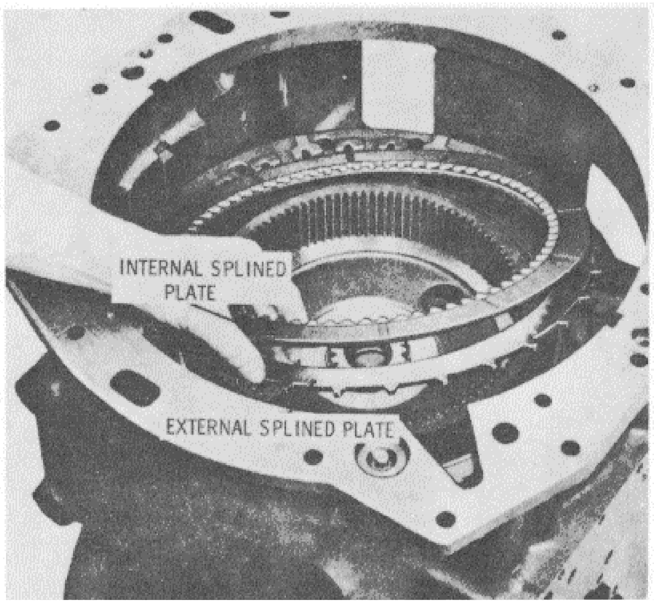
5. With the hose installed on the tube, install the splitter overdrive oil jumper tube, hose end first, through the transmission housing into the oil passage port of the splitter overdrive clutch piston housing (Figure 15-148).



S1683

Figure 15-148. Installing Splitter-Overdrive Clutch Oil Jumper Tube

6. Beginning with an external-splined plate, alternately install one external and one internal-splined, splitter overdrive clutch plate (Figure 15-149). Continue in this

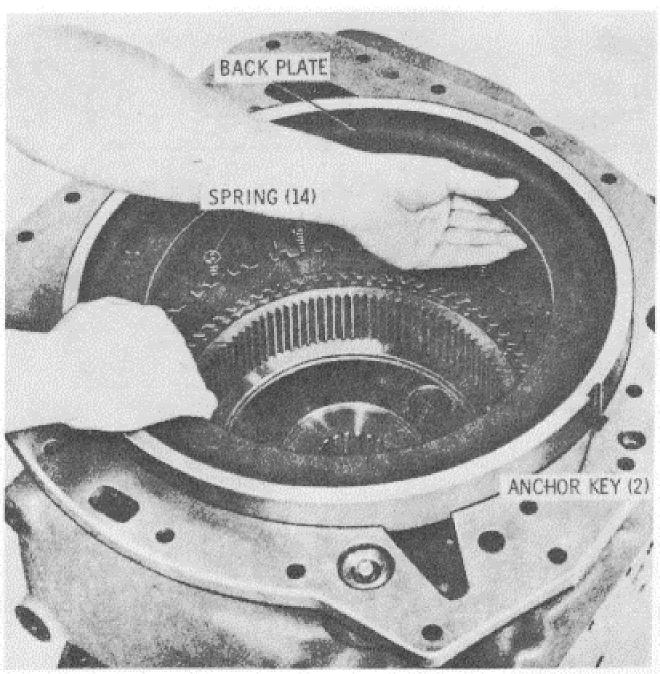


S1684

Figure 15-149. Installing Splitter-Overdrive Clutch Plates

manner until all six splitter-overdrive clutch plates are installed.

7. Install fourteen splitter-overdrive clutch piston return springs (Figure 15-150). Install, flat side first, the splitter overdrive clutch backplate. Align the keyways in the backplate with the anchor keys in the transmission housing.



S1685

Figure 15-150. Installing Splitter-Overdrive Clutch Backplate

8. Install the spacer (Figure 15-151) notched area facing down and open section toward the bottom of the transmission housing. Secure the spacer with two retainers and two 3/8-16 x 3/4 inch bolts. Tighten the bolts to 26-32 lb ft(3643 N.m).

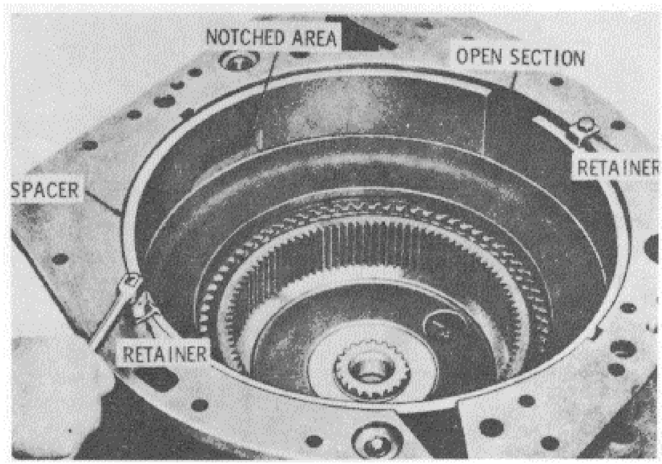


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Figure 15-151. Installing Splitter-Overdrive Clutch Backplate Spacer Retainers

9. Install two oil jumper tubes, each with a hose (Figure 15-152).

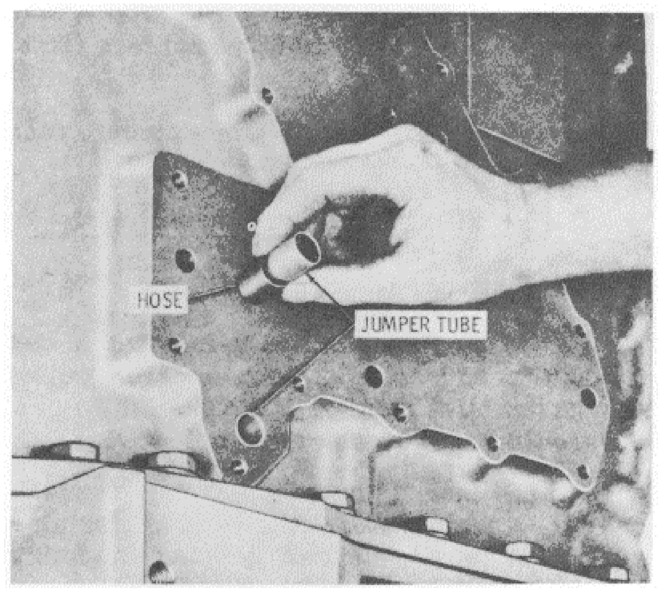

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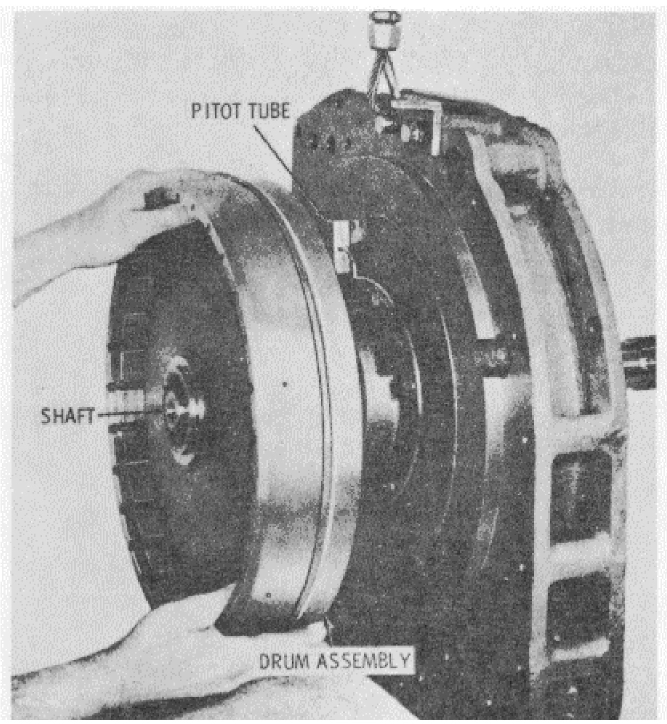
Figure 15-152. Installing First-and-Second-Gear and Third-and-Fourth-Gear Clutch Oil Jumper Tubes

INSTALLING SPLITTER PLANETARY, SPLITTER-DIRECT CLUTCH AND HYDRAULIC RETARDER. Install splitter material and hydraulic retarder as follows:

1. Install lockstrip 15 (B, Foldout 6) and one 5/16-24 x 2 inch bolt 14. The bolt must pass through the web of the retarder housing, and be threaded loosely into pitot tube 23.
2. Heat the hydraulic retarder rotor in an oven or hot oil bath to 3000F(1480C)(maximum). (Do not use direct flame.) Install snap ring 11 into the groove on the largest splined diameter of the turbine output shaft. Press the shaft, rear end first, into the front of the rotor 1 2. Seat snap ring 11 against the hub of the rotor.
3. Install splined spacer 13 onto the rear of the turbine output shaft. Install the hydraulic retarder housing onto the assembled shaft and rotor (Figure 15-155).
4. Install the ball bearing, seal ring and oil transfer hub onto the rear of the retarder housing (Figure 1 5-1 56). Retain the hub with five 1/2-13 x 1-1/4 inch bolts and lockwashers. Tighten the bolts to 67-80 lb ft (91-108 N.m).
5. Install the splitter-direct clutch and drum assembly onto the rear of the turbine output shaft (Figure 15-153).



S1691

Figure 15-153. Installing Splitter-Direct Clutch and Drum Assembly

6. Using a thin metal strip between the clutch and drum assembly and the retarder housing, position the pitot tube to receive the remaining pitot tube bolt (Figure 15-154) use access holes in the retarder rotor.
7. Install a 5/16-24 x 2 inch bolt through the lockstrip, through the retarder housing web, and into the pitot tube. Tighten both pitot tube bolts to 14-18 lb ft (19-24 N.m). Bend a corner of the lockstrip against each bolt head.

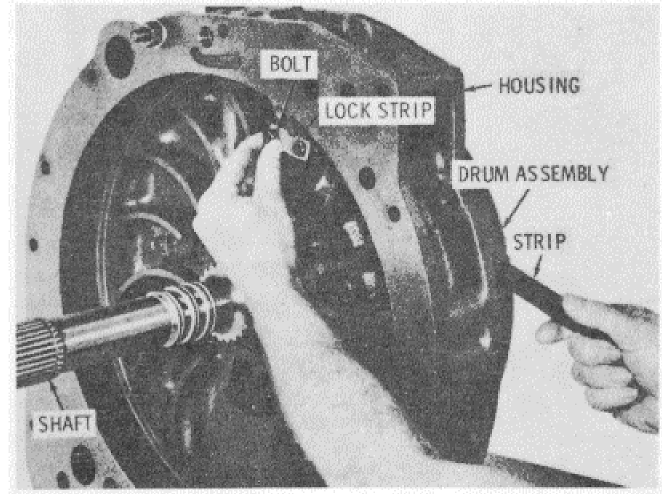


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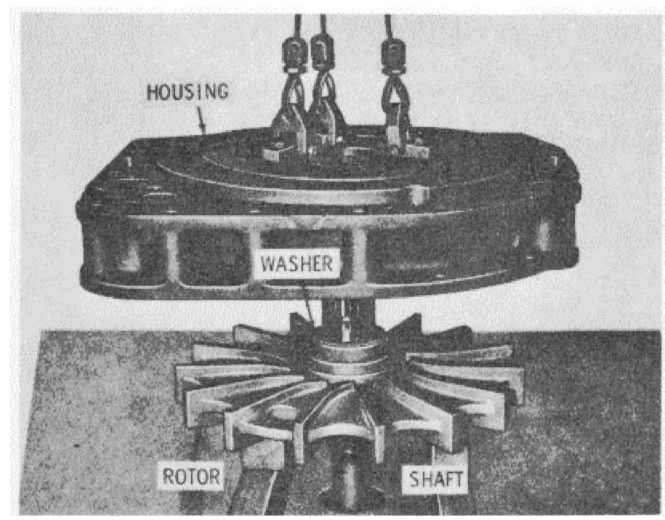
Figure 15-154. Installing Pitot Tube Bolt



S1693

Figure 15-155. Installing Retarder Housing onto Retarder Rotor and Turbine Shaft

8. Install two (models without lockup) or three (models with lockup) hook-type seal rings onto the turbine output shaft (Figure 15-157).
9. Install the splitter-direct clutch hub over the splitter planetary carrier, indexing the splitter sun gear with the splitter carrier pinions (Figure 15-158). Support the carrier on a press and place a pressing tool on the inner race of the bearing. Press the bearing onto the hub of the carrier.
10. Carefully tip the retarder housing so the rotor end of the turbine shaft rests on the work table (Figure 15-159). Install the splitter planetary carrier assembly and splitter clutch hub onto the turbine shaft. Install the snap ring onto the end of the turbine shaft.

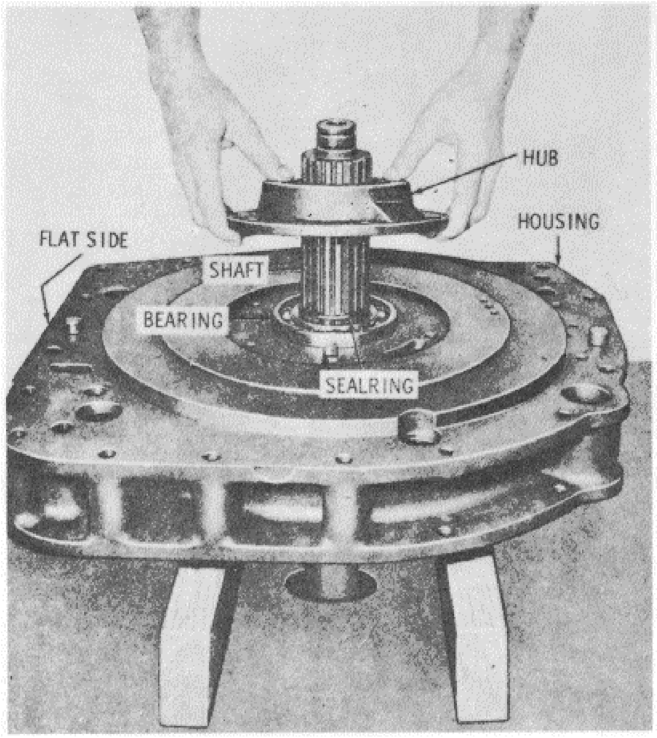


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Figure 15-156. Installing Oil Transfer Hub onto Retarder Housing

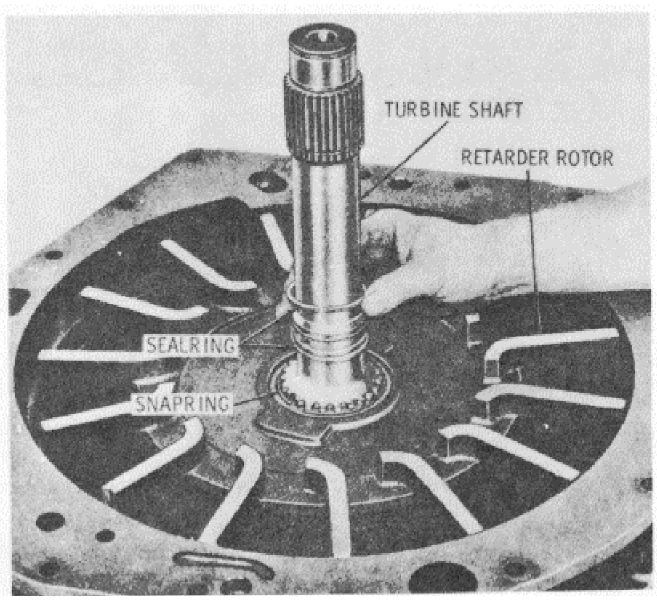

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Figure 15-157. Installing Seal Rings onto Turbine Output Shaft

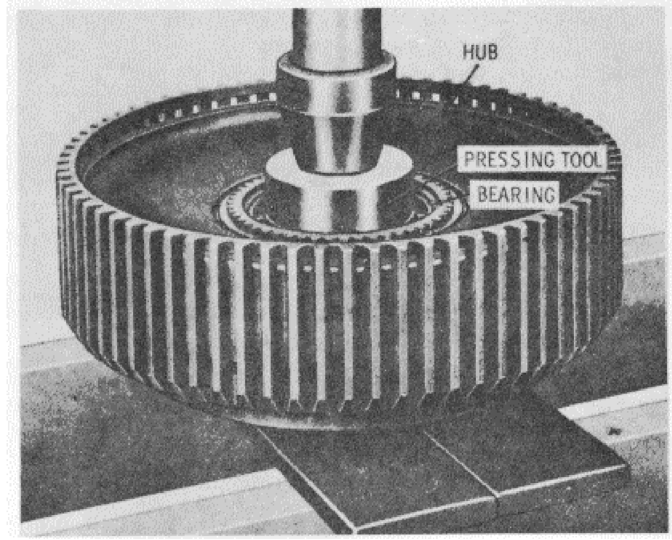

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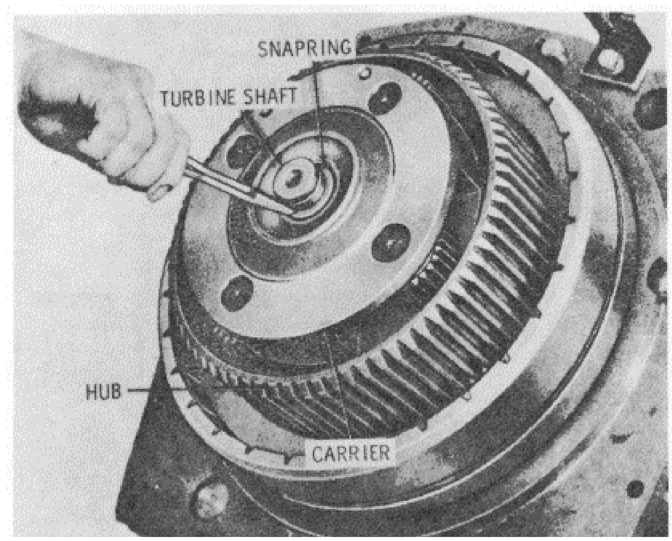
Figure 15-158. Installing Splitter-Direct Clutch Hub



S1696

Figure 15-159. Installing Snap Ring that Retains Splitter Planetary

11. Install the seal ring onto the turbine shaft (Figure 151 60). Install one internal-, then one external-, then another internal-splined clutch plate into the splitter-direct clutch drum.

12. Install the backplate into the splitter-direct clutch drum (Figure 15-161). Install the internal snap ring.

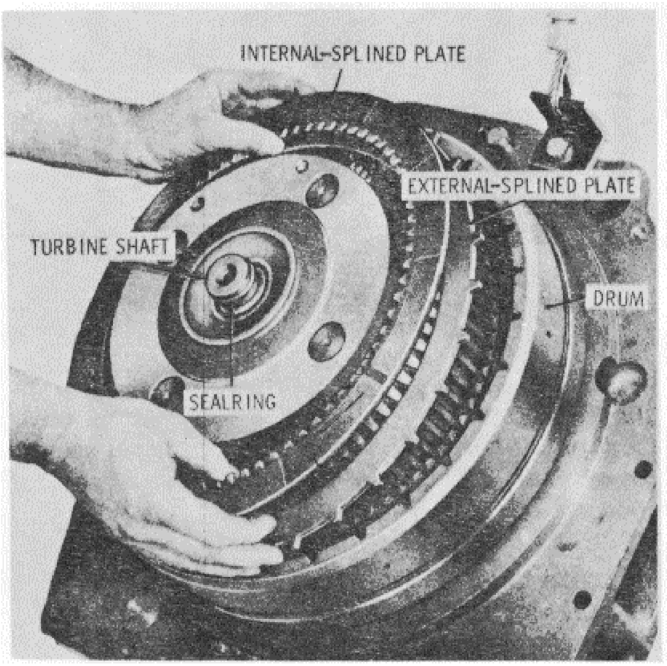


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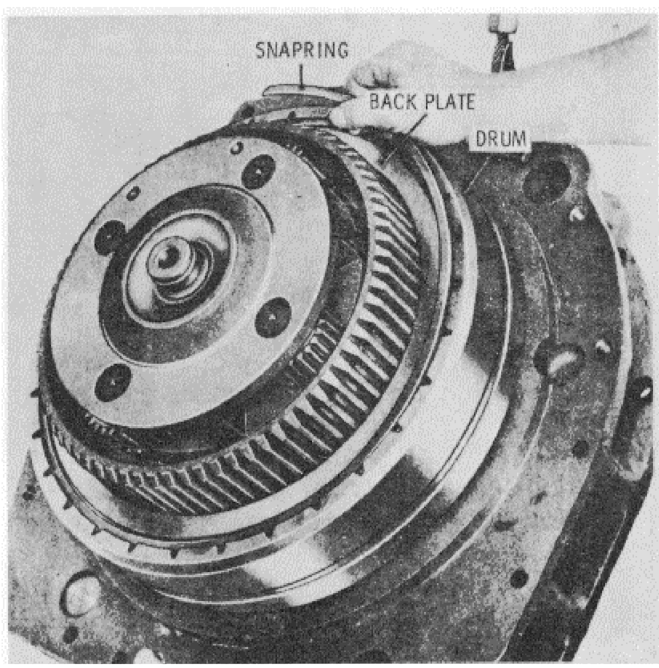
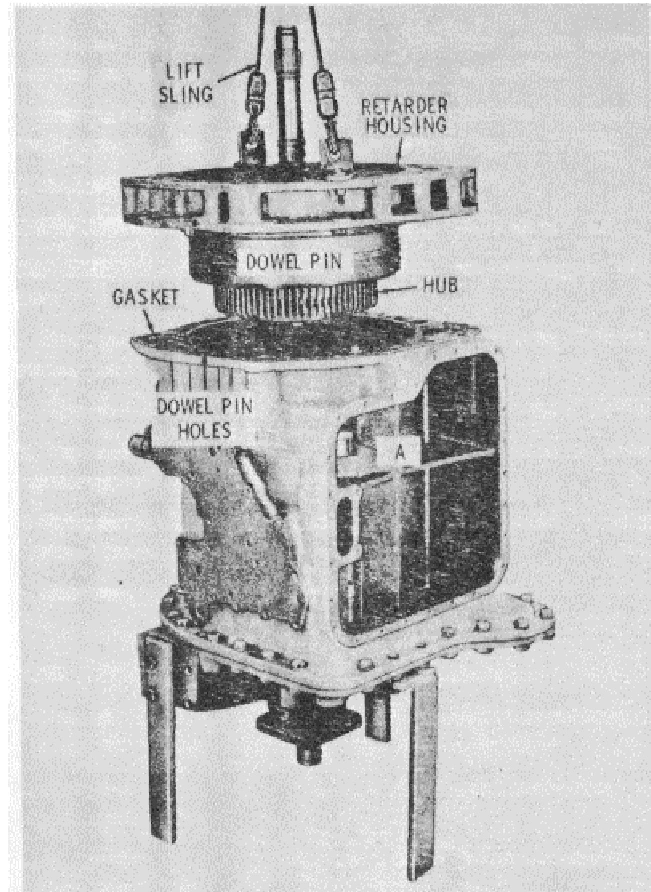
Figure 15-160. Installing Splitter-Direct Clutch Plates



S1698

Figure 15-161. Installing Splitter-Direct Clutch Backplate Snap Ring

13. Install the gasket onto the transmission housing (Figure 15-1 62). Attach the two-strand lifting sling to the rotor side of the retarder housing and lower the housing and attached parts onto the transmission. Align the splines of the



S1699

Figure 15-162. Installing Retarder Housing onto Transmission Housing

splitter-direct clutch hub with splines of the splitter-overdrive clutch plates inside the transmission. It may help to use a screwdriver at location A (Figure 15-162) to engage the hub with the splitter-overdrive clutch plates. Engage the splitter ring gear, inside the transmission, with the splitter planetary pinions. Align the dowel pins in the retarder housing with the dowel pin holes on both sides of the transmission housing. Install seven 1/2-13 x 1-3/4 inch bolts and lockwashers through the transmission housing side of the splitline. Tighten the bolts to 67-80 lb ft (91-108 N.m).

INSTALLING CONVERTER HOUSING COMPONENTS. Install converter housing components as follows:

1. Block the converter housing in an upright position (Figure 15-163). Install the input pressure oil pump drive gear bearing into the housing. Install the oil pump drive gear, longer end of the hub toward the rear, into the housing recess behind the bearing.

2. Support the pump drive gear with one hand and, with the other hand, engage the pump drive gear hub and bearing by pushing it halfway into the pump drive gear (Figure 151 64). Partial installation of the gear hub will allow space for the gear spacer (Figure 15-165).

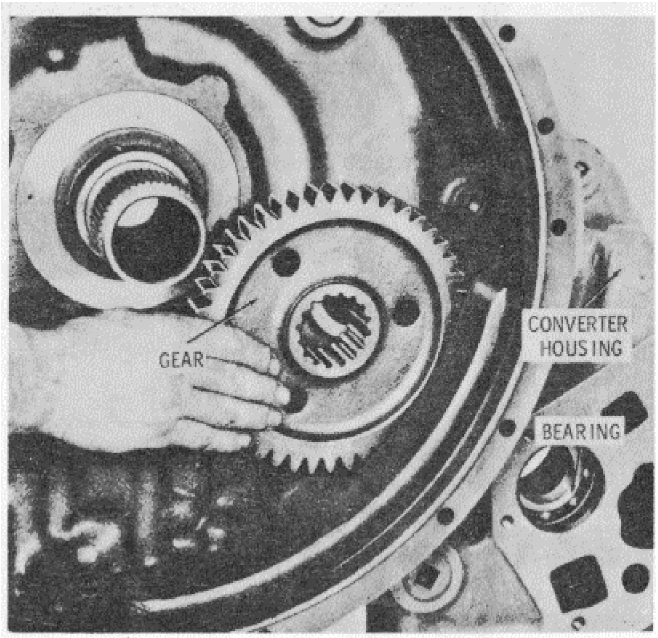


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Figure 15-163. Installing Oil Pump Drive Gear

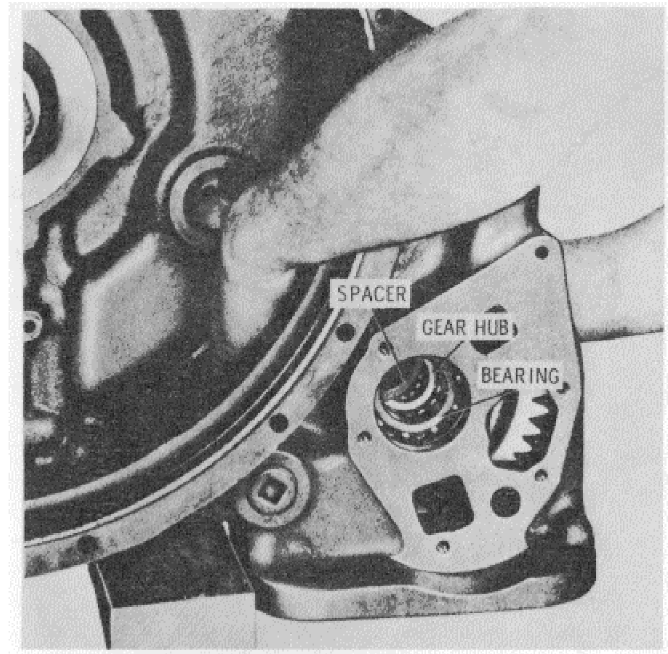

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Figure 15-165. Installing Pump Drive Gear Spacer

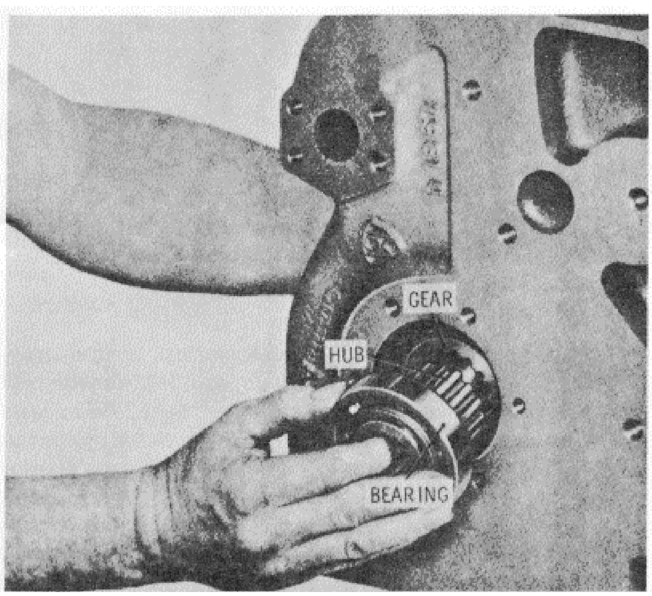

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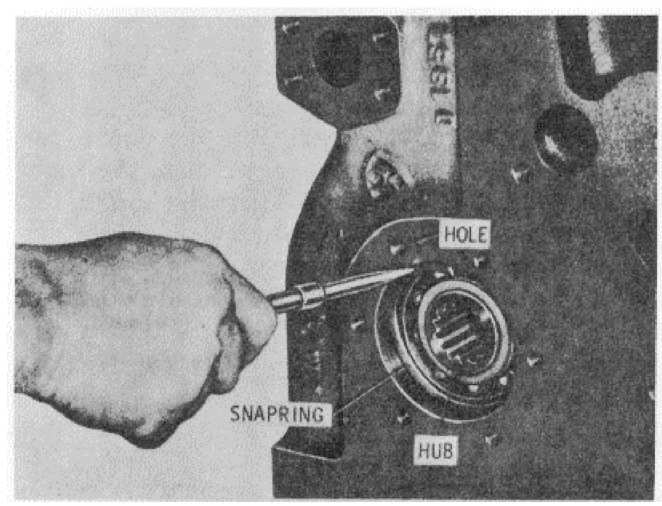
Figure 15-164. Installing Pump Drive Gear Hub



S1703

Figure 15-166. Installing Pump Drive Gear Hub Bearing Snap Ring

3. Support the gear hub and bearing with one hand and, with the other hand, install the pump gear spacer. Push the gear hub through the spacer and all the way into the pump gear (Figure 15-165).

4. Tap on the gear hub to seat it in the pump drive gear. Secure the bearing with the snap ring (Figure 15-166). Install the pump drive gear hub gasket and cover (Figure 15-167) onto the converter housing and install six 3/8-16 x 7/8 inch bolts and lockwashers. Tighten the bolts to 26-32 lb ft (36-43 N.m).

5. Install the bearing into the oil pump idler gear. Secure the bearing with the snap ring (Figure 15-168).

6. Install the oil pump idler gear and bearing assembly (snap ring down) over the idler gear spindle bore in the converter housing (Figure 15-169). Align the gear with the spindle bore.

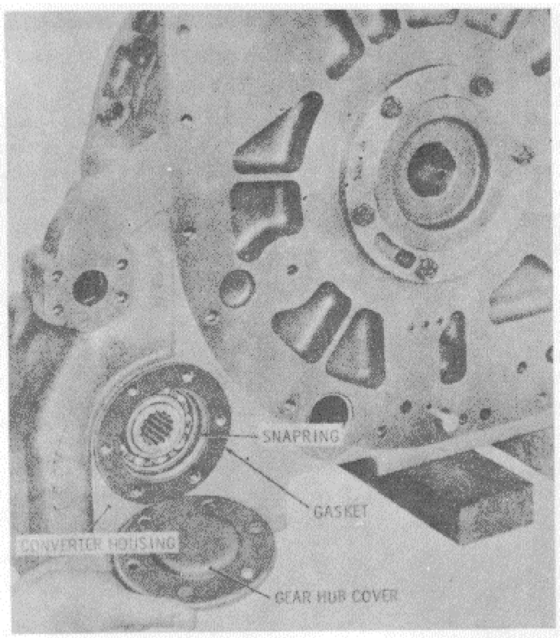


Figure 15-167. Installing Pump Drive Gear Hub Cover

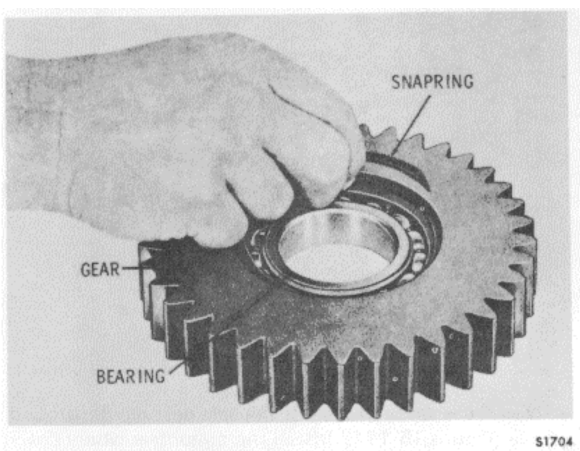


Figure 15-168. Installing Oil Pump Idler Gear (or PTO Idler Gear) Bearing Snap Ring

7. Install one hook-type seal ring onto the converter ground sleeve (Figure 15-170). Install a headless, 1/2-13 guide bolt into the tapped hole at the bottom of the drive gear spindle bore. Using gloves, install the spindle, which has been chilled in dry ice. Remove the guide bolt and secure the spindle with a 1/2-13 x 2-1/2 inch bolt and lock-washer. If power takeoff (PTO) is used, install the power takeoff idler gear and spindle in the same manner. Tighten the bolt(s) to 67-80 lb ft (91-108 N.m).

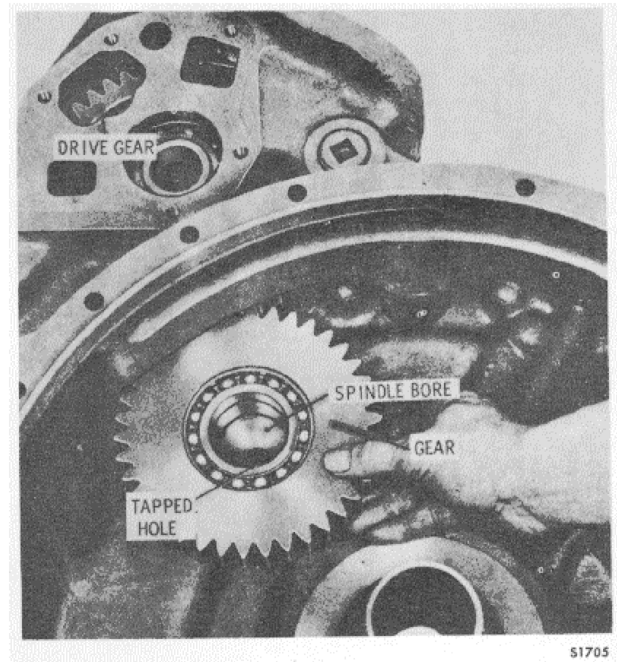


Figure 15-169. Installing Oil Pump Idler Gear Assembly

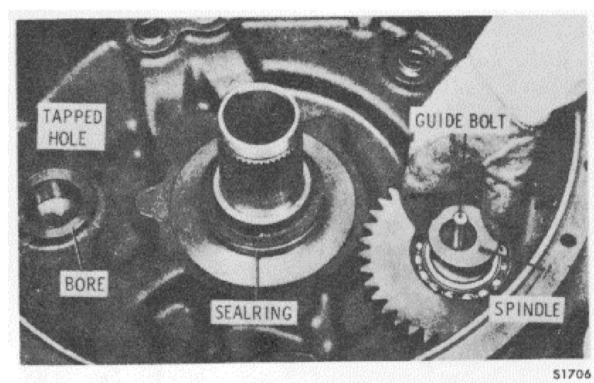


Figure 15-170. Installing oil pump idler gear spindle

INSTALLING CONVERTER HOUSING. Install converter housing as follows:

CAUTION

When lowering the converter housing, lower it slowly and carefully, keeping it centered over the turbine shaft, so the hook-type seal rings on the shaft will not be damaged during the installation.

1. Attach a two-strand lifting sling to the converter housing (Figure 15-171). Install a gasket onto the retarder housing. Lower the converter housing, aligning dowel pins in the

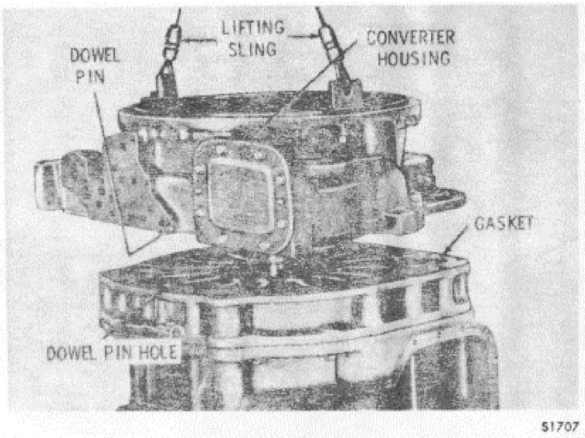


Figure 15-171. Installing Converter Housing onto Retarder Housing

converter housing with dowel pin holes on both sides of the retarder housing.

2. Install seven 1/2-13 x 1-1/2 inch bolts and lockwashers and twelve 1/2-13 x 5 inch bolts and lockwashers into the converter housing. The short bolts go through the front flange of the retarder housing; the long bolts through the front of the transmission housing and through the retarder housing. Two of the 5 inch bolts (Figure 15-172) are located In the bottom of the transmission. Tighten the bolts to 67-80 lb ft (91-108 N.m).

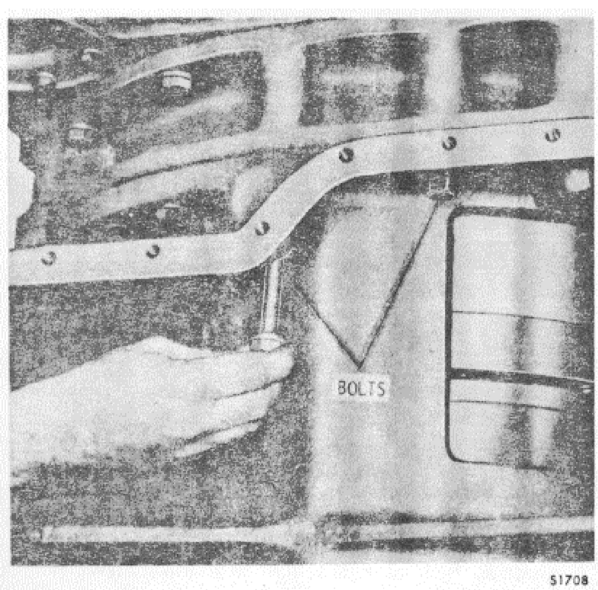


Figure 15-172. Installing Converter Housing Bolts at Bottom of Transmission

INSTALLING TORQUE CONVERTER PUMP, STATORS. Install torque converter pump and stators as follows:

1. Install one seal ring onto the ground sleeve (Figure 15-173).

2. Install the torque converter pump with the input accessory drive gear onto the torque converter ground sleeve (Figure 15-173). Index the accessory drive gear with the power takeoff idler gear and the oil pump idler gear. Tap on the inner race of the converter pump bearing to seat it against the shoulder on the ground sleeve.

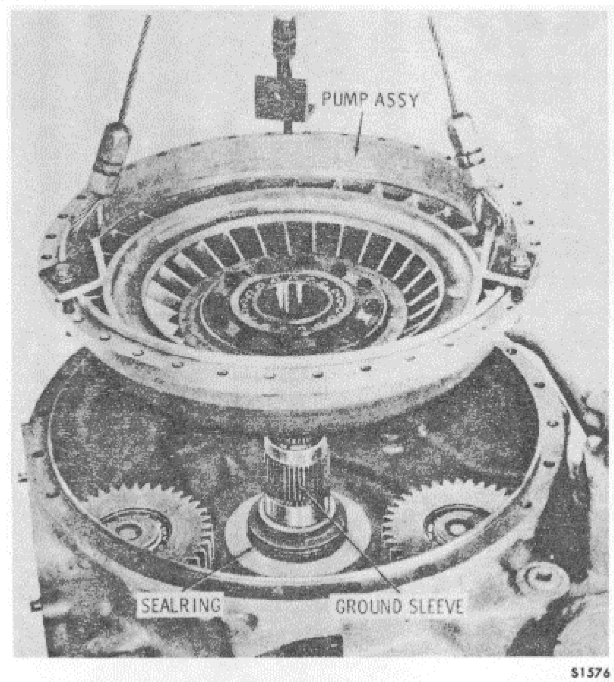


Figure 15-173. Installing Torque Converter Pump Assembly

3. Install the stator backplate, flat side up, onto the ground sleeve (Figure 15-174). Install the stator freewheel roller race, notches up, onto the ground sleeve. Install the spanner nut onto the stator ground sleeve. Using spanner wrench J-6534-02 (Figure 15-22), tighten the spanner nut to 275-325 lbft (373-440 N.m). Stake the outer flange of the spanner nut into one of three notches in the stator free-wheel roller race.

4. Install the converter stator assembly (Figure 15-175) displacing the J-23552 installation sleeve with the roller race. Install the thrust washer. Check to make sure the stator freewheels clockwise - locks up in the opposite direction. If used, install the snap ring into the groove in the turbine shaft.

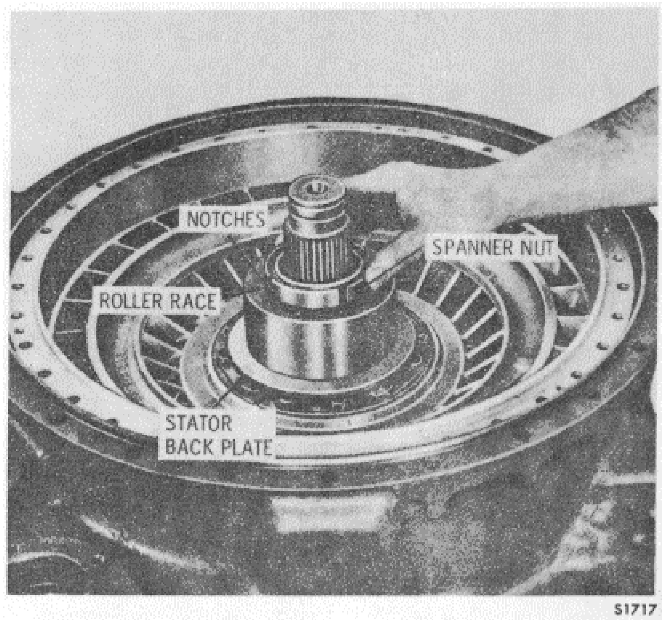


Figure 15-174. Installing Freewheel Roller Race Spanner Nut

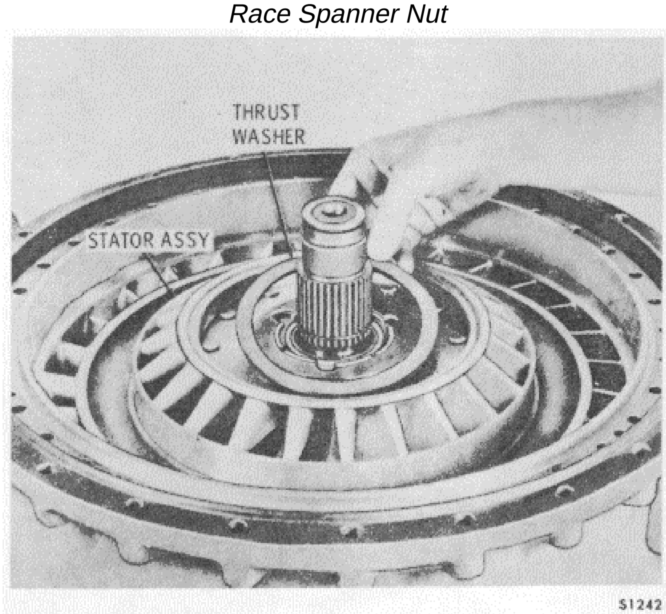


Figure 15-175. Installing Stator Front Thrust Washer

INSTALLING TORQUE CONVERTER TURBINE, LOCKUP CLUTCH, AND INPUT COMPONENTS. Install torque converter components as follows:

1. On models with a lockup clutch, make sure the internal snap ring is in the turbine hub. Install the torque converter turbine (Figure 15-176).
2. Install bearing spacer 4 (A, Foldout 4) into the hub of turbine-6.

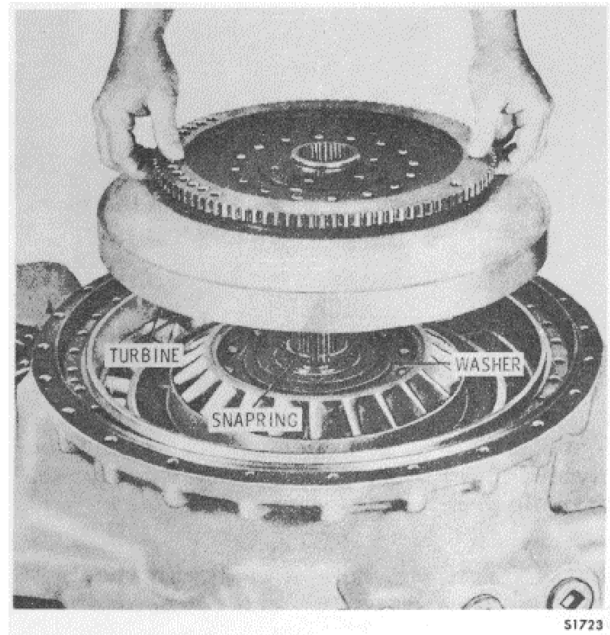


Figure 15-176. Installing Torque Converter Turbine

3. Install the roller bearing inner race (Figure 15-177). Install the snap ring to retain the race. Install the seal ring onto the turbine output shaft.
4. Install the lockup clutch backplate, flat side upward, onto the torque converter pump (Figure 15-177). Install the lockup clutch plate.

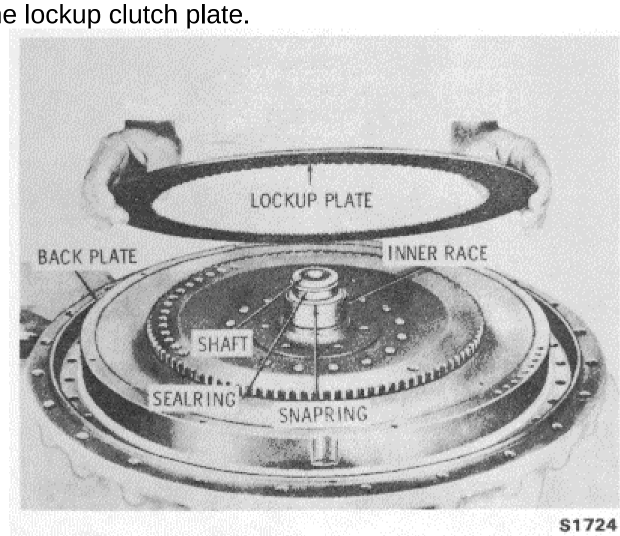


Figure 15-177. Installing Lockup Clutch Plate

5. Install the seal ring onto the hub of the hub of the converter drive housing (Figure 15-178). Install the seal ring onto the piston. Install the piston, engaging the recesses in the piston with four dowel pins in the piston housing.

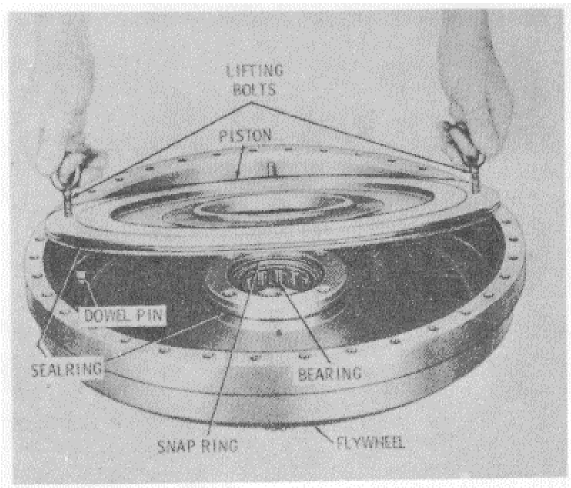


Figure 15-178. Installing Lockup Clutch Piston

6. Install anchor keys 6 (B, Foldout 3) into the recesses in the bore of the converter drive housing. Retain them with oil-soluble grease.
7. Using a lifting hook, install the flywheel with lockup clutch components onto the transmission (Figure 15-179). The two anchor keys must engage respective slots in the lockup clutch backplate.

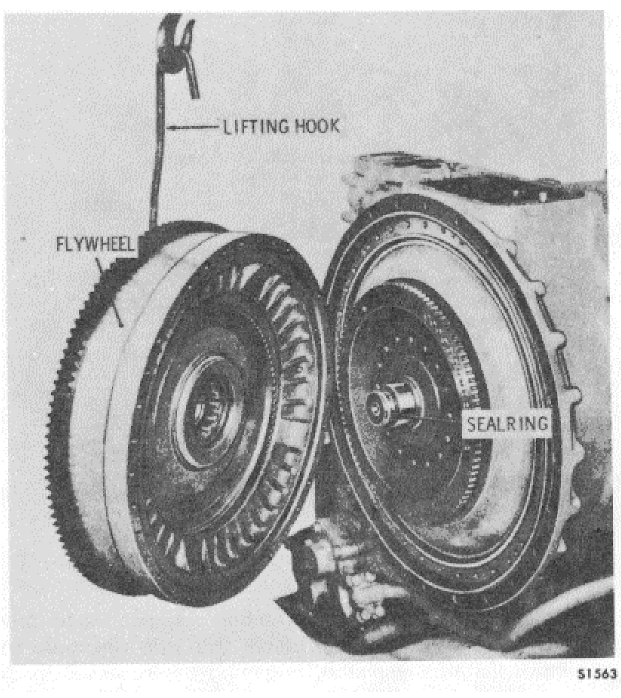


Figure 15-179. Installing Flywheel Assembly

8. Rotate the flywheel housing on the converter pump to align the bolt holes (Figure 15-180). Through the PTO opening, install four 3/8-24 x 1-1/4 inch self-locking bolts with flat washers at 900 intervals. Tighten these bolts to 10 lb ft (13 N.m).
9. Install the remaining thirty-two bolts and flat washers. Tighten all thirty-six bolts to 41-49 lb ft (56-66 N.m).

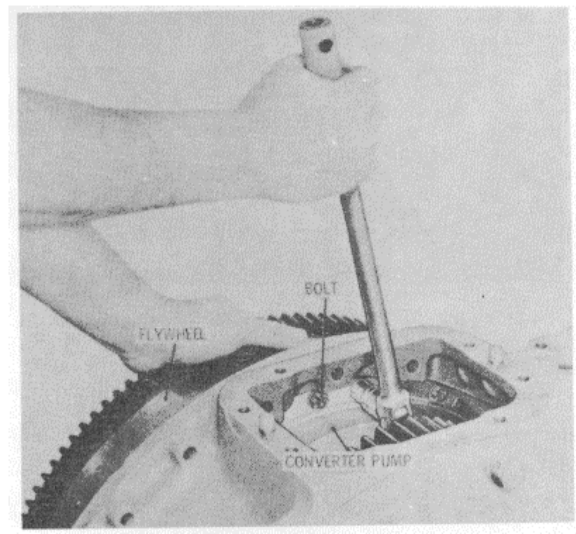


Figure 15-180. Tightening Flywheel Bolts

INSTALLING EXTERIOR COMPONENTS. Install exterior components as follows:
1. Install the oil pump drive gear coupling onto the oil pump drive gear shaft (Figure 15-181). Install the oil pump gasket onto the converter housing. Install oil screen 30 (A, Foldout 5), if removed. Install the input-driven charging and

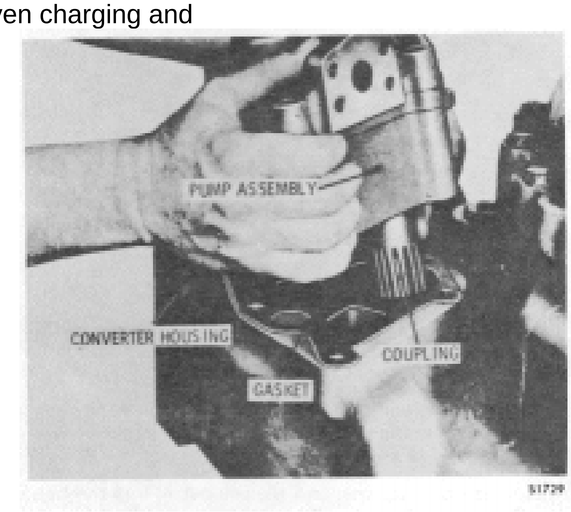


Figure 15-181. Installing Oil Pump Assembly

scavenge oil pump assembly onto the converter housing. Secure the pump with six 3/816 x 5 inch bolts 4 (A, Foldout 5) and lockwashers 5. Tighten the bolts to 2632 lb ft (3643 N.m).

2. Install two scavenge oil discharge tube gaskets (Figure 15-182). Install the tube and secure itwith four 3/8-16 x 1 -3/4 inch bolts 1 (A, Foldout 5) and lockwashers 2 at the pump end of the tube, and four 3/8-16 x 1 inch bolts 6 and lockwashers 7 at the other end. Tighten the bolts to 26-32 lb ft (36-43 N.m).

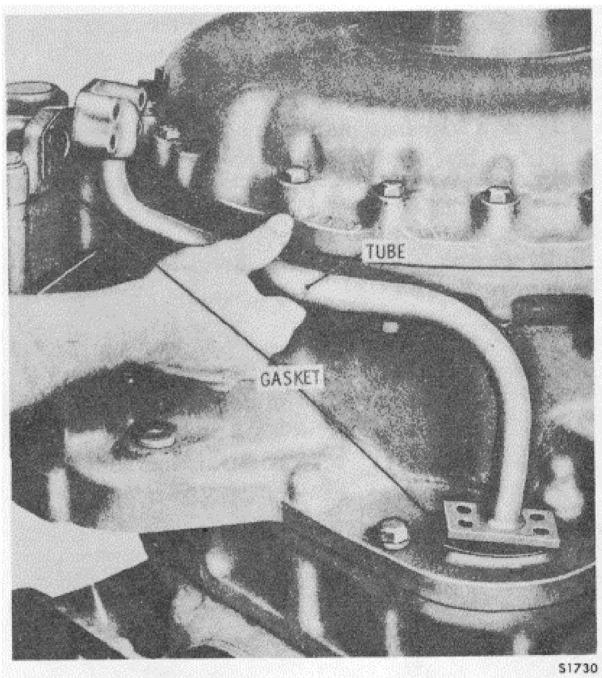


Figure 15-182. Installing Scavenge Oil Discharge Tube

3. Install headless guide bolts into the bottom of the transmission housing (Figure 15-183). Install the transmission oil pan gasket onto the transmission housing. Install the transmission oil pan onto the transmission housing. Secure the oil pan with four evenly spaced 3/8-16 x 1-1/8 inch bolts 13(A, Foldout 10) and lockwashers 12. Remove the headless guide bolts. Install the remaining twenty 1-1/8 inch bolts and lockwashers and four 3/8-16 x 5 inch bolts 13 and lockwashers 12. Tighten the bolts to 26-32 lbft(36-43 N.m).

4. Install strainer gasket 5 (A, Foldout 10) and oil strainer assembly 6. See Figure 15-184. Secure the oil strainer with six 3/8-1 6 x 7/8 inch bolts and lockwashers. Tighten the bolts to 26-32 lb ft (36-43 N.m).

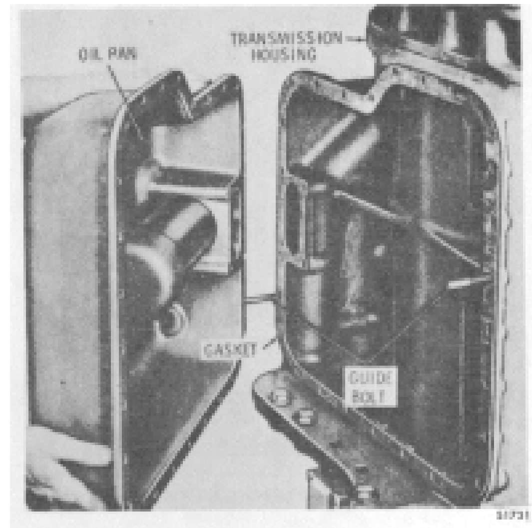


Figure 15-183. Installing Oil Pan

Figure 15-184. Installing Oil Strainer Assembly

5. Install the lockup shift valve body gasket(Figure 15-185).Install the lockup shift valve body assembly onto the transmission.

6. Install seven 3/8-1 6 x 2-3/4 inch bolts 1 (A, Foldout 6) with lockwashers 2 and two 3/8-16 x 1-1/4 inch bolts 4 with lockwashers 5 to retain the lockup valve body. Tighten all the bolts 26-32 lb ft (36-43 N.m). For electric-shift models, if not previously installed, install pressure switch 20. Tighten it enough to prevent leakage.

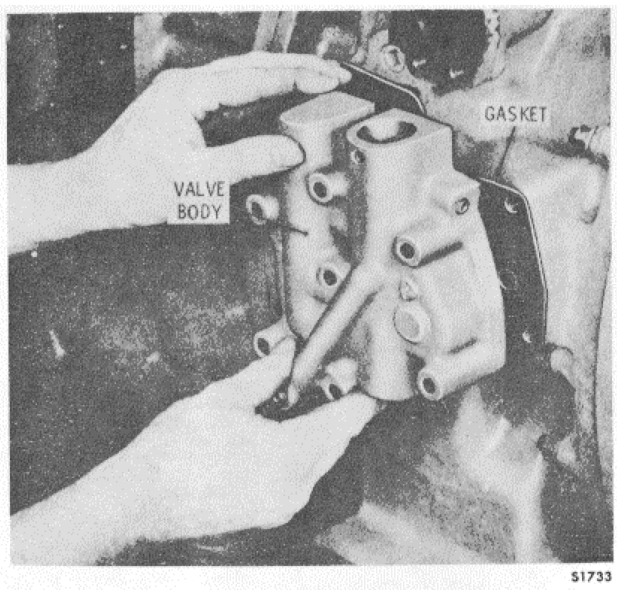


Figure 15-185. Installing Lockup Shift Valve Body Assembly

7. See Figure 15-186. Install two 3/8-16 x 6 inch headless guide bolts into holes marked C at the front and rear of the valve body mounting pad on the transmission housing. These bolts should be installed near the upper part of the mounting pad.

8. Install gasket L onto the guide bolts.

9. Install oil transfer plate K and retain it with three 3/8-16 x 1-3/8 inch bolts F and lockwashers.

10. Also, through oil transfer plate K, install two 3/8-1 6 x 1-1/4 inch self-locking bolts E and flat washers. Tighten bolts E and F to 26-32 lb ft (35-43 N.m).

11. Install gasket J, separator plate I, and gasket H.

NOTE

Do not interchange gaskets J and H. Each gasket is marked for location. Gasket J is installed against transfer plate K. Then plate I is installed, followed by gasket H. See the parts catalog.

12.Install the main valve body G.

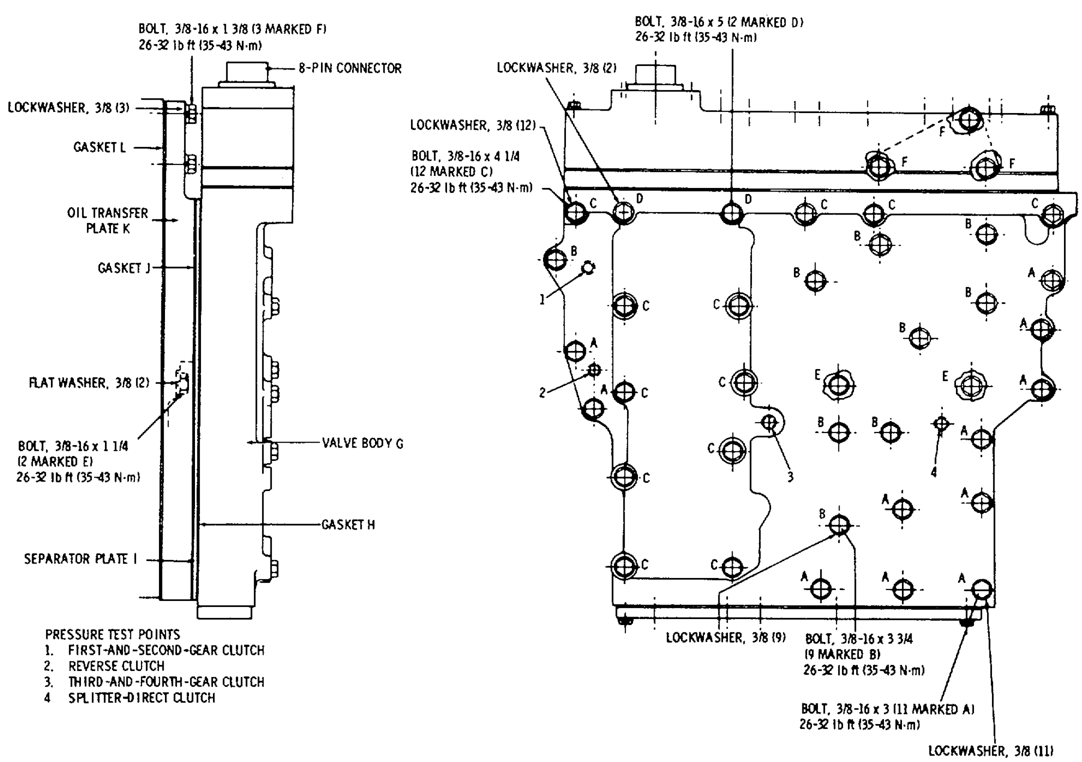


Figure 15-186. Valve Body Components and Mounting Bolts

13. Install the following bolts with lockwashers and tighten to 26-32 lb ft (35-43 N.m).

Eleven 3/8-16 x 3 inch, marked A
Two 3/8-16 x 5 inch, marked D
Twelve 3/8-16 x 4-1/4 inch, marked C
(remove 6 inch guide bolts for two)
Nine 3/8-16 x 3-3/4 inch, marked B

14. For all models, install the connecting block with a seal ring at the upper location on the converter housing (Figure 15-187). Secure the block with two 7/16-14 x 2 inch and two 7/16-14 x 2-1/4 inch bolts and lockwashers. Tighten the bolts to 42-50 lb ft (57-67 N.m).

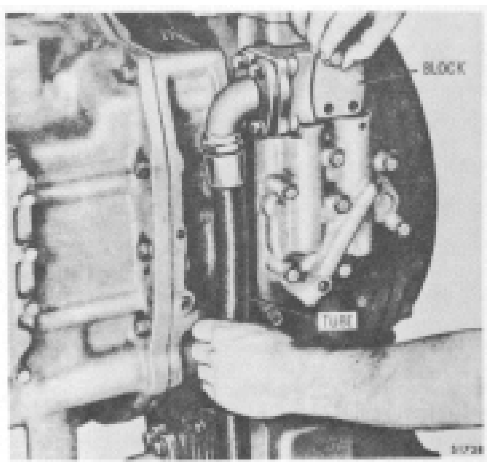


Figure 15-187. Installing Oil Pump Pressure Tube

15. Install the pressure hose, seal rings and split flanges and retain with eight 7/1 6-14 x 1-1/4 inch bolts and lock-washers. Be sure the flanges and seal rings are properly seated. Shake the hose slightly and allow it to shift into position, free of binding.

16. While holding the hose in its free position, tighten the bolts to 42-50 lb ft (57-67 N.m).

WARNING

Hose pressures and temperatures can exceed 350 psi (2413 kPa) and 2750F (1 350C). Protect them from vehicle physical contact. Abrasions will weaken the hose, and failure with possible personnel injury may occur.

17. Install two guide bolts into the retarder valve body mounting pad (Figure 15-188). Install retarder valve body gasket 03 (A, Foldout 7), restrictor plate 17, and gasket 18. Install the retarder valve body assembly (Figure 15-188) and secure with seven 3/8-16 x 4-1/4 inch bolts and lockwashers, removing the guide bolts to install the final two retaining bolts. Tighten the bolts to 26-32 lb ft (36-43 N.m).

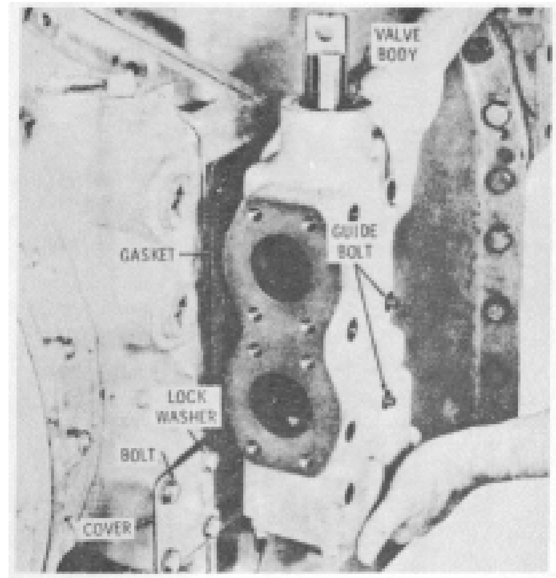


Figure 15-188. Installing Hydraulic Retarder Control Valve Body Assembly

18. Install the power takeoff cover gasket, and cover (Figure 15-189). Secure with eight 7/16-14 x 7/8 inch bolts and lockwashers. Tighten the bolts to 42-50 lb ft (57-67 N.m).

19. Install the regulator valve body gasket (Figure 15-189). Install the main-pressure regulator valve body assembly. Secure the valve body by installing two 7/16-14 x 3-1/2 inch bolts with lockwashers into holes marked A on Figure 15-189. Secure the assembly with five 7/16-14 x 7 inch bolts 2 and two 7/16-14 x 4-1/2 inch bolts with lockwashers 3 and 5. Tighten bolts 2 and 4to 42-50 lbft (57-67 N.m).

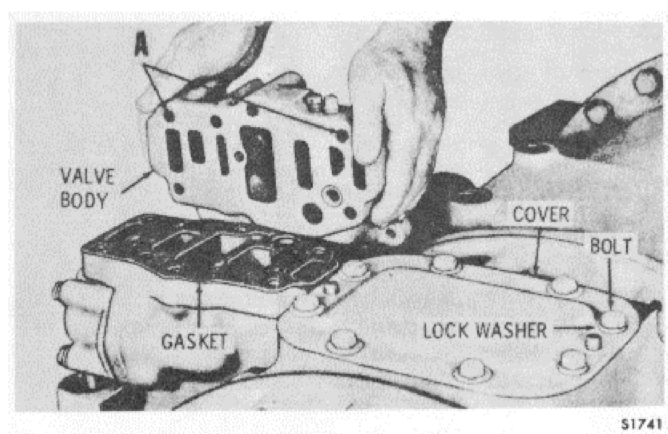


Figure 15-189. Installing Main-Pressure Regulator Valve Body Assembly

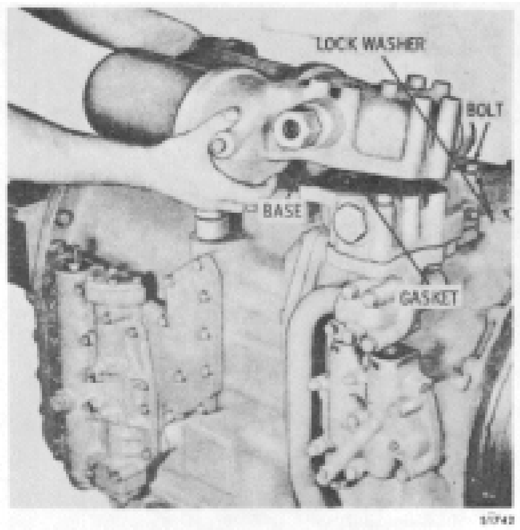


Figure 15-190. Installing Oil Filter and Base Assembly

20. Install output flange(s) and attaching hardware. See page 15-43 for installation and shimming instructions. POWER TAKEOFF GEAR BACKLASH. See page 15-45 for backlash recommendations and a method for measuring backlash.

INSTALLATION

To install the main transmission, proceed as follows:

1. Using a suitable lifting device lift the transmission into place from under the carrier.
2. Align the transmission with the engine and slide the transmission forward to the engine.
3. Install and tighten the transmission to engine bolts.
4. Connect the engine braces to the transmission using the attaching hardware.
5. Connect the propeller shaft. See Subsection 9E.
6. Connect the transmission shift and retarder cables. Reconnect all air, electric and hydraulic lines that were removed during transmission removal.
7. Install sheet metal over transmission.

WEAR LIMITS AND SPRING DATA

WEAR LIMITS DATA

MAXIMUM VARIATIONS. Wear limits information in this section shows the maximum wear at which components are expected to function satisfactorily. Table 15-4 lists the wear limits data and is referenced to the exploded views (Foldout 3 through 12) in the back of this section.

CLEANING, INSPECTION. Parts must be clean to permit effective inspection for wear or damage.

BEARINGS, BEARING JOURNALS, BORES. The application of bearings to any product is based on the recommendations of the bearing manufacturer and, therefore, no diametrical dimensional deviation should be permitted in the bearing or mated parts. Bearings should be carefully checked for signs of distress before reinstalling them into the transmission.

GEARS. Gears should be inspected for load pattern and signs of distress. Any distress indicates a possible future failure, and the reuse of such gears should be the decision of the individual customer, based on experience. Backlash cannot be used to establish critical wear of a gear. The backlash tolerances are of such nature that a gear usually pits, scuffs, scores, or galls long before the gear wear becomes critical.

SPLINES. Unless severe, spline wear is not considered detrimental except where it affects tightness of an assembly such as drive-line flanges. Backlash cannot be used to establish critical wear because both mating parts must be concentrically located to obtain accurate measurement of backlash.

HOOK-TYPE SEAL RINGS. Sides of the seal ring should be smooth with maximum wear of 0.005 inch (0.13 mm). The sides of the groove into which the seal rings fit should be smooth (50 microinch (127 micrometers) equivalent), and square with the axis of rotation within 0.002 inch (0.05 mm). A new seal ring should be installed if grooves are reworked, or if there is wear on the seal ring outside diameter.

SPRING DATA

Springs must be clean to permit effective inspection. Springs should be replaced if there are signs of overheating, wear due to rubbing adjacent parts, or permanent set. Discard springs which do not meet the load-height specifications in the spring chart. Inspection criteria (load vs height) and identification characteristics of the springs are presented in Table 15-5. The spring data are keyed to the exploded views (Foldouts 3 through 12) in the back of this section.

NOTE

When more than one spring part number is listed for the same location, refer to Parts Catalog to determine which spring is used in your specific assembly number.

Table 15-4. Wear Limits

Illustration	Description	Wear Limit in	(mm)
B, Foldout 3	LOCKUP CLUTCH		
4	Piston, max face wear	0.010	0.25
5	Friction-faced clutch plate:		
	Thickness, min	0.155	3.94
	Cone, max	0.010	0.25
7	Backplate, max face wear	0.010	0.25
A, Foldout 4	FIXED-CAPACITY TORQUE CONVERTER (5960)		
8	Stator thrust washer, min thicknesst	0.117	2.97
9	Freewheel race, min OD	4.749 (no scoring or surface damage permissible)	120.62
10	Stator, max ID	4.773	121.23
15	Stator backplate, min thicknesst	0.288	7.32
A, Foldout 5	INPUT-DRIVEN PRESSURE AND SCAVENGE OIL PUMP		
14,17	Gear, max diametral clearance of body 14 with gear 17*	0.012	0.31
14,17,21	Gear, max end clearance in body 14 and plate 21 (with gasket 18 installed)**	0.010	0.25
21,23,28	Gear, max end clearance in plate 21 and		
body 28 (with gasket 25 installed)**		0.010	0.25
23,28	Gear, max diametral clearance of gear 23 in body 28*	0.012	0.31
21,24,28	Gear, max end clearance in plate 21 and body 28 (with gasket 25 in place)**	0.010	0.25
24,28	Gear, max diametral clearance of gear		
24 in	body 28.*	0.012	0.31
B, Foldout 5	MAIN-PRESSURE REGULATOR VALVE AND OIL FILTER		
14,15	Main-pressure regulator valve		
15, max	clearance in body 14	0.004	0.102
A, Foldout 6	LOCKUP VALVE ASSEMBLY		
7,8	Lockup valve 8, max clearance in body 7	0.004	0.102
7,16	Lockup cutoff valve 16, max clearance in body 7	0.004	0.102
A, Foldout 7	HYDRAULIC RETARDER CONTROL VALVE		
7,9	Retarder control valve 9, max. clearance in body 7	0.006	0.152
B, Foldout 7	SPLITTER-DIRECT CLUTCH		
10	Piston, max face wear	0.020	0.51

+Dimension A (Figure 15-191) minus dimension B shall not be less than 0.040 in. (1.02 mm).

*See Figure 15-28

**See Figure 15-27

+Groove depth should exceed 0.005 in. (0.13 mm)

Table 15-4. Wear Limits (Continued)

Illustration	Description	Wear Limit in	(mm)
13	Friction-faced clutch plate. t		
	Thickness, min	0.180	4.57
	Cone, max	0.012	0.31
14	Steel clutch plate:		
	Thickness, min	0.184	4.67
	Cone, max	0.030	0.76
	Minimum clutch pack thickness	0.544	13.82
15	Backplate, max face wear	0.020	0.51
A, Foldout 8	SPLITTER PLANETARY AND SPLITTER-OVERDRIVE CLUTCH		
2	Thrust washer, min thickness	0.055	1.38
3,5	Pinion 3, max end clearance with carrier 5	0.055	1.38
16	Backplate, max face wear	0.020	0.51
17	Friction-faced clutch plate. t		
	Thickness min	0.180	4.57
	Cone, max	0.012	0.31
18	Steel clutch plate:		
	Thickness, min	0.184	4.67
	Cone, max	0.030	0.76
	Minimum clutch pack thickness	1.092	27.74
A, Foldout 9	FIFTH-AND-SIXTH-GEAR CLUTCH		
9	Piston, max face wear	0.020	0.51
12	Friction-faced clutch plate: t		
	Thickness, min	0.180	4.57
	Cone, max	0.012	0.31
13	Steel clutch plate:		
	Thickness, min	0.184	4.67
	Cone, max	0.030	0.76
14	Backplate, max face wear	0.020	0.51
B, Foldout 9	ELECTRIC-CONTROL VALVE BODY ASSEMBLY		
20,21,23,26, 29,30,32,45, 47,55,57,64, 66,67,69 all valves	Valve, max clearance in body 36	0.003	0.08
B, Foldout 10	INTERMEDIATE-RANGE PLANETARY AND THIRD-AND-FOURTH-GEAR CLUTCH		
6	Thrust washer, min thickness	0.055	1.40
3,7	Pinion 7, max	end clearance	
	in carrier 3	0.005	1.40

+Dimension A (Figure 15-191) minus dimension B shall not be less than 0.040 in. (1.02 mm).

*See Figure 15-28

**See Figure 15-27

+Groove depth should exceed 0.005 in. (0.13 mm)

Table 15-4. Wear Limits (Continued)

Illustration	Description	Wear Limit in	(mm)
19	Friction-faced clutch plate: t		
	Thickness, min	0.180	4.57
	Cone, max	0.012	0.31
20	Steel clutch plate:		
	Thickness, min	0.184	4.67
	Cone, max	0.030	0.76
	Minimum clutch pack thickness	1.092	27.74
B, Foldout 10			
25	Piston housing, reaction		
	surface step	0.020	0.51
A, Foldout 11	LOW-RANGE PLANETARY AND FIRST-AND-SECOND-GEAR CLUTCH		
9	Thrust washer, min thickness	0.055	1.40
10,15	Pinion 10, max	end clearance	
	in carrier 15	0.055	1.40
21	Friction-faced clutch plate: t		
	Thickness, min	0.180	4.57
	Cone, max	0.012	0.31
22	Steel clutch plate:		
	Thickness, min	0.184	4.67
	Cone, max	0.030	0.76
	Minimum clutch pack thickness	1.456	36.98
A, Foldout 11			
27	Piston housing reaction surface,		
	max step wear	0.20	0.51
B, Foldout 11	REVERSE PLANETARY AND CLUTCH		
4	Thrust washer, min thickness	0.075	1.91
8	Thrust washer, min thickness	0.055	1.40
7,10	Pinion 10, max	end clearance	
	in carrier 7	0.055	1.40
18	Friction-faced clutch plate: t		
	Thickness, min	0.180	4.57
	Cone, max	0.012	0.31
19	Steel clutch plate		
	Thickness, min	0.184	4.67
	Cone, max	0.030	0.76
	Minimum clutch pack thickness	1.820	46.23
A, Foldout 12	SPEEDOMETER DRIVE BUSHING		
6	Bushing, max ID	0.377	9.58

+Dimension A (Figure 15-191) minus dimension B shall not be less than 0.040 in. (1.02 mm).

*See Figure 15-28

**See Figure 15-27

+Groove depth should exceed 0.005 in. (0.13 mm)

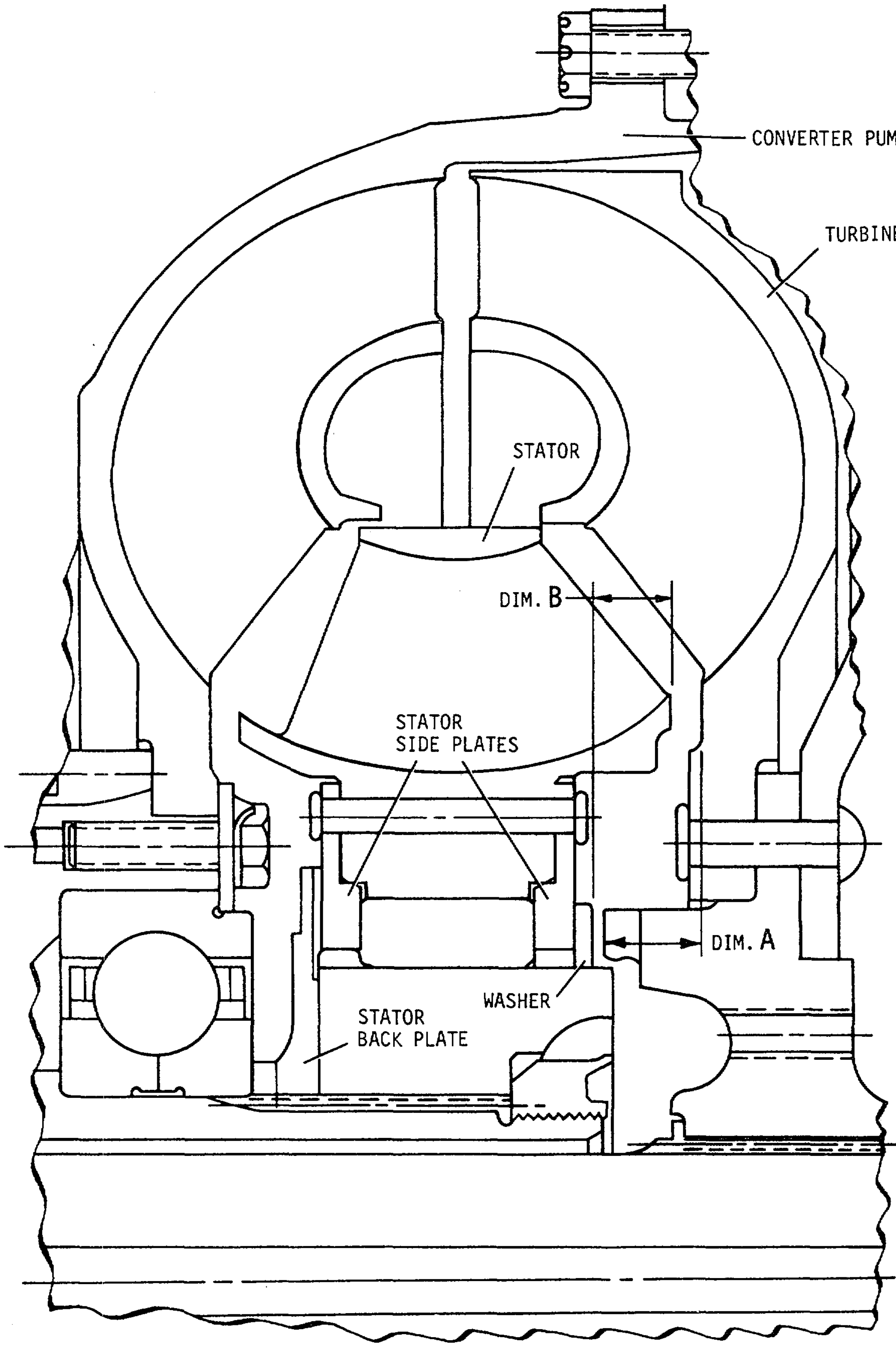


Figure 15-191. Converter Element Clearances

Table 15-5. Spring Data

Fold-out	Ref	Spring	No Coils	Wire Dia in (mm)	Outside Dia in (mm)	Approx. Free Length in (mm)	Length Under Load in (mm)	Length Under Load lb (N)
A,4	13	Freewheel roller	43	0.018 (0.46)	0.156 (3.96)	1.57 (39.9)	1.07 (27.2)	0.63-0.77 (2.8-3.4)
B,4	61	Lubrication regulator valve	21	0.092 (2.34)	0.670 (17.02)	3.23 (82.0)	2.34 (59.4)	23.8-26.2 (106-116)
B,5	17	Main pressure regulator valve	20	0.135 (3.43)	0.800 (20.32)	4.50 (114.3)	3.51 (89.2)	83.0-95.0 (370-422)
B,5	30	Filter bypass valve	11	0.109 (2.77)	1.133 (28.78)	4.59 (116.6)	2.66 (67.6)	35.1-42.7 (156-190)
B,5	45	Filter shell stud	7.8	0.120 (3.05)	1.172 (29.77)	2.31 (58.7)	1.50 (38.1)	31.5-38.2 (140-170)
A,6	11	Lockup valve, inner	13.5	0.079 (2.01)	0.690 (17.53)	2.84 (72.14)	1.58 (40.1)	26.0-28.0 (116-124)
			13	0.120 (3.05)	0.794 (20.17)	2.81 (71.37)	2.11 (53.6)	57.2-63.6 (255-282)
			14	0.080 (2.03)	0.690 (17.53)	2.65 (67t3)	1.62 (41.1)	21.1-23.3 (94-103)
			12	0.092 (2.34)	0.875 (22.22)	2.99 (75.9)	1.56 (39.6)	29.1-32.1 (130-142)
			14	0.080 (2.03)	0.690 (17.53)	2.56 (65.0)	1.62 (41.1)	19.2-21.4 (86-95)
A,7	10	Retarder control valve	24	0.092 (2.34)	1.060 (26.9)	7.00 (177.8)	4.80 (121.9)	10.4-11.6 (47-51)
B,7	11	Splitter-direct piston return		Belle-ville	10.710 (272.03)	0.44* (11.2)		
A,8	20	Splitter-overdrive piston return	12	0.080 (2.03)	0.625 (15.88)	1.77 (45.0)	1.31 (33.3)	14.9-18.2 (67-80)
			9.5	0.106 (2.69)	0.625 (15.88)	1.43 (36.3)	1.32 (33.5)	14.4-21.6 (64-96)
B,8	4	Converter pressure relief valve	13	0.106 (2.69)	0.710 (18.03)	2.35 (59.7)	1.75 (44.4)	42.0-46.0 (187-204)
B,8	22	Converter pressure regulator valve	18	0.063 (1.60)	0.530 (13.46)	2.66 (67.6)	1.79 (45.5)	10.8-13.2 (48-58)
A,9	10	Fifth-and-sixth-gear clutch piston return		Belle-ville	10.710 (272.03)	0.44* (11.2)		

*Replace if not within 0.025 in. (0.63 mm) of free height

Color Code:
No Color
1 Green Stripe
2 Red Stripe
3 White Stripe
4 Solid Green
5 Yellow Stripe

Table 15-5. Spring Data (Continued)

Fold-out	Ref	Spring	No Coils	Wire Dia in (mm)	Outside Dia in (mm)	Approx. Free Length in (mm)	Length Under Load in (mm)	Length Under Load lb (N)
B,9	19	Solenoid pressure regulator valve	12	0.062 (1.57)	0.440 (11.18)	1.56 (39.6)	1.02 (25.9)	19.5-23.7 (87-105)
			12	0.067 (1.70)	0.434 (11.02)	1.55 (39.4)	1.02 (25.9)	31.4-34.6 (140-153)
B,9	22	Splitter shift valve	11	0.086 (2.18)	0.700 (17.78)	1.83 (46.5)	1.22 (31.0)	21.0-25.0 (94-111)
B,9	24	Priority valve, inner	32	0.072 (1.83)	0.565 (14.35)	4.94 (125.5)	2.60 (66.0)	22.5-27.5 (100-122)
B,9	25	Priority valve, outer	9.5	0.101 (2.57)	0.830 (21.08)	1.78 (45.2)	1.26 (32.0)	26.1-28.9 (116-128)
B,9	27	Fifth-and-sixth-gear shift valve	11	0.086 (2.18)	0.700 (17.78)	1.83 (46.5)	1.22 (31.0)	21.0-25.0 (94-111)
B,9	28	Third-and-fourth-gear shift valve	11	0.086 (2.18)	0.700 (17.78)	1.83 (46.5)	1.22 (31.0)	21.0-25.0 (94-111)
B,9	31	First-and-second-gear shift valve	11	0.086 (2.18)	0.700 (17.78)	1.83 (46.5)	1.22 (31.0)	21.0-25.0 (94-111)
B,9	34	Reverse-gear shift valve	11	0.086 (2.18)	0.700 (17.78)	1.83 (46.5)	1.22 (31.0)	21.0-25.0 (94-111)
B,9	42	Check valve	15	0.020 (0.51)	0.330 (8.38)	1.25 (31.8)	0.94 (23.9)	0.17-0.20 (0.76-0.88)
B,9	46	Splitter-direct trimmer, upper valve	15	0.062 (1.57)	0.850 (21.59)	4.50 (114.3)	1.03 (26.2)	11.2-13.6 (50-60)
B,9	48	Splitter-direct trimmer, lower valve, inner	16	0.105 (2.67)	0.750 (19.1)	3.32 (84.3)	3.05 (77.5)	11.4-12.6 (51-56)
B,9	49	Splitter-direct trimmer lower valve, outer	7	0.113 (2.87)	1.060 (26.92)	1.61 (40.9)	1.06 (26.9)	27.0-33.0 (121-146)
			16	0.058 (1.47)	0.850 (21.59)	4.24 (107.7)	1.03 (26.2)	6.9-8.5 (31-37)
B,9	56	Third-and-fourth-gear trimmer, upper valve	15	0.062 (1.57)	0.850 (21.59)	4.50 (114.3)	1.03 (26.2)	11.2-13.6 (50-60)
B,9	58	Third-and-fourth-gear trimmer, lower valve, inner	18	0.092 (2.34)	0.769 (19.53)	3.78 (96.0)	1.85 (47.0)	38.0-42.0 (169-186)
B,9	59	Third-and-fourth-gear trimmer, lower valve, outer	7	0.113 (2.87)	1.060 (26.92)	1.61 (40.9)	1.06 (26.9)	27.0-33.0 (121-146)

Color Code:
No Color Code
1 Green Stripe
5 Yellow Stripe
6 Solid Light Blue

Table 15-5. Spring Data (Continued)

Fold-out	Ref	Spring	No Coils	Wire Dia in (mm)	Outside Dia in (mm)	Approx. Free Length in (mm)	Length Under Load in (mm)	Length Under Load lb (N)
B,9	62	First-and-second-gear trimmer, lower valve, outer	7	0.113 (2.87)	1.060 (26.92)	1.61 (40.9)	1.06 (26.9)	27.0-33.0 (121-146)
B,9	63	First-and-second-gear trimmer, lower valve, inner	18	0.092 (2.34)	0.769 (19.53)	3.78 (96.0)	1.85 (47.0)	38.0-42.0 (169-186)
B,9	65	First-and-second-gear trimmer, upper valve	15	0.062 (1.57)	0.850 (21.59)	4.50 (114.3)	1.03 (26.2)	11.2-13.6 (50-60)
B,9	68	Reverse trimmer, upper valve	15	0.062 (1.57)	0.850 (21.59)	4.50 (114.3)	1.03 (26.2)	11.2-13.6 (50-60)
B,9	70	Reverse trimmer, lower valve, inner	16	0.092 (2.34)	0.730 (18.54)	2.97 (75.4)	1.58 (40.1)	36.4-40.4 (162-179)
			18	0.092 (2.34)	0.769 (19.53)	3.78 (96.0)	1.85 (47.0)	38.0-42.0 (169-186)
B,9	71	Reverse trimmer lower valve, outer	8	0.120 (3.05)	1.060 (26.92)	2.06 (52.3)	1.06 (26.9)	57.0-63.0 (254-280)
			12	0.120 (3.05)	1.060 (26.92)	3.58 (90.9)	1.90 (48.3)	57.0-63.0 (254-280)
B,10	18	Third-and-fourth-gear piston return	16	0.092 (2.34)	0.625 (15.88)	2.64 (67.1)	1.94 (49.3)	27.9-34.1 (125-151)
			14	0.106 (2.69)	0.625 (15.88)	2.48 (63.0)	1.88 (47.8)	57.9-70.7 (258-314)
A,11	20	First-and-second-gear piston return	20	0.092 (2.34)	0.625 (15.88)	3.20 (81.3)	2.38 (60.5)	27.9-34.1 (125-151)
			16	0.121 (3.07)	0.625 (15.88)	2.83 (71.9)	2.36 (59.9)	72.0-88.0 (321-391)
B,11	16	Reverse piston return	25	0.106 (2.69)	0.625 (15.88)	3.68 (93.5)	3.21 (81.5)	22.5-27.5 (100-122)
			22	0.121 (3.07)	0.625 (15.88)	3.70 (94.0)	3.09 (78.5)	64.8-79.2 (289-352)
B,12	5	Shift tower leveler	7	0.045 (1.14)	0.300 (7.62)	0.56 (14.3)	0.46 (11.7)	6.9-8.5 (31-37)
B,12	61	Shift tower override	4.5	0.045 (1.14)	0.600 (15.24)	0.75 (19.0)	0.65 (16.5)	1.3-1.7 (6-7)
B,12	77	Shift tower outer clutch	5-6	0.038 (0.97)	0.480 (12.19)	0.88 (22.4)	0.56 (14.2)	5.0-6.0 (22-26)

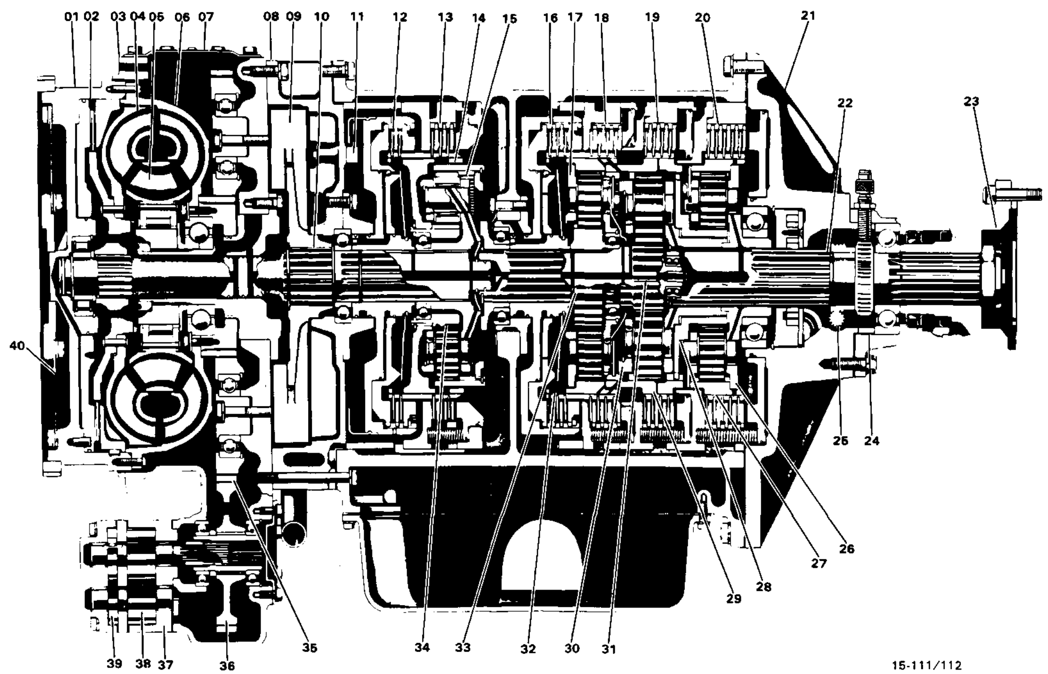
*Tension spring

Color Code:
No Color Code
1 Green Stripe
2 Red Stripe
7 Solid Red
8 Solid Black

A

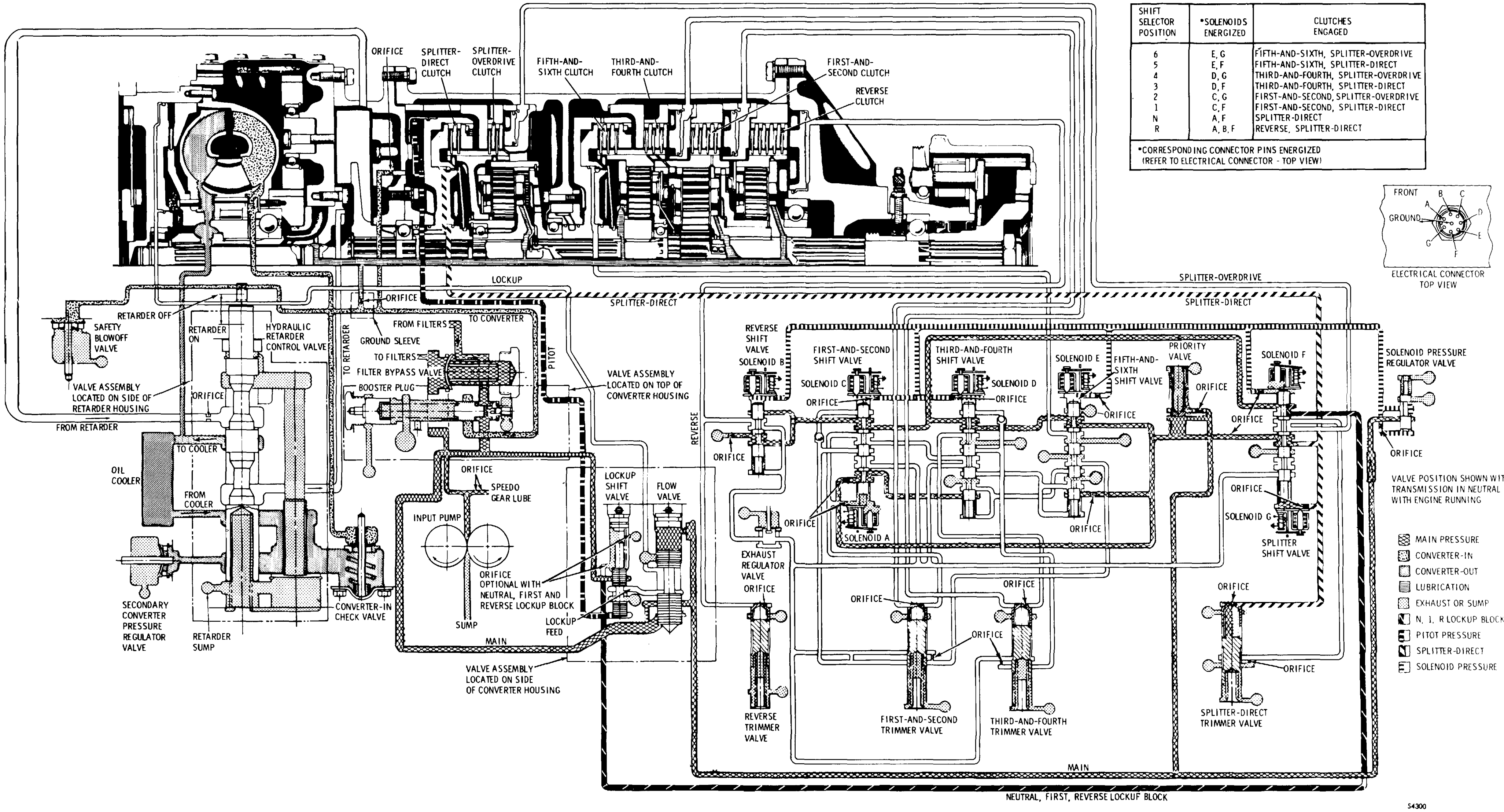
01. FLYWHEEL
02. LOCKUP CLUTCH
03. CONVERTER HOUSING
04. TORQUE CONVERTER TURBINE
05. TORQUE CONVERTER STATOR
06. TORQUE CONVERTER PUMP
07. POWER TAKEOFF PAD COVER
08. HYDRAULIC RETARDER HOUSING
09. HYDRAULIC RETARDER ROTOR
10. TURBINE SHAFT
11. GOVERNOR (PITOT) ASSEMBLY
12. LOW-SPLITTER CLUTCH (DIRECT DRIVE)
13. HIGH-SPLITTER CLUTCH (OVERDRIVE)
14. HIGH-SPLITTER RING GEAR
15. HIGH-SPLITTER PLANETARY CARRIER
16. HIGH-RANGE CLUTCH
17. INTERMEDIATE-RANGE PLANETARY CARRIER
18. INTERMEDIATE-RANGE CLUTCH
19. LOW-RANGE CLUTCH
20. REVERSE-RANGE CLUTCH
21. TRANSMISSION REAR COVER (OUTPUT DRIVE HOUSING)
22. TRANSMISSION OUTPUT SHAFT
23. OUTPUT FLANGE
24. SPEEDOMETER DRIVE GEAR
25. SPEEDOMETER DRIVEN GEAR
26. REVERSE-RANGE PLANETARY CARRIER
27. REVERSE-RANGE RING GEAR
28. REVERSE-RANGE SUN GEAR
29. LOW-RANGE RING GEAR
30. LOW-RANGE PLANETARY CARRIER
31. LOW-RANGE SUN GEAR
32. INTERMEDIATE-RANGE PLANETARY CARRIER
33. INTERMEDIATE-RANGE SUN GEAR
34. HIGH-SPLITTER SUN GEAR
35. INPUT OIL PUMP IDLER GEAR
36. INPUT OIL PUMP DRIVE GEAR
37. INPUT AND SCAVENGE OIL PUMP ASSEMBLY
38. INPUT OIL PUMP
39. SCAVENGE OIL PUMP
40. FLEX DISC DRIVE ASSEMBLY

A



Foldout 1. CLBT 5960-4 Torqmatic Transmission -Cross -Section View

15-111/112



SHIFT SELECTOR POSITION	*SOLENOIDS ENERGIZED	CLUTCHES ENGAGED
6	E, G	FIFTH-AND-SIXTH, SPLITTER-OVERDRIVE
5	E, F	FIFTH-AND-SIXTH, SPLITTER-DIRECT
4	D, G	THIRD-AND-FOURTH, SPLITTER-OVERDRIVE
3	D, F	THIRD-AND-FOURTH, SPLITTER-DIRECT
2	C, G	FIRST-AND-SECOND, SPLITTER-OVERDRIVE
1	C, F	FIRST-AND-SECOND, SPLITTER-DIRECT
N	A, F	SPLITTER-DIRECT
R	A, B, F	REVERSE, SPLITTER-DIRECT

*CORRESPONDING CONNECTOR PINS ENERGIZED (REFER TO ELECTRICAL CONNECTOR - TOP VIEW)

Foldout 2. 5900 Series Transmissions-Manual Electric-Shift Hydraulic System Schematic

A

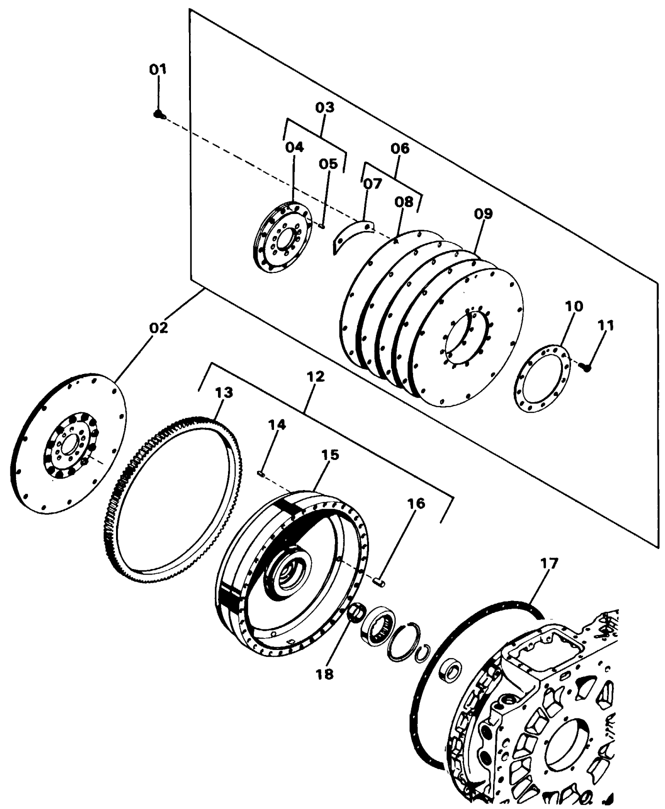
01. BOLT, SELF-LOCKING
    1/2-20 x 1-in. (12) A
02. FLEX FLYWHEEL DISK ASSEMBLY
03. HUB ASSEMBLY
04. HUB
05. DOWEL PIN
06. FLEX DISC AND WASHER ASSEMBLY
07. FLEX DISC WASHER (6)
08. FLEX DISC
09. FLEX DISC
10. PLATE
11. BOLT, SELF-LOCKING
    1/2-20 x 3/4-in. (12) A
12. FLYWHEEL ASSEMBLY
13. STARTER RING GEAR
14. DOWEL PIN
15. FLYWHEEL
16. PIN (4)
17. GASKET
18. SLEEVE (USED ONLY IN REWORK OF FLYWHEEL 15)

TORQUE	LB FT	N.m
A	96-115	131-155

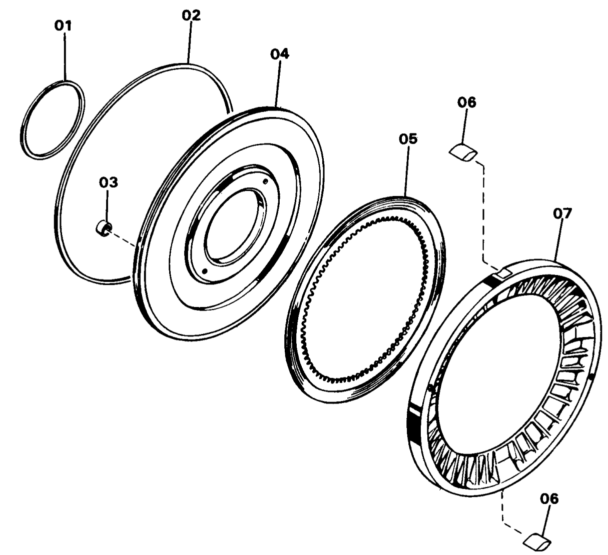
B

01. SEALRING
02. SEALRING
03. BUSHING (USED ONLY IN REWORK OF PISTON 4)
04. LOCKUP CLUTCH PISTON
05. CLUTCH PLATE
06. KEY (2)
07. BACKPLATE

A



B



A, Foldout 3. Flex Disc and Flywheel
B, Foldout 3, Lockup Clutch
15-115/116

A

01. ROLLER BEARING
02. SNAPRING
03. SNAPRING
04. BEARING SPACER
05. SNAPRING
06. TORQUE CONVERTER TURBINE
07. SPANNER NUT A
08. THRUST WASHER
09. STATOR FREEWHEEL ROLLER RACE
10. STATOR
11. CUP (24)
12. NEEDLE ROLLER (12)
13. SPRING (12)
14. ROLLER (12)
15. STATOR BACKPLATE
16. BOLT, 3/8-24 x 1-1/8" (12) B
17. LOCKSTRIP (6)
18. CONVERTER PUMP RETAINER
19. SINGLE-ROW BALL BEARING
20. TORQUE CONVERTER PUMP
21. WASHER
22. BOLT, SELF-LOCKING 3/8-24 x 1-1/4" (36) C
23. ACCESSORY DRIVE GEAR

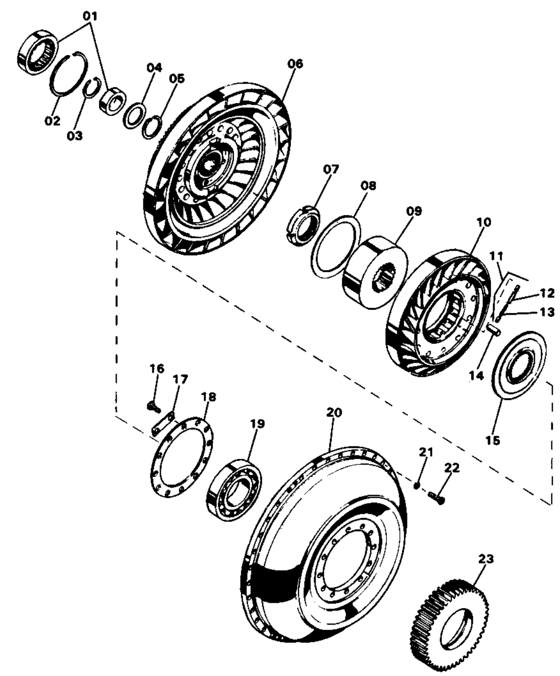
TORQUE	LB FT	N.m
A	275-325	373-440
B	33-40	45-54
C	41-49	56-66

B

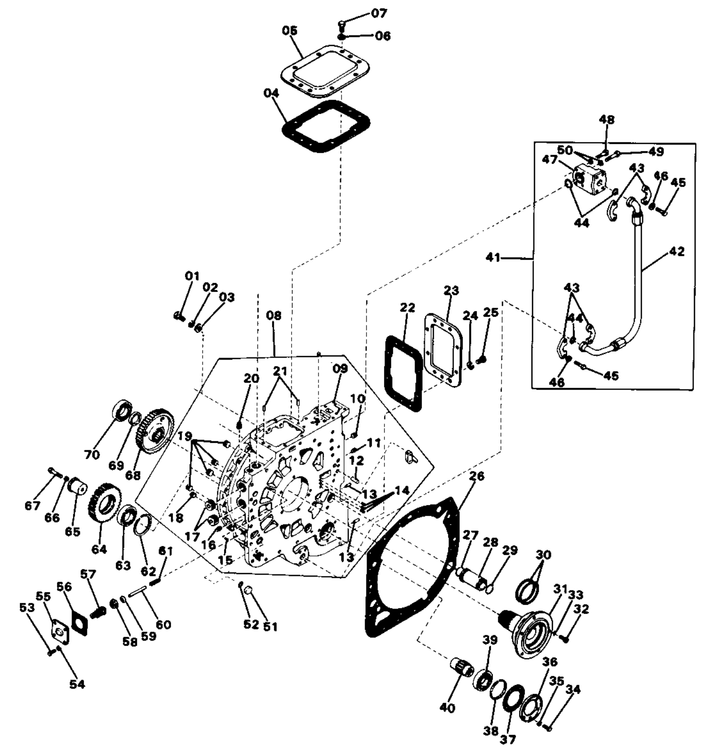
01. BOLT, 1/2-13 x 3/4" A (MODELS WITHOUT PTO)
02. LOCKWASHER, 1/2" (MODELS WITHOUT PTO)
03. PLAIN WASHER, 1/2" (MODELS WITHOUT PTO)
04. GASKET
05. POWER TAKEOFF PAD COVER
06. LOCKWASHER, 7/16" (8)
07. BOLT, 7/16-14 x 7/8" (8) (C)
08. TORQUE CONVERTER HOUSING ASSEMBLY
09. TORQUE CONVERTER HOUSING
10. PIPE PLUG, 1/2" D
11. PIPE PLUG, 1/4" D
12. DOWEL PIN, 3/4 x 1-1/4" (2)
13. DOWEL PIN, 7/16 x 1" (2)
14. PIPE PLUG, 1/8" (3) D
15. DRIVE SCREW, 1/8"
16. PIPE PLUG, 1/4" D
17. PIPE PLUG, 1-1/4" (2) D
18. PIPE PLUG, 3/4" D
19. PIPE PLUG, 1" (4) D
20. PIPE PLUG, 1/2" D
21. DOWEL PIN, 7/16 x 1" (2)
22. GASKET
23. POWER TAKEOFF PAD COVER
24. LOCKWASHER, 7/16" (8)
25. BOLT, 7/16-14 x 7/8" (8) C
26. GASKET
27. SEALRING
28. OIL PUMP SUCTION TUBE
29. SEALRING
30. STEP JOINT SEALRING (1, 2 SOME MODELS)
31. CONVERTER GROUND SLEEVE
32. BOLT, SELF-LOCKING 1/2-13 x 1-1/8" (5) E
33. LOCKWASHER (5)
34. BOLT, 3/8-16 x 7/8" (6) F
35. LOCKWASHER, 3/8" (6)
36. COVER
37. GASKET
38. SNAPRING
39. BALL BEARING
40. OIL PUMP DRIVE GEAR HUB
41. HOSE ASSEMBLY
42. OIL PUMP PRESSURE HOSE
43. SPLIT FLANGE (4)
44. SEALRING (3)
45. BOLT, 7/16-14 x 1-1/4" (8) C
46. LOCKWASHER, 7/16" (8)
47. BLOCK, HOSE CONNECTING
48. BOLT, 7/16-14 x 2" (2) C
49. BOLT, 7/16-14 x 2-1/2" (2) C
50. LOCKWASHERS, 7/16" (4)
51. CUP PLUG
52. SEALRING
53. BOLT, 3/8-16 x 3/4" (4) F
54. LOCKWASHER, 3/8" (4)
55. VALVE COVER
56. GASKET
57. SPRING
58. SEAT
59. CONVERTER-IN CHECK VALVE
60. GUIDE PIN
61. SPRING
62. SNAPRING
63. BALL BEARING
64. OIL PUMP IDLER GEAR
65. SPINDLE
66. LOCKWASHER, 1/2"
67. BOLT, 1/2-13 x 2-1/2" A
68. OIL PUMP DRIVE GEAR
69. SPACER
70. BALL BEARING

TORQUE	LB FT	N.m
A	67-80	91-108
B	14-18	19-24
C	42-50	57-67
D	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	
E	81-97	110-131
F	26-32	36-43

A



B



A, Foldout 4. Torque Converter-Exploded View
B, Foldout 4. Torque Converter Hosing-Exploded View

A

01. BOLT, 3/8-16 x 1-3/4" (4) A
02. LOCKWASHER, 3/8" (4)
03. GASKET
04. BOLT, 3/8-16 x 5" (6) A
05. LOCKWASHER, 3/8" (6)
06. BOLT, 3/8-16 x 1" (4) A
07. LOCKWASHER, 3/8" (4)
08. SCAVENGE OIL DISCHARGE TUBE
09. GASKET
10. INPUT-DRIVEN PRESSURE AND SCAVENGE OIL PUMP ASSEMBLY
11. LOCKWASHER, 3/8" (4)
12. BOLT, 3/8-16 x 2-1/4" (4) A
13. SCAVENGE PUMP BODY ASSEMBLY
14. SCAVENGE PUMP BODY
15. NEEDLE BEARING (2)
16. NEEDLE ROLLER
17. SCAVENGE PUMP GEAR (2)
18. GASKET
19. SEPARATOR PLATE ASSEMBLY
20. DOWEL
21. SEPARATOR PLATE
22. DOWEL
23. OIL PUMP DRIVE GEAR
24. OIL PUMP DRIVEN GEAR
25. GASKET
26. INPUT OIL PUMP BODY ASSEMBLY
27. NEEDLE BEARING (2)
28. INPUT OIL PUMP BODY
29. STAR TOLERANCE RING (4)
30. SCREEN
31. GASKET
32. COUPLING

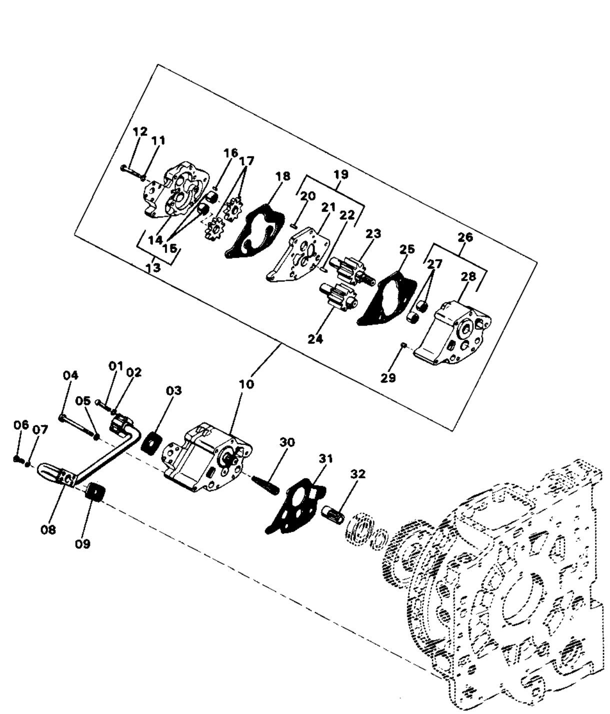
TORQUE	LB FT	N.m
A	26-32	36-43

B

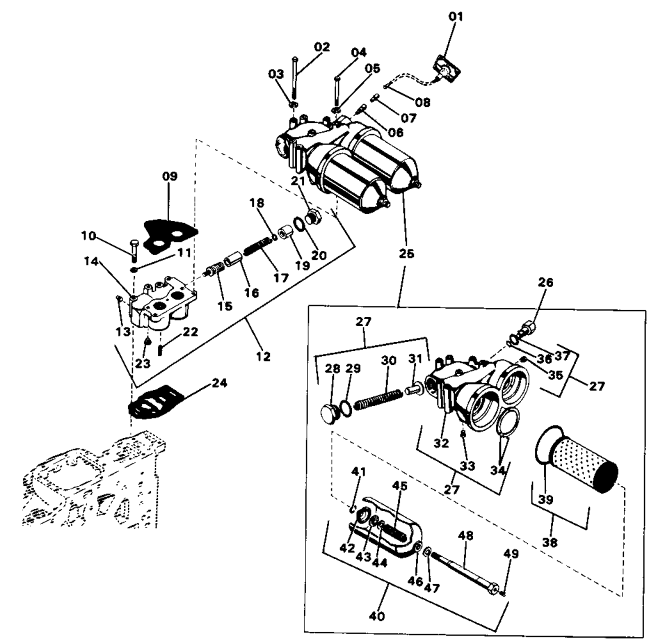
01. OIL FILTER WARNING LIGHT PLATE
02. BOLT, A
    7/16-14 x 7" (5)
03. LOCKWASHER, 7/16 (5)
04. BOLT, A
    7/16-14 x 4-1/2" (2)
05. LOCKWASHER, 7/16 (2)
06. SINGLE SHELL, MALE
07. NYLON SLEEVE
08. TERMINAL, FEMALE
09. GASKET
10. BOLT, 7/16-14 x 3-1/2" (2) A
11. LOCKWASHER, 7/16" (2)
12. MAIN-PRESSURE REGULATOR VALVE ASSEMBLY
13. PIPE PLUG, 1/4" B
14. MAIN-PRESSURE REGULATOR VALVE BODY
15. MAIN-PRESSURE REGULATOR VALVE
16. STOP
17. SPRING
18. SHIM (AR)
    0.0428" (1.087 mm)
    0.0528" (1.341 mm)
19. BOOSTER PLUG
20. GASKET
21. PLUG, 1-3/8" B
22. SETSCREW C
23. VALVE
24. GASKET
25. OIL FILTER ASSEMBLY
26. OIL PRESSURE SIGNAL SWITCH B
27. OIL FILTER BASE ASSEMBLY
28. BYPASS VALVE PLUG B
29. GASKET
30. SPRING
31. BYPASS VALVE
32. FILTER BASE
33. PIPE PLUG (2) B
34. PLATE AND SCREW (2)
35. PIPE PLUG B
36. SEALRING
37. GASKET
38. OIL FILTER ELEMENT (2)
39. SEALRING (2)
40. SHELL AND CENTER STUD ASSEMBLIES (2)
41. SNAPRING (2)
42. RETAINER (2)
43. SEAL (2)
44. WASHER (2)
45. SPRING (2)
46. SHELL (2)
47. GASKET (2)
48. CENTER STUD (2) D
49. PLUG (2)

TORQUE	LB FT	N.m
A	42-50	57-67
B	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	
C	36-60 (LB IN.)	4.07-6.78
D	45-55	61-74
E	26-32	36-43

A



B



A Foldout 5. Input-Driven Pressure and Scavenge Oil Pump
B, Foldout 5. Main-Pressure Regulator Valve and Oil Filters

A

01. BOLT, A
    3/8-16 x 2-3/4" (7)
02. LOCKWASHER, 3/8" (7)
03. GASKET
04. BOLT, A
    3/8-16 x 1-1/4"(2)
05. LOCKWASHER, 3/8" (2)
06. LOCKUP VALVE ASSEMBLY
07. LOCKUP VALVE BODY
08. LOCKUP VALVE
09. SHIM (AR)
10. WASHER
11. SPRING
12. VALVE PLUG
13. SEALRING
14. SEALRING
15. PLUG
16. LOCKUP CUTOFF VALVE
17. SPRING PIN (2)
18. VALVE
19. PLUG (4) B
20. INHIBITOR PRESSURE SWITCH
    (MANUAL-ELECTRIC MODELS)

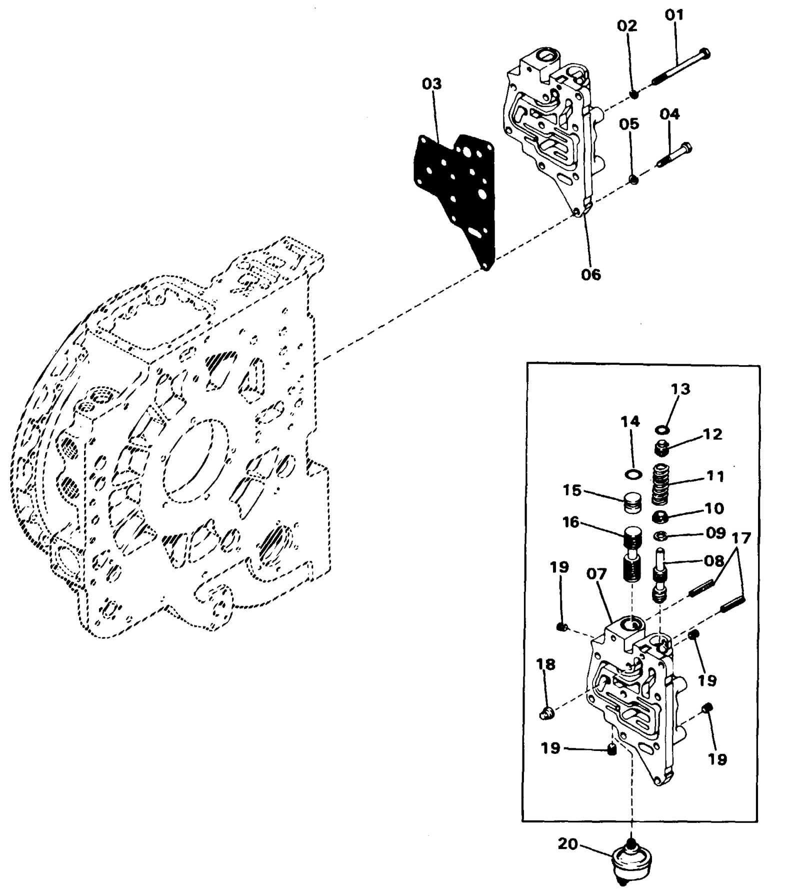
TORQUE	LB FT	N.m
A	26-32	36-43
B	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	

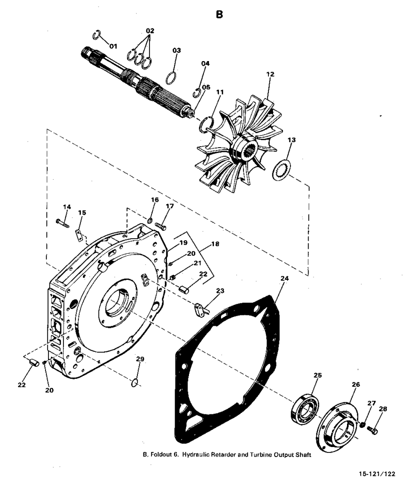
B

01. STEP-JOINT SEALRING
02. HOOK-TYPE SEALRING (3)
03. SEALRING
04. STEP-JOINT SEALRING
05. TURBINE OUTPUT SHAFT
11. SNAPRING
12. RETARDER ROTOR
13. ROTOR WASHER
14. BOLT, PITOT TUBE
    5/16-24 x 2" (2) A
15. LOCKSTRIPS
16. LOCKWASHER, 1/2" (7)
17. BOLT, 1/2-13 x 1-1/2" (7) B
18. RETARDER HOUSING ASSEMBLY
19. RETARDER HOUSING
20. PIPE PLUG, 1/8" (2) C
21. PIPE PLUG, 1/4" C
22. DOWEL PIN, 1/4"
23. PITOT TUBE
24. GASKET
25. BALL BEARING ASSEMBLY
26. OIL TRANSFER HUB
27. LOCKWASHER, 1/2" (5)
28. BOLT, 1/2-13 x 1-1/4" (5) B
29. SEALRING (LATER MODELS)

TORQUE	LB FT	N.m
A	14-18	19-24
B	67-80	91-108
C	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	

A





A, Foldout 6. Lockup Valve Assembly
B, Foldout 6. Hydraulic Retarded and Turbine Output Shaft
15-121/122

A

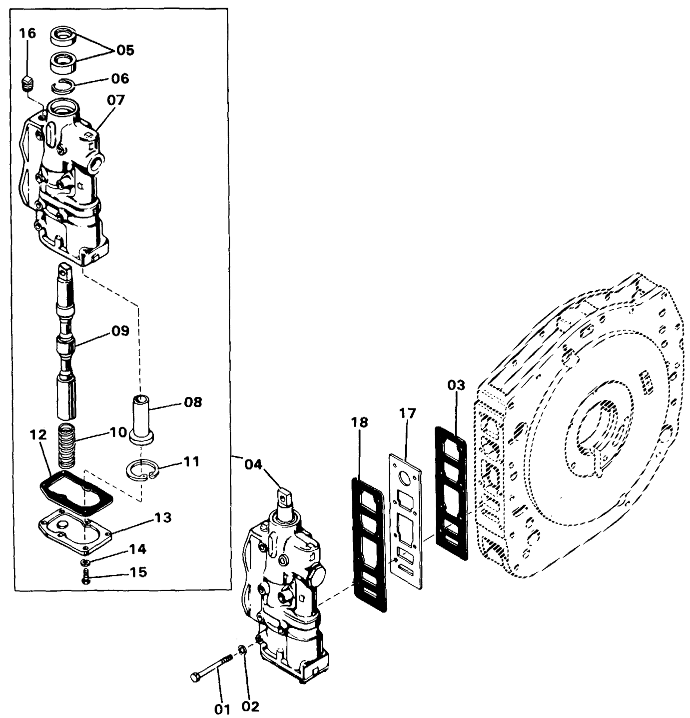
01. BOLT, A
    3/8-16 x 4-1/4" (7)
02. LOCKWASHER, 3/8" (7)
03. GASKET
04. RETARDER CONTROL VALVE ASSEMBLY
05. OIL SEAL ASSEMBLY
06. SNAPRING
07. RETARDER CONTROL VALVE BODY
08. OIL TRANSFER EXHAUST TUBE
09. RETARDER CONTROL VALVE
10. SPRING
11. SNAPRING
12. GASKET
13. VALVE COVER
14. LOCKWASHER, 3/8" (6)
15. BOLT, 3/8-16 x 1" (6) A
16. PIPE PLUG, 1/2" B
17. PLATE
18. GASKET

TORQUE	LB FT	N.m
A	26-32	36-43
B	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	

B

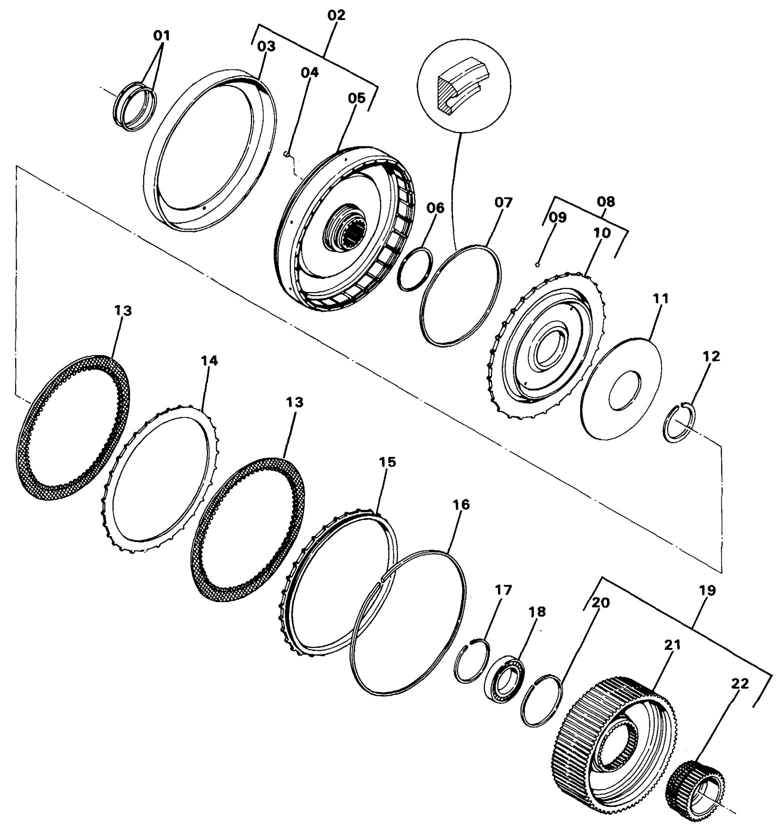
01. STEP-JOINT SEALRING (2)
02. SPLITTER-DIRECT DRUM ASSEMBLY
03. PITOT OIL COLLECTOR RING
04. DOWEL PIN (8)
05. SPLITTER-DIRECT DRUM
06. PISTON SEALRING
07. PISTON SEALRING
08. PISTON ASSEMBLY
09. BALL (2)
10. PISTON
11. BELLEVILLE SPRING
12. SNAPRING
13. INTERNAL-SPLINED PLATE (2)
14. EXTERNAL-SPLINED PLATE
15. BACKPLATE
16. SNAPRING
17. SNAPRING
18. SINGLE-ROW BALL BEARING
19. SPLITTER CLUTCH HUB
    AND SUN GEAR ASSEMBLY
20. SNAPRING
21. SPLITTER CLUTCH HUB
22. SPLITTER PLANETARY SUN GEAR

A



A, Foldout 7. Hydraulic Retarder Control Valve Assembly

B



B, Foldout 7. Splitter-Direct Clutch

A

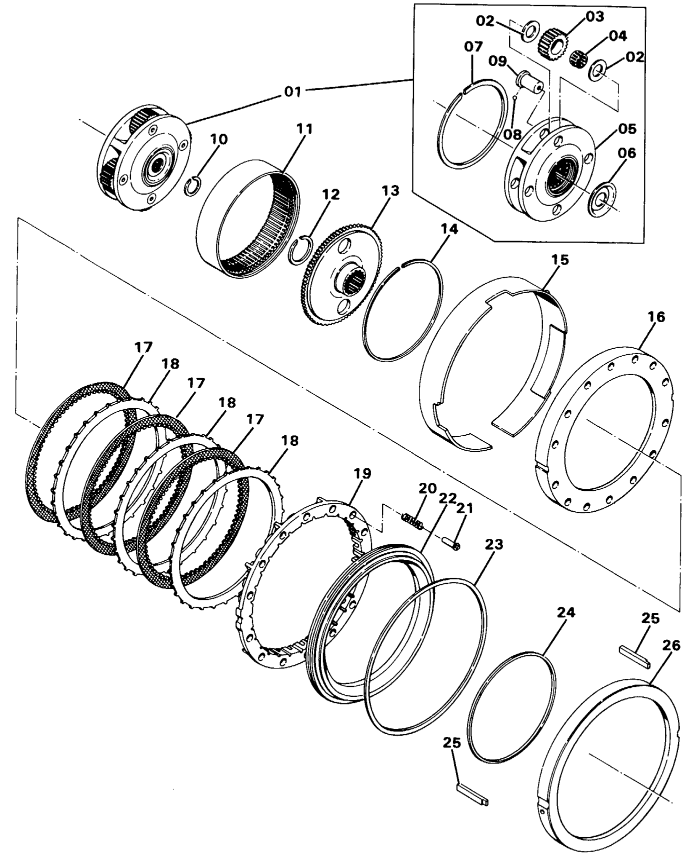
01. SPLITTER PLANETARY CARRIER ASSEMBLY
02. PINION THRUST WASHER (8)
03. PINION (MATCHED SET OF 4)
04. NEEDLE BEARING (4)
05. CARRIER
06. LUBRICATION SHIELD
07. SNAPRING
08. LOCK BALL (4)
09. SPINDLE (4)
10. SNAPRING
11. SPLITTER RING GEAR
12. SNAPRING
13. SPLITTER RING GEAR HUB
14. SNAPRING
15. SPACER
16. CLUTCH BACKPLATE
17. INTERNAL-SPLINED PLATE (3)
18. EXTERNAL-SPLINED PLATE (3)
19. SPLITTER CLUTCH ANCHOR
20. PISTON RETURN SPRING (14)
21. GUIDE PIN (14)
22. SPLITTER-OVERDRIVE CLUTCH PISTON
23. LIP-TYPE SEALRING
24. LIP-TYPE SEALRING
25. KEY, 3.91" (99.3 mm) (2)
26. SPLITTER-OVERDRIVE CLUTCH PISTON HOUSING

B

01. SNAPRING
02. SEAT
03. CONVERTER PRESSURE RELIEF VALVE
04. SPRING
05. BOLT, 3/8-16 x 3/4" (2) A
06. BEARING RETAINER (2)
07. TRANSMISSION HOUSING ASSEMBLY
08. OIL TRANSFER TUBE
09. VALVE PIN (2)
10. TRANSMISSION HOUSING
11. REDUCER BUSHING
12. BREATHER
13. LOCKWASHER, 1/2" (12)
14. BOLT, 1/2-13 x 5" B
15. JUMPER TUBE HOSE (3)
16. JUMPER TUBE (3)
17. LOCKWASHER, 1/2" (7)
18. BOLT, B 1/2-13 x 1-3/4" (7)
19. OIL TRANSFER HUB
20. LOCKWASHER, 5/8" (27)
21. BOLT, 5/8-11 x 1-3/4" (27) C
22. SPRING
23. CONVERTER PRESSURE REGULATOR VALVE
24. SEAT
25. SNAPRING
26. BALL BEARING
27. BEARING RETAINER
28. LOCKWASHER, 1/2" (6)
29. BOLT, 1/2-20 x 1-7/8" (6)D
30. PLUG E
31. WASHER

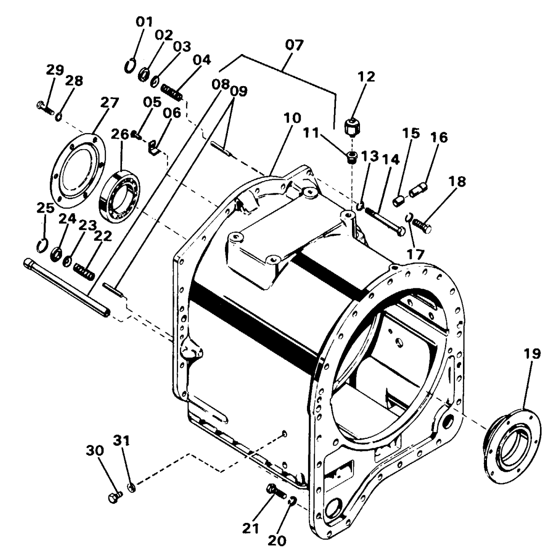
TORQUE	LB FT	N.m
A	26-32	36-43
B	67-80	91-108
C	117-140	159-189
D	96-115	131-155
E	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	

A



A, Foldout 8. Splitter Planetary and Splitter-Overdrive Clutch

B



B, Foldout 8. Transmission Housing

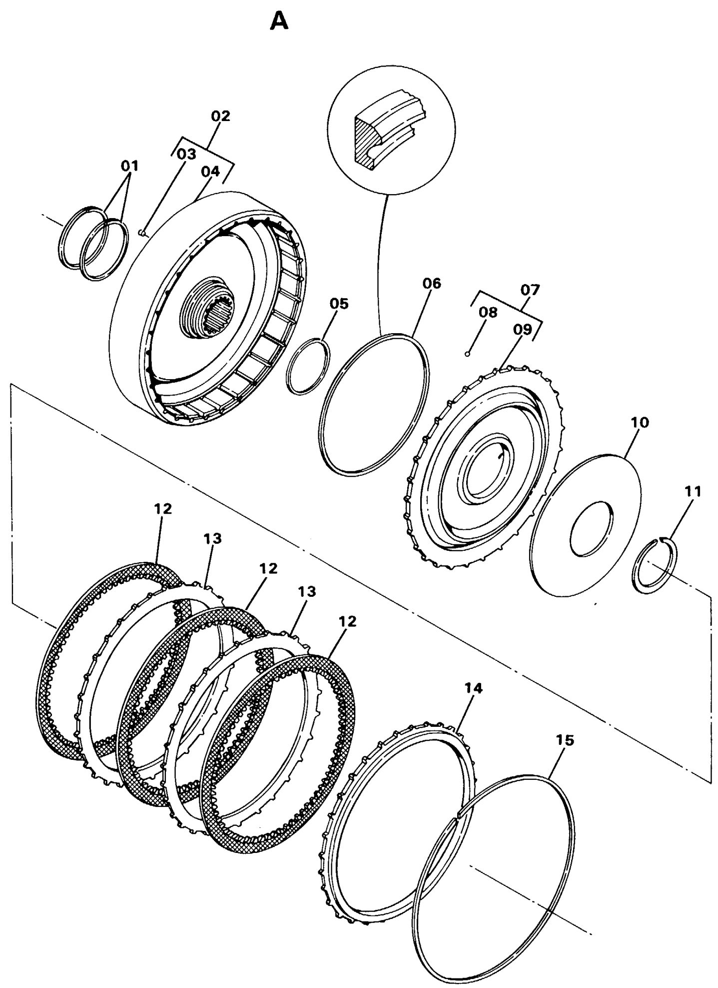
A

01. STEP-JOINT SEALRING (2)
02. FIFTH-AND-SIXTH-GEAR CLUTCH DRUM ASSEMBLY
03. DOWEL PIN (8)
04. FIFTH-AND-SIXTH-GEAR CLUTCH DRUM
05. INNER SEALRING
06. LIP-TYPE SEALRING
07. PISTON ASSEMBLY
08. BALL (2)
09. PISTON
10. BELLEVILLE SPRING
11. SNAPRING
12. INTERNAL-SPLINED PLATE (3)
13. EXTERNAL-SPLINED PLATE (3)
14. BACKPLATE
15. *INTERNAL SNAPRING*

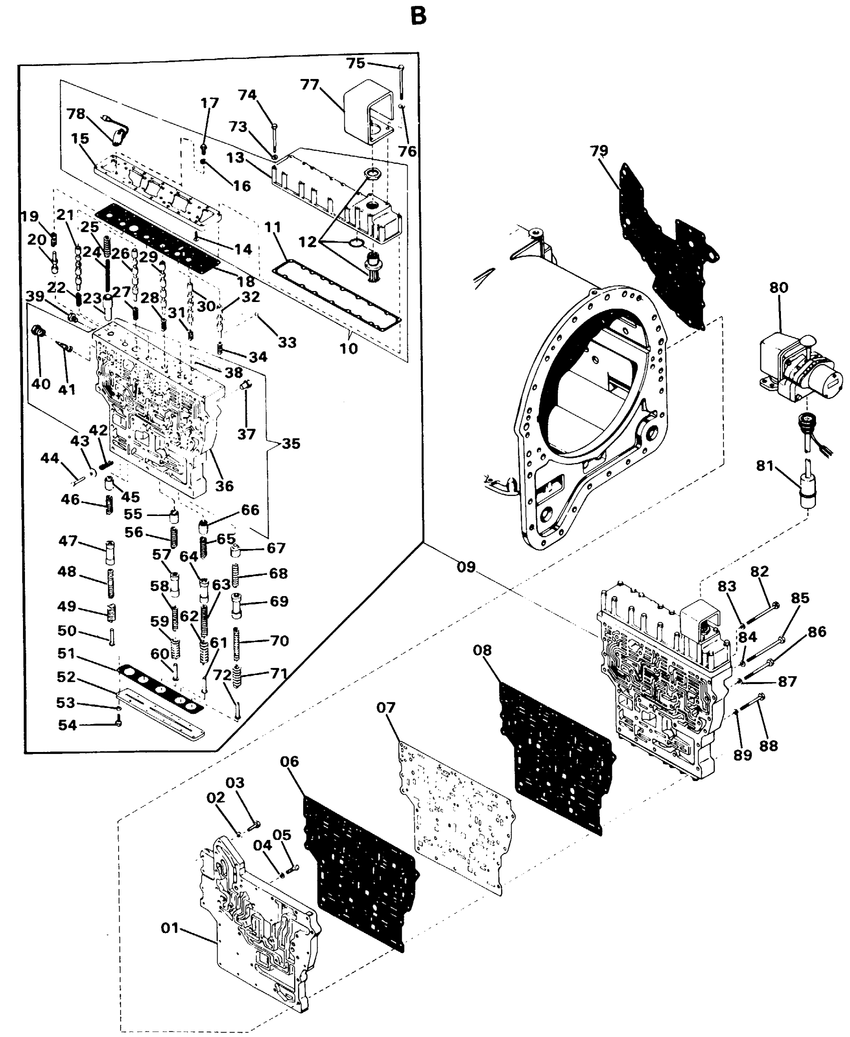
B

01. OIL TRANSFER PLATE
02. LOCKWASHER, 3/8" (3)
03. BOLT, 3/8-16 x 1-3/8" (2)
04. FLAT WASHER, 3/8" (2)
05. BOLT, SELF-LOCKING 3/8-16 x 1-1/4" (2) A
06. GASKET
07. SEPARATOR PLATE
08. GASKET
09. CONTROL VALVE ASSEMBLY
10. SOLENOID COVER AND PLATE ASSEMBLY
11. GASKET
12. VALVE BODY INTERNAL WIRING HARNESS AND RETAINING NUT B
13. SOLENOID COVER
14. FLAT-HEAD SCREW, 10-24 x 1" (2) C
15. SOLENOID PLATE
16. LOCKWASHER, 1/4" (14)
17. BOLT, 1/4-20 x 5/8" (14) D
18. SOLENOID PLATE GASKET
19. SPRING
20. SOLENOID PRESSURE REGULATOR VALVE
21. SPLITTER SHIFT VALVE
22. SPRING
23. PRIORITY VALVE
24. INNER SPRING
25. OUTER SPRING
26. FIFTH-AND-SIXTH-GEAR SHIFT VALVE
27. SPRING
28. SPRING
29. THIRD-AND-FOURTH-GEAR SHIFT VALVE
30. FIRST-AND-SECOND-GEAR SHIFT VALVE
31. SPRING
32. REVERSE-GEAR SHIFT VALVE
33. STEEL BALL, 5/16" (2)
34. SPRING
35. VALVE BODY ASSEMBLY
36. VALVE BODY (EARLIER MODELS)
37. PLUG, 1/8-27 (4) E
38. ORIFICE PLUG (5) E
39. PLUG E
40. PLUG, 1/8-27E
41. OIL SCREEN ASSEMBLY
42. SPRING
43. CHECK VALVE
44. PIN
45. SPLITTER-DIRECT TRIMMER UPPER VALVE
46. SPRING
47. SPLITTER-DIRECT TRIMMER LOWER VALVE
48. INNER SPRING
49. OUTER SPRING
50. STOP
51. GASKET
52. VALVE BODY COVER
53. LOCKWASHER, 1/4" (14)
54. BOLT, 1/4-20 x 1" (14) D
55. THIRD-AND-FOURTH-GEAR TRIMMER UPPER VALVE
56. SPRING
57. THIRD-AND-FOURTH-GEAR TRIMMER LOWER VALVE
58. INNER SPRING
59. OUTER SPRING
60. STOP
61. STOP
62. OUTER SPRING
63. INNER SPRING
64. FIRST-AND-SECOND-GEAR TRIMMER LOWER VALVE
65. SPRING
66. FIRST-AND-SECOND-GEAR TRIMMER UPPER VALVE
67. REVERSE TRIMMER UPPER VALVE
68. SPRING
69. REVERSE TRIMMER LOWER VALVE
70. INNER SPRING
71. OUTER SPRING
72. STOP
73. LOCKWASHER, 1/4" (14)
74. BOLT, 1/4-20 x 3-5/8" (14) D
75. BOLT, 1/4-20 x 4" (4) D
76. LOCKWASHER, 1/4" (4)
77. HARNESS GUARD
78. SOLENOID (7)
79. OIL TRANSFER PLATE GASKET
80. MANUAL SELECTOR ASSEMBLY
81. WIRING HARNESS ASSEMBLY
82. BOLT, 3/8-16 x 4-1/4" (12) A
83. LOCKWASHER, 3/8" (12)
84. LOCKWASHER, 3/8" (2)
85. BOLT, 3/8-16 x 5" (2) A
86. BOLT, 3/8-16 x 3-3/4" (9) A
87. LOCKWASHER, 3/8" (9)
88. BOLT, 3/8-16 x 3" (11) A
89. LOCKWASHER, 3/8" (11)

TORQUE	LB FT	N.m
A	26-32	35-43
B	30-35	41-47
C	24-36 (LB IN.)	2.71-4.07
D	9-11	12.2-14.9
E	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	



A, Foldout 9. Fifth-and-Sixth-Gear Clutch



B, Foldout 9. Electric-Shift Control Valve Assembly

A

01. GASKET
02. OIL PAN ASSEMBLY
03. OIL PAN
04. OIL STRAINER SHIELD
05. GASKET
06. OIL STRAINER
07. BOLT, 3/8-16 x 7/8" (6) B
08. LOCKWASHER, 3/8" (6)
09. OIL DRAIN PLUG, 3/4" A
10. LOCKWASHER, 3/8" (4)
11. BOLT, 3/8-16 x 5" (4) B
12. LOCKWASHER, 3/8" (24)
13. BOLT, 3/8-16 x 1-1/8" (24) B

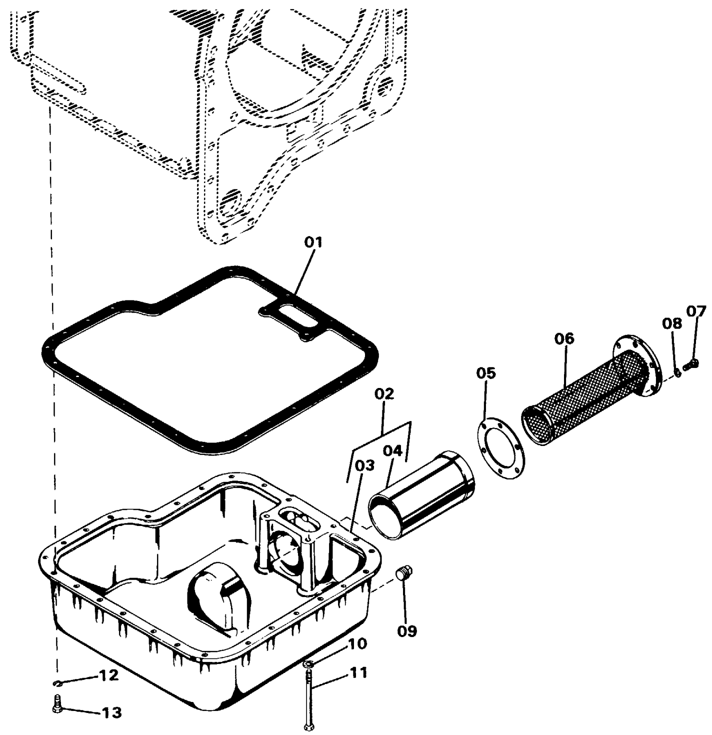
TORQUE	LB FT	N.m
A	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	
B	26-32	36-43

B

01. SUN GEAR
02. INTERMEDIATE-RANGE PLANETARY CARRIER ASSEMBLY
03. PLANETARY CARRIER
04. SPINDLE (4)
05. BALL, 3/16" (4)
06. THRUST WASHER (8)
07. PINION (MATCHED SET OF 4)
08. SINGLE-ROW BALL BEARING ASSEMBLY
09. SEALRING
10. OIL COLLECTOR RING
11. RETAINER (4)
12. BOLT, SELF-LOCKING 3/8-24 x 5/8" (8) A
13. RING GEAR
14. COMPRESSION (CRUSH) RING
15. BACKPLATE
16. KEY, 2.63-2.69" (66.8-68.3 mm) (2)
17. ANCHOR
18. PISTON RETURN SPRING (14)
19. INTERNAL-SPLINED PLATE (3)
20. EXTERNAL-SPLINED PLATE (3)
21. SEALRING
22. PISTON
23. SEALRING
24. PISTON HOUSING ASSEMBLY
25. PISTON HOUSING
26. PIN (2)
27. ROLLER BEARING (4)

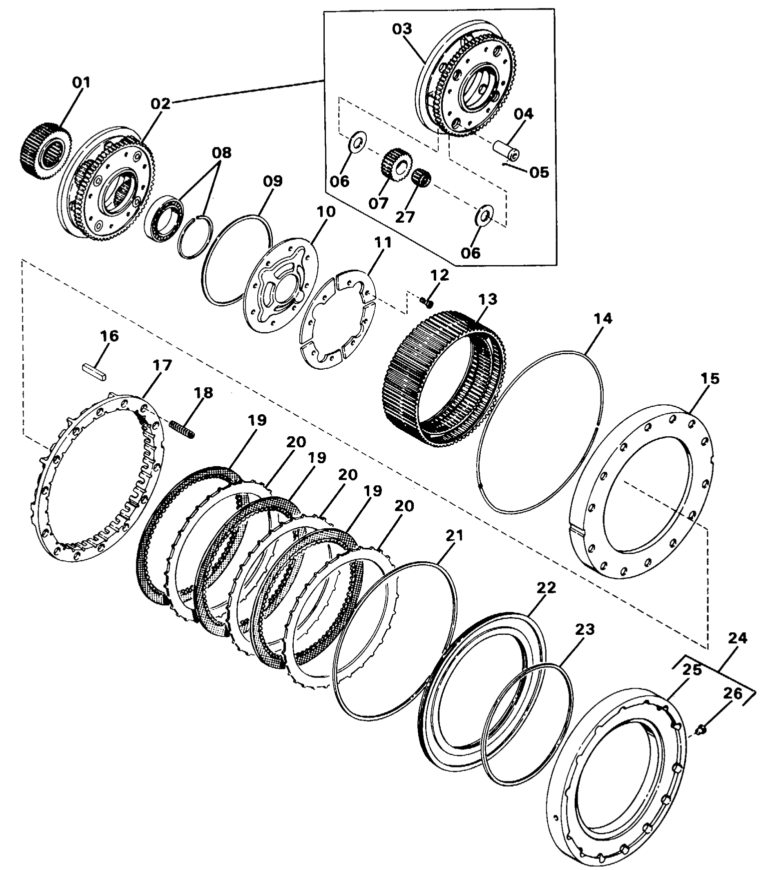
TORQUE	LB FT	N.m
A	41-49	56-66

A



A, Foldout 10. Oil Pan

B



B, Foldout 10. Intermediate-Range Planetary and Third-and-Fourth-Gear Clutch

A

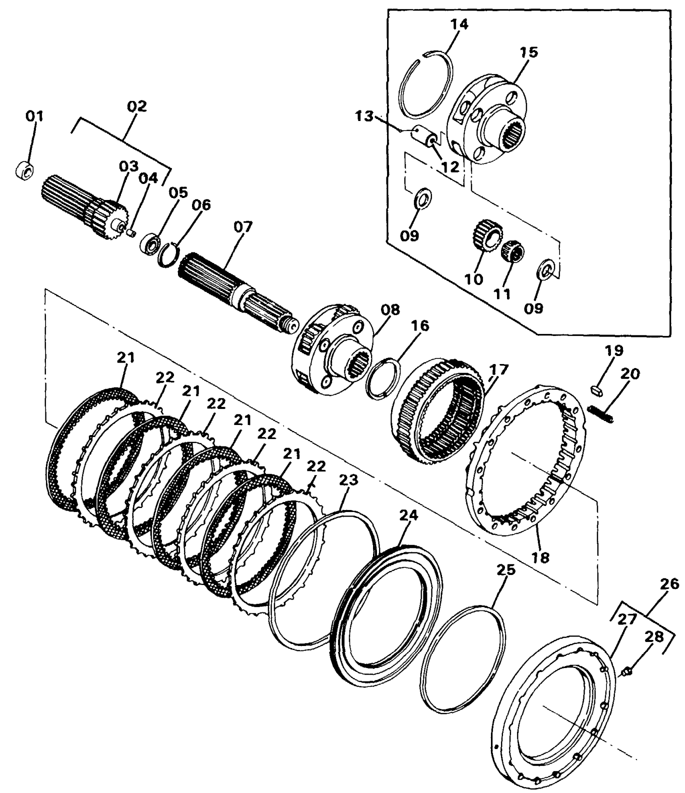
01. SLEEVE (USED ONLY WHEN REWORKING SPLITTER SHAFT 3)
02. SPLITTER SHAFT ASSEMBLY
03. SPLITTER SHAFT
04. ORIFICE TUBE
05. BALL BEARING
06. SNAPRING
07. TRANSMISSION OUTPUT SHAFT
08. LOW RANGE PLANETARY CARRIER ASSEMBLY
09. THRUST WASHER (8)
10. PINION (4)
11. ROLLER BEARING (5)
12. SPINDLE (4)
13. BALL (4)
14. SNAPRING
15. LOW-RANGE PLANETARY CARRIER
16. THRUST WASHER
17. RING-GEAR
18. ANCHOR
19. KEY, 1.234-1.264" (31.34-32.10 mm) (2)
20. PISTON RETURN SPRING (14)
21. INTERNAL-SPLINED PLATE (4)
22. EXTERNAL-TANGED PLATE (4)
23. SEALRING
24. PISTON
25. SEALRING
26. PISTON HOUSING ASSEMBLY
27. PISTON HOUSING
28. PIN (2)

B

01. SUN GEAR
02. BOLT, 3/8-24 x 5/8" (6) B
03. RETAINER
04. THRUST WASHER
05. RING GEAR
06. REVERSE PLANETARY CARRIER ASSEMBLY
07. PLANETARY CARRIER
08. THRUST WASHER (12)
09. SPACER (2)
10. PINION (MATCHED SET OF 6)
11. ROLLER (144)
12. STEEL BALL, 3/16" (6)
13. SPINDLE (6)
14. BALL BEARING
15. ANCHOR
16. PISTON RETURN SPRING (14)
17. KEY, 1.70-1.73" (43.2-43.9 mm) (2)
18. INTERNAL-SPLINED PLATE (5)
19. EXTERNAL-SPLINED PLATE (5)
20. SEALRING
21. PISTON
22. SEALRING

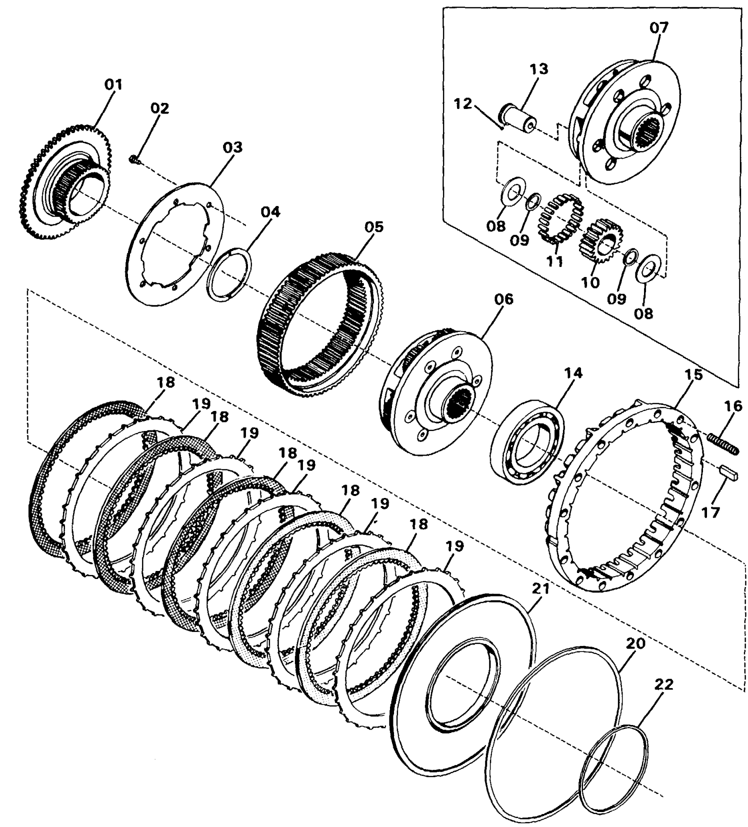
TORQUE	LB FT	N.m
B	41-49	56-66

A



A, Foldout 11. Low-Range Planetary and First-and-Second-Gear Clutch

B



B, Foldout 11. Reverse Planetary and Clutch

A

01. GASKET
02. OUTPUT DRIVE HOUSING ASSEMBLY (LATER MODELS)
03. *PIPE PLUG, 3/4" A*
04. DOWEL PIN, 3/4 x 1-1/4" (2)
05. OUTPUT DRIVE HOUSING
06. BUSHING
07. *GASKET*
08. LOCKWASHER, 5/8"
09. BOLT, 5/8-11 x 3-3/4" B
10. BALL BEARING
11. WASHER, 5/8" (8)
12. BOLT, 5/8-11 x 1-3/4" (8) B
13. BEARING RETAINER ASSEMBLY
14. *BEARING* RETAINER
15. OIL SEAL
16. BAFFLE
17. NIPPLE
18. MAGNETIC PICKUP D
19. LOCKWASHER
20. BOLT, 5/8-11 x 3-3/4" B
21. NAME PLATE
22. DRIVE SCREW (4)
23. OIL LEVEL CHECK *PLUG* (2) A
24. SPEEDOMETER DRIVE GEAR ASSEMBLY
25. SPEEDOMETER DRIVE GEAR
26. MAGNETIC PICKUP GEAR
27. SPACER
28. GASKET
29. LOCKWASHER, 5/16" (2)
30. BOLT, 5/16-18 x 7/8" (2) D
31. COVER, *SPEEDOMETER*

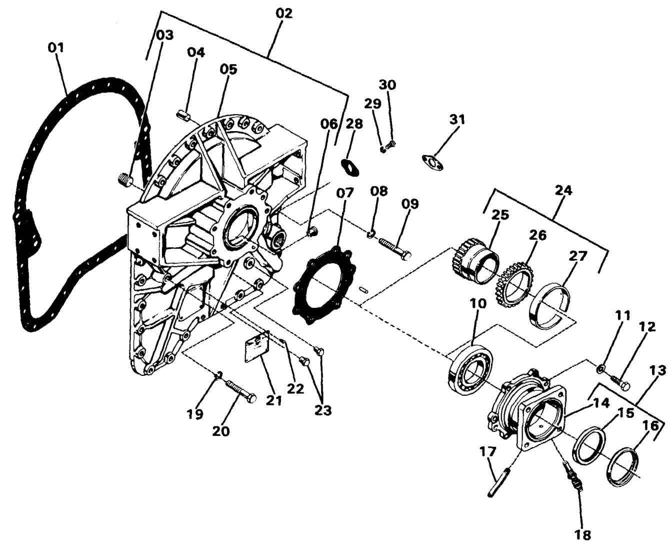
TORQUE	LB FT	N.m
A	TIGHTEN SUFFICIENTLY TO PREVENT LEAKAGE	
B	117-140	159-189
C	*134-160*	183-216
D	13-16	18-21
E	67-80	91-108

B

01. MANUAL-ELECTRIC SHIFT TOWER ASSEMBLY
02. INHIBITOR INNER CLUTCH
03. *SEALRING, 1-1/8" OD*
04. LEVELER
05. LEVELER SPRING
06. DRIVE SCREW (4)
07. NAMEPLATE
08. SHIFT TOWER BODY
09. SHIFT GATE PIN (3)
10. *SCREW, 5/16-18 x 5/8" (3)*
11. LOCKWASHER, 5/16" (3)
12. BUSHING
13. NUT
14. *SEALRING, 9/16" OD*
15. SPACER PLATE
16. HANDLE
17. *KNOB*
18. DRIVE ADAPTER
19. SHIM (AR)
20. SEALRING, 2-11/16" OD
21. *SCREW, 6-32 x 3/4" (2)*
22. WASHER, NO. 6 (2)
23. MOUNTING BRACKET
24. MICROSWITCH ASSEMBLY
25. *SWITCH COVER SEAL*
26. SWITCH COVER
27. WASHER, NO. 10 (4)
28. *SCREW, 10-24 x 5/8" (4)*
29. SEALRING, 1-1/2" OD
30. SCREW, 6-32 x 3/8" SELF-TAPPING (4)
31. WIRING HARNESS KIT
32. 16-PIN CONNECTOR AND WIRING
33. SWITCH JUMPER WIRE
34. HEAT-SHRINK TUBING, 9"
35. 4-PIN CONNECTOR AND WIRING
36. 4-PIN SOCKET AND WIRING
37. SETSCREW, 10-32 x 1/4"
38. PIN
39. ROTARY KEY
40. DOWEL PIN (2)
41. LIGHT SOCKET PLATE ASSEMBLY
42. RESISTOR (24V ASSY)
43. RIVET (24V ASSY)
44. RESISTOR HOLDER (24V ASSY)
45. LIGHT PLATE AND SOCKET
46. ROTARY KEY PIN
47. LAMP, NO. 1816
48. SEALRING, 3/8" OD
49. SCREW, 6-32 x 3/8" (4)
50. SCREW, 8-32 x 1/2" (3)
51. LOCKWASHER, NO. 8 (3)
52. SOLENOID COVER
53. GASKET
54. SOLENOID ASSEMBLY
55. SOLENOID CORE
56. WASHER
57. SOLENOID COIL
58. SEALRING, 15/16" OD
59. RETAINER RING
60. SPRING SEAT
61. *OVERRIDE SPRING*
62. GUIDE PIN (2)
63. SOLENOID HOUSING
64. SEALRING, 2-1/8" *OD*
65. FUSE, SFE 9
66. FUSE HOLDER ASSEMBLY
67. CAP
68. *BODY*
69. NUT
70. SCREW, 1/4-20 x 1"
71. LOCKWASHER, 1/4"
72. *BODY* COVER ASSEMBLY
73. GATE PIN (4)
74. BODY COVER
75. *SHIFT INDICATOR*
76. SHIFT INDICATOR SUPPORT
77. INHIBITOR CLUTCH SPRING
78. INHIBITOR OUTER CLUTCH
79. *WASHER, 17/64 x 1/2 x 1/16" (2)*
80. SCREW, 1/4-20 x 1-3/4" (2)

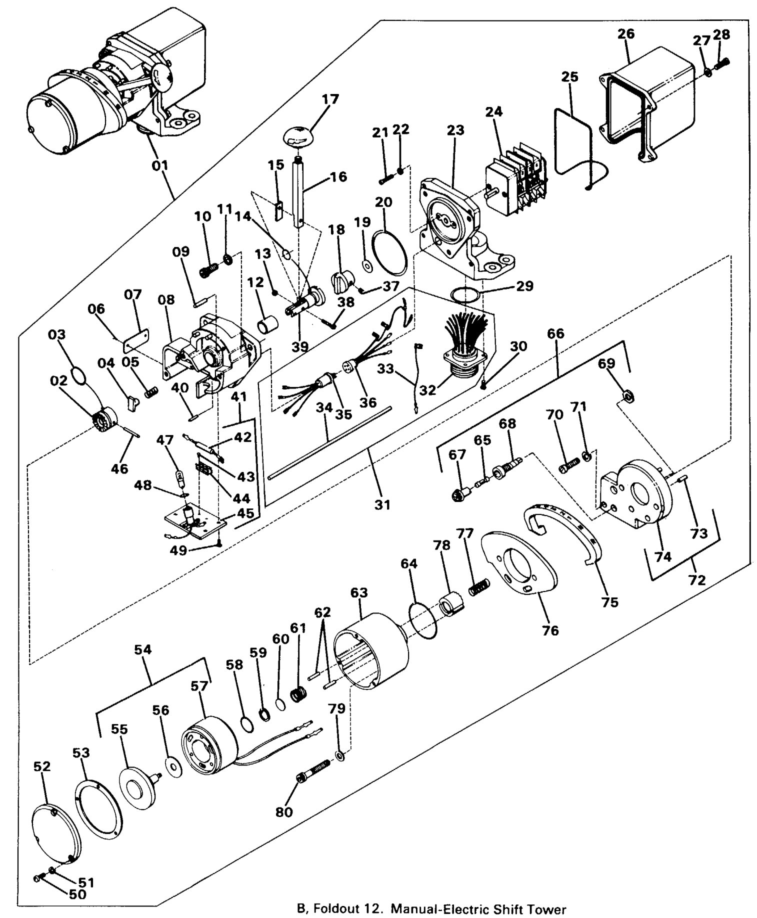
TORQUE
HAND TIGHTEN ALL FASTENERS

A



A, Foldout 12. Output Drive Housings and Speedometer Drive

B



B, Foldout 12. Manual-Electric Shift Tower

SECTION XVI

ENGINE

SUBSECTION **PAGE**

SUBSECTION 16A

GENERAL

CONTENTS

This section contains complete disassembly, rebuild and assembly instructions for the upper and lower engines.

At the beginning of each subsection is an exploded view of the components covered in that Subsection. A table of pertinent specifications is listed at the end of the subsection.

Near the end of the section, Subsection 16Q, is a complete tabulation of parts dimensions, worn limits, torque specifications, lubricating oil, fuel oil and coolant specifications. Worn limits, as used in this manual, indicate that the part may be reused if it does not exceed the worn limit. Damage to the part could be in other areas not covered by the worn limit; therefore, the reuse of any part is the responsibility of the person making the inspection.

Service tools are listed in the front of each subsection. Procedures for the use of the service tools that are the most difficult to use are described near the end of the subsection. Service tools that are designated 0000000 are being developed at this time. As these tools are designed and released for use in the field, tools numbers will be assigned and added to this section. Do not order the service tools designated 0000000. These service tools can be ordered from the nearest Cummins Distributor.

DATAPLATE

The engine models covered can be identified from the engine dataplate as to design, aspiration, cubic inch displacement, application and maximum rated horsepower:

Example: KT-1 150-C-xxx

K	= Engine Family
T	= Turbocharged (if there is no letter "T", the engine is naturally aspirated)
1150	= Cubic Inch Displacement
C	= Construction
xxx	= Maximum Rated Horsepower

Application Designations (Combinations of Letters may be used)

	Automotive (On-Highway) Has no letter or displacement code.
C	Construction (Construction industry)
C	Used before horsepower - custom rated.

SPECIFICATIONS

Engine specifications are listed in Table 16A-1.

Table 16A-1. Specifications

Engine	HP @ RPM Seal Level 600 F	HP @ RPM 500/850 F	Aspiration	No. Cyl.	Bore and Stroke	Displacement Cu. In.
Upper and Lower	450 @ 2100	450 @ 2100	Turbocharged	6	6-1/4 x 6-1/4	1150

SUBSECTION 16B

ENGINE DISASSEMBLY

TOOLS

The following service tools or tools of equal quality are considered necessary to disassemble the engines.

Essential Service Tools (Or Equivalent)

Service Tool Number	Tool Name
3375016	Camshaft Gear Puller
ST-1286 (2)	Engine Lifting Hook
ST-1258	Lifting Fixture
3375193	Engine Rebuild Stand
ST-1307	Engine Stand Adapter
ST-1313	Camshaft Pilot

Desirable Service Tools (Or Equivalent)

ST-647	Puller (Pulley)
3376000	Injector Removal Tool
ST-1116	Main Bearing Cap Puller
ST-1209	Liner Puller
3375629	Liner Puller Bridge
ST-1281	Cup Plug Driver
3375049	Filter Wrench
3375098	Connecting Rod Guide Pins
ST-1319	Tube Driver
3375834	Gear Puller Assembly
3375835	Jaw

Standard Tools - Obtain Locally

	Hoist (Power or Chain)
	Steam Cleaner
	Cleaning Tank
	Rinsing Tank
	Impact Wrench
	Glass Bead Cleaner

UNIT REMOVAL AND CLEANING

Before the disassembly of an engine orany unit used on the engine, an inspection of the overall engine condition should be made. Information noted before and during disassembly can save considerable time when the engine is reassembled.

Inspection of each unit and tagging of the electrical wires, components, bearing shell positions and other parts identification will help insure correct assembly. Remove the units and component parts from the cylinder block in a convenient order by removing mounting hardware, such as clamps, mounting brackets, capscrews, flatwashers, lockwashers, drive belt, etc. Mark or identify mounting components, as removed, for the mounting location. Place the parts and units (except electrical parts) on a cart for cleaning. Discard the hose, O-rings, gaskets and lockplates.

NOTE

The capscrew length should be noted as capscrews are removed from the components, such as oil cooler housing, lubricating oil pan adapter, front gear cover and steelplate, etc. to assure proper thread engagement during assembly.

ENGINE DATAPLATE

Engine dataplates are located on the top side of the lubricating oil cooler housing, Figure 16B-1. Another dataplate is located at the rear of the engine block above the flywheel housing. Information on dataplates should be used when ordering parts.

Figure 16B-1. Engine Dataplate Location

DRAIN WATER AND OIL

Drain the complete engine of water, lubricating oil and fuel. Bleed the compressed air system, in the lower engine.

1. Open the vent cock in the thermostat housing and drain the cocks in the oil cooler housing and water pump, Figure 16B-2.

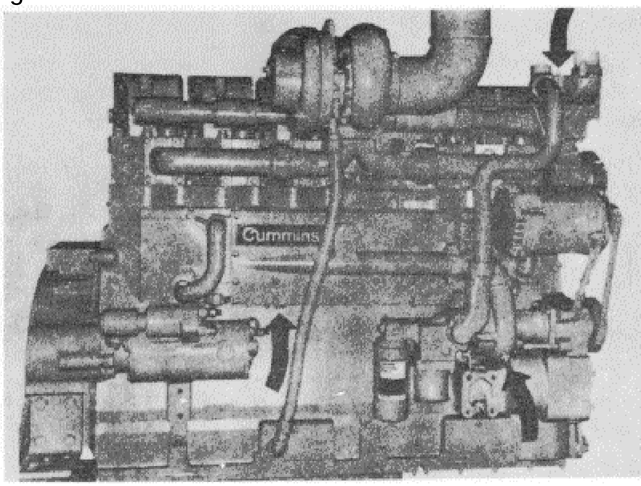


Figure 16B-2. Cooling System Drain Points

2. Remove the drain plugs in oil pan sump(1), Figure 16B-3 and pan adapter cover plate (2).

NOTE

It is necessary to remove the drain plug in the adapter cover plate when draining lubricating oil.

3. Drain the fuel oil from the pump, filter(s) and fuel lines, if petcock is located below the fuel filter can.

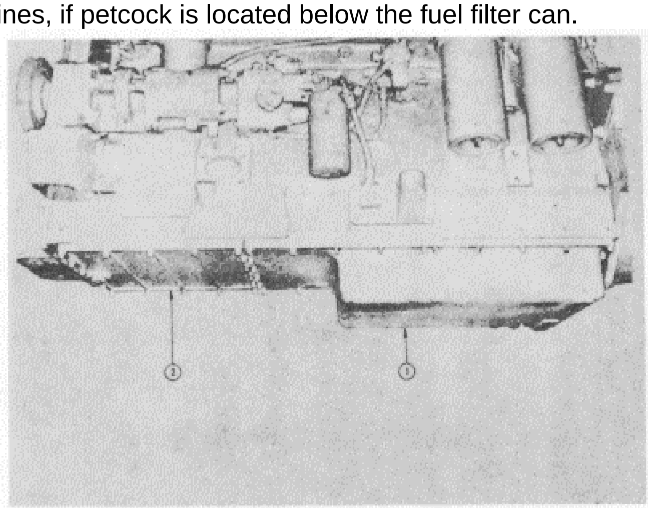


Figure 16B-3. Lubricating Oil Pan

STEAM CLEAN ENGINE EXTERIOR

Prior to steam cleaning, remove all electrical components, such as the alternator and adjusting link, Figure 16B-4, cranking motor, Figure 16B-5, and electrical controls, as used. Tag the wire leads as removed. Cover all the openings with moisture proof tape. In addition to the actual time saved by cleaning prior to disassembly, inspections can be made more quickly and accurately if the surfaces are clean.

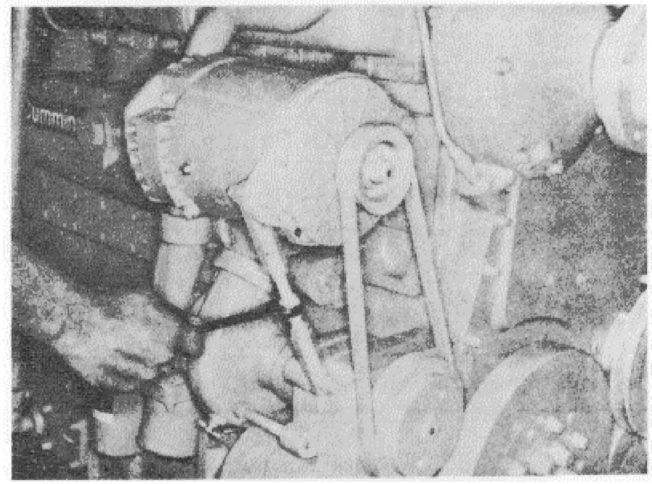


Figure 16B-4. Remove the Alternator and Adjusting Link

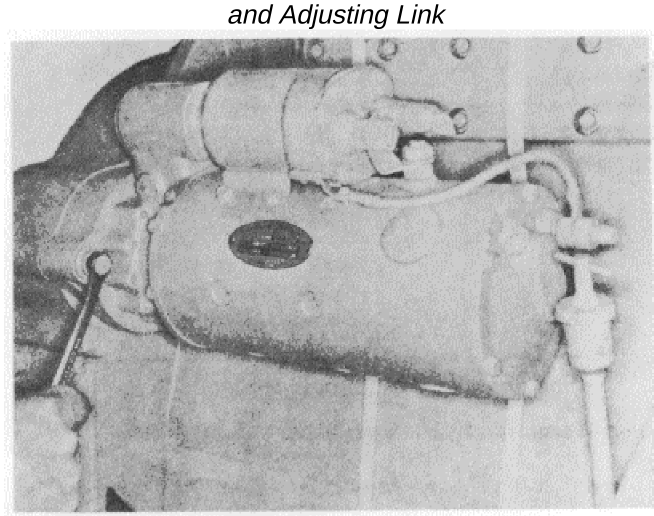


Figure 16B-5. Remove the Cranking Motor

ENGINE-DISASSEMBLY

GENERAL

Before mounting the engine to the rebuild stand, several components on the exhaust manifold side of engine must be removed.

FAN

1. Remove capscrews securing fan blade assembly to fan hub, lift off fan.
2. Place box end wrench over flats on idler lever cap and lift up to release the belt tension, remove fan drive belt.

TURBOCHARGER

1. Remove the oil supply and drain lines, Figure 16B-6.

NOTE

If Klincher type nuts are stuck or frozen, they may be removed by placing a chisel between the corners of the hex nut and striking it with a hammer.

2. Remove the strap connecting the air crossover to the turbocharger (Figure 1 6B-7).

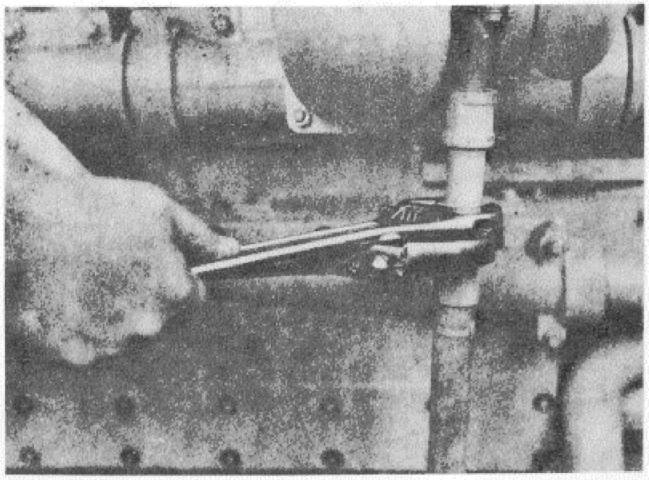


Figure 16B-6. Remove the Turbocharger Oil Lines

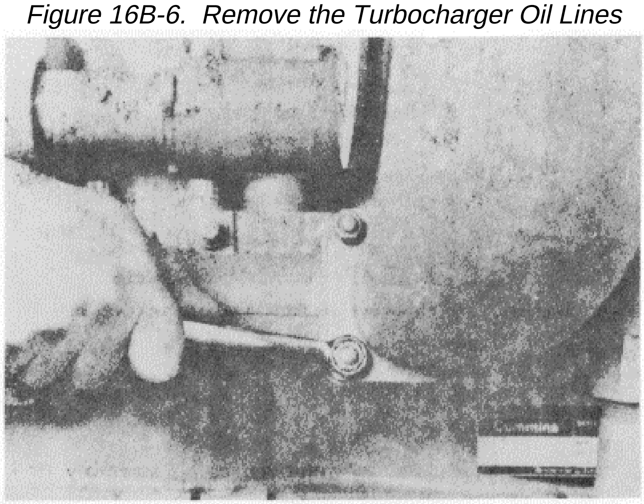


Figure 16B-7. Remove the Turbocharger

3. Remove the air crossover tube connecting the turbocharger to the intake manifold connection, Figure 16B-8.

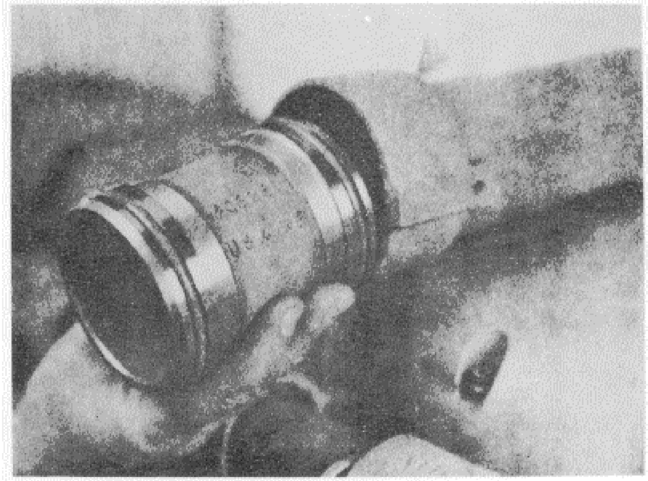


Figure 16B-8. Remove the Crossover Tube

WATER PUMP

1. Close the valve above the water filter. Remove and discard the water filter, Figure 1 6B-9.

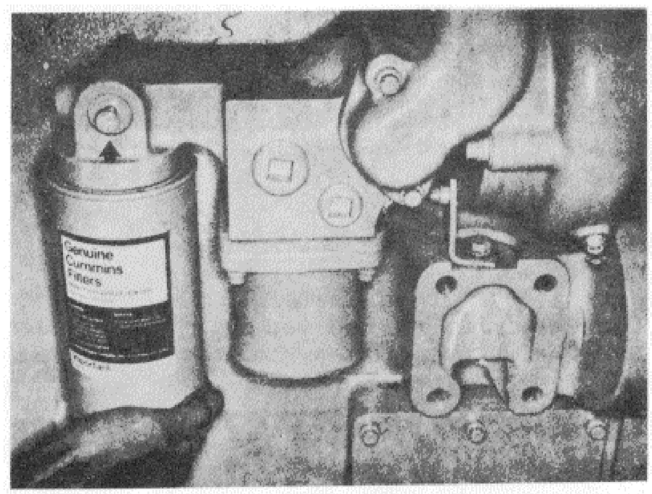


Figure 16B-9. Remove the Water Filter

2. Remove the tube assembly connecting the water pump to the cooler housing, Figure 16B-10.
3. Remove the by-pass tube assembly connecting the water pump to the thermostat housing, Figure 16B-1 1.
4. Remove the bracket from the water pump, Figure 16B-12.

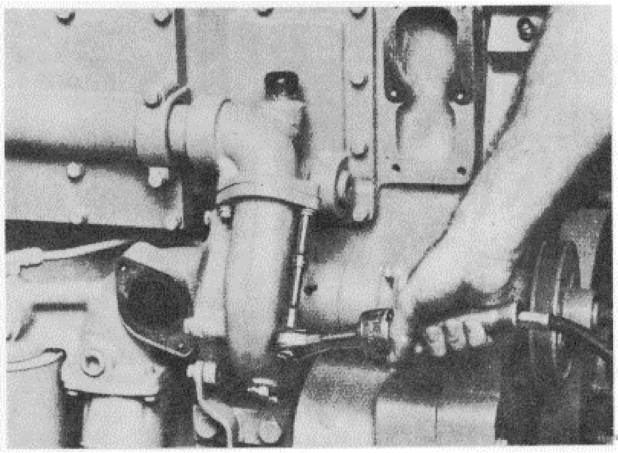


Figure 16B-10. Remove the Water Pump From the Cooler Transfer Tube

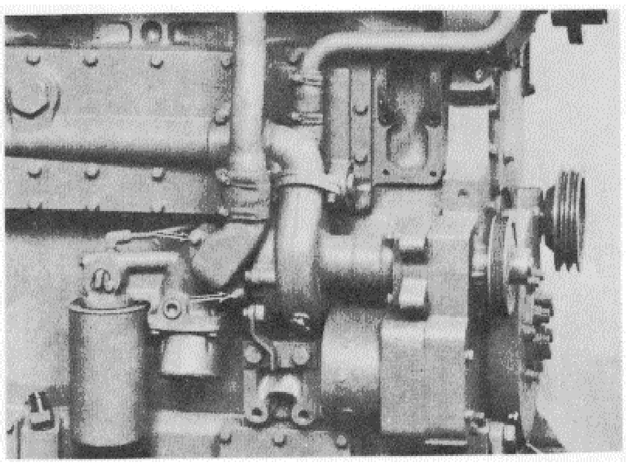


Figure 16B-11. Remove the Water By-Pass Tube Assembly

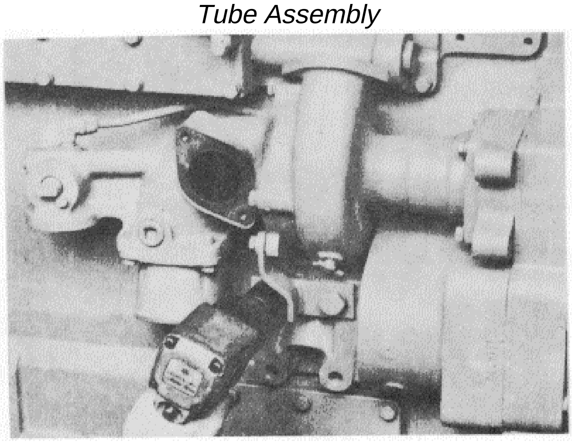


Figure 16B-12. Remove the Water Pump Assembly

NOTE

The water pump must be moved parallel with the engine or straight back during the removal to clear the drive shaft and stud.

ALTERNATOR MOUNTING BRACKET

Remove the alternator mounting bracket from the block.

LUBRICATING OIL COOLER

1. On lower engine, remove cooler cover from housing, lift out torque converter oil cooler elements. Discard gasket and O-rings.1
2. Remove capscrews securing engine oil cooler elements to housing, lift out elements. Discard gaskets and elements.
3. On upper engine remove cooler cover, Figure 16B-13, cooler housing, Figure 16B-14.

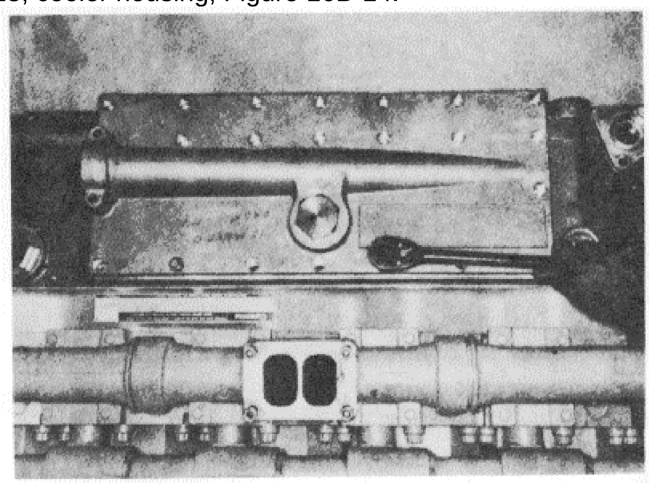


Figure 16B-13. Remove the Lubricating Oil Cooler Cover Plate

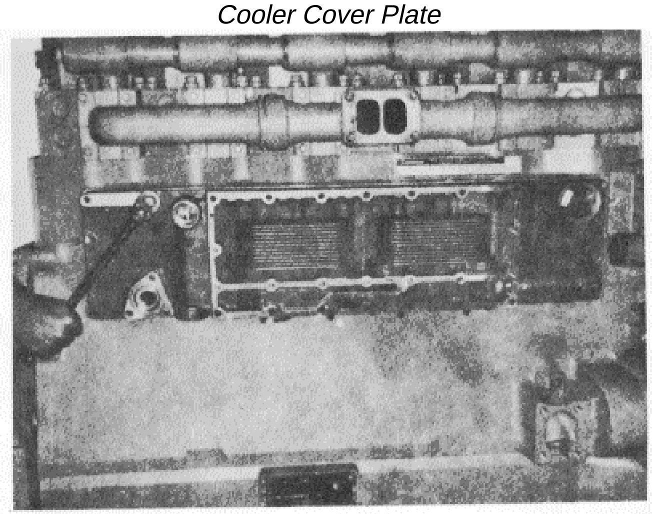


Figure 16B-14. Remove the Lubricating Oil Cooler Housing

4. Remove capscrews securing oil cooler element to housing. Lift out elements. Discard gaskets and elements.

NOTE

When removing cooler housing, it must be pulled straight from block to clear oil transfer tubes.

5. Oil transfer tubes are O-rings sealed in housing and block. Remove tubes, discard O-rings.

EXHAUST MANIFOLD

The exhaust manifolds may be removed as an assembly or in separate sections.

MOUNT ENGINE ON REBUILD STAND

1. Secure the ST-1307 Engine Stand Adapter to the 3375193 Engine Rebuild Stand.

CAUTION

The ST-548 Engine Rebuild Stand is not recommended for use with this engine.

2. Use the ST-1258 Lifting Fixture, two (2) ST-1286 Lifting Hooks and a suitable hoist to position the engine to the stand adapter. Start in the center and tighten the capscrews alternately while securing the engine to the adapter, Figure 16B-15.

NOTE

Use 3/8-16 x 3-1/2 inch capscrews to secure the engine to the adapter plate.

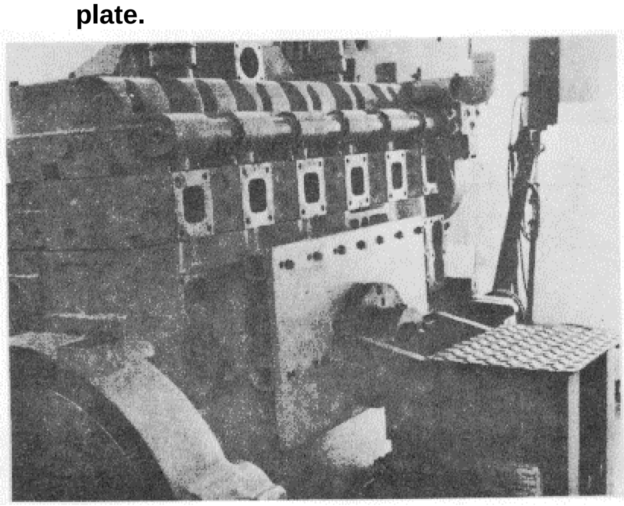


Figure 16B-15. Mount the Engine to the Rebuild Stand

LUBRICATING OIL FILTER

1. Remove and discard the oil filters, Figure 16B-16.

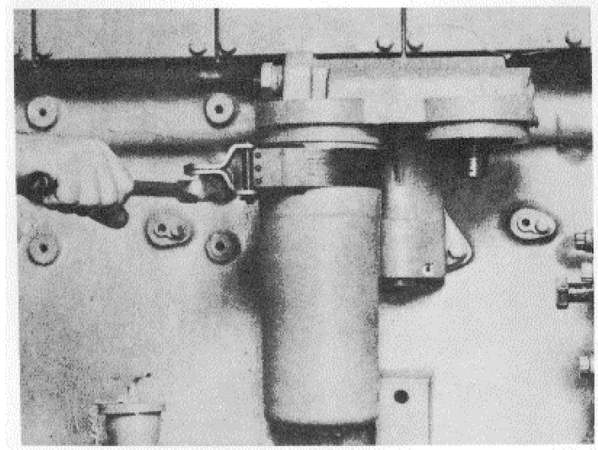


Figure 16B-16. Remove the Lubricating Oil Filter

2. Remove the filter head, Figure 16B-17.

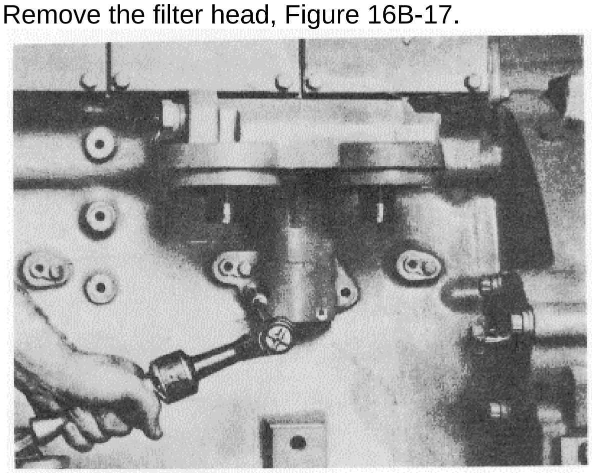


Figure 16B-17. Remove the Lubricating Oil Filter Mounting Head

OIL GAUGE AND BRACKET

Remove the oil gauge tube and mounting bracket, Figure 1 6B-18.

NOTE

The oil gauge tube may be removed from the mounting bracket allowing the bracket to remain on the oil pan adapter if so desired.

FUEL FILTER - UPPER ENGINE

1. Remove and discard the filter elements.
2. Remove the hose connecting the filter to the fuel pump.
3. Remove the filter head and mounting bracket.

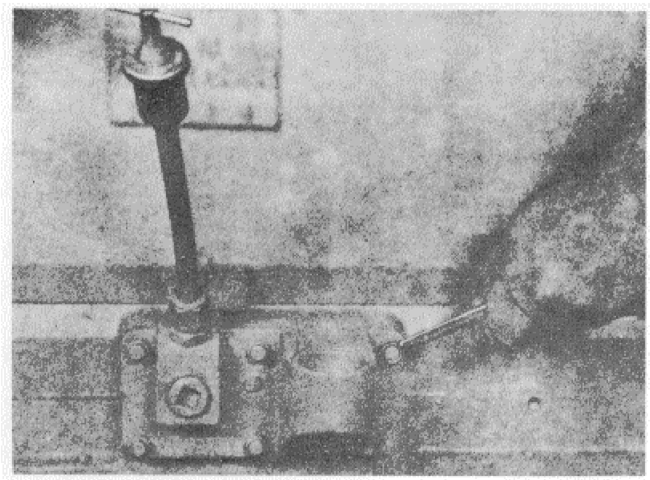


Figure 16B-18. Remove the Oil Dipstick Gauge and Bracket

FUEL PUMP

1. Remove the fuel supply and drain the tubes from the fuel manifold and fuel pump, Figure 16B-19.
2. On lower engine, remove the throw-away filters, fuel pump mounted. Discard filters.

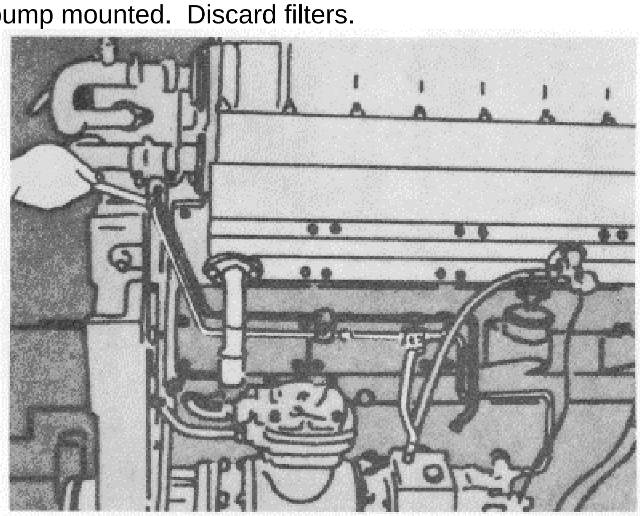


Figure 16B-19. Remove the Fuel Tubing

3. Remove the fuel pump from the accessory drive housing or air compressor, Figure 16B-20. Lift out the drive buffer coupling.

AIR COMPRESSOR - LOWER ENGINE

1. Loosen the hose clamps and remove the air supply from the intake manifold.
2. Remove the water inlet and drain the tubing hose and connections.

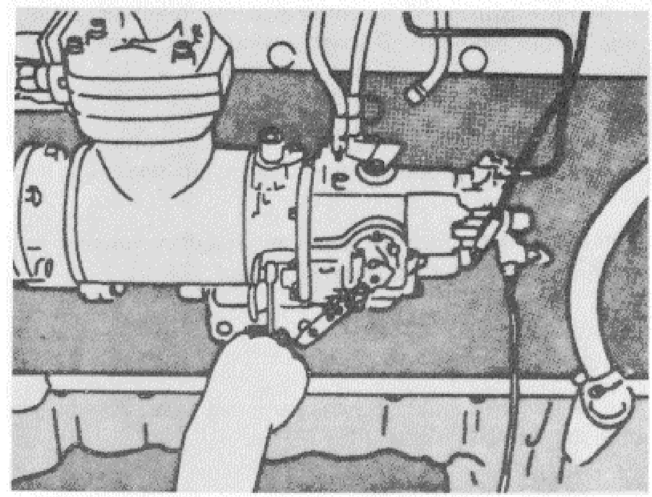


Figure 16B-20. Remove the Fuel Pump

3. Remove the air compressor support.
4. Remove the air compressor from the accessory drive housing, Figure 1 6B-21. Lift out the splined drive.

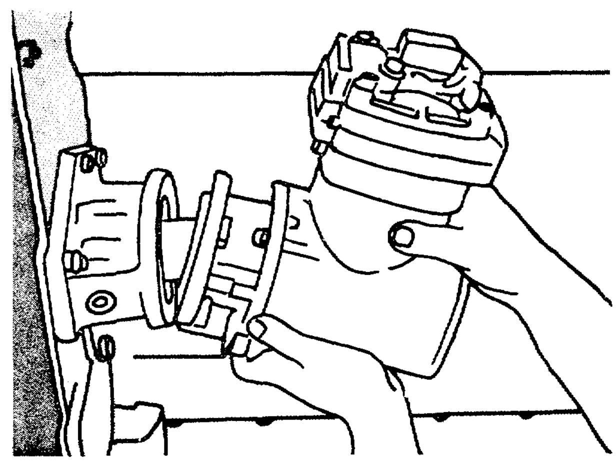


Figure 16B-21. Remove the Air Compressor

ACCESSORY DRIVE

1. Use the ST-647 Puller to remove the accessory drive pulley, Figure 16B-22.

2. After removing the capscrews and stud nut, Figure 1 6B-23, tap the pulley end of the shaft with a soft hammer to remove the drive assembly.

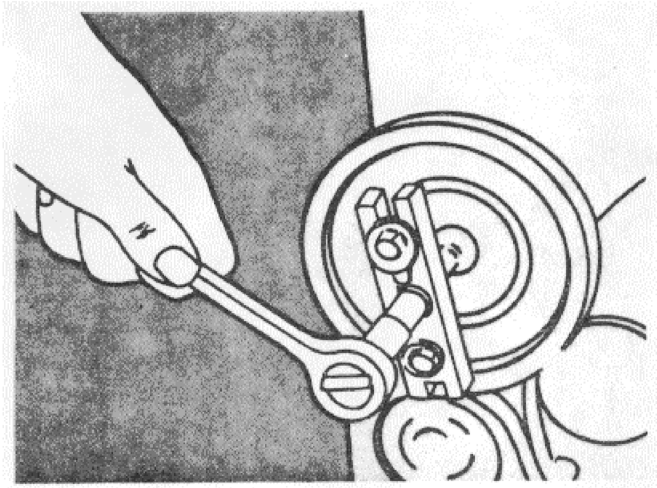


Figure 16B-22. Remove the Accessory Drive Pulley

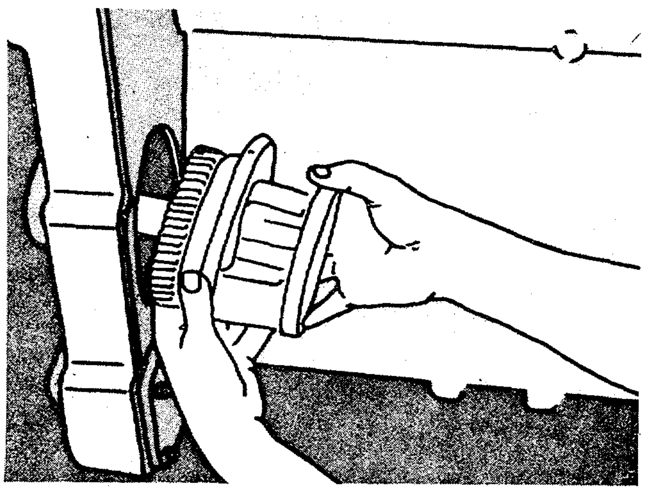


Figure 16B-23. Remove the Accessory Drive Assembly

AIR INTAKE MANIFOLD AND

AIR CROSSOVER

1. Remove the air crossover connection if not previously removed.
2. Remove the intake air manifold, Figure 16B-24.

FUEL MANIFOLD

The fuel manifold is attached to each individual cylinder head; remove the screws, Figure 16B-25. Discard the 0 rings.

CAM FOLLOWER COVERS

Two of the follower covers have crankcase breather and/or oil filler cap openings, Figure 16B-26. The covers are interchangeable.

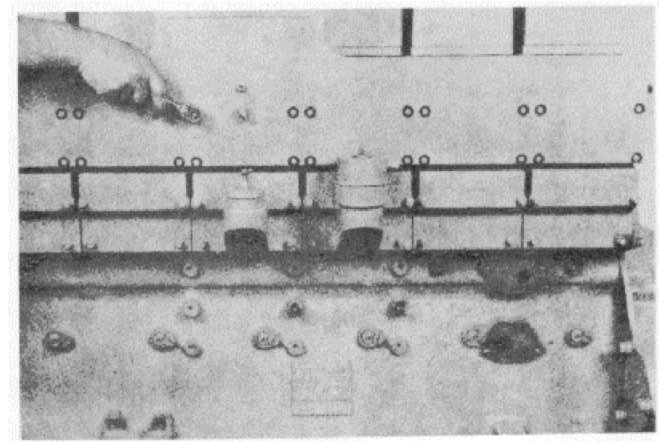


Figure 16B-24. Remove the Intake Manifold

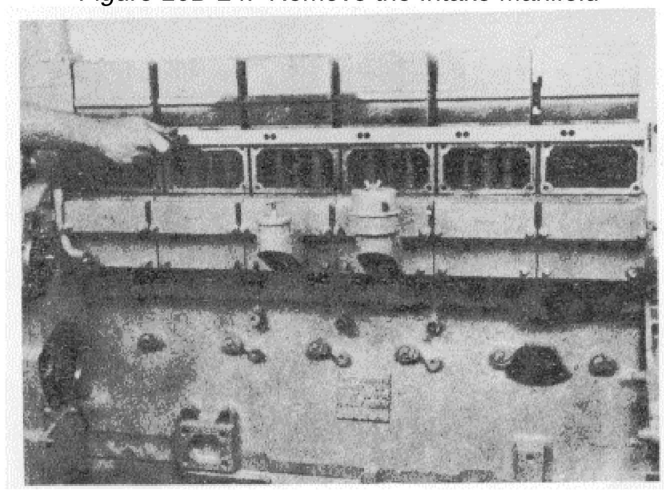


Figure 16B-25. Remove the Fuel Manifold

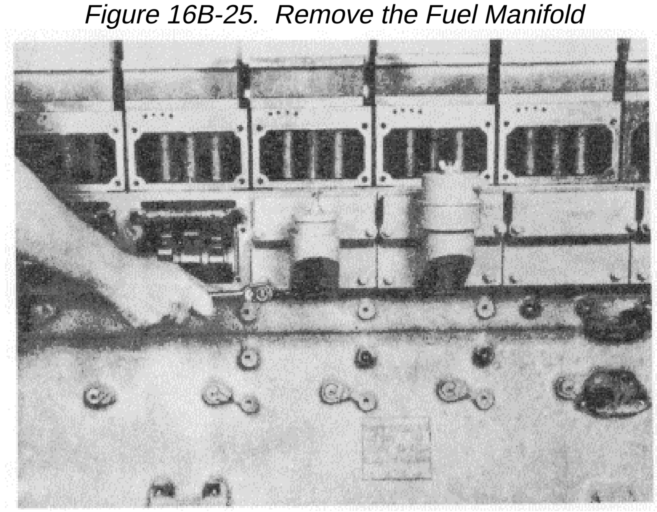


Figure 16B-26. Remove the Cam Follower Covers

PISTON COOLING NOZZLES

Remove the slotted screws or capscrews securing each nozzle to the block. Remove the nozzles, Figure 16B-27.

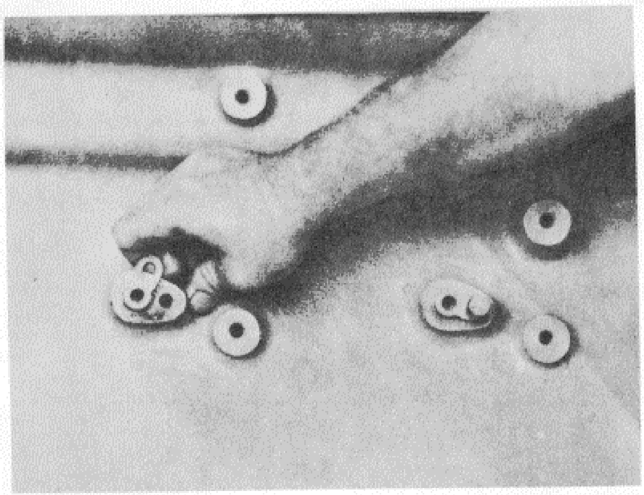


Figure 16B-27. Remove the Piston Cooling Nozzles

ROCKER LEVERS AND HOUSING COVER

1. Remove the rocker lever housing covers, Figure 16B-28.
2. Loosen the valve and injector adjusting screw locknuts and back out the adjusting screws to remove the tension from the push rods.

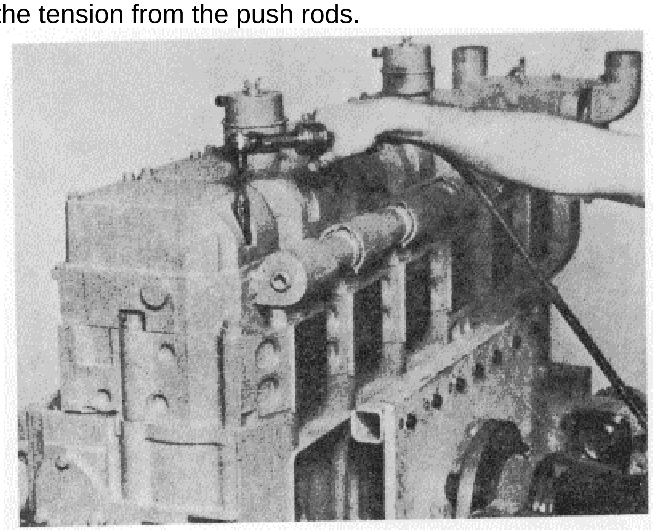


Figure 16B-28. Remove the Rocker Lever Housing Covers

3. The rocker lever shafts are mounted on top of the housings and have ring dowels under one capscrew. When removing, pull straight up to clear the ring dowel, Figure 1 6B-29.

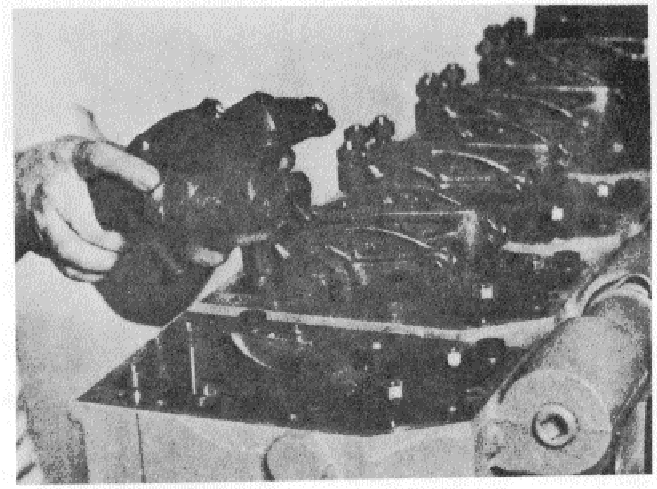


Figure 16B-29. Remove the Rocker Lever Assemblies

VALVE CROSSHEADS

Remove all the valve crossheads, Figure 16B-30.

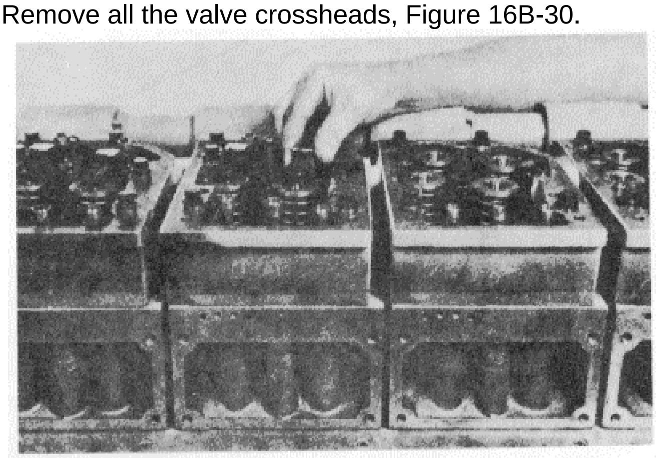


Figure 16B-30. Remove the Crossheads

INJECTOR PLUNGER LINKS AND PUSH RODS

It is recommended that the push rods, injector links, rocker levers, cam followers, etc. be marked for position as removed. If these parts are to be reused, more accurate adjustments will result due to the wear pattern established.

Remove the injector plunger links, Figure 16B-31, and the push rods, Figure 16B-32.

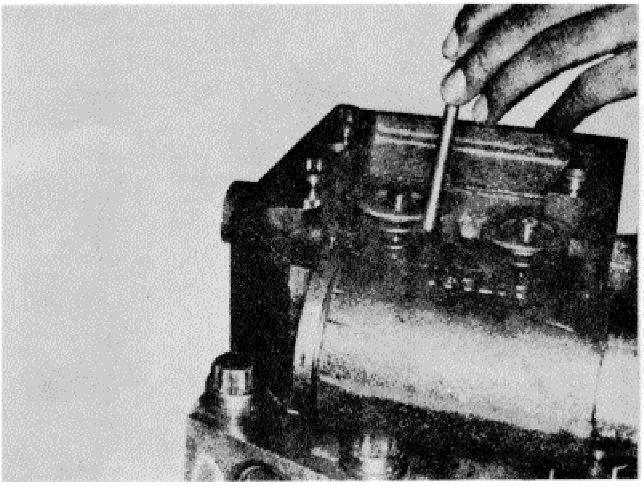


Figure 16B-31. Remove the Injector Plunger Links

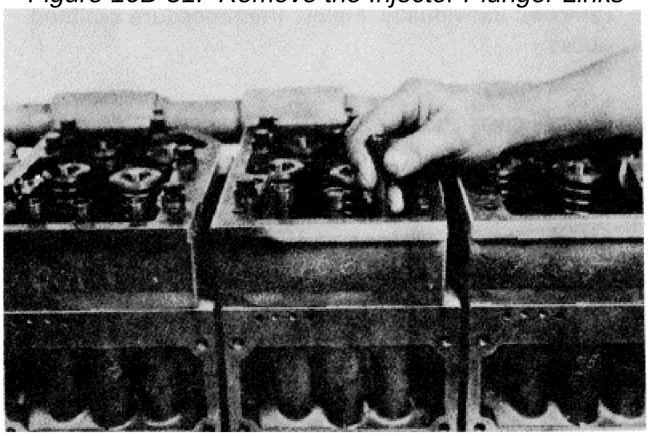


Figure 16B-32. Remove the Push Rods

ROCKER LEVER HOUSINGS/WATER MANIFOLD AND THERMOSTAT HOUSING

The water passages which are cast in the rocker housings and the water transfer tubes sealed with O-rings are held in position with the retaining rings which make up the water manifold.

The housings are dowel fit to the cylinder heads. When removing the rocker housings from the rear of the cylinder block:

1. Remove the water transfer tube retaining ring between the No. 5 and No. 6 cylinders.
2. Use a tube driver ST-1319 to drive the transfer tube in the No. 5 rocker housing far enough to clear flange of the No. 6 housing.
3. Remove the rocker housing capscrews and lift the housing from the cylinder head, Figure 16B-33.

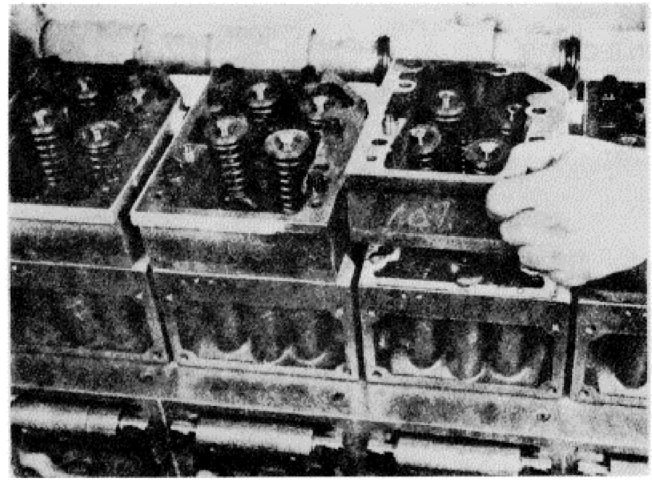


Figure 16B-33. Remove the Rocker Lever Housings

4. Remove the water transfer tube from the No. 5 housing. Discard the O-rings.
5. Follow the same procedure when removing housing No's. 5, 4, 3 and 2.

NOTE

The thermostat housing must be removed before the No. 1 rocker housing is removed.

6. Remove the by-pass tube, turbocharger supply line and air compressor drain tube from the housing, if not previously removed.
7. Remove the housing support bracket.
8. Remove the capscrews securing the thermostat housing to the gear housing.
9. If the fan hub has not been removed, cock the thermostat housing enough to clear the hub support. Pull the thermostat housing and transfer tube from rocker housing, Figure 16B-34.

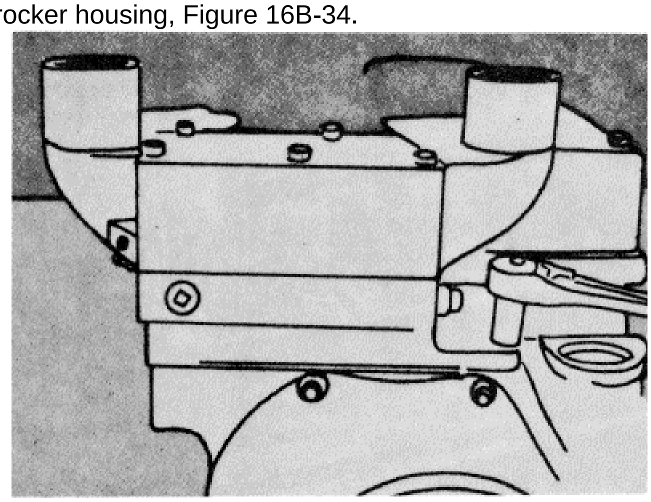


Figure 16B-34. Remove the Thermostat Housing

10. Remove the remaining rocker housings from the cylinder head.

INJECTORS

1. Remove the injector hold-down plate, Figure 16B-35.

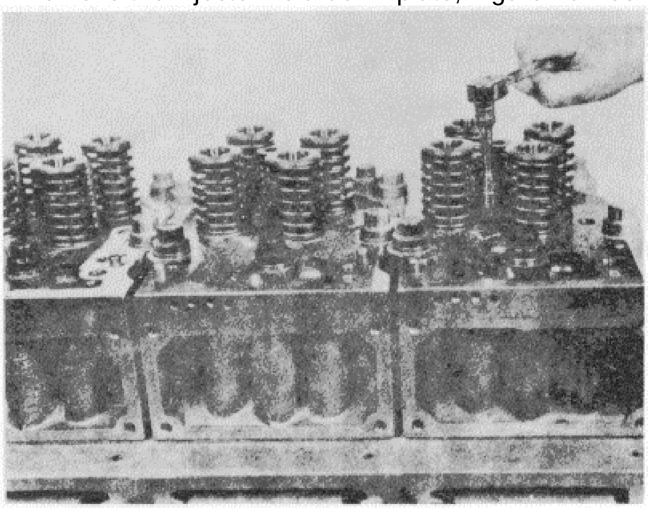


Figure 16B-35. Remove the Injector Hold-Down Clamp

2. Use the 3376000 Injector Removal Tool or a suitable prying tool to remove the injectors.

CAUTION

To avoid getting dirt in the injector barrel and cup, do not remove the plunger and the spring.

CYLINDER HEADS

The cylinder heads are dowel fit to the block. Remove the capscrews, Figure 168-36. Lift cylinder heads straight up from the block, Figure 168-37, to clear the dowels. Discard the gaskets.

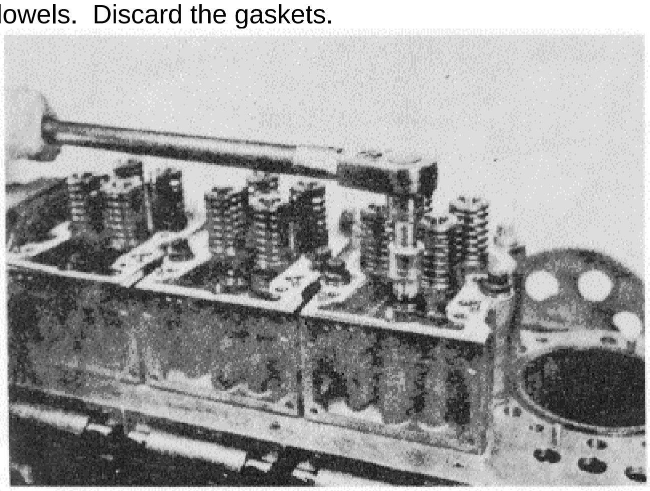


Figure 16B-36. Remove the Cylinder Head Capscrews

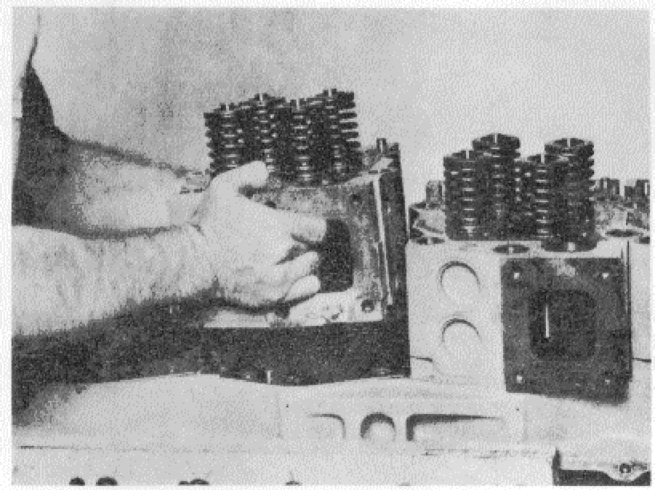


Figure 16B-37. Remove the Cylinder Head

NOTE

The rocker lever housings and cylinder heads may be removed individually. Follow the procedure outlined above.

CAM FOLLOWERS

Remove the capscrews securing the cam followers to the cylinder block, Figure 168-38. Remove the shaft from the ring dowels.

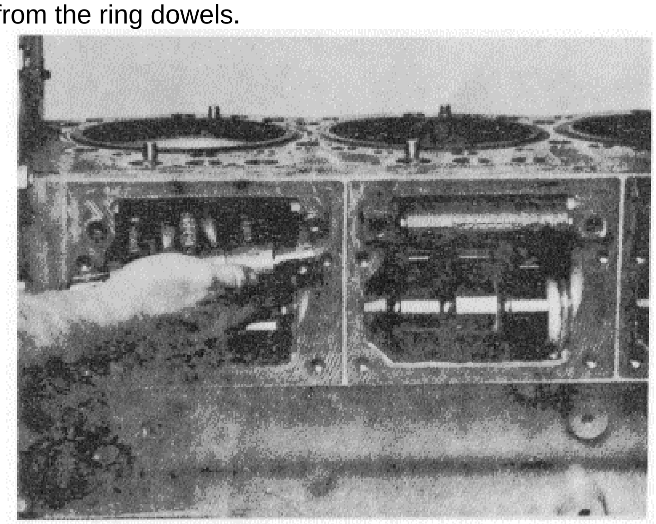


Figure 16B-38. Remove the Cam Followers

FAN IDLER AND HUB - LOWER ENGINE

1. Remove capscrew securing upper end of shock absorber to gear cover.
2. Remove capscrews securing spring support to alternator bracket, lift off idler assembly.

3. Remove hex nuts from fan hub support, pull hub forward to remove, Figure 16B-39.

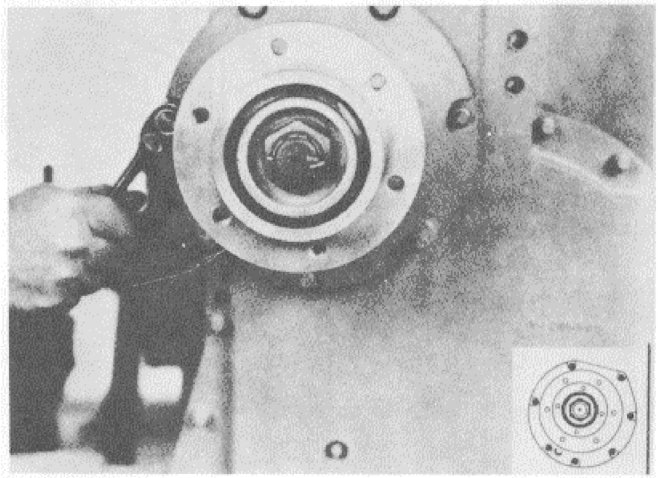


Figure 16B-39. Remove the Fan Hub

ALTERNATOR DRIVE PULLEY

The alternator drive pulley is mounted on the water pump drive shaft. Use the ST-647 Puller to remove the pulley from the shaft, Figure 16B-40.

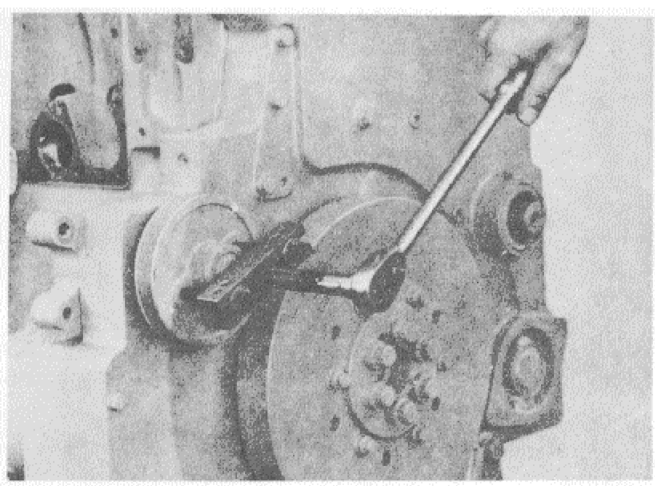


Figure 16B-40. Remove the Alternator Drive Pulley

WATER PUMP DRIVE SUPPORT

After removing the capscrews and stud nut, use a soft hammer on the front of the shaft, to drive the support from the gear front housing, Figure 16B-41.

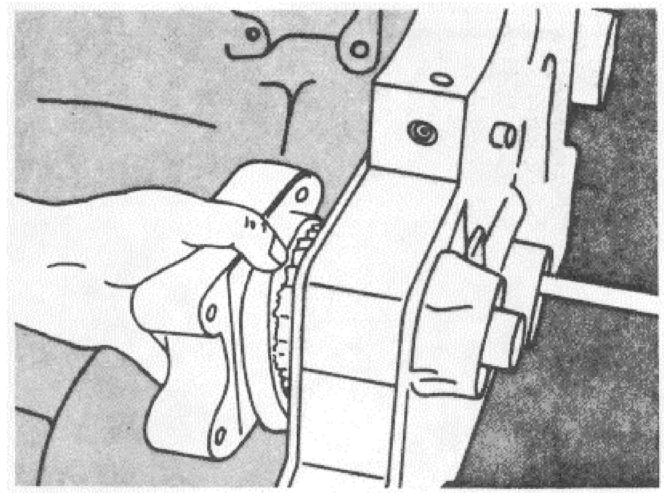


Figure 16B-41. Remove the Water Pump Drive Support

VIBRATION DAMPER

1. The vibration damper and the crankshaft adapter may be removed separately, Figures 16B-42 and 16B-43, or as an assembly by removing the capscrews securing the adapter to the crankshaft.

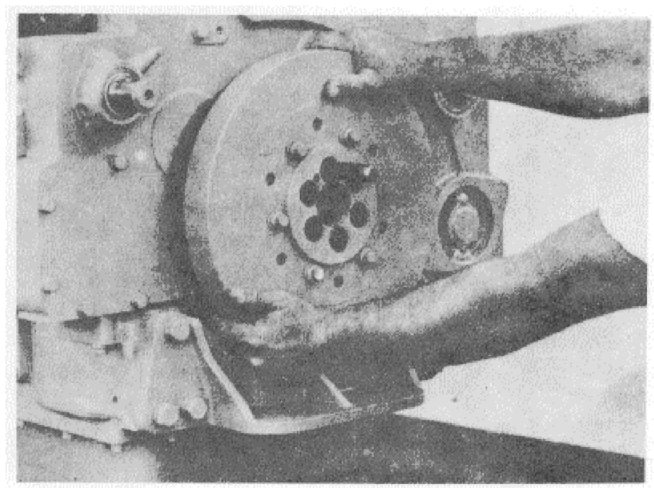


Figure 16B-42. Remove the Vibration Damper

2. During removal pry and/or tap on adapter.

CAUTION

Do not pry or pound on the vibration damper. Denting the outer shell will make the damper ineffective.

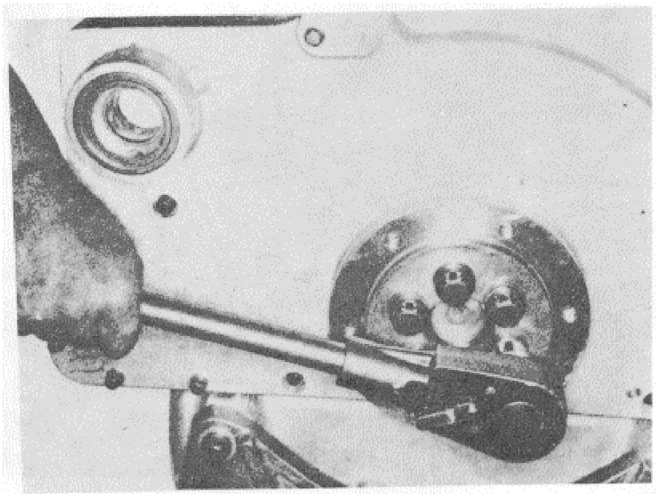


Figure 16B-43. Remove the Crankshaft Adapter

REMOVING THE FRONT GEAR COVER

1. Remove the front cover capscrews.

2. Use a suitable puller to remove the master dowel, Figure 16B-44.

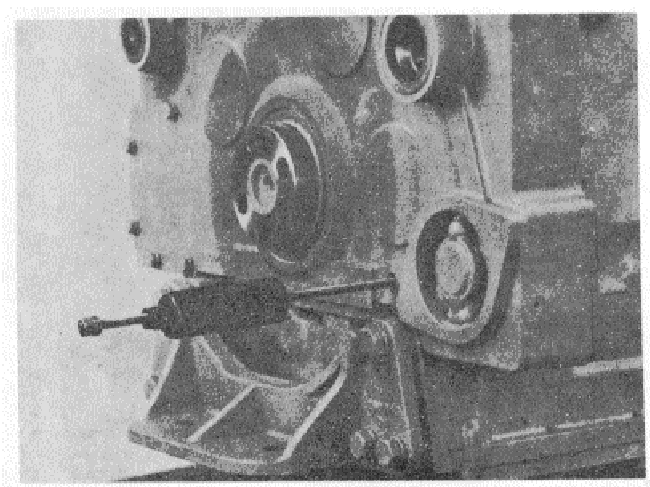


Figure 16B-44 Remove the Master Dowel

3. Remove the front gear cover, Figure 16B-45.

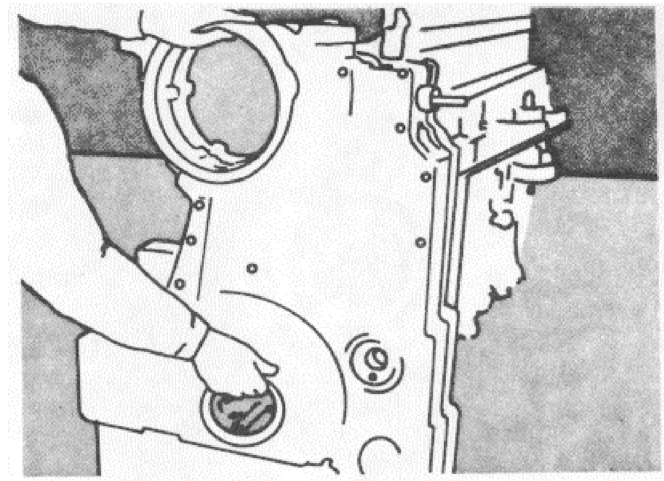


Figure 16B-45. Remove the Front Gear Cover

IDLER GEARS

1. Remove the idler gear retainers and outer thrust bearings.

2. Remove the idler gear, Figure 16B-46.

3. Remove the inner thrust bearings.

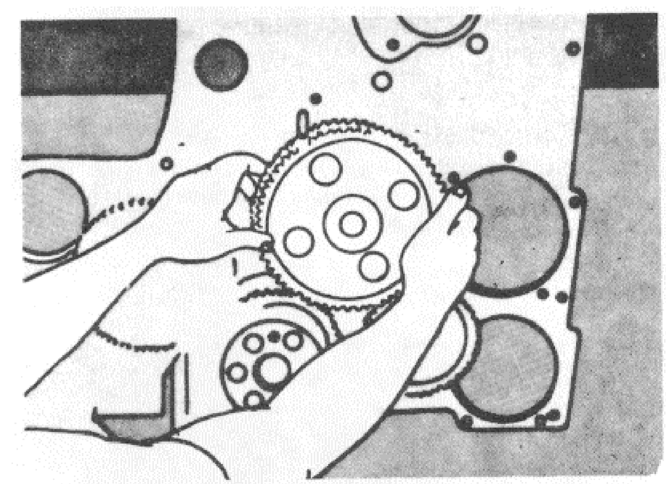


Figure 16B-46. Remove the Idler Gear

CAMSHAFT

1. Remove the camshaft rear cover at the rear of the block.

Attach the ST-1313 Camshaft Pilot to the rear of the camshaft.

2. Straighten the lockplate and remove the capscrews securing the camshaft thrust plate to the block.

3. Rotate the camshaft gear, lifting slightly while removing the camshaft and pilot from the block, Figure 16B-47.

CAUTION

Due to the length of the camshaft, two men may be required when removing the camshaft to avoid damage to the camshaft and the bushings.

4. Remove the camshaft pilot. Do not remove the camshaft gear.

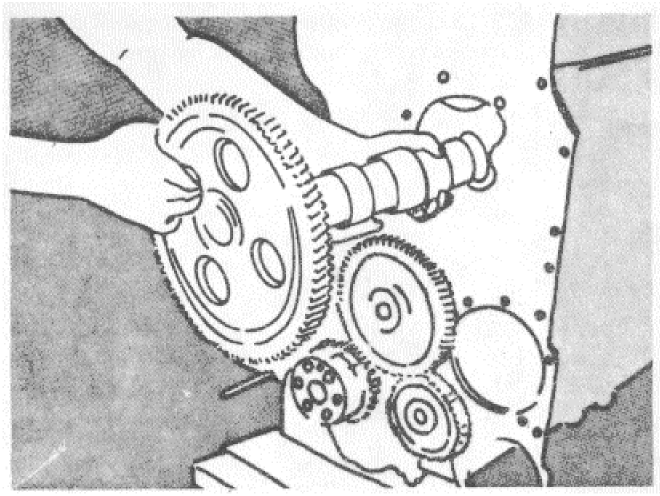


Figure 16B-47. Remove the Camshaft

REMOVING THE BARRING DEVICE

1. Remove the retaining ring from the barring device shaft.

2. Pull out on the shaft to remove the barring device shaft. This will remove the spring and the worm gear.

3. Remove the barring shaft guide assembly, Figure 16B48.

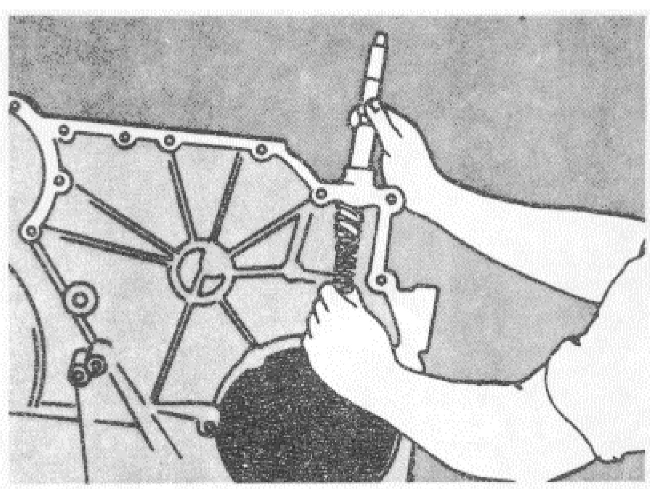


Figure 16B-48. Remove the Barring Device Shaft

LUBRICATING OIL PUMP

1. Remove the three (3) outer capscrews securing the pump body to the block.

2. Remove the pump from the block, Figure 16B-49.

NOTE

A small pry bar may be required to remove the pump.

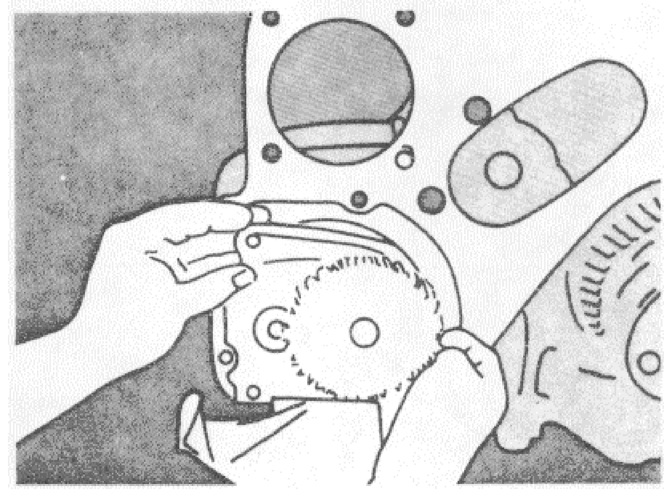


Figure 16B-49. Remove the Lubricating Oil Pump

3. Remove the sealing ring which seals the pump cover to the cylinder block. Discard the sealing ring and O-rings.

LUBRICATING OIL PAN AND ADAPTER

1. Remove the oil pan adapter cover.

2. Remove the lubricating oil pan (sump) from the adapter, Figure 16B-50

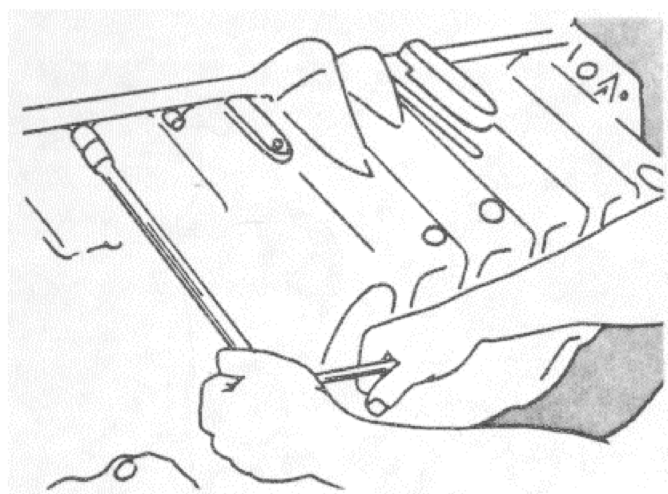


Figure 16B-50. Remove the Lubricating Oil Pan

3. Remove the capscrews securing the adapter to the cylinder block.

NOTE

The capscrews securing the suction tube connection to the adapter and the block must be removed before the adapter is removed, Figure 16B-51.

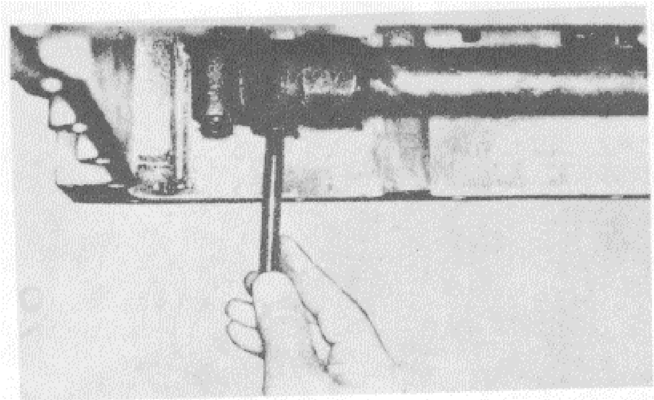


Figure 16B-51. Remove the Suction Tube Capscrew

4. Remove the capscrews securing the adapter to the flywheel housing and front gear cover.

5. Remove the adapter and the suction tube assembly.

6. Remove the suction tube assembly from the adapter.

STEEL PLATE REMOVAL

1. Remove the steel plate capscrews.

2. Remove the steel plate, Figure 16B-52.

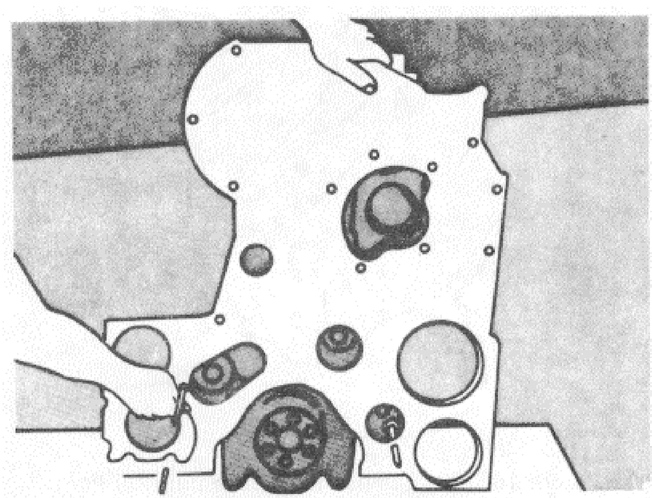


Figure 16B-52. Remove the Steel Plate

FLYWHEEL

1. Remove the two(2)flywheel mounting capscrews on the opposite sides of the flywheel.

2. Install the two (2) 5/8-18 guide studs in the crankshaft flange to provide support for the flywheel during removal.

3. Remove the remaining mounting capscrews and install the two (2) 1/2-1 3 capscrews, threaded their entire length, to act as jackscrews when removing the flywheel from the crankshaft.

4. Remove the flywheel, Figure 16B-53.

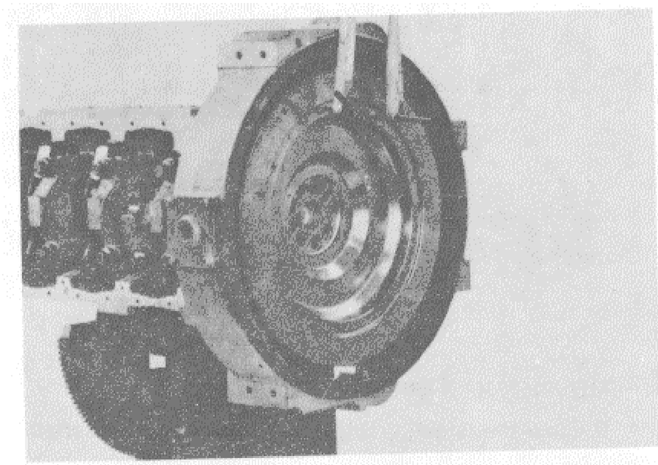


Figure 16B-53. Remove the Flywheel

FLYWHEEL HOUSING AND SEAL

1. Remove the oil seal plate and discard the oil seal and 0ring.

2. Remove the mounting capscrews securing the flywheel housing to the cylinder block, Figure 16B-54.

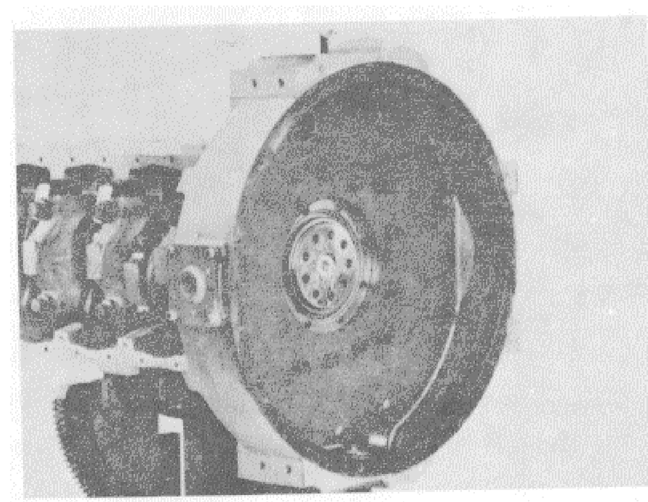


Figure 16B-54. Remove the Flywheel Housing

3. Install the two (2) 5/8-11 guide studs through the housing into the block to provide support for the housing during removal.

4. Drive the housing from the dowels by tapping on the back side with a soft hammer.
5. Use a suitable lifting device and hoist to lift the housing from the guide studs.

CONNECTING ROD AND PISTON ASSEMBLIES

1. Rotate the engine until the head surface is up. Clean all the carbon from the top of the cylinder liner wall. Polish with a fine emery cloth. Clean area thoroughly.
2. Remove the connecting bolts and caps, Figure 16B-55.

NOTE

The connecting rod caps are located to rods with ring dowels. It may be necessary to rotate the crankshaft slightly during rod removal.

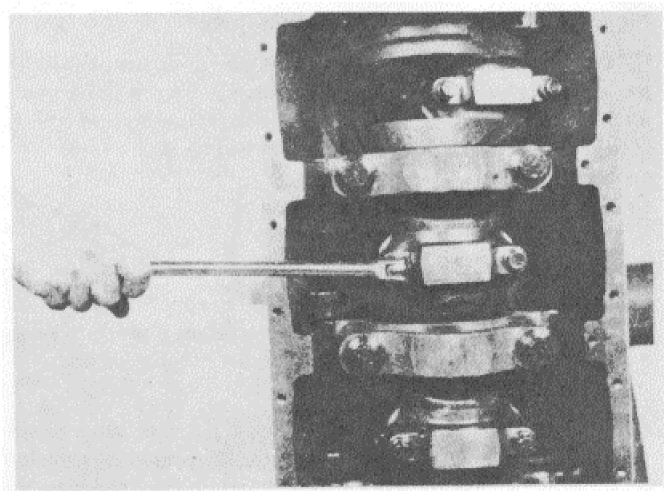


Figure 16B-55. Remove the Connecting Rod

3. Use care not to damage the cylinder liners as the connecting rods are withdrawn. Reassemble each connecting rod cap to its mating rod, with the numbered side of the cap to the numbered side of the rod.
4. Use the ST-1269 Ring Expander to remove and discard the piston rings.
5. Remove the piston pin snap rings.
6. To facilitate the removal of the piston pins, heat the pistons in hot water to approximately 2000F (930C). Use thumb pressure to push the pin from the piston. Do not drive or otherwise force the pin from the piston.

CAUTION

Care must be taken when removing and/or installing the piston/connecting rod assemblies that damage to the piston cooling nozzles does not occur. Inspect the piston cooling nozzles to insure no damage has occurred.

CYLINDER LINERS

Use 3375629 Line Puller Bridge and ST-1209 Liner Puller Assembly with an impact wrench or ratchet to remove the cylinder liners, Figure 168-56. Discard the O-rings.

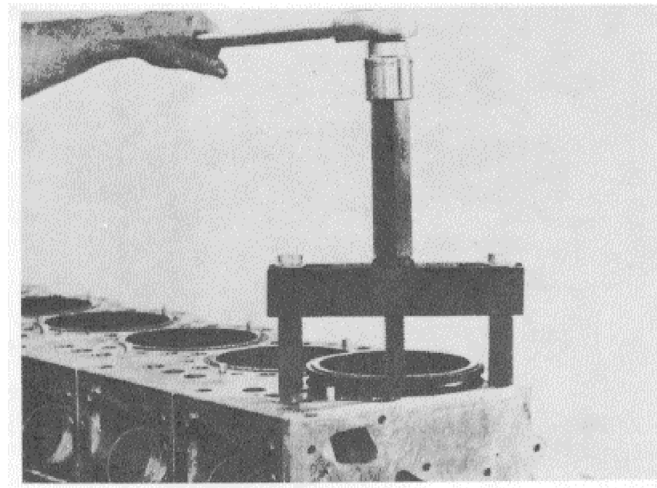


Figure 16B-56. Remove the Cylinder Liner

CRANKSHAFT AND MAIN BEARINGS
1. Remove the main bearing capscrews.
2. Use the ST-1116 Main Bearing Cap Puller to remove the caps, Figure 16B-57.

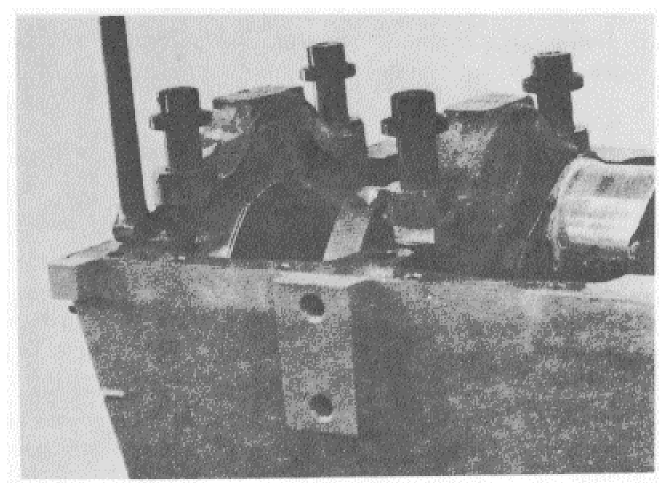


Figure 16B-57. Pull the Main Bearing Caps

CAUTION

Care must be taken when removing No. 6 main bearing cap to avoid damage to the dowels.

3. Remove the lower main bearing shells. Remove the thrust ring halves from the No. 6 bearing cap.
4. Remove the upper thrust ring halves from the cylinder block.
5. Use a lifting strap, Figure 16B-58, or hooks protected with rubber hose to lift the crankshaft from the cylinder block.

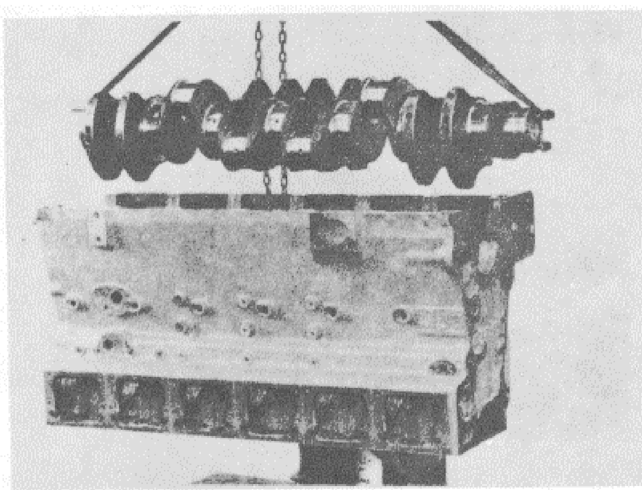


Figure 16B-58. Lift the Crankshaft from the Cylinder Block

NOTE

Rotate the crankshaft slightly, if necessary, to facilitate the removal.

6. Remove the upper main bearing shells from the cylinder block.

NOTE

If bearing shell inspection is to be performed, tape the upper and lower shells together. Identify the shells as removed. Discard the bearings after inspection, as required.

STEAM CLEANING

Place the parts in trays (except parts listed in following note) and clean with steam jet to remove exterior dirt, etc. Dry thoroughly with moisture-free compressed air.

Cover plates, pipe plugs, etc., should be removed as applicable to facilitate the cleaning of oil and water passages.

NOTE

Do not steam clean the following:
Electrical components, wiring, injectors, fuel pump, belts and rubber hose, or bearing shells.

GLASS BEAD CLEANING

Glass bead cleaning has been proven most effective for pistons, valves, cylinder heads, etc. The nature and degree of treatment is controlled by the size of glass beads used, operating pressure and exposure time.

Bead Size for pistons and other similar parts, use U.S. sieve size No. 70. For general purpose cleaning, use No. 60.

Operating Pressure 90 psi (620.5 kPa) for pistons etc. for general cleaning, pressures from 90 to 125 psi (620.5 to 861.9 kPa) may be used.

Do not expose the part being cleaned to the bead blast any longer than absolutely necessary. This is particularly true when cleaning soft material such as aluminum.

The only additional cleaning required is to wash with a solvent and dry with compressed air. Be sure all foreign material has been removed from the parts before reassembling.

SOLVENT/ACID CLEANING

Several solvent and acid type cleaners are effective cleaning solutions; always follow the manufacturer's recommendations as to concentration and use.

Remove all gasket material, O-rings and deposits of sludge, carbon, etc., with a wire brush or scraper, from units such as cylinder heads, oil pan, rocker lever housing and cover, etc. before submerging these units in the wash tank.

CAUTION

Do not damage the gasket surfaces.

The solvent solution should be heated to approximately 180 to 2000F (82 to 930C) and kept in constant agitation. With sufficient heat, the agitation can be accomplished by built in baffle plates.

After unit disassembly, put all small parts in wire mesh baskets, steam clean and then immerse in cleaning tank for as long as necessary. Larger parts can be lowered directly by a hoist into the tank.

The cylinder block must have all pipe and expansion plugs removed from oil and water passages, etc. Run rods with bristle-brushes through all oil passages, Figure 16B-59.

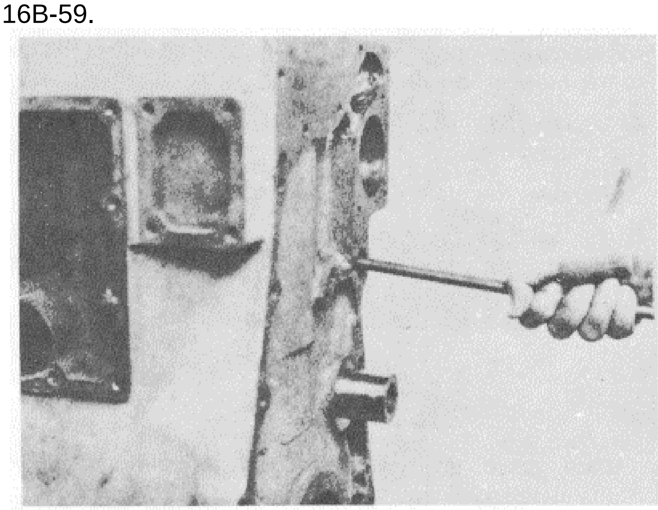


Figure 16B-59. Clean the Cylinder Block Oil Passages

Scrape the liner counterbore lightly to remove scale; sand the lower liner bore or use emery cloth to remove any nicks or burrs that might damage the packing rings as the liner is installed.

To remove the heavy deposits of lime, use a circulated acid type cleaner.

WARNING

The use of acid may be extremely dangerous to workmen and injurious to machinery. Always provide a tank of strong soda water as a neutralizing agent.

Rinse all parts in hot water and dry with compressed air. Blow the cleaning fluid or water from the capscrew holes to prevent damage when the capscrews are tightened.

Replace the pipe and expansion plugs, Figure 16B-60, removed for cleaning; tighten the pipe plugs to the specifications.

NOTE

Coat the surface of the new cup plugs with 3375067 Cup Plug Sealant or equivalent before installation. If rebuild machining is required, clean the affected area again and replace the pipe plugs after the machining is completed.

If the parts are not to be reused immediately after cleaning, dip them in a suitable rust proofing compound.

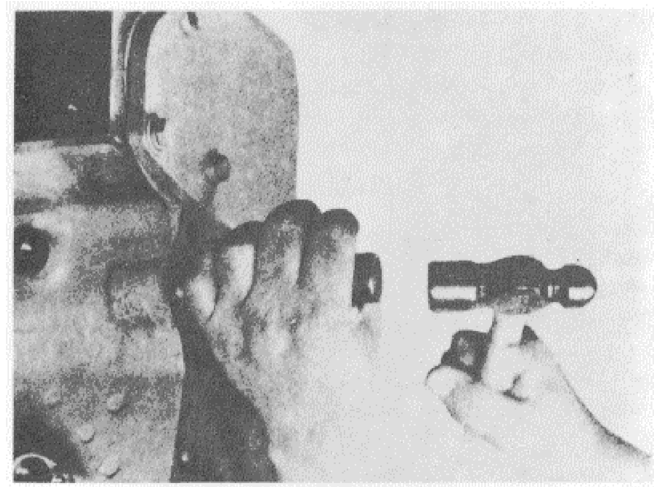


Figure 16B-60. Replace the Expansion Plugs with ST-1281

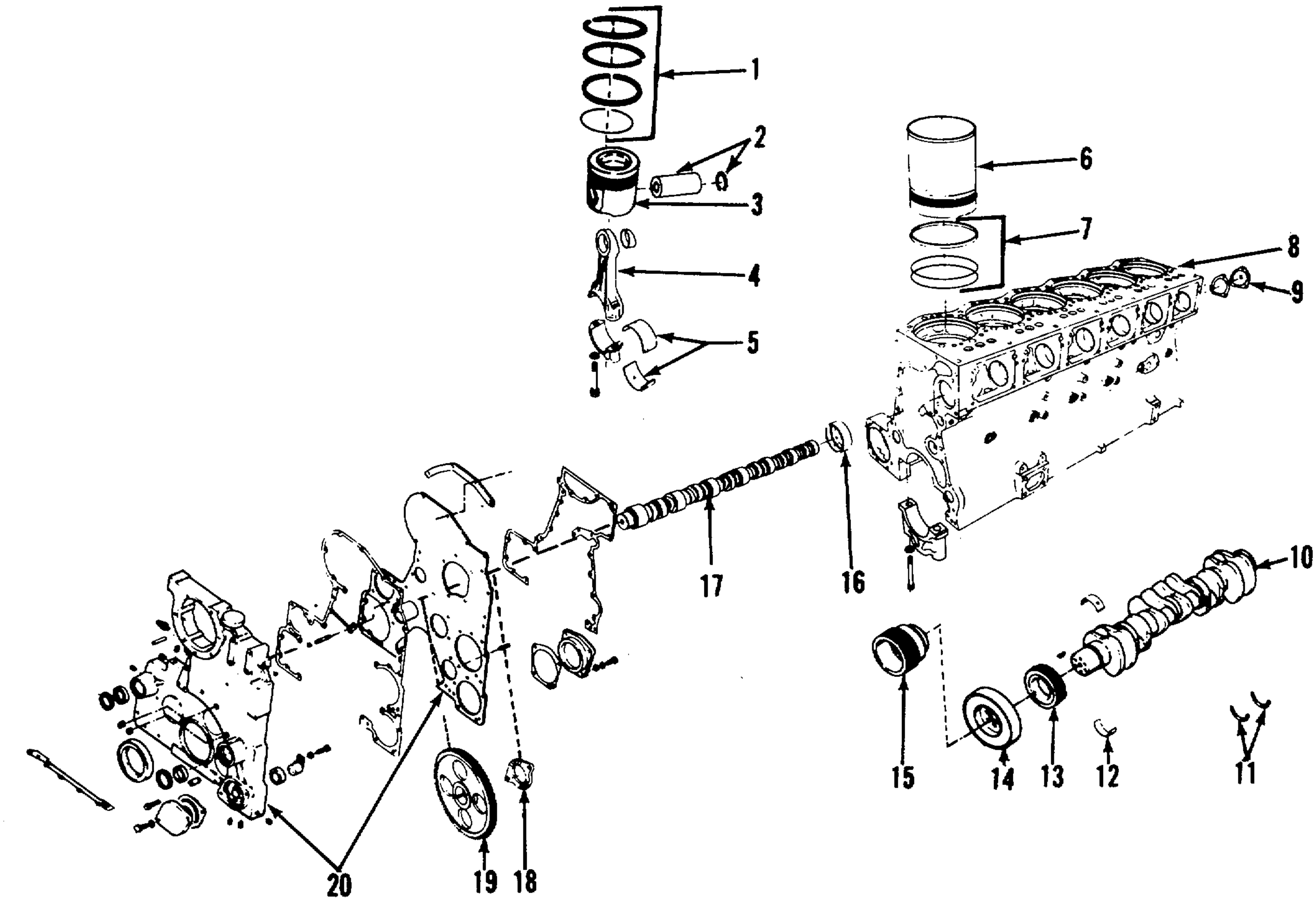
NOTE

The rust proofing compound must be removed before installing the parts in the engine.

CYLINDER BLOCK

DESCRIPTION

The cylinder block group contains the cylinder block, cylinder liners, crankshaft, bearings, vibration damper, con-necting rods, pistons, rear seal, camshaft, steel plate and front gear cover.



1. Piston Rings	6. Cylinder Liner	11. Thrust Rings	16. Camshaft Bushing
2. Piston Pin	7. Liner Sealing Rings	12. Main Bearings	17. Camshaft
3. Piston	8. Cylinder Block	13. Crankshaft Gear	18. Thrust Plate
4. Connecting Rod	9. Camshaft Cover	14. Vibration Damper	19. Camshaft Gear
5. Rod Bearings	10. Crankshaft	15. Crankshaft Pulley	20. Gear Cover and Steel Plate

Figure 16C-1. Cylinder Block

TOOLS

The following service tools or tools of comparable quality are necessary to repair or rebuild the cylinder block as described in this group.

Service Tool Number	Tool Name
Essential Service Tools (Or Equivalent)	
ST-1168	Liner Counterbore Tool
3375442	Counterbore Conversion Kit
3375444	Adapter Kit
3375115	Boring Machine
ST-1177	Boring Tool (Main Bearing Bore)
ST-1228	Camshaft Bushing Drive Kit
ST-1252	Concentricity Gauge
ST-1309	Counterbore Tool
3375980	Counterbore Tool Holder
Desirable Service Tools (Or Equivalent)	
3375196	Thread Insert Kit
ST-547	Gauge Block
ST-561	Checking Fixture (Connecting Rod)
ST-1281	Plug Driver
ST-1305	Locating Mandrel (Connecting Rod)
ST-1296	Plug Gauge
ST-598	Bushing Mandrel (Gear Cover)
ST-1290	Ring Gauge
ST-1171	Bushing Mandrel (Accessory Drive)
ST-1292	Ring Gauge
ST-1291	Ring Gauge
ST-1116	Puller (Main Bearing Cap)
ST-1267	Cylinder Liner Hold Down Tool
ST-1285	Mandrel Set
3375290	Idler Shaft Puller
ST-1134	Dowel Puller
Standard Tools - Obtain Locally	
	Dial Bore Gauge
	Dial Bore Indicator's
	1/2 Inch Electric Drill
	Micrometers

CYLINDER BLOCK

INSPECTION

GENERAL. Before parts are reused, an inspection must be taken. The inspection is to include wearing surfaces and general conditions.

NOTE

Inspection and machining of cylinder block must be performed on a flat surface to prevent distortion. Do not attach to the engine stand.

Check for oil cooler element interference with the cylinder block.

When installing the oil cooler assemblies or elements, the block to element clearance should be checked with a 0.030 inch (0.76 mm) feeler gauge at the locations indicated before tightening the cooler assemblies or elements in position. If there is contact or insufficient clearance, grind the block surface in the area shown to obtain the specified clearance. Grinding must be done so that no sharp corners or notches exist which can cause stress risers. Ground surfaces must blend into unground surfaces with smooth radii. Do not grind away excessive material or the block will be weakened.

The letter "C" should be steel stamped on the upper right hand corner of the oil cooler cove if the block is ground.

Engines that can have cooler element to block interference are between serial numbers 31103629 to and including 31106342 plus 31103515, 31103516, 31103517, 31103518 and 31103627.

Grinding of production and service blocks began 8-12-77.

USING DYE PENETRANTS TO LOCATE CRACKS. After cleaning defective area, apply dye penetrant, allow time for it to enter into the defect; do not "force" dry. Apply developers so that defect will stand out. Caution must be observed as area may be a non-damaging forging lap.

CORROSION. Corrosion normally occurs at areas of the block nearest the cylinder liners and is shown by pitting. Discard block if the area cannot be cleaned, or if the area is distorted and cannot be repaired by sleeving as described under "Parts Replacement and Repair" following.

CAMSHAFT BUSHINGS. Use micrometers or dial bore gauge to measure the camshaft bushing inside diameter, Figure 16C-2. Mark the bushings for replacement if worn larger than "Worn Limit, " Table 16C-1 (1) or are chipped, or scratched. If the bushings have turned in the bore, check the bore size; see Table 16C-1 (1). If bushing replacement is necessary, see "Parts Replacement and Repair".

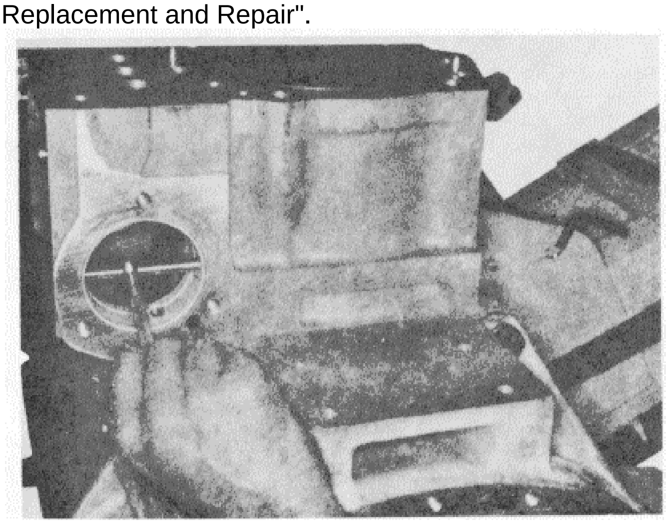


Figure 16C-2. Measure Camshaft Bushing

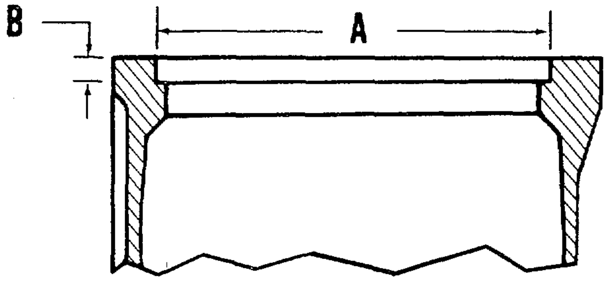


Figure 16C-3. Cylinder Liner Counterbore Dimension Location

CYLINDER LINER COUNTERBORE. Inspect the upper liner counterbore and remove the sharp edges and dirt so that the liner will enter without distortion (A), Figure 16C-3. If the counterbore exceeds limits listed in Table 16C-1 (2), mark the blocks for counterbore repair. The counterbore edge must be smooth and square with the liner bore to within 0.005 inch (0.13 mm) total indicator reading. Use a straight edge to check the flatness of the top of the block. Refer to '7op Surface Refinishing".

Check the counterbore depth so the installed liner will be assembled to the correct protrusion and to determine if a refinish of the counterbore surface is necessary. Depth of the counterbore on a new block is listed in Table 16C-1 (2). If worn to or beyond limit, the cylinder block may be salvaged. If worn less than the worn limit, the surface can be refinished and shims installed under the cylinder liner to restore the proper protrusion.

Installed cylinder liners must protrude 0.003 to 0.006 inch (0.08 to 0. 1 5 mm) above the block. To check for proper protrusion without installing liner:

A. Measure the liner flange, outside bead with a micrometer. Do not include the bead on top of the liner flange in taking the measurement, Figure 16C-4.

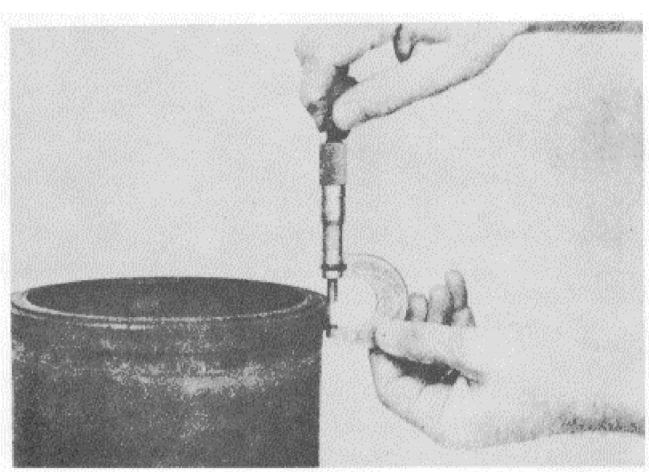


Figure 16C-4. Measuring Liner Flange

B. Measure the block counterbore depth with a dial indicator depth gauge or ST-547 Gauge Block. Always measure the counterbore depth on the ledge at the edge of liner bore, Figure 16C-5.

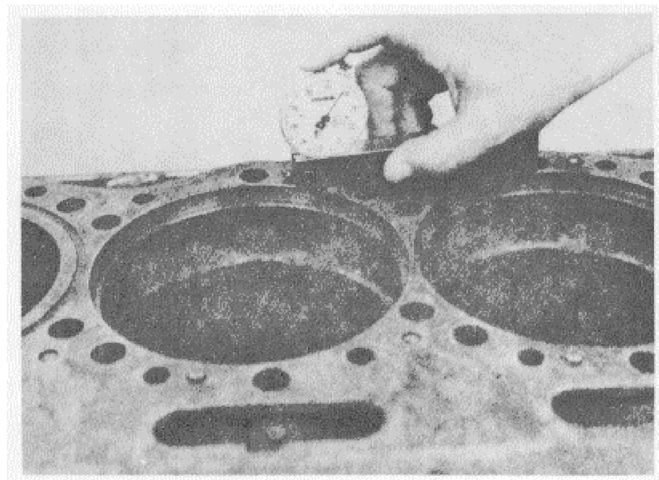


Figure 16C-5. Using ST-547 to Check Liner Counterbore Depth

C. Check the depth at four equidistant locations. The edge must not be "cupped" more than 0.0014 inch (0.036 mm). The depth must not vary more than 0.001 inch (0.03 mm) throughout the counterbore circumference.

D. The counterbore must always be resurfaced if it slants downward toward the center or if the dimensions do not meet the standards. See "Parts Replacement and Repair".

E. Subtract the counterbore depth from the liner flange thickness to determine the amount of shims and depth of the counterbore cut that must be used to provide 0.003 to 0.06 inch (0.08 to 0.15 mm) liner protrusion; 0.007 inch (0.18 mm) shims are thinnest available.

The most accurate method of checking protrusion is as follows:

A. Install the liner in the block with the proper number of liner shims beneath the flange. Shims are available from 0.007 to 0.031 inch (0.18 to 0.79 mm). Use ST1267 Cylinder Liner Hold-Down Tool. Tool should be spaced so even load will be applied. Torque to 50 ft-lbs. (68 N.m).

B. Use a ST-547 Gauge Block and check the liner protrusion above the cylinder block at four equidistant points outside the bead, Figure 16C-6. Add or remove shims from beneath the liner flange as needed to reach 0.003 to 0.006 inch (0.08 to 0.15 mm) protrusion.

C. With the liner installed, check for out-of-round as described under "Install Liner in Block", Subsection 16N.

CYLINDER LINER LOWER BORE. Install a new cylinder liner into the block, without packing rings or crevice seal.

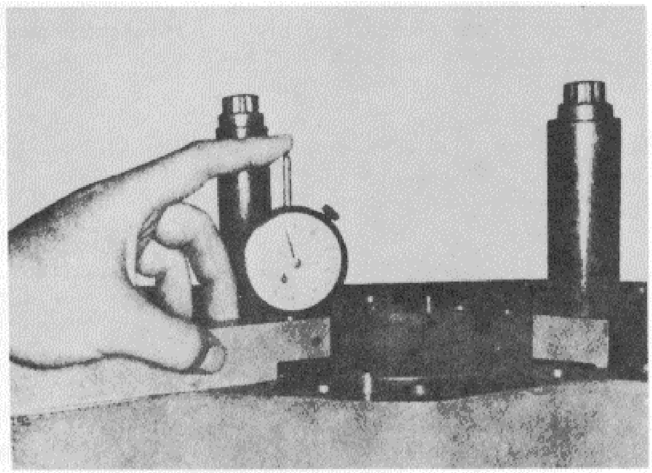


Figure 16C-6. Checking the Liner Protrusion

Clearance between the liner and block should be as listed, but liner contact with the block is permissible as long as it does not cause liner out-of-round, Figure 16C-7.

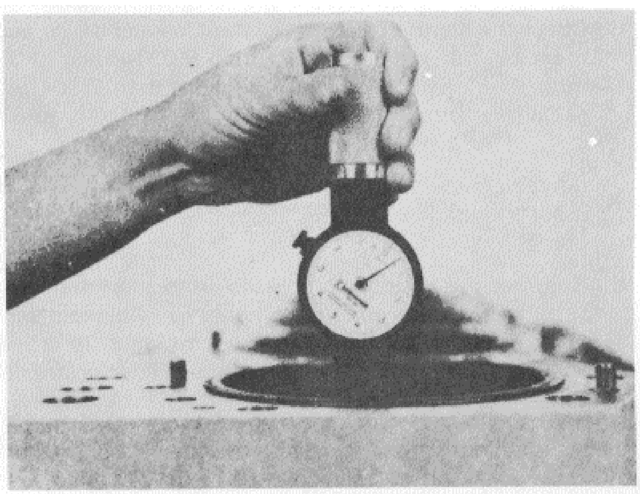


Figure 16C-7. Check the Liner for Out-of-Round

If clearances do not fall within limits, recheck after counterboring; limits do not apply with cylinder head installed and tightened to operating torque. Check the lower block packing ring bore inside diameter, Figure 16C-8.

The common center of the lower liner bore should be measured with a ST-1252. If a piston seizure has occurred or after counterboring the cylinder block, measure the common centers of the counterbore to lower cylinder liner bore. Follow Service Tool Instructions. The liner bore should be centered within 0.005 inch (0.13 mm) total indicator reading.

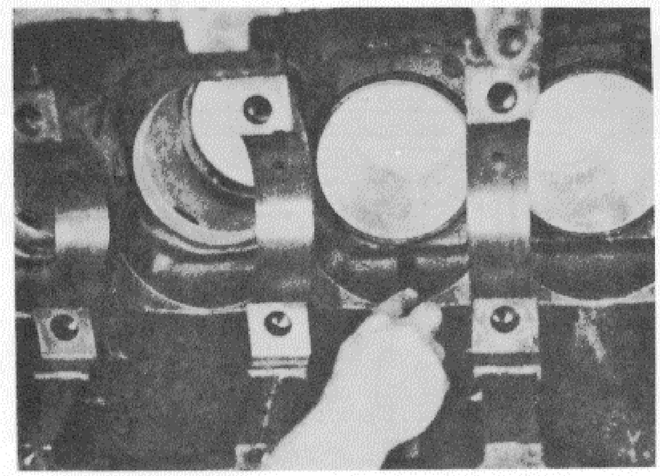


Figure 16C-8. Check the Liner to Block Clearance

MAIN BEARING CAPS. Caps are press fit in block with no clearance permitted. Machined areas of cap must meet like areas of the block to prevent distortion during tightening.

Replacement caps are available as service parts.

MAIN BEARING BORE. Assemble the main bearing caps to block in operating position. Tighten the capscrews to the operating tension. See Table 16C-1.

Measure the main bearing bores vertically and then every 45 degrees with the dial bore gauge, Figure 16C-9 or inside micrometers properly adjusted. See Table 16C-1 (3) for dimensions.

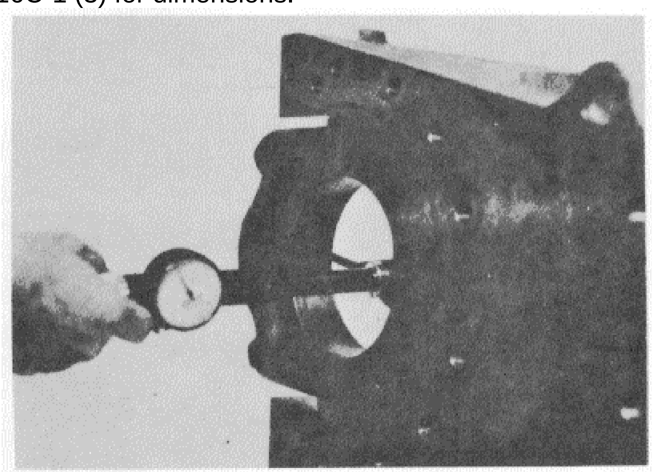


Figure 16C-9. Check the Main Bearing Bore

The ST1 77 Boring Tool can also be used to check the main bearing bore alignment; see Service Tool Instructions. If it is definitely determined that a main bearing has been distorted, mark the block for reaming.

WATER PASSAGES. Inspect all the cylinder block water passages to see they are open. Also check for eroded water holes, which will prevent seating of the head gasket or grommet retainers.

Water holes not eroded more than 1/1 6 inch (1.59 mm) from the edge of the hold can be sleeved.

Check for erosion within 1/32 to 3/32 inch (0.79 to 2.38 mm) from the liner counterbore. A maximum of 0.010 inch (0.25 mm) material, can be removed.

PARTS REPLACEMENT AND REPAIR

CAMSHAFT BUSHING REPLACEMENT. No repair work may be performed on the camshaft bushings. The bushings may be removed and installed with a ST-1228 Camshaft Bushing Driver Kit. Drive in the bushings so the oil holes in the block are aligned, Figure 16C-10.

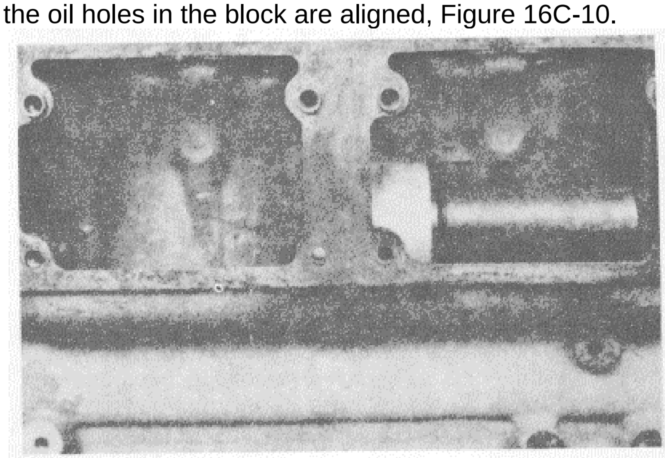


Figure 16C-10. Install the Camshaft Bushing

MAIN BEARING CAP REPLACEMENT. Replacement main bearing caps have 0.015 inch (0.38 mm) additional material in the bore. Other dimensions are the same as finished main bearing caps. Number Six replacement cap does not have cap-to-block dowel holes and must be machined to match the block.

Semi-finished main bearing caps provide 0.002 to 0.005 inch (0.05 to 0.13 mm) pressed fit in the block.

When the cap is Number Six:

A. Remove the dowels from the block. Locate the cap so that the thrust faces of the cap and block are even. Use Blueing on the block surface to locate the dowel holes in the cap.

B. Remove the cap. Drill dowel holes, Figure 16C-11. Install the cap and ream the dowel holes to the smallest available oversize. Install the dowels in the block.

Install all caps on the block and ream the bore as described in Service Tool Instructions found on page.

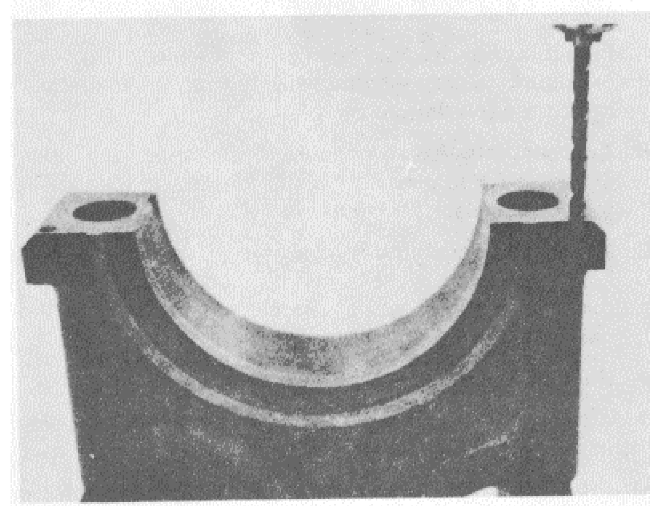


Figure 16C-11. Drill the Main Bearing Cap Dowel Hole

TOP SURFACE MACHINING. If necessary, a cylinder block can be repaired by removing a maximum of 0.010 inch (0.25 mm) of material from the top surface as follows:

1. Use a milling machine or large surface grinder. Locate the block on the main bearing pads.

2. Use ST1134 Dowel Pin Extractor to remove the dowels from the head mounting surface. Make cuts of 0.001 to 0.003 inch (0.03 to 0.08 mm) deep. Remove only enough material to make the block usable.

3. Measure the distance from centerline of main bearing bore (1) Figure 16C-12, to the top of the block. See Table 16C-1 (4).

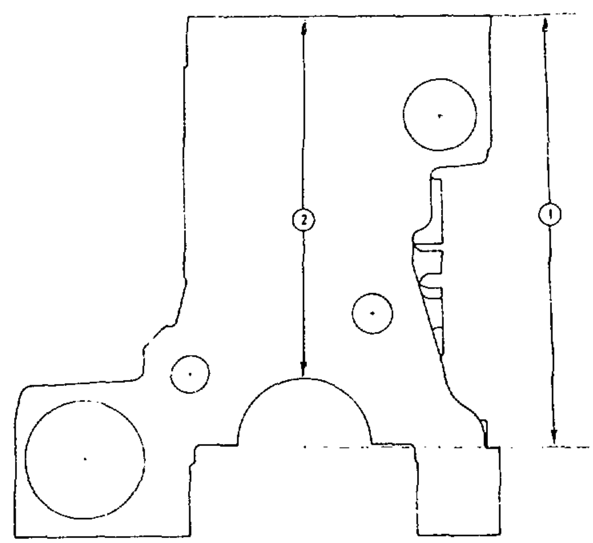


Figure 16C-12. Cylinder Block Height Checking Location

A. Find this dimension by positioning the block, top down, on a surface plate and measuring from the main bearing bore centerline to the plate.

B. Another method is to measure the distance from the installed main bearing bore alignment tool to the top surface of the block (2) Figure 16C-12.

C. The distance from the head surface to the main bearing bore center line must be within 0.002 inch (0.05 mm) throughout the length of the block. Head surface flatness must be within 0.002 inch (0.05 mm).

4. Machine the surface to a smoothness of 125 R.M.S.

5. Machine the counterbore to correct the liner protrusion. Inspect for liner to block contact in the crevice seal area.

MACHINE CYLINDER BLOCK LOWER BORE. If the lower bore of the liner lower bore chamfer is beyond the tolerances, or damaged by corrosion, one of the following operations can be performed to salvage the cylinder block.

If the corrosion damage has occurred only on the chamfer and not in the packing ring drive sealing area, the chamfer can be corrected by the use of a plastic steel material such as Devcon Plastic Steel, Type "A". The manufacturer's instructions are to be followed for this procedure. Check the chamfer depth after this operation and machine the chamfer if beyond acceptable tolerances.

CYLINDER LINER COUNTERBORE. Machine the correct counterbore to the correct liner protrusion if the block has been resurfaced, or the ledge is uneven.

CYLINDER LINERS

INSPECTION. Inspect the cylinder liners as follows: 1. Check for cracks in the cylinder liners just under the top flange, at bottom of the liner, or above the top seal ring groove as follows:

A. Magnetic Method.

B. Dye Method.

2. Discard any liner with corrosion 1/16 inch (1.59 mm) deep or more, or if marks or defects on underside of liner flange cannot be removed by lapping.

3. Measure the worn liners with a dial bore gauge. Replace if worn more than the Worn Limit as shown in Table 1 6C-1 (5).

CLEANING. Liners must be cleaned with solvent, steam or hot soap and water. The cleaning operation is to be finished by cleaning the bore with a bristle brush to remove as much foreign material as possible. Dry the liners with compressed air. Lubricate the bore of the liners with clean lubricating oil. Let the liners stand five or ten minutes. Use white cloths to clean lubricating oil from the liner bores. Note gray and even black material that is left with oil on white cloths. Repeat the application of lubricating oil and clean again with white cloths.

CRANKSHAFT

DISASSEMBLY AND INSPECTION. Disassemble and inspect the crankshaft as follows:

1. Clean all drilled oil passages in the crankshaft with a bristle-brush, Figure 16C-13.

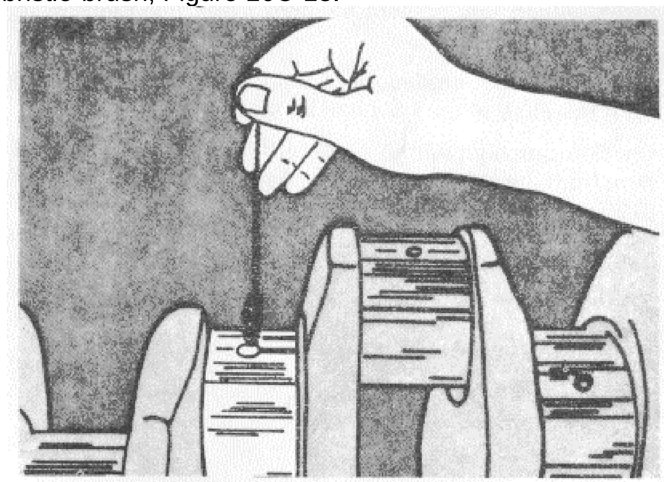


Figure 16C-13. Clean the Oil Drillings in the Crankshaft

2. If the crankshaft gear is chipped, cracked, or worn, replace the gear.

NOTE

If the crankshaft gear condition meets requirements, do not remove the gear.

3. Attach 3375076 Puller Jaw behind the crankshaft gear along with 3375075 Bridge Assembly.

CAUTION

The maximum torque is not to exceed 350 ft-lbs (475 N.m). Apply heat as necessary to loosen the press fit of the gear if the torque exceeds 350 ft-lbs (475 N.m). When heat is necessary to remove gear, discard the gear.

4. Check the crankshaft for scratches, cracks and wear pattern. Measure the crankshaft journals with micrometers. See Figures 16C-14 and 16C-15 and Table 16C-1 (6).

5. Measure the crankshaft for out-of-round condition. End crankshaft journals are worn out-of-round more than 0.002 inch (0.05 mm).

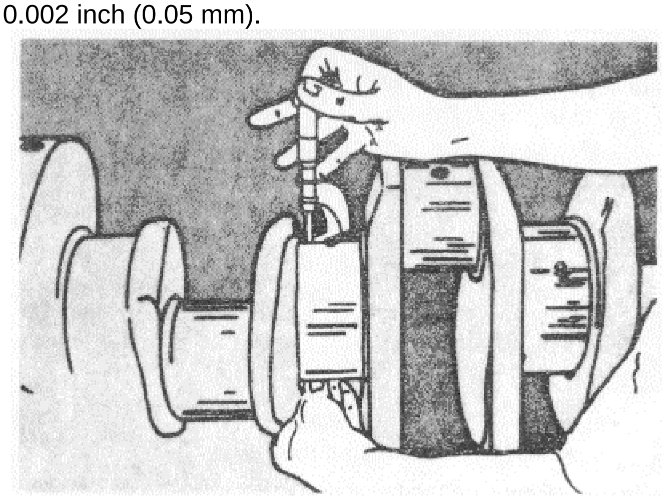


Figure 16C-14. Measure the Crankshaft Main Journal

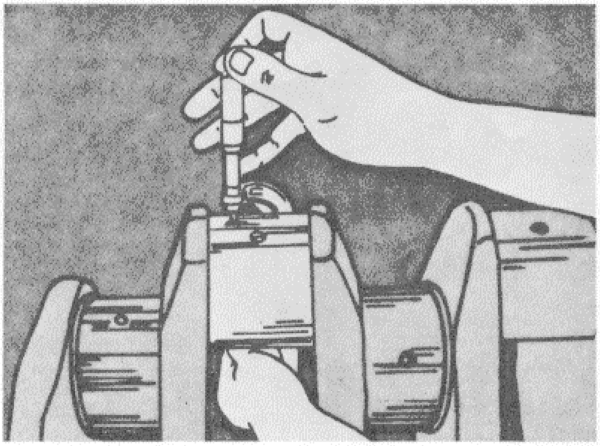


Figure 16C-15. Measure the Crankshaft Connecting Rod Journal

6. Measure and check visually crankshaft thrust flange at Number Six main bearing. See Figure 16C-16 and Table 16C-1. If the surfaces are damaged, regrind the crankshaft and install oversize thrust rings.

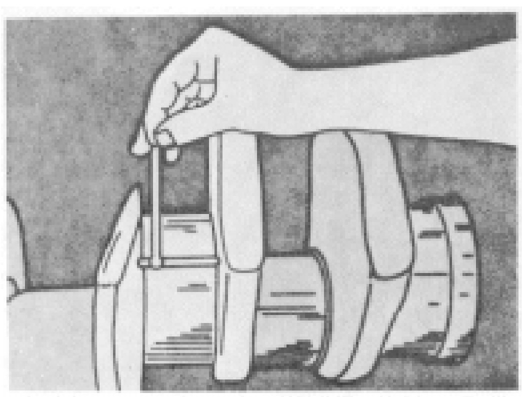


Figure 16C-16. Check the Thrust Flange for Wear

7. When regrinding crankshafts or when undersize bearings and/or oversized thrust rings are used, mark the crankshaft so that the correct bearing shells and thrust rings can be installed in correct position, Figures 16C-17 and 16C-18.

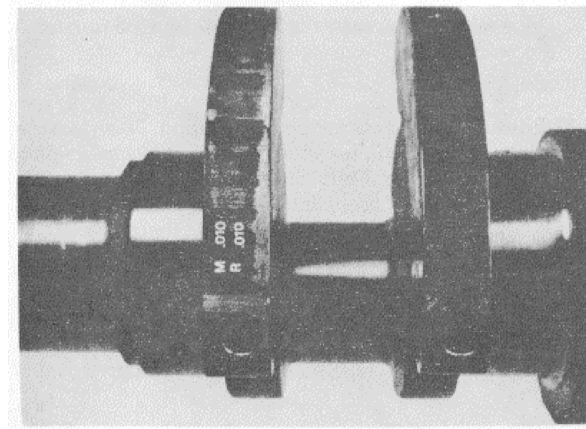


Figure 16C-17. Undersize Main and Connecting Rod Marking on the Crankshaft

8. The marking for undersized rod and main bearings should be on the front counterweight, oversize thrust ring size on the rear counterweight. Both thrust ring size and ring must be included in markings as shown in Figure 16C. 18.

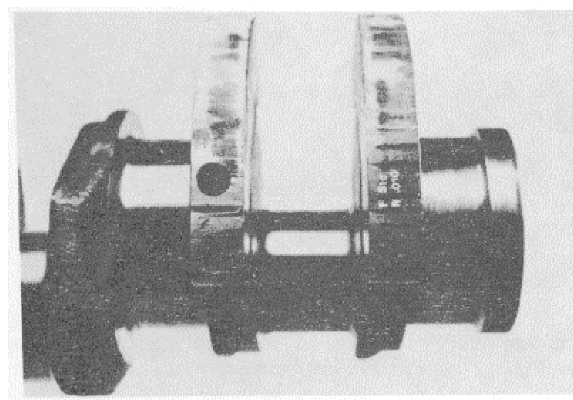


Figure 16C-18. Oversize Thrust Bearing Mark on the Crankshaft

For Example: Front-- Standard and rear--0.010 inch (0.25 mm).

ASSEMBLY. Install the crankshaft gear, if removed, as follows:

NOTE

Check the parts catalog for the correct gear part number.

1. Install the key in the shaft.
2. Heat the gear in an oven heated to 425°F (151° C) for a minimum of one hour. Do not use a torch to heat the gear.
3. Lubricate the flange with a high pressure grease and drive the gear onto the shaft with a piece of tubing.

NOTE

The engine timing marks on the gear face the front of the crankshaft.

BEARINGS

GENERAL. Main and connecting rod bearings(or shells)are two-piece units. The upper main bearing shells contain oil holes for lubrication. Connecting rod bearing shells both contain oil holes for lubrication and are interchangeable. Thrust rings are used at the Number Six main bearing.

INSPECT BEARING SHELLS. Measure the shell with a ball point micrometer (Figure 1 6C-19), dial indicator thickness gauge or comparator. Discard shells that are worn more than 0.001 inch (0.03 mm) or if chipped or otherwise damaged. See Table 1 6C-1 (7-8)for thickness of standard shells.

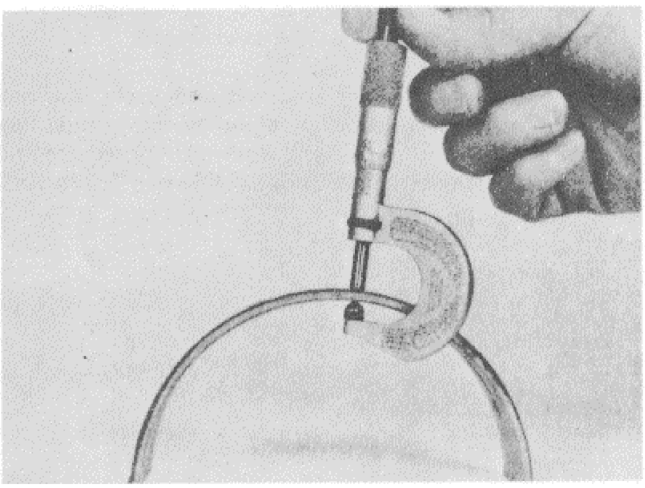


Figure 16C-19. Measure the Bearing Shell

The total worn maximum oil clearance is not to be more than 0.002 inch (0.05 mm) between main bearings. See Table 16C-1 (7-8).

NOTE

Do not scrape bearing shells, filed to increase oil clearances. A properly fitted bearing will look dull gray after a period of service, indicating it is running on an oil film. Bright spots indicate metal-to-metal contact and black spots indicate excessive clearance.

CRANKSHAFT THRUST RINGS

The best measurement of wear on the crankshaft thrust rings is the crankshaft end clearance check. See "Engine Assembly" Subsection 16N and Table 16C-1 (9-10), Figure 16C-20.

Oversize thrust rings are available. Use the same size (thickness) half-ring on both the upper and lower positions. Mark the crankshaft rear counterweight showing size used.

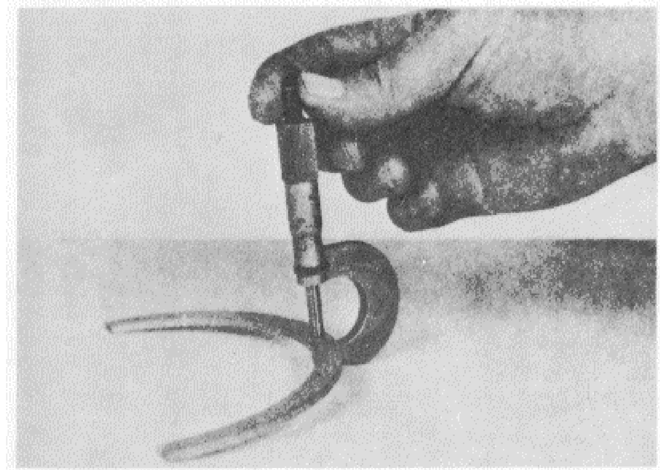


Figure 16C-20. Check the Thrust Ring for Wear

NOTE

The maximum amount of wear on the thrust ring is figured by wear of the crankshaft surfaces with the crankshaft in a cylinder block, the crankshaft end clearance is not to exceed 0.021 inch (0.53 mm) at rebuild, Figure 16C-21.

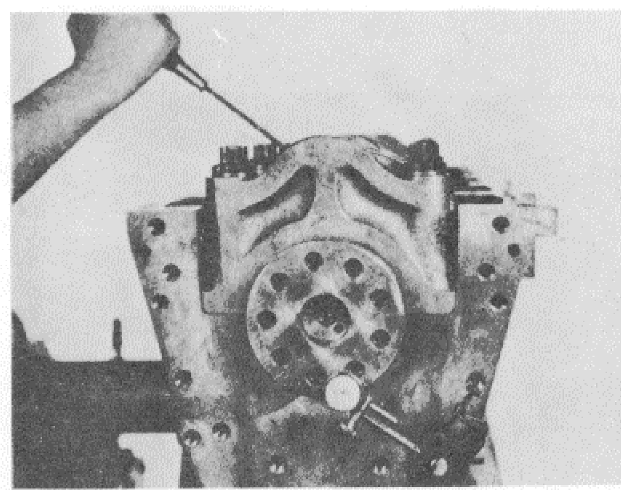


Figure 16C-21. Check the Crankshaft End Clearance

VIBRATION DAMPER

GENERAL. The vibration damper is a unit which counteracts twisting or torsional vibrations of crankshaft. The damper is engineered to match engine model on which it is used. To prevent failures make sure it is operative at all times.

CLEANING. The vibration damper should be cleaned of rust, dirt or grease with a suitable solvent cleaner.

The damper is not subject to field repair; therefore, if inspection shows it to be defective, install new damper.

INSPECTION. Inspect the vibration damper as follows:

1. Check the damper for defects as in 1 and 2, Figure 16C-22. Discard if these defects show up.

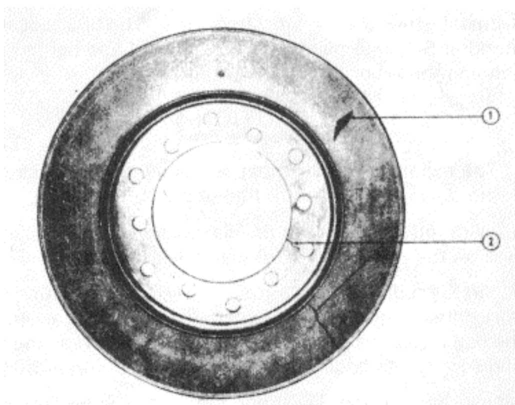


Figure 16C-22. Inspect the Viscous Damper

2. Spray the damper with dye penetrants, Type SKD-NF, or equivalent. Heat the damper in an oven heated to 200°F (93°C).
3. Remove the damper from the oven and inspect for oil smudges or fluid leakage. If oil shows, discard the vibration damper.
4. Remove paint, dirt and grit from the front and rear surface of damper in four (4) equally spaced areas. Clean the surface with paint solvent and fine emery cloth.
5. Use a micrometer to measure and record the thickness of the dampers at the four areas cleaned in Step Four. Take a reading approximately 0.125 inch (3.18 mm)from the outside edge of the front cover plate.
6. Replace the damper if the difference of the four readings exceeds 0.010 inch (0.25 mm).

VIBRATION DAMPER MOUNTING FLANGE. Check the damper mounting capscrew hole threads.

Maximum run out of the mounting flange, measured on the outside diameter of pilot, is not to exceed 0.004 inch (0.10 mm) total indicator reading. Face of the flange, measured at 2-3/4 inch (69.85 mm) radius, is not to exceed 0.003 inch (0.08 mm). The above readings are to be taken after assembly to the engine. The crankshaft must be kept to the front or

rear thrust limit while the face is checked.

CONNECTING RODS

INSPECTION. Inspect the connecting rods as follows:

1. Inspect all connecting rods, caps and bolts with magnetic flux crack detecting tool.

NOTE

Rod and cap are to be kept mated at all times.

A. Check rods for cracks with 1800 ampere current AC equipment or 1500 ampere current DC or rectified AC equipment longitudinally between plates.
B. Check the rods for cracks with 300 to 3400 ampere turns with the AC equipment or 2600 to 2800 ampere turns with DC or rectified AC equipment in a coil. Give special attention to the shaded critical areas shown in Figure 1 6C-23.

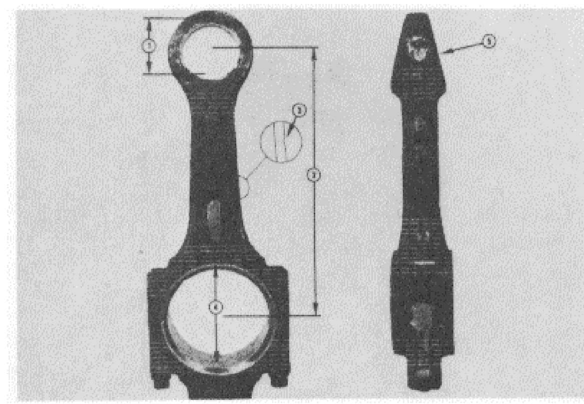


Figure 16C-23. Connecting Rod Critical Areas

NOTE

Ampere turns are the amperage flowing through the coil, multiplied by the number of turns in the coil. Most coils contain four turns. Only 700 amperes need to be applied with DC equipment or 850 amperes with AC equipment.

C. Apply one and one-half percent wet solution while the current is on. Visually inspect after each application of current.

2. Assemble the cap to the rod with the ring dowels in position and tighten the bolts to the torque described in Table 16C-1
3. Measure the crankpin bore with a dial bore gauge or inside micrometer, Figure 16C-24.

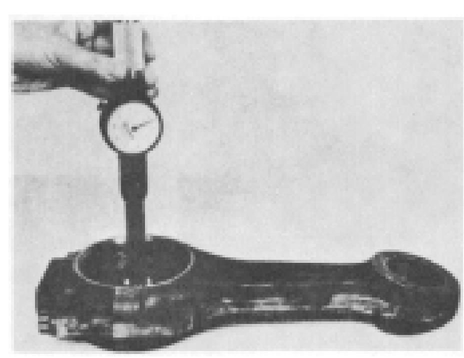


Figure 16C-24. Check Rod Crankpin Bore

A. The bore diameter must be within 4.2520 to 4.2535 inch (108 to 108.2 mm) up to thirty degrees on either side of the parting line, Figure 16C-25.
B. The bore diameter must be within 4.2517 to 4.2527 inch (108 to 108.2 mm) 30 degrees on either side of the parting line.
C. If the limits are not met, the rod must be replaced.

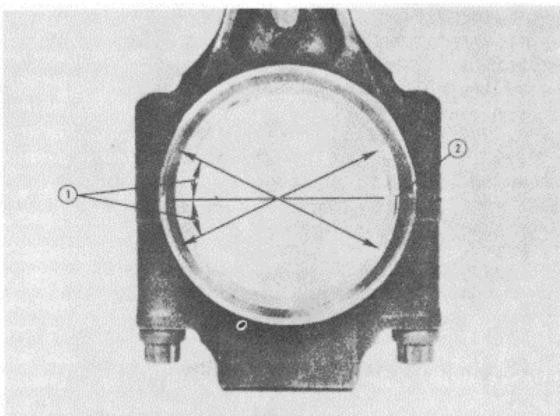


Figure 16C-25. Connecting Rod Wear Limits

4. Measure the piston pin bushing diameter with the dial bore gauge. See Table 16C-1 (1.1), Figure 16C-26.
5. Use ST-561 Checking Fixture and ST-1305 Locating Mandrel to check rod alignment.
6. Scrap a rod with defects in excess of 1/32 inch (0.80 mm) deep on the "I" beam.

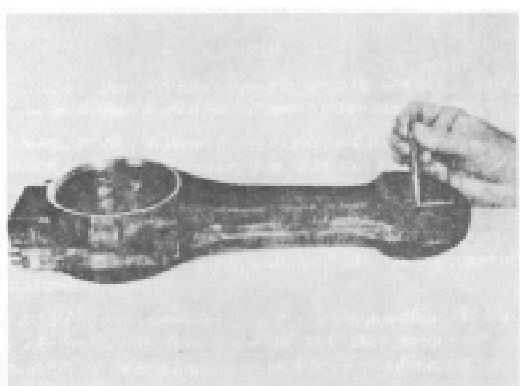


Figure 16C-26. Check the Piston Pin Bushing in the Rod

Calibrate ST-561 Checking Fixture For Rod Size.
1. Select a new rod that has been measured for correct absolute center to center length, 11.406 inch (289.71 mm) between centers. New production rods measurements are from 11.405 to 11.407 inch (289.69 to 289.74 mm).
2. Assemble the cap to the rod as described in Step 2 under inspection.
3. Install the piston pin, from the ST-1305 Locating Mandrel Set, into piston pin bore. Install and tighten, expanding the arbor into the crankpin bore.

CAUTION

The expanding arbor must be installed with locking pin down and on center line of rod.

4. With rod in fixture, set the dial holder so the dials indicate on the piston pin. Turn dial indicators to zero (0).
5. Lift the rod, arbor and pin assembly from the fixture; turn horizontally 180 degrees; reinstall into the fixture. Adjust the dial indicators to divide the difference between the first and second readings. The fixture is now calibrated.

Measure Rod Bend, Twist and Center to Center Distance.
1. Measurements read directly from the dial indicator compare the length and alignment of bores. Measurements apply with or without bushing installed.
2. Assemble the ST-1 305 Locating Mandrel into the rod to be checked. Put the rod on the fixture. Be sure the pin of the mandrel is down and in locked position with the centerline of the rod.
3. Take center to center readings for length (compared to length set up on calibration of fixture) and alignment of bores (difference in reading from one indicator to other).
4. Rotate the rod 180 degrees. The reading must not exceed 0.008 inch (0.20 mm) when the connecting rod does not contain a bushing or 0.0015 inch (0.038 mm) with the bushing installed and bored to size. Center to center distance must be 11.405 inch (289.687 mm) to 11.407 inch (289.737 mm).

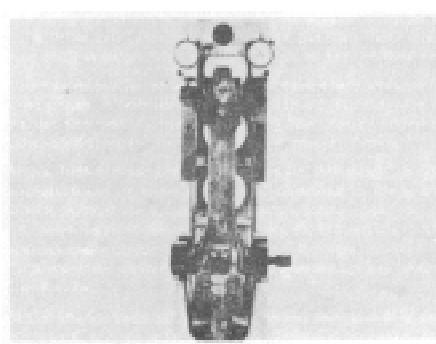


Figure 16C-27. Measure the Connecting Rod Bend

5. Measure the rod twist with a thickness gauge between the piston pin and dial holding plate. When measuring the connecting rod twist in a ST-561 and the rod does not contain the piston pin bushing, the twist must not exceed 0.007 inch (0.18 mm). The twist must not exceed 0.001 inch (0.10 mm) with the bushing in place and bored to size, Figure 16C-28.

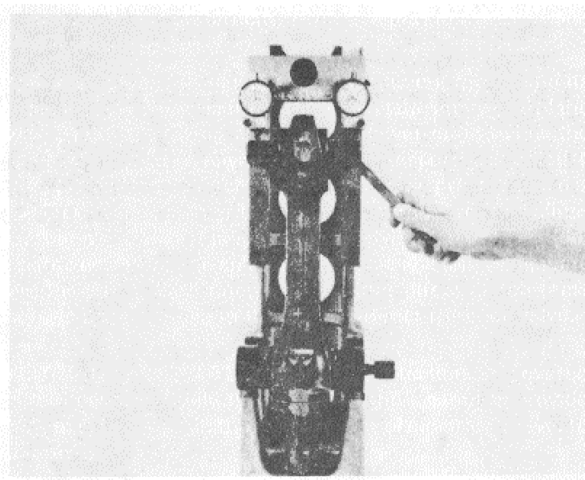


Figure 16C-28. Measure the Connecting Rod Twist

BOLTS, BOLT PADS AND RING DOWELS. Inspect bolts, bolt pads and ring dowels as follows:

1. If the connecting rod bolts have been tightened excessively, they may be permanently stretched, if so they are to be discarded. Discard the bolts if the smallest diameter is less than listed in the specifications, Figure 16C-29.
2. Discard all bolts that have distorted threads.

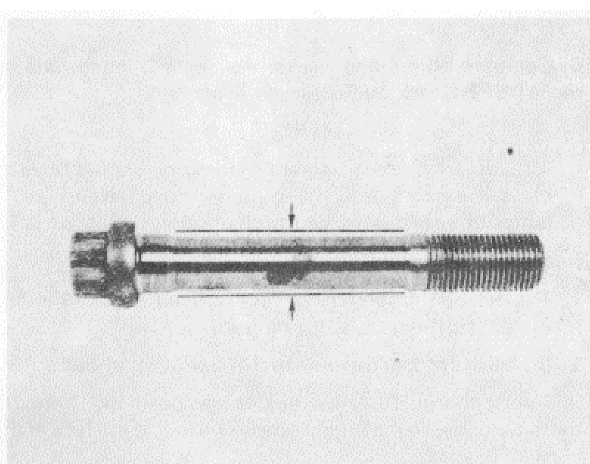


Figure 16C-29. Connecting Rod Bolt Dimensions

3. Inspect the bolt pad radius. See 1, Figure 16C-30 for damage.

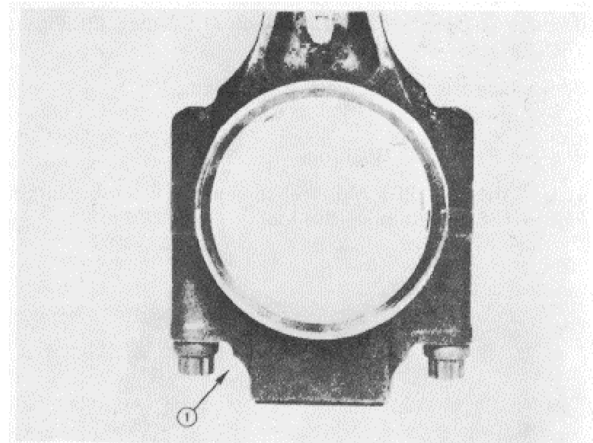


Figure 16C-30. Connecting Rod Bolt Pad Radius

4. Remove the ring dowels, if damaged, Figure 16C-31.

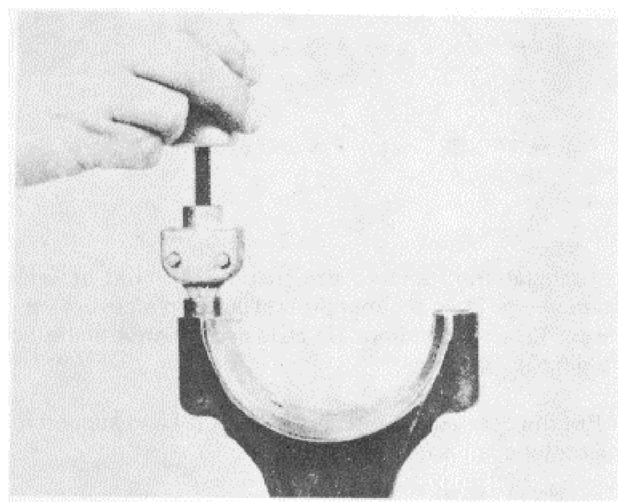


Figure 16C-31. Pull the Connecting Rod Ring Down

REPAIR. Repair the connecting rods as follows:

Cap Fillet and Rod Repair.

1. A dimension of 0.020 to 0.025 inch (0.51 to 0.64 mm), Figure 16C-30, fillet radius must be present at all corners where the cap is machined for the bolt head. The maximum 1/16 inch (1.59 mm) depth of the metal may be machined off the pad to restore the radius. Polish the fillet to 16 M.U. AA.

2. Remove damaged areas in the rod which are less than 1/16 inch (1.59 mm) deep by grinding or filling with a half round file. The radius must be 1/2 inch (12.7 mm) or more. Blend radius at the ends of the cut. Discard the rod if the damage is deeper than 1/16 inch (1.59 mm) (3), Figure 16C-23.
3. Replace the ring dowels, if removed.

Replace Piston Pin Bushing.

1. Use the ST-1285 Mandrel to remove worn bushings, Figure 16C-32. Remove the tool.

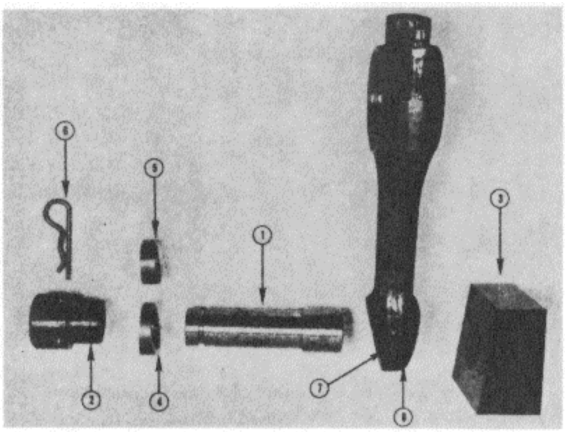


Figure 16C-32. Piston Pin and Bushing Mandrel Set

2. To install the standard size bushing (7) in rod: assemble the bushing (7) on the mandrel (1) position sleeve (4), then the cup (2) on the mandrel (1). Hold in position with the locking pin (6).
3. Put the connecting rod on the block (3) and support it in horizontal position.
4. Install the mandrel with all the components listed in Step 2 into the connecting rod bushing bore.
5. Align the sleeve (4) with the middle of the boss on the rod.

NOTE

Line up the oil holes in the bushing.

6. Use an arbor press to install the bushing into the bore until the sleeve (4) contacts the side of the rod pin boss.
7. To install thick-wall bushings in the rods which have been sized at cap end, install by the same method as described in Steps 2 through 6 above.

Bore Rod Piston Pin Bushing End.

1. Fill the lubricating holes with soap to Keep out, se shavings.
2. Position the connecting rod on the ST-526 Boring Machine.

NOTE

The lower mandrel is to have only the two horizontal blades in position to locate the side position of the piston pin end of rod.

3. Follow the instruction book kept with ST-526 for the operating instruction.
4. Bore the bushing to 2.401 to 2.4015 inch (60.98 to 60.993 mm) inside diameter. Remove the rod from the ST-526 and measure with the dial bore gauge, Figure 16C-33.

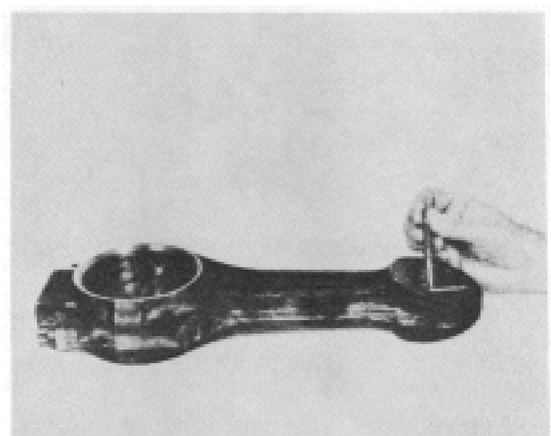


Figure 16C-33. Miking the Piston Pin Bushing

5. Remove the sharp edge with a scraper. Remove foreign material and soap by washing in mineral spirits and dry with compressed air.
6. Compare all dimensions on the reconditioned rods on the ST-561 Checking Fixture as described.

NOTE

All connecting rods used in the engine should have the same part number and number code. Never attempt to interchange cap from another rod.

Chamfer Piston Pin Bore.

1. The ST-861 Chamfering Tool is used to chamfer the piston pin bushing bore, if required.
2. Install the proper bushing tool by use of a flathead screw.
3. Adjust the guide screw holder into position. There are three notches, so that guide screw will follow the face of the bore.
4. Adjust the tool bit until the point just clears the guide screw and tighten in position with the two setscrews.

5. Install the unit into the bore and adjust the guide screw until the tool bit just engages the bore.

NOTE

A slight pressure is required against the guide screw. Tighten the setscrew in the end of the holder against the guide screw.

6. Use the drive ratchet to turn the tool one complete turn to clean the edge of the bore.

7. Loosen the guide screw and again turn the tool one or more complete turns to give a clean cut.

NOTE

Repeat until a uniform chamfer of 0.020to0.030 inch (0.508 to 0.772 mm) depth is reached.

8. Remove the tool from the bore. Turn the rod over and chamfer the other side of the bore. With both sides chamfered, remove the tool.

9. Use emery cloth to remove sharp edges which may have been left on the chamfer. Wash the rod before installing the bushing.

Piston Rings.

New rings are to be measured in the cylinder liner in which they are to be used to make sure the end gaps are correct.

1. Install each ring in to the cylinder liner. Position the ring with the head of the piston so it seats horizontally in the ring area of the liner.

2. Measure the ring gap with a feeler gauge. The gap isto be within the limits listed in Table 16C-1 (14), Figure 16C34.

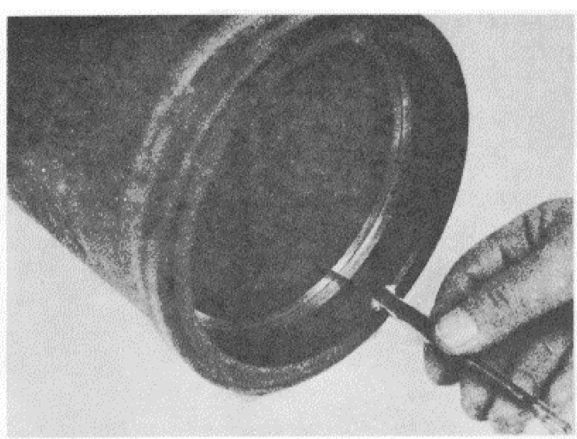


Figure 16C-34. Measure the Piston Ring tap in the Liner

3. Never file or alter the end gap of the chrome-plated rings and never use chrome-plated rings in chrome-plated cylinder liners.

4. Check the parts catalogs to be sure of the proper ring/piston combination.

PISTONS

INSPECTION. Inspect the pistons as follows:

1. Measure the top and second ring grooves with a new ring and feeler gauge.

   A. Hold the ring in the groove, even with the side of piston, and insert a 0.006 inch (0.15 mm) feeler gauge, Figure 1 6C-35.

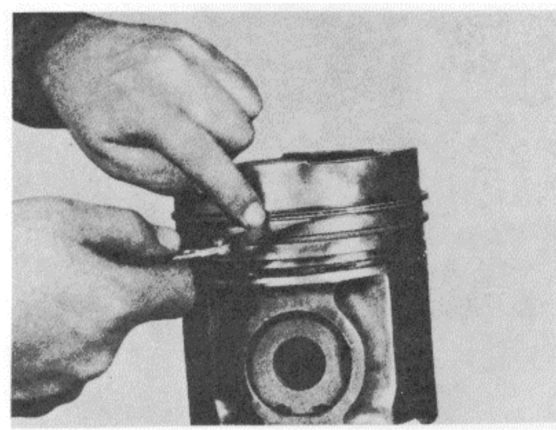


Figure 16C-35. Check the Piston Ring Groove for Wear

   B. If the gauge enters the groove without forcing or disengaging the ring, the wear is excessive and the piston is not to be used.

2. Measure the piston skirt diameter with a micrometer at a light angle to the piston pin bore. Pistons are not to be used if worn more than 6.235 inch (158.37 mm), Figure 16C-36.

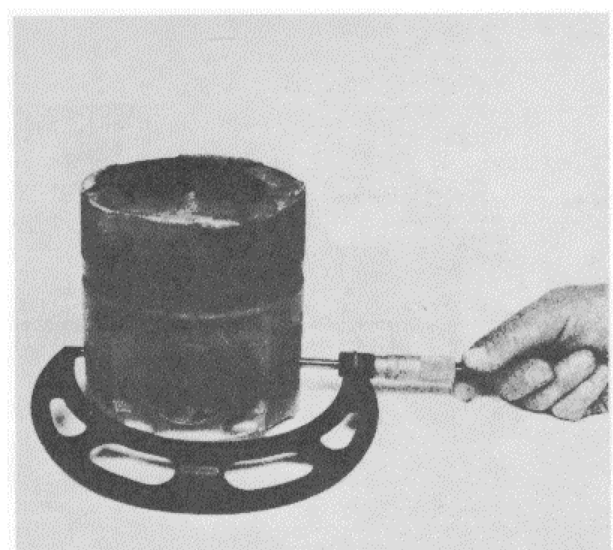


Figure 16C-36. Miking Piston Skirt

3. Pistons should be measured at a temperature of 70 to 90°F (21 to 32°C). After measuring the piston and comparing it with the liner inside diameter, the piston-to-liner clearance may be computed if desired.

4. Measure the piston pin bore at 70°F (21°C). It is to be within the limit given in Table 16C-1; add 0.005 inch (0.013 mm) per 10°F (-12°C) up to 90°F (32°C), Figure 16C-37.

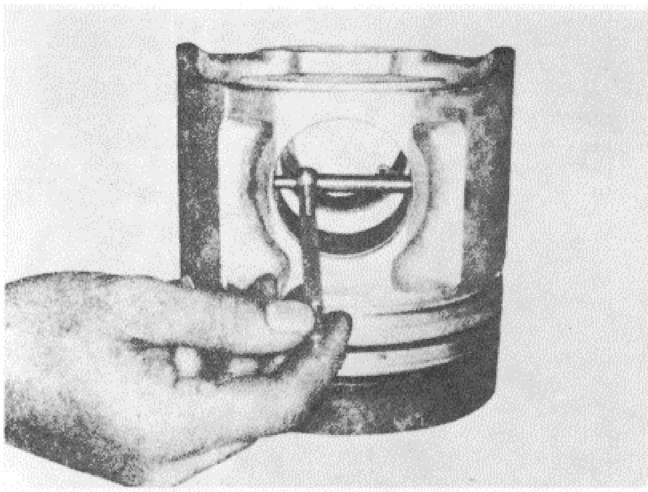


Figure 16C-37. Miking the Piston Pin Bore in the Piston

5. Measure the piston pin outside diameter with a micrometer, Figure 16C-38. Pins are not to be used if out-of round more than 0.001 inch (0.03 mm) or worn smaller than the figures given in Table 16C-1 (13). Boring of the piston pin bores and use of oversize pins are not done because the misalignment that results from such procedures will cause seizure of a piston or failure of connecting rod bearings.

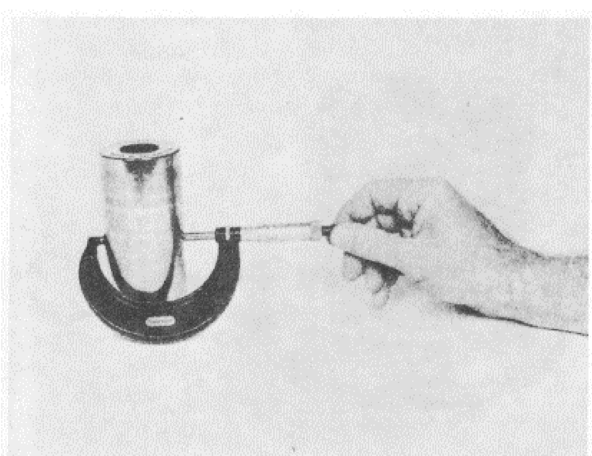


Figure 16C-38. Miking the Piston Pin

PISTON-TO-CONNECTING ROD ASSEMBLY

1. The pistons are machined to a very close weight tolerance. As long as the same part number piston is used throughout the engine, the weight does not affect engine operation.

2. Be sure the rod and cap are stamped with the cylinder number from which they were removed before disassembly to prevent mixing the parts, Figure 1 6C-39.

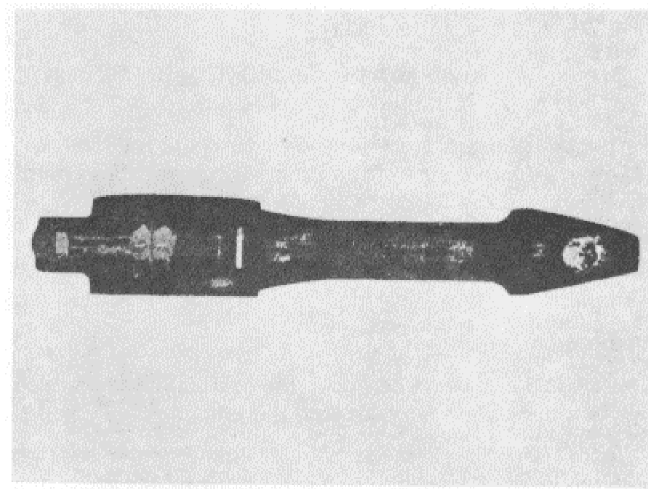


Figure 16C-39. Connecting Rod and Cap Cylinder Number

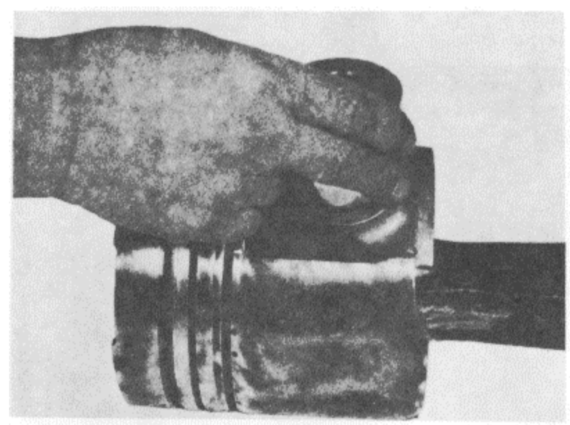


Figure 16C-40. Installing the Piston Pin

3. Install one piston pin retaining ring into the groove oft he piston pin bore.

4. Heat the aluminum piston in boiling water or in an oven at or below 120°F (40°C) for approximately thirty minutes and install the pin through the piston and connecting rod pin bores before the piston cools. At 70°F (21 °C) the pin fit is

0.0001 to 0.0005 inch (0.003 to 0.013 mm) which prevents the pin assembly from fitting unless the piston is heated. Secure the pin with a second retaining ring in the groove at the opposite end of the pin bore, Figure 16C39 and 16C-41.

CAUTION

Never drive a piston pin into the pistons. Driving will cause distortion of the piston, causing piston seizure in the cylinder liner.

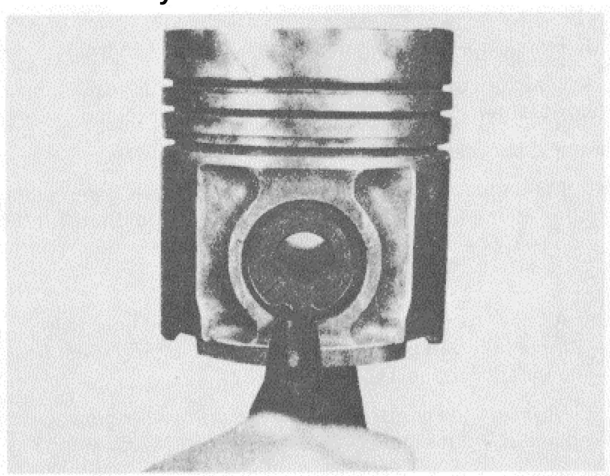


Figure 16C-41. Install the Piston Pin Snap Ring

REAR OIL SEAL

The rear oil seal is a unit which requires replacement of the O-rings only. Damaged oil seal retainers require replacement by a new assembly.

Alignment during engine assembly is the biggest factor for correct performance of the rear seal unit, see Subsection 16N.

CAMSHAFT

INSPECTION. Measure the camshaft bushing journals with micrometers, Figure 1 6C42. Replace the camshaft if the journals are worn beyond the limits given in Table 16C1 (15).

Replace the camshafts that have damaged or badly worn camshaft lobes. Check for possible cracks by magnetic inspection.

Cummins Engine Company, Inc. does not approve of grinding camshaft bores.

CAMSHAFT GEAR

1. Remove the gear if the thrust bearing is scored or the gear is damaged or visibly worn. The gear is press-fit onto the camshaft.

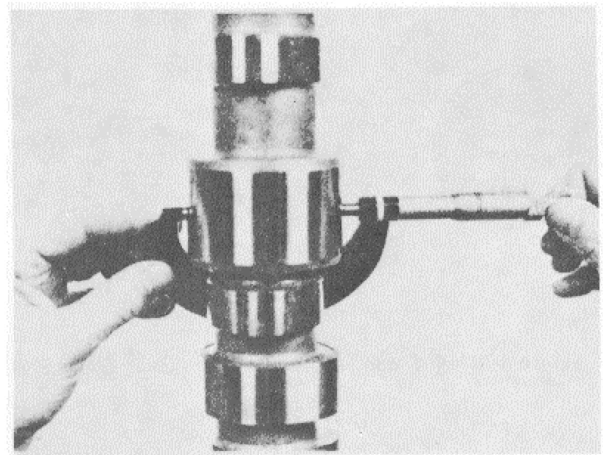


Figure 16C-42. Miking the Camshaft Journal

2. Press the camshaft from the gear. Remove the key. Lift off the thrust bearing.

3. Use a micrometer to measure the thrust bearing for wear, Figure 1 6C-43. Replace if worn to less than 0.359 inch (9.12 mm).

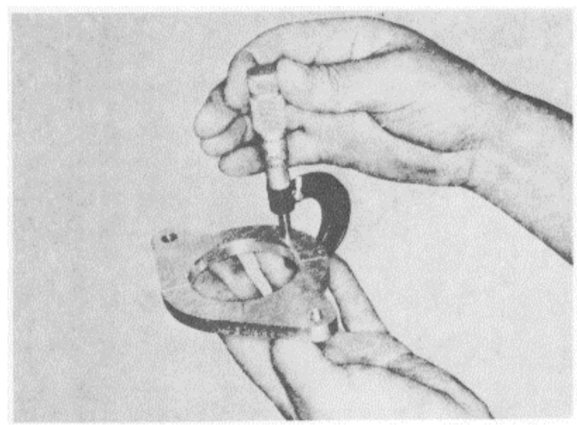


Figure 16C-43. Miking the Thrust Bearing

4. Heat the camshaft gear in an oven heated to 425°F (151°C) for a minimum of one hour.

NOTE

Do not use torch to heat the gear.

5. Note the type of key used. See Figure 16C-44. Key "A" advances the engine timing, key "B" is a straight key and key "C" retards engine timing.

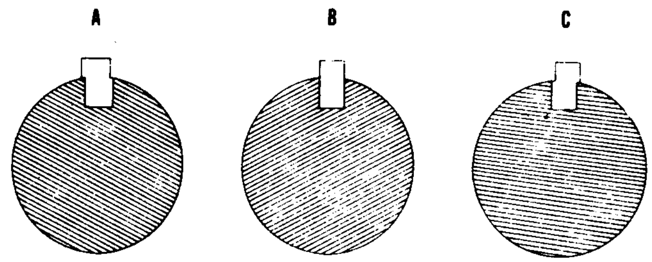


Figure 16C-44. Camshaft Key from the Gear Cover End

NOTE

The camshaft key part number is stamped on the key for identification purposes.

6. Coat the camshaft thrust bearing with a high pressure lubricant. Install the thrust bearing on the camshaft.
7. Coat the camshaft gear hub area with a high pressure lubricant.
8. Place the camshaft into a press. Install a key in the camshaft. Install the camshaft gear while hot.

NOTE

Check the timing when a new camshaft or gear is installed in an engine.

GEAR HOUSING

1. Inspect for cracks, leaks or other damage. Repair as necessary.
2. Check the stud threads; replace if damaged.
3. Inspect the capscrew threads and repair with threads inserts, if the threads are damaged.
4. If the dowels are damaged, replace or ream out for the next oversize.
5. The one piece gear cover requires a blind plug when the power steering pump is not used in the power steering shaft hole.

GEAR COVER

INSPECTION. Inspect the gear case cover as follows:

1. Remove and discard all oil seals. Measure the bushings for wear.
2. Check the cover for cracks, leaks or other damage; repair as necessary.

NOTE

Crank seal, water pump seal, accessory drive seal are to be installed after the cover has been assembled to the engine.

Drive Bore Bushings.

1. Measure the bore of alternator and accessory (fuel pump and compressor) drive. If worn larger than 1.571 inch (39.90 mm), replace.
2. If either shaft is worn enough to use an oversize bore bushing (minimum clearance of 0.003 inch (0.08 mm)) between shaft and bushing, use bushings as listed in Table 16C-1 (16).
3. Install the new bushing. (Use ST-598 Mandrel.)
4. Measure the bore of the hydraulic pump drive bushing; if worn larger than 1.506 inch (38.25 mm), replace. Idler Gear and Shafts.
1. Measure the bushing bore of the camshaft and water pump idler gears; if the bushing is worn larger than 1.8785 inch (47.714 mm), replace.

NOTE

All idler gear bushings must be precision bored after installation in gears. The gear and bushing must be concentric. See Table 16C-1 (17).

2. Measure the camshaft and water pump idler gear shafts; replace if worn smaller than 1.872 inch (47.55 mm).
3. The camshaft and water pump idler gear thrust must be less than 0.018 inch (0.46 mm).
4. Replace the hydraulic pump idler shaft if worn smaller than 1.747 inch (44.37 mm).
5. Measure the hydraulic pump gear bushing. Replace if worn larger than 1.7535 inch (44.539 mm).
6. The hydraulic pump gear end thrust, when mounted on the engine, must be less than 0.022 inch (0.56 mm). Select oversize thrust bearings to bring gear end clearance between 0.009 to 0.018 inch (0.23 to 0.46 mm).
7. New idler gear thrust washers are 0.092 to 0.095 inch (2.34 to 2.41 mm). See the parts catalog for part numbers of oversize thrust washers. Discard the standard washers if worn thinner than 0.088 inch (2.23 mm).
8. Backlash on each gear of the front gear train is 0.003 to 0.01 3 inch. Replace the gear if the backlash exceeds 0.020 inch (0.50 mm).

SERVICE TOOL INSTRUCTIONS

ST-1252 CONCENTRICITY GAUGE

Check the common centers of the cylinder liner counter bore to lower bore as follows:

1. Put the gauge flat on the top surface of the cylinder block with the pins against the counter bore inside diameter.
2. Raise or lower the shaft to the position indicator in the area of the lower bore to be checked.

3. Holding the gauge pins firmly against the counterbore inside diameter, turn the indicator to zero.
4. Release the pressure. Position the gauge again to check the indicator reading. Turn the indicator to zero if necessary.
5. Turn the gauge 180 degrees from original setting position. Hold the pins against the counterbore inside diameter and record the indicator reading.
6. Move the gauge 90 degrees and repeat the procedure.

NOTE

Indicator readings recorded are two times the actual shift of the bore. (Example: Indicator reading--0.002 inch (0.05 mm). Actual shift from center of bore 0.001 inch (0.03 mm)).

ST-1177 MAIN BEARING BORING TOOL

This tool is designed for both the boring and checking functions. Before the boring operation, the tool and block are stabilized to room temperature.

ASSEMBLY TO BLOCK

1. Remove two main bearing caps which are as close as possible to the end of the block and have not been damaged.
2. Install the proper centering rings into two bores and strike the top of the centering ring with a plastic hammer in order to correctly position.
3. Install the main bearing caps and tighten to the specification following the steps in Table 16C-1.

NOTE

If the centering ring must be installed in the journals which have had the caps replaced by semifinished caps, limit the torque to 10 ft-lbs. (14 N.m).

4. Oil the centering ring bores and boring bar. Install the boring bar (ST-1177-16, Figure 16C-45) through the centering rings rotating the bar slowly. The boring bar should spin free. Slide the boring bar out one end until the checking ring (ST-1177-55) can be installed in the bar. Oil the outside diameter of the checking ring.

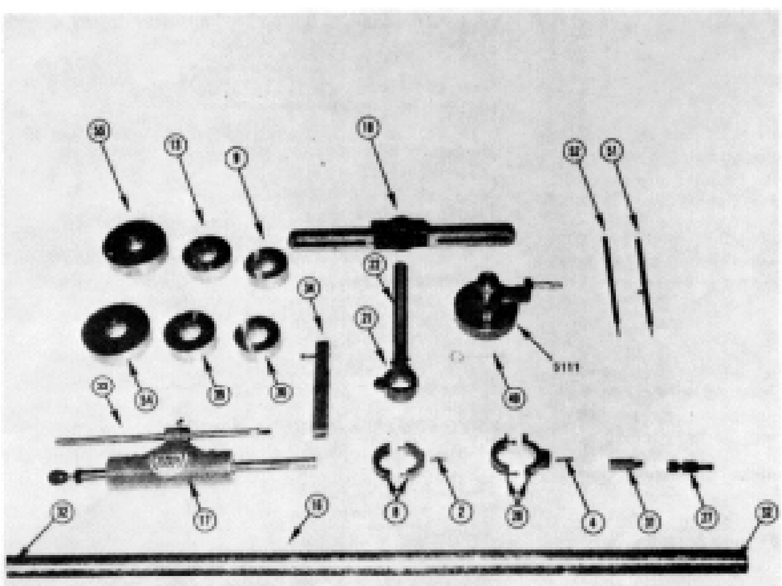
5. Use finger pressure against the checking ring on both sides of the boring bar to push the checking ring through each bore. The bar must be turned during this check.

A. Check the bore for sharp edges if the checking ring will not pass through the bore.

B. A 0.003 inch (0.08 mm) feeler gauge (not over 1/2 inch (12.70 mm) wide) can be used in detecting problems in the bore.

C. Attempt to insert a feeler gauge between the bore and slip ring. Run the gauge completely around the slip ring on each side of the bore. Evaluate as follows:

(1) The gauge does not enter at any point, the boring bar rotates freely - standard bore.



1–5. Cutting Tools
8. Cutter Holder
9–15 & 55. Checking Rings
16. Bore Bar
17. Bore Feed Assembly
18. Bore Bar Bridge
21. Bearing Bar
27. Swivel Joint
28. Cutter Holder
31. Drive Adapter
32. Capscrew
33. Torsion Bar
34. Bracket
36–42 & 54. Centering Rings
49. Cutter Pin
51 & 52. Allen Wrenches
5111. Micrometer Assembly
54. Centering Ring
55. Checking Ring

Figure 16C-45. Exploded View of the ST-1177 Boring Tool

(2) The gauge enters on one side and not on the opposite side slight misalignment. No problem if the boring bar rotates freely.
(3) The gauge is loose - oversize bore.
(4) The gauge enters on the front and not on the rear of the bore - tapered bore.

6. Mark the bores to be salvaged.

ASSEMBLING MICROMETER TOOL BIT

SETTING GAUGE AND TOOL BIT

1. Install the micrometer base shaft (ST1177-46) through the bore of the micrometer bracket (ST-1177-45) and thread into the micrometer base (ST-1 177-44) and tighten.
2. Tighten the socket head screw (ST-1177-29) in the micrometer bracket until the bracket is tight on the micrometer base shaft. The micrometer hole in the micrometer bracket must be in alignment with the cutting tool hole in the micrometer base shaft.
3. Install the centering ring (ST-1177-54) over the micrometer base shaft and micrometer (ST-1177-511 1):
   A. Adjust the micrometer thimble to the value stamped on the centering ring.
   B. Hold the micrometer spindle against the centering ring and tighten the socket head screw in the micrometer bracket. Check to see that the micrometer spindle turns freely.
4. Remove the centering ring and install the cutter holder over the micrometer shaft.
5. Align the tool bit hole in the cutter holder with the hole through the micrometer base shaft and tighten the cutter holder socket head screws. Scribed lines are used on the base shaft and cutter holder for this purpose. Keep even gaps between the two halves of the cutter holder.
6. Insert the cutting bit in the tool holder. The tool must be short enough so that it does not extend into the bore of the tool holder. When adjusting the micrometer or tool cutter, be careful with the tool to prevent damage.
7. With the cutter (ST1177-49), adjust the tool bit against the micrometer spindle and tighten the tool bit retaining screw in the cutter holder. Back off the micrometer and check the tool bit setting.

NOTE

Do not tighten the micrometer spindle against the tool bit point or carbide may be chipped. Do not sweep the micrometer spindle across the carbide cutter since it will chip the cutting edge.

8. Back off the micrometer and remove the cutter holder from the micrometer base shaft.

CUTTING BORES

NOTE

Review the use of bridges before boring.

1. Install the bore feed assembly (ST-1 177-17) in one end of the boring bar and tighten the socket head screw (ST1177-32).

CYLINDER BLOCK

2. Install the torsion bar (ST-1177-33), threaded end first, through the bore feed assembly, (ST-1177-17). Start the threads into the end hole of the torsion bracket (ST-1 17734). The flats on the bar can be used to secure it to the bracket.
3. Locate the tapped hole in the end of the block and secure the torsion bracket to the block with a suitable capscrew and washer.
4. Pull out the plastic knob of the feed assembly until the pin is free of the slot and turn one-fourth turn, then pull the complete feed assembly back all the way to the knob and tighten the wing setscrew in the feed assembly to secure on the torsion bar.
5. Install the square head set bolt in the second threaded hole of the torsion bracket end and tighten against the cylinder block to hold the torsion assembly.
6. Turn the plastic knob on drive assembly one-fourth (1/4) turn until the pin seats in the groove.
7. Install the adapter (ST-1177-31) in the other end of the boring bar with the 1/2 inch square drive out. Lock with the socket head setscrew.
8. Lock the swivel joint (ST-1 177-27) in a one half inch drill chuck. These instructions assume use of a right hand rotation drill.
9. Install the tool bit holder on the boring bar, next to the journal to be cut. When operating‘, the boring bar will feed toward the feed assembly. Make sure the tool bit cutting edge is turned in the direction of the drill rotation.
10. With the swivel joint on the boring bar adapter, cut the main bore. Keep the boring bar lubricated during all boring operations.

CAUTION

Do not use a drill of less than ten amperes or over 450 rpm.

11. To cut the next main bore:
    A. Remove the cutter holder from the boring bar.
    B. Pull out the plastic knob on the feed assembly and turn a one-fourth turn.
    C. Push in the feed shaft (the knob) until it stops against the feed assembly.
    D. Turn the plastic knob one fourth turn, until the pin seats in the slot.
    E. Repeat Steps 9 and 10.

1 2. Clean the block and measure the size of the bore with a dial bore gauge and alignment with the checking ring.

USE OF THE BRIDGES

The bridges and bearings are intended for additional support of the boring bar and are designed to compensate for any distortion of the block oil pan surface. It is not necessary to use bridges if the centering rings are located equally apart.

For example: If Number One, Three, Four, Five or Seven main bores are to be bored and the centering rings are in Number Two and Six main bores, bridges are not necessary.

1. Assemble the bearing bar (ST-1166-22) on the bearing bridge (ST-1 177-21) with the hexagon head capscrew (ST1177-23) finger tight.

2. Install the bearing over the boring bar at the point where the support is needed. Allow room for the cutter holder, if it is next to the bore being cut.

3. Lower the liner bore bridge (ST-1177-18) over the bearing bar and secure to the oil pan rails.

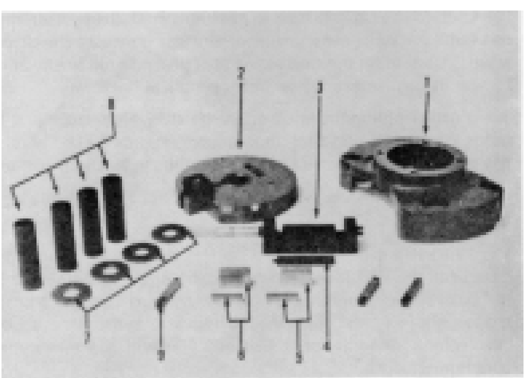
4. Tighten the socket head screw(ST-1177-25)in the bearing until the bearing is tight on the boring bar; do not overtighten.

5. Tighten the hexagon head capscrew (ST-1177-25) in bearing bar and socket head capscrew (ST-1177-19) in bridge.

6. Turn the boring bar to see that it is free.

LINER COUNTERBORE CONVERSION KITS

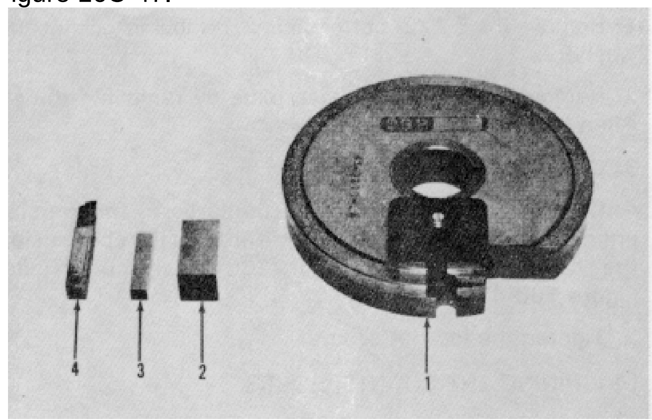
1. The 3375442 liner counterbore conversion kit is for machining the standard diameter KT/KTA series engine cylinder liner counterbores to accept 0.010 and 0.20 inch (0.25 and 0.50 mm) oversize service liners, Figure 1 6C-46.



1. Base Plate
2. Cutter Head (0.10 inch [0.75 mm] O/S Liner
3. Tool Bit Setting Tool
4. Master Set Block
5. Depth Spacer Block
6. Depth Spacer Block
7. Washers
8. Spacer Pipes
9. Tool Bits

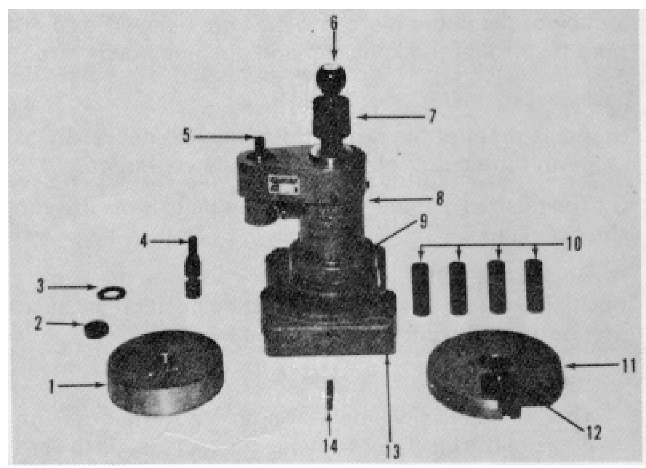
Figure 16C-46. 3375442 Liner Counterbore Conversion Kit 16C-19

2. The 3375444 Adapter Kit is to be used in conjunction with the liner counterbore conversion kit to machine the cylinder liner counterbores which have already been machined 0.010 inch (0.25 mm) oversize to accept 0.20 inch (0.50 mm) oversize liners. Do not attempt to enlarge 0.010 inch (0.25 mm) oversize counterbores to 0.020 inch (0.50 mm) without the 3375444 adapter kit, Figure 16C-47.



1. Cutter Head (0.020 inch [0.50 mm] OIS Liner)
2. Depth Spacer Block
3. Depth Spacer Block
4. Tool Bit

Figure 16C-47. 3375444 Adapter Kit



1. Bushing Device
2. Jam Nut
3. Cutoff Washer
4. Universal Drive Adapter
5. Drive Shaft
6. Knob
7. Depth Collar
8. Main Housing Assy.
9. Capscrews
10. Stud Adapters
11. Cutter Plate
12. Capscrews
13. Base Plate
14. Tool Bit

Figure 16C-48. ST-1168 Liner Counterbore Boring Tool

3. The 3375442 and the 32375444 kits are designed to be used with the ST-1168 counterbore boring tool. They

cannot be used with the ST-1255, ST-1295 or the 3375005 counterbore tools.

CONVERTING ST-1168 COUNTERBORE TOOL TO MACHINE COUNTERBORES

CONVERSION PROCEDURE

1. Remove the 5-1/2" cutter plate by removing locknut and washer.

2. Remove the universal base plate by removing the (4) Allen Head capscrews.

3. Clean tool thoroughly.

4. Convert the tool for cutting counterbores for oversize liners by assembling tool in reverse order of the above using the "K" engine base plate, Figure 16C-46, and cutter head, Figure 16C-47.

5. Tighten the locknut securely.

MACHINING THE COUNTERBORES

NOTE
Where possible, it is recommended that the assembled tool be checked out by machining one or more bores in a scrap block before proceeding to a good block.

1. Place the boring tool assembly on the cylinder block above the counterbore to be cut. Mount with 4 capscrews, spacers and flatwashers. Tighten finger-tight.

2. Lower the cutter plate into the bore below the counterbore by turning the knob left and pushing downward.

NOTE
Adjustment of the depth collar may be necessary to permit the cutter plate to enter the counterbore.

3. The tapered diameter of the cutter plate is used to center the boring tool.

4. Rotate the cutter plate slowly by rotating the knob, and position the tool assembly by shifting position on the capscrews until the cutter plate turns freely.

NOTE
This is especially important on Vee engines. The angle of the block deck causes the tool to slide toward the lower side of the counterbore.

5. Torque down the capscrews alternately 25-35 ft-lbs (3447 N.m). Recheck for free rotation or alignment of the cutter plate.

6. Retract the cutter plate by pulling up on the knob. Lock in place by turning the knob to the right.

7. Adjust the tool bit with the special micrometer set block. Set the micrometer. Loosen the setscrew in the end of the tool bit, allowing the spring loaded plunger to contact the end of the micrometer. Tighten the setscrew. Double check by backing off the micrometer thimble and recheck the setting.

A. Set the micrometer spindle to the following value

(1) 7.5015/7.5020 If 0.010 inch (0.25 mm), oversize liner is to be used.

(2) 7.5115/7.5120 If 0.020 inch (0.50 mm), oversize liner is to be used. (3375444 Adapter Kit.) Place the tool bit in the set block with carboloy tip held firmly at the bottom end against the stop or hardened pad.

B. Loosen the setscrew in the end of the tool bit allowing the spring loaded plunger to contact the end of the micrometer. Tighten the setscrew.

C. Double check by backing off the micrometer thimble and recheck the setting. Repeat the procedure until the setting required under "1" above is achieved.

8. Remove all the dirt and shavings from the tool bit recess in the cutter plate.

9. Insert the tool bit into the recess cutter plate. Do not push the tool bit all the way in. Fasten the tool bit to where it extends about 1/4" beyond the edge of the block counterbore.

10. While pulling upon the knob, turn it to the left and carefully lower the cutter plate toward the block deck until the tool bit is resting on it.

11. Loosen the depth collar setscrew, and rotate the collar as required until the space can be inserted between the collar and the boring machine main body. Adjust the depth collar until there is a slight drag on the spacer. Tighten the setscrew in the depth collar and remove the spacer.

12. Retract the cutter plate by lifting up on the knob. Turn the knob to the right to lock in position. Push the tool bit into the cutter plate recess until the plunger contacts the drive shaft. Push up on the end of the tool bit and hold firmly bottomed in the recess while tightening the setscrew.

13. While holding the knob up, turn to the left and lower the guide plate until the tool bit is approximately 1/16" above the block deck. Turn the knob to the right to lock in position.

14. Chuck the universal driver adapter in a heavy duty electric drill.

15. With the drill positioned on the drive shaft, bore the hole until the drill free wheels. Let the drill free wheel for 5 to 10 revolutions of cutter plate to clean up the counterbore ledge. Allow the drill to free wheel the same amount of revolutions for each bore being cut. This will provide a more consistent depth.

NOTE
The operator should be prepared for increased load on the drill when the tool bit begins cutting the counterbore ledge.

16. Retract the cutter plate by turning knob to the left and pulling upward. Lock in position by turning the knob to the right.

17. Remove the tool bit from the guide plate.

18. Remove the boring tool from the block.

19. Clean the counterbore and remove all the burrs.

20. Check the counterbore depth and diameter at several equidistant points. The depth must be 0.731 to 0.733 inch

(18.56 to 18.61 mm) and the diameter must be 7.5015 to 7.5035 inch (190.538 to 1 90.588 mm) for 0.010 inch (0.25 mm) oversize liner or 0.741 to 0.743 inch (18.82 to 18.87 mm) depth and 7.5115 to 7.5135 inch (1 90.792 to 190,842 mm) diameter for 0.020 inch (0.50 mm) oversize liner.

If the counterbore is not 0.731 to 0.733 inch (18.56 to 18.61 mm) use the ST-1309 and tool holder assembly 3375445 for 0.010 inch (0.25 mm) oversize or 3375447 for 0.020 inch (0.50 mm) oversize.

NOTE

The 3375446 Tool Bit must be ground accurately to cut a 0.062 inch (1.52 mm) radius.

Position the ST-1309 and the appropriate tool holder over the counterbore to be cut and adjust the tool bit in the holder such that the tool just contacts the counterbore wall uniformly during the rotation. Cut the counterbore required amount in the usual manner. Remove the tool and clean the counterbore thoroughly. Install the liner or liners.

Table 16C-1. Cylinder Block Specification -Inch (mm)

Table 16C-1. Cylinder Block Specification — Inch (mm)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Camshaft Bushing			
1.	Inside Diameter	**3.0035 [76.276]**	3.000 [76.200]	3.002 [76.250]
	Camshaft Bushing Bore			
	Inside Diameter		3.2535 [82.638]	3.2545 [82.664]
	Cylinder Liner Counterbore (Thin Flange) Before Engine Serial No. 31121670			
A	Block Upper Counterbore Inside Diameter		7.399 [187.934]	7.401 [187.985]
			7.409 [188.188]	7.411 [188.239]
			7.419 [188.442]	7.421 [188.493]
B	Block Upper Counterbore Depth		0.300 [7.62]	0.302 [7.67]
			0.310 [7.87]	0.312 [7.92]
			0.320 [8.13]	0.322 [8.18]
C	Block Lower Bore Inside Diameter		7.090 [180.086]	7.092 [180.136]
D	Liner Flange Outside Diameter		7.400 [187.960]	7.402 [188.010]
			7.410 [188.214]	7.412 [188.264]
			7.420 [188.468]	7.422 [188.518]
E	Liner Flange Thickness		0.305 [7.747]	0.306 [7.772]
			0.315 [8.001]	0.316 [8.026]
			0.325 [8.255]	0.326 [8.280]
F	Liner Lower Outside Diameter		7.093 [180.162]	7.095 [180.213]

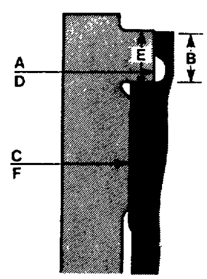
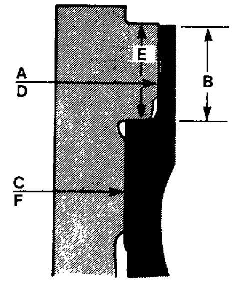


Table 16C-1. Cylinder Block Specification — Inch (mm) (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Cylinder Liner Counterbore (Thin Flange) After Engine Serial No. 31121670			
A	Block Upper Counterbore Inside Diameter		7.491 [190.271]	7.493 [190.322]
B	Block Upper Counterbore Depth		0.521 [13.233]	0.523 [13.284]
C	Block Lower Bore Inside Diameter		7.090 [180.068]	7.092 [180.1368]
D	Liner Flange Outside Diameter		7.492 [190.296]	7.494 [190.347]
E	Liner Flange Thickness		0.526 [13.360]	0.527 [13.385]
F	Liner Lower Outside Diameter		7.093 [180.162]	7.094 [180.187]
	Main Bearing Bore			
3.	Inside Diameter	**5.8465 [149.50]**	5.845 [148.46]	5.846 [148.49]
	Block Ref. Fig. 16C-12			
4.	Height from Main Bearing Centerline	**18.994 [482.45]**	19.004 [482.70]	19.006 [482.75]
	Height from Installed Alignment Bar	**16.071 [408.20]**	16.081 [408.46]	16.084 [408.53]
	Cylinder Liner			
5.	Inside Diameter	**6.255 [158.88]**	6.2495 [158.74]	6.2510 [158.78]



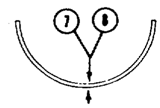
Note: New cylinder liners dimensions at 60 to 70°F [16 to 21°C]; may be 0.0002 to 0.0006 inch [0.005 to 0.015 mm] smaller than indicated due to lubrite coating.

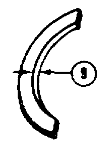
Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Protrusion (Installed)		0.003 [0.08]	0.006 [0.15]
	Crankshaft			
6.	Connecting Rod Journal Outside Diameter	**3.997 [101.524]**	3.9985 [101.562]	4.0000 [101.600]
	Main Bearing Journal Outside Diameter	**5.4975 [139.636]**	5.4985 [139.662]	5.5000 [139.700]
	Thrust Bearing Surface Between Counterweights	**2.379 [60.43]**	2.374 [60.30]	2.376 [60.35]
	Main and Rod Journals Out-of-round T.I.R.**	**0.002 [0.05]**		
	Main and Rod Journal Taper (Width of Journal)	**0.0005 [0.013]**		

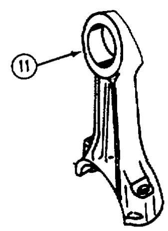
**T.I.R.—Total Indicated Runout

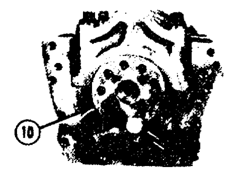
Table 16C-1. Cylinder Block Specification — Inch (mm) (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Main Bearings			
7.	Shell Thickness	**0.1690 [4.293]**	0.1705 [4.331]	0.1712 [4.348]
	Journal Clearance	**0.0085 [0.216]**	0.0026 [0.066]	0.0065 [0.165]
	Rod Bearings			
8.	Shell Thickness	**0.1230 [3.124]**	0.1245 [3.162]	0.1250 [3.175]
	Journal Clearance	**0.0075 [0.191]**	0.002 [0.05]	0.005 [0.13]
	Crankshaft Thrust Ring			
9.	Thickness	**	0.1505 [3.823]	0.1535 [3.899]
	*Use Crankshaft End Clearance			
	Crankshaft End Clearance			
10.	End Clearance	**0.021 [0.53]**	0.004 [0.10]	0.016 [0.41]
	Connecting Rod			
	Crankpin Bore Inside Diameter*	***0.0015 [0.038]**	4.2517 [107.993]	4.2527 [108.018]
	Center to Center Length		11.405 [289.68]	11.407 [289.74]
	Piston Pin Bushing			
11.	Inside Diameter	**2.4025 [61.023]**	2.4010 [60.985]	2.4015 [60.998]
	Connecting Rod			
	Alignment Without Bushing	**0.008 [0.20]**		
	Alignment With Bushing	**0.004 [0.10]**		
	Twist Without Bushing	**0.020 [0.51]**		
	Twist With Bushing	**0.010 [0.25]**		
	Rod Dowel Pilot		0.8137 [20.668]	0.8142 [20.681]
	Cap Dowel Pilot		0.8140 [20.676]	0.8145 [20.688]
	Connecting Rod Bolt			
	Outside Diameter		0.8147 [20.693]	0.8152 [20.751]
	Inside Diameter		0.700 [17.78]	0.705 [17.91]
	Piston			
12.	Skirt Diameter at 70°F [21°C]	**6.235 [158.37]**	6.238 [158.45]	6.239 [158.47]
	Piston Pin Bore			
13.	Inside Diameter at 70°F [21°C]	**2.3990 [60.935]**	2.3985 [60.922]	2.3989 [60.932]
	Piston Pin			
	Outside Diameter	**2.398 [60.91]**	2.3988 [60.929]	2.399 [60.94]









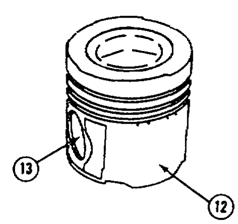
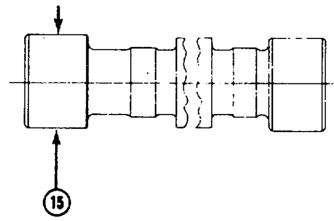
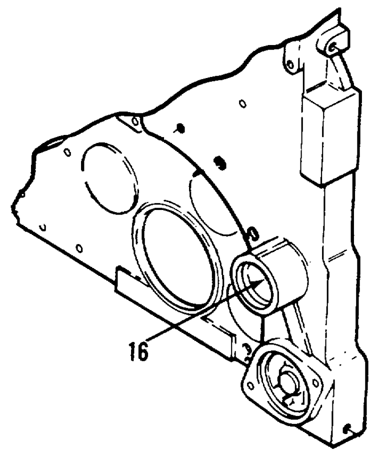
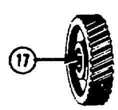


Table 16C-1. Cylinder Block Specification — Inch (mm) (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Piston Ring Gap			
14.	Top Ring	**	0.025 [0.64]	0.040 [1.02]
	Center Ring	**	0.025 [0.64]	0.040 [1.02]
	Oil Ring	**	0.015 [0.38]	0.030 [0.76]
	Camshaft Journal			
15.	Outside Diameter	**2.995 [76.07]**	2.996 [76.09]	2.997 [76.12]
	Thrust Bearing			
	Thickness	**0.359 [9.12]**	0.368 [9.35]	0.372 [9.45]
	Gear Cover Accessory and Alternator Drive Bushing			
16.	Inside Diameter	**1.571 [39.90]**	1.565 [39.50]	1.569 [39.60]
	0.010 U.S. [0.25]			
	Inside Diameter	**1.561 [39.65]**	1.555 [39.50]	1.559 [39.60]
	0.020 U.S. [0.25]			
	Inside Diameter	**1.551 [39.40]**	1.545 [39.24]	1.549 [39.34]
	Hydraulic Pump Drive Bushing	**1.506 [39.25]**	1.501 [38.13]	1.504 [38.20]
	Idler Gears and Shafts			
17.	Cam and Water Pump **Shafts**	**1.8720 [47.549]**	1.8735 [47.587]	1.8740 [47.600]
	Cam and Water Pump Gear Bushing (Installed)	**1.8785 [47.714]**	1.8755 [47.638]	1.8765 [47.663]
	Cam and Water Pump Gear End Thrust	**0.018 [0.457]**	0.004 [0.102]	0.014 [0.356]
	Hydraulic Pump Shaft	**1.7470 [44.374]**	1.7485 [44.412]	1.7490 [44.425]







* As measured 30° either side of parting line; tolerance for inner diameter beyond 30° either side of parting line is same as it is for new rods 4.2517" - 4.2527".

** Add 0.003 inch [0.08 mm] ring gap to new maximum limit for 0.001 inch [0.03 mm] wear in cylinder liner wall.

Table 16C-1. Cylinder Block Specification — Inch (mm) (Cont'd.)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Hydraulic Pump Gear Bushing	**1.7535 [44.539]**	1.7505 [44.463]	1.7515 [44.488]
	Hydraulic Pump Gear End Thrust	**0.022 [0.559]**	0.009 [0.229]	0.018 [0.457]
	Thrust Bearings Thickness	**0.088 [2.23]**	0.092 [2.34]	0.095 [2.41]
	Hydraulic Pump Gear Backlash	**0.020 [0.50]**	0.003 [0.08]	0.0105 [0.267]

Camshaft Offset Keys

Key Part No.	Amount of Offset	Change in Push Tube Travel	Angle of Offset
200711	0.0070 [0.179]	0.0033 [0.084]	0° 20′
200709	0.0150 [0.381]	0.0070 [0.178]	0° 42′
200704	0.0197 [0.500]	0.0095 [0.241]	0° 56′
200708	0.0230 [0.584]	0.0110 [0.279]	1° 5′
200706	0.0328 [0.833]	0.0155 [0.394]	1° 33′
200714	0.0390 [0.991]	0.0185 [0.470]	1° 50′
216782	0.0110 [0.279]	0.0055 [0.140]	0° 31′
216294	0.0035 [0.089]	0.0017 [0.043]	0° 10′
3000491	0.0270 [0.686]	0.0135 [0.343]	1° 16′
3000492	0.0360 [0.914]	0.0180 [0.457]	1° 42′
3000493	0.0430 [1.092]	0.0215 [0.546]	2° 1′
3000494	0.0470 [1.194]	0.0235 [0.597]	2° 12′
3000495	0.0510 [1.295]	0.0256 [0.650]	2° 24′
S-302	(Straight Key)	0	0

Torque Specifications ft-lb [N•m]

Pipe Plug Size	Minimum	Maximum
1/8	15 [20]	20 [27]
1/4	30 [41]	35 [47]
3/8	35 [47]	45 [61]
1/2	45 [61]	55 [75]
3/4	60 [81]	70 [95]
1-1/4	75 [102]	85 [115]
1-1/2	90 [122]	100 [136]
Main Bearing Capscrews		
Step 1. Tighten to	190 [258]	200 [271]
Step 2. Advance to	440 [597]	450 [610]
Step 3. Loosen	All	All
Step 4. Tighten to	190 [258]	200 [271]
Step 5. Advance to	440 [597]	450 [610]
Connecting Rod Bolts		
Step 1. Tighten to	70 [95]	80 [108]
Step 2. Tighten to	140 [190]	150 [203]
Step 3. Tighten to	210 [285]	220 [298]
Step 4. Loosen	All	All
Step 5. Tighten to	70 [95]	80 [108]
Step 6. Tighten to	140 [190]	150 [203]
Step 7. Advance to	210 [285]	220 [298]

SUBSECTION 16D

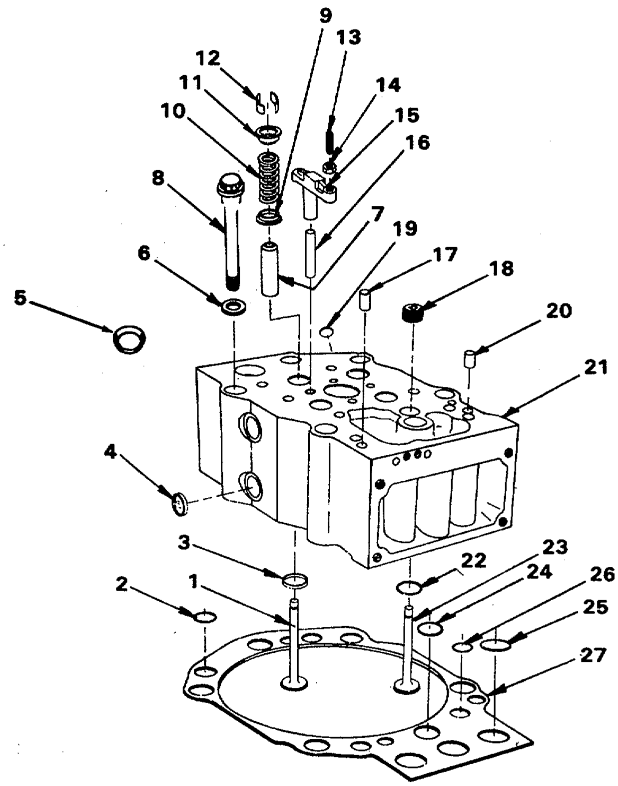
CYLINDER HEAD

DESCRIPTION

Cylinder head group covers inspection, repair and assembly of cylinder head, valves and guides, crossheads and guides, valve seat inserts, spacer plates, injector seal seats and valve springs.

TOOLS

The following service tools or tools of comparable quality are necessary to repair or rebuild the cylinder heads as described in this section.



01. EXHAUST VALVE
02. GROMMET
03. VALVE SEAT
04. EXPANSION PLUG
05. INJECTOR SEAL SEAT
06. CYLINDER HEAD WASHER
07. VALVE STEM GUIDE
08. CYLINDER HEAD CAPSCREW
09. VALVE SPRING GUIDE
10. VALVE SPRING
11. VALVE SPRING RETAINER
12. VALVE COLLET
13. (3/8"-24) SCREW
14. (3/8"-24) NUT
15. CROSSHEAD
16. CROSSHEAD GUIDE
17. GROOVE PIN
18. (1/2") PIPE PLUG
19. EXPANSION PLUG
20. GROOVE PIN
21. CYLINDER HEAD
22. VALVE SEAT, SPACER PLATE
23. INTAKE VALVE
24. GROMMET
25. GROMMET
26. GROMMET
27. HEAD GASKET

Figure 16D-1. Cylinder Head

Essential Service Tools (Or Equivalent)	
Service Tool Number	**Tool Name**
ST-257	Valve Seat Tool
ST-1257-A or D	Valve Vacuum Tester
ST-1310	Valve Seat Insert Cutter Set
3375946	Valve Guide Arbor Set
3376256	Valve Facing Machine
ST-685	Valve Seat Grinding Machine
ST-1012	Hydrostatic Tester
3375070	Hydrostatic Tester Base Plate
ST-1134	Dowel Pin Extractor
ST-1265	Valve Guide Driver (Tapered Top)
ST-1280	Cup Plug Driver 0.760 Plug I.D.
ST-1282	Cup Plug Driver 1.485 Plug I.D.
ST-1315	Valve Guide Driver (Flat Top)
3375182	Valve Spring Tester

Desirable Service Tools (Or Equivalent)	
3375043	Valve Spring Compressor Plate
ST-448	Valve Spring Compressor
ST-547	Inj. Protrusion Gauge Block
ST-583	Head Holding Fixture
ST-1264	Crosshead Guide Spacer
ST-876	Fuel Passage Cleaning Brush
ST-11; 2	Staking Tool Driver
ST-1288	Valve Seat Insert Staking Tool
ST-1323	Valve Seat Extractor
ST-1166	Magnetic Crack Detector
3375155	Injector Protrusion Com-parator
3375369	Injector Seat Cutter
3375939	Valve Head Checking Tool (Exhaust)
3375940	Valve Head Checking Tool (In-take)

Standard Tools - Obtain Locally	
	0-1 Micrometers
	Small Bore Gauge
	Vernier Depth Gauge

CYLINDER HEAD

DISASSEMBLY AND TESTING

DISASSEMBLY. Disassemble the cylinder head as follows:

1. Use the ST-4481-6 (1), Figure 16D-2, 3375043 valve spring compressor to compress the valve springs. Remove the half collets (2), retainers, springs, valve spring guides and valves, Figure 16D-3.

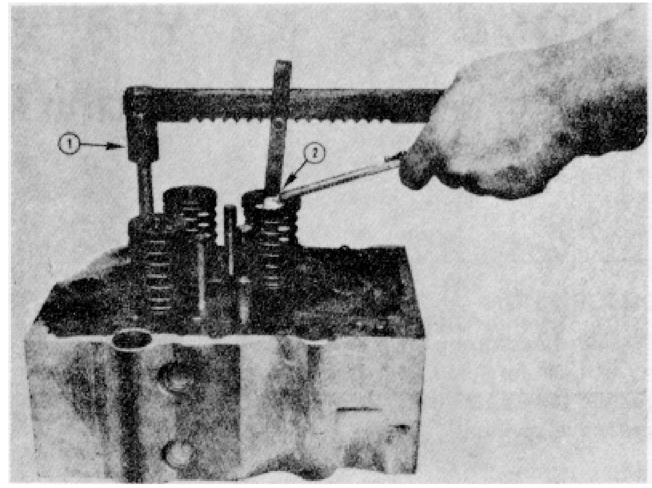


Figure 16D-2. Remove the Valve Springs

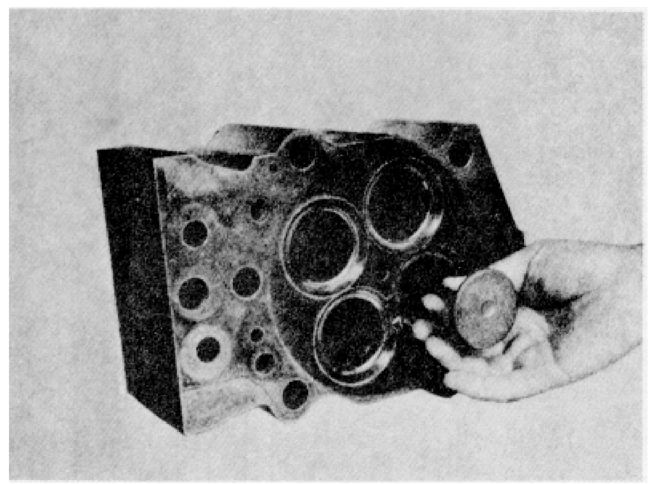


Figure 16D-3. Remove the Valves

NOTE
A small magnet may be used as an aid in removing the half collets (2), Figure 16D-2.

2. Pull the valves on a numbered valve rack for inspection.

PRESSURE TESTING. Put the cylinder heat in the ST-1012 Hydrostatic Tester and 3375070 Adapter Plate, Figure 1 6D4.

AIR TEST. Use a hoist or another suitable lifting device to position the head and testing device over the water tank. Connect an air line with a coupler. Apply 30to40 psi (206.9 to 275.8 kPa) air pressure. Set the head in water deep enough to cover the head. Check carefully around the expansion plugs, valve seats and injector seal seat area for cracks. Discard the head if it is cracked.

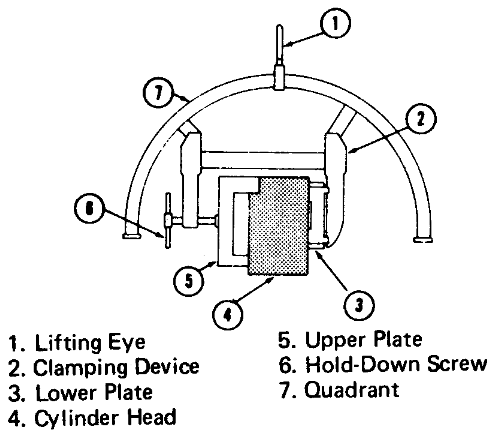


Figure 16D-4. Cylinder Head Installed in the ST-1012 Hydrostatic Tester

WATER TEST. Water test the cylinder heads as follows:

1. Test the cylinder head for leaks at 35 to 85 psi (241.3 to 586.1 kPa) water pressure with the water temperature at 180 to 2000F (82 to 930C) if possible. Check carefully around the valve seats and the injector seal seat area for cracks even when such cracks do not show water leakage. Discard the head if it is cracked.

2. Open the water outlet of test fixture. Check for free water flow through the cylinder head. If it is restricted, remove all the expansion plugs and pipe plugs. Clean the water jackets of deposits with alkaline or solvent type cleaners. To remove heavy deposits of lime, use acid-type cleaner.

WARNING

The use of acid is dangerous to you personally and damaging to machinery. Always make available a tank of strong soda water as a neutralizing agent.

3. Clean the fuel passage with the ST-876 Brush. Flush the passages with the solvent to remove the deposits.

INSPECTION CYLINDER HEADS. Use the ST-1166 Magnetic Crack Detector, Figure 1 6D-5 to inspect the cylinder head for cracks in the valve and injector areas. Discard the head if cracked.

VALVE SEATS. Inspect valve seats as follows:

1. Inspect for loose valve seats in the cylinder head by striking lightly with a hammer near the valve seat. If the valve seat is loose enough to bounce, mark for valve seat replacement.

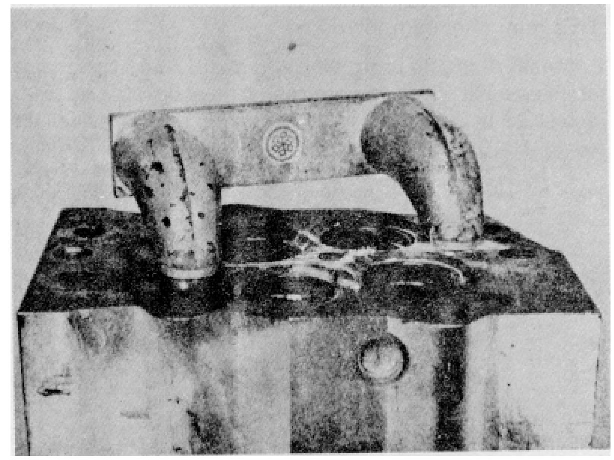


Figure 16D-5. Check the Cylinder Head For Cracks

2. If the seat *area* width (2), Figure 16D-6, exceeds 0.100 inch (2.54 mm) at any point and cannot be narrowed sufficiently (1) during regrinding, the valve should be marked for replacement.

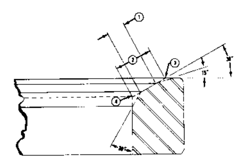


Figure 16D-6. Valve Seat Cross-Section.

3. The valve must not have a negative protrusion of more than -0.020 inch (-0.51 mm). If it does, mark for replacement.

INJECTOR SEAL SEATS. Inspect for cracks, scratches and indentation caused from injector hold-down clamp torque and other damage. Discard unserviceable parts.

INJECTOR TIP PROTRUSION. Cylinder heads that have passed the above tests must further be checked for injector tip protrusion (seat depth) and seating pattern as follows:

1. Lightly cover the injector cup with bluing compound. Install the injector *assembly and seal seat into* injector hole.

Tighten to 11 to 13 ft-lbs (15to 18 N.m)torque. Remove and check the seat pattern. The bluing band must be 0.060 inch (1.52 mm) minimum in width.

2. Measure the tip protrusion with the ST-547 Dial Indicator, Figure 1 6D-7. The tip protrusion must be 0.090 toO. 110 inch (2.29 to 2.79 mm). Injector sealing rings are available std. in 0.010, 0.020 and 0.030 widths to correct protrusion.

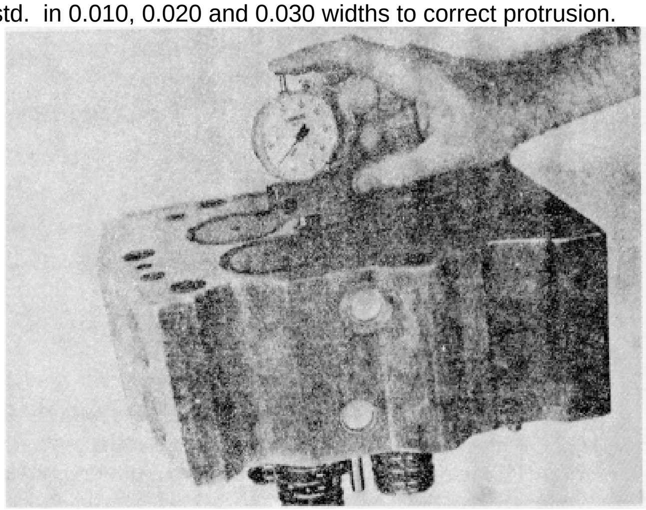


Figure 16D-7. Measure the Injector Tip Protrusion

VALVE CROSSHEAD GUIDES AND CROSSHEADS. Inspect the valve crosshead guides and crossheads as follows:

1. Measure the guide outside diameter with micrometers, Figure 16D-8. See Table 16D-1 (10) for worn limits.

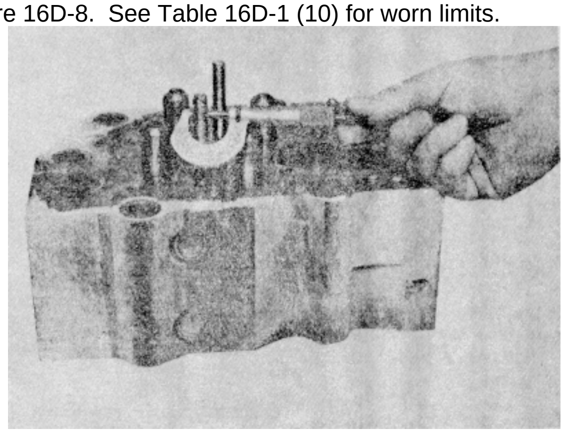


Figure 1 6D-8. Measure the Crosshead Guide Outside Diameter

2. Measure the guide for straightness, which is to be at right angles with milled surface of head. Mark the guides for replacement if not straight or worn beyond limits.

3. Inspect the crossheads for cracks by the Magnaflux process.

4. Measure the stem inside diameter (3), Figure 16D-9. Use a small bore gauge set at 0.4402 inch (11.181 mm). The gauge should not fit into the bore at this setting.

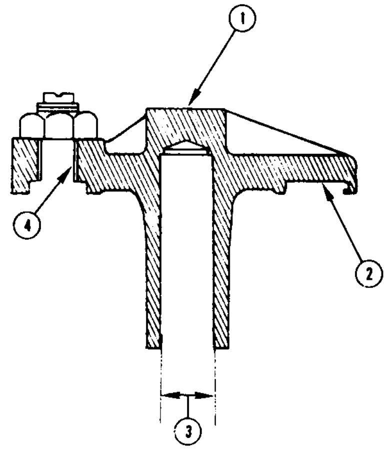


Figure 16D-9. Crosshead Wear Points

5. Measure for out-of-round holes. Set the gauge at several points 90 degrees apart.

6. Visually check for wear on the rocker lever (1) and valve stem contact surface (2). Check the adjusting screw and crosshead threads (4) for wear or distortion.

VALVE GUIDES. Inspect valve guides as follows:

1. Measure the guide inside diameter. Use a small bore gauge set at 0.4989 inch (12.672 mm). The gauge should not enter the bore at this setting. Table 16D-1 (3).

2. Measure for out-of-round holes. Set the gauge at several points of the head, Figure 16D-10. Visually check the valve guides for chips, cracks or sharp edges. Mark guides which show extra amounts of wear or damage for replacement.

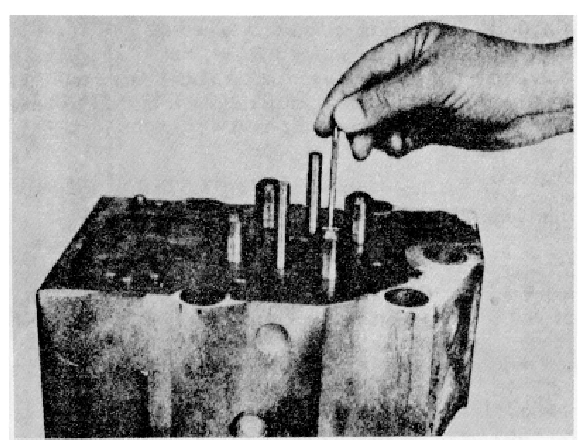


Figure 16D-10. Check the Valve Guide for Out-of-Round

VALVES. Inspect valves as follows:

Clean the valves and polish with crocus cloth. Inspect and then discard if:

The heads are bent, cracked, or worn too thin to grind to within limits. Measure the valve head rim thickness (1), Figure 16D-1 1, which is to be a minimum of 0.105 inch (2.67 mm). The stems, Figure 16D-12, are worn beyond worn limit as listed in Table 16D-1 (1). The collet groove is worn so that new collets will not fit securely.

Magnetic Method. Inspect valves using the magnetic method as follows:

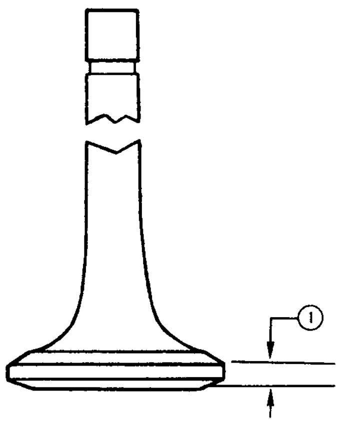


Figure 16D-11. Minimum Valve Head Rim Thickness

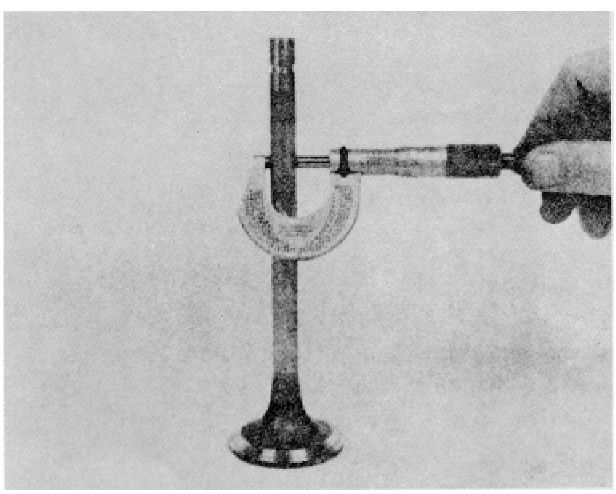


Figure 16D-12. Measure Valve Stem

1. The surface to be inspected must be cleaned to remove all foreign material which will give negative indications. Vapor cleaning is recommended with a penetrant or developer.

2. Welded valves which have two types of metal, may be Magnaflux inspected. Because of the change of metal at weld, there will be magnetic leakage at this point. This will be indicated by a broad fuzzy pattern of magnetic particles. These valves should be magnetized in the coil at low amperage, (100 to 200 amps) and then inspected residually with Magnaflux. A crack at, or near, the weld would show as a sharp bright fluorescent line.

3. Valves with only one type of metal can be inspected in normal way. Magnetize and inspect in two directions. For coil magnetization, use 100 to 300 amps. Inspect with residual Magnaflux. Defects found after this magnetization will be in a transverse direction. Follow by headshot magnetization, at 500 to 700 amps, use residual Magnaflux. Defects by this magnetizing method will be radial.

4. Magnetic indications can be as follows, see Figure 16D-13.

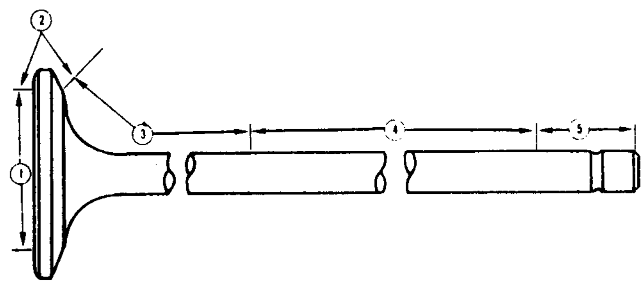


Figure 16D-13. Magnetic Indication Areas of Magnaglo

A. No magnetic indication over 1/2 inch (12.70 mm) in length or more than five indications spaced closer than 1/8 inch (3.18 mm) will be acceptable in area (1).
B. No visual or magnetic indication is acceptable in area (2).
C. No visual or magnetic indications are acceptable in areas (3) and (4), if they run the circumference of the valve.
D. No visual or magnetic indication is acceptable in area (5).

NOTE

Visual means indication can be seen by use of a three power magnifying glass after removing magnetic particle suspension.

5. Magnetically remove all magnetism from acceptable parts.

REBUILDING

MACHINE CYLINDER HEAD. Machine cylinder head as follows:

If the cylinder head has been scratched, etched or is uneven at the point of contact in the gasket sealing area, the head may be milled or surface ground.

1. Use the ST1323 Valve Seat Extractor, Figure 1 6D14, to remove all the valve seat inserts and intake seat spacer plates.

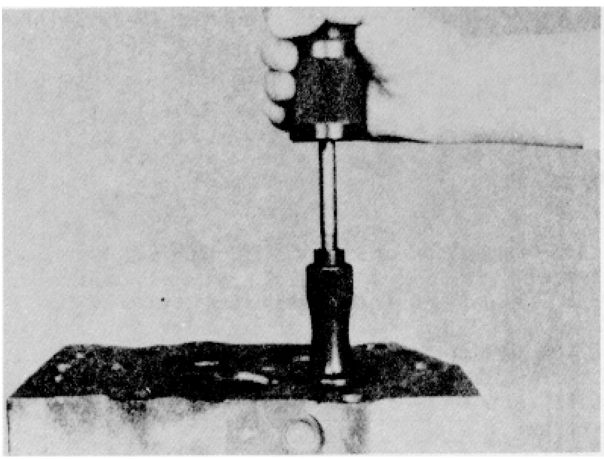


Figure 16D-14. Remove the Valve Seat Insert

2. After machining, use a micrometer or a Vernier depth gauge to measure the head height, Figure 16D-15.

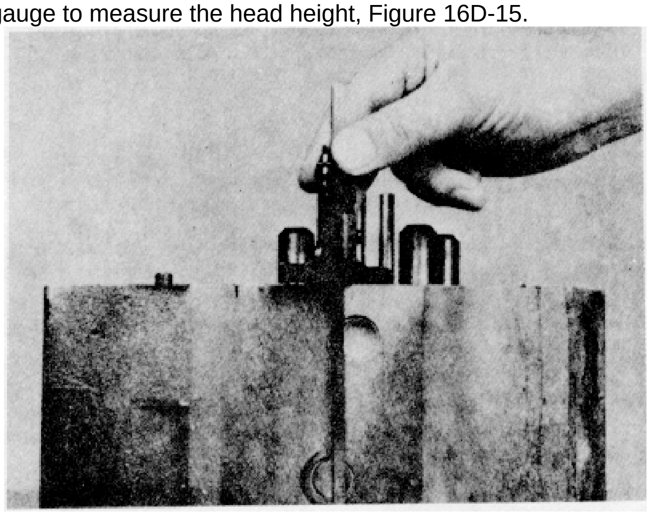


Figure 16D-15. Measure the Cylinder Head

3. Machine the valve seat counterbore and remove the amount of material equal to that removed during head surfacing.

4. Sand the surface of the cylinder head with a sander, Figure 16D-16. Do not use a disc sander.

5. Clean area thoroughly.

6. Install injector shims to correct for amount of material removed during head machining.

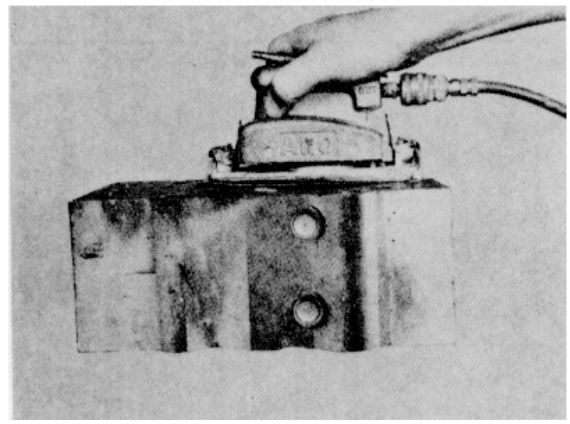


Figure 16D-16. Sand the Cylinder Head

REPLACE VALVE GUIDES. Replace valve guides as follows:

1. Drive out the guides marked for replacement from the valve head side of the cylinder head, Figure 16D-17. Install the new valve guide with the ST1265 Valve Guide Driver, Figure 16D-18.

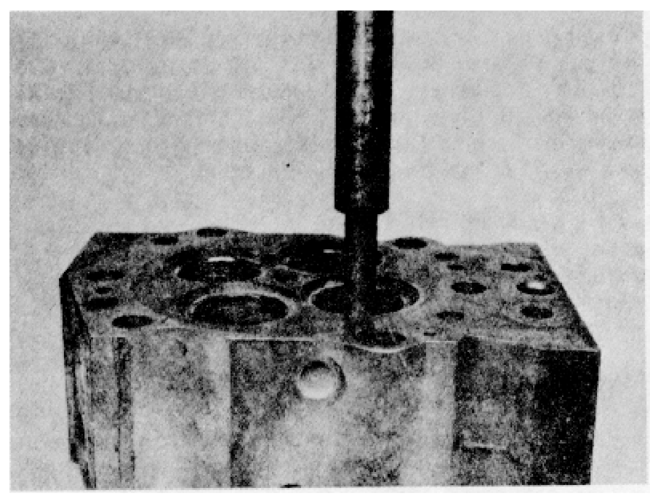


Figure 16D-17. Remove the Valve Guides

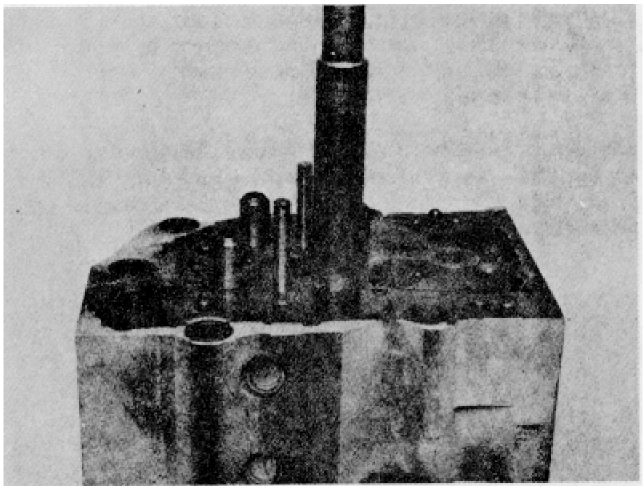


Figure 16D-18. Install the Valve Guides

2. If the proper valve guide driver is not available, press guide into head. See Table 1 6D-1 (4) for valve guide assembled height.

CROSSHEAD GUIDES. Replace crosshead guides as follows:

1. Use the ST-667 or ST-1 134 Dowel Puller to remove the crosshead guides marked for replacement, Figure 16D-19.

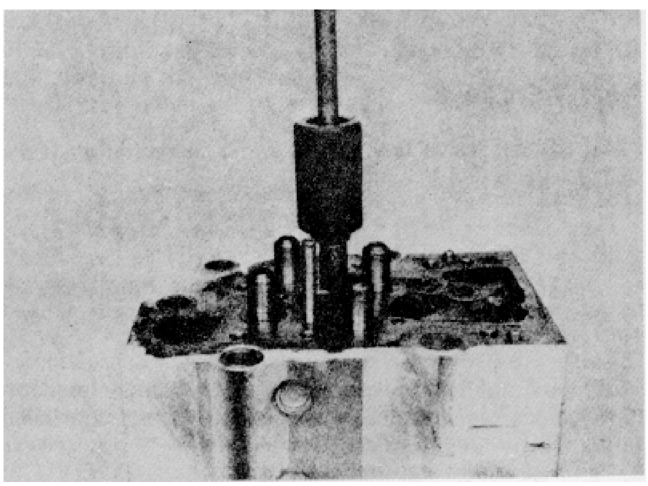


Figure 16D-19. Remove the Crosshead Guides

2. Use the ST-1264 Crosshead Guide Driver to press the new guides into the cylinder head, Figure 16D-20. If the new driver is not available, press the new guides into the head to obtain the assembled height as listed in Table 16D1 (11).

VALVE SEAT. Replace valve seats as follows:

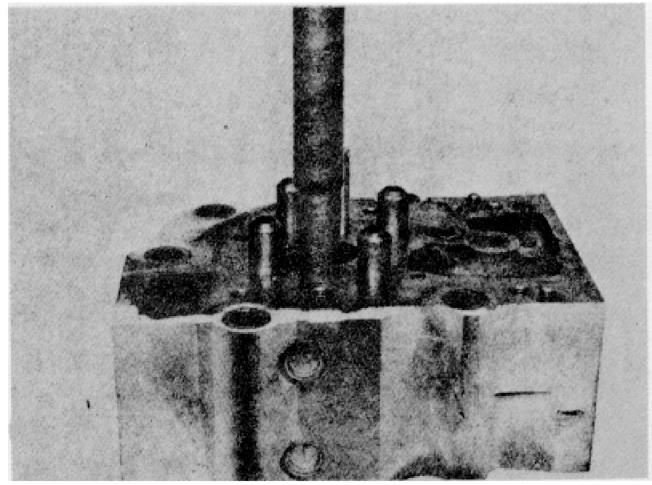


Figure 16D-20. Install the Crosshead Guides

1. Use the ST-1323 Valve Seat Extractor to remove the valve seats and the (intake) swirl plates that are marked for replacement, if this has not been done already.

2. Machine the counterbore to the next available oversize. The valve seats are available as listed in the Parts Book.

3. Use the 3375946 Valve Guide Arbor and ST-257 Valve Seat Tool Driver to hold and drive the ST-1310 Valve Seat Cutter when cutting the valve seat insert counterbore.

4. Machine the counterbore 0.006 to 0.010 inch (0.15 to 0.25 mm) deeper than the seat thickness to permit swaging or peening of the head to hold to seat. Allow the cutter to dwell upon reaching the proper depth to insure a flat seating surface.

5. Install the valve seat and swirl plate (when used) and stake the seat into head using the ST-1 122 Tool Driver over the shaft of ST-1288 Valve Seat Swaging Tool. A 1/4 inch (6.35 mm) diameter round point punch may be used if the swaging tool is not available.

CAUTION

Over swaging around the insert may crack the cylinder head.

GRIND VALVE SEATS. Grind valve seats as follows:

1. Use the ST-685 Valve Seat Grinder to correct the arbor from the 3375946 Valve Guide Arbor Set.

2. Grind the valve seats to assure negative valve protrusion in the cylinder head. Rough grind and finish with the correct stones from the ST-685. The rough grinder stone must be cut to 30 degrees before the grinding operation. Check the valve seat width. It should be 0.060to 0.100 inch (1.52 to 2.54 mm). See 1, Figure 16D-6. If the seating area (1) is wider than 0. 100 inch (2.54 mm) maximum, stock can be removed from the points (3) and (4) with specially cut stones. Narrowing is not to extend beyond the chamfer on the valve seat. The chamfer provides metal for staking or peening.

3. Check the valve seat with a valve seat indicator, Figure 1 6D-21. Total out-of-round is not to exceed the valve listed in Table 16D-1 (7).

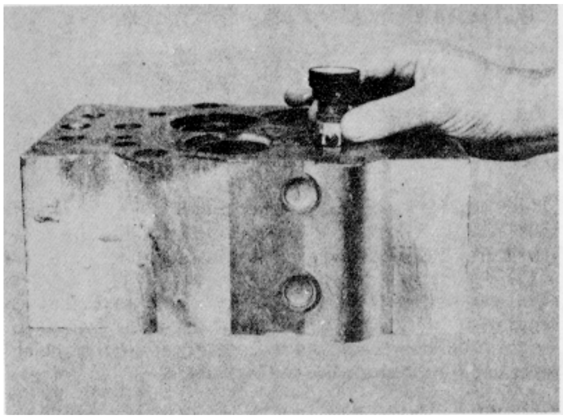


Figure 16D-21. Check the Valve Seat Common Centers

GRIND VALVES. Grind valves as follows:

1. Use a new valve and an indicator gauge to check the valve grinder setting.

A. Put the valve in the chuck of the valve grinder on the guide area of the stem. Relieved portions on both ends of guide area are not necessarily parallel to guide area of stem.
B. Indicate on the face of valve.
C. Turn the valve and mark the high area on the head of the valve.
D. Again put a valve in grinder chuck and center 180 degrees from first position.
E. Repeat B and C. If high areas are the same for both A and D position, the valve is bent. If the high areas occur in different positions, the chuck is out of alignment. Out of-round is not to exceed 0.001 inch (0.03 mm).

2. Wet-grind the valves to an exact 30 degree angle from horizontal. Check the rim thickness as shown in Figure 16D-1 1. If the rim is less than 0.105 inch (2.67 mm), do not use valve.

3. Mark with lead the valve face as shown in Figure 1 6D22. Put the valve guide against a newly ground valve seat and rotate the valve 10 degrees. A good seat will be indicated if all lead marks are broken. If lead marks are not broken, the grinder wheel needs cutting or grinder has not been properly adjusted. The final check should be made with a vacuum tester.

VALVE SPRINGS. Check valve springs for replacement as follows:

Weak valve springs may cause valve float which will result in excessive wear on both the valve and seat. The valve float interferes with valve timing and may cause the valve to strike the top of the piston.

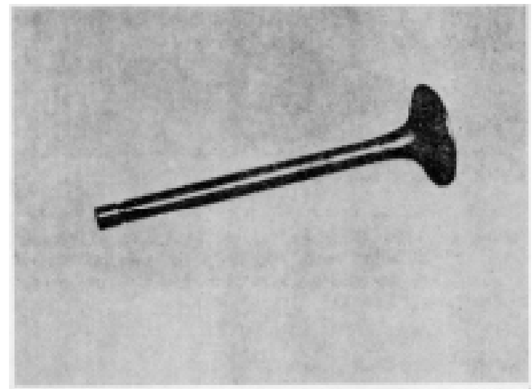


Figure 16D-22. Pencil Marks on the Valves

1. Use the valve spring tester, Part No. 3375182 to test the valve springs. Apply the required load for length as listed in Table 1 6D-1 (9). If the valve springs compress to the dimensions shown at less than the load indicated under "worn-limit", discard the valve spring.

2. Spacers are to be used under the valve spring when the seat and valve have been ground more than a total of 0.030 inch (0.76 mm). A maximum of two spacers may be used under each valve spring.

ASSEMBLY
1. Use sealant, the ST-1280 and the ST-1282 Expansion Plug Drivers to install the expansion plugs.

2. Install pipe plugs and use sealant or Teflon tape, then tighten to the torque listed in Table 16D-1.

3. Insert the valve stems into clean engine lubricating oil. Put them into the valve guides. Place the cylinder head face down on a wood bench or protective surface to prevent marking the finish surface.

4. Install the lower valve spring guides over the valve guides.

5. Assemble the spring, spring seats, and spring spacers as required. Install the upper valve spring retainer over springs. Compress with the ST-448-6 Valve Spring Compressor. Install new half-collets.

VALVE AND SEAT VACUUM TEST

Use the ST-1257 Vacuum Tester with ST-1257-38 Cup to check the valves and seats for leakage.

CAUTION

Never vacuum test a cylinder head with the injectors installed. Installation of injectors while the head is removed from block will cause out of alignment of the valves in the valve seat area and result in leakage during testing which will not normally occur during engine operation.

1. Operate the vacuum pump until the hand on vacuum gauge (1), Figure 16D-23 reaches 18 to 25 inches (457 to 635 mm) vacuum. Close the shutoff valve (2). Keep the motor running while checking the vacuum.

2. Time the fall of the gauge hand as follows:
   - A. Begin timing as soon as the hand reaches "18" on the gauge.
   - B. Stop the timing when the gauge reaches "8".
   - C. If the time elapsed is less than ten seconds, the valve seat is not satisfactory.

3. Hit the stem end of the valve with a soft-faced mallet and test again. If valve seat is not satisfactory: A. Check for leakage at the connections in the tester. Operate the vacuum pump against a clean glass or a smooth flat surface, the fall of the gauge indicates a loose connection.

B. Check the valve and seat face area to be sure that they are free of dirt particles.

4. Grind the seat and face valve again if necessary; however, it is possible to mistake leakage around the valve seat

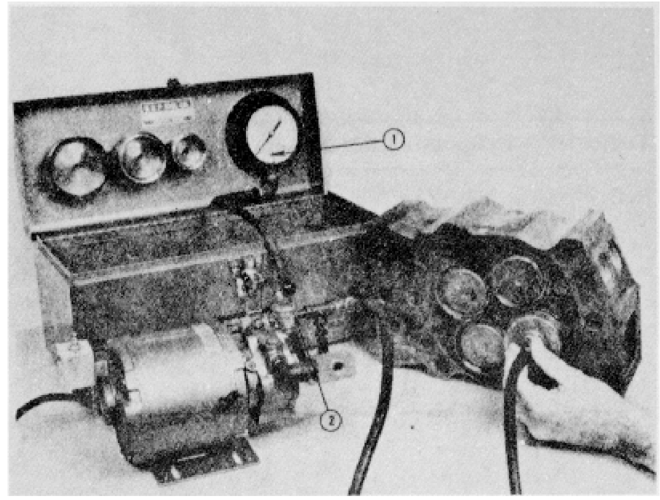


Figure 16D-23. Vacuum Test the Valves for Leaks

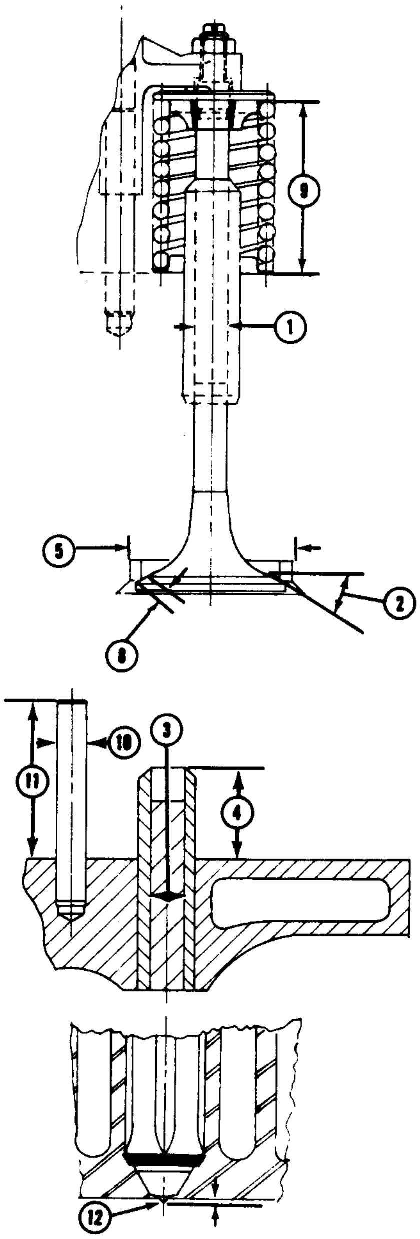
for valve seat leakage. If this type leakage is suspected, apply grease around the outside edge of valve seat to make a seal.

5. Again vacuum test and inspect the seal for a break indicating air leakage between the wall of the counterbore and the valve seal. If a leak around the valve seat is found:

   - A. Swike or peen valve seat, vacuum test.
   - B. Remove the valve seat, counterbore for the next oversize. See "Replace Valve Seat Insert".

Table 16D-1. Specifications - Inch (mm)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Cylinder Head			
	Height (See Fig. 16D-15)	4.715 [119.76]	4.745 [120.52]	4.755 [120.78]
	Valve Guide Bore		0.8435 [21.415]	0.8445 [21.450]
	Crosshead Guide Bore		0.4315 [10.960]	0.4325 [10.986]
	Valve Stem			
1.	Outside Diameter	0.4935 [12.535]	0.4945 [12.560]	0.4955 [12.586]
	Valve Guide			
2.	Face Angle		30 deg.	30 deg.
3.	Inside Diameter (Installed)	0.4987 [12.668]	0.4961 [12.601]	0.4971 [12.626]
	Outside Diameter	0.8441 [21.440]	0.8456 [21.478]	0.8461 [21.491]
4.	Assembled Height		1.375 [34.93]	1.390 [35.31]
	Valve Seat Insert			
5.	Outside Diameter		2.3805 [60.465]	2.3815 [60.490]
6.	**Counterbore Inside Diameter**		2.377 [60.38]	2.378 [60.40]
7.	Insert Counterbore Depth			
	Intake		0.512 [13.00]	0.517 [13.13]
	Exhaust		0.492 [12.50]	0.497 [12.62]
	Run Out In 360 Deg.	0.002 [0.05]		
8.	**Faced Seat Width**		0.060 [1.52]	0.100 [2.54]
	Valve Spring			
9.	Assembled Height			2.470 [62.74]
	Crosshead Guide			
10.	Outside Diameter	0.432 [10.97]	0.433 [11.00]	0.4335 [11.011]
11.	Assembled Height		2.350 [59.69]	2.370 [60.20]
12.	**Injector Tip Protrusion**		0.090 [2.29]	0.110 [2.79]
	Seal Seat Thickness (Std.)		0.0135 [0.343]	0.0165 [0.419]



Cylinder Head Pipe Plug Torque—ft-lbs [N• m]	Plug Size	Minimum	Maximum
	1/8 Inch	5 [7]	10 [14]
	3/8 Inch	35 [47]	45 [61]
	1/2 Inch	60 [81]	70 [95]
	3/4 Inch	65 [88]	75 [102]
	1 Inch	135 [186]	145 [197]

Table 16D-1. Specifications - Inch (mm) (Reference Figure 16D-1) (Cont'd.)

Valve Seat Insert Part No.	Oversize Diameter	Oversize Depth
205945	0.005 [0.13]	Std.
205981	0.010 [0.25]	Std.
205982	0.020 [0.50]	0.005 [0.13]
205983	0.030 [0.76]	0.010 [0.25]
205984	0.040 [1.02]	0.015 [0.38]

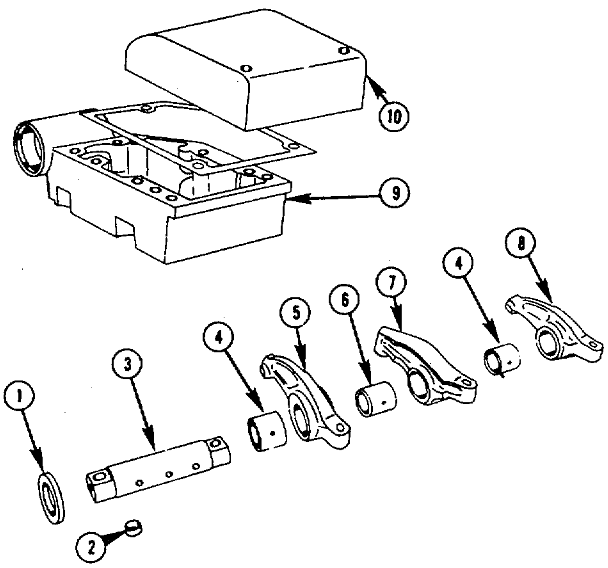
Be sure to measure insert before machining head or installing insert in head.

Valve Spring Data

Approximate Free Length Inch [mm]	No. Coils	Wire Diameter Inch [mm]	Length Inch [mm]	Required Load For Length Lb [kg] Worn Limit	Lb [kg] New Minimum	Lb [kg] New Maximum
3.349 [85.06]	7.8	0.234 [5.94]	1.908 [48.46]	253 [114.8]	266 [120.7]	294 [133.4]

SUBSECTION 16E

ROCKER LEVERS AND HOUSING



1. Spacer	4. Bushing	7. Injector Lever	10. Cover
2. Ring Dowel	5. Exhaust Lever	8. Intake Lever	
3. Shaft	6. Bushing (Injector Lever)	9. Housing	

Figure 16E-1. Rocker Levers, Shaft, Cover and Housing

DESCRIPTION

The Rocker lever group contains rocker levers, rocker lever shafts, covers and housings. Rocker lever housings also contain a water passage that makes up part of the water manifold.

TOOLS

The following service tools are necessary to repair or rebuild the rocker lever assembly as described in this group.

Service Tools (Or Equivalent) Required

Service Tool Number	Tool Name
ST-1 284	Bushing Driver
ST-0000	Expansion Plug Driver

Standard Tools - Obtain Locally

	Small Bore Gauge
	Micrometers

ROCKER LEVERS

DESCRIPTION

Rocker levers and shafts are removed from the housings during engine disassembly.

DISASSEMBLY AND INSPECTION

1. Remove the levers and spacer (when used) from the shaft, Figure 1 6E-2.
2. Mark the rocker lever for position as removed from the shaft.

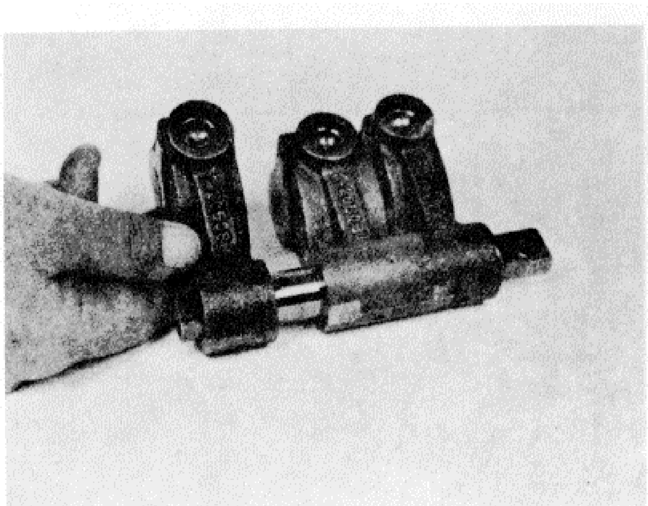


Figure 16E-2. Remove the Rocker Levers from the Shaft

3. Remove the adjusting screws and nuts.
4. Inspect for surface defects by magnetic inspection. Apply coil amperage at 300 to 500 with residual Magnaflux. See Figure 16E-3 for most likely areas. Magnetically remove all magnetism from acceptable parts.

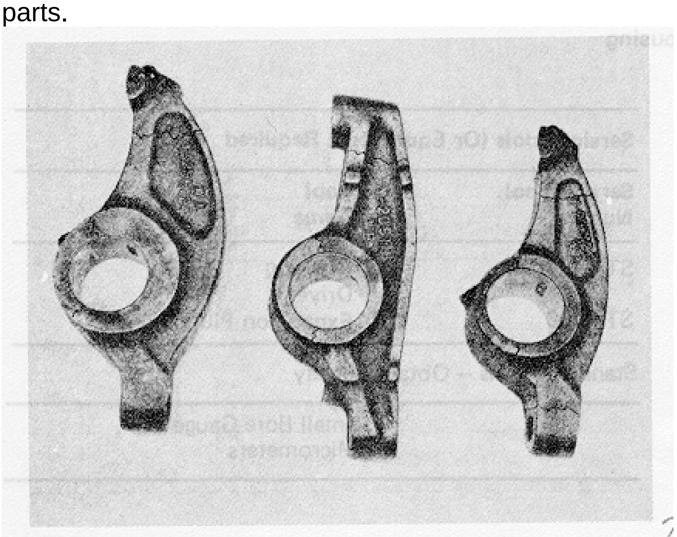


Figure 16E-3. Magnetic Inspection Crack Indication

5. Use a 1/4 inch (6.35 mm) radius gauge to measure the ball end of the rocker lever adjusting screw, Figure 16E-4. The ball end and socket of the push rod should "blue in" 80 percent of the seat area.

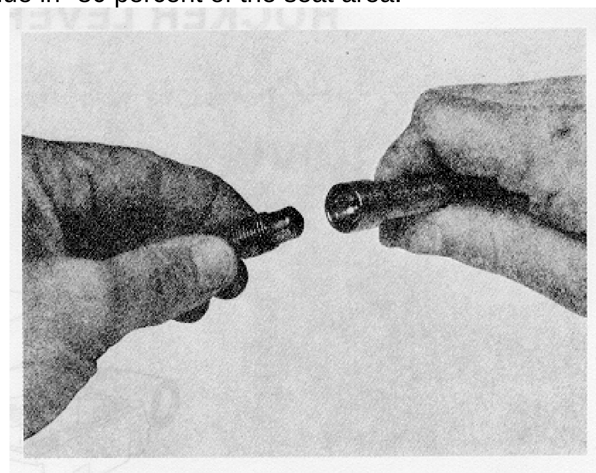


Figure 16E-4. Check the Rocker Lever Adjusting Screw Ball End

6. Check the thread condition on all screws and levers. Screws must turn freely through the levers.
7. Inspect the injector lever sockets for fit to the injector links. Remove the damaged or badly worn sockets by drilling a small hole in the lever above the socket, drive the socket out with a punch. After the socket is removed, weld the hold closed or install and swage a plug in the hole.

NOTE

New injector lever sockets must be installed against the bottom of the socket bore when replaced.

8. Visually inspect the rocker lever bushings for scratches, pitting or scoring. Use inside micrometers or a small bore gauge to measure bushing inside diameter, Figure 16E-5. If

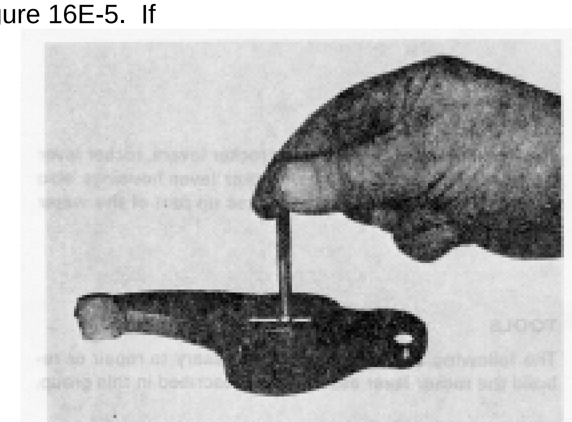


Figure 16E-5. Check the Rocker Lever Bushing for Wear the bushing is worn larger than 1.3776 inch (34.991 mm), use ST-1824 Bushing Driver to remove it, Figure 16E-6.

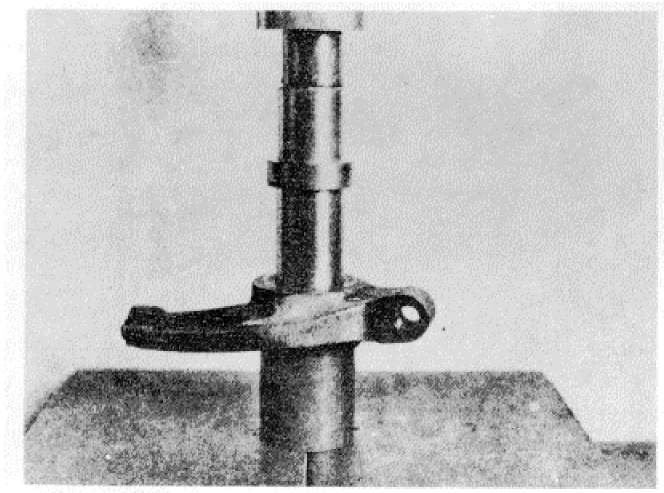


Figure 16E-6. Remove the Rocker Lever Bushing

9. Clean the rocker levers in an approved solvent. Be sure oil drillings are open. Install new bushings as follows:

A. Cut the bushing so that oil holes in the bushing and lever are aligned.

B. Use the ST-1284 Bushing Driver and an arbor press to press the bushing into the lever until flush, or 0.020 inch (0.51 mm) below the machined surface of the rocker lever, Figure 16E-7.

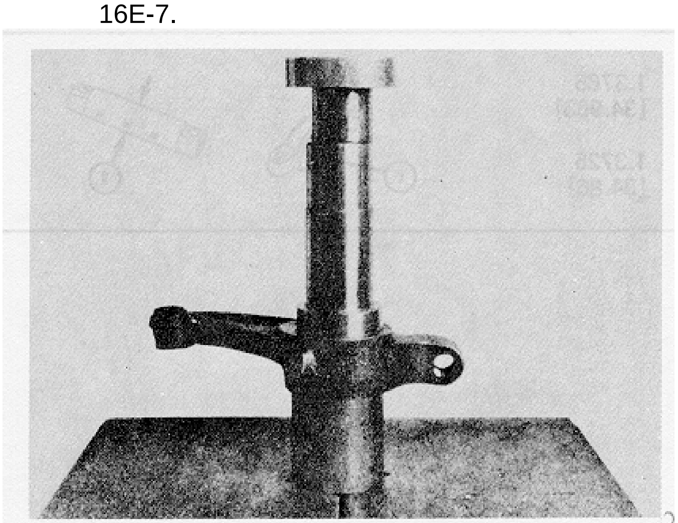


Figure 16E-7. Install the Rocker Lever Bushing

10. Inspect visually the intake and exhaust rocker lever-to-crosshead contact surfaces. If worn or damaged, replace with the new rocker lever.

11. Measure the rocker lever shaft for wear, Figure 1 6E-8. If the shaft is worn smaller than 1.371 inch (34.82 mm), replace with a new shaft.

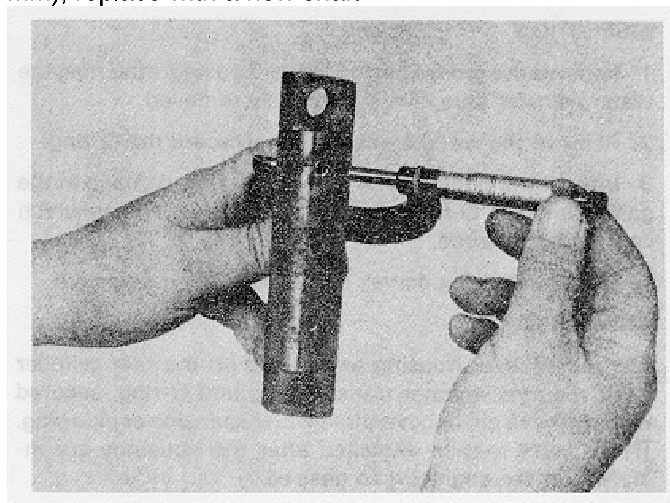


Figure 16E-8. Measure the Rocker Lever Shaft

12. Flush the shaft bore with an approved cleaning solvent. Dry with compressed air. Replace the cup plug if removed.

ASSEMBLY

Rocker levers are not attached to the housings until after the housings are installed on the cylinder head.

1. Install the adjusting screws and locknuts in the rocker levers. Do not tighten the locknuts.

2. Cover the rocker lever shaft with clean lubricating oil.

3. Install the rocker levers on the shaft in the following order: intake (1), Figure 16E-9, injector (2), exhaust (3).

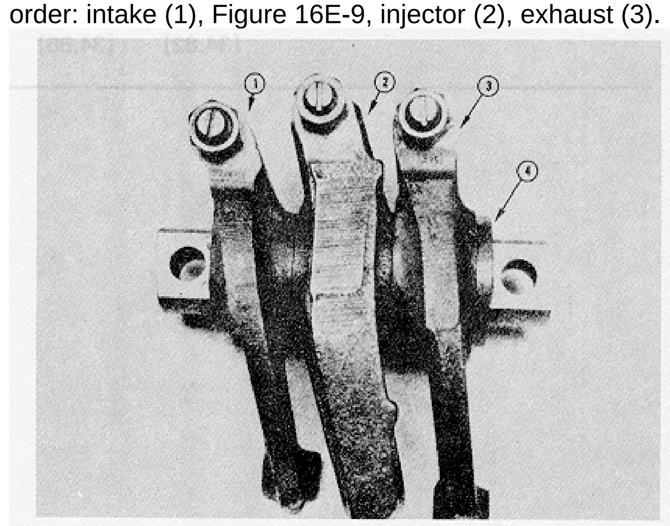


Figure 16E-9. Rocker Lever Assembly

ROCKER LEVER HOUSING

DESCRIPTION
The rocker lever housings have a water passage that makes up a part of the water manifold.

INSPECTION
1. Remove the groove pin in the rear housing, attaching the water transfer plug, if not previously removed.
2. Remove the water transfer plug. Discard the O-ring.
3. Inspect the housings for cracks, or other damage in the gasket and the O-ring sealing areas. Discard parts which can not be repaired.
4. Replace the ring dowel, Figure 16E-10, if defective.

ASSEMBLY
The rocker lever housing to be used on the rear cylinder head requires a water transfer plug and O-ring, secured with a groove pin or coverplate with expansion or pipe plug. These parts may be installed after the housings are installed on the engine, if so desired.

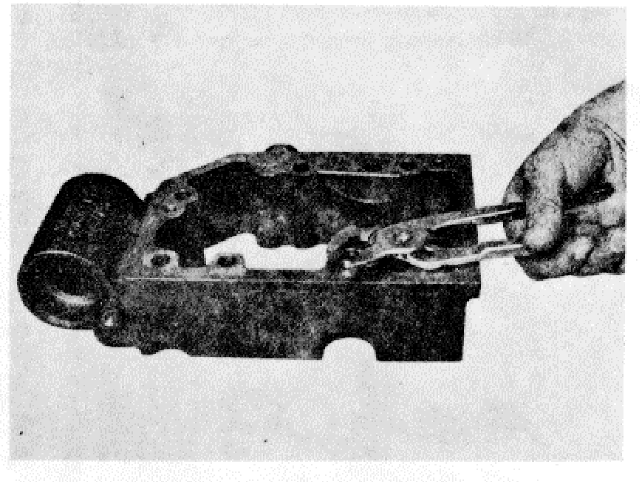


Figure 16E-10. Remove the Ring Dowel

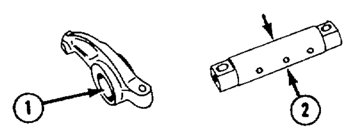
ROCKER HOUSING COVER

INSPECTION AND REPAIR
1. Visually check the cover for cracks or other damage that may affect the gasket sealing area.

2. Repair small cracks b / welding. If the gasket surface must be welded through, use a large flat smooth cut file to return the surface to the original smoothness.

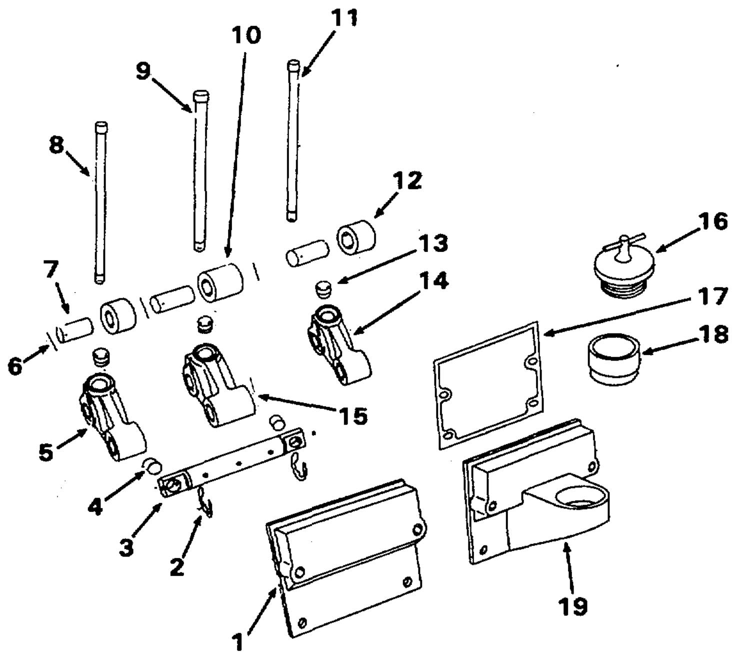
Table 16E-1. Specifications — Inch (mm)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Bushing			
1.	Inside Diameter	**1.3776 [34.991]**	1.3735 [34.887]	1.3765 [34.963]
	Shaft			
2.	Outside Diameter	**1.371 [34.82]**	1.372 [34.85]	1.3725 [34.86]



SUBSECTION 16F

CAM FOLLOWERS AND PUSH RODS



01. PLAIN COVER
02. SNAP RING
03. SHAFT
04. RING DOWEL
05 VALVE CAM FOLLOWER
06. LOCK WIRE
07. ROLLER PIN
08. PUSH ROD
09. PUSH TUBE
10. INJECTOR ROLLER
11. PUSH ROD
12. VALVE ROLLERS
13. SOCKET
14. VALVE CAM FOLLOWER
15. INJECTOR CAM FOLLOWER
16. OIL FILLER CAP
17. FILLER COVER GASKET
18. OIL FILLER TUBE
19. FILLER TYPE COVER

Figure 16F-1. Cam Followers, Cover

DESCRIPTION
The cam follower group contains cam followers, shaft, ring dowel, injector push rods, valve push tubes, oil filler cap, crankcase breather, and cam follower covers.

TOOLS
The following service tools are considered necessary to repair and/or rebuild the cam follower assembly as described in this group.

Service Tools (Or Equivalent) Required

Service Tool Number	**Tool Name**
ST-1283	Cam Follower Roller Pin Block.

Standard Tools - Obtain Locally

Small Bore Gauge
Micrometer (O to 1 inch)
Micrometer (1 to 2 inch)
Snap Ring Pliers
Feeler Gauge

CAM FOLLOWERS

DESCRIPTION
Cam followers are mounted to the cylinder block and receive lubrication during operation through special slotted mounting capscrew.

DISASSEMBLY AND INSPECTION

1. Remove the snap rings holding the spacers and followers on the shaft, Figure 1 6F-2.
2. Remove the spacers and cam follower levers from the shaft. Clean the parts in solvent.

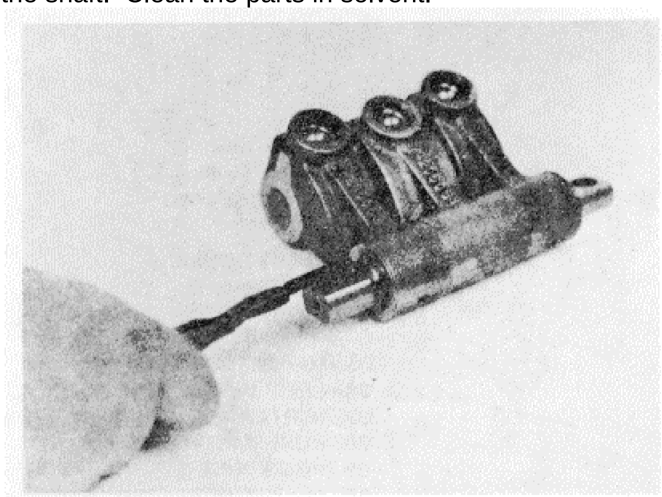


Figure 16F-2. Remove the Cam Follower Snap Ring

3. Measure the outside diameter of the shaft with micrometers, Figure 16F-3. If worn smaller than 0.873 inch (22.17 mm) or is damaged, mark for replacement.

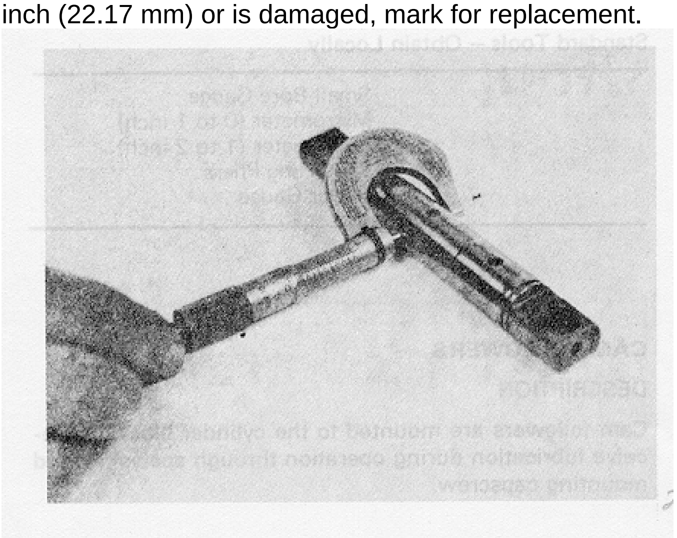


Figure 16F-3. Measure the Cam Follower Shaft

4. Check the inside diameter of the cam follower for damage. Measure the inside diameter with a small bore gauge, Figure 1 6F-4. If worn larger than 0.8777 inch (22.28 mm), mark for replacement.

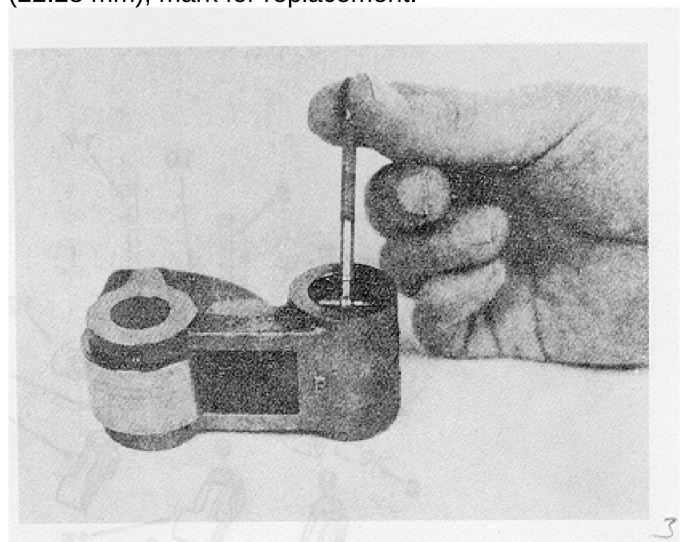


Figure 16F-4. Measure the Cam Follower Inside Diameter

5.Check for surface cracks by magnetic inspection. Apply amperage at 300 to 500 with residual Magnaglo. See ire 1 6F-5 for most likely areas. Magnetically remove the magnetism from all serviceable parts.

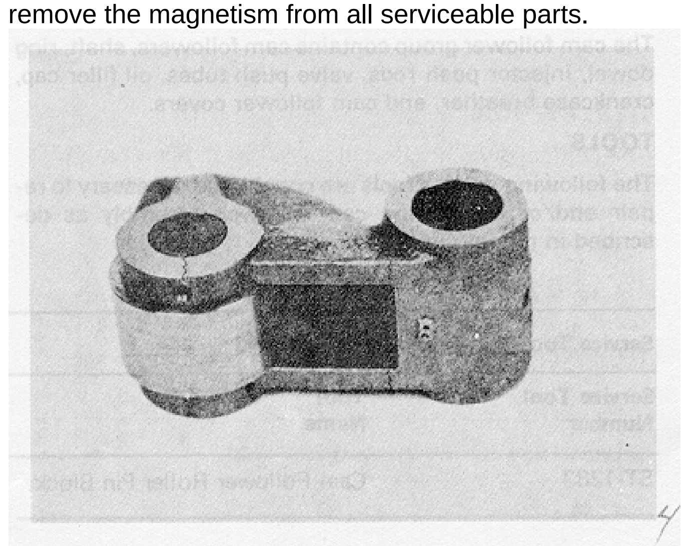


Figure 16F-5. Magnetic Crack Detection Check

6. Cam follower levers have a removable socket (2), Figure 16F-6. These must be replaced if scored or worn. Check with a new push rod ball with bluing compound. This area must show a continuous blue pattern over 80 percent of radius area or the socket must be replaced, Figure 16F-7.

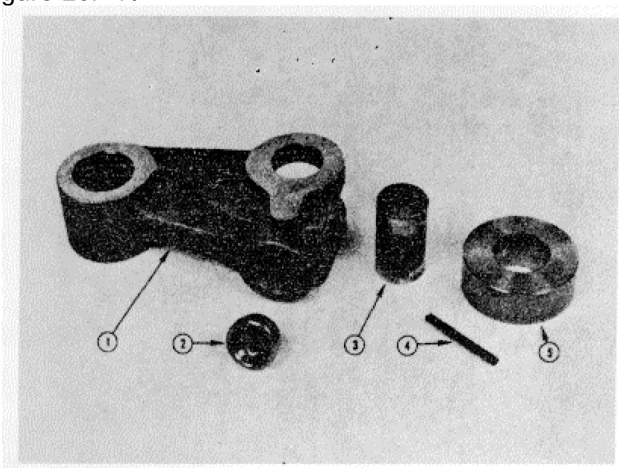


Figure 16F-6. Cam Follower - Exploded View

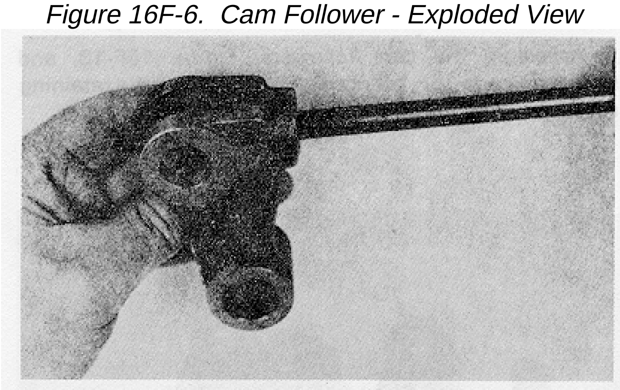


Figure 16F-7. Check the Cam Follower Socket with the Push Tube

7. Remove the roll pins (1), Figure 16F-8, and cam roller pins (2). Remove the rollers from the cam followers.

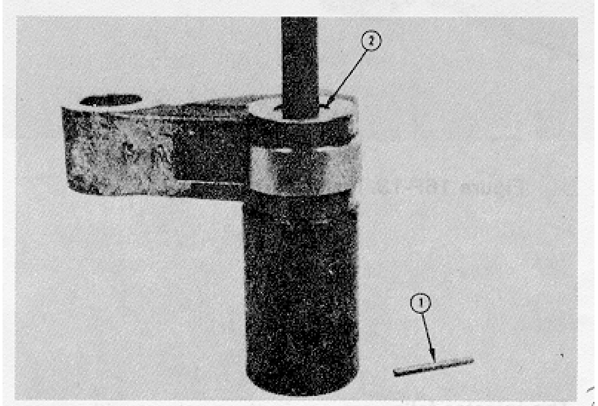


Figure 16F-8. Remove the Cam Roller Pin

8. Use a small bore gauge to measure the cam roller inside diameter as in Figure 1 6F-9. Discard the roller if worn larger than values given in Table 16F-1 (3) at the end of this section, or if the bore is found to be out-of-round.

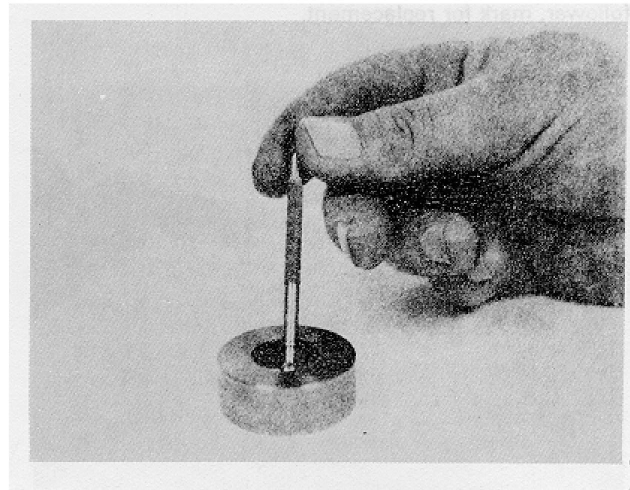


Figure 16F-9. Check the Cam Roller Inside Diameter

9. Use the micrometers to measure the outside diameter of the rollers, Figure 16F-10. If worn smaller than 1.622 inch (41.20 mm) or otherwise damaged, mark for replacement.

NOTE

The cam roller inside diameter must be parallel with the outside diameter within 0.002 inch (0.05 mm). Sides must be square to the bore and parallel to each other within 0.004 inch (0.10 mm).

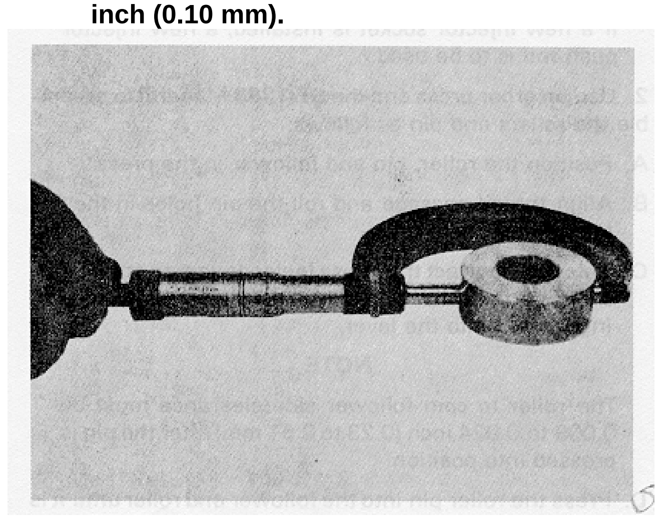


Figure 16F-10. Measure the Cam Roller Outside Diameter

10. Check the cam roller pins for scratches, or other damage. Measure the outside diameter with micrometers, Figure 16F-1 1. If worn smaller than 0.748 inch (19.00 mm), where the roller rides or at least a 0.002 inch (.005 mm) press fit no longer exists between the pin and pin bore in the follower, mark for replacement.

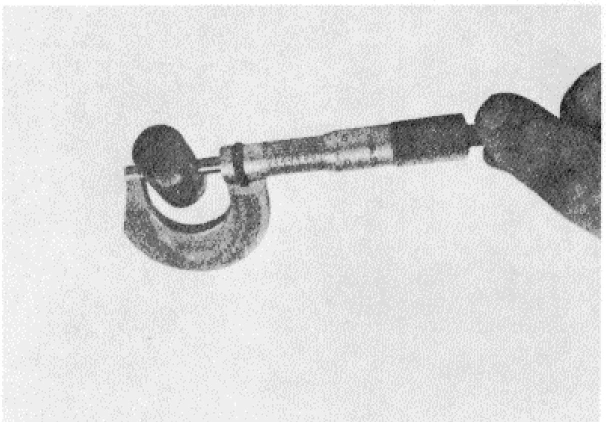


Figure 16F-11. Measure the Cam Roller Pin

ASSEMBLY

NOTE

Lubricate the lever assembly with clean 20W or 30W engine lubricating oil and check for free rotation of roller before installation.

1. If removed, press in a new lever socket (2), Figure 16F-6. Align the oil drillings, make sure the socket is securely seated.

NOTE

If a new injector socket is installed, a new injector push rod is to be used.

2. Use an arbor press and the ST-1283 Mandrel to assemble the rollers and pin as follows:

A. Position the roller, pin and follower in the press.

B. Align the oil passage and roll the pin holes in the follower and roller pin.

C. Select the correct thickness feeler gauge, and position it between the roller and lever as a support while pressing the pin into the lever.

NOTE

The roller to cam follower side clearance must be 0.009 to 0.024 inch (0.23 to 0.61 mm) after the pin is pressed into position.

D. Press the roller pin into the follower and roller until it is flush, Figure 16F-12.

E. Remove the feeler gauge and again measure the side clearance. See Note above.

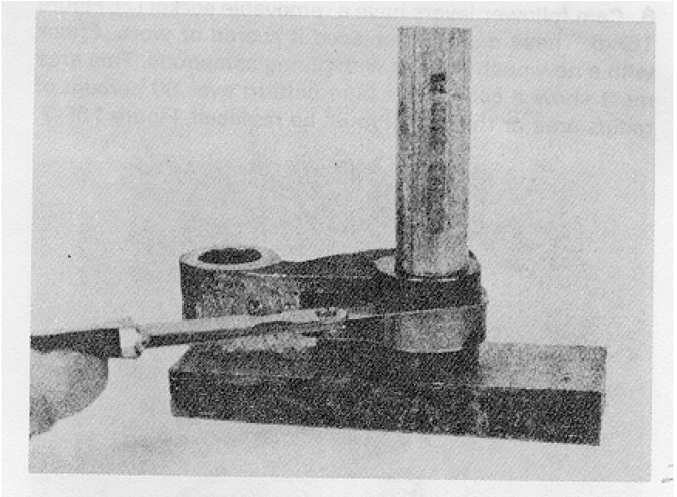


Figure 16F-12. Install the Cam Follower Roller Pin

F. Use a soft hammer to drive the roll pin into position.

3. Assemble the cam followers, Figure 16F-13, and spacers, Figure 16F-14, onto the shaft. Install the retaining rings.

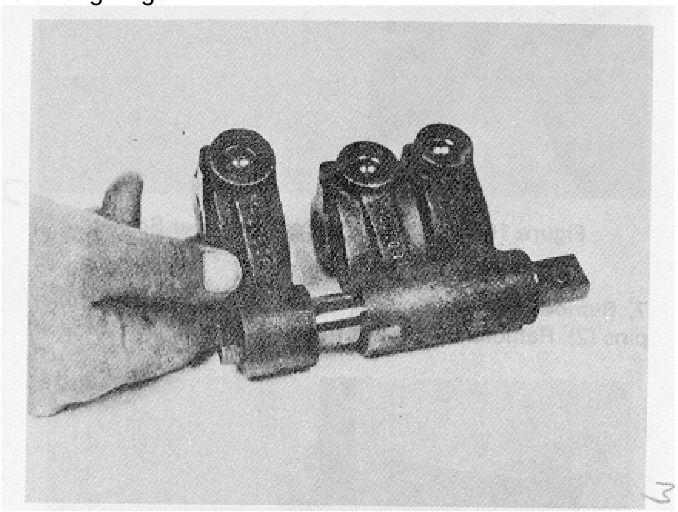


Figure 16F-13. Install the Cam Followers

NOTE

The injector followers are in the center position on each shaft.

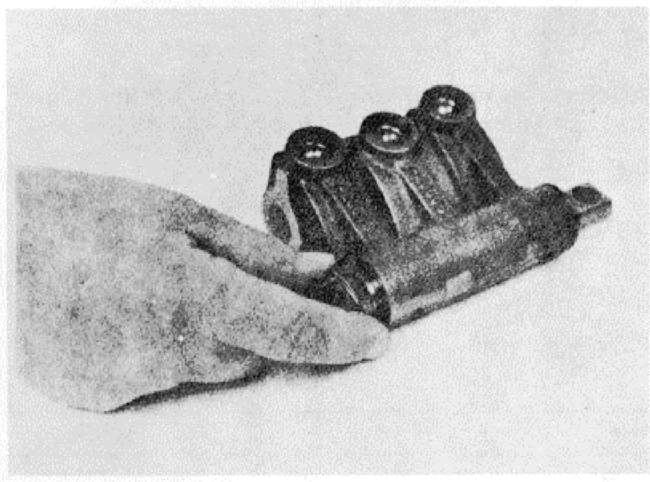


Figure 16F-14. Install the Spacer on the Shaft

PUSH RODS

INSPECTION

1. Check the injector push rod and valve push rod ball ends for wear with blue compound applied on a new cam follower socket. See "Cam Followers, Disassembly and Inspection", Step 6.

NOTE

The push rods with worn ball ends are not to be installed in new cam follower sockets.

2. Check the socket of the push rod with the ball end of a new rocker lever adjusting screw or with 1/2 inch (12.7 mm) check ball. Contact should show in 80 percent of seat area, Figure 16F-15.
3. Check the push rods to see if they are bent. Push rods that are bent have normally had the adjusting screw over tightened or tightened out of sequence.

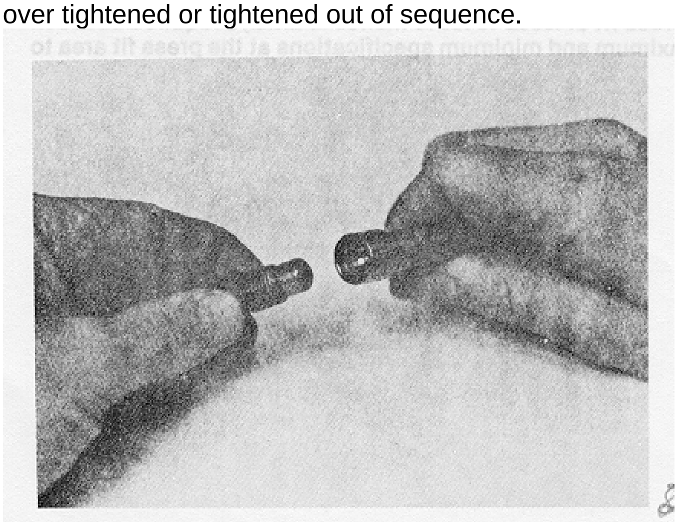


Figure 16F-15. Check the Push Rod Socket

NOTE

Support the push rods at the ends. Place the dial indicator midway between ends. Rotate the shaft 360degrees. Runout must not exceed 0.025 inch (0.64 mm) total indicator reading.

CAM FOLLOWER COVERS

DESCRIPTION

Two types of cam follower covers are used: plain and breather, and/or oil filler tube type, Figure 16F-16.

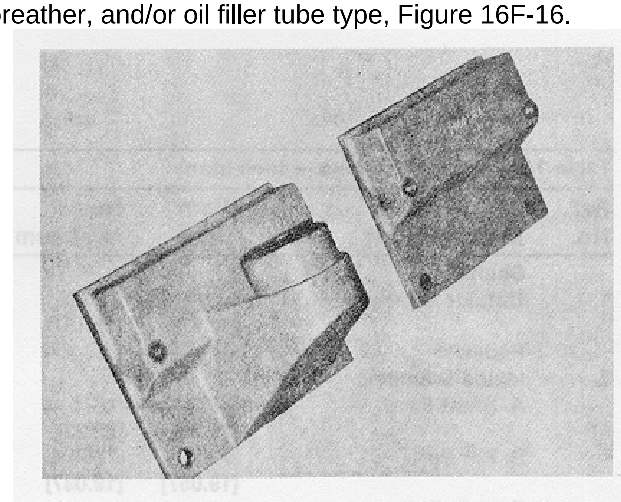


Figure 16F-16. Cam Follower Covers

INSPECTION

Inspect the cover for cracks, or other damage in gasket sealing area. Inspect the breather/filler type covers for cracks in the area where the breather or filler tube presses in. Discard all unserviceable parts.

CRANKCASE BREATHER

DISASSEMBLY AND INSPECTION

1. Remove the cover (4), Figure 16F-17, and lift out the top screen (6), mesh element (7) and bottom screen (8). Clean in approved cleaning solvent.

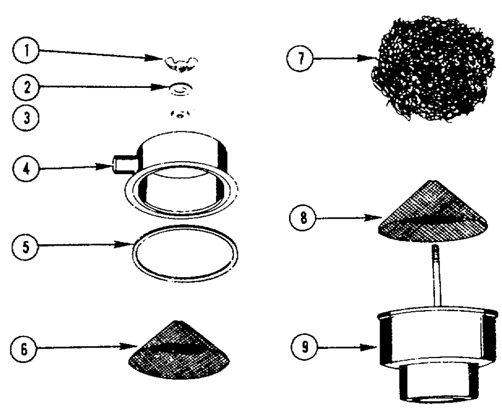


Figure 16F-17. Crankcase Breather

2. Inspect the rubber gasket (5), body (9) and cover (4) for racks or other damage. Discard and replace damaged parts.

ASSEMBLY

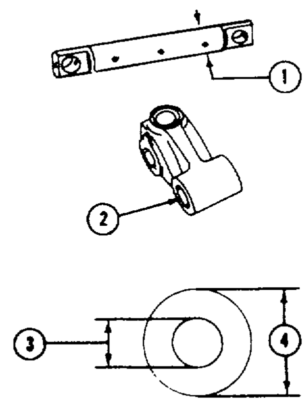
1. Install the bottom screen (8), new or cleaned element(7) and top screen (6) into the breather body (9).

2. Place the rubber gasket (5) into the cover (4). Position the cover assembly to body (9).

3. Position the rubber washer (3) and flatwasher (4) over the shaft of the body (9). Hold in place with a wingnut (1).

Table 16F-1. Specifications - Inch (mm)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Shaft			
1.	Outside Diameter	**0.873**	0.8735	0.874
		[22.17]	[22.187]	[22.20]
	Follower			
2.	Inside Diameter			
	A. Shaft Bore	**0.877**	0.875	0.876
		[22.28]	[22.23]	[22.25]
	B. Pin Bore	.7503	.7495	.7502
		[19.057]	[19.037]	[19.055]
	Cam Rollers			
3.	Inside Diameter	**0.756**	0.754	0.755
		[19.20]	[19.15]	[19.18]
4.	Outside Diameter	**1.622**	1.624	1.625
		[41.20]	[41.25]	[41.28]
	Cam Roller Pins			
	Outside Diameter	***0.748**	0.7505	0.751
		[19.00]	[19.06]	[19.08]
	Roller To Pin		0.003	0.0045
	Clearance		[0.08]	[0.11]
	Roller To Follower		0.009	0.024
	Side Clearance		[0.23]	[0.61]



* This dimension is measured when roller rides on pin; A press fit of .0002 to .0015 inches is always required between the pin and the cam follower pin bore; use the pin's new maximum and minimum specifications at the press fit area to determine whether it is usable.

SUBSECTION 16G

FUEL PUMP

DESCRIPTION

The identifying letters, "PT," are an abbreviation for "pressure-time."

The designation PT (type G) stands for "Governor-Controlled." Hereafter, this designation will be used to describe both the fuel system and the fuel pump.

TOOLS

Service Tools (Or Equivalent) Required

Service Tool No.	Tool Name
ST-302	Ball Joint Vise
ST-435	Fuel Pressure Gauge
ST-709	Puller
ST-848	Fuel Pump Test Stand
ST-853	Governor Barrel Lock Clip Driver
ST-884	Gear Pump Lock Plate
ST-984	Idle Adjusting Tool
ST-1032	Tachometer Drive Seal Driver
ST-1190	Fuel Rate Checking Tool
ST-1231	Weight Carrier Gear Block
ST-1241	Plunger Protrusion Checking Tool
3375014	Fuel Filter Replacement Adapter
3375015	Fuel Filter Replacement Adapter Gasket
3375133	Front Cover Mounting Plate
3375137	AFC Plunger Adjusting Tool
3375140	AFC No-Air Needle Valve Adjusting Tool
3375146	AFC Plunger O-ring Installation Tool
3375148	AFC Needle Valve O-ring Installation Tool
3375204	Throttle Shaft Ball Installation Block
3375355	Throttle Lever Travel Template
3375364	Test Stand Test Oil - 55 Gallon Drum
3375372	Air Cylinder Assembly Tool

Desirable (Or Equivalent) Service Tools

ST-419	joil Seal Assembly Sleeve
ST-490	Drive Shaft Reaming Fixture
ST-537	Dial Depth Gauge
ST-774	Hand Tachometer
ST-835	Throttle Shaft (1/2 inch) O-ring Assembly Tool
ST-1250	VS Pump Pressurizing Valve Driver
ST-1326	Tachometer Shaft Puller

Standard Tools - Obtain Locally

Dial Indicator (Starrett No. 1 96-B)
.750 inch Reamer
Torque Wrenches (Inch pound and foot pound)
Arbor Press
900 Block with Steel Puller
"V" Block with Steel Puller
Oven, 5000F, Maximum
Cleaning Solvent

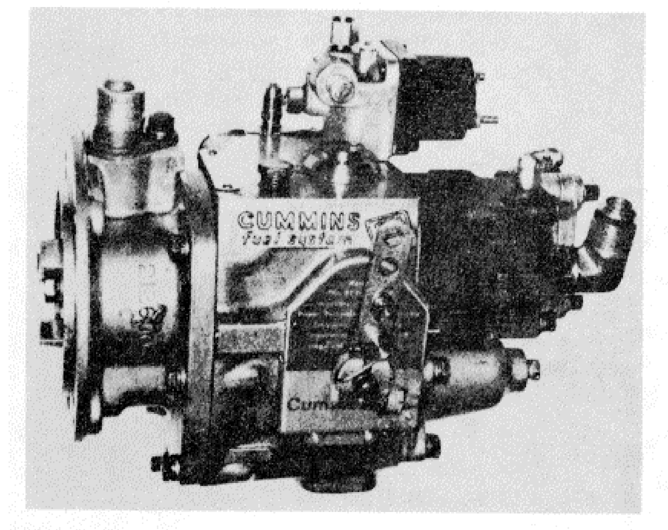


Figure 16G-1. AFC Fuel Pump (Lower Engine)

OPERATING PRINCIPLES

We can better understand the PT fuel pumps if we know the basic functions of the complete fuel system. Detailed operation of the injectors is described in Subsection 1 6H, which covers operation, cleaning and calibration of injectors.

The operation of the Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the size of passage the liquid flows through. To apply this simple principle to the Fuel System, it is necessary to provide:

1. A fuel pump to draw fuel from the supply tank and deliver it to individual injectors for each cylinder, Figure 1 6G-3.

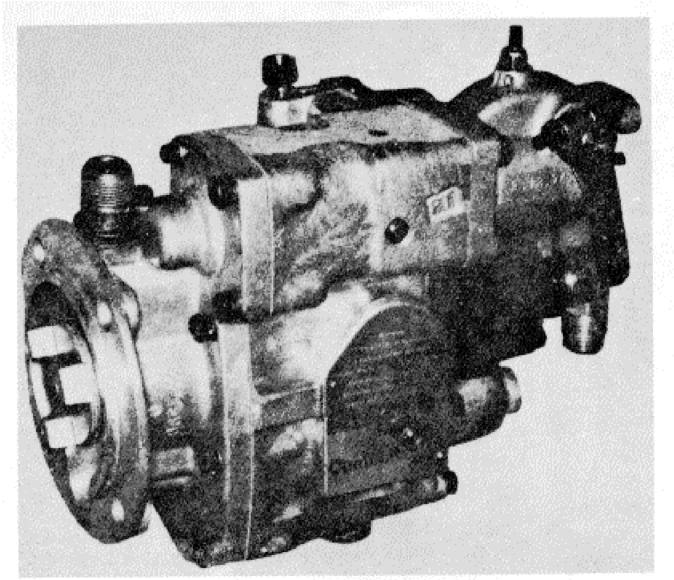


Figure 16G-2. Fuel Pump with VS Governor (Upper Engine)

2. A means of controlling the pressure of the fuel being delivered by the fuel pump to the injectors so the individual cylinders will receive the right amount of fuel for the power required of the engine.

3. Fuel passages of the proper size and type so that the fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.

4. Injectors to receive low-pressure fuel from the fuel pump and deliver it into the Individual combustion chambers at the right time, in equal quantity and proper condition to burn.

FUEL PUMP

GENERAL

The fuel pump is coupled to the compressor or fuel pump drive which is driven from the engine gear train. The fuel pump main shaft turns at engine crankshaft speed. The main shaft drives the gear pump, governor and tachometer shaft. he fuel pump assembly is made up of three main units.

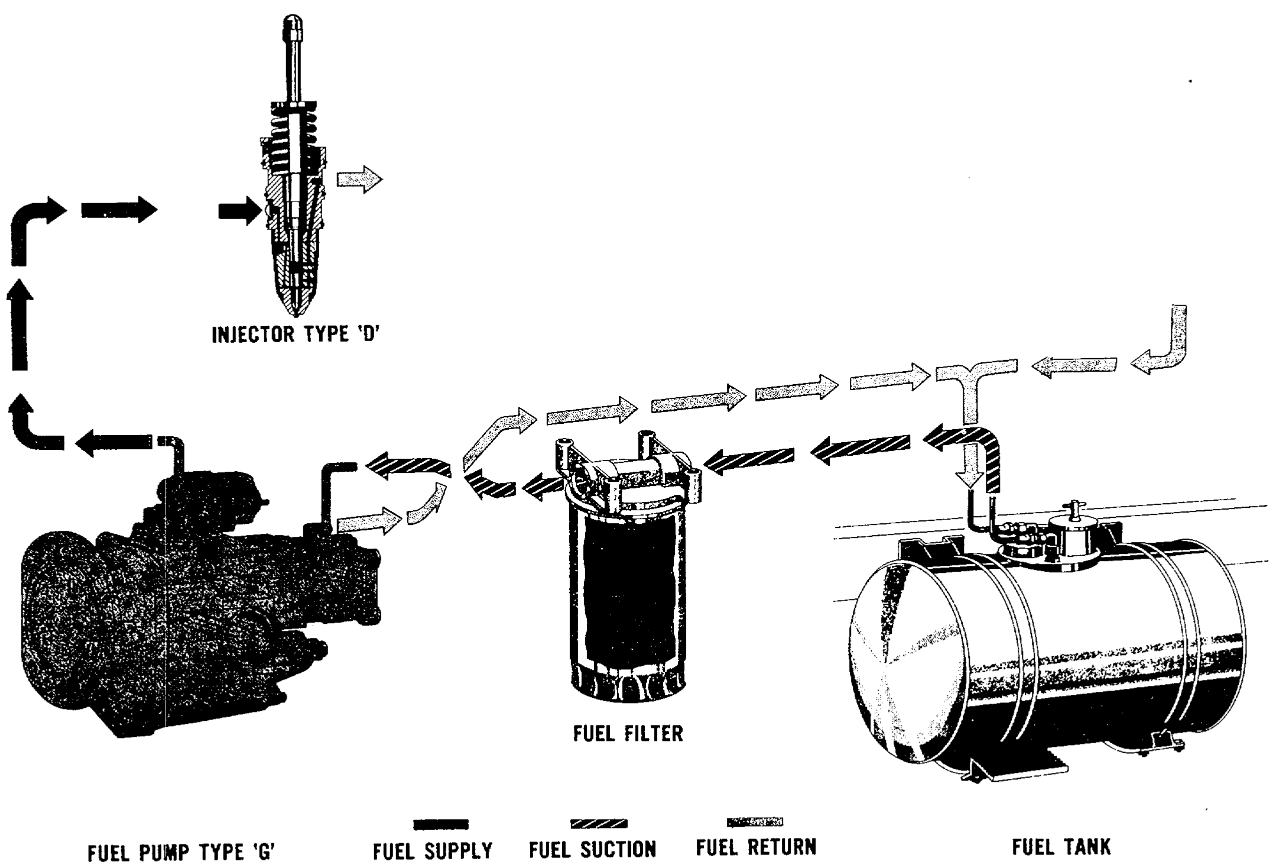


Figure 16G-3. Fuel Flow in PT Fuel System

1. The gear pump which draws fuel from the supply tank and forces it through, the pump filter screen to the governor.
2. The governor which controls the flow of the fuel from the gear pump, as well as the maximum and idle engine speeds.
3. The throttle which provides a manual control of fuel flow to the injectors under all conditions in the operating range. The location of fuel pump components is indicated in Figure 16H-4.

GEAR PUMP AND PULSATION DAMPER

The gear pump and pulsation damper are located at the rear of the fuel pump.

The gear pump is driven by the pump main shaft and contains a single set of gears to pick-up and deliver fuel throughout the fuel system. A pulsation damper mounted to the gear pump contains a steel diaphragm which absorbs pulsations and smooths fuel flow through the fuel system.

From the gear pump, fuel flows through the filter screen and to the governor assembly as shown in Figure 16G-4.

The gear pump is equipped with a bleed line (to the engine injector return line or to tank)which prevents excessive fuel temperatures within the fuel pump. The bleed line functions primarily when the pump throttle is set at idle speed but when gear pump output is high, due to engine rotative speed, as occurs during down hill operation. A special check valve and/or fitting is used in the gear pump to accomplish the bleed action.

PRESSURE VALVE

The pressure valve is used only in PT (type G) VS governor fuel pump. The valve is located near gear pump drive shaft in the rear of the fuel pump housing. It restricts return fuel coming from governor barrel thereby creating low fuel pressure in housing.

THROTTLE

The throttle provides a means for the operator to manually control engine speed above idle as required by varying operating conditions of speed and load.

In the fuel pump, fuel flows through the governor to the throttle shaft. At idle speed, fuel flows through the idle port in the governor barrel, past the throttle shaft. To operate above idle speed, fuel flows through the main governor barrel port to the throttling hole in the throttle shaft.

SHUT-DOWN VALVE

An electric shut-down valve is used on the fuel pumps.

The manual control knob must be fully counterclockwise to permit the solenoid to open the valve when the "switch key" is turned on. For emergency operation in case of electrical failure, turn manual knob clockwise to permit fuel to flow through the valve.

GOVERNORS

IDLING AND HIGH-SPEED MECHANICAL GOVERNOR

The mechanical governor, sometimes called "automotive governor," is actuated by a system of springs and weights,

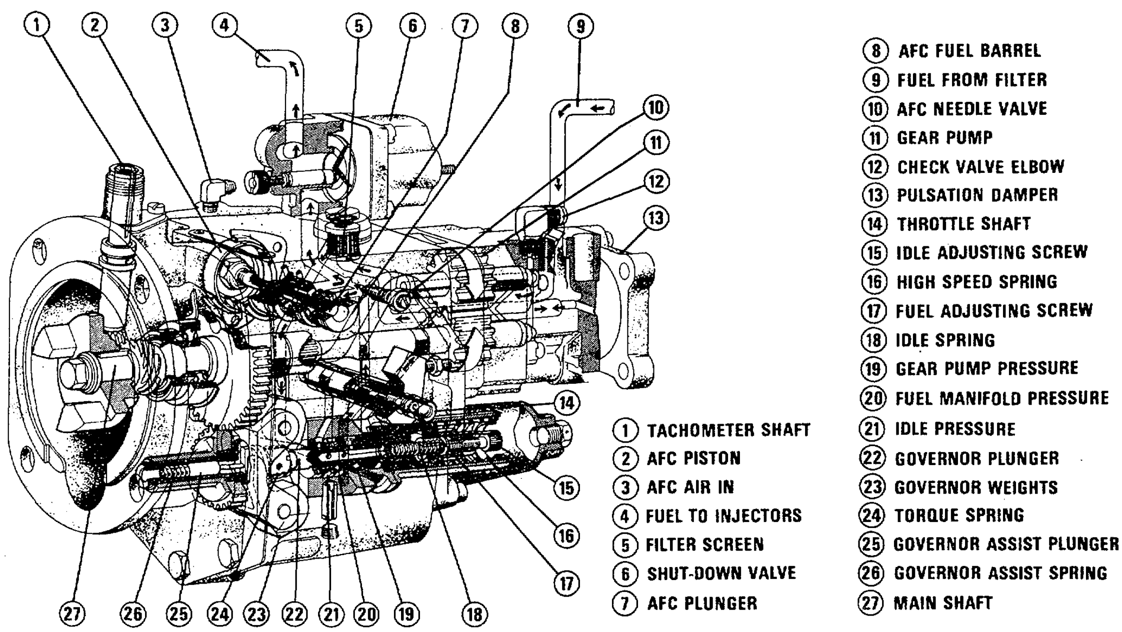


Figure 16G-4. Fuel Pump Cross-Section and Fuel Flow with Air Fuel Control and has two functions. First, the governor maintains sufficient fuel for idling with the throttle control in idle position; second, it cuts off fuel to the injectors above maximum rated rpm. The idle spring in the governor spring pack positions the governor plunger so the idle fuel port is opened enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel flows through the governor to the injectors in accord with the engine requirements as controlled by the throttle and limited by the size of the idle spring plunger counterbore. When the engine reaches governed speed, the governor weights have moved the governor plunger to close the fuel passages to injectors. At the same time another passage is opened and fuel is dumped back into the main pump body. In this manner engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the pump flows through the shut-down valve, supply lines and cylinder head drillings into the injectors.

The engines are equipped with what is commonly referred to as the automotive, or maximum speed governor. This includes the normal throttle shaft to which the foot throttle is attached. The throttle shaft position may be used to control engine RPM between idle RPM and maximum no load engine speed so long as the load on the engine does not fluctuate.

VARIABLE SPEED (VS) GOVERNOR
(UPPER ENGINE)

The VS governor assembly is located in upper portion of fuel pump housing and front cover. The VS governor weights are located in upper front cover and are gear driven through an idler gear assembly from fuel pump mainshaft. A standard automotive governor is in conventional location in bottom of housing, Figure 16G-5.

The housing of this governor is pressurized therefore, all fuel pump suction air leaks are eliminated. The pressure valve is located in housing near gear pump drive shaft.

The fuel screen is in bottom of housing under shut-off valve.

A snap ring is used to retain screen and plug in housing.

AIR FUEL CONTROL (LOWER ENGINE)

The air fuel control (AFC) functions as a fuel pressure and flow restrictor to provide the proper air fuel delivery rate to the engine during acceleration.

In the VS pump (upper engine) fuel passes directly from the throttle shaft through a passage to the shut-down valve. The main difference in an AFC (lower engine) is the fuel passes through the AFC unit after leaving the throttle shaft and before reaching the shut-down valve, Figures 1 6G-4 and 16G-5.

When no air pressure is on AFC bellows, fuel from the throttle shaft flows through the no-air needle valve passage where the needle valve restricts the pressure and flow. The AFC plunger blocks fuel from passing through the AFC barrel. After passing the needle valve the fuel flows to the shut-down valve.

As turbocharger speed and intake air manifold pressure increases, the air pressure acting on the AFC bellows and piston overcomes the AFC spring force, causing the AFC plunger to move away from the AFC cover plate. As the plunger moves, the plunger chamfer begins allowing fuel to

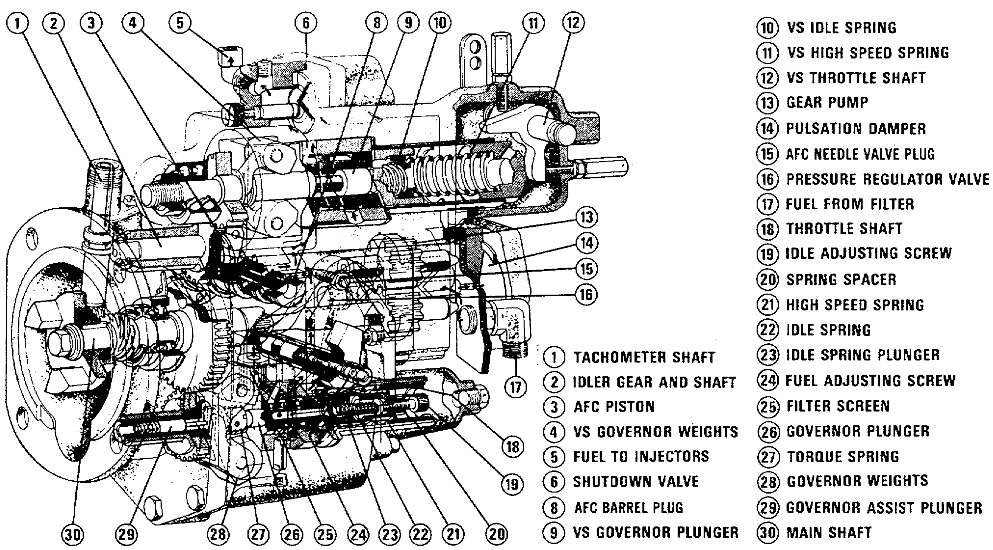
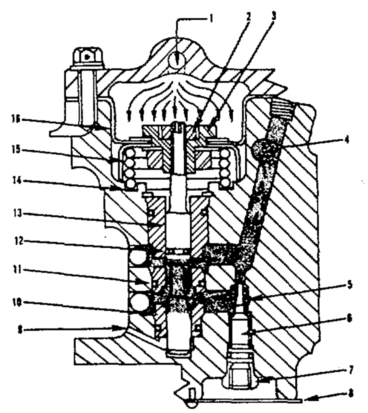


Figure 16G-5. Fuel Pump with Variable Speed Governor and Air Fuel Control flow through a drilling in the AFC barrel common to the drilling from the fuel pump throttle shaft. This allows fuel to bypass the no air adjust needle valve and flow down the AFC barrel to a second drilling leading to the shutdown valve. As the intake manifold air pressure increases the AFC plunger uncovers more of the drillings until a minimum fuel restriction level is reached and intake manifold air pressure above the AFC unit holds the plunger in full fuel position, Figure 16G6.

Fuel pumps used on engines not requiring the air fuel control feature will have a specially designed plug in the housing in place of the AFC barrel assembly (upper engine).



1. AIR MANIFOLD PRESSURE
2. LOCKING JAM NUT
3. CENTER BOLT
4. FUEL TO SHUTDOWN VALVE
5. FUEL FROM THROTTLE SHAFT
6. NO AIR ADJUSTING VALVE
7. LOCKING JAM NUT
8. THROTTLE COVER PLATE
9. VENT TO HOUSING
10. BARREL
11. BARREL SEALS
12. PLUNGER SEALS
13. PLUNGER
14. WASHER
15. SPRING
16. DIAPHRAM

Figure 16G-6. Cross-Section of AFC in Fuel Pump

REMOVAL OF FUEL PUMP UNITS

CLEAN AND MOUNT

1. Clean outside of fuel pump thoroughly with an approved solvent. Remove lockwires and seals if used.

NOTE

Many solvent cleaners are injurious to aluminum. Make sure your cleaner is suitable before using it on aluminum.

2. Mount fuel pump on 3375133 Mounting Plate and ST-302 Swivel Vise, Figure 16H-7. PUMP COOLING KIT

1. Remove check valve orifice elbow assembly from top of gear pump.
2. Clean parts in clean fuel oil and dry with compressed air blown through both ends.

SHUT-DOWN VALVE, PULSATION DAMPER AND GEAR PUMP

1. Remove shut-down valve from top of main housing and discard O-ring.
2. Remove pulsation damper from gear pump and discard O-ring.

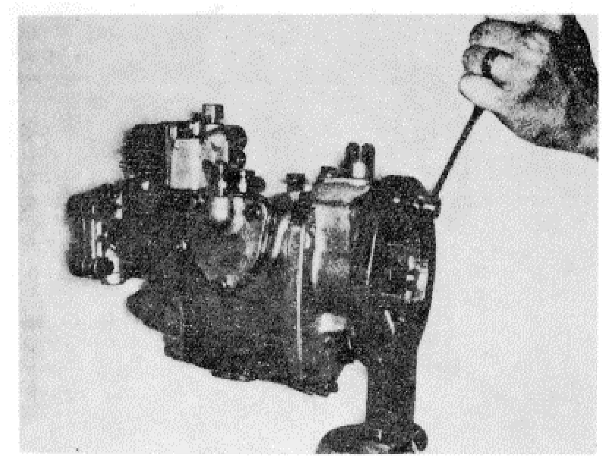


Figure 16G-7. Mounting AFC Type Fuel Pump to 3375133 Mounting Plate

3. To remove gear pump from main housing, tap sides of gear pump with a plastic hammer to loosen from dowel. Remove gear pump and discard gasket, Figure 16G-8.

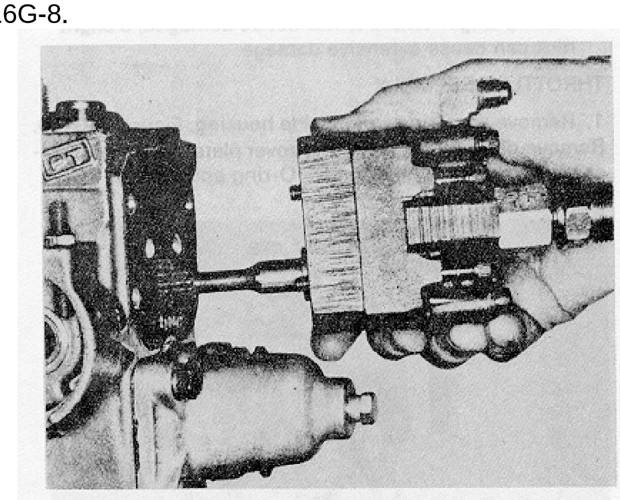


Figure 16G-8. Removing Gear Pump

FRONT DRIVE COVER AND GOVERNOR PLUNGER

1. To remove drive cover from main housing, tap edge of cover lightly with a plastic hammer to loosen. Lift cover off dowels and discard gasket, Figure 16G-9.

NOTE

Never use a steel hammer on aluminum, or on a finished surface, it can cause extensive damage.

2. Remove weight assist plunger, spring and shims from weight carrier assembly. Slide governor plunger from barrel.

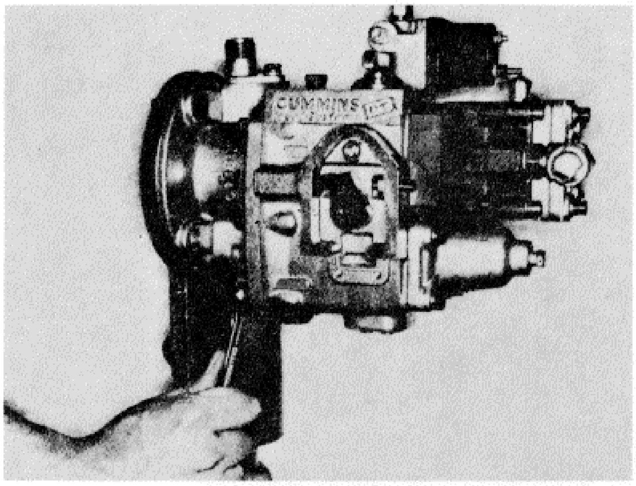


Figure 16G-9. Removing Front Drive Cover from AFC Pump

CAUTION

Place plunger where it will not be damaged, a slight nick can cause extensive damage.

THROTTLE ASSEMBLY

1. Remove snap ring from inside housing, Figure 16G-10. Remove drive screws securing cover plate. Pull throttle assembly from housing. Remove O-ring and discard.

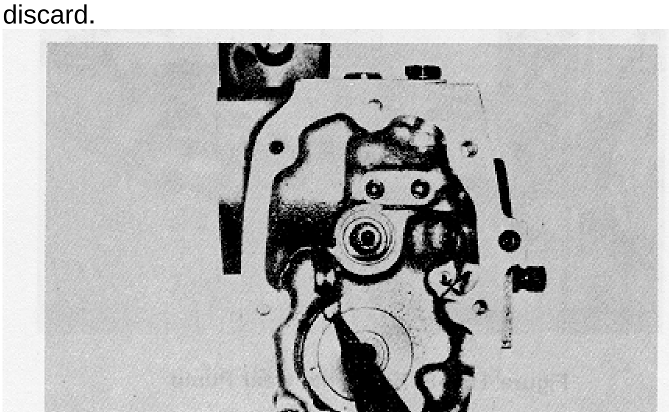


Figure 16G-10. Remove Snap Ring from Throttle Shaft

2. If throttle shaft sleeve is damaged, replace sleeve. Sleeves are available in 0.010 and 0.020 inch (0.25 and 0.51 mm) oversize on outside diameter.
3. Loosen jam nut, remove "no air" AFC fuel adjusting screw (lower engine) and discard O-ring.

GOVERNOR SPRING-PACK COVER

The "Automotive" or idling and high speed mechanical governor is on both engines. See Governor Spring-Pack section for other governors.

1. Remove spring-pack cover from main housing, lift off cover and discard gasket.
2. For disassembly of spring-pack, see Spring-Pack section.

FILTER SCREEN

1. Screw off screen cover on top of main housing (lower engine). Lift cap, spring and filter screen assembly from main housing; discard O-ring.
2. On VS governed pumps (upper engine), remove snap ring from bottom of housing. Pull out retainer, remove spring and screen.

TACHOMETER DRIVE

1. Remove tachometer drive cover.
2. Lift drive cover from front cover.
3. Carefully drive tachometer drive assembly from pump front cover. Use a brass punch and hammer or use ST-667-10 collet with ST-667 Dowel Puller or use ST-1326 to pull tachometer seal, shaft and bushing, Figure 16G-11.
4. Remove oil seal from shaft and discard.

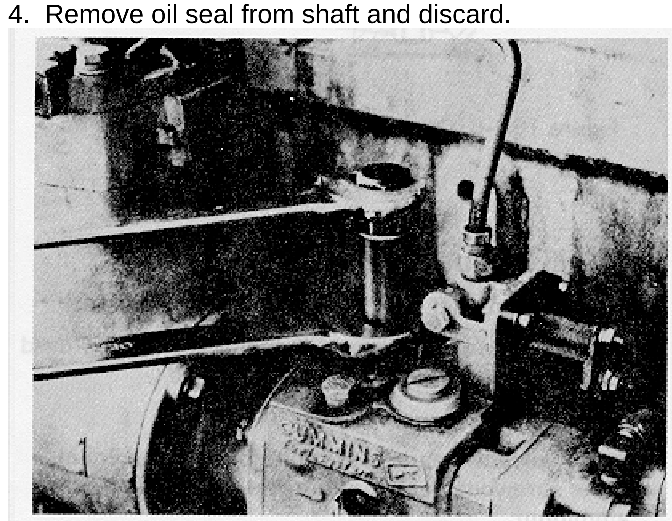


Figure 16G-11. Removing Tachometer Drive Assembly with ST-1 326

GENERAL REPAIR

Fuel pump subassembly repair, cleaning, inspection and rebuild instructions are listed in the following.

Worn replacement limits are given to help the mechanic decide when to replace parts or to use parts that have many hours or miles of useful life.

However, parts that are worn beyond replacement limits must not be reused.

CLEANING

A clean shop, clean tools and good cleaning practices are essential to good quality fuel pump repair. Special care must be taken when cleaning aluminum alloy parts since some cleaning solvents will attack and corrode aluminum. However, cleaning time is always well spent. Most fuel pump failures occur because of dirt. Clean all parts before rebuild or assembly.

INSPECTION

Time spent on inspection is profitable. It can save many dollars worth of parts and also prevent failure of the rebuilt pump.

Too often inspection is performed too lightly or not performed at all. Proper tools are essential to do a satisfactory job of inspection.

TOOLS

Using proper tools has many advantages. The fuel pump consists of several aluminum parts, which makes it light; but the parts may be easily damaged if the right tool is not used to perform the job being done.

NOTE

Aluminum parts must be handled carefully.

Service tools may be purchased from Cummins if you perform your own rebuild work.

An arbor press should be used for all pressing operations to control pressure and alignment. Always make sure that the part is properly supported when pressing in another part; the parts can easily be damaged beyond repair if not properly supported.

PRESSING LUBRICANT

A high pressure lubricant should be used on mating surfaces in all pressing or driving operations. The lubricant prevents galling or scoring during assembly. Be sure to remove all burrs from mating parts before pressing together.

CAPSCREWS AND WASHERS

Capscrews used in connecting a part to aluminum should have an engaging thread length two times the diameter. Observance of this rule will prevent stripping threads with a capscrew that is too short or breaking a part from using a capscrew that is too long.

Lockwashers must never be used next to aluminum. Always use a flatwasher between the lockwasher and aluminum part.

FUEL PUMP FILTER SCREEN

DESCRIPTION

Cummins engines are equipped with a single screen that is located in fuel pump housing.

DISASSEMBLY AND INPSECTION

Two types of screens are used on Fuel Pumps.

1. The standard automotive screen assembly (lower engine) mounts in top of fuel pump housing, Figure 16G-12.

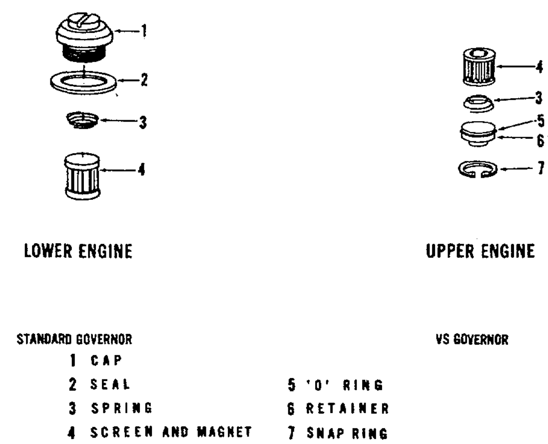


Figure 16G-12. Fuel Filter Screens

A. Remove upper retainer, the top retainer contains a magnet to pick up any iron particles that may have entered the fuel pump. Some screens are one piece.

B. The lower retainer and screen has hole in center to permit fuel flow.

C. Clean retainer in fuel oil and blow dry with compressed air. Visually inspect retainer and magent for damage or excessive wear.

D. Proper cleaning of the filter screens can best be accomplished by soaking in a carbon-dissolving agent, followed by flushing in a sonic cleaner unit; or clean the screen and retainer portion in fuel oil and dry with compressed air.

E. Visually inspect screen for holes or imbedded metal particles in mesh.

F. Discard damaged or worn parts and replace with new parts.

2. The VS governed fuel pump screen (upper engine) is the same as standard automotive screen except, it is located in the bottom of fuel pump housing under shut-off valve. Install in housing with hole up.

FUEL PUMP HOUSING

DESCRIPTION

The fuel pump housing is the largest part of the fuel pump and contains the governor barrel and the throttle shaft. Other units attach to the housing.

The drive shaft bushing, throttle sleeve, governor barrel and spring pack housing still remain in the fuel pump main housing.

The drive shaft bushing and governor barrel can be removed if damaged. The throttle sleeve was honed to size after assembly to the housing, and due to the close tolerances must be returned to a Cummins Distributor for repair or replacement. Exchange housings are available to reduce downtime to a minimum, as this is a specialized repair and only performed by Factory Repair Stations.

DRIVE SHAFT BUSHING

1. Check drive shaft bushing for sign of seizure or burrs.
2. Check drive shaft bushing I.D. with inside micrometers; if worn beyond 0.7525 inch (19.11 mm) replace bushing.
3. Remove worn bushing using a gouge chisel or half inch pipe tap. After tapping bushing, screw a half inch pipe cap on a close nipple and screw the half inch nipple into the bushing. Insert a punch through the rear of the housing and drive out the bushing.
4. Apply a thin coat of high pressure lubricant to a new front drive shaft bushing; press bushing into housing flush with housing bore using an arbor press.
5. Line ream bushing to 0.7495 to 0.7505 inch (19.04 to 19.06 mm) with ST-490 Ream Fixture, and a well oiled 0.750 inch (3/4 inch (19.05 mm)) reamer, Figure 16G-1 2A. Check bushing inside diameter.

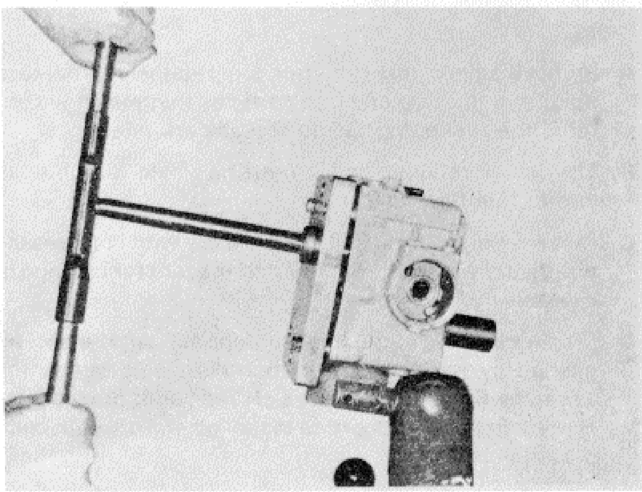


Figure 16G-12A. Reaming Drive Shaft Bushing with ST-490

GOVERNOR BARREL, PLUNGER AND SPRING PACK HOUSING

INSPECTION

1. Check governor barrel and plunger visually for wear.
2. If worn, replace governor plunger with a new plunger of same class size as etched on face of governor barrel.

NOTE

Due to hardness of governor barrel sleeve, it wears very little. If worn excessively or if plunger shows signs of scoring, barrel should be replaced.

STANDARD GOVERNOR BARREL REPLACEMENT

1. If governor barrel is worn or shows signs of scoring, it will be necessary to heat housing in oven to 3000F (1490C) and press out governor barrel. Heat will expand the aluminum housing and permit the steel barrel to be pressed out with less chance of damaging housing bore.

NOTE

Check through plug hole in bottom of pump for spring dowel which secures barrel in fuel pumps built after May 1963, before attempting to remove governor barrel. Sometimes a wire hook, inserted into the hole provided, will pull the spring dowel, Figure 16G-13.

2. Check barrel bore in housing to determine whether standard (1.5020 to 1.5025 inch (38.15 to 38.16 mm) O.D.) barrel, 0.01 0 inch (0.25 mm) or 0.020 inch (0.51 mm) oversize must be used. Minimum 0.002 inch (0.05 mm) interference fit is required. Check bore for score marks, remove if found.

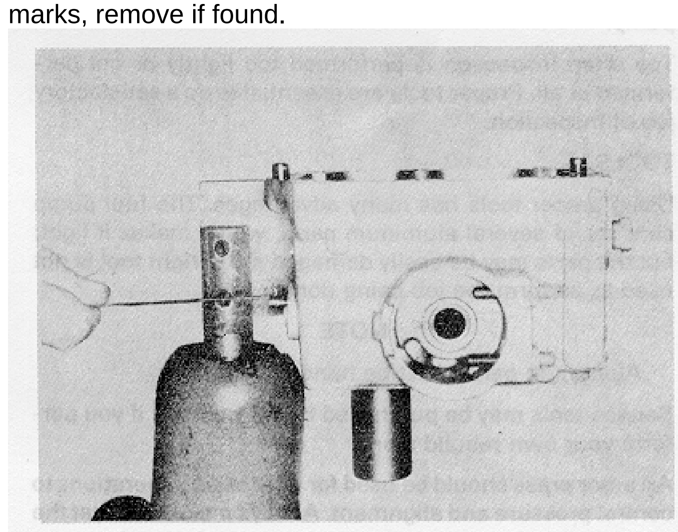


Figure 16G-13. Removing Locking Pin from Bottom of Barrel

ASSEMBLY AND FITTING

1. To locate a new governor barrel in the housing, scribe a center line on barrel and housing, lining up the fuel passages so fuel flow will not be restricted, Figures 1 6G-14and 16G-15.

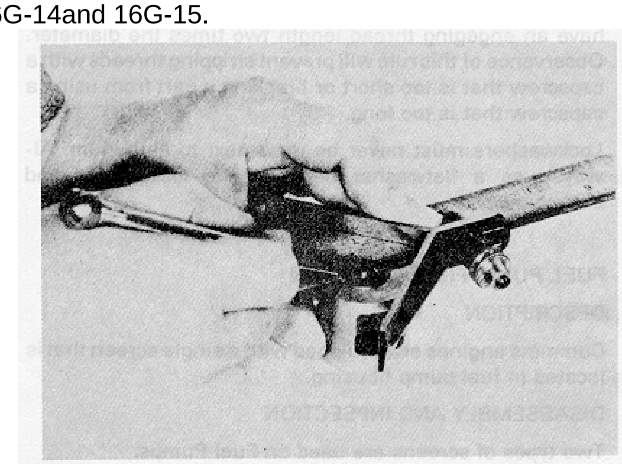


Figure 16G-14. Scribe Center Line on Governor Barrel

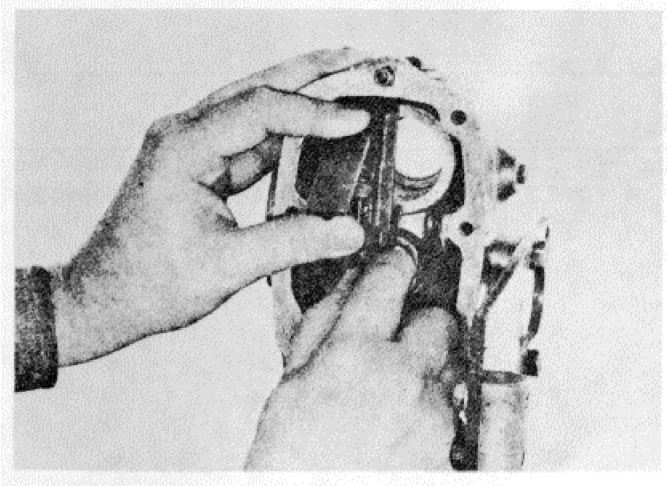


Figure 16G-15. Scribe Center Line on Fuel Pump Housing

2. Heat housing in oven to 3000F (1490C).
3. Coat new governor barrel with high pressure lubricant. Drop spring pack housing in place.
4. Place governor barrel in housing bore with chamfered end first and location pin hole on bottom side, lining up scribe marks, then press barrel in housing with arbor press until it bottoms against spring pack housing. This is important to align barrel retaining pin holes.
5. Select a new Class 2 (green color code) plunger and attempt to fit it in barrel, if plunger enters, try a Class 3 (yellow). Keep trying larger sizes until one will not enter barrel, then select pluger two sizes smaller than last plunger which did enter for use. Plunger must drop into bore of its own weight. Remark governor barrel with class size of plunger used. See Table 16G-1 for class sizes and color codes.

Table 16G-1. PT (Type G) Governor Plungers,

Code	Red	Blue	Green	Yellow	
Size	0	1	2	3	
Code	Orange	Black	Gray	Purple	Usage
Size	4	5	6	7	

6. Install spring dowel into bottom of barrel with ST-853 driver with slot of pin to front of housing.

VS GOVERNOR BARREL REPLACEMENT (UPPER ENGINE)

The VS governor barrel is replaced in same way as the standard governor barrel. The barrel locating setscrew is found above the standard throttle shaft on side of housing.

VS governor barrel sleeves can be identified by an "X" stamped on front surface. The four hole sleeve is stamped "X".

Governor barrels are available in 0.010 inch (0.25 mm) and 0.020 inch (0.51 mm) oversize.

GOVERNOR PLUNGER

DISASSEMBLY

1. If necessary, remove torque spring by twisting spring off shoulder. Do not use a straight pull which will stretch spring beyond its elastic limit so it has to be replaced, Figure 1 6G-16.

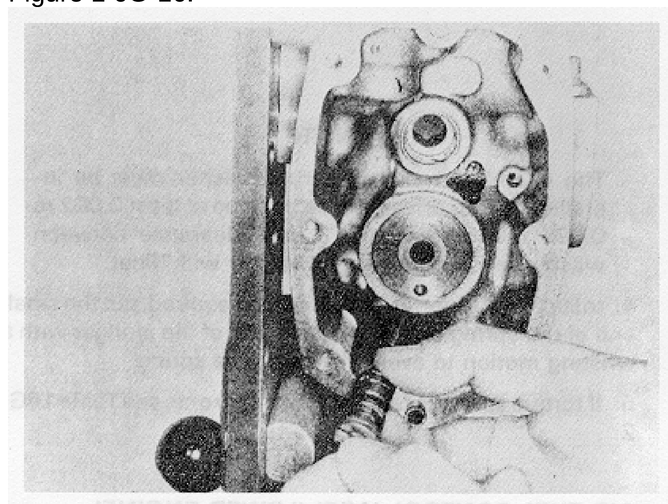


Figure 16G-16. Removing Torque Spring

2. If governor plunger outside diameter is worn, replace with new plunger of same class size as etched on barrel face. See "Governor Barrel and Plunger."
3. If only thrust washer is worn, drive retainer pin from plunger and pull governor plunger drive from plunger.

NOTE

The chamfer on small diameter of thrust washer is provided as a relief for fillets of plunger drive.

4. If it is necessary to remove stop sleeve, press stop sleeve off shaft.

ASSEMBLY

1. If stop sleeve was removed, press stop sleeve on plunger with notched end going on plunger first (notches toward governor barrel).
2. Assemble plunger driver through thrust washer and drive into plunger. Driver must have interference fit in plunger.

NOTE

The plunger has a lubrite finish. Protect it by laying the plunger on a copper jawed vise or V-block to prevent damage to the finish when installing pin.

3. Drive retainer pin through the plunger and plunger driver.

Table 1 6G-2. Torque Springs and Specifications

Engine	Color Code	Wire Dia. Inches (mm)	Number Coils	Pounds Load (kg)	Inches (mm) @ Length	Free Length Inches (mm)
Lower	Red/Green	.051 (1.30)	5.9	5.00/5.40 (2.3/2.4)	@ .340 (8.64)	.590/.610 (14.99/15.49)
Upper	Blue/Green	.051 (1.30)	5.2	6.00/6.48 (2.7/2.9)	@ .340 (8.64)	.590/.610 (14.99/15.49)

NOTE

The chamfered side of thrust washer must be installed next to driver. There must be at least 0.002 to 0.005 inch (0.05 to 0.13 mm) clearance between washer face and driver so washer will "float."

4. Install torque spring and shims as required, put the small end of the spring on the shoulder end of the plunger with a twisting motion to avoid distorting the spring.
5. If torque spring is replaced with new one, see Table 1 6G-2.

AIR FUEL CONTROL (AFC) (LOWER ENGINE)

GENERAL

Fuel pumps with Air Fuel Control (AFC) must be mounted to Swivel Vise, ST-302, with front cover Mounting Plate, No. 3375133, Figure 16G-7.

DISASSEMBLY

1. Remove AFC cover plate, Figure 16G-17.
2. Carefully lift bellows away from sealing surface around AFC cavity and pull bellows, piston and plunger assembly from AFC barrel, Figure 16G-18.
3. Remove AFC bellows spring and steel shim between spring and fuel pump housing, Figure 1 6G-19.
4. Remove Al-C barrel retaining ring, Figure 1 6G-20.
5. Remove AFC barrel, discard barrel O-rings. Remove barrel spring.
6. Remove plunger jam nut and unscrew plunger from center bolt. Remove O-ring from plunger.
7. Remove center bolt jam nut, washer, and gasket; remove bellows from piston, Figure 16G-6.

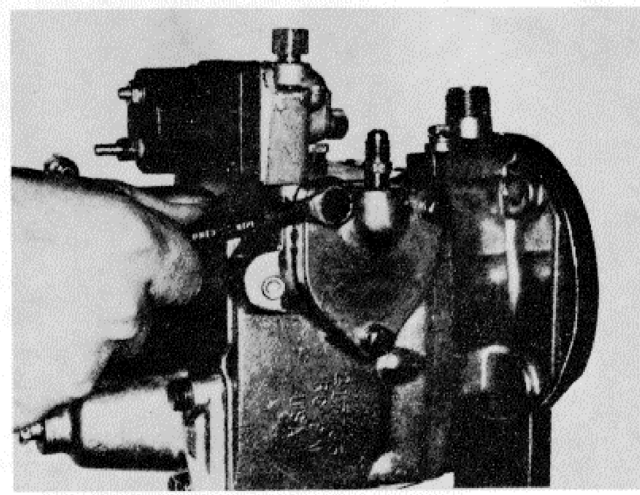


Figure 16G-17. Removing AFC Side Cover Plate

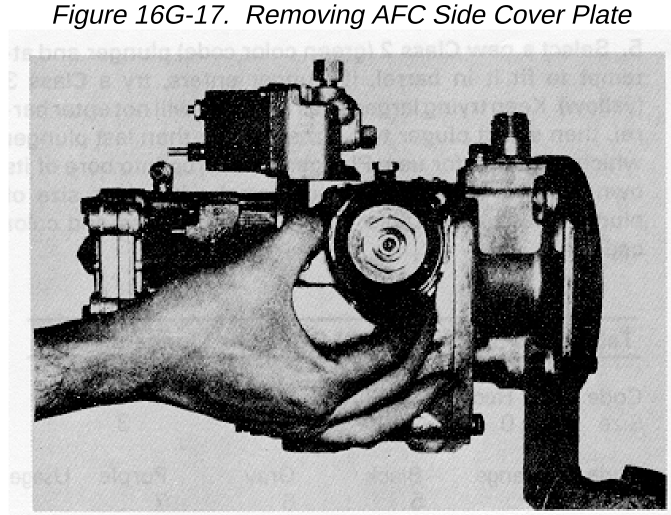


Figure 16G-18. Removing AFC Bellows and Piston Assembly

Table 16G-3. AFC Spring and Specifications (Lower Engine)

Color Code	Wire Dia. Inch (mm)	No. Coils	Load @ Length Pounds (kg)	Inch (mm)	Free Length Inch (mm)
Green-Yellow	.148 (3.76)	4.0	40.3-43.7 (18.28-19.82)	.850 (21.59)	1.200 (30.48)

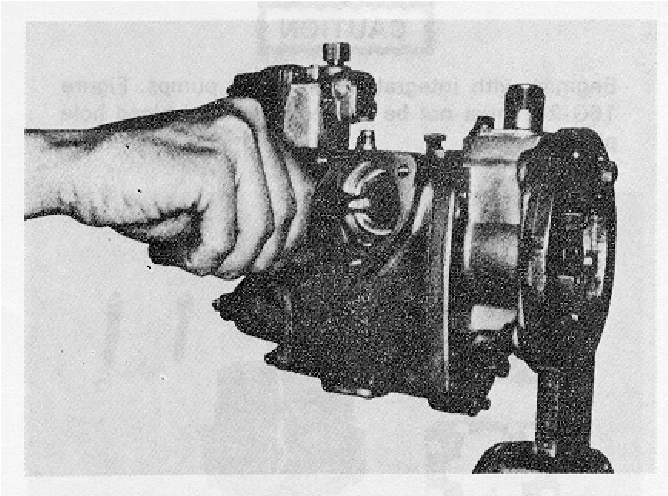


Figure 16G-19. Removing AFC Bellows Spring and Washer

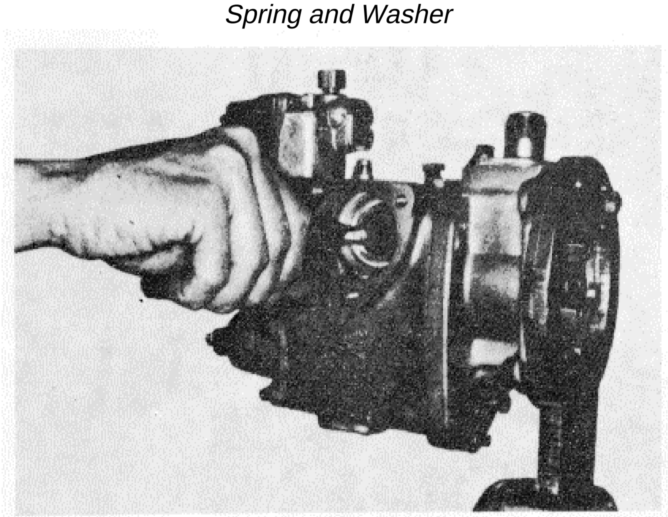


Figure 16G-20. Removing AFC Barrel Retaining Ring

AFC ASSEMBLY INSTALLATION

1. Install barrel spring in barrel cavity. Lubricate barrel 0-rings and install in grooves in barrel, press barrel into housing and secure with snap ring.

Lightly coat all O-rings with a 50-50 mixture of a lubricating oil additive (such as STP) and clean lubricating oil just before installation, Figure 16G-20.

2. Place steel shim in bellows spring seat groove.
3. Install spring with small end in housing, Figure 16G-19.
4. Assemble center bolt, gasket, washer (rounded edge toward bellows), bellows (with part number toward piston), piston, washer and jam nut.
5. Hold assembly by hex on center bolt and center bellows piston and washers; without twisting bellows tighten jam nut to 30 to 40 in-lbs (3.4 to 4.5 N.m) torque. Make sure parts are centered.
6. Install O-ring on AFC plunger.

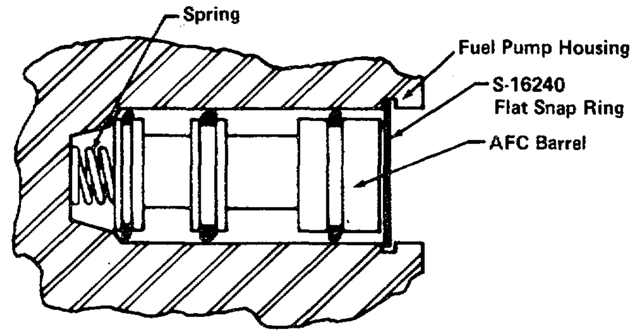


Figure 16G-21. AFC Barrel, with Spring, in Fuel Pump Housing

7. Screw plunger into center bolt until threaded end of plunger is flush with center bolt surface. Install jam nut, leave loose.
8. Side plunger and piston/bellows assembly into barrel, Figure 16G-18.
9. Cup bellows downward between piston and housing to ensure bellows does not wrinkle when cover is installed.
10. Line up bellows holes with housing and cover plate holes, install capscrews and washers. Capscrews are to be tightened to 30 to 35 in-lbs (3.4 to 4.0 N.m) torque after setting AFC on test stand, Figure 16G-17.
11. Install lubricated O-ring on needle valve using assembly tool, No. 3375148, and screw into housing above throttle shaft until it bottoms in housing; install jam nut loosely until set on test stand.
12. On upper engine, install plug and torque 30to45 in-lbs (3.4 to 5.1 N.m).

AIR FUEL CONTROL (AFC) PLUG (UPPER ENGINE)

DISASSEMBLY

1. Remove AFC cover plate.
2. Remove AFC barrel retaining ring.
3. Remove AFC barrel, discard barrel O-rings. Remove barrel spring.

ASSEMBLY

1. Install barrel plug-spring in barrel cavity.
2. Lubricate barrel O-rings and install in grooves in barrel. Press barrel into housing and secure with snap ring.
3. Install AFC cover plate. Tighten capscrews to 30 to 35 in lbs (3.4 to 4.0 N.m) torque, Figure 16G-17.

TACHOMETER DRIVE

DISASSEMBLY

1. Remove oil seal and spacer from tachometer drive shaft.

2. Press tachometer drive shaft from drive gear and bushing, if the gear is badly worn or shaft and bushing are galling or scoring. Check shaft outside diameter and bushing inside diameter. Replace if necessary, Table 16G-4.

Table 16G-4. Tachometer Drive Parts Specifications

Part Description	**In. [mm]**
Front Cover Mounted	
Tachometer Shaft	.3950/.3955 [10.033/10.046]
Shaft Bushing	.3963/.3970 [10.066/10.084]

ASSEMBLY
Place bushing on tachometer shaft with chamfered end of bushing toward gear end. Press gear onto shaft until flush with end of shaft, Figure 16G-22. Check to see that shaft turns freely in bushing. Maximum clearance between gear and bushing is 0.005 inch (0.127 mm).

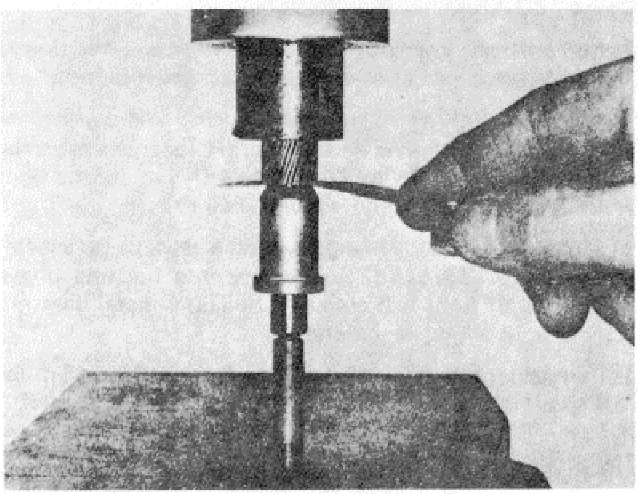


Figure 16G-22. Pressing Tachometer Gear on Shaft

NOTE
Check gear to make sure it matches with tachometer drive gear, Figure 1 6G-23.

GEAR PUMP AND PULSATION DAMPER
GENERAL
The gear pump draws fuel from the tank through a filter and supplies the fuel to the fuel pump. Fuel at a given pressure is then routed to the injectors.
GEAR PUMP
DESCRIPTION. Fuel pumps have gear pumps with hollow idle shafts and the gear pump cover is drilled for cooling.

NOTE
Special C.I.T.E. fuel gear pumps will have the BM or AR number stamped on the side of the gear pump.

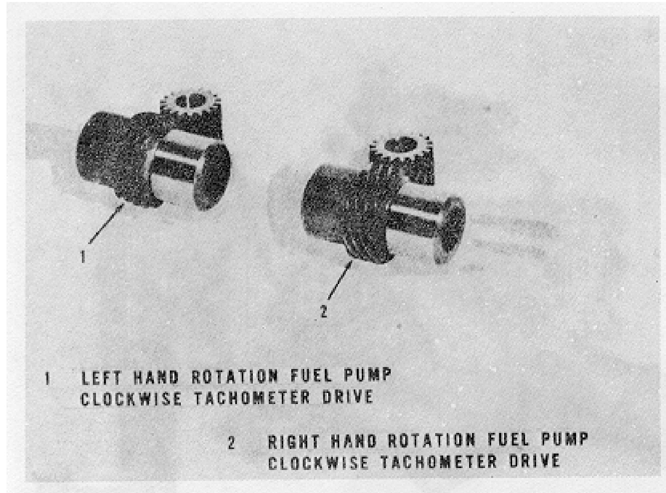


Figure 16G-23. Tachometer and Matching Drive Gears

CAUTION
Engines with integral cooling gear pumps, Figure 1 6G-24, must not be run with the fuel bleed hole plugged.

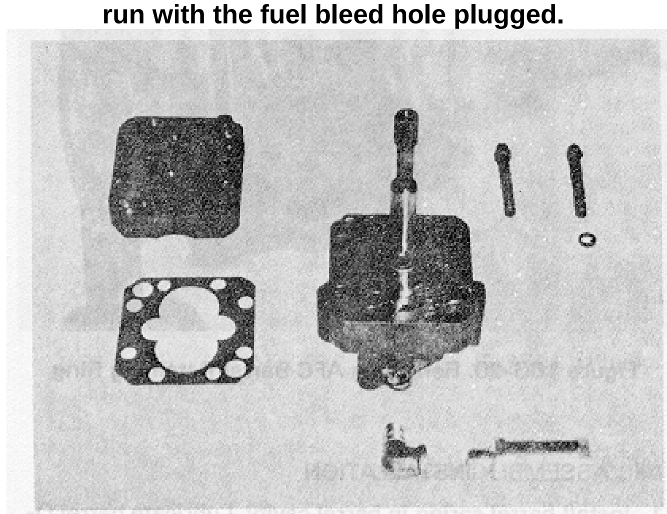


Figure 16G-24. Gear Pump with Integral Cooling

DISASSEMBLY. Disassemble the gear pump as follows:
1. Remove capscrews securing gear cover to gear body.
2. Drive against dowels with flat end punch to remove gear cover from dowels in gear body. Discard gasket.
3. Lift drive and driven gears and shafts from gear pump body.
CLEANING AND INSPECTION. Clean and inspect the gear pump as follows:
1. Check pump shafts for wear or scoring; discard if damaged. Replace shaft if worn smaller than 0.4998 to 0.5001 inch (12.695 to 12.703 mm) diameter.

2. Check gear width. See Table 16G-5. If gears are scored or worn badly, the gears must be replaced.
3. Check gear body and cover for scoring or wear, replace parts as needed. Check gear pocket depth, Figure 16G-25. See Table 16G-5.

Table 16G-5. Gear Width and Pocket Depth-Figure 1 6G-25

Pump Size Inch [mm]	**Gear Width Inch [mm]**	**Gear Pocket Depth In. [mm]**
3/4 [19.05)	0.7483/0:7486 [19.006/19.014]	0.7478/0.7483 [18.994/19.006]

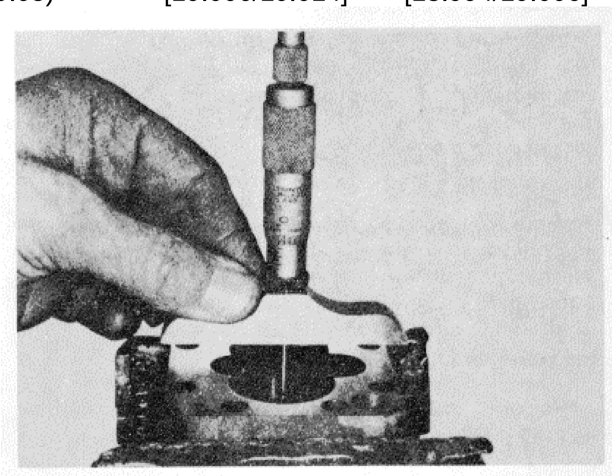


Figure 16G-25. Gear Pump Pocket Depth

4. Shaft bore in cover and body must be 0.5013 to 0.5016 inch (12.733 to 12.740 mm) I.D. in 3/4 inch (19.05 mm) cast iron bearing gear pumps. if gears are removed from shaft, press gears on shaft 0.680 to 0.690 inch (17.27 to 17.53 mm) from body end of shaft. Oil shaft before assembly.
5. Check lubrication holes in cover and body; they must be clean.
6. Clean cooling kit components, if used, and dry with compressed air.

ASSEMBLY. Assemble the gear pump as follows:
1. Lubricate and slide shafts and gears into cover. Make sure parts are clean.
2. Position new gasket and install body to cover. Align locating notches together, Figure 1 6G-26.

NOTE

Location of notches or ridges and drive shaft determines pump rotation.

3. When a right hand rotation pump is being assembled, place the driven gear shaft of the gear pump in the pocket nearest the locating notches or ridges. Place the driving gear shaft in the other pocket. The ring dowel is always located around the drive shaft. See page 16G-30.

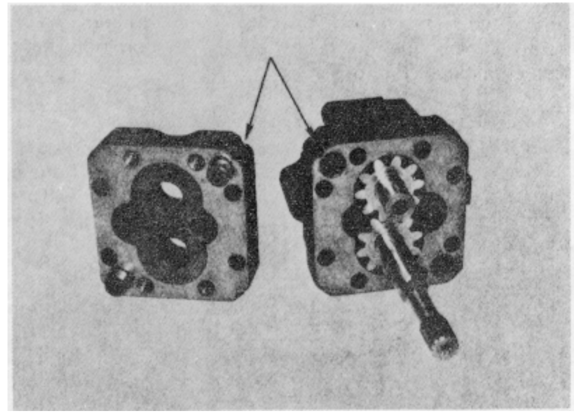


Figure 16G-26. Locating Notches or Ridges for Right Hand Pump

4. Secure cover and body with dowels, tighten capscrews to 11 to 13 foot pounds (15 to 18 N.m). Check to see that pump turns freely with finger pressure.

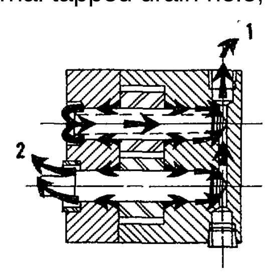
NOTE

Total gear backlash must be 0.001 to 0.004 inch (0.025 to 0.102 mm). The drive shaft must protrude 2.370 to 2.412 inch (60.2 to 61.3 mm) from the body. End clearance should not exceed 0.0015 inch (0.0377 mm) nor be less than 0.0009 inch (0.0228 mm). Gaskets are available in .0020 inch (.051 mm) (red) and .0015 inch (.038 mm) (purple). If pump binds or has excessive play, check for error in assembly which must be corrected to prevent early pump failure.

5. Install gear pump cooling elbow check valve in the top of gear pump.

INTEGRAL FUEL PUMP COOLING

The bleed fuel is that fuel which flows through and lubricates gear pump bearing bores. The lubricating fuel flow through three gear pump bearings is bled off through an external tapped drain hole, Figure 16G-27.



1 TO INJECTOR DRAIN LINE OR FUEL TANK
2 TO FUEL PUMP HOUSING

Figure 16G-27. Gear Pump Fuel Flow

The inboard main shaft bearing bore returns its fuel to the gear pump suction. The inboard idler shaft bearing fuel flows through the hollow idler shaft to the external drain line. As can be seen from the sketch, both outboard gear pump bearings drain externally.

Since three of the bearing bores drain externally, it is apparent that both tapped holes in the gear pump housing cannot be plugged. Plugging both tapped openings will prevent lubricating and cooling fuel flow through the three bearing bores and gear pump seizure will occur.

Both ends of through drain drillings are tapped so that gear pumps can be converted from R.H. to L.H. in normal manner.

CAUTION

Under no circumstances should the pump be operated with cooling return flow plugged. This fuel flow is necessary to lubricate the bearing surfaces within the gear pump.

1. Fuel pumps with the integral cooling feature may be identified by a 1/8 inch N.P.T.F. hole in top of gear pump.

NOTE

The spring-loaded check valve is necessary to prevent fuel in pump from draining away and causing hard starting.

2. Check valve may be pressure checked with calibration test oil, in direction of flow at 4 to 9 psi (27.6 to 63 kPa).
3. To test for leakage, apply 3-1/2 psi (24 kPa) for 5 minutes. Replace if leak occurs.
4. To test leakage in opposite direction of flow, apply ¼ psi (172 kPa) for 5 minutes. Replace if check valve leaks.

PULSATION DAMPER

DISASSEMBLY AND INSPECTION. Disassemble arid inspect the damper as follows:

1. Remove housing from cover. Remove spring steel diaphragm. Discard O-rings and nylon washer.

NOTE

Diaphragm must be kept clean prior to assembly.

2. Check for corrosion, excessive wear or cracks in cover or diaphragm. Replace if necessary, Figure 1 6G-28.

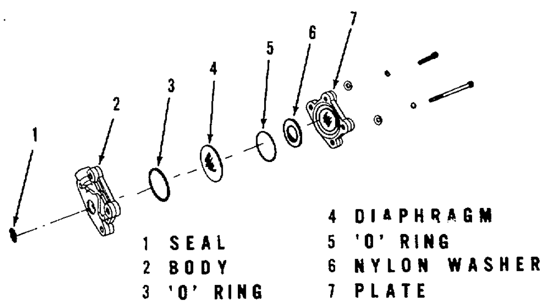


Figure 16G-28. Pulsation Damper - Exploded View

ASSEMBLY. Assemble the damper as follows:

1. Install new O-rings in grooves and new nylon washer.
2. Coat the diaphragm with a good grade of 10W or 20W oil and lay in cover.
3. Assemble cover to housing, torque capscrews to 11 to 13 foot pounds (15 to 18 N.m).

SHUT-DOWN VALVES

DESCRIPTION

The electric shut-down valve, controls flow of fuel from the pump to the injectors. The electric valve is equipped with a knob which will open the valve in case of electrical power failure, keep in counterclockwise position to operate electrically.

The electric shut-down valve is held while current is flowing through the electric coil, or solenoid. When current is not flowing, valve will shut unless the shut-down valve is locked open manually.

DISASSEMBLY

Remove coil housing from valve housing. Remove coil housing, fuel shield and discard O-ring. Remove spring washer and plate-type valve. Remove manual override knob, and unscrew override shaft from coil end. Discard shaft and O-ring, Figure 1 6G-29.

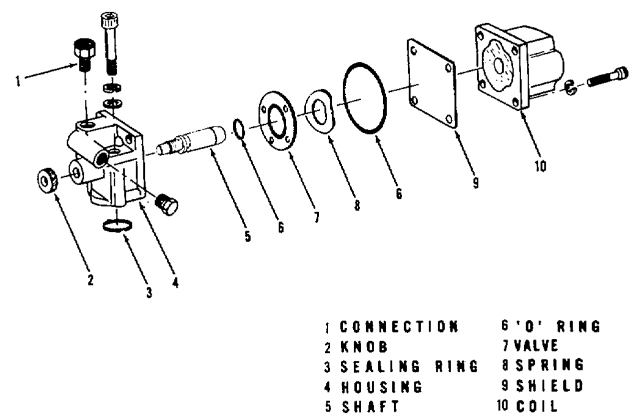


Figure 16G-29. Electric Shut-Down Valve - Exploded View

CLEANING AND INSPECTION

1. Clean all parts except the coil assembly in mineral spirits.

NOTE

Do not wet the coil with solvent; instead, wipe it clean with a lint free cloth.

2. Visually check valve and valve seat for wear, bonding failure or corrosion. Replace if necessary. Valve seat should have a minimum seat 0.015 inch (0.38 mm) wide, Figure 1 6G-30.

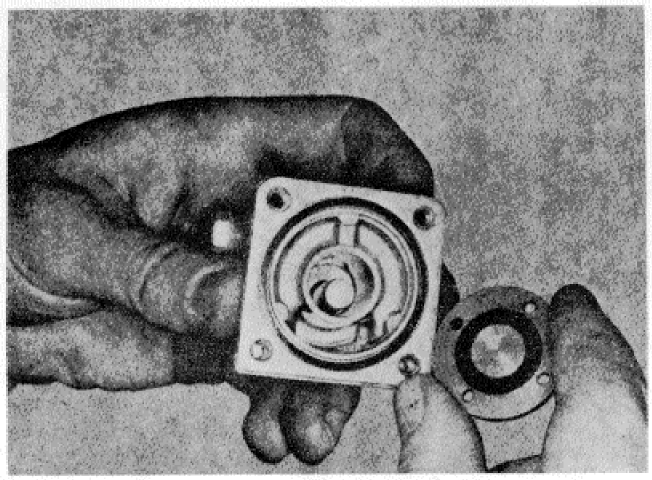


Figure 16G-30. Inspecting Plate Type Valve

3. Check coil assembly with an ohmmeter, replace if below values given in Table 16G-6.

CAUTION
Be sure starting switch is in off position when checking coil.

Table 1 6G-6. Coil Resistances

Engine	Voltage and Type	Coil Resistance (Ohms)
Lower	12 V.D.C. Single Terminal	7.5 + 0.5
Upper	24 V.D.C. Single Terminal	30 +2

ASSEMBLY

1. Install a new O-ring on new override shaft and coat with lubricant, Figure 16G-31.

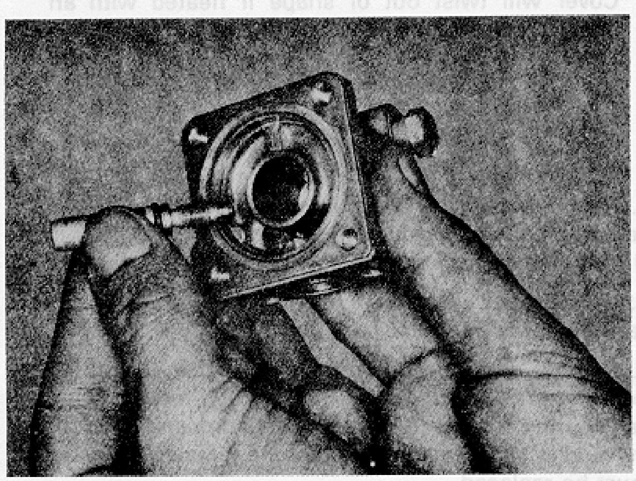


Figure 16G-31. Installing Override Shaft

2. Screw shaft into housing until it reaches bottom of its bore. Use depth micrometer set at 0.118 inch (2.997 mm) and check distance from face of valve housing to tip of shaft. If necessary, screw shaft out until it is 0.118 inch (2.997 mm) below housing face. Do not move shaft and press on knob until it contacts valve housing which will act as a stop, Figure 16G-32.

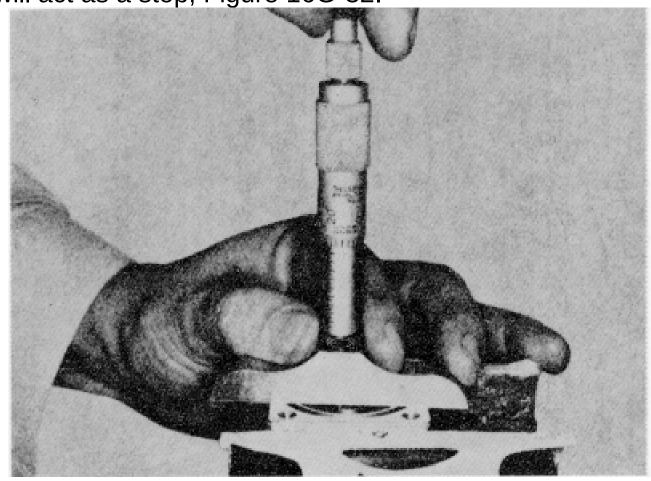


Figure 16G-32. Checking Shaft Tip Depth

3. Place valve into valve housing with rubber side toward housing.
4. Apply lubricant to housing O-ring and seat in groove.
5. Drop spring washer on valve with concave side up and piloted around valve locator, Figure 16G-33.

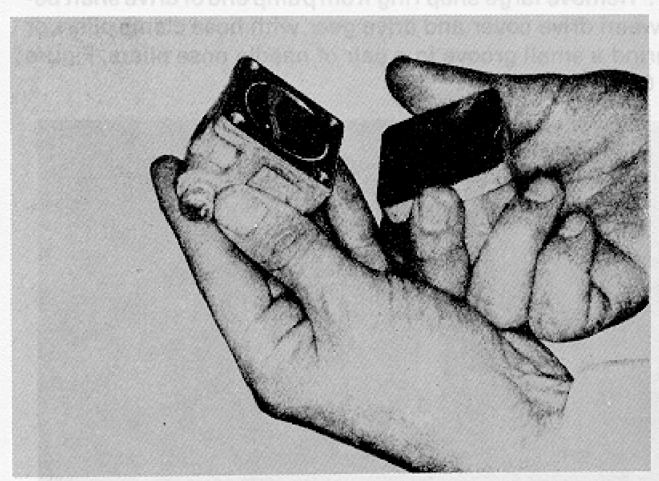


Figure 16G-33. Assembling Shut-Down Valve

6. Place fuel shield on valve housing and tighten screws to 25 to 30 inch pound (2.8 to 3.4 N.m) torque.
7. Energize valve and pump fluid through valve at 300 psi (2068 kPa). De-energize valve and valve should withstand the 300 psi (2068 kPa) load with no leakage through valve.

8. Should leakage exist, check the main body for nicks or depressions where body and plate come in contact. Check the rubber seal in the plate for swelling or other defects.

FRONT COVER ASSEMBLIES

GENERAL

Front cover assemblies consist of the cover, tachometer drive, main shaft and bearing, and the governor weight carrier assembly. The cover may be flange mounted to the compressor or fuel pump drive.

DISASSEMBLY AND INSPECTION OF STANDARD COVER (LOWER ENGINE)

1. Check governor weight carrier shaft in its bushing before removal. Excessive wear can be felt by moving shaft from side to side in the bushing.

2. Observe gear backlash between weight shaft gear and drive gear. Normal backlash is 0.005 to 0.009 inch (0.13 to 0.23 mm).

NOTE

Remove weight assist plunger if not previously removed.

3. Remove governor weight carrier assembly from drive cover. Use an internal engaging puller of ST-709 to pull bushing.

4. Remove fuel pump drive coupling retainer capscrew and washers. Pull the coupling with ST-709 puller.

5. Screw out the tachometer drive housing.

6. Use ST-667 dowel puller or brass punch to remove tachometer shaft, seal and bushing from front cover; discard seal.

7. Remove large snap ring from pump end of drive shaft between drive cover and drive gear with hose clamp pliers or grind a small groove in a pair of needle nose pliers, Figure 16G-34.

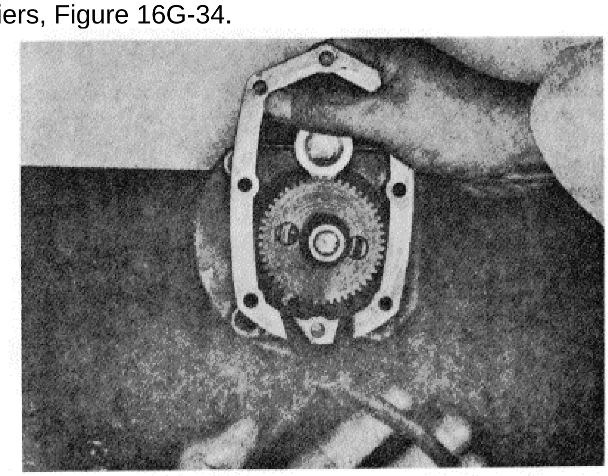


Figure 16G-34. Removing Snap Ring from Groove

8. Install a longer capscrew in place of drive coupling retainer capscrew; press on capscrew to remove drive shaft bearing and shaft assembly from front cover, Figure 16G-35.

9. Remove drive shaft oil seals from drive shaft.

10. Governor weight assembly can be disassembled to change the weights, pins, gear and bushing. If bushing is worn larger than 0.504 inch (12.80 mm), replace bushing.

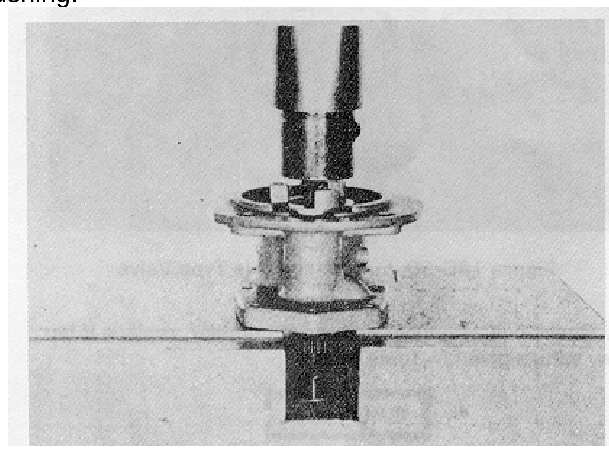


Figure 16G-35. Press Drive Gear Assembly from Front Cover

DISASSEMBLY OF VARIABLE SPEED FUEL PUMP COVER (UPPER ENGINE)

1. Remove lower governor weight carrier, main drive shaft and gear, drive coupling, tachometer drive and oil seals as previously described.

2. When cover is hot, remove idler and bushing assembly. If idler shaft cannot be removed, heat area with propane torch.

NOTE

Cover will twist out of shape if heated with an acetylene torch. If idler shaft has been tapped, secure gear to shaft with a capscrew and washer, and pull assembly with ST-709 Puller. If idler shaft has not been tapped, do not use a gear puller to pull idler shaft and gear. Gear will pull off of shaft.

3. Remove snap ring, thrust washer and bushing from idler gear shaft. If idler bushing is worn larger than 0.507 inch (12.88 mm), replace bushing.

4. Normal gear backlash of idler gear and upper governor carrier gear is 0.005 to 0.009 inch (0.13 to 0.23 mm).

5. Remove upper governor weight carrier with ST-709 Puller with 3375360 Jaws. Remove self-locking nut and ball bearing. If cover is heated with a propane torch to remove idler shaft self-locking nut and main shaft, oil seals must be replaced.

6. Inspect ball bearing and replace if found defective.

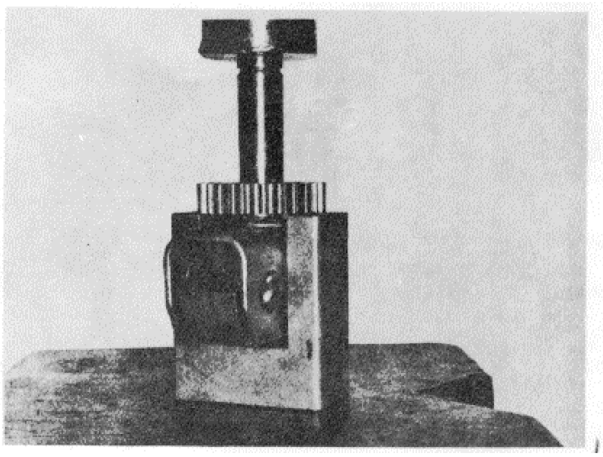


Figure 16G-36. Removing Gear from Weight Carrier with ST- 1231

UPPER AND LOWER **UPPER**

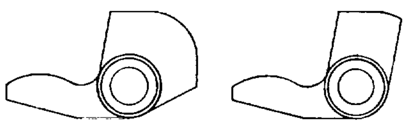


Figure 16G-37. Governor Weight Identification

GOVERNOR WEIGHT CARRIER

The governor weight carrier assemblies may be purchased as a complete unit or as separate parts.

1. Press shaft into carrier until end of shaft is flush to 0.005 inch (0.13 mm) below carrier surface (weight side).

NOTE

Do not reuse parts unless there is a minimum of 0.0005 inch (0.013 mm) interference fit between shaft and carrier.

2. If removed, press on gear. Do not press against carrier as it may be damaged. Press against inside end of the carrier shaft, if possible. The rough edge of gear goes toward carrier weight.

DRIVE SHAFT

DISASSEMBLY. Disassemble the drive shaft as follows:

1. Press gear pump drive coupling and governor drive gear from drive shaft, Figure 16G-38.
2. Remove front cover tachometer drive gear with small gear puller, remove key.

NOTE

Press away from bearing because shaft has a shoulder under bearing.

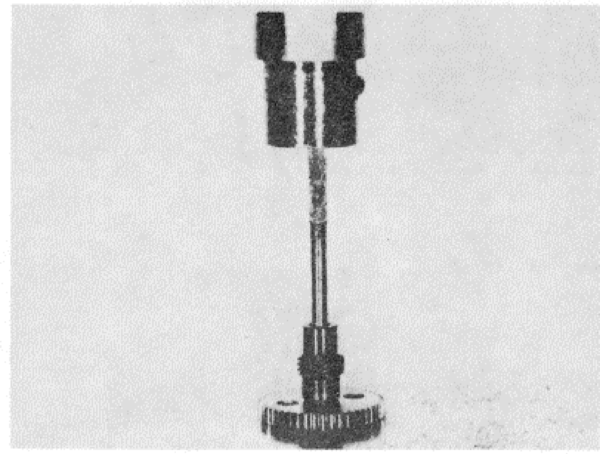


Figure 16G-38. Press Shaft from Gears

3. Press drive bearing from shaft only if bearing is rough or shaft has worn grooves.

ASSEMBLY. Assemble the drive shaft as follows:

1. If bearing or shaft is replaced, lubricate shaft with high pressure lubricant and press bearing over shaft, pressing against inner race of bearing, Figure 16G-39.

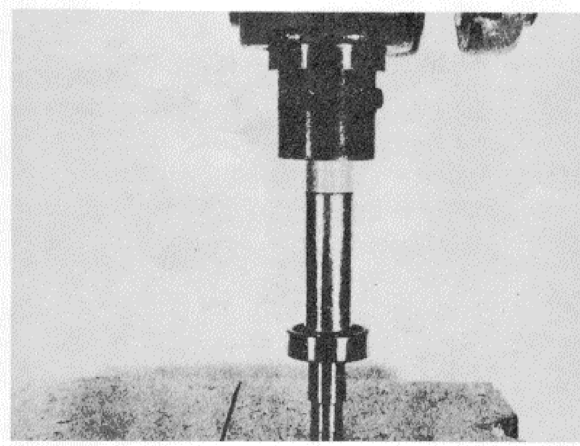


Figure 16G-39. Pressing Drive Bearing on Shaft

2. Press governor drive gear to drive shaft bearing over shaft.
3. Lubricate shaft and bore before pressing gear pump drive coupling on the shaft; press against governor drive gear, Figure 16G-40.
4. Check to see if parts are firmly seated. Insert snap ring between ball bearing and governor drive gear.

DRIVE COVER

1. Clean all parts thoroughly with mineral spirits or equivalent.

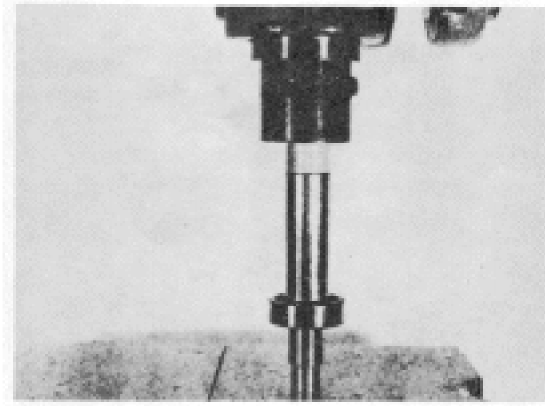


Figure 16G-40. Pressing Tachometer Gear on Shaft

2. Install first oil seal into drive cover with lip toward outside of pump, and press second oil seal into drive cover with sealing lip toward inside of fuel pump. Seals must be spaced so the "telltale" hole is not covered, Figure 16G-41.

CAUTION

The cover and shaft must be dry when installing the seals.

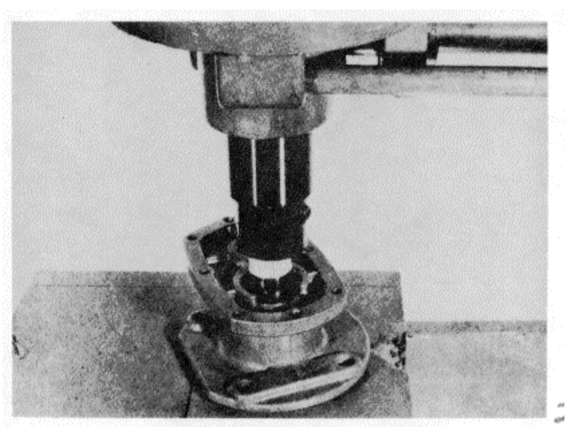


Figure 16G-41. Installing Drive Cover Oil Seal

3. Install ST-419 Assembly Tool over main shaft. Place snap ring between drive gear and bearing. Press main shaft assembly into front cover and through seals, Figure 16G42. Secure snap ring in cover groove, Figure 16G-43.
4. Line up oil groove in top of tachometer drive bushing with fuel pump drive shaft. Press bushing, shaft and gear assembly into cover until bushing bottoms.
5. Install spacer on top of bushing with slotted edge down. Install new oil seal, with spring side down. Spacer must bottom on bushing.

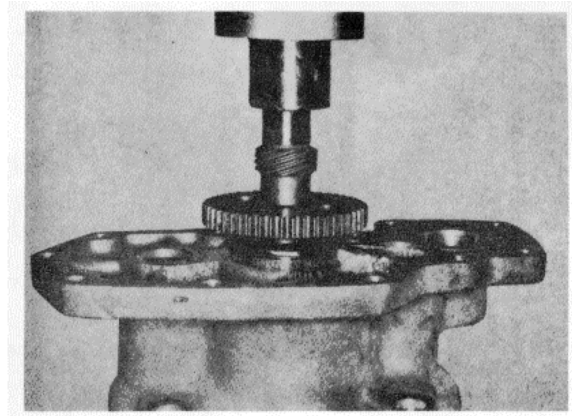


Figure 16G-42. Press Drive Shaft Assembly into Cover

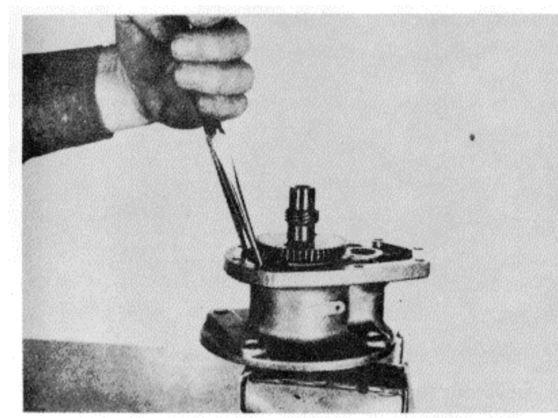


Figure 16G-43. Securing Snap Ring in Groove

CAUTION

Do not overpress spacer. It can be flattened eliminating its effectiveness.

6. Cover top of seal with a thin coat of lubricating oil. Secure tachometer housing to cover.
7. Install key, press coupling and front tachometer drive gear into position on drive shaft. Press slow and straight. Be certain tachometer gear teeth are aligned.
8. Install coupling retainer flat washer, lockwasher and capscrew to shaft and tighten in place. Hold coupling or main shaft in a copper-jawed vise while tightening.
9. Coat governor carrier bushing with high pressure lubricant and press into front cover. The bushing must seat against housing. Slide carrier assembly into bushing. Rotate weight assembly, with weights opened out, to be sure it will turn completely in housing.

10. Install about 0.860 inch (21.8 mm) shims in the lower engine fuel pump and about 0.750 inch (19.1 mm) shims in the upper engine fuel pump.

NOTE

This is a reference setting and may be changed when the pump is calibrated.

11. Install shims, when required, spring and governor assist plunger between governor weights and into bore of governor weight carrier shaft, Figure 16G-44.

NOTE

Always check and assemble weight assist plunger with smallest end of plunger to weights. This will prevent weights from sticking.

12. Gauge protrusion with a dial depth gauge having a base approximately 4 inches long or use ST-1120 or ST-1241.

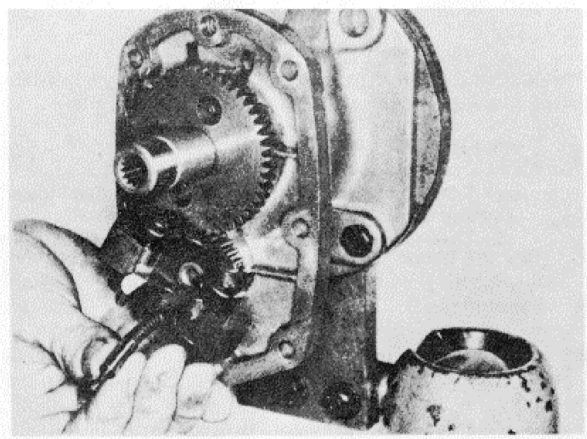


Figure 16G-44. Installing Weight Assist Plunger in Cast Weight Carrier

ASSEMLY OF VARIABLE SPEED FUEL PUMP COVER (UPPER ENGINE)

1. Heat cover in hot oil for 15 minutes, an oven at 400°F (2000C) for 30 minutes or with propane torch in idler shaft area.
2. While cover is heating, assemble idler gear thrust washer and snap ring on idler gear shaft. Slide bushing on shaft and press gear on shaft with smooth side of gear against bushing. Bushing end clearance is 0.002 to 0.007 inch (0.05 to 0.18 mm), Figure 16G-45.

NOTE

Remove snap ring and bushing and check shaft for burr near gear.

3. Press gear on shaft with lead in chamfer toward weights.
4. Press against inner race of ball bearing to assemble on shaft, Figure 16G-46. Secure with new self-locking nut, Figure 16G-47.
5. Remove cover from heat and press idler gear and bushing assembly into cover. Press against gear, Figure 16G-48.

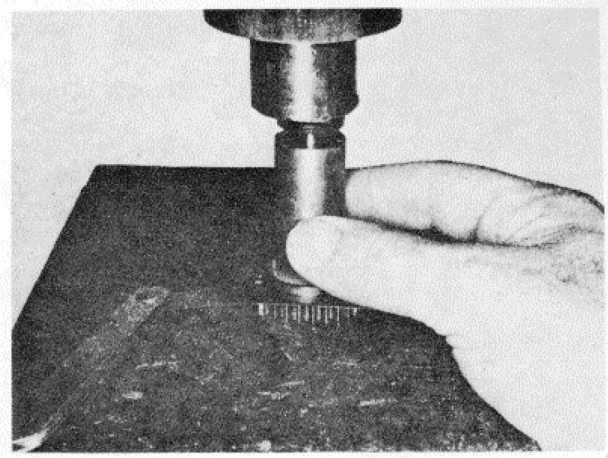


Figure 16G-45. Pressing Idler Gear on Shaft

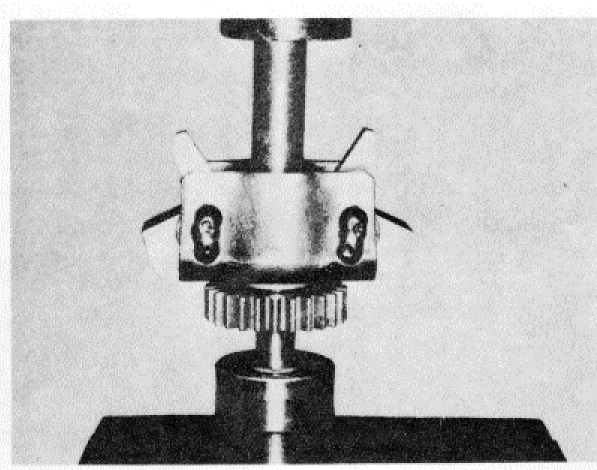


Figure 16G-46. Installing Governor Weights on Shaft

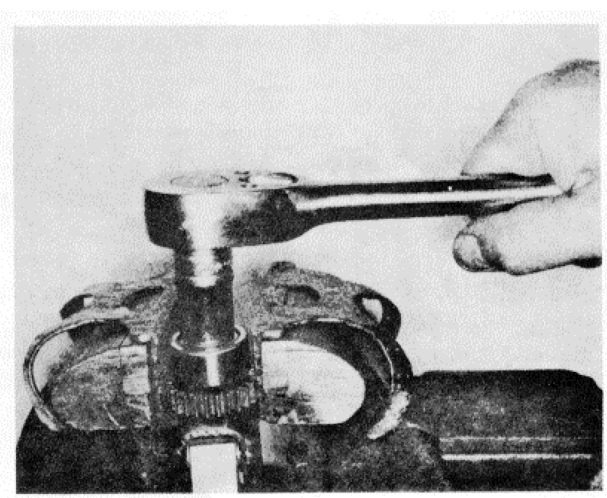


Figure 16G-47. Installing Self-Locking Nut on Shaft

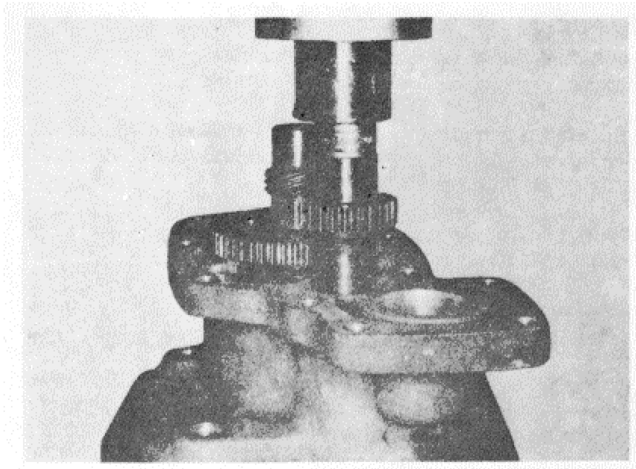


Figure 16G-48. Pressing Idler Gear into Cover

6. Install upper weight carrier pressing against shaft inside carrier or use ST-1231. If cover cools off, this may require pressing, Figure 16G-49

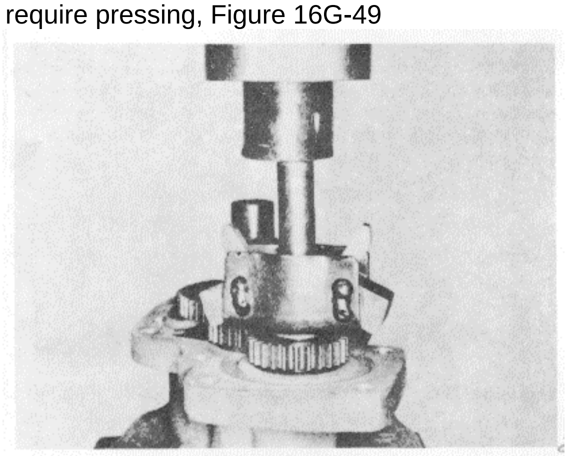


Figure 16G-49. Pressing VS Governor Weights into Cover

7. Allow cover to cool before installing new oil seals, main shaft and drive coupling as previously described.
8. Press in lower weight carrier bushing. Slide in weight side carrier assembly. Be sure both weight carriers are horizontal.

CHECKING PROTRUSION WITH ST-1 120 OR ST-1 241

DESCRIPTION. ST-1120 or ST-1241 is a bracket which rests on the machined surface of the fuel pump front support and support a dial indicator arranged to give a direct reading plunger protrusion, Figure 1 6G-50.

NOTE

The dial indicator is a special light loaded pickup type. Do not attempt to use other indicators. The internal assist spring and cause false readings.

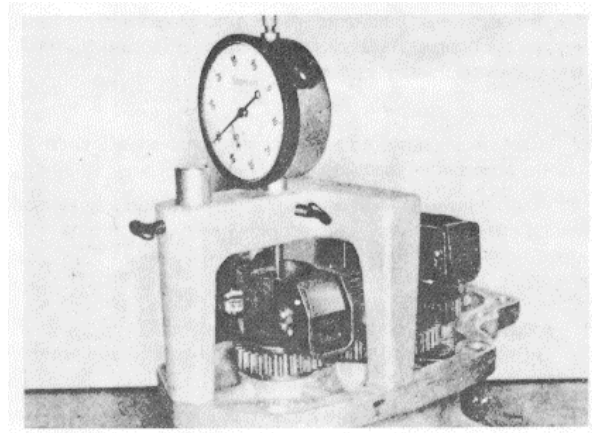


Figure 16G-50. Checking Weight Assist Protrusion on VS Pump with ST-1241

MEASURING PROTRUSION (CARRIER IN COVER). Measure protrusion (carrier in cover) as follows:
1. Place the bracket assembly on a surface plate with dial indicator's contact point resting on the 1/2 inch (12.7 mm) diameter 1.000 inch (25.4 mm) gauge pin. Zero dial indicator.
2. Remove gauge pin and place bracket assembly on front cover, locating dial indicator's contact point over weight assist plunger.
3. The dial indicator will give a direct reading of amount of protrusion. If protrusion is below specifications, add shims (see Page 1 6G-38). If the protrusion is above specifications, remove shims or grind exposed end of weight assist plunger (grind only if no shims are being used), Figure 16G-50.

MEASURING PROTRUSION (CARRIER NOT IN COVER). Measure protrusion (carrier not in cover) as follows:
1. Place the governor weight assembly, including the bushing, into the 5/8 inch (15.87 mm) hole provided in the test gauge body.
2. Follow Steps 1 and 2 as listed above.
3. Remove the bracket assembly from the test body and turn it 1800 and also place it onto test gauge body. This will position the dial indicator's contact point over the weight assist plunger.
4. Follow Step 3 as listed above.

CHECKING PROTRUSION WITH DEPTH MIKE

1. Place one leg of the depth mike base of pedestal across the carrier walls and measure down to the front cover gasket surface (no gasket), Figure 16G-51. Move the depth mike to the opposite side of the carrier and again measure to the front cover gasket surface directly across the cover from the previous measurement (do not turn carrier or cover).Average these two measurements. This procedure is necessary to eliminate any possible influence of uneven carrier wall heights.

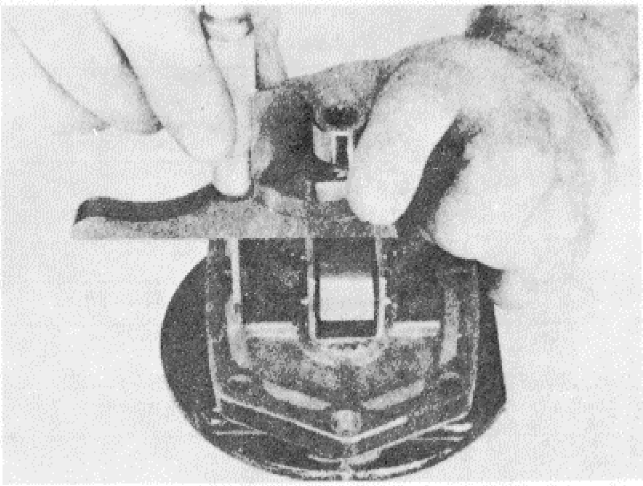


Figure 16G-51. Measuring Assist Plunger Protrusion

2. Position the depth mike across the carrier directly over the weight assist plunger. Measure down to the plunger. Do not depress spring.
3. Subtract Step 2 from the average determined under Step 1. The result is the weight assist protrusion. If weight assist protrusion is below specifications, (see Fuel Pump Calibration Data) add shims. If the weight assist protrusion is above specifications, remove shims or grind the exposed end of the weight plunger (grind only if no shims are being used).

GOVERNOR SPRING PACK
DESCRIPTION
The governor spring pack consists of the idle and maximum or high-speed springs, plungers, adjusting screw and shims. The springs control engine speed and adjustments are made by the shims or adjusting screw, Figures 16G-52 and 16G-53.

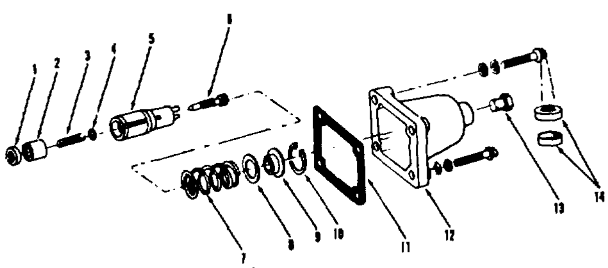


Figure 16G-52. Standard Governor - Exploded View (Lower Engine)

1 ADAPTER	6. ADDUS TIN SCR NEW	11 GASKET
2 IDLE SPRING PLUGNER	7 HI -SPEED SPRINI	12 COVER
3 IDLE	8 SPRING I	13 PLUG
4 WASHER	9 RETAINER	14 SEAL
5 GUIDE AND CLIP	I0 SNAP IING	

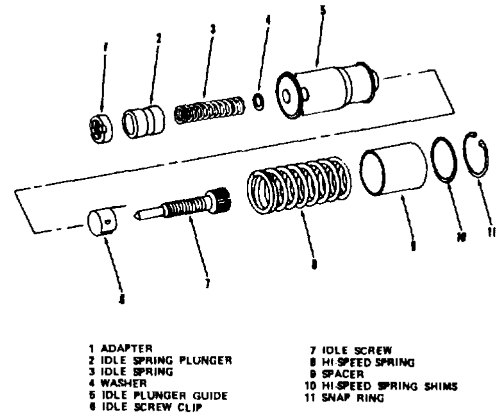


Figure 16G-53. Standard Governor in VS Pump (Upper Engine)

STANDARD AUTOMOTIVE SPRING PACK
1. Remove snap ring which holds governor spring pack in sleeve with a pair of snap ring pliers.

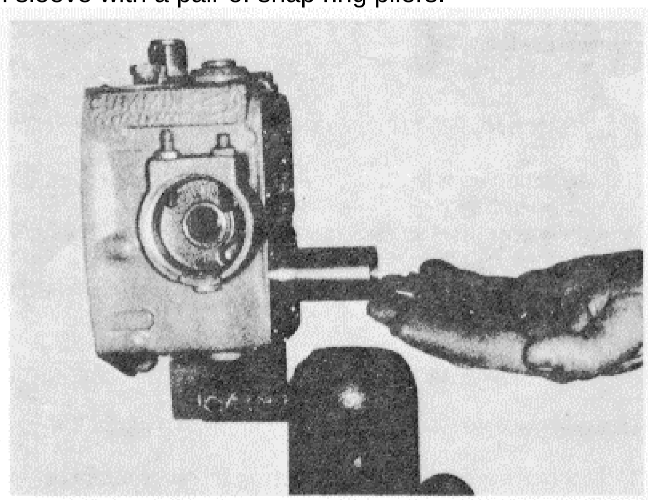


Figure 16G-54. Removing Standard Spring Pack Assembly

2. Remove high-speed spring, spring retainer and shims from spring-pack housing.
3. Remove idle spring plunger guide, idle spring or springs, idle spring plunger and spring washer, Figure 16G-54.

See Fuel Pump Assembly section for assembly of governor spring pack to fuel pump.

STANDARD SPRING PACK USED WITH
VS GOVERNOR (UPPER ENGINE)
1. Remove snap ring, shims and spacer from governor sleeve, Figure 16G-55.
2. Pull on idle adjusting screw to remove maximum speed spring and idle button guide which contains idle adjusting screw, screw clip, idle screw adjusting washer, idle spring and idle spring plunger.

Table 16G-7. Governor Springs

Color Code	Wire Dia. Inch (mm)	Number Coils	Pounds Load (kg)	Inches Length @ (mm)	Free Length Inch (mm)
Maximum or High Speed Spring and Specifications (Upper and Lower Engine)					
Blue/Purple	.086 (2.18)	8.4	11.65/10.75 (5.28/4.89)	@ 1.00 (25)	1.487 (37.8)
VS Governor Spring and Specifications (Upper Engine)					
Blue	.072 (1.83)	8.5	8.03-6.57 (3.64-2.98)	@ 1.12 (28)	1.318 (33.5)
Weight Assist Springs and Specifications					
Blue (Lower Engine)	.028 (.711)	9.7	3.30-3.70 (1.50-1.68)	@ .325 (8.2)	.584 (14.8)
White/Yellow (Upper Engine)	.022 (.599)	10	0.90-1.10 (.41-.50)	@ .325 (8.2)	.475 (12.1)
Idle Springs and Specifications					
None (Idle) VS (Upper)	.032 (.813)	6.5	0.28-0.36 (0.13-0.16)	@ .265 (6.7)	.335 (8.50)
Yellow (Upper and Lower)	.039 (.991)	11.5	*		.900 (23)

*Preload 3.5 lb., compress .250 more, load must be 11.75-12.75.

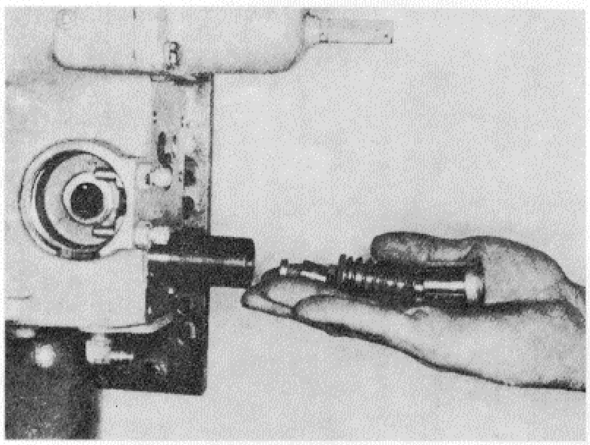


Figure 16G-55. Removing Spring Pack Assembly of VS Pump

PRESSURE VALVE (UPPER ENGINE)

1. The VS governed fuel pump housings are pressurized. The pressure valve is located in the rear of the housing near the gear pump drive shaft.
2. Remove valve with long nose pliers.
3. Drive in new pressurizing valve into housing with ST1250 Mandrel, allowing 0.030 to 0.090 inch (0.76 to 2.29 mm) to protrude out of housing. The open end is assembled toward outside of housing. This allows the gear pump gasket to 3eal the end of the valve when gear pump is assembled, Figure 16G-56.
4. Test valve at full rated rpm by loosening top adjusting screw in VS spring pack cover.

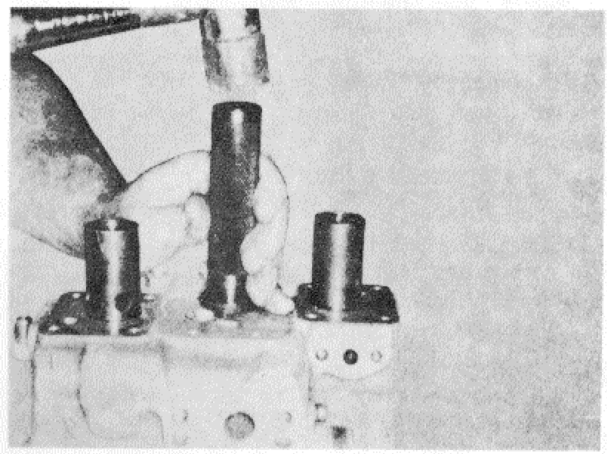


Figure 16G-56. Driving Pressure Valve into Housing

NOTE

Do not remove lower plug at high rpm, Figure 16G-57.

FUEL PUMP ASSEMBLY

GENERAL

The pump assembly requires all parts to be dirt free, and the actual operations performed with the utmost care, to insure proper and trouble free performance.

VISE AND HOLDING FIXTURE

Mount the fuel pump on Holding Fixture 3375133 and Swivel Vise ST-302.

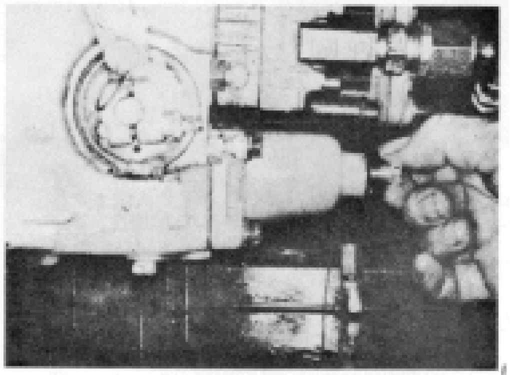


Figure 16G-57. Checking Pressure Valve at 600 RPM

FILTER SCREEN

1. Assemble the filter screen assembly into top of standard lower engine) housing, hole in retainer goes down, Figure 16G-58.

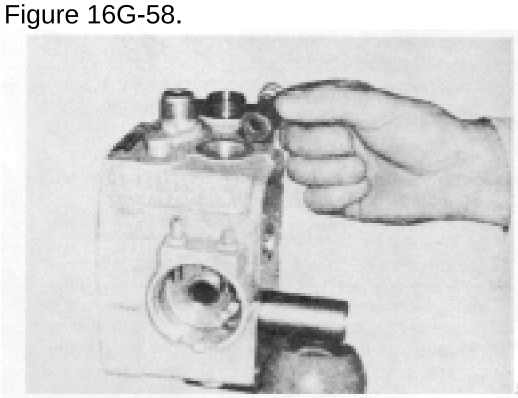


Figure 16G-58. Installing Fuel Screen in Standard Housing

2. Install O-ring using grease to hold in place.

3. Position spring and tighten cover in place. Torque cap to 3 to 12 foot pounds (11 to 16 N.m). Overtightening is not necessary or desirable.

4. Assemble screen in bottom of VS governed housing upper engine) with hole in screen up, Figure 16G-59.

5. Install spring, plug and secure with snap ring.

GOVERNOR SPRING PACK

1. Assemble idle screw into plunger guide, place small washer over screw point inside guide, Figure 16G-60. Place small idle spring into guide and place idle plunger (button) against spring in guide, Figure 16G-61.

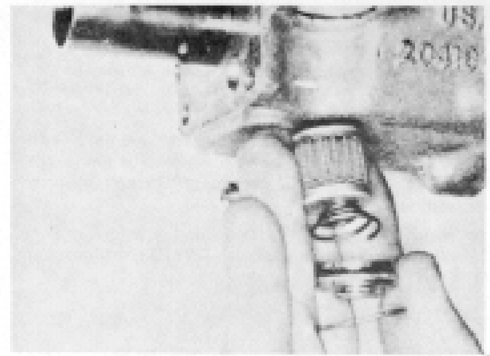


Figure 16G-59. Installing Fuel Screen in VS Housing

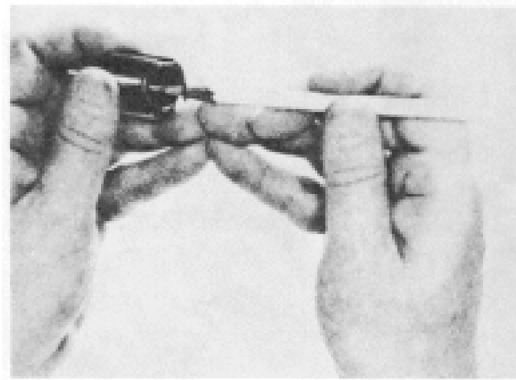


Figure 16G-60. Installing Washer Over Idle Screw

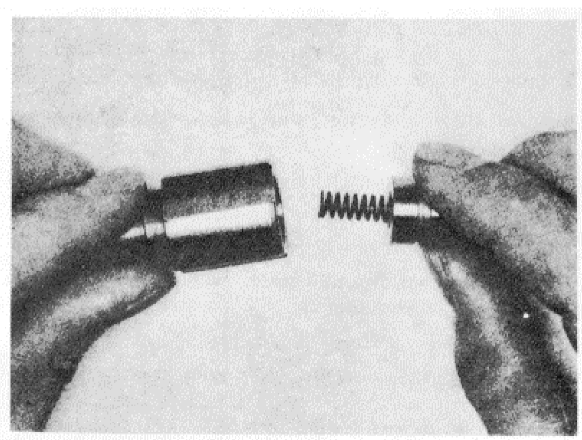


Figure 16G-61. Installing Idle Plunger Button

2. The plunger controls maximum fuel pressure produced by the fuel pump.

NOTE

There are different maximum speed springs available and each is identified by color stripes. See Governor Spring Pack section, Table 1 6G-7, for tabulation and specifications.

Shims are available in 0.005, 0.010 and 0.020 inch (0.13, 0.25 and 0.51 mm) thickness. The final number of shims must be determined during fuel pump calibration.

3. Install the spring pack cover and new gasket. Secure over to housing, torque capscrews to 9 to 11 foot pounds 12 to 15 N.m).

THROTTLE SHAFT

1. Lubricate O-ring and slide on new fuel adjusting screw with screwdriver slot.
2. Insert fuel adjusting screw into throttle shaft about 6 urns. Do not restrict throttle shaft fuel port, Figure 16G-62.

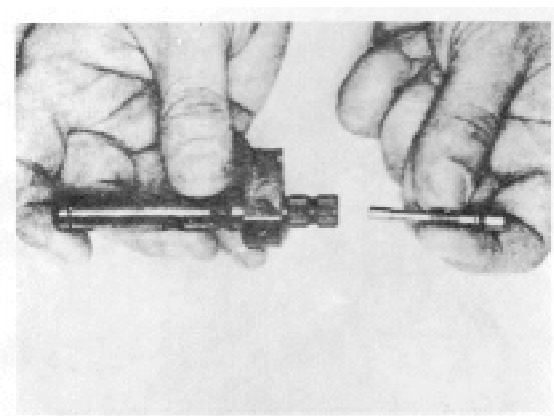


Figure 16G-62. Installing Fuel Adjusting Screw in Throttle Shaft

3. Lubricate O-ring and slide on throttle shaft.
4. Insert throttle shaft in housing with counterbored port own.
5. Install the throttle shaft with throttle stop up in AFC pump.
6. Install snap ring on end of throttle shaft, Figure 16G-63.
7. Install ball in throttle shaft, with Service Tool No. 3375204, after pump has been calibrated.

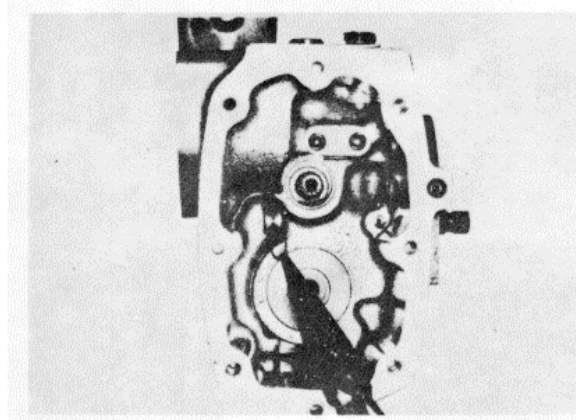


Figure 16G-63. Installing Snap Ring in Throttle Shaft

THROTTLE LEVER

Install the throttle lever on throttle shaft and tighten securely. Throttle levers are available in lengths of about 11/4 to 5 inches (31.7 to 1 27 mm); use the correct length for the pump application.

The spring loaded throttle lever is used to prevent throttle shaft bushing wear and scoring that can occur when excessive pressure is applied to the throttle lever in full fuel position. The spring loaded lever is designed to collapse under this excessive pressure and then spring back when the pressure is released.

This will also prevent the throttle lever from turning on the shaft and mutilating the serrated shaft diameter.

NOTE

The throttle lever stop in the vehicle chassis should be adjusted so there will be a minimum or negligible amount of collapsing of throttle lever. Otherwise, the purpose of the spring loaded lever will be defeated as the lever can collapse only so far. When the throttle linkage stop is not properly adjusted, the spring loaded lever may permit the bell crank in the linkage mechanism to go "over center," locking the throttle in full fuel position.

GOVERNOR PLUNGER

1. Lubricate with engine oil and install the plunger into barrel, Figure 16G-64. Make sure plunger is correct fit and change number if replaced. Remark governor barrel if oversize plunger is used, so size of barrel and plunger correspond.

Table 16G-8. Throttle Shafts 1/2" PT (Type G)

Standard, except as noted:									
Code	Red	Blue	Green	Yellow	Orange	Black	Gray	Purple	Note
Size	0	1	2	3	4	5	6	7	AFC-0.173 Fuel Port

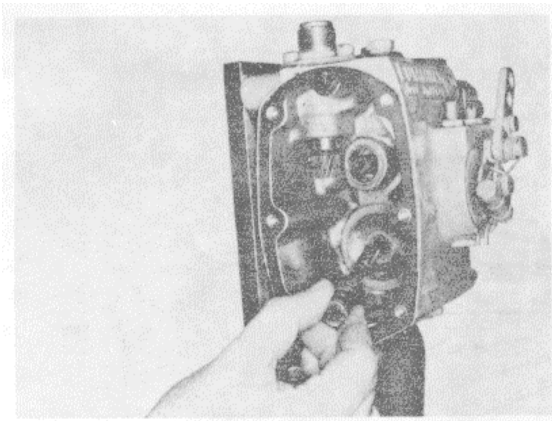


Figure 16G-64. Installing Governor Plunger

2. Lubricate VS plunger with engine oil and install in upper barrel.

DRIVE COVER ASSEMBLY

1. Place a new gasket over the pump housing dowel pins.

2. Place the assist plunger in the weight shaft bore with spring and shims.

3. Hold the governor weights in to hold the assist plunger while assembling cover to housing, meshing with tachometer gear, Figure 16G-65.

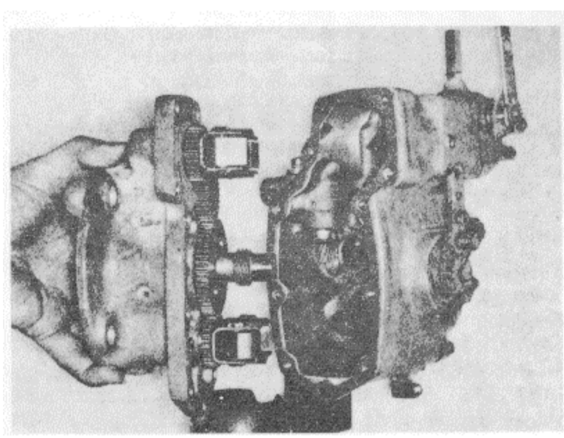


Figure 16G-65. Installing Front Cover on VS Housing

4. Position plunger drive tang horizontally, position weight carrier horizontally.

NOTE

The weights straddle the governor plunger driver.

5. Torque capscrews 9 to 11 foot pounds (12 to 15 N.m)securing cover to housing.

6. Rotate drive shaft to be certain tachometer gear meshes.

GEAR PUMP

1. Assemble the gear pump to the main housing using a new gasket. Locate notch or ridge for right hand or left hand rotation. For right hand rotation locate notch or ridge to upper right hand corner (looking from behind the fuel pump); for left hand rotation locate the notch or ridge to bottom left hand corner. See page 16G-30.

NOTE

Use correct gasket and be sure it is positioned correctly. Be certain housing fuel holes match gear pump holes.

2. Torque capscrews in increments to 1 !1 to 13 foot pounds (15 to 18 N.m), Figure 16G-66. Check gear pump rotation freedom.

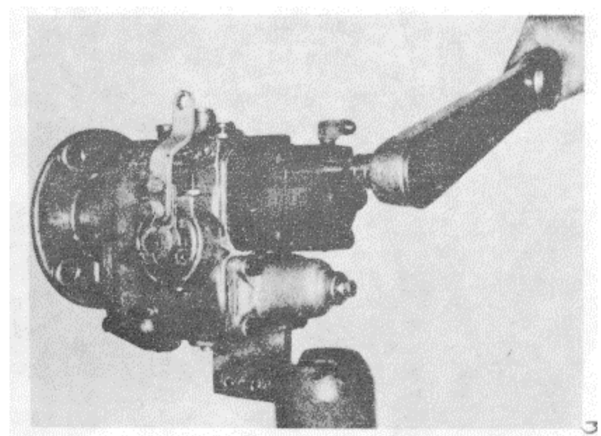


Figure 16G-66. Torquing Gear Pump Capscrews

3. Install fuel inlet connection with same type threads as gear pump. Current gear pumps use a 3/4 inch-16UNF threaded connection with an O-ring.

4. Install cooling check valve elbow into top of gear pump.

SHUT-DOWN VALVE AND PULSATION DAMPER

1. Install the shut-down valve with new O-ring on fuel pump housing.

2. Install damper with new O-ring to the gear pump. Torque capscrews to 11 to 13 foot pounds (15 to 18 N.m).

CALIBRATION TEST EQUIPMENT

GENERAL

Correct calibration of the fuel pump is one of the most important procedures to satisfactory engine operation. Correct calibration is possible only with accurate test equipment as described in the following paragraphs.

ST-848 TEST STAND

DESCRIPTION. Cummins ST-848 fuel pump test stand has the following features to provide accuracy:

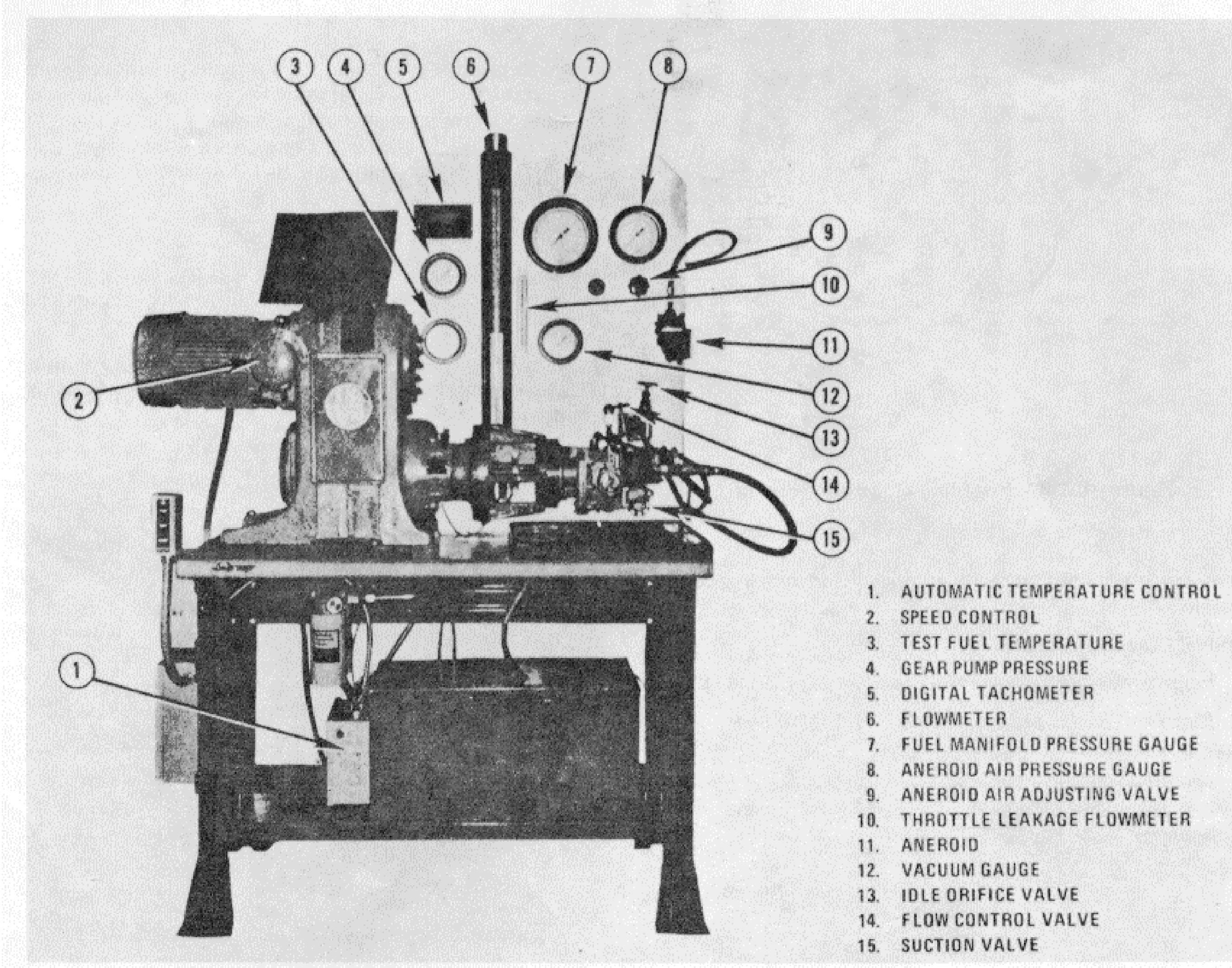


Figure 16G-67. Cummins ST-848 Fuel Pump Test Stand

1. Large dial, laboratory accurate gauges. However, gauges are only accurate if properly maintained and should, therefore, be checked at regular intervals.
2. A digital tachometer is now in ST-848.
3. A flowmeter, which permits the tester to adjust each fuel pump for total flow and correlate it with pressure calibration. The "fuel manifold pressure" thus obtained on the test stand will duplicate fuel manifold pressure on the engine.

TEST OIL. Cummins fuel pump test stands must be filled with clean Cummins Test Oil, Service Tool No. 3375364 or equivalent since all calibration data has been established using this test oil.

NOTE

Hydraulic oils or any other oils are not suitable to use as test oils.

Duplication of factory test methods and materials is the key to correct calibration and insures uniform results wherever the fuel pump is adjusted.

CHEMICAL AND PHYSICAL REQUIREMENTS

Kinematic viscosity at 100°F
centiStokes, ASTM D445 .... 2.55-2.85
Specific gravity at 600F,
ASTM 1298.. 0.819-0.829
Flash point, P.M., closed cup, ASTM D93
167°F min. color, ASTM D1 500....................3 max.
Water and sediment, ASTM D2273 ....0.01
Corrosion, ASTM D130.................... must pass Class 1
Galvanic corrosion, ASTM 5322-1 .... must pass 10 days
Sulphur % weight, ASTM D129 ....0.4
Distillation at 5% volume,
ASTM D86..410°F max.
Foaming tendency, 75°F
ASTM D-892..................................5 min. (blow) 50
Foaming stability, 75°F
ASTM D-892...................................2 min. (settle) 0
Gum, ASTM D-892 .... Anti-gumming
Rust protection sand blasted panel,
ASTM D-1748..................................pass 100 hours

FUEL PUMP

Cloud point, ASTM D2500................................140F max.
Aromatic components, ASTM D2140................12% max.

Viscosity Oil Co., SAE J967d and Mobil Oil Company No. 68605 meet the above requirements. Cummins Service Tool Part No. 3375364.

The material shall be a straight oil or a blend of oils containing parafinic, aromatic, or napthenic compounds, but not olefinic compounds, which show little or no change in physical properties during storage or use. The use of various additives and/or inhibitors to stabilize the oil is left to the discretion of the supplier. The additives must be antifoaming, anti-corrosive and anti-gumming. The fuel, additives, and color dye must be non-toxic and non-harmful to personnel.

INSTRUMENTS. A fuel pump cannot be calibrated with any greater precision than that of instruments on the test stand. Pressure, speed and flow measurements must be very accurate, since these are the factors which determine the pump characteristics.

The instruments on a fuel pump test stand and engine test stand have the accuracy required for precision calibration and testing when new, but this accuracy must be periodically checked and maintained.

CAUTION

Cummins Engine Company, Inc. assumes no responsibility of damage if fuel pump is calibrated to a different specification than listed for a specific engine model and pump code.

FORMULA TO DETERMINING SAE BRAKE HORSEPOWER. Evaluation of engine performance during testing is for the most part, based on accurate horsepower readings. Therefore, it is imperative that the following formulas be used with test procedures. The basic formula to determine brake horsepower is as follows:

Brake Horsepower =

$$\frac{\text{Torque in (ft. lbs.) x Engine rpm}}{5252}$$

Most engine dynamometer manufacturers provide a figure known as a "brake constant" with each dynamometer. The constant simplifies the process of computing brake horsepower since only engine rpm and the scale reading (in pounds) need be found by the test mechanic. The formula used with a known constant is:

Brake Horsepower =

$$\frac{\text{Lbs. (on Dyno. Scale) x Engine rpm}}{\text{Dynamometer Constant}}$$

Example: Dynamometer in operation has brake constant of 500. Scales show a reading of 50 pounds and tachometer shows engine rpm of 1600.

Brake Horsepower =

$$\frac{50 \times 1\ 600}{500}$$

The above formulas apply to engine dynamometers only. Where chassis dynamometers are used, a factor of approximately 25% must be used to compensate for gear ratios, tire size, etc.

CALIBRATION INSTRUCTIONS

GENERAL

The purpose of fuel pump testing and calibration is simply to make adjustments prior to pump installation on an engine which will assure engine performance within specifications. Test stand calibration then is a time-saving practice. The fuel pump could be calibrated or completely adjusted on the engine if you were able to control the load as is done on a dynamometer, but the time required would be prohibitive.

PUMP HOOKUP

1. Install the proper drive coupling to test stand, which matches pump drive shaft coupling, so pump being tested may be driven, Figure 16B-68.

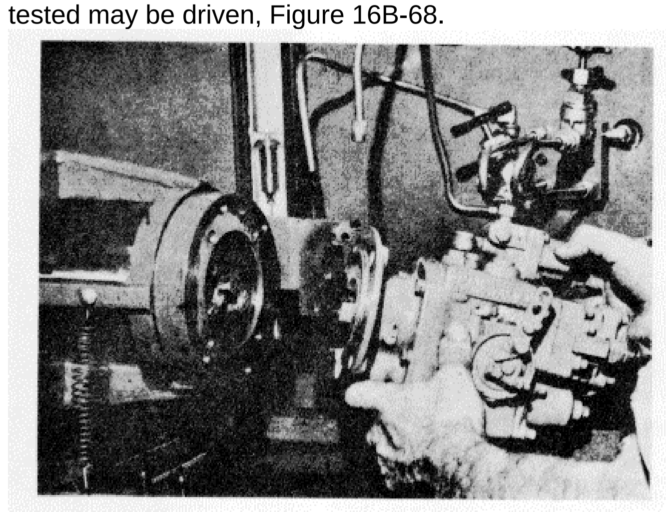


Figure 16G-68. Mounting Fuel Pump with Buffer Type Drive

2. Before mounting fuel pump, check the location of the mounting holes; it may be necessary to change the test stand adapter plate.
3. Squirt SAE-30 lubricating oil or a 50-50 mixture of lubricating oil and isobutylene polymer or methacrylic copolymer lubricating oil additive (such as STP) on tachometer drive gears to provide adequate lubrication during calibration, Figure 16G-69.
4. Remove AFC cover plate (lower engine) and replace with plunger adjusting Service Tool No. 3375137, on AFC pumps, Figure 16G-70.
5. Mount fuel pump on test stand mounting bracket leaving about 1/16 inch (1.587 mm) between fuel pump coupling and test stand drive coupling.

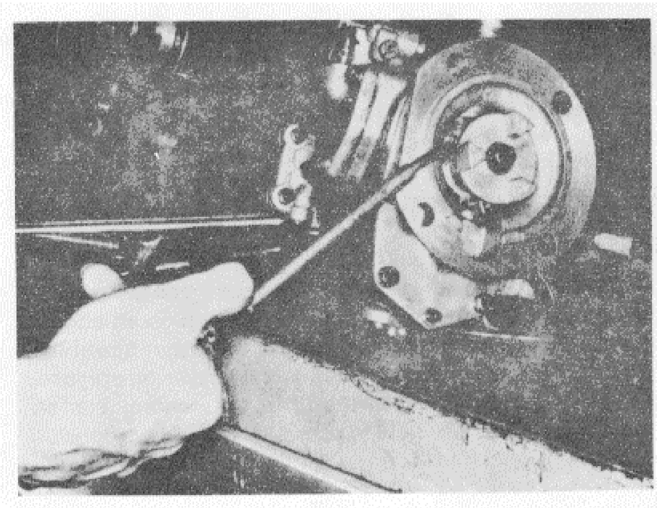


Figure 16G-69. Lubricating Front Cover Tachometer Drive Gears

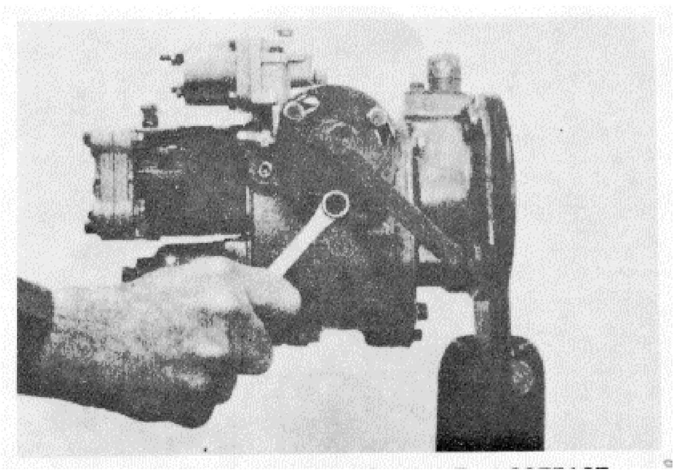


Figure 16G-70. Installing Service Tool 3375137 on AFC Fuel Pump

NOTE

To obtain the 1/16 inch clearance, it may be necessary to adjust the test stand coupling.

6. Squirt some clean test oil into the gear pump inlet hole, so pump will pick up faster, then connect suction ljne, Figure 16G-71.
7. Fill fuel pump housing with clean test fuel through the plug hole on top of pump. Reinstall plug or fitting.
8. Connect line to fuel pump shut-down valve. Remove pipe plug to rear of AFC plug cavity on VS pump (upper engine) and connect gear pump pressure line.
9. Connect a 0 to 60 in-Hg (O to 1524 mm Hg) 30 psi (207 kPa) regulated air pressure line to the AFC plunger adjusting service tool fitting (lower engine).
10. Set air pressure to 50 in-Hg (1270 mm Hg), 24.5 psi (169 kPa).

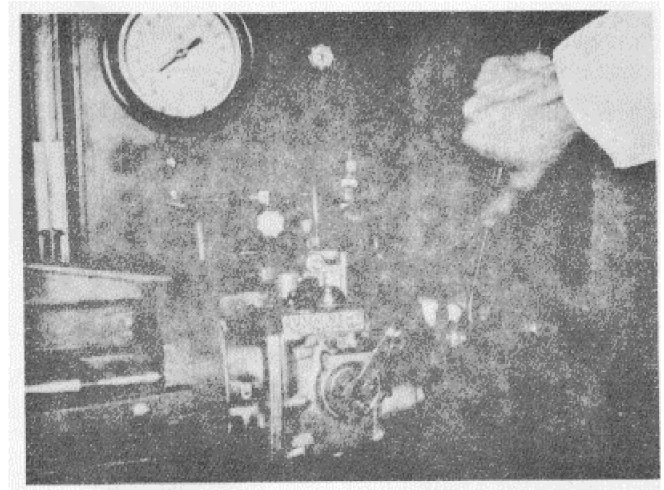


Figure 16G-71. Connect Gear Pump Suction Line

11. Connect a No. 4 hose to the check valve on gear pump, if used. Drain into splash tray under pump.

CAUTION

Never operate gear pump having cooling drain with the check valve hole plugged.

12. Never remove fuel pressure damper either during testing or operation as it will cause erratic pump performance and accelerate wear.
13. Use digital tachometer connected to the fuel pump drive shaft to obtain most accurate speed readings.
14. The ST-848 Test Stands with 60 cycle current require only that the reverse or forward start button be pressed depending on right or left hand pumps, Figure 1 6G-72.

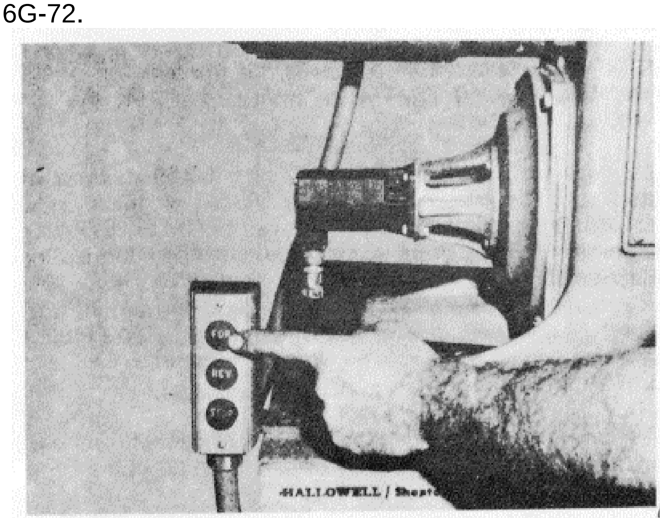


Figure 16G-72. Starting 60 Cycle Motor

15. The ST-848 Test Stands with 50 cycle current requires a change in motor brush location to reverse motor for left hand fuel pumps, Figure 16G-73. Rotate cover shown to position required by loosening two cover screws.

FUEL PUMP

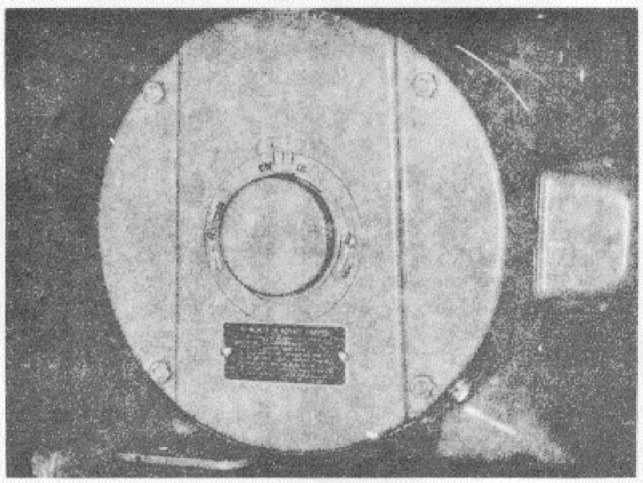


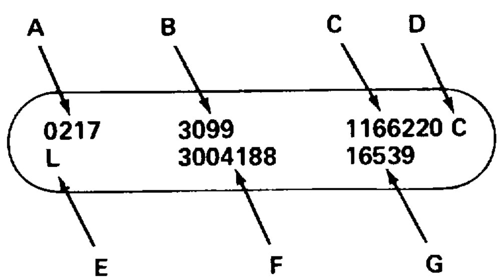
Figure 16G-73. 50 Cycle Motor Brush Location to Reverse Motor

16. Remove fuel pump mounted fuel filter and replace with fuel filter adapter, Service Tool No. 3375014, and gasket 337501 5.

CHECK PUMP NAMEPLATE

Make sure the fuel pump nameplate properly describes the fuel pump to be calibrated.

1. The first item in the top line is Control Part List. 0217.
2. The next four spaces will be the Base Fuel Pump Code. 0217 3099, Figure 16G-74.



A Control Parts List
B Fuel Pump Code
C Pump Serial Number
D Latest Code Revision
E Left Hand Rotation
F Pump Assembly Number
G Engine Shop Number Number

Figure 16G-74. Fuel Pump Nameplate

3. The next eight spaces give fuel pump Serial Number. 0217 3099 1166220 C. The letter following the serial number is the latest code revision.
4. The first space on the bottom line will be stamped "L" when pump is left handed. Right hand fuel pumps will not be stamped.

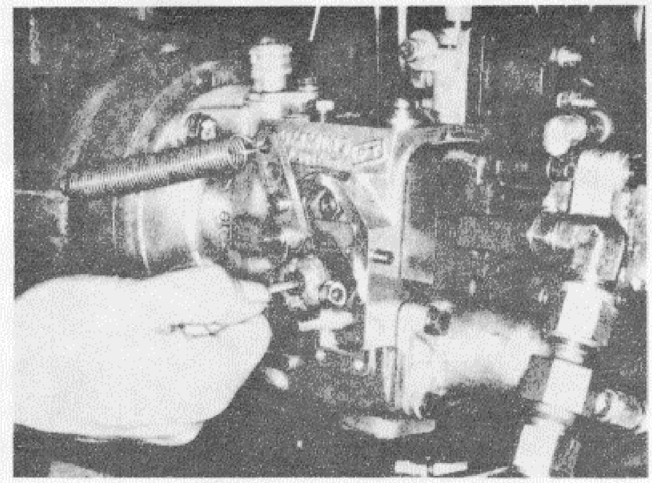


Figure 16G-75. Adjusting Throttle Shaft Internal Fuel Adjusting Screw

5. The next seven spaces on bottom line will be the Fuel Pump Assembly Number. L 3004188.
6. The last five spaces on the bottom line give the Engine Shop Order Number. L 3004188 16539.

RUN-IN

1. Check the restriction plunger to be certain throttle shaft hole is completely open, Figure 1 6G-75. This is not necessary if calibration is being checked as a troubleshooting step. Replace shaft, if removed.
2. Move and hold throttle control lever to full fuel position, it may be necessary to adjust the throttle screws to ensure that the fuel port in the throttle is fully open and indexed with the fuel passage in the fuel pump body. It is not necessary to adjust the throttle screw if the calibration is merely being checked as a troubleshooting step.

NOTE

The front throttle stop screw is for throttle travel adjustments; rear screw is for throttle leakage adjustments.

3. Open completely the fuel pump shut-down valve, by turning knob clockwise, Figure 1 6G-76 and open test stand flow control valve. Shift throttle to wide open position, (secure with a spring) start and run pump at 500 rpm. Check gear pump pick-up.
4. Increase test stand rpm to 100 rpm under pump rated speed.
5. If pump is newly rebuilt or has been opened, run for two or three minutes to flush, and purge all airfrom the system.
6. Before starting calibration, check pump fuel flow in the flowmeter for air. If air is present, correct leak before continuing test.
7. The test oil or fuel temperature must be 90 to 1000F (32 to 380C).
8. Set fuel pump suction restriction at 8 inch (21 cm) Hg. vacuum during run-in. This setting will aid in finding test stand or fuel supply line restriction and air leaks.

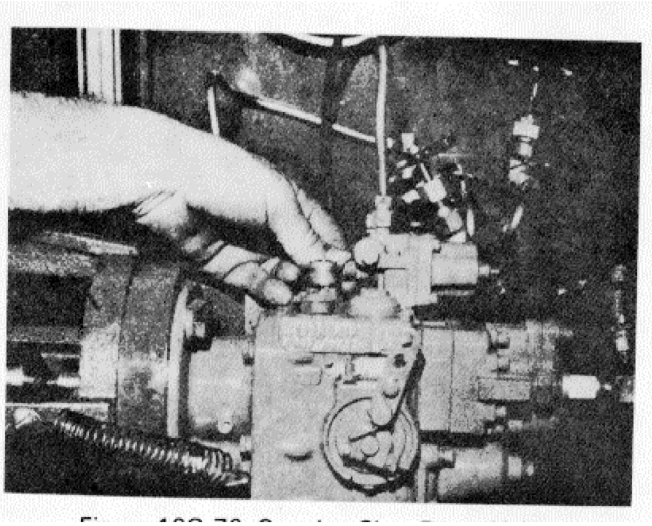


Figure 16G-76. Opening Shut-Down Valve

CALIBRATION PROCEDURE AFC STANDARD AUTOMOTIVE GOVERNOR (LOWER ENGINE)
The fuel pump code for the lower engine is E045.

GOVERNOR CUTOFF SPEED. Set governor cutoff speed as follows:
1. Close idle orifice and leakage valves. Open flow control valve.
2. Increase pump speed to 2100 rpm.
3. Make sure you have 50 in-Hg. (1 270 mm Hg.) 24.5 psi (169 kPa) air pressure to AFC.

Table 16G-9. Fuel Pump Calibration (Lower Engine)

1 Pump Code	E045 I
2 Date - Control Parts List	JAN80 0183
3 Test H.P @ R.P.M.	441 - 459 @ 2100
4 Rail P.S.I.	171 - 185
5 Torque Rise % Curve	20 C-3562
6 No Air Snaprail P S I	
7 Fuel Rate Pound Per Hour	164 - 171
8 Auto Gov. Cutoff	2130 - 2150
9 V.S. Gov Cutoff	–
10 Throttle Leakage - Cc-Pph	75
11 Throttle Travel	28
12 Idle Speed P.S.I. @ R.P.M	10 @ 700
13 Idle Speed C C @ R.P.M	@
14 Intake Mfd. Press. In./Hg	32 - 40
15 Calibration P.S.I. @ R.P.M	180 @ 2100
16 Calibration Flow	525
17 Check Point (1) P S I @ R P M	128 - 134 @ 1500
18 Check Point Flow	436
19 Check Point (2) P S I @ R P M	67 - 73 @ 1000
20 Check Point Flow	285
21 Weight Assist Setting - Spring	860 143847
22 Idle Plunger Code Part No.	35 140922
23 Auto Idle Spring	3018767
24 Auto Gov Spring	143251
25 Gear Pump Size	.750
26 Auto Gov Weights	146437
27 Auto Gov. Plunger	182530
28 Torque Spring - Shims	138790 .000
29 V.S Gov Max Spring	
30 V S Gov Idle Spring	
31 V S Gov Weights	
32 V S Gov Plunger	
33 V S Gov. Sleeve	
34 Aneroid Assembly	
35 A F.C In./Hg - P.S.I.	10 - 4.9
36 A F.C Or Aneroid R P M	1600
37 A F C P S I - Flow	79 - 335
38 A F C Spring	179830
39 A F C No Air Setting R P.M	1600
40 A F C No Air P S I - Flow	59 - 252
41 Certified - Year - By	1979 EPA
42 Certified By	
43 Engine Model	KT-450
44 Notes	

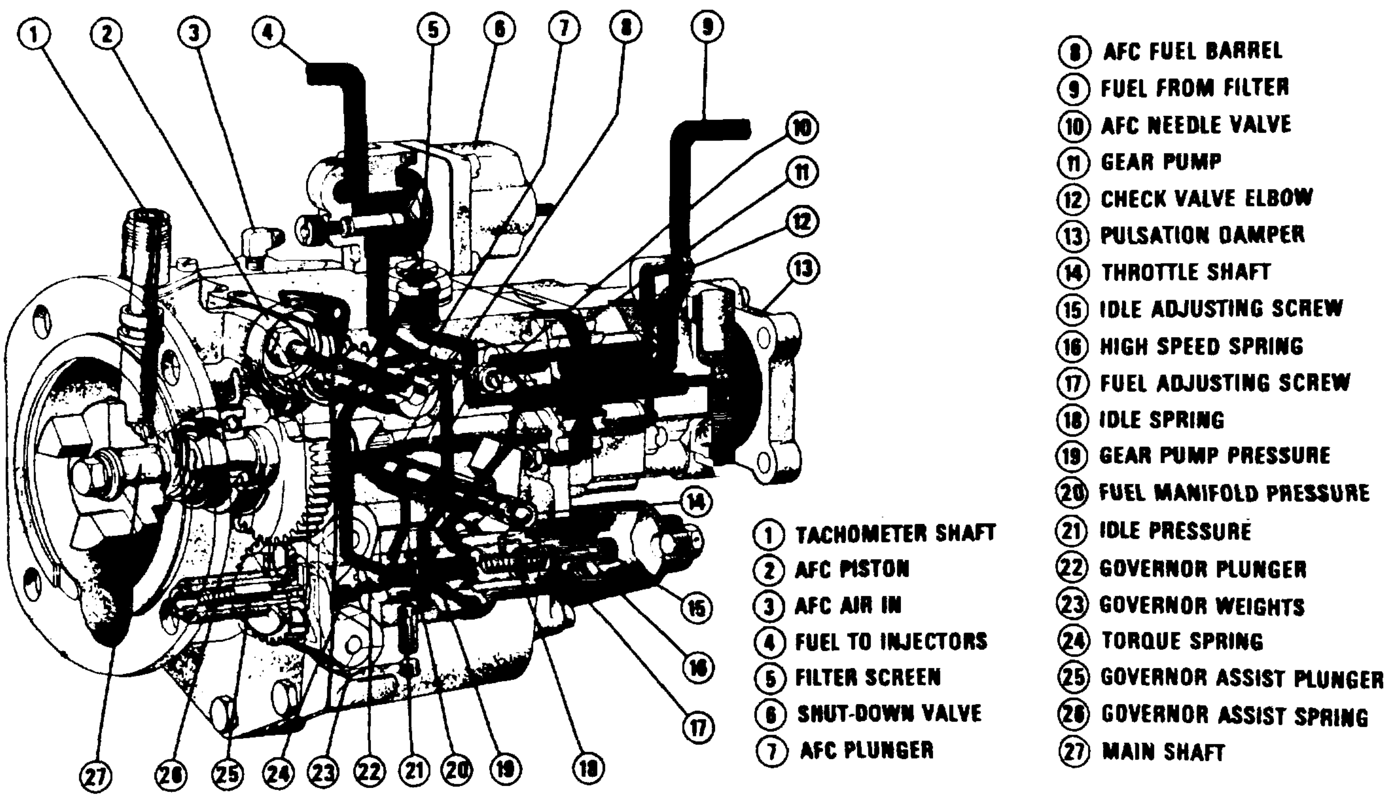


Figure 16G-77. PT (Type G) Fuel Pump Cross-Section and Fuel Flow with Air Fuel Control

FUEL PUMP

4. Close the flow control valve until the flowmeter shows 525 flow. There must be no air visible in the flowmeter.
5. Adjust vacuum valve in fuel pump suction line to obtain 5 inch (12.7 cm) Hg. on vacuum gauge, Figure 1 6G-78.

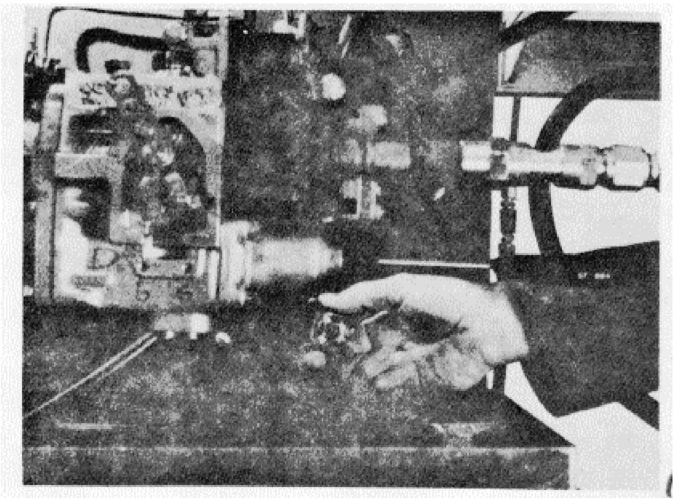


Figure 16G-78. Adjusting Vacuum Valve in Fuel Pump Suction Line

6. If you cannot obtain 5 inch (12.7 cm) Hg. of vacuum, check for restriction in test stand filter or fuel supply line.
7. If flow value cannot be obtained and held, check idle plunger (fuel button) and governor cut-off rpm. The difference between plungers is about 5 to 10 psi.
8. Open fuel pressure gauge valve. With throttle in full fuel position, increase pump speed until point at which fuel pressure drops 1 psi. This should occur at 2130/2150 rpm.
9. If speed is lower than specified, add shims between governor spring and retainer, Figure 16G-79. Check Table 1 6G-12 for spring specifications. To reduce speed, remove shims. Each 0.001 inch shim thickness will change speed approximately 2 rpm. Shims are available 0.005, 0.010 and 0.020 inch (0.13, 0.25 and 0.51 mm) thick.

NOTE

When pump is closed after making adjustments, move throttle lever back and forth with pump running, until flowmeter shows no air. After air is expelled, reset flowmeter flow as previously outlined in Step 6.

THROTTLE LEAKAGE -AFC STANDARD GOVERNOR. Set throttle leakage as follows:

NOTE

Make sure fuel is up to 90to 1 000F (32 to 380C)when setting throttle leakage.

1. Open throttle leakage valve; close main flow and idle orifice valves.
2. Run test stand at 2100 rpm.
3. Move throttle toward gear pump and hold *firmly* against stop.

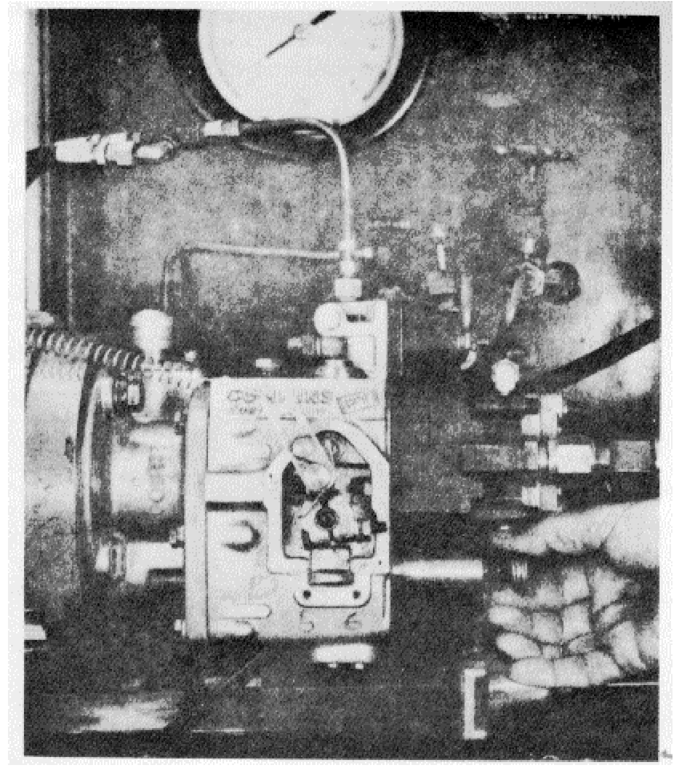


Figure 16G-79. Shimming High Speed Governor Spring

4. Check throttle leakage with throttle leakage flowmeter if test stand is so equipped. For an alternate method, use a 200 cc graduate to collect fuel delivery for one minute. Do not keep at this setting any longer than necessary to keep fuel temperature within limits.
5. Delivery should be 75 cc. If not to specifications, screw rear throttle stop screw in or out until cc delivery meets specifications. This setting is extremely important as it affects the deceleration time of the engine, Figure 16G-80.

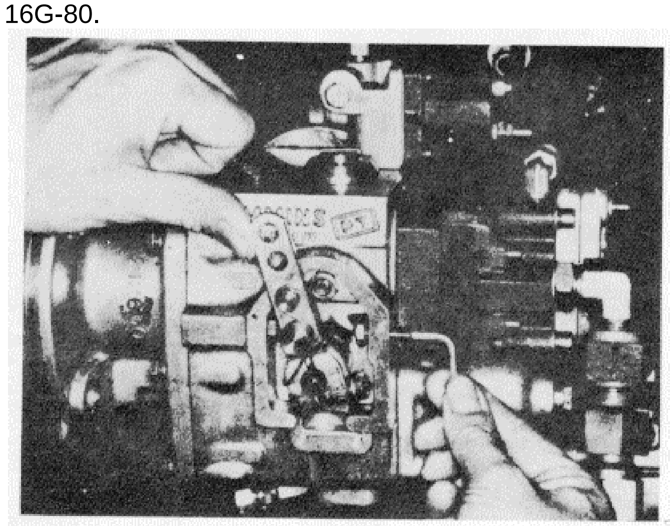


Figure 16G-80. Setting Throttle Leakage

6. Check leakage with light and heavy lever load, if leakage is decreased by additional pressure in the throttle closed position, set leakage under these conditions.
7. Lock screw when setting is correct and recheck.
8. Close throttle leakage valve.
9. If test oil temperature exceeds 1000F (380C) idle test stand and allow test oil to cool If temperature exceeds 1350F (570C), drain and replace with new test oil.

IDLE SPEED AFC STANDARD GOVERNOR. Set idle speed as follows: 1 Run test stand at 700 rpm.
2. Main flow control valve is closed. Open idle orifice valve or leakage flowmeter, if available, Figure 16G-81.

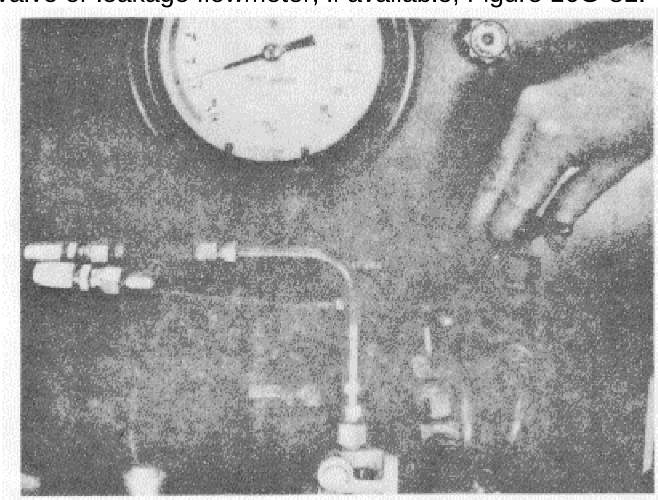


Figure 16G-81. Open Test Stand Idle Orifice Valve

3. Set throttle shaft in idle position (toward gear pump) and hold firmly against stop.
4. Check pressure on fuel manifold pressure (rail) gauge, it should be 10 psi. If cc or pressure is low, screw idle adjusting screw in with ST-984 Spring Pack Adjusting Tool; this screw is located inside governor spring pack housing. To lower pressure, back out screw, Figure 1 6G-82.

NOTE

In rare cases, where high weight assist settings are used (if screw bottoms in guide and pressure is still low), it may be necessary to add one additional spring seat washer on the spring end of the idle screw.

CALIBRATION PRESSURE AND THROTTLE TRAVEL AFC STANDARD GOVERNOR. Adjust calibration pressure and throttle travel as follows:
1. Close idle orifice valve and open main flow valve. Place throttle in full fuel position.
2. Run test stand speed up to 2100 rpm.
3. Adjust fuel flowmeter to 525 pph. Check fuel pressure on fuel manifold (rail) pressure gauge, the pressure must be

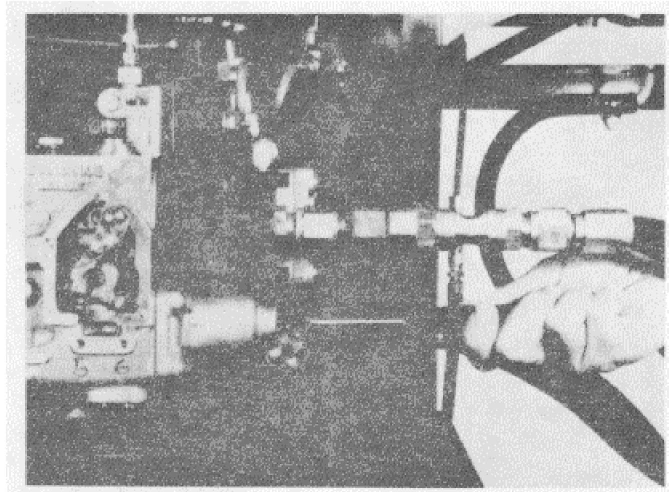


Figure 16G-82. Adjusting Lower Governor Idle Speed

180 psi. Adjust fuel pump suction restriction to 5 in. Hg. Or as close as possible.
4. Use a throttle lever travel template Service Tool 3375355 or a protractor and set the throttle lever idle position centerline at 27-290 from vertical (toward gear pump) throttle shaft centerline. Lock throttle lever retaining capscrew and nut, Figure 16G-83.

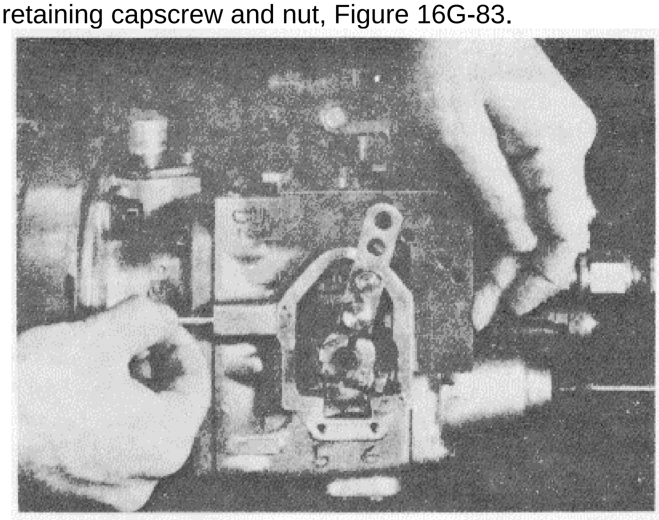


Figure 16G-83. Adjusting Front Throttle Stop Screw to Set Throttle Travel

5. Move the throttle lever to wide open position. It should be on vertical centerline (resulting in 280 idle to wide open throttle travel), lock front throttle stop screw. Lever position may now be changed as desired to accommodate linkage. *Do not adjust rear throttle screw from value set under throttle leakage.*
6. Adjust fuel calibration pressure to 180 psi by adjusting throttle shaft internal fuel adjusting screw, Figure 1 6G-84.
7. If torque required to turn fuel adjusting screw is less than 1-1/2 in. lb, a new screw should be installed.

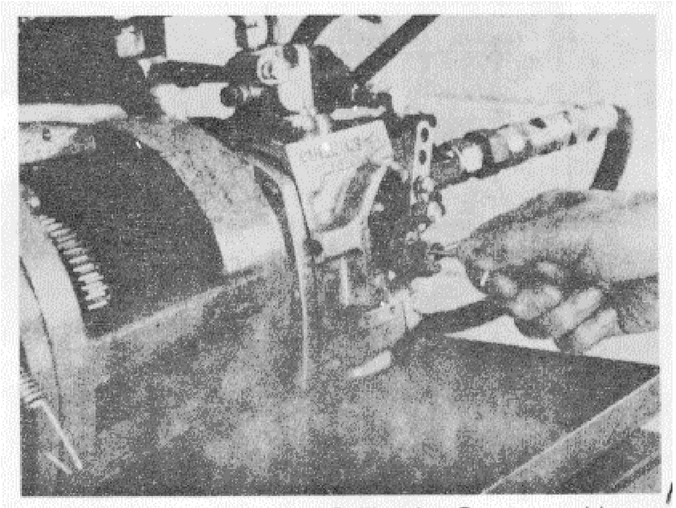


Figure 16G-84. Setting Calibration Pressure with Throttle Fuel Adjusting Screw

COMPARE CHECK POINT PRESSURE AFC STANDARD GOVERNOR. Compare check point pressure as follows:

1. Reduce speed to 1500 rpm.
2. Adjust flowmeter to 436 pph.
3. Check pressure at fuel manifold pressure gauge. The pressure must be 128/134 psi.
4. If the pressure is above or below range, check the torque spring on the governor plunger; it may not be seated, improperly shimmed, or the wrong spring. If spring is changed, recalibrate fuel pump. Torque spring shims are available 0.005, 0.010 and 0.020 inch (0.13, 0.25 and 0.51 mm) thick. See Table 16G-14 for torque spring specifications.
5. Reduce speed to 1000 rpm. Set the flow at 285. The pressure must be 67/73 psi. If out of specifications, check weight assist protrusion (see Step 6 following).
6. If fuel pressure is low at lowest rpm check point, add shims behind the governor weight assist plunger in the governor weight carrier. To decrease pressure remove shims. Shims are available 0.007 and 0.015 inch (0.18 and 0.38 mm) thick.

NOTE

Governor weight assist plunger protrusion can be checked and set by using ST-1241 Plunger Protrusion Checking Tool.

CAUTION

Weight assist plunger must be installed with the smallest end to governor plunger

AIR FUEL CONTROL PLUNGER SETTING. Adjust air fuel control plunger setting as follows:

1. Close idle and leakage valves. Open flow control valve.
2. Using Service Tool 3375140, loosen no-air needle valve jam nut, then turn no-air needle valve screw clockwise until it bottoms, Figure 16G-85.

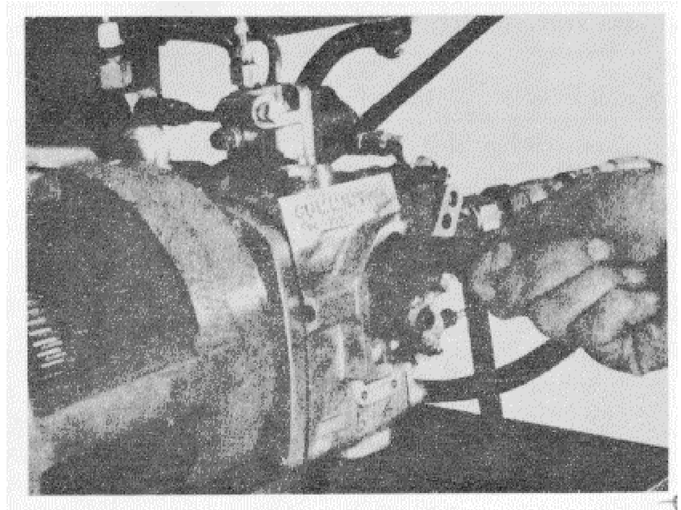


Figure 16G-85. Adjusting No-Air Needle Valve

NOTE

AFC plunger setting cannot be adjusted or checked unless no-air needle valve screw is turned in all the way.

3. Set pump to 1600 rpm.
4. Reduce AFC air pressure to 0 in. Hg. Let fuel pressure and flowmeter go to zero (0). Increase air pressure to 10 in. Hg.

CAUTION

This setting must always be reached while increasing air pressure on the AFC bellows. If specified pressure is overshot, reduce pressure to O in. Hg., and wait until flow stabilizes at or near zero before increasing to correct setting.

5. Adjust test stand flowmeter to 335.
6. Using the AFC control plunger positioning tool 3375137, unlock the plunger locknut, and adjust plunger position to obtain 79 psi fuel pressure ±2 psi. Adjusting the plunger will require resetting the flow until specified pressure and flow are obtained, Figure 16G-86.

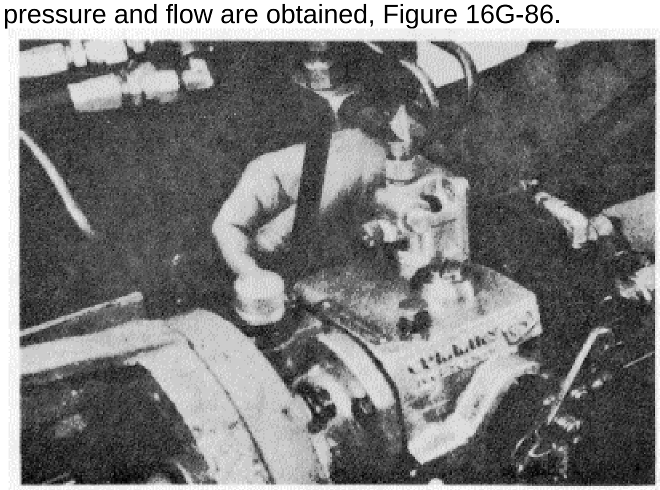


Figure 16G-86. Setting AFC Plunger Position with Service Tool 3375137

Table 16G-10. AFC Spring - Specifications (Lower Engine)

Color Code	Wire Dia. Inch	[mm]	No. Coils	Load @ Length Pounds	[kg]	Inch	[mm]	Free Length Inch	[mm]
Green-Yellow	.148	[3.76]	4.0	40.3-43.7	[18.28-19.82]	.850	[21.59]	1.200	[30.48]

CAUTION

The AFC plunger is easily broken when tightening the jam nut, use extreme care in tightening to 25 to 35 in lb (2.8 to 4.0 N.m) torque. Large and small hex sockets of Service Tool 3375137 must be fully retracted after loosening plunger jam nut to avoid interfering with AFC piston travel. If AFC piston position is disturbed while adjusting plunger, repeat sequence beginning with Step 4.

7. When AFC control plunger setting is correct, tighten plunger locknut to 25 to 35 in-lb(2.8to 4.0 N.m)torque then recheck pressure and flow to make sure limits are correct. See Table 1 6G-10 for AFC spring specifications.

NOTE

To insure tightening locknut did not change setting, check air set pressure to ensure it meets limits. Increase to 50 in. Hg (1270 mm Hg.) or 24.5 psi (169 kPa), then decrease air pressure to specified limit. If fuel (rail) pressure is more than 15 psi (104 kPa)above limits check plunger and barrel for sticking (hystersis) from contamination or improperly sized barrel or plunger.

8. Reduce air pressure to "O", remove adjusting tool and install cover plate using plain capscrews at top and lock-wire drilled capscrew in lower position. Tighten capscrews to 30 to 35 in-lb (3.4 to 4.0 N.m) torque.

AIR FUEL CONTROL NO AIR SETTING. Check and set air fuel control no-air setting as follows:

1. Set air pressure at "O" in. Hg., and run pump at 1600 rpm.
2. Using the no-air needle valve adjusting tool, 3375140, set needle valve to obtain 59 psi fuel pressure and 252 flow. Adjusting the needle valve will require resetting flow until specified pressure and flow are obtained, Figure 1 6G-85.
3. Using 3375140, Needle Valve Adjusting Tool, tighten the needle valve jam nut when the setting is correct, then recheck.
4. Throttle shaft cover plate is not secured until after the final adjustments on the engine.

PUMPS WITH VS (VARIABLE SPEED) GOVERNOR (UPPER ENGINE)

GENERAL. The VS (variable speed) fuel pump has a single throttle lever on the VS throttle shaft, Figure 1 6G-87. The l fuel pump code for the upper engine is E641.

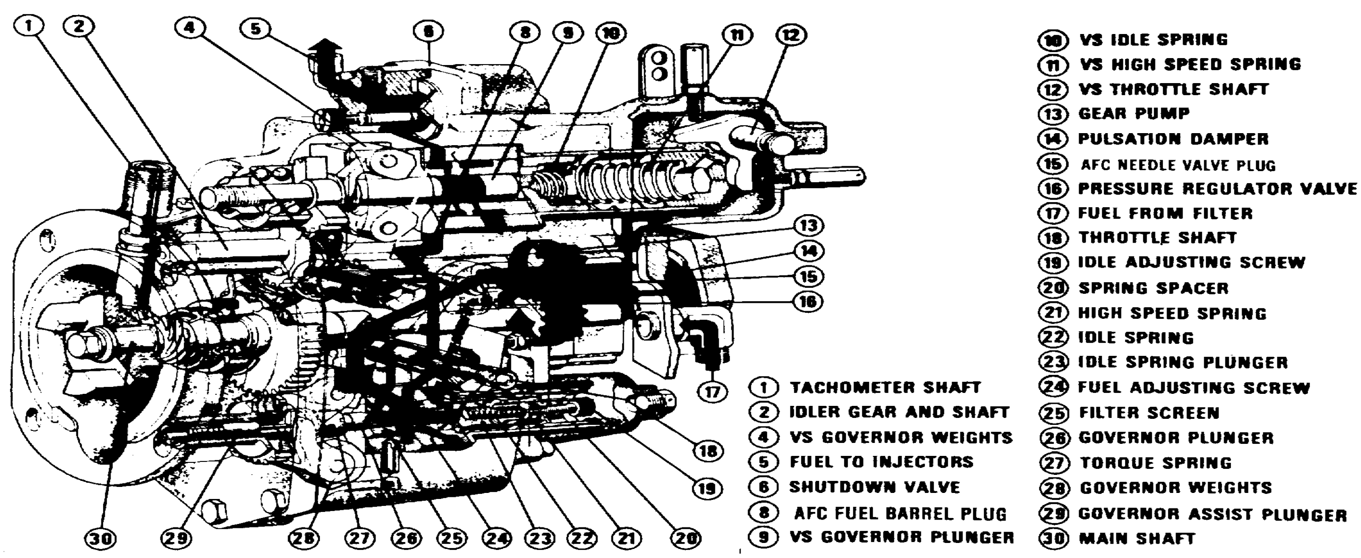


Figure 16G-87. PT (Type G) Fuel Pump with Variable Speed Governor and Air Fuel Control

Table 16G-1 1. Fuel Pump Calibration (Upper Engine)

1 *Pump Code*	*E641-A*
2 Date - Control Parts List	JUN80 0444
3 Test H.P. @ R.P.M.	441 - 459 @ 2100
4 Rail P.S.I.	179 - 193
5 Torque Rise % Curve	20
6 No Air Snaprail P.S.I.	
7 Fuel Rate Pound Per Hour	164 - 171
8 Auto Gov. Cutoff	2195 - 2215
9 V.S. Gov. Cutoff	2130 - 2140
10 Throttle Leakage - Cc-Pph	110
11 Throttle Travel	28
12 Idle Speed P.S.I. @ R.P.M.	10 @ 700
13 Idle Speed C.C. @ R.P.M.	250 @ 700
14 Intake Mfd. Press. In./Hg.	35 - 43
15 Calibration P.S.I. @ R.P.M.	184 @ 2100
16 Calibration Flow	535
17 Check Point (1) P.S.I. @ R.P.M.	130 - 136 @ 1500
18 Check Point Flow	436
19 Check Point (2) P.S.I. @ R.P.M.	- @
20 Check Point Flow	
21 Weight Assist Setting - Spring	.750 143855
22 Idle Plunger Code - Part No	32 141634
23 Auto. Idle Spring	3018767
24 Auto. Gov. Spring	143251
25 Gear Pump Size	.750
26 Auto. Gov. Weights	146437
27 Auto. Gov. Plunger	3009380
28 Torque Spring - Shims	138792 .000
29 V.S. Gov. Max. Spring	109686
30 V.S. Gov. Idle Spring	70778
31 V.S. Gov. Weights	163826
32 V.S. Gov. Plunger	212350
33 V.S. Gov. Sleeve	212148
34 Aneroid Assembly	
35 A.F.C. In./Hg. - P.S.I.	-
36 A.F.C. Or Aneroid R.P.M.	
37 *A.F.C. P.S.I. - Flow*	-
38 A.F.C. Spring	
39 A.F.C. No Air Setting R.P.M.	
40 A.F.C. No Air P.S.I. - Flow	-
41 Certified - Year - By	9999 CONS
42 Certified By	
43 Engine Model	KT-1150-C
44 Notes	

PRELIMINARY SETTINGS. Prepare pump for testing as follows:

1. Connect fuel line to fuel pump shut-down valve. This line must be connected at point used when on engine; if not, possible flow restriction can cause incorrect calibration.
2. Adjust pump housing lower throttle screws so throttle lever has full travel in both directions and so port is wide open. Do not tighten locknuts.
3. Loosen VS (upper governor) throttle lever adjusting screws, and back out until they have no effect on the lever travel. Lock the screws with the locknuts.
4. Close off test stand idle and leakage valves. All valves turn clockwise to close. Open main flow and vacuum gauge valves completely.
5. The pump housing lower throttle lever turns counterclockwise to open. The VS throttle lever turns clockwise. Attach a spring to pump housing throttle lever and solid piece of wire to VS governor throttle lever to hold them both full open. The VS governor throttle lever *cannot* be held with a weak spring. 6. Increase pump rpm to 2100 rpm. Run pump until all air is purged by watching the flowmeter.

PRESSURIZING VALVE - VS GOVERNOR. Check pressurizing valve as follows:

With pump running at 2100 rpm, loosen the VS throttle adjusting screw jam nut (top screw) and locknut. Fuel should leak around the screw if the pressure valve is properly pressurizing the housing. This can also be done by *loosening* the plug in the standard governor spring pack housing cover with pump at 600 rpm. *Do not* remove this plug while the pump is running at 2100 rpm because the pump body is pressurized when the pressurizing valve is functioning properly, Figure 16G-88. Fuel pressure inside housing should be between 1/2 and 5 psi from 600 rpm to 2100 rpm.

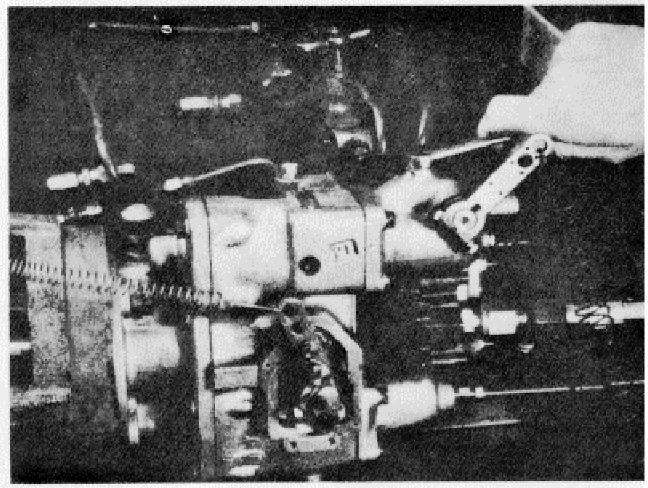


Figure 16G-88. Checking Housing Pressurizing Valve

GOVERNOR CUTOFF SPEED AFC-VS GOVERNOR. Set governor cutoff speed as follows:

1. Close idle, leakage and pressure valves. Open flow control valve.
2. Increase pump speed to engine 2100 rpm.
3. Close the flow control valve until the flowmeter shows 525 pph. There must be no air visible in the flowmeter.
4. Adjust vacuum valve in fuel pump suction line to obtain 5 inches (12.7 cm) Hg. on vacuum gauge.
5. If you cannot obtain 5 inches (12.7 cm) Hg. of vacuum, check for restriction in test stand filter or fuel supply line.
6. If flow value cannot be obtained and held, check idle plunger (fuel button) and governor cutoff rpm. The difference between plungers is about 5 to 10 psi.
7. Open fuel pressure gauge valve. With lower throttle in full fuel position, increase pump speed until point at which fuel pressure drops 1 psi. This should occur at 2195/2215 rpm.
8. If speed is lower than specified, add shims between governor spring and retainer. Check Table 16G-12 for spring specifications. To reduce speed, remove shims. Each 0.001 inch shim thickness will change speed approxi-

mately 2 rpm. Shim are available 0.005, 0.010 and 0.020 inch (0.13, 0.25 and 0.51 mm) thick, Figure 16G-89.

NOTE

When pump is closed after making adjustments, open flow control valve wide open and move throttle lever back and forth with pump running, until flowmeter shows no air After air is expelled, reset flowmeter flow as previously outlined in Step 3.

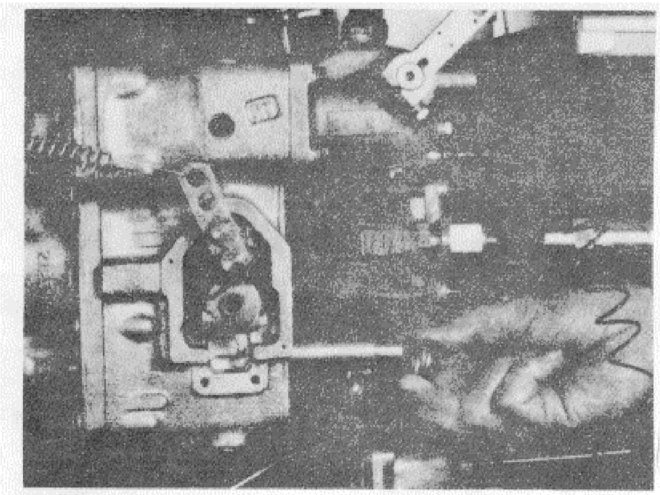


Figure 16G-89. Shimming High Speed Governor Spring

9. With pump operating at rated rpm, turn VS maximum speed screw (top screw) in until pressure starts to drop, Figure 16G-90.

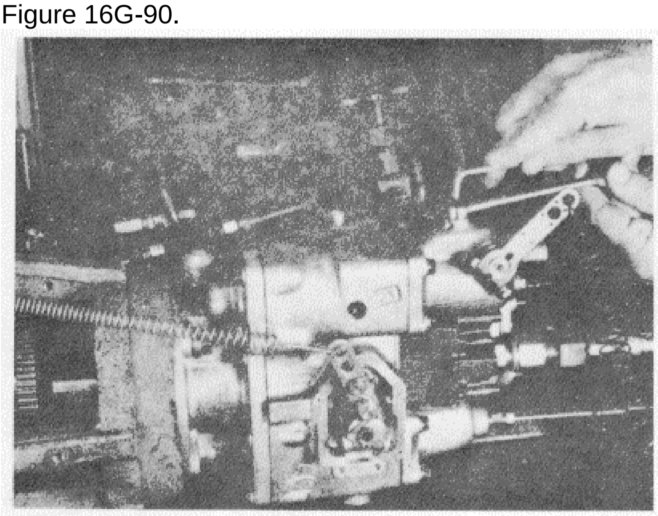


Figure 16G-90. Setting VS Maximum Governing Speed

10. Set VS governor cutoff speed to 21 30/21 40 rpm.
11. Check by increasing rpm until pressure starts to drop.

THROTTLE LEAKAGE VS GOVERNOR. Set throttle leakage as follows:

1. Make sure fuel is up to 90 to 100°F (32 to 380C) when setting throttle leakage.
2. Open throttle leakage valve; close main flow and idle valves.
3. Run test stand speed at 2100 rpm.
4. Move lower throttle toward gear pump and hold firmly against stop
5. Check throttle leakage with throttle leakage flowmeter, if test stand is so equipped. For an alternate method, use a 200 cc graduate to collect fuel delivery for one minute Do not keep at this setting any longer than necessary to keep fuel temperature within limits.
6. Delivery should be 110 cc. If not to specifications, screw rear lower throttle stop screw in or out until cc delivery meets specifications.
7. Check leakage with light and heavy lever load, if leakage is decreased by additional pressure in the throttle closed position, set leakage under these conditions, Figure 1 6G91.

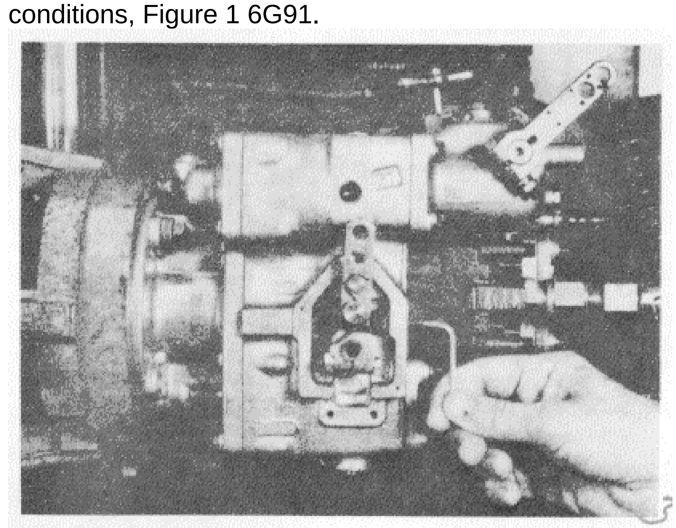


Figure 16G-91. Setting Throttle Leakage Screw

8. Snug tighten the screw when setting is correct and recheck
9. Close throttle leakage valve.
10. If test oil temperature exceeds 1000F (380C) idle test stand and allow test oil to cool. If temperature exceeds 1350F (570C), drain and replace with new test oil.

IDLE SPEED ON SINGLE LEVER VS PUMP. Set idle speed as follows:

1. Decrease stand rpm to 700 rpm. Close main flow valve and open idle orifice or flowmeter valve.
2. Move VS throttle lever to idle position and hold.
3. Screw in idle adjusting screw in standard governor spring pack housing to about midway of it's travel, Figure 16G-92.
4. Adjust the rear VS governor throttle screw to 10 psi, Figure 16G3-93.

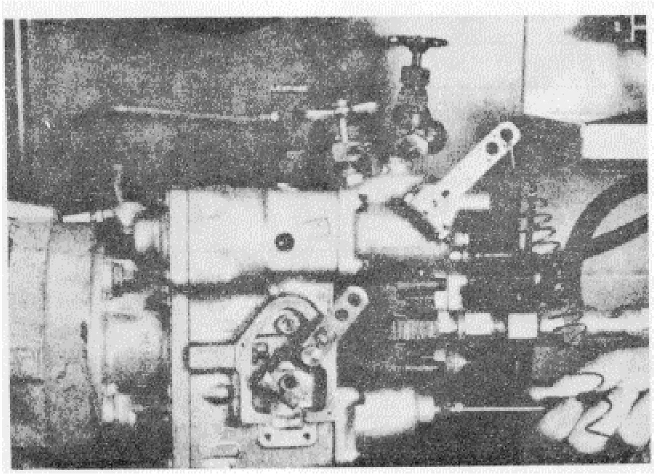


Figure 16G-92. Setting Standard Idle Speed with ST-91

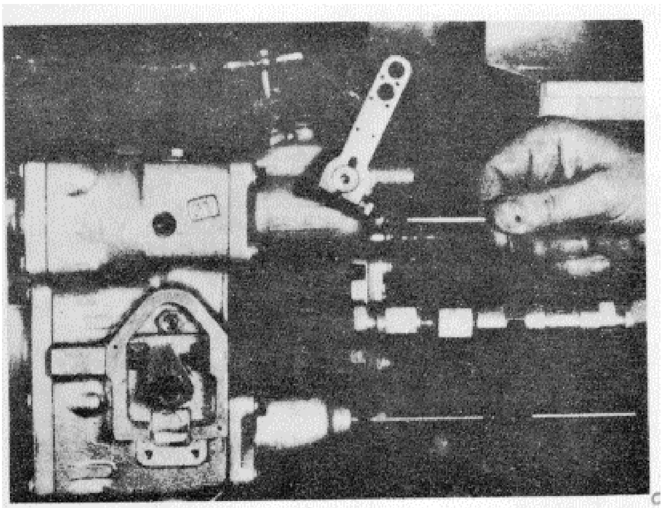


Figure 16G-93. F5341 Setting VS Idle Speed

CALIBRATION PRESSURE ON SINGLE LEVER VS PUMP Adjust calibration pressure as follows:

1. Move VS governor throttle lever clockwise to full fL position and hold with wire. Close idle orifice valve, op main flow valve.

2 Increase rpm to 2100 rpm.

3. Adjust main flow valve until flowmeter reads 525 flow.

4. Set vacuum at 5 in. Hg. and the flowmeter at require flow before each check. (Rated speed only.).

5. Turn in fuel adjusting screw in standard throttle shaft get 187/191 psi, Figure 16G-94.

6. Fuel pressure must be 184 at 2100 rpm. Adjust both the main housing throttle shaft screws. Turn in rear screw while backing out front screw. Lock the locknuts when correct value is reached.

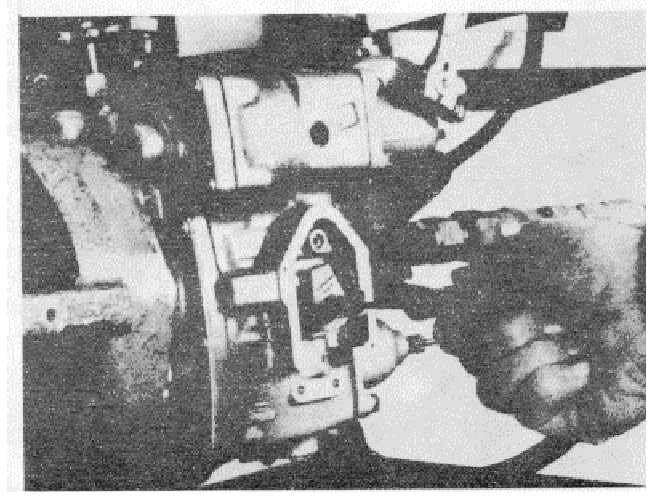


Figure 16G-94. Adjusting Throttle Shaft Fuel Adjusting Screw

CECK POINT PRESSURE - VS GOVERNOR. Compare check point pressure as follows:
1. Reduce speed to 1500 rpm.
2. Adjust flowmeter to 436.
3. Check pressure at fuel manifold pressure gauge. It must 130/136 psi.
4. If the pressure is above or below range, check the torque ring on the governor plunger; it may not be seated, improperly shimmed, or the wrong spring. If spring is changed, calibrate fuel pump. Torque spring shims are available)05, 0.010 and 0.020 inch (0.13, 0.25 and 0.51 mm) thick.
5. Check weight assist protrusion (see Step 6 following). It approximately .750 inch.
6. If fuel pressure is low at lowest rpm check point, add shims behind the governor weight assist plunger in the governor weight carrier. To decrease pressure remove shims. Shims are available 0.007 and 0.015 inch (0.18 and 38 mm) thick.

NOTE

Governor weight assist plunger protrusion can be checked and set by using ST-1241 Plunger Protrusion Checking Tool.

CAUTION

Weight assist plunger must be installed with the smallest end to governor plunger.

Table 16G-12. Governor Spring and Specifications - High Speed (Upper and Lower Engines)

Color Code	Wire Dia. Inch (mm)	No. Coils	Pounds Load (kg)	Inches Length @ (mm)	Free Length Inch (mm)
Blue-Purple	.086 (2.18)	8.4	11.65-10.75 (5.28-4.89)	@ 1.00 (25)	1.487 (37.8)

Table 16G-13. Idle Spring Plunger Data (Button)

Code No.	Engine	Counterbore Diameter Inch	(mm)
32	Upper	.2635-.2665	(6.69-6.77)
35	Lower	.2685-.2715	(6.82-6.89)

Table 16G-14. Torque Springs and Specificaitons

Engine	Color Code	Wire Dia. Inches (mm)	Number Coils	Pounds Load (kg)	Inches (mm) @ Length	Free Length Inches (mm)
Lower	Red/Green	.051 (1.30)	5.9	5.00-5.40 (2.3-2.4)	@ .340 (8.64)	.590-.610 (14.99-15.49)
Upper	Blue/Green	.051 (1.30)	5.2	6.00-6.48 (2.7-2.9)	@ .340 (8.64)	.590-.610 (14.99-15.49)

Table 16G-15. Weight Assist Springs and Specifications

Engine	Color Code	Wire Dia. Inch (mm)	No. Coils	Pounds Load (kg)	Inches Length @ (mm)	Free Length Inch (mm)
Lower	Blue	.028 (.711)	9.7	3.30-3.70 (1.50-1.68)	@ .325 (8.2)	.584 (14.8)
Upper	White/Yellow	.022 (.559)	10.0	0.90-1.10 (0.41-0.50)	@ .325 (8.2)	.475 (12.1)

Table 16G-16. VS Governor Spring and Specifications (Upper Engine)

Color Code	Wire Dia. Inch (mm)	No. Coils	Pounds Load (kg)	Inches Length @ (mm)	Free Length Inch (mm)
Blue	.072 (1.83)	8.5	8.03-6.57 (3.64-2.98)	@ 1.12 (28)	1.318 (33.5)

Table 16G-17. VS Idle Spring and Specifications (Upper Engine)

Color Code	Wire Dia. Inch (mm)	No. Coils	Pounds Load (kg)	Inches Length @ (mm)	Free Length Inch (mm)
None	.032 (0.813)	6.5	0.28-0.36 (0.13-0.16)	@0.265(6.7)	0.335 (8.5)

RECHECK SPECIFICATIONS

1. When a fuel pump is calibrated on one test stand and rechecked on another test stand, the calibration values may vary. This can occur because test stands are not exactly alike, due to manufacturing tolerances, gauge tolerances, test oil viscosity variations, etc.
2. This variance can also occur with a pump that is adjusted on the engine and then checked on a test stand.
3. The current Calibration Unit program is aimed at reducing test variations to an acceptable limit of +2 psi from a given base line by correcting gauging and plumbing errors and checking procedures.
4. A tolerance has been established on fuel pump calibration values for rechecking pump; (A) On another fuel pump test stand or; (B) On any fuel pump test stand after it has been calibrated on a test stand and then readjusted on engine. These tolerances are listed on the following pages.
5. If fuel pump is not within the tolerances listed under "B" above, one or more of the following is indicated:

A. Injectors are not properly calibrated and/or installed and/or adjusted.
B. Intake, exhaust or fuel suction restrictions are excessive.
C. Engine has incorrect components for the particular fuel pump calibration involved. (Injector cups, camshaft, pistons, etc.).
D. Pump was adjusted on engine to give other than specified fuel manifold pressure and fuel rate.
E. Test stand used for the recheck is not within acceptable limits.

PUMP SPECIFICATIONS

1. Governor Cutoff RPM

The governor cutoff rpm is defined as the rpm where the manifold pressure starts to decrease from the maximum observed pressure as the speed is increased.

A. When checking from one test stand to another, cutoff speed can vary +10 rpm from the published cutoff rpm (i.e., 2520-2540 rpm cutoff speed, reflow can be 25102550 rpm).

Suction vacuum must be set at 5 in. Hg.

B. Recheck from engine test to test stand; cutoff speed can be from rated speed to 50 rpm above rated speed (i.e., rated speed 2500 rpm, cutoff speed at reflow can be 2500-2550 rpm).

Suction vacuum must be set at 5 in. Hg.

2. Throttle Leakage

Throttle leakage is set with the throttle lever held firmly closed. The pump is operated at rated speed and the fuel delivery is measured for one minute.

Recheck from one test stand to another or from tested engine to test stand can vary +1 5 cc from published value (i.e., 35 cc throttle leakage can be 20 to 50 cc at reflow), if leak-

Table 16G-18. Calibration Recheck Specifications

Check	Recheck A-One test stand to another	Recheck B-Tested and readjusted on engine to fuel pump test stand
Governor cutoff rpm	-0 to +10 rpm from published values	Rated Speed to 50 rpm above rated speed
Manifold pressure at idle speed	+10% or +1 psi whichever is larger	+30% from published value
Manifold pressure at rated speed	-2 psi from published value	Same variance as on engine manifold pressure tolerance plus an additional -+2 psi
Throttle leakage	+15 cc if 100 cc/min or less +15 cc to -35 cc/min. if over 100 cc/min.	
Idle setting	-2 to +4 psi	
First manifold pressure check point	+1 psi from published values. Rated speed manifold pressure must first be to spec by adjusting flow valve	
Second manifold pressure point	A. If first check point is +1 psi, second check point to be from published min. Spec to +1 psi above published max. B. If first check point is -1 psi, second check point to be from published max. spec. to -1 psi below published min. C. If first check point is within published spec. second check point must be within published spec.	
Manifold pressure at Wt. Assist check point	+1 psi from published value	
AFC control plunger	±3 psi from published value	
No-air needle valve	+2 psi from published value	
Throttle travel	±1 degree from published value	
Pressure limiter valve dump	+2 psi from published value	
Pressure limiter valve reset	f3 psi from published value	

age is 100 cc/min. or less. When leakage is 100 cc/min. or over, it can vary +15 cc to -35 cc/min. (i.e., 150 cc/min. leakage can be 115 cc to 165 cc/min. at reflow).

3. Idle Speed Manifold Pressure

A. Recheck from one test stand to another; manifold pressure can vary +10% from specifications or +1 psi whichever is larger (i.e., 20 psi @ 500 rpm can be 18-22 psi at recheck or 3 psi @ 500 rpm can be 2-4 psi at recheck).

B. Recheck after engine adjustment; manifold pressure can vary +30% from specifications (i.e., 20 psi @ 500 rpm can be 14-26 psi at recheck).

4. Manifold Pressure at Rated Speed

A. Recheck from one test stand to another, manifold pressure can vary +2 psi from published specifications (i.e., 1 26 psi manifold pressure can be 124-128 psi at reflow).

Suction vacuum must be set at 5 in. Hg.

B. Recheck after engine adjustment; manifold pressure can vary the same as the engine fuel pressure tolerance plus an additional f2 psi (i.e., if on engine pressure specification is 114-126 psi or ±6 psi the tolerance for the manifold pressure at recheck is (+6) + (+2) = +8 psi. Then 120 psi manifold pressure can be 112-128 psi at reflow).

Suction restriction must be set at 5 in. Hg.

5. Manifold Pressure Check Point

Recheck pump at rated speed and obtain exact manifold pressure per calibration specification by adjusting the flow control valve.

Suction restriction must be set at 5 in. Hg.

A. First check point can vary +1 psi from the published specifications (i.e., 100-106 psi @ 2000 rpm can be 99107 psi at reflow).

B. Second check to be as follows:

(1) If pump checks +1 psi at first check point, it must be at published minimum specifications to +1 psi above published maximum specifications at second check point (i.e., 75-81 psi @ 1500 rpm can be 75-82 at recheck).

(2) If pump checks -1 psi at first check point, it must be published maximum to -1 psi below published minimum specifications at second check point (i.e., 7581 psi @ 1500 rpm can be 74-81 at recheck).

(3) If pump checks within the published tolerance at first check point, it must check within the published tolerance at second check point.

6. Manifold Pressure at Weight Assist Check Point

Recheck of the manifold pressure at the weight assist check point can vary +1 psi from the published specification (i.e., 35-41 psi manifold pressure can be 34-42 psi at reflow).

CHECK PUMP SEALS (LOWER ENGINE)

1. With test stand operating at 500 rpm, close vacuum valve in fuel pump suction line until vacuum gauge reads 15 inches vacuum. The fuel flow control or needle valve should be open during this check.

2. Put a small amount of Lubriplate or light cup grease over the vent or "weep" hole at main shaft seal bore of fuel pump cover, Figure 1 6G-95.

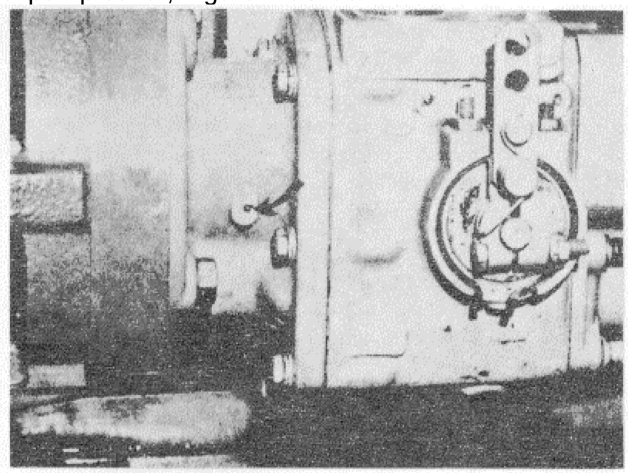


Figure 16G-95. Checking 'Weep" Hole for Leakage

3. If the lubricant is sucked into the hole at the 15 inch vacuum setting, it is an indication that the seal will not permit proper engine performance and should be replaced.

4. The above check may also be performed on the throttle shaft to check the shaft O-ring. Apply lubricant at the throttle bushing to shaft outside diameter.

5. On the VS governor fuel leakage may occur at the speed control shaft or speed adjusting screws. Adjusting screws and screw covers should always be equipped with copper gaskets.

6. During above checks, observe flowmeter for air in the meter which may or may not indicate air leakage into pump. Air may be entering lines between tank and pump. A slow leak may not show up promptly as air in the meter. Observe fuel level in tank for possibility of low fuel causing air bubbles.

7. Leakage may occur at the gear pump to pump housing gasket if gear pump is not positioned correctly.

8. Tighten all capscrews, hose connections, pipe plugs and filter screen cap. Check VS filter pump O-ring.

GEAR PUMP TEST

1. Use a "dummy" fuel pump built up with only the parts required to drive the gear pump, minimum of pump body, with tachometer drive and a complete front cover assembly. If desired, a complete fuel pump can be used if the governor plunger and weight assist plunger and spring assembly are removed and pump housing is filled with fuel; this will prevent any possible damage to governor plunger or governor barrel. Gear pump may be mounted directly to test stand with adapter bracket.

2. Install ST-844 Gear Pump Block Plate, with gasket on each side, between gear pump and fuel pump body, Figure 16G-96.

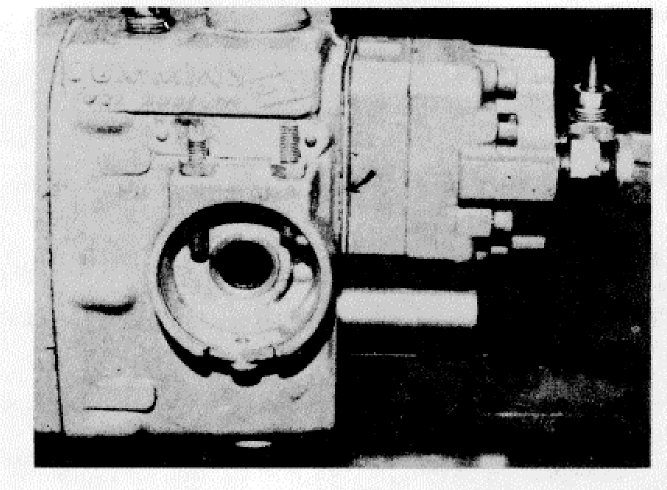


Figure 16G-96. ST-844 Gear Pump Block Plate

3. Remove gear pump damper from gear pump and connect copper line from orifice block to gear pump pressure tap.
4. Connect the fuel suction line to the suction side of the gear pump. Run a line from the gear pump bleed connection to the fuel supply tank.
5. On gear pumps not tapped, use a damper with a tapped hole to make this connection.
6. Shut off the fuel manifold pressure to prevent damage from over pressure.
7. The valve in the suction line and the valve controlling the main flow orifice are to be fully open. All other valves must be completely closed. With the valves in this position, fuel will be routed through the manifold orifice.
8. Start the pump drive in the proper direction and run the pump at 400 to 450 rpm. The gear pump must pick up at this speed without the aid of priming. Any gear pump which fails to pick up fuel after 30 seconds, must be reworked or replaced. The remaining steps of this check need not be made on any pump failing to pick up.
9. Increase pump speed and adjust pressure to 350 psi for the following checks:

Table 16G-19. Gear Pump Flow

Gear Pump	**RPM**	**Minimum Total Flow**
3/4 [19.05]	2100	1175 lb/hr

Any gear pump with delivery below the listed value should be reworked or replaced. Any gear pump which is wet to touch after this check should be reworked or replaced.

10. Any gear pump with a delivery above the listed minimum is to be considered acceptable for fuel pump operation, and it can be installed on a fuel pump for proper calibration.
11. The following check should be made if the gear pump delivery is just above the listed minimum described in Step 9.

The unrestricted manifold pressure should be checked for a 10-15% higher pressure at rated speed than the manifold pressure. If it is too low or too high, it may be necessary to change idle plunger (button) to give the correct unrestricted pressure of 10-15% above final manifold pressure.

NOTE

The idle plunger (counterbore diameter) may be decreased in size to increase the amount of pressure available at the calibration set point.

CAUTION

Step 11 is to be used only if gear pump is worn preventing it from delivering enough pressure for proper calibration. Never change idle plunger to exceed the 10 to 15% unrestricted manifold pressure.

FUEL PUMP TROUBLESHOOTING WITH ST-848

This material should be fully understood by the fuel pump test operator, and through this knowledge they should be able to produce a properly calibrated fuel pump.

Fuel pump calibration on the ST-848 Fuel Pump Test Stand combined with injector calibration has produced widespread acceptance of fuel system accuracy. There have been reports of erratic results, but investigations have revealed that the cause for such problems fall into three basic categories: (1) mechanic and/or test or error, (2) instrumentation errors or (3) maintenance status.

1. Mechanic and/or Test or Error
A. Misapplication of specifications and parts.
(1) Calibrating a specific fuel pump model to the wrong value.
(2) Calibrating a specific injector model to the wrong flow value.
(3) Lack of familiarity with this bulletin.
(4) Use of camshaft and pistons other than those shown in fuel pump calibration specifications or in the control parts lists.

NOTE

Pistons, camshafts and injectors are sometimes superseded by others, requiring a different calibration.

(5) Use of wrong injector assemblies in a specific engine model.
(6) Use of governor and torque springs other than those specified in fuel pump calibration data.

B. Engine Test
   (1) Restricted intake air in engine.
   (2) Excessive exhaust back pressure.
   (3) Restricted fuel supply to engine.
   (4) Aerated fuel supply to engine.
   (5) Excessive high oil level in engine crankcase.
   (6) Incorrect injector adjustment.
   (7) Dirt entering balance orifice.

2. Instrumentation Errors

A. Erroneous fuel manifold pressure gauge on engine and/or chassis dynamometer.

B. Erroneous flowmeters.

C. Erroneous dynamometer load indicators.

D. Incorrect tachometer.

3. Neglect of Maintenance

A Use of hose lengths, diameters and resiliencies other than those which are specified.

B. Fuel routing which is not to specifications.

C. Filter assemblies which have a different dampening effect on the system.

D. Critical components of the test stand such as check valve, gauge and hydraulic injector clamping poorly maintained

E. Failure to make checks with master ST-768 Gauge Snubbers.

AFC FUEL PUMP TROUBLESHOOTING (LOWER ENGINE)

The following chart contains troubleshooting aids for use with the PTG-AFC fuel pumps. Before testing or troubleshooting any fuel system, make sure pressure gauges, regulators, flowmeters, tachometers, etc., are operating correctly and have been recently calibrated.

Troubleshooting of the AFC (Air Fuel Control) falls within two basic complaint areas, fuel leakage and/or driveability.

Table 16G-20. Fuel System Troubleshooting

POSSIBLE CAUSE \ COMPLAINTS	Acceleration Slow	Air Leaks	Carboned Valves, Injector Cups	Deceleration Slow	Failure To Pick-Up Fuel	Fuel Consumption Excessive	Fuel Manifold, PSI High	Fuel Manifold, PSI Low	Governed Speed High	Governed Speed Low	High Speed Surge VS	Idle Speed Too High	Idle Surge VS	Idle Undershoot VS	Low Power	Rough Operation	Smoke Black, Low Speed	Throttle Leakage Excessive	Wear Rate High
Air Signal Attenuator Filter Plugged	●							●		●					●				
Air Leaks	●	●			●			●		●	●		●		●	●		●	●
Cooling Line By-Passing					●	●		●							●				
Cranking Speeds Slow					●														
Filter Suction Restricted	●				●			●		●					●				●
Fuel Dirty	●		●												●	●			●
Fuel With Water					●										●	●			●
Fuel, Wrong Type	●					●									●	●			●
Gear Pump Worn	●			●	●			●		●					●				
Governor Plunger Chamfer, Inadequate											●					●			
Governor Plunger Scored				●		●					●	●				●			
Governor Plunger, Wrong/Worn/Sticking	●			●		●	●	●		●			●	●	●	●			
Governor Plunger, Worn/Scored	●			●				●	●		●				●	●	●	●	
Governor Spring Shims Low	●							●		●					●				
Governor Spring Shims High						●	●		●										
Governor Weights Incorrect (Heavy)	●						●			●	●		●		●	●			
Governor Weight, Pin Wear								●	●	●					●				
High Speed Spring Shimming Wrong	●			●			●	●	●	●	●		●		●				
Idle Plunger (Button) Wrong	●		●			●	●	●	●						●		●		
Idle Plunger Spring Weak				●								●	●						
Idle Spring Wrong				●								●	●	●			●		
Injector Adjustment Loose	●		●					●							●	●	●		●
Injector Cup Cracked, Wrong, Damaged			●			●		●		●			●			●	●		
Injector Flow High			●	●		●	●		●			●					●		
Incorrect Injector	●		●	●		●	●	●	●			●			●	●	●		
Injector Orifice Size Wrong			●			●	●	●	●	●					●	●	●		
Injector Plunger Worn	●							●							●				
Pressure Valve Failure	●	●																	
Reverse Rotation, Drive Failure					●														
Screw Adjust, Incorrect							●	●	●	●	●	●	●		●		●	●	
Shut-down Valve Restriction							●			●					●				
Speed Settings, Unmatched auto or VS									●	●	●		●		●				
Spring Fatigue								●		●	●		●		●	●			
Throttle Leakage Excessive				●		●						●						●	
Throttle Linkage	●			●		●	●	●	●			●			●		●	●	
Throttle Shaft Restricted								●		●					●	●			
Throttle Shims Excessive			●			●	●		●								●	●	
Throttle Shims Insufficient	●						●	●							●				
Torque Spring Wrong	●			●			●	●	●			●	●		●	●			
Weight Assist Setting High				●						●	●	●							
Weight Assist Set Wrong				●			●	●	●	●	●	●	●			●	●		

Table 16G-21 AFC Troubleshooting (Lower Engine)

Complaint	Possible Cause	Checking Procedure	Correction
Fuel leakage	AFC barrel out of location	Check AFC barrel retaining ring. Heavy leakage	Install retaining ring, shim if necessary, make sure locks in position.
	Damaged seal on AFC plunger	Check plunger O-ring Small leakage. Check barrel and plunger finish.	Carefully install new seal, barrel and plunger.
	Scratched AFC barrel plunger bore	Small leakage seal, make sure parts are clean.	Replace barrel, plunger and

Driveability - Driveability is classified into two general areas each with separate complaints.

1. Starting and/or sluggish acceleration
2. Low power and/or no acceleration.

Complaint	**Possible Cause**	**Checking Procedure**	**Correction**
Startability and/or Sluggish Acceleration			
Hard starting or engine will not start	No-air needle valve shut-off, or set too lean.	Apply 25 psi air pressure to AFC unit	If engine starts reset "no-air" needle valve.
		CAUTION Excessive pressure will rupture bellows	If engine does not start, AFC is not at fault.
	AFC plunger too short	Length should be 3.340-3.360 inch.	Replace plunger.
	AFC cover center die diameter too deep	Face of cover to bottom of die hole 0.190-0.200 inch deep	Replace cover.
	Barrel meter hole edge too deep	Distance to hole 1.615-1.635 inch.	Replace barrel.
No-air valve will not set to limits	Set before AFC plunger adjustment not after.	Reset no-air valve.	Make AFC adjustment then
	Pressure too high	Reset	Loosen jam nut, turn valve (cw) until pressure is correct, tighten jam nut.
	Pressure too low	Reset	Loosen jam nut, turn valve (ccw) until pressure is correct, tighten jam nut.

NOTE: After any adjustment to pump, readjust AFC and no-air valve settings.

AFC pressure will not set to limits.	No air needle valve not bottomed during adjustment	Reset. Check thread depth so valve seats.	Loosen jam nut on valve and bottom valve against seat, check for no flow before adjusting. AFC Bottom tap threads 5/16-24UNF.
	Pressure set too high	Reset	Loosen jam nut, turn AFC plunger (ccw) until pressure is correct, tighten jam nut.
	Plunger sticking	Differential pressure should not exceed 15 psi	See "AFC Doesn't Repeat."

Table 16G-21 AFC Troubleshooting (Lower Engine) (Continued)

Complaint	Possible Cause	Checking Procedure	Correction
AFC Doesn't Repeat Within Recheck Limits AFC recheck +3 psi No-air recheck +2 psi	High plunger-to-barrel seal movement resistance record value exceed 15 psi difference in values.	Set AFC to limits, increase air to 25 psi and decrease to setting, Must not O-ring.	Work AFC plunger in and out several times. Check barrel surface finish and replace
Sluggish acceleration	Plugged drain tube	Blow through freely	Clean each time removed, and "C" Maintenance Check.
	Loose AFC barrel	Add parts noted, as necessary	Correct installation or add 3018655 Spring to bottom of barrel and add S-16240 Snap Ring.
Low power	Air pressure required to actuate AFC higher than specifications; bellows	Apply 25 psi air pressure to AFC unit, large air leakage will be noted at drain tube.	Replace bellows. Bellow's action forces air out. Small air leak expected.
	Wrong AFC spring or setting	Check AFC spring setting, and/or color code.	Adjust AFC setting or change spring.
	AFC plunger stuck in starting position	Apply 25 psi pressure to AFC unit and check for rise in fuel pressure as throttle is advanced.	Remove and check plunger and barrel and clean. Check seals.
	Ruptured bellows	Large air leak	Install new bellows Watch, small air leak may be bellow's action.
	AFC restricts early-power fall off rapid near torque peak.	Check AFC setting	Reset. AFC control should occur at least 100 rpm below torque peak.
	Plugged drain tube	Blow through freely	Clean each time removed, and "C" Maintenance Check.
Bellows leak	Improper use of AFC service tool or overtightened cover.	Frayed edges, elongated holes or stretched Torque capscrew	Index tool sockets over nuts and tighten to 30-35 in lb. only.
	Bellows upside down Not aligned with bolt pattern.	Visual check	Change or replace.
	Bubbles, cracks, separated bellows.	Visual check	Replace bellows.
Fall off in power	AFC barrel movement.	See sluggish acceleration.	

Table 16G-21 AFC Troubleshooting (Lower Engine) (Continued)

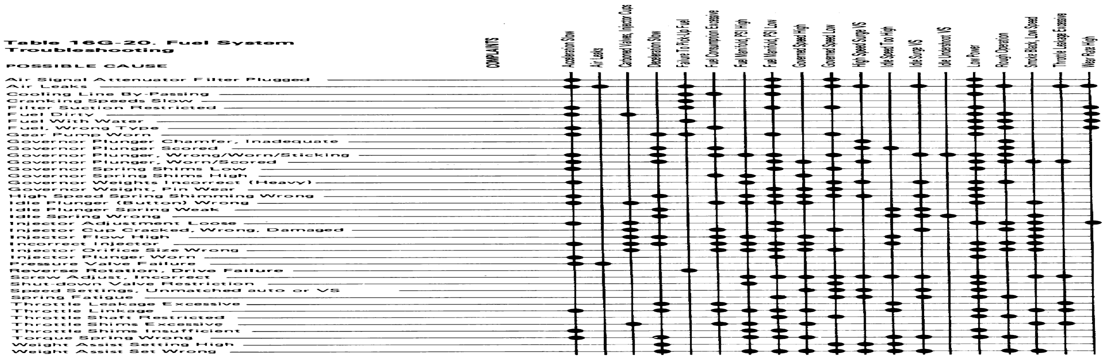
Complaint	Possible Cause	Checking Procedure	Correction
Engine will not accelerate properly	Air line to AFC leaking, plugged, not connected	Check for loose line, connections, or plugged line.	Tighten connection lines or replace line.
	Ruptured bellows	Apply 25 psi air pressure to AFC air leakage at vent screw.	Replace bellows.
	Plugged drain tube	Remove tube and check AFC operation.	Clean or replace.
	No-air needle valve set low.	Reset	Reset.
	Sticking AFC plunger	Remove cover and check plunger movement see "AFC Doesn't Repeat."	Remove and check plunger Also and barrel and clean. Check seals.
	Wrong AFC setting, delay too much.	Check plunger setting	Reset to specifications.
Air leakage at AFC drain tube	Bellows damaged	Large air leakage in drain tube.	Replace bellows.
	AFC seal gasket (cork) not compressed, damaged or missing.	Small air leakage from drain tube	Tighten nut on piston assembly to 30-40 in lb.
			Center bolt in piston so gasket seats.
			Replace gasket.
	Teflon tape seal on AFC plunger threads	Remove plunger nut and check for tape or sealant.	Retape plunger thread.
Excessive smoke	Fuel pump flow exceeding calibration specifications	Connect ST-435 pressure gauge to pump shut-down valve 25 psi air pressure to AFC unit sure against calibration specifications.	If fuel pressure is within specifications fuel rate Apply is satisfactory If above specification adjust fuel Check pres- pump pressure.
Also check: Injectors Turbocharger Engine Timing	Wrong AFC spring, plunger setting or no air setting.	Check plunger and no air settings on test stand	Change spring; adjust plunger or no air needle valve.
Fuel leakage no no-air needle valve.	No-air needle valve O-ring	Check O-ring for damage and valve bore for burrs	Replace O-ring Remove burrs as necessary using appropriate tools.

NOTES:

1. When checking AFC barrel inside diameter a polished appearance is normal, but deep scratches will cause leakage even with a new seal, replace barrel.
2. AFC plungers will show a polished appearance. Light scratches are normal, but severe scratches require plunger replacement.
3. When any fuel pump component is replaced special attention should be given to cleanliness and lubrication. With the AFC section be sure to use torque wrenches and make the "Hystersis Check" described under "AFC Doesn't Repeat Within Recheck Limits."

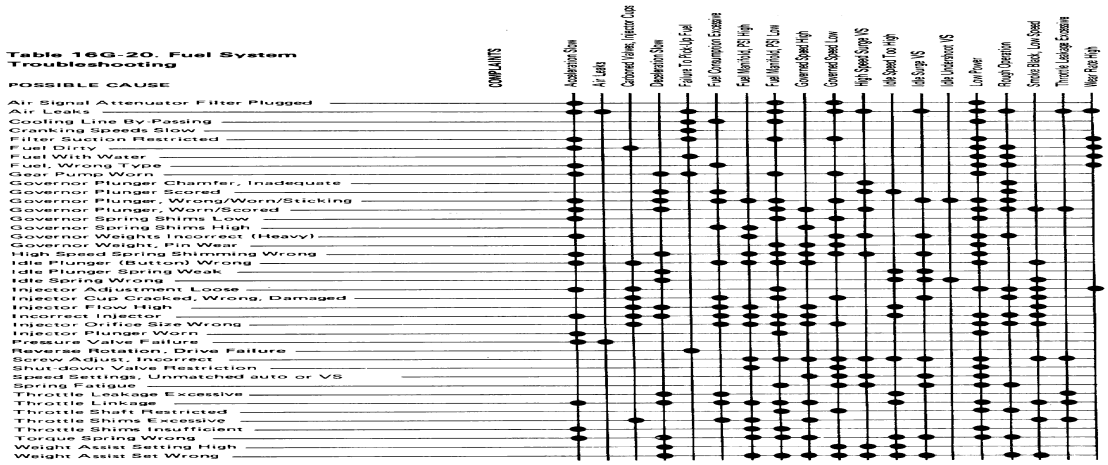
Table 16G-22. Complaint and Corrections - PT (Type G) (Both Engines)

Charted on the following pages are the complaints, showing the items to check for correction of the complaints if the fuel pump test stand has been properly maintained leaving no test stand error. Each check is numbered, so you may go immediately to the tabulated description of the causes and corrective action as necessary.



Cause	Correction
Check 1: Openings not sealed correctly.	Seal all openings and use new gaskets where necessary.
Check 2: Suction connection is not tight or is damaged.	Tighten suction connection or replace if mutilated.
Check 3: Idle plunger dirty.	Check face of idle plunger (pressure control button) for any foreign material.
Idle plunger worn.	Change idle plunger to give a square fit with governor plunger (use same idle plunger code number).
Check 4: Governor plunger dirty.	Clean idle plunger mating face of foreign material.
Governor plunger worn.	Change governor plunger to give a square fit with idle plunger.
Check 5: Blocked fuel passages.	Clean fuel passages so they are all open.
Check 6:. Faulty governor assembly.	Check governor assembly for proper assembly.
Check 7: Pump turning wrong direction.	Check pump for right or left hand rotation and set test stand accordingly.
Check 8: Flow valve not open.	Open test stand flow valve to allow fuel to enter gear pump.
Check 9: Shut-down valve not open.	Open shut-down valve on top of fuel pump.
Check 10: Gear pump worn.	Replace gear pump if it will not deliver required flow.
Check 11: Drive coupling not in mesh.	Mesh fuel pump and test stand drive couplings.

Table 16G-22. Complaint and Corrections - PT (Type G) (Both Engines) (Continued)



Cause	Correction
Check 1: Front seal leakage.	Remove fuel pump from test stand then remove front cover and install new seals in cover.
Check 2: Suction connection not tight or is damaged. This can be determined by pouring lube oil over suction connection.	Tighten suction connection or replace if mutilated.
Check 3: Main housing or spring pack housing gasket leaking air.	Replace gaskets as required.
Check 4: Fuel level in test stand reservoir low.	Fill fuel reservoir with Cummins test oil.
Check 5: Throttle shaft O-rings or housing leakage can be determined by pouring fuel oil over housing.	Replace O-ring on throttle shaft or replace housing if leaking.

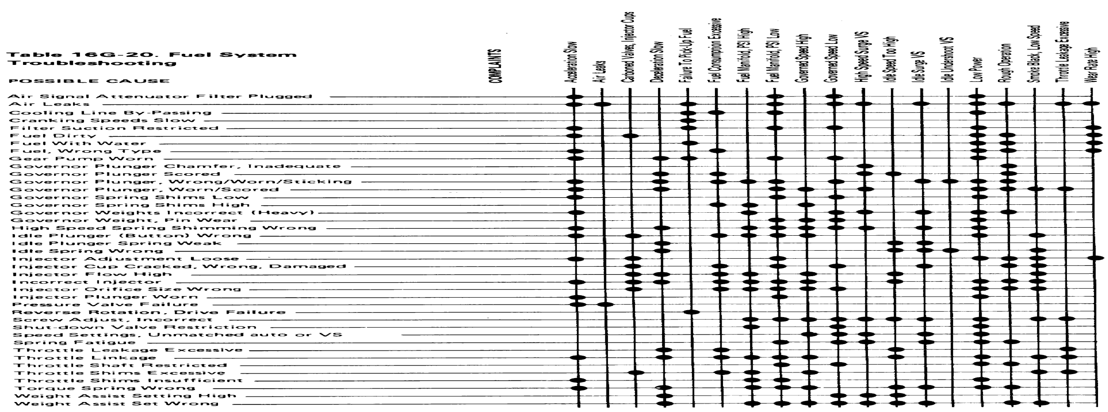
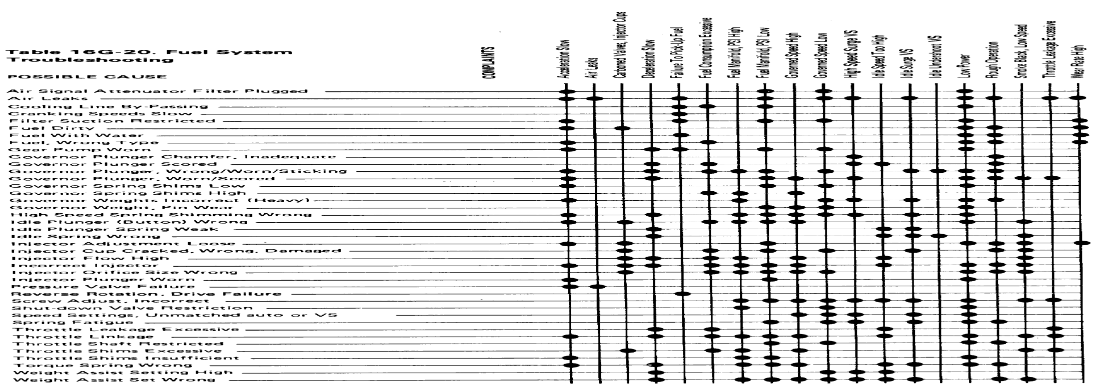
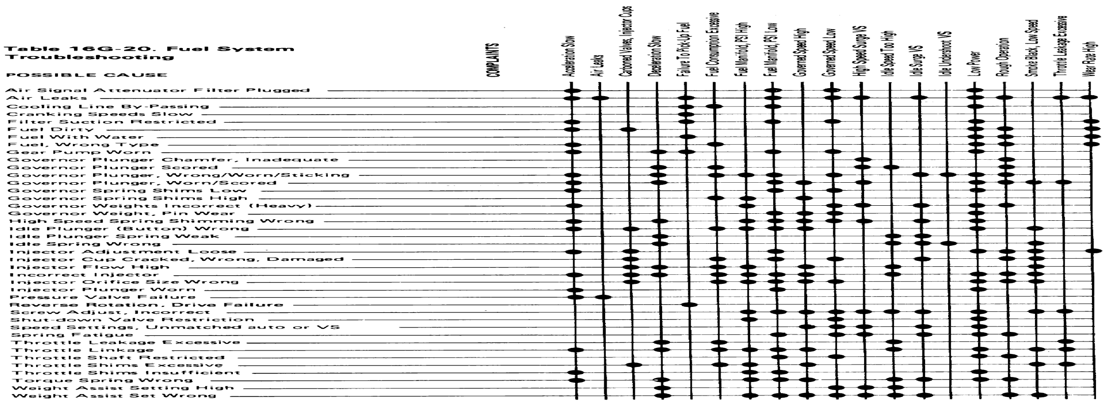


Table 16G-22. Complaint and Corrections - PT (Type G) (Both Engines) (Continued)

Cause	Correction
Check 1: Governor spring incorrect due either to wear or incorrect governor spring.	Replace spring if worn beyond limits.
	Replace with new parts as necessary.
Check 2: Loose or broken weights. Broken weld, weight pins or carrier.	
Governor weights incorrect for that specific pump.	Governor weights, of the correct weight, should be installed (heavy or shaved).
Check 3: Governor plunger improper fit in governor barrel.	Refit the governor plunger to the barrel. This usually requires a plunger one or two classes larger than previously used and must be lapped to fit with No. 80 fine grit lapping compound. Remove all lapping compound after use.
Sheared governor plunger drive tangs.	Replace drive tangs on plunger assembly.
Check 4: Governor barrel not located in housing correctly, preventing fuel passages from lining up.	Line up the fuel passages as not to restrict fuel flow. This may be done by heating housing in oven at 3000F (1490C) and removing barrel and then reinstalling in housing.
Governor barrel not pinned into position.	Make sure fuel passages are lined up and install pin into governor barrel.
Check 5: Spring pack lock ring out of position.	Lock ring must be in groove to correctly adjust governor.
Check 6: Gasket leakage between fuel pump housing and gear pump.	Gasket should be replaced or relocated. Correct gasket must be used.



Cause	**Correction**
Check 1: Throttle shaft scored or incorrect fit in throttle sleeve.	Install next size larger throttle shaft, if necessary. Fit to bore must be free without sticking tendency when rotating or moving in or out of bore by hand. If oversize shaft does not correct leakage, send housing to rebuild center.
Check 2: Governor plunger incorrect fit in governor barrel.	Install next size larger plunger. Fit to bore must be free without sticking tendency when rotating or moving in or out of the bore by hand.
Check 3: Leakage past VS plunger.	Install next size larger plunger or remove shims between snap ring and governor housing.



Cause	Correction
Check 1: Low fuel manifold pressure.	Replace fractured pulsation damper diaphragm.
Check 2: Fuel manifold pressure too high or too low because of incorrect idle plunger (button) or surface finish.	Replace idle plunger (button) with correct plunger if incorrect plunger was used. Polish surface of plunger if rough burrs or chipped areas are found on surface of plunger.
Check 3: Gear pump fails to obtain delivery and pressure.	Replace gear pump.
Check 4: Wrong throttle restriction.	Set throttle restriction to correct values.
Check 5: Test stand set at wrong flow rate.	Set test stand at flow rate indicated in calibration data pertinent to fuel pump being calibrated.
Check 6: Throttle screw out of adjustment.	Adjust throttle screw.
Check 7: Governor weight carrier assembly incorrect or faulty.	Replace with correct new governor weight carrier assembly.
Check 8: Scored governor plunger.	Replace with new governor plunger and lap to fit.

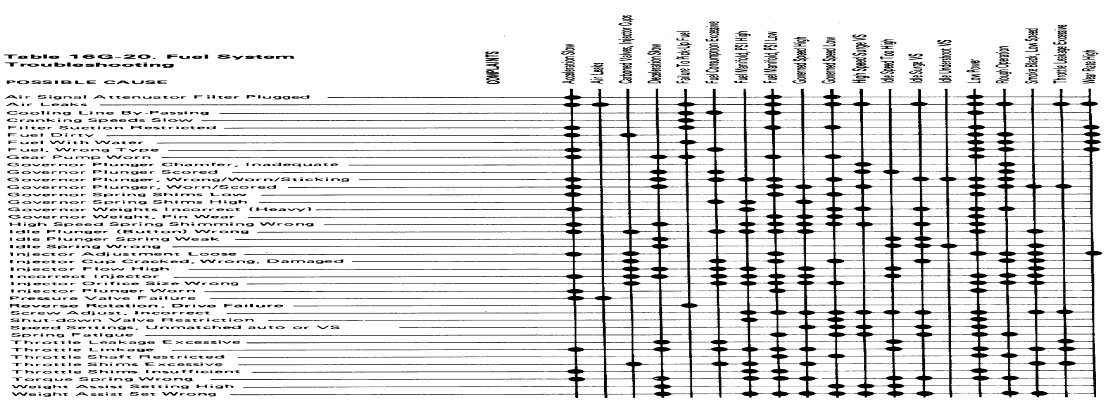
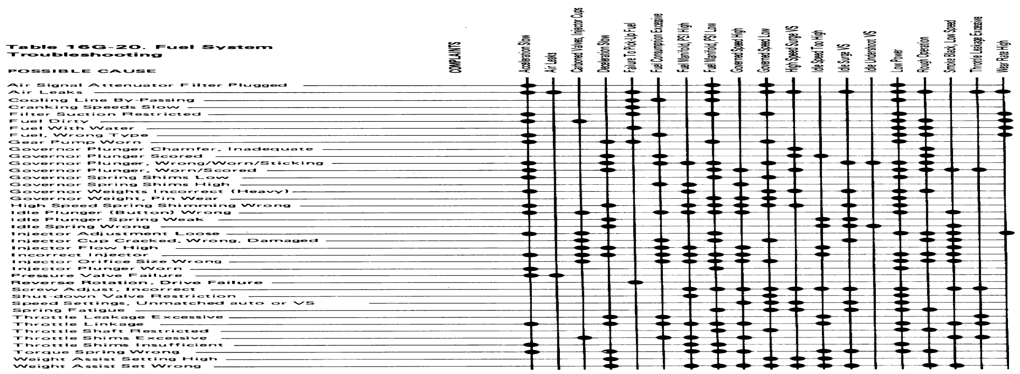
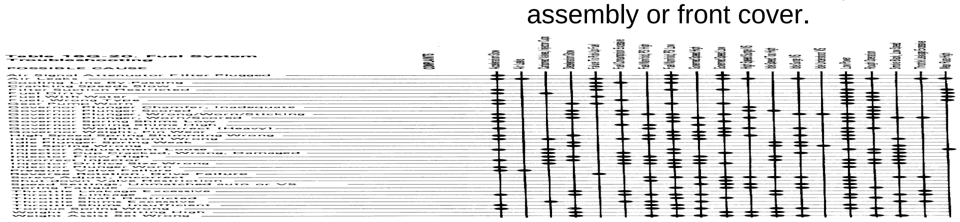


Table 16G-22. Complaint and Corrections - PT (Type G) (Both Engines) (Continued)

Cause	Correction
Check 1: Idle plunger or governor plunger rough or has voids.	Polish surface with oil stone or replace if necessary.
Check 2: Check lowest rpm checkpoint.	Check lowest checkpoint under Complaint No. 7 to be sure it is within specifications before proceeding.
Check 3: Incorrect torque or governor spring.	Remove front cover and check for proper torque or governor spring and free length of spring. Shim torque spring.
Check 4: Incorrect weight assist protrusion.	Make correct weight assist setting by proper shimming or replace front cover assembly.
Check 5: Incorrect weights or worn weight carrier assembly.	Replace with correct new weight carrier assembly.
Check 6: Gear pump delivery low.	Check gear pump delivery.
Check 7: Flow reading incorrect.	Adjust flowmeter valve.



Cause	Correction
Check 1: Checkpoint pressure is too low.	If weight assist protrusion is within specifications, one or more shims may be added to assembly.
Check 2: Checkpoint pressure is too high.	Remove weight assist shims to decrease pressure. If no shims can be removed, install new weight assist assembly or front cover.



Cause	Correction
Check 1: Throttle shaft too loose.	Remove and check fit in throttle sleeve.
Check 2: Pressure drop across throttle shaft over 20%.	Check fit of plunger and install correct size plunger to give correct pressure drop for degree of throttle travel.

NOTE

Be sure to remark throttle or governor sleeve if different size shaft of plunger has been installed.

AIR FUEL CONTROL (LOWER ENGINE)

AIR FUEL CONTROL
The air fuel control (AFC) functions as a fuel pressure and flow restrictor to provide the proper air fuel delivery to the engine during acceleration.

The fuel pump used on upper engine does not require the air fuel control. It will have a specially designed plug in the housing in place of the AFC barrel assembly.

OPERATING PRINCIPLES
The main operational difference between the PT (type G) VS and the T (type G) AFC fuel pumps occurs between the fuel pump throttle shaft and the shut-down valve on the AFC pump. The fuel passes from the throttle shaft through a passage to the shut-down valve in the PT (type G) VS fuel pump while in a PT (type G)AFC the fuel passes through the AFC unit after leaving the throttle shaft and before reaching the shut-down valve, Figures 16G-97 and 16G-98.

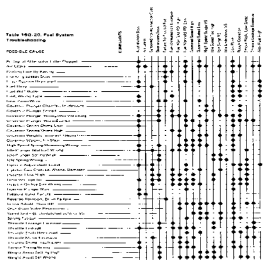


Figure 16G-97. AFC Top View - Cross Section with Control Plunger in "No Air" Position

The flow route of fuel when the AFC control plunger is in the "no-air" position is illustrated in Figure 16G-97. This condition exists during engine start-up and when the lower engine (turbocharger) speed and the resulting air manifold pressure is too low to overcome the AFC spring. Fuel from the throttle shaft flows through the no-air needle valve passage where the needle valve restricts the pressure and flow. The AFC plunger blocks fuel from passing through the AFC barrel. After passing the needle valve the fuel flows to the shut-down valve. As turbocharger speed and intake air manifold pressure increases, the air pressure acting on the AFC bellows and

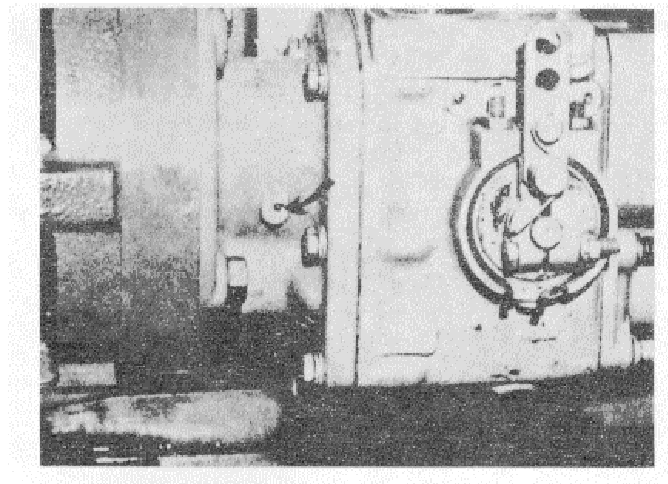


Figure 16G-98. AFC Control Plunger in "Full Air" Position

piston overcomes the AFC spring force causing the AFC plunger to move away from the AFC cover plate. As the plunger moves, the plunger profile begins allowing fuel to flow through a drilling in the AFC barrel common to the drilling from the fuel pump throttle shaft. This allows fuel to bypass the no-air adjust needle valve and flow down the AFC barrel to a second drilling leading to the shut-down valve. As the intake manifold air pressure increases the AFC plunger uncovers more of the drillings until a minimum fuel restriction level is reached and intake manifold air pressure above the AFC unit holds the plunger in full fuel position. This position is shown in Figure 16G-98..

Two steel balls are pressed into two housing drillings common to the two AFC barrel drillings to keep fuel from leaking into the fuel pump housing cavity.

ADJUSTMENT ON ENGINE

GENERAL

Accuracy of the following adjustments depends on the condition of the engine, parasitic loads and accuracy of the instruments used. At no time should adjustments be made on a cold engine. The engine should be run before making adjustments until oil temperature reaches 1 650F and with the valves and injectors set according to specifications.
PUMP HOOK-UP
If the fuel pump has been removed from engine for calibration, proper hook-up is necessary.
1. Install fuel pump to accessory drive or to compressor with new gasket and proper rubber buffer, nylon buffer or spline coupling and tighten securely.

NOTE

Use white nylon buffer (spider).

2. Squirt some clean lube oil into gear pump inlet hole. This aids gear pump fuel pick-up.
3. Connect the fuel pump line from the pump shut-off valve to the fuel manifold or to front or rear of engine.
4. The throttle lever linkage should not be connected to the throttle lever, thus leaving the throttle free for pump adjustments.
5. Install accurate tachometer to fuel pump tachometer drive shaft connection or use ST-774 Hard Tachometer.
6. Connect the shut-off valve electrical connections properly, leaving the manual control button in a closed position (screwed out).
7. Connect pump cooling and drain line to check valve elbow on gear pump and AFC drain tube.
8. Connect the air line to the AFC cover plate of the lower engine.

CHECKING AND ADJUSTING THE FUEL PUMP ON THE ENGINE

Before making fuel system checks or adjustments on engine, be sure the following rules are observed:
1. Engine is at operating temperature. Fuel temperature is not above 110°F (430C).
2. Timing, valves and injectors are properly adjusted.
3. Instrumentation (gauges and tachometers) must have high accuracy.

CAUTION

Do not alter pump settings to satisfy gauges and tachometers of unknown accuracy.

4. Vehicle throttle control linkage is adjusted so full throttle is obtained and when released throttle is stopped by throttle adjusting screw (throttle leakage adjusting screw).

NOTE

Vehicle throttle control linkage should have a maximum throttle stop, so when fuel pump full throttle is obtained override pressure will not be on throttle shaft.

5. When fuel pump has been properly calibrated, very little adjustment should be required after installation on the engine except idle since this setting is dependent on parasitic loads. Fine adjustment of governor settings and fuel manifold pressure is permissible within the specified limits if justified by engine performance tests.

GOVERNOR SETTINGS

IDLE SPEED. Adjust idle speed as follows:
1. After fuel pump installation, engine must be operated a sufficient period of time to purge all air from the fuel system and to bring engine up to operating temperature (at least 1650F (74°C) oil temperature).

NOTE
Idle speed adjustment should never be made on a cold engine.

2. Remove pipe plug from spring pack cover.
3. The idle adjusting screw is held in position by a spring clip. Turn screw in to increase or out to decrease the speed. Use ST-984 to adjust idle speed while engine is running. This tool seals the spring pack housing, permitting an accurate adjustment.
4. Replace pipe plug when idle speed is correct.
5. On VS governor (upper engine) fuel pump the maximum and idle adjusting screws are located on governor cover.

A. To adjust idle loosen rear idle adjusting screw locknut.
B. Screw adjusting screw in or out to get 700 rpm.
C. Tighten adjusting screw locknut immediately after adjustment to prevent air entrainment.

HIGH SPEED. Adjust high speed as follows:
1. A means of loading the engine must be used to perform this check. The tachometer and fuel manifold pressure gauge must be of high accuracy. The engine fuel system must be purged of all air and at operating temperature.
2. The preferred method of checking governor setting is to "load" the engine on an engine dynamometer.
3. Maximum engine speed is adjusted by adding or removing shims under the high speed governor spring. Normally, this adjustment is made on the fuel pump test stand as the fuel pump is calibrated and does not need to be changed on the engine.

CUTOFF SETTING. Set cutoff as follows:

1. At full throttle, increase load until the speed is pulled down to at least 100 rpm below engine rated speed, then decrease the load gradually while observing the fuel manifold pressure gauge. (The fuel manifold pressure will increase with decreasing load until the governor begins restricting fuel and then the pressure will begin decreasing with decreasing load.)
2. Continue decreasing load until fuel manifold pressure reaches its peak and decreases 1 to 2 psi. This is the so called "governor goes dead", "governor break" or "governor cutoff" point. This speed is between 30to 50 rpm higher than engine rated speed to assure that governor is not restricting before rated speed. For example: On a 2100 rpm engine this speed should be 2130 to 2150 rpm.
3. If the governor cutoff point is higher or lower than specifications, shims should be removed or added from behind governor high speed spring accordingly.
4. Recheck the governor cutoff point adjustment.

ENGINE HI-IDLE OR MAXIMUM NO-LOAD SPEED. Set engine hi-idle or maximum no-load speed as follows:
1. Operate engine to purge all air from fuel system and bring up to operating temperature.
2. With transmission in neutral or the clutch disengaged, open throttle and hold fully open. Note the maximum en-

gine speed. This speed will be 10 to 12% greater than the governor "cutoff" speed, depending upon engine parasitic loads (fans, pumps, etc.).

3. This check should not be used to check or make governor speed adjustments. This check is of secondary importance and must be considered as such unless the no load speed is significantly greater than specifications in which case the governor assembly should be examined for malfunction or improper parts.

FUEL MANIFOLD PRESSURE. Listed below are two methods of checking fuel manifold pressure. The engine must be at operating temperature and fuel system purged of all air:

1. The preferred method of checking engine manifold pressure is to load engine on an engine or chassis dynamometer as follows:
A. Check governor cutoff as detailed previously.
B. At full throttle, increase load until engine is pulled down to rated speed (accurate tachometer must be used). Read fuel manifold pressure. If engine fuel manifold pressure is below minimum or above maximum specifications, make the following adjustments.

To Raise Pressure:

(1) Screw out maximum throttle opening stop screw and utilize throttle restriction that may be present.

CAUTION

Do not screw the screw out beyond maximum throttle opening point otherwise a dead throttle travel may occur.

(2) Adjust AFC fuel adjusting screw in throttle shaft. Drive steel ball into end of shaft after adjusting.

To Decrease Pressure:

(1) Adjust AFC throttle screw as required.

CAUTION

Under no circumstances should engine manifold pressure be set above maximum specifications. Doing so will void engine warranty.

(2) It should not be necessary to adjust fuel manifold pressure on a newly calibrated pump more than +2 psi (0.14 kg/sq cm). If adjustments greater than this are required, fuel pump test, injector test stand or engine problems may exist.

2. The next best method of checking maximum engine fuel manifold pressure is to note maximum pressure while accelerating at full throttle when going up through the transmission ratios. With proper gauge snubbing, this method can be relatively accurate, especially if a heavy load is being pulled and engine acceleration in the higher gears is slow (Figure 166G-99).

CHECKING AND ADJUSTING ENGINE FUEL RATE

Engine fuel rate (fuel consumption) in lbs. per hr. is measured by using ST-1190 Flow Rater. Figue 16G-100 is a typical installation of checking fuel with ST-1190.

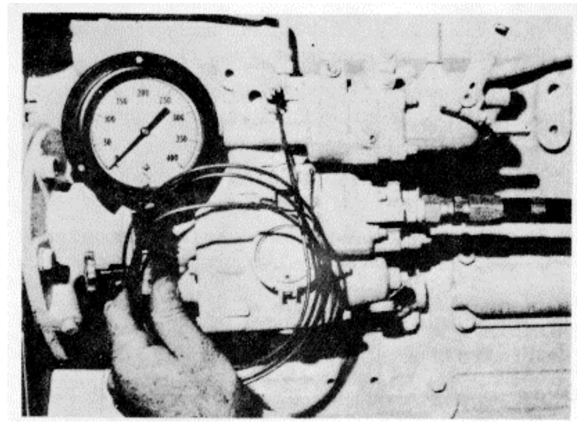


Figure 16G-99. Checking Fuel Manifold Pressure

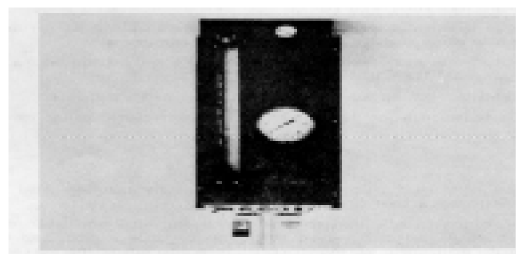


Figure 16G-100. Checking Fuel Rate with ST-1190

1. The fuel rate specified on fuel pump calibration specifications is at full throttle and rated speed.

2. An engine dynamometer, chassis dynamometer or other controlled means of loading engine must be used. Accurate fuel manifold pressure and speed readings must also be taken.
3. To check engine fuel rate, load engine at full-throttle until engine speed is pulled down to and kept at rated speed (check governor cutoff speed as previously described while loading engine), Note fuel manifold pressure at rated speed. Hold engine speed and load stable at rated speed long enough for the flowmeter float to stabilize. Take the fuel rate reading.

THROTTLE LEAKAGE

1. The purpose of throttle leakage is to keep fuel lines or supply drillings and injector drillings full of fuel during closed throttle engine motoring.

2. Throttle leakage prevents engine response hesitation when throttle is opened after down grade closed throttle motoring and prevents the engine from stalling when it decelerates to idle.

A. Excessive throttle leakage will cause engine to decelerate too slowly.

B. Insufficient throttle leakage will cause engine response hesitation after closed throttle motoring and stalling after decelerating to idle.

NOTE

If throttle leakage is adjusted correctly on fuel pump test stand, adjustment after fuel pump installation on engine is not required.

3. If throttle leakage adjustment on engine is required, it should be performed in the following manner.
4. Engine must be operated long enough to purge all air from fuel system and at operating temperature.

CAUTION

Never check engine deceleration or adjust throttle leakage on a cold engine. Engine will decelerate faster when cold due to greater friction drag.

5. Vehicle throttle linkage must be adjusted so pump throttle just contacts the rear throttle stop screw when throttle is closed.
6. A fuel manifold pressure gauge must not be in use.
7. A stop watch or other suitable timer and tachometer must be used to perform the following check.
8. With transmission in neutral or clutch disengaged, open throttle fully and let engine run at hi-idle(maximum no load speed).
A. Release or move throttle to closed position quickly and start stop watch simultaneously.
B. Stop the stop watch when engine reaches 1000 rpm and note deceleration time. Repeat several times.
C. If engine begins to stall (idle governor does not catch engine) after decelerating from hi-idle, throttle leakage must be increased.
(1) Note position of throttle leakage adjusting screw.
(2) Turn screw in while checking engine deceleration as described previously until deceleration time is increased 1 to 2 seconds. Lock screw in this position and recheck idle speed. Readjust as necessary.
9. If engine decelerates too slowly, it may be necessary to decrease throttle leakage. Before decreasing throttle leakage, be sure it is required by first checking deceleration time when shut-down valve is closed (engine is shut-down) while running at hi-idle. If deceleration is not faster by this method, throttle leakage is not the problem. If deceleration is significantly faster by this method, throttle leakage should be reduced.
A. Note position of throttle leakage adjusting screw.
B. Back screw out while checking engine deceleration as described previously until engine tends to stall after decelerating from hi-idle. Turn screw in until deceleration time is increased 1 to 2 seconds. Lock screw in position and check idle speed. Adjust idle speed as required.

NOTE

If a combination automotive and VS governor pump is in use and there is excessive VS governor barrel to plunger leakage, this may be the source of high throttle leakage and not the throttle shaft. This can be checked by adjusting the VS governor so engine will idle on the VS (with automotive throttle fully open). With automotive throttle held fully open, accelerate and decelerate engine with VS governor. If engine decelerates significantly faster by this method than when the VS is held in maximum speed position and engine is accelerated and decelerated by the automotive throttle, there is excessive VS governor barrel to plunger leakage.

FUEL FILTER RESTRICTION

1. Fuel filter restriction can be checked using ST-434 Vacuum Gauge, Figure 16G-101.

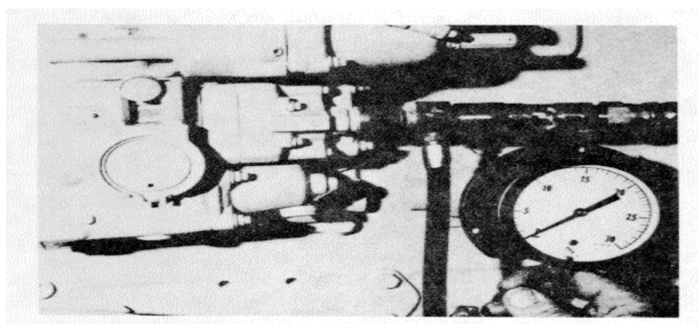


Figure 16G-101. Checking Fuel Restriction

2. Connect gauge using the special adapter furnished in ST-434.
3. If restriction reads 8 inch vacuum while engine is running at full speed and load, filter must be changed or other sources of restriction remedied. Sight glass gauge (ST-998), will show air bubbles with air entrainment and possible gasket or other leaks.

SEAL FUEL PUMP

To prevent unauthorized adjustments of the fuel pump after final adjustments are made, seal the spring pack housing lower capscrews, the AFC cover plate and the front cover, Figue 16G-102.

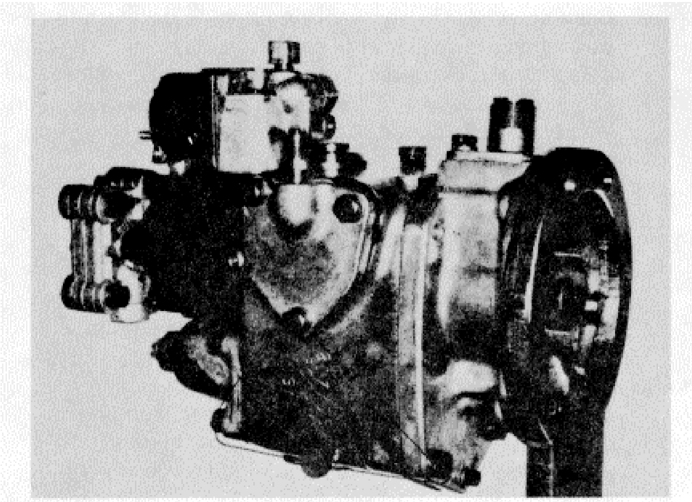


Figure 16G-102. Sealing AFC Fuel Pump

FUEL PUMP SEALS

All fuel pumps for highway engines and most fuel pumps for other applications will be sealed at the factory. The lead seal marking relates to a manufacturing control system. All warranty claims sent to the factory must have the seal attached. After completing any fuel pump repair, the pump must be resealed using your code on the new seal.

FUEL PUMP CERTIFICATION AND MODIFICATIONS

Abbreviations are used in the notes column of the calibration tables to signify those calibrations that are emission certified.

Abbreviations are as follows:

EPA	U.S.A. Environmental Protection Agency
Calif.	California Air Resources Board
BSAU	British Standards for Automotive
Austr.	Australia Certification
TUV	German Certification (Technische Uberwachungsverein)

Modifications of the fuel pump are permitted within certain limits. The fuel pump assembly is not certified. Fuel pump part may be changed to allow for wear or operating conditions. Fuel pump performance is certified within the following limits.

AFC or aneroid setting values.
Fuel rates at rated speed.
Fuel rate at peak torque.
Idle speed (low).
Governor cutoff speed (high idle).

The fuel rate in millimeters cubed per stroke (mm3/s) is used in certification. This value is listed in the fuel rate column in parenthesis ().

INJECTORS

TOOLS

Service Tools (Or Equivalent) Required

Tool No.	Description
ST-995	Injector Cup Retainer Wrench
ST-1072	Crowfoot Wrench
ST-1089	Injector Plunger Extension
ST-1298	Injector Holding Fixture (Air Operated)
3375000	Ultrasonic Cleaner
3375084	Injector Holding Fixture (Manual)
3375182	Spring Tester
3375209	Injector Plunger Sticking Checking Tool
ST-668-14	Fuel Hole Plug
ST-990	Injector Leakage Tester
3375089	Injector Adapter Spacer Ring
3375375	Injector Leakage Tester
3375398	Injector Link
3375440	Injector Adapter
3375459	Fuel Fittings
3376010	Ball Checking Kit
ST-668	Injector Spray Tester
ST-1254	Injector Adapter Pot
ST-708	Burnishing Tool
STU-790	Injector Test Stand
ST-1129	Injector Flow Comparator
ST-1 1262	Master Injector
ST-1 332	Orifice Sizing Tool
3375317	Injector Test Stand
3375364	Injector Test Oil
3375365	Injector Test Oil
3375366	Test Stand Audit Kit
3375367	Installation and Training Kit
3375408	Burnishing Tool
3375410	Injector Calibration Kit
3375421	Injector Calibration Kit
3375317	Injector Test Stand
ST-1217	Injector Removal Tool
3375161	Injector Removal Tool
3375181	Injector Removal Tool
Torque Wrench	
ST-788	Burnishing Tool
ST-790	Injector Test Stand
ST-1261	"K" Injector Conversion Kit
3375187	Test Stand Audit Kit

OPERATING PRINCIPLES

INJECTOR DESCRIPTION

The injector is a simple mechanical unit which receives fuel from the fuel pump under pressure. The injector meters, injects and atomizes fuel through fine injector cup spray holes into the combustion chamber.

The general description "PT Injectors" is used only to indicate that the injector is used with the PT fuel system and not with the former Cummins Disc fuel system.

CYLINDRICAL PT (TYPE D) INJECTORS

The PT(Type D) injector is a refinement of the PT (Type B and C) cylindrical injectors used in Cummins Engines with internal fuel drillings. The PT (Type D) top stop injector is shown in Figure 16H-1.

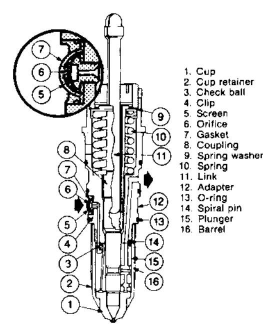


Figure 16H-1. Cylindrical PT (Type D) Top Stop Injector Cross Section

 INJECTORS

By part design changes, the PT (Type D) provides more parts that can be interchanged. The areas which are subject to wear are localized in smaller parts for easier servicing. Previous types of injectors have a body with the moving part of plunger running the full length. The PT (Type D) has a short barrel and plunger to provide the same function. The shorter barrel plunger bore makes possible the use of materials with greater wear resistance and results in a smaller replacement assembly. The barrel/plunger assembly is made of a coupling (8), Figure 16H-1, plunger (15) and barrel (16). The coupling and plunger are a swaged assembly.

INJECTOR PARTS

ADJUSTABLE ORIFICE PLUG. An orifice plug is used in the inlet drilling of the cylindrical injectors to adjust the fuel delivery. Fuel delivery is adjusted by changing the orifice plug or by burnishing the plug in its operating position. See "Injector Description". The orifice plugs have a flange and require a gasket beneath the flange.

DRAIN ORIFICE. The drilled orifice in the cup end of the injector is the drain drilling. This orifice is fixed in size and must not be altered in any way.

ADAPTER. In Figure 16H-1, the adapter (12) houses the plunger return spring (10), adjustable orifice (6), orifice gasket (7), fuel screen (5) and screen retainer (4).The adapter has O-ring seals (1 3)on the outside, which seal against the head to form the fuel inlet and drain passages. Fuel enters through the orifice (6) and flows to the barrel (16), past the check ball (3) to the cup-to-barrel passage, then up to the metering orifice where it is metered into the cup(1). In the direct fuel feed barrels, the fuel goes directly from the check ball to the metering orifice. Fuel not used circulates past the metering orifice, around the plunger and out the drain passage while the plunger is seated in the cup. The cup, adapter and barrel are held in the assembled position by the cup retainer (2).

METERING ORIFICE OF PT (TYPE D) INJECTOR. The metering orifice, near the cup end of the barrel, is of fixed size and must not be altered in any way. Barrels differ for different engine models in relation to the size of the metering orifice as governed by the engine fuel requirements.

DISASSEMBLY, REPAIR AND ASSEMBLY

GENERAL

The disassembly, cleaning, inspection, repair and assembly procedures, described on the following pages, are operations which must be performed in a clean, well equipped shop. Operations other than those described here must be performed in a qualified Cummins Fuel Systems Rebuild Location.

DISASSEMBLY

1. Lift out the injector plunger and spring. Remove the spring from the coupler and test as described on the following pages.
2. Store the plunger by standing it on the coupling end.

NOTE

The injector barrels and plungers are class fit. Do not interchange these parts.

3. Remove the O-rings from the injector adapter and discard.
4. Remove the button style screen retainer ring, and discard the screen.

NOTE

Do not remove the adjustable orifice plug from the inlet groove.

5. Insert the injector into the loading fixture.
6. Slide a 3375102 Body Wrench over the flats on the injector. Place at ST-995 Retainer Wrench on the injector.
7. Activate the air cylinder, or tighten the special screw, to hold the injector in place. Loosen the cup retainer but do not remove it, Figure 16H-2.

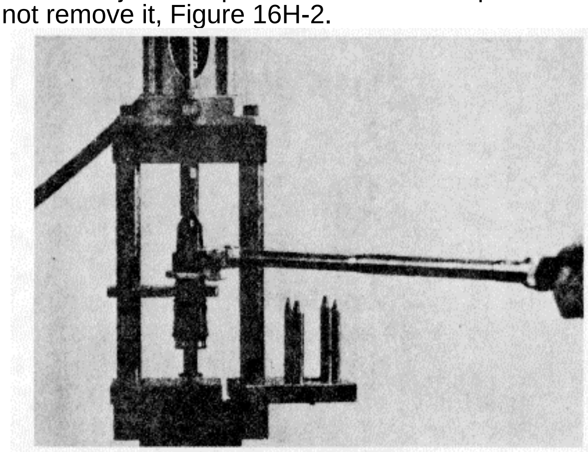


Figure 16H-2. Loosening the Cup Retainer

8. Deactivate the air cylinder or loosen the special screw.
9. Remove the injector clamp and ST-995 from the fixture.
10. Another method of loosening the retainer is to use a 11/4 inch box, or an open end wrench, on ST-995 and a 1 inch wrench on the injector.

11. Screw off the cup retainer and remove the cup and barrel and discard the gasket, if used. Do not lose the check ball.

12. Remove the check ball from the top of the barrel, Figure 16H-3.

CLEANING

1. Clean the injector parts thoroughly of any carbon varnish. Soak them in a solvent such as "Bendix Metal Cleane", "Kelite Formula 1006", or an equivalent. Ultrasonic cleaning in Service Tool 3375000 is recommended for the barrel, plunger and cup.

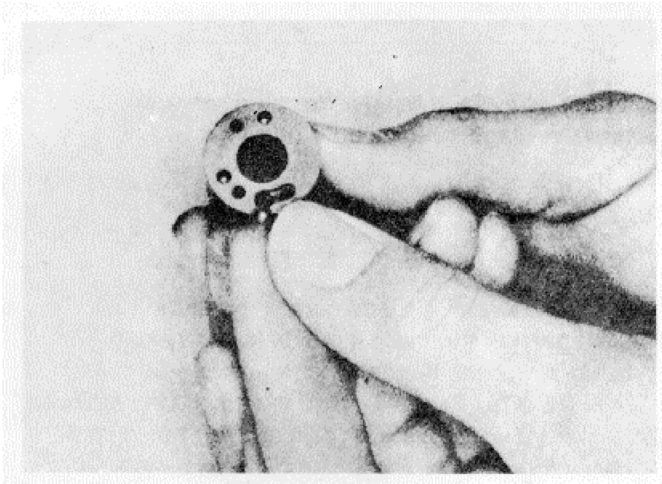


Figure 16H-3. Removing the Check Ball

2. Neutralize the solvent after cleaning by dipping the parts in mineral spirits.
3. Dry with compressed air.
4. A clean shop, clean tools, and good cleaning practices are essential to good injector repair Most injector failures occur because of dirt. Clean all parts before assembly.

CAUTION

Do not use drills or other instruments to clean the cup holes. This will alter the size of the holes. Wires may be used if a smaller size wire is used than the spray hole. Do not use a wire brush or crocus cloth to clean the cups that have the part number printed on the side.

INSPECTION

PT (TYPE D) INJECTORS PLUNGER LINK. Replace the plunger link if worn excessively, Figure 16H-4.

INJECTOR PLUNGER COUPLING. Inspect coupling as follows:

1. Check closely for metal seizure. As a rule this is the only true indication of scuffing or scoring.
2. Bright spots or surface disruption at the top of the plunger machined area, on the opposite side at the bottom of the plunger or at the mid-point, usually are normal results of rocker lever thrust action. Unless metal is displaced or wear is measurable at these points, the plunger may be reused. If worn excessively return the barrel and plunger to a Cummins Rebuild Location for the fitting of a new plunger.
3. Narrow streaks running the length of the plunger usually are the result of the varying thickness of the penetrant treatment used to prevent rusting. The plunger is satisfactory for reuse unless a surface disruption is evident.

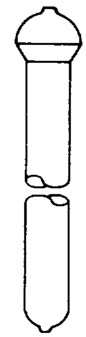


Figure 16H-4. Plunger Link Wear

4. Check the area where the plunger is swaged to the coupler for cracks and looseness. Attempt to rotate it by hand.
5. Excessive wear or fretting may be found on the spring contact area of the coupling flange.
6. Check the socket for wear or cracking.

CAUTION

Handle the injector plunger with care to prevent damage which could render it useless.

7. Check for carbon on the small diameter, near the tip of the plunger.

INJECTOR SPRING. Inspect injector springs as follows:

1. Check the spring for excessive wear or mutilation.
2. Test the spring tension on the spring tester, 3375182, Figure 16H-5. This spring tester is capable of very accurate measurements of spring lengths and applied load by means of standards and a dial indicator gauge. See Table 16H-1.
3. If the injector springs compress to the dimensions shown at less than the load indicated under the "worn limits", the springs must be discarded.

Figure 16H-5. Testing Injector Spring on 3375182 Tool

Table 16H-1. Injector Spring Data

Approximate Free Length Inches [mm]	No. Coils	Wire Dia. Inches [mm]	Pounds [kg] Load Required to Compress Springs to Length — Inch [mm] Length	New Min.	New Max.	Worn Limit
2.82 [71.6] Yellow	11	0.187 [4.75]	2.40 [61]	134.25 [60.9]	149.75 [67.9]	129 [58.5]

INJECTOR CUP - PT (TYPE D). Inspect injector cup as follows:

1. Inspect the injector spray holes and tip with a magnifying glass. Compare them with a new cup as shown in Figure 16H-6. Discard the cup if any of the following conditions exist.

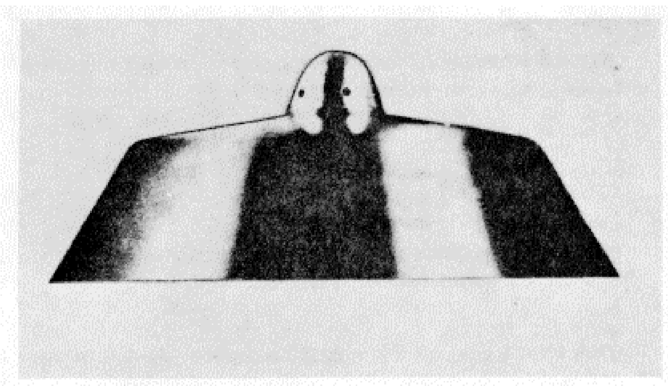


Figure 16H-6. New Injector Cup Tip

A. Abrasive wear: This wear can begin internally; therefore, inspect both interior and exterior, Figure 16H-7.

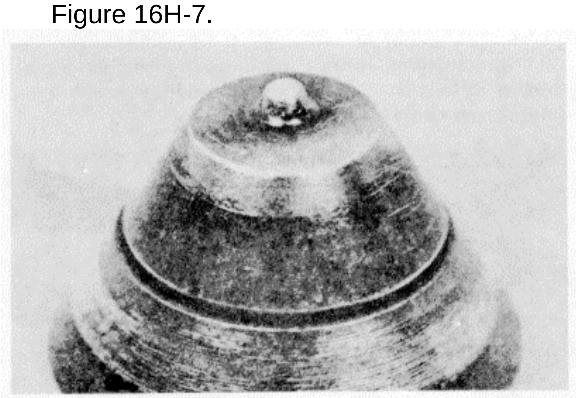


Figure 16H-7. Cup Tip Damaged by Wire Brushing

B. Corrosion damage and the effect of excessive heat: This condition usually results from high acid or sulphur content in the fuel or overload operating conditions, Figure 16H-8.

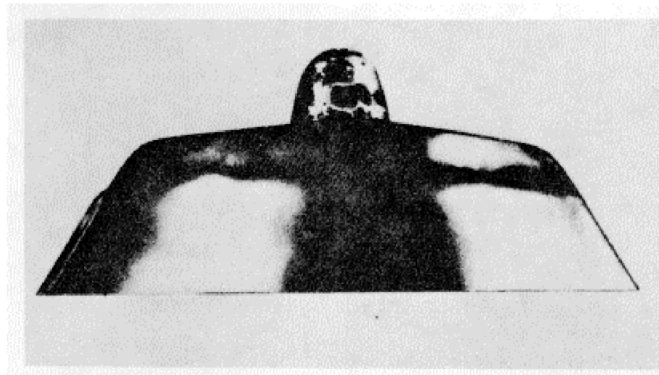


Figure 16H-8. Corroded Injector Cup Tip

C. Enlarged or distorted spray holes: This is caused by cleaning with drills or other instruments.

2. Inspect the cup for plunger seat pattern. Select a new plunger and coat with Prussian Blue. Insert the plunger in a cup and rotate 900. If plunger covers a 40% continuous area around the cup cone or plunger bore, it is possible the cup may be reused. The cup must pass the ST-990 or 3375375 cup-to-plunger leak test. Seat location is not important, Figure 16H-9.

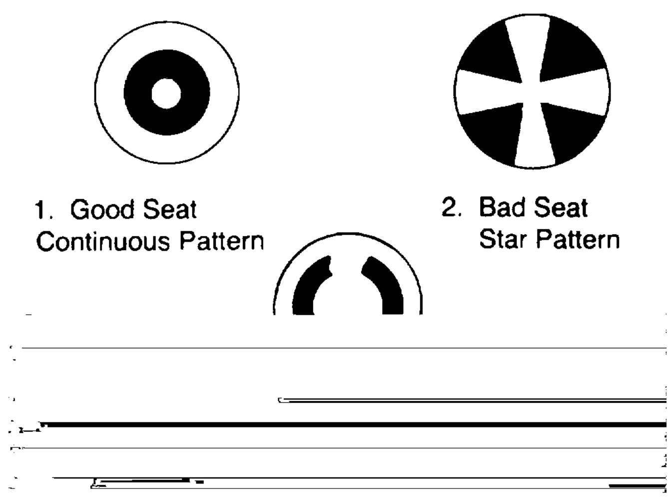


Figure 16H-9. Seat Pattern of Plunger in Cup

CAUTION

Never alter the size of the injector cup spray holes.

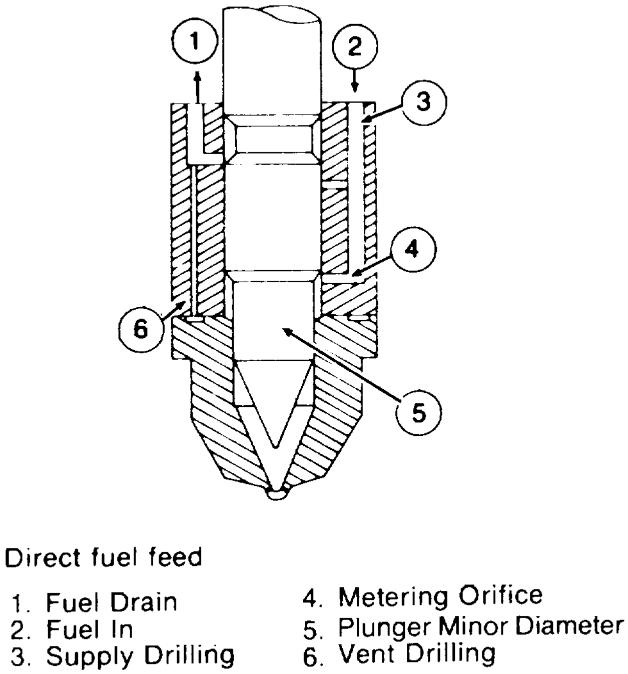


Figure 16H-10. Direct Fuel Feed PT (Type D) Injector

3. Check the injector cup barrel surface for mutilation and flatness.
   A. For mutilation, check in the area (black area).
   B. Use a flat steel plate (preferably a lapping plate) and "bluing" to check for surface flatness.
   C. If mutilation or unevenness are found, mark for repair.

CUP RETAINER. Inspect cup retainers as follows:

1. Inspect the threads for damage.
2. Check the outside cone area for nicks or burrs which could prevent proper seating with the sleeve in the head.
3. Inspect the inside of the cone area on the cup seating ledge for nicks or burrs which could prevent the cup from seating.

INJECTOR BARREL- PT(TYPE D) INJECTORS. Inspect injector barrels as follows:

1. Inspect the injector barrel plunger bore for scoring. If the injector will pass the ST-990 or 3375375 leakage test, the barrel is usable. If the leakage is too high, the barrel and plunger must be replaced.
2. Use a strong magnifying glass to check for burrs, carbon and distorted radii in the orifice. When the metering orifice is damaged, the injector will not function properly. Do not attempt cleaning with wires, plug gauges, etc. Use solvent cleaners
3. Check the fuel passage plugs for looseness and the barrel for cracks.
4. Check the injector barrel surfaces for mutilation and flatness in the black area as shown in Figure 16H-11. The groove has been removed from the cup end of the barrels.
   A. Thoroughly clean and dry the barrel of all oil film before bluing.
   B. Use a surface plate (preferably a lapping plate) and "bluing" to check for surface flatness.
   C. If mutilation or unevenness are found, lap to repair.
   D. Do not use crocus cloth or a wire brush on the barrel and cup contact area.

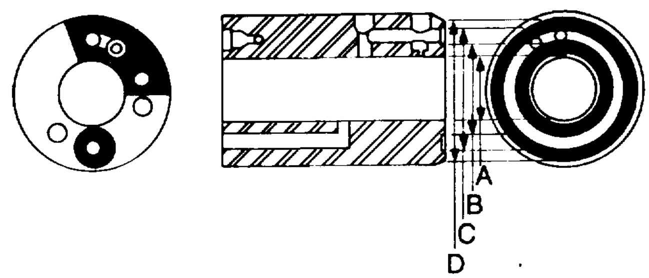


Figure 16H-11. Barrel Surface at Cup Contact Area

Table 16H-2. Cup Contact Area of Barrel

"A' Dia. " Inch [mm]	B" Dia.	"C" Dia.	"D" Dia.
0.400 [10.16]	0 540 [13.72]	0.710 [18.03]	0.820 [20.83]

CHECK BALL AND SEAT. Inspect check ball and seat as follows:

1. Check the ball seat for nicks or burrs.
   A. Do not attempt to improve the check ball seat by inserting a ball and tapping. The barrel is as hard as the ball and will damage the ball if attempted.
   B. If the seat is marred, lap the barrel.
2. If any wear or mutilation is found, replace the ball. The PT (Type D) injector check balls are made of special material. Do not attempt to substitute with a commercial made ball.

ADAPTER. Inspect adapters as follows:

1. Check the balance orifice for burrs or other obstructions.
2. Inspect both fuel passages to be certain they are open.
3. Inspect the cup retainer threads for damage.
4. Check the O-ring areas for nicks or burrs which could damage the O-rings during installation.

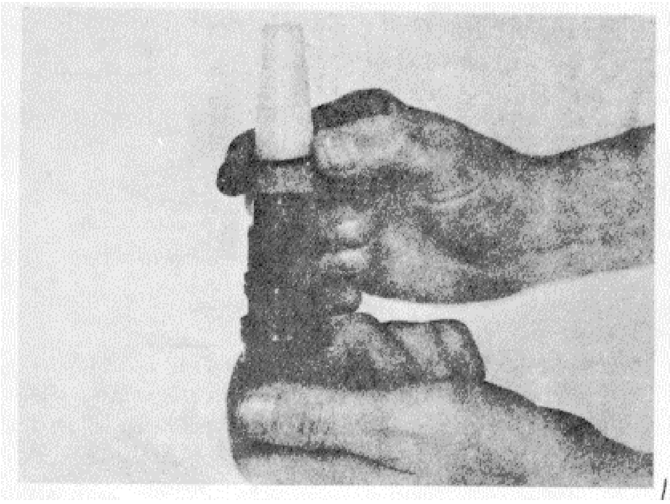


Figure 16H-12. Installing O-Ring with Assembly Tool

5. Inspect the barrel mating surface for nicks or burrs. If damage is found, lap to repair.

ASSEMBLY

The ST-1298, 3375084 and 3375536 are three types of loading fixture tools.

The ST1298 has been redesigned so the cup to plunger adjustment pressure is maintained by an air cylinder. The air cylinder reduces the injector assembly time.

If you have ST1057 or 3375084 and wish to add the air cylinder attachment, it is available as ST-1298-5111.

1. Drop the check ball into the top of the barrel.

CAUTION

Be certain all mating surface parts are clean and free of burrs or other imperfections which could result in incorrect flow or torque Lap to repair.

2. In the repair of the injector, the gasket between the barrel and adapter is required.
3. Hold the barrel with the check ball up and place the new adapter spiral pins into the barrel.
4. Turn the adapter and barrel with the barrel up and place the cup on the barrel, Figure 16H-13
5. Lubricate the cup retainer threads, and the cup flange contact area, with 20or 30W lubricating oil and assemble to the adapter. Screw the retainer down finger tight and loosen 1/4 turn.
6. Immerse the injector plunger in clean injector test oil and install it in the adapter without the spring
7. Raise the 3375103 Special Stud in the 3375084 Holding Fixture.
8. Insert the injector into the loading fixture.
9. Slide the 3375102 Body Wrench over the flats on the injector adapter

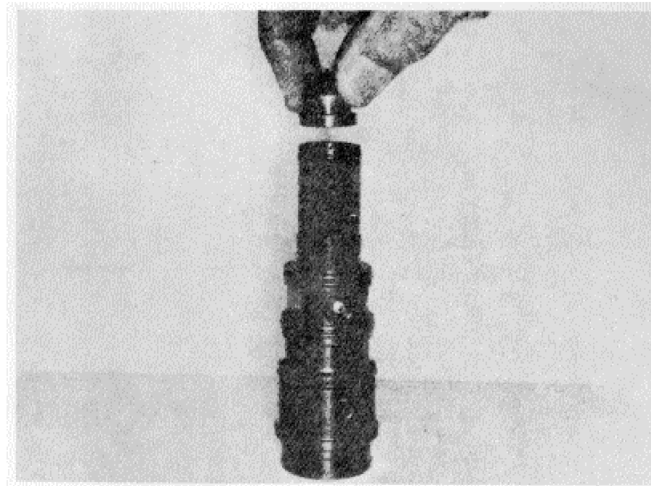


Figure 16H-13. Installing the Cup on the Barrel

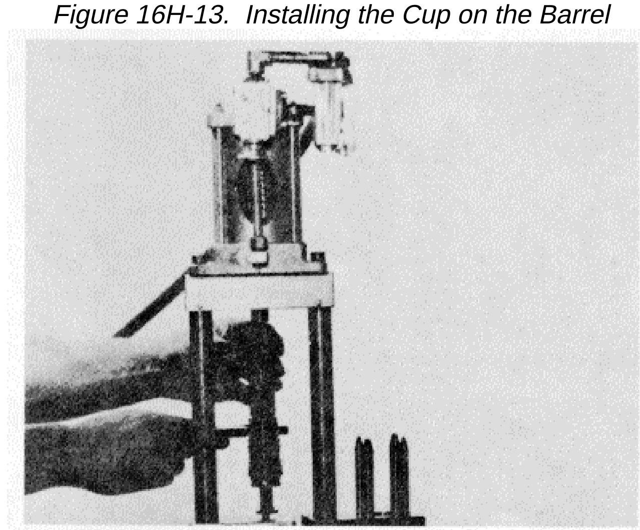


Figure 16H-14. Installing the Retainer Wrench on Injector

10. Place the ST-995 Retainer Wrench upon the injector retainer.
11. Lubricate the threads of 3375103 Stud and screw in the 3375084 Loading Fixture Stand far enough to hold the injector.
12. Tighten the stud in 3375084 to 75 in. lb. (8.5 N m), Figure 1 6H-1 5 or activate the air cylinder on ST-i 298 to 70 psi (483 kPa)to align the cup and plunger, Figure 16H-16.
13. Tighten the cup retainer with the ST-1072 Crowfoot Wrench and ST-995 Retainer Wrench to 70 ft. lb. (95 N.m) torque, Figure 16H-17.
14. Remove the injector from the loading fixture being careful not to hit the cup on the stud.
15. To check the cup to plunger alignment by hand, remove the plunger and coat it with either clean fuel oil or test oil. Install the ST-1089 on the plunger.
16. Hold the injector in a vertical position (cup down) and allow the plunger to drip a few drops of oil into the cup.

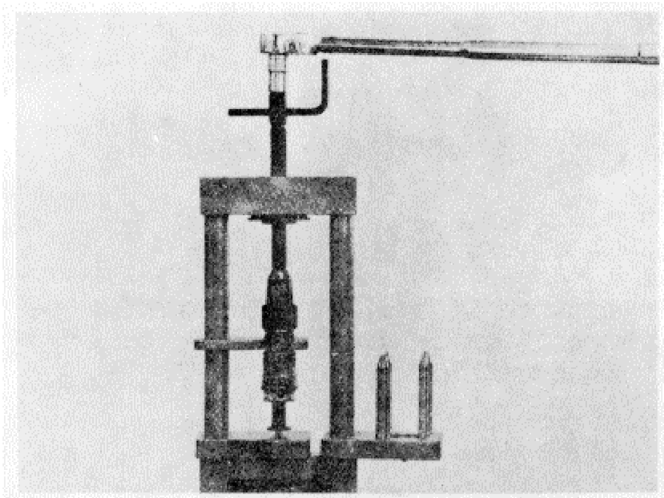


Figure 16H-15. Torquing the Loading Fixture Stud of 3375084

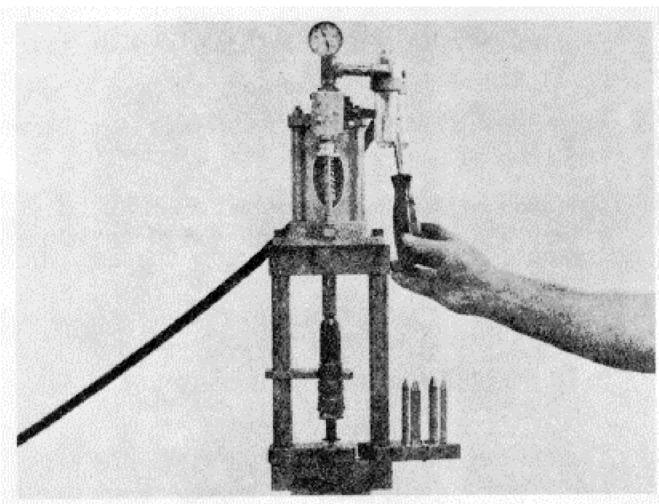


Figure 16H-16. Adjusting the Air Pressure on ST-1298

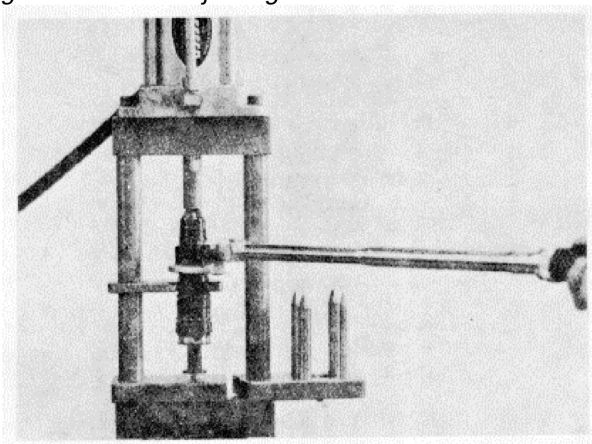


Figure 16H-17. Torquing the Cup Retainer -Injector ST-1298

17. Insert the plunger about 1/2 inch (12.7 mm) into the barrel to be certain the plunger is started straight.
18. Jam the coupling with the palm of your hand to seat the plunger in the cup and rotate 900 while holding the plunger firmly against the cup seat, Figure 16H-18.

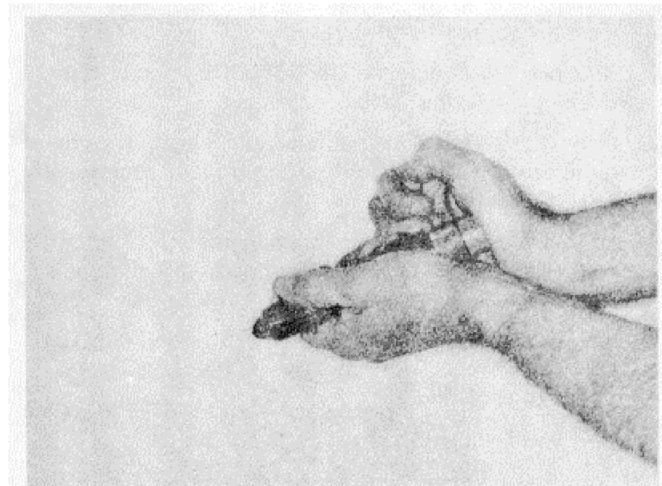


Figure 16H-18. Checking the Plunger to Cup Binding

19. Hold the cup up and the plunger should slide out when the injector is lifted quickly.
20. If the plunger does not slide out, remove the plunger, coat the tip and repeat the test.
21. To check the injector plunger sticking in the PT(Type B, C, D) and flanged injectors, use 3375209 Injector Plunger Sticking Checking Tool, Figure 16H-19.

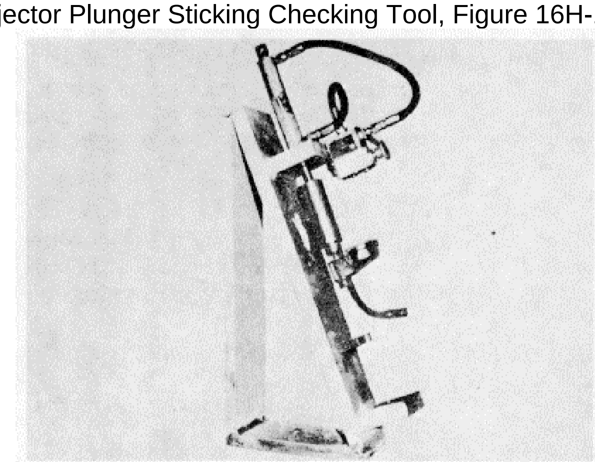


Figure 16H-19. Injector Plunger Sticking Tool

A. Place the assembled injector in the tool (cup in bearing).
B. Loosen the setscrews on the torque wrench stem, slide to the required length and tighten the setscrews.

C. Actuate the air cylinder and adjust the air regulator to 30 $\pm$ 2 psi (207 + 15 kPa).
D. Rotate the injector body and observe the torque wrench reading.
E. If the reading exceeds 2 in. lb. (32 in. oz.)(0.226 N.m), remove the injector, place it in the assembly fixture, loosen and retorque the retainer.
F. Recheck the injector in the 3375209 Injector Plunger Sticking Checking Tool.
G. If the 3375209 Tool is not available, loosen the cup retainer, rotate the cup one-fourth turn, and retorque. Repeat as necessary.

22. Remove the plunger from the adapter and lubricate the plunger with test oil. Install the spring on the plunger and insert into the adapter.

23. Check the plunger leakage on 3375375, ST-990 or ST570 as described on the following pages.

24. Check the cup spray pattern on an ST-668 as described on the following pages.

25. Another method of checking for open cup spray holes is as follows:

A. Remove the plunger and spring
B. Fill the barrel and cup full of fuel oil.
C. Insert the plunger with an ST1089, less spring, into the injector and force fuel out the spray holes, Figure 1 6H18.

WARNING

At any time fuel is forced from the cup spray holes, be sure to keep hands or body out of the spray stream to prevent injury.

D. Remove the plunger and install the spring and spring retainer.

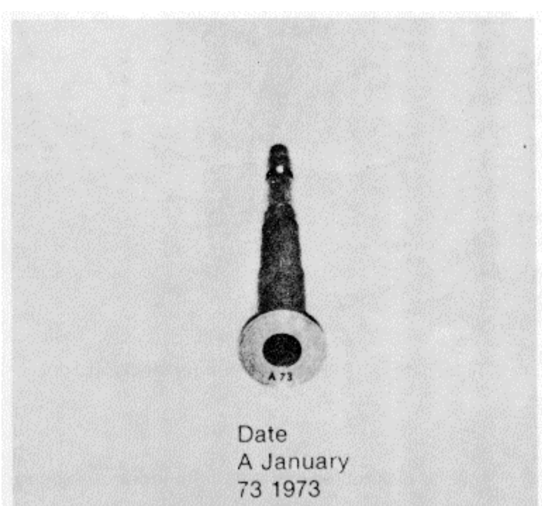


Figure 16H-20. Marking Location on the Plunger

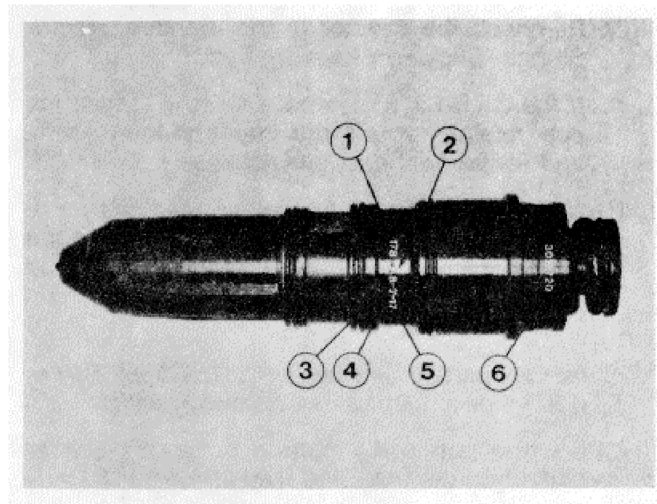
26. Lubricate and install new O-rings into the proper grooves in the adapter.

NOTE

Viton O-rings are identified by a green band.

NOTE

These injectors require three different O-rings.



1. 178 Injector Flow	4. 7 Size of Holes (.007)
2. A 80%0/ Flow	5.17 Degree of Holes
3. 8 Number of Holes	6. Assembly Number

Figure 16H-21. Size Location on the PT (Type D) Injector Adapter

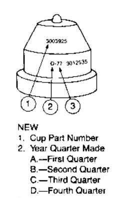


Figure 16H-22. Size Marking on the PT (Type D) Injector Cups.

27. Install a new fuel inlet screen and retainer, Figure 1 6H23.

28. After assembly, store in a clean place until ready for the leakage test.

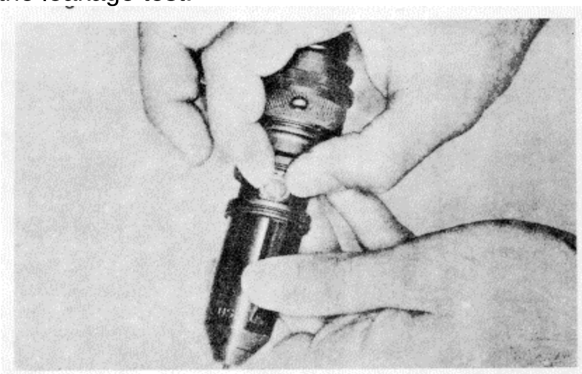


Figure 16H-23. Installing the Fuel Inlet Screen and Retainer

LEAKAGE CHECKS

GENERAL

The plunger-to-barrel and the plunger-to-cup leakage check gives a measurement of the fuel bypassed between the plunger barrel and the plunger cup. This check will determine if the injector is to be rehoned or can be calibrated and reused in an engine

ST-990 INJECTOR LEAKAGE TESTER

DESCRIPTION. The ST990 Injector Leakage Tester is used to determine the degree of acceptability of used injectors, Figure 1 6H-24.

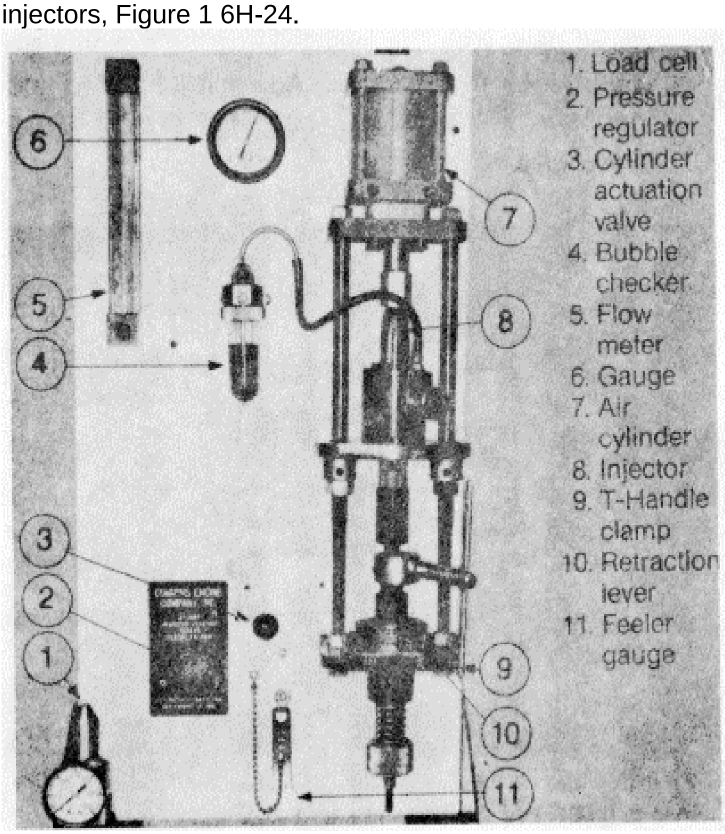


Figure 16H-24. ST-990 Injector Leakage Tester

The ST990 performs tests on all current injectors. These tests are as follows:

1. Barrel-to-plunger leakage in area below the metering orifice. The plunger is retracted off the cup seat by approximately 0.048 inch (1.22 mm). Air is forced through the cup spray holes, past the barrel-to-plunger clearance and is measured with a precision flowmeter.

2. Cup-to-plunger seat. The plunger is seated in the cup with 200 lbs (90.72 kg) load. Any leakage is measured in bubbles which are released under a fluid level. The injector check ball can be tested on ST-990by installing kit number 3376010. Follow the kit instructions for installation and testing procedures.

INSTALLATION REQUIREMENTS OF ST990. The following facilities are necessary for acceptable installation of the ST-990:

1. A clean area with good lighting. An enclosed fuel systems area is preferred. When a tightly enclosed room is used, the ball float will fluctuate slightly during opening and closing of the door. Other than not being able to obtain an accurate reading during actual swinging of the door, such a room has no adverse effects and is desirable.

2. A work bench of standard height which is not subject to pounding or other heavy work. The bench must not have a vise or other shop equipment which is generally subject to impacts.

3. An air supply of 80 psi (552 kPa) minimum pressure. The air line to the ST-990 should not be in a location where intermittent pressure drops are caused by actuation of other shop air equipment.

ASSEMBLY AND INSTALLATION OF ST-990. Assemble and install ST-990 as follows:

1. Mount the rubber isolation pads to the feet with the capscrews provided.

2. Mount the feet to the panel When the feet-to-panel capscrews are snug, the panel must be installed in a vertical position to ensure proper operation of the air flowmeter.

3. Fill the air cylinder oilier 1/3 to 1/2 full of injector test oil, Figure 1 6H-25. Make sure the sealing ring is in place before tightening the bowl retainer

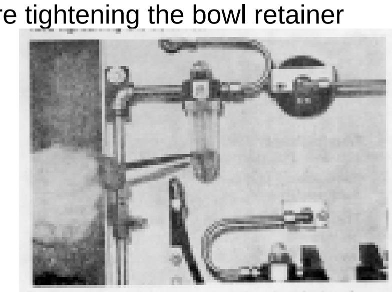


Figure 16H-25. Air Cylinder Oiler Oil Level

4. Fill the bubble checker bowl with injector test oil to the oil level marker, Figure 1 6H-26. An easier method to fill the bowl to the specified level, is to fill it approximately 3/4 full and then drain it to the proper level through the valve at the bottom of the bowl.

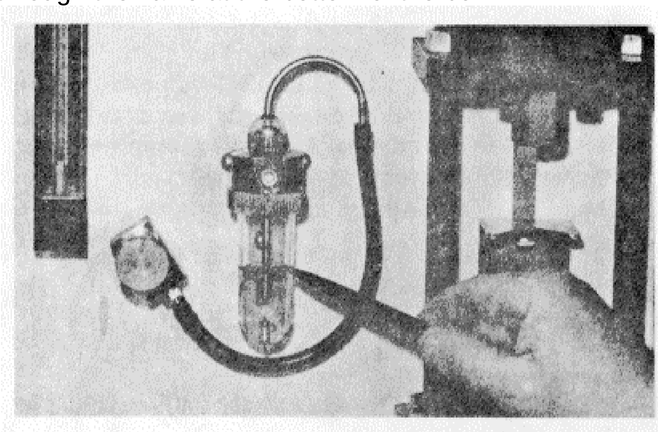


Figure 16H-26. Bubble Checker Bowl Oil Level

5. Use a lock jaw wrench or pliers while connecting the air supply line to prevent disturbance to the threads.
6. Install the T-handle clamping mechanism. Back out approximately 1/2 thread turn from a snug position.
7. the retraction handle and lock into position with the jam nut.
8. Set the pressure regulator at 60 psi (414 kPa).
9. Operate the air cylinder a few times and set the final pressure at precisely 60 psi (414 kPa). The air pressure must be held at 60 psi (414 kPa) during all tests.
10. The velocity of the air cylinder piston rod may be adjusted as desired with the small valve at the rear of the panel. Loosen the locknut and screw the valve stem into decrease the piston speed. Back the screw out to increase the piston speed. Lock the nut on the stem when the desired
piston speed is attained.
11. With the retraction lever in the "A" position, install the load cell and clamp it into position, Figure 1 6H-27.

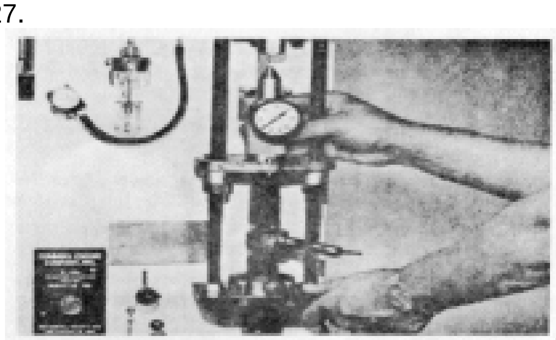


Figure 16H-27. Installing the ST-990 Load Cell

12. Adjust the knurled knob until the load cell reads 200 psi (1379 kPa), Figure 16H-28 The psi (kPa) reading on the load cell is a direct reading in pounds(kg) load, since the load cell piston area equals 1 square inch (6 45 sq cm). Adjust the knurled knob to obtain 200 lbs (90.7 kg) load during several clamping cycles.

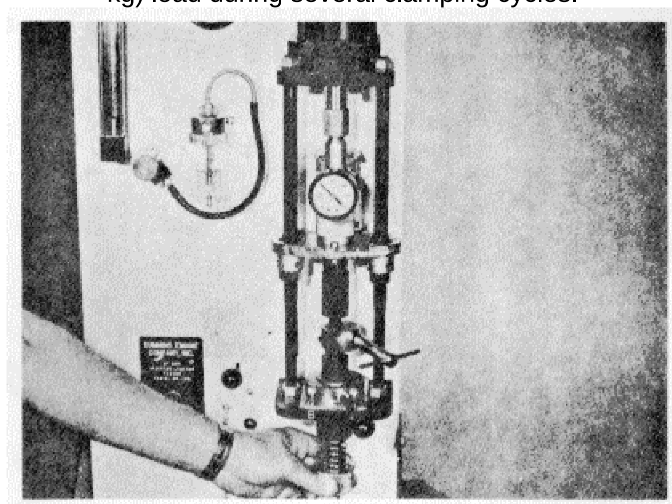


Figure 16H-28. Adjusting the Load Cell Pressure

13. With the load cell clamped at 200 lbs (90.7 kg) load, use the feeler gauge to adjust the locknuts into position and tighten, Figure 16H-29. The clamping mechanism should be checked daily with the load cell and the locknuts adjusted if necessary. Do not adjust the locknuts unless the load cell is used.

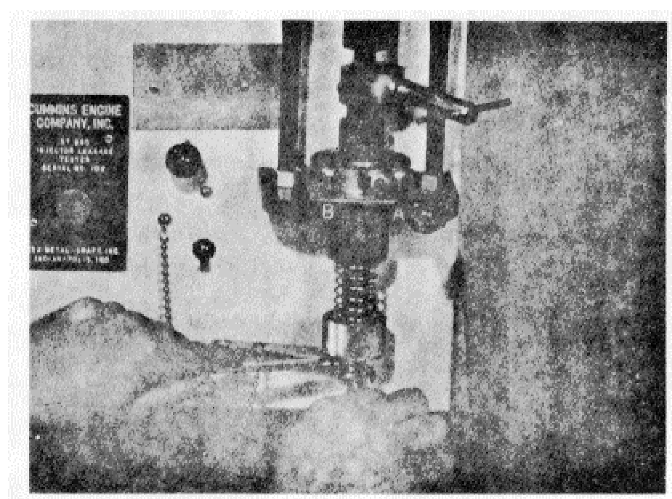


Figure 16H-29. Using the Feeler Gauge to Check the Locknut

ST-990 PLUNGER-TO-BARREL AND PLUNGER-TO-CUP CHECK

1. Remove the ST-1254-3 Locating Screw from Service Tool ST-1254 Adapter Pot Assembly. Oil the injector 0rings. Install the ST-1089 Plunger Extension on the plunger Remove the spring
2. Align the injector delivery orifice with the burnishing hole in the adapter pot.
3. Using hand pressure, anST-1298 or 3375084, press the injector into the pot until it bottoms, Figure 1 6H-30.
4. Insert and tighten the locating screw

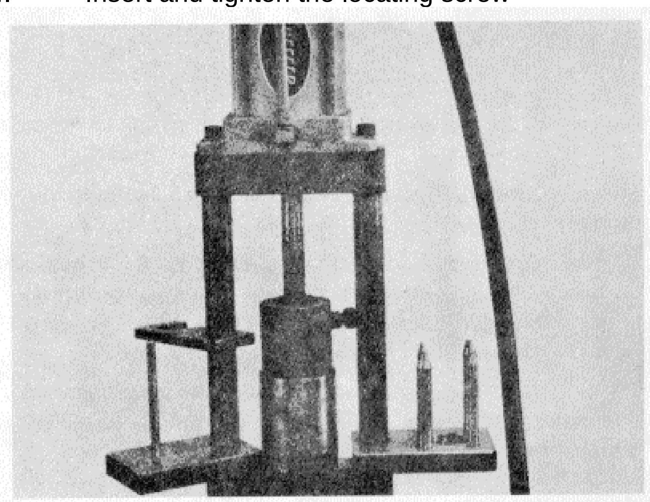


Figure 16H-30. Inserting the Injector into ST-1058 Pot

NOTE

When testing injectors, a Service Tool 3375098 or ST-1058-6 Spacer must be installed on top of the adapter within the pot, Figure 16H-31.

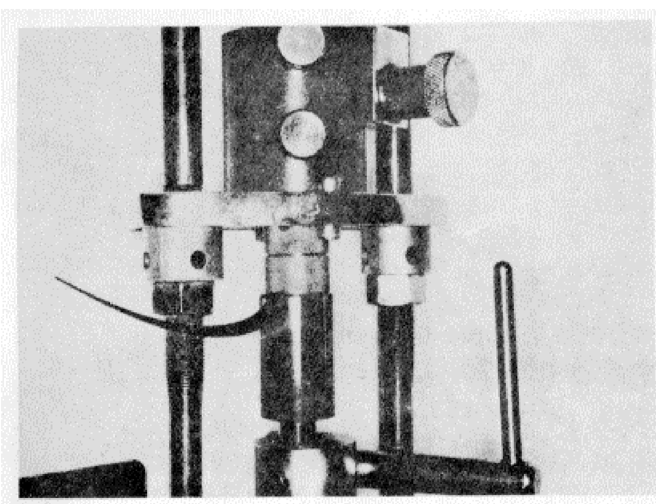


Figure 16H-31. ST-1089 Spacer Used with Injector

5. Plug the fuel inlet port with an ST-668-14.
6. Install the injector into the ST-990 and clamp it into position. The support plate may be tilted for easier installation of the injector, Figure 16H-32.

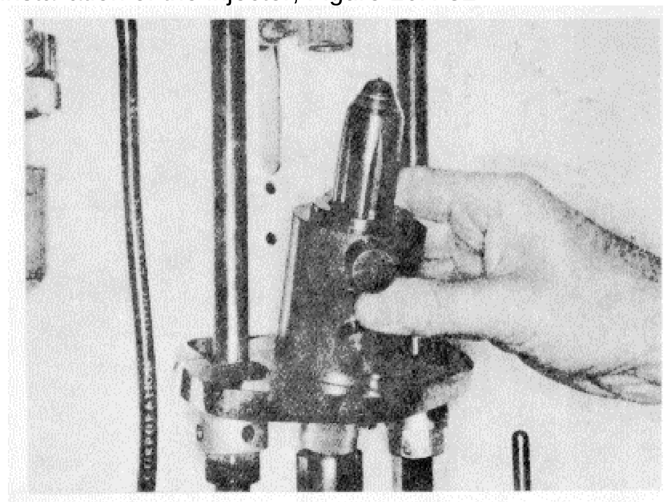


Figure 16H-32. Installing the Injector in ST-990

7. Adjust the knurled knob to obtain the proper clearance with a feeler gauge between the knob and the locknuts, Figure 16H-33. Do not adjust the locknuts.
8. Install and tighten the transfer line in the injector drain port. This is the port on the operator's right when facing the front of the test stand.

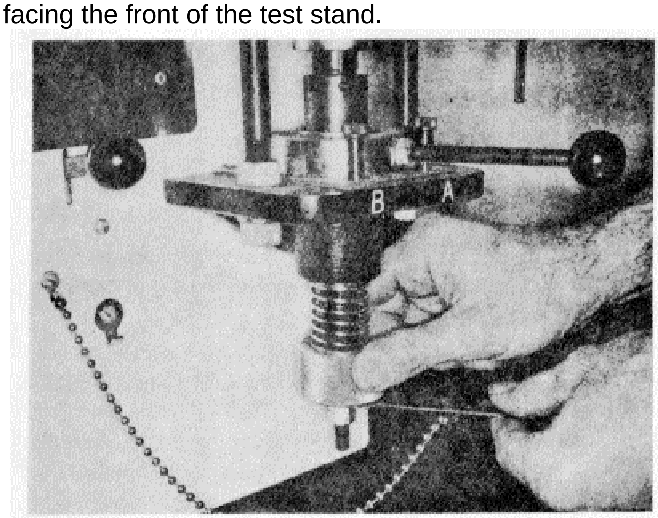


Figure 16H-33. Adjusting the Knurled Nut for Feeler Gauge Clearance

9. Tighten the T-handle clamp, Figure 16H-34
10. Shift the retraction lever from the "A" to the "B" position, Figure6H-35. This the removes the load from plunger and allows it to be retracted from the cup seat by approximately 0.048 inch (1.22 mm). Make sure the plunger retracts. The plunger may stick in the cup seat.

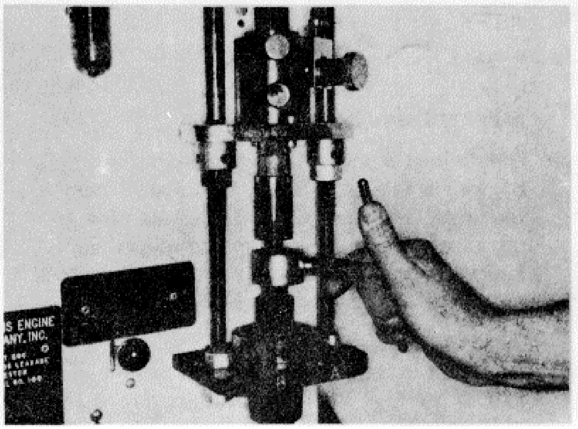


Figure 16H-34. Tighten the T-Handle Clamp

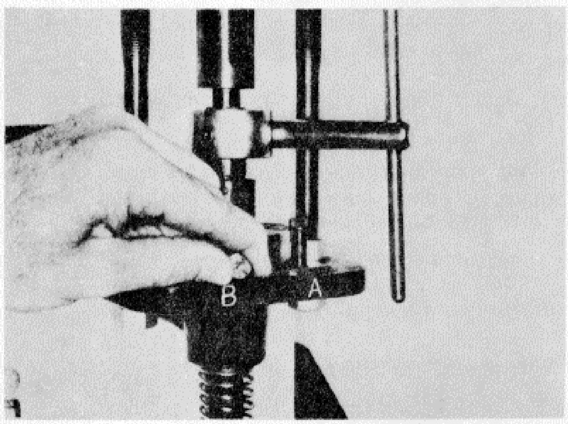


Figure 16H-35. Shifting the Retraction Lever

11. In this position the presence of bubbles in the bubble checker is disregarded. Read the air flowmeter at the top of the ball float.
12. Rotate the plunger top in a clockwise direction by very small increments. Observe the flowmeter reading, Figure 16H-36. Do not touch the plunger top or any part of the clamping mechanism while taking the reading. External forces will disturb the plunger from its normal position and may affect the barrel-to-plunger leakage in the cup area.
13. Continue to rotate the plunger by small increments to find the highest reading on the flowmeter.
14. Maximum readings on the injectors which will satisfactorily perform throughout another service period are 2.5 to 4.5 units.
15. If maximum leakage of the injector being checked exceeds the specified values, the injector barrel must be sent to a rebuild station for replungering.
16. If the maximum leakagedoes not exceed 4.5 units, shift the retraction lever back to the "A" position and loosen the

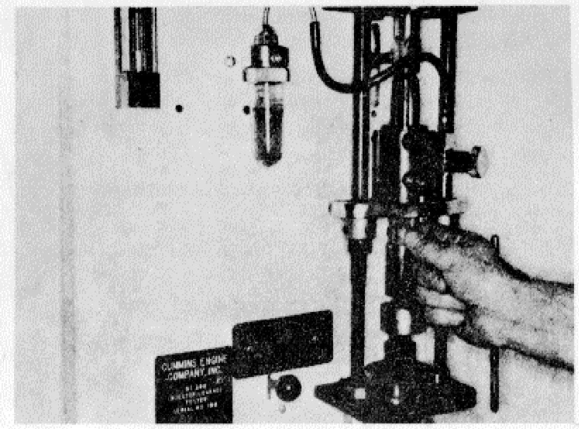


Figure 16H-36. Rotating the Plunger Coupling and Spacer

T-handle clamp. This applies 200 lbs (90.7 kg) load to the plunger.
17. The cup-to-plunger seal is acceptable if no bubbles occur in 10 seconds or if the time interval between consecutive bubbles of air observed in the bubble checker exceeds 5 seconds
18. If the cup seat is damaged in any way and the injector does not pass the ST-990 cup-to-plunger seat test, the plunger may be lapped into the cup to obtain a good seat. This lapping is to be done in a careful manner without using the barrel. Use no greater than a 600 grade paste lapping compound. Apply light pressure and rotate the plunger in the cup back and forth for approximately one minute, Figure 16H-37.

CAUTION

After lapping, both the cup and the plunger must be cleaned thoroughly. Lapping compound will damage the fuel system parts unless removed. The most effective cleaning process is the use of an "ultrasonic cleaner" and an after rinse in fuel oil.

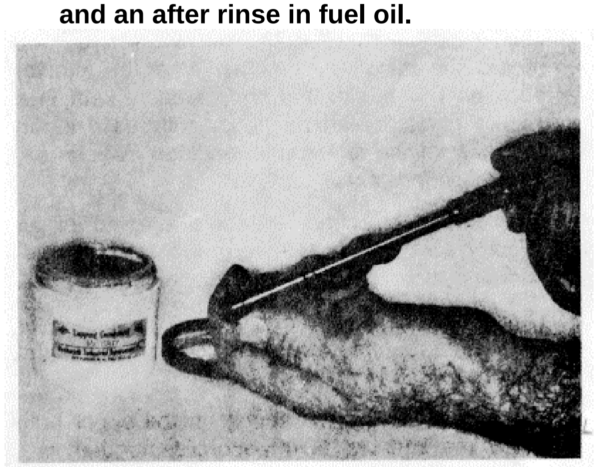


Figure 16H-37. Lapping the Injector Plunger in the Cup

1 9.With these checks completed and the retraction lever in the "A" position, disconnect the transfer line, exhaust the air cylinder and remove the injector.

20. Remove the plunger. Reinstall the spring and the plunger.

ALTITUDE COMPENSATION

The ST-990 is an altitude sensitive device and when it is used to check the body, or the barrel to plunger leakage, the unit readings should be corrected to allow for altitude variations. For every 1,000 feet (305 m) altitude rise above 600 feet (183 m), 0.2 units should be subtracted from the unit reading. See Table 16H-3.

EXAMPLE: If your shop is 6,600 feet (2012 m) above sea level, you should subtract 1.2 (6 x 0.2) units from your unit measurement. The altitude does not affect the cup to plunger leakage check.

MAINTENANCE

1. All ST-990 injector leakage testers are checked for gauge and flowmeter accuracy, leaks, operation and compatibility with other ST-990's before release to the field.

2. It is strongly recommended that each ST-990 location select a clean used injector which has a maximum leakage in the 8 to 10 unit area and record the maximum reading. When an injector such as this is selected and carefully kept in a secure place, it can be periodically used as an indicator of the test stand condition over an extended period of use. The careful selection and safe keeping of an injector such as this is a very important troubleshooting tool in the event that discrepancies arise.

3. Drain the sediment from the air inlet trap daily or weekly, as required, depending upon the amount of contamination in the air lines A yellow indicator will appear in the upper bulb when the sintered filter becomes clogged with foreign matter. The filter must then be removed and cleaned with solvent.

4. Do not obstruct the flowmeter vent in any way. Oil and oil mist must never be allowed to enter either the drain or the inlet of the flowmeter as this will cause the float to stick to the sides of the tube.

5. Do not readjust or move the injector plate supports on the rods. These have been adjusted at the factory for proper alignment and must not be disturbed 6. Maintain the air cylinder oiler at 1/2 to 1/3 full of injector test oil at all times to ensure proper cylinder action.

7. All fittings, filter oiler and bubble checker bowls (upper and lower) must be kept tight and free from air leaks.

8. Any oil that collects in the bowl of the separator, mounted by the dry type filter, must be drained regularly. This separator also contains a sintered filter which must be cleaned in a solvent at least twice yearly.

9. The dry type filter element should be changed twice yearly, under normal conditions, if the sediment bowl adjacent is drained regularly.

3375375 INJECTOR LEAKAGE TESTER

DESCRIPTION. The 3375375 Injector Leakage Tester was developed to measure the injector plunger to barrel or body leakage, plunger to cup leakage and injector check ball leakage, Figure 16H-38.

This tool is more accurate than the ST-990 which will improve the acceptability of rebuilt injectors.

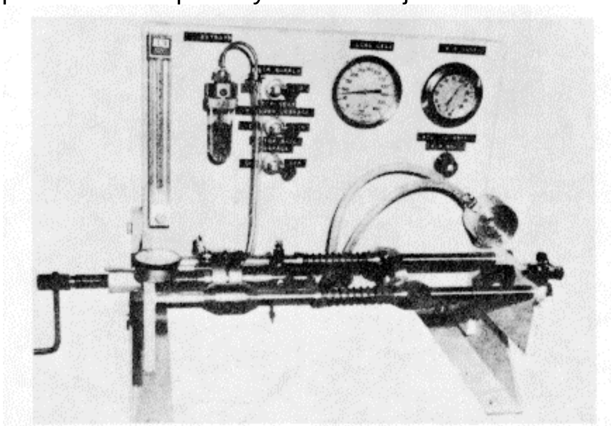


Figure 16H-38. Injector Leakage Tester

INSTALLATION REQUIREMENTS. The following facilities are necessary for an acceptable installation of a 3375375 Injector Leakage Tester:

1. A clean area with good lighting. An enclosed fuel system area is preferred. When a tightly enclosed room is used, the ball float may fluctuate slightly when opening or closing the door. Except for the inaccurate reading during the time when the door is opened and closed, such a room has no adverse effects and is therefore desirable.

2. A workbench of standard height that is not subject to pounding or heavy work. The bench should not have a vise or other shop equipment that is subject to impacts.

3. An air supply of 80 psi (552 kPa) minimum pressure. The air line to 3375375 should not be in a location where intermittent pressure drops are caused by actuation of other shop air equipment

ASSEMBLY AND INSTALLATION OF 3375375 INJECTOR LEAKAGE TESTER. Assemble and install the tester as follows:

1. The panel must be in a level position to ensure the proper operation of the air flowmeter.

2. Fill the bubble checker bowl one-half full with injector test oil, Figure 16H-39.

3 Adjust the two screws on the load cell lock to show 50 pounds force, Figure 16H-40.

4 Install the dial indicator and the extension in the clamp.

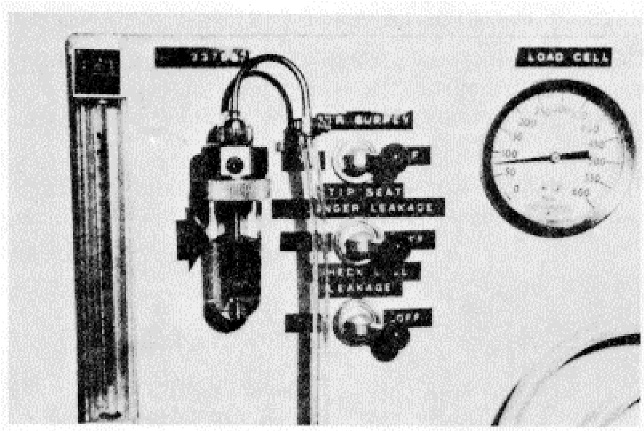


Figure 16H-39. Bubble Checker Bowl One Half Full of Oil

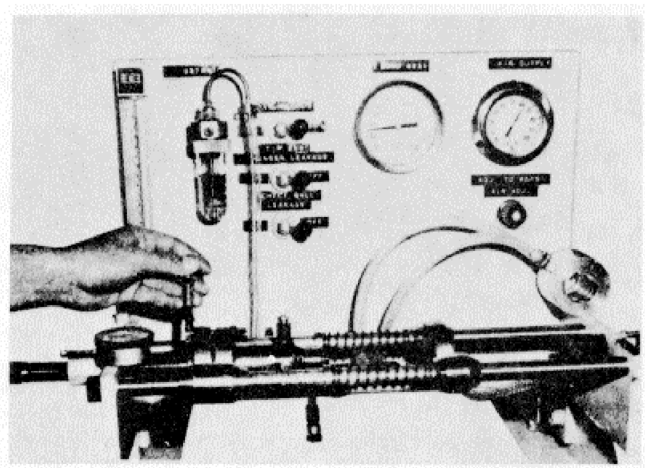


Figure 16H-40. Adjusting the Load Cell Lock

MAINTENANCE. Maintain testers as follows:

1. All 3375375 Leakage Testers are checked for gauge and flowmeter accuracy, leaks, operation and compatibility with other leakage testers.

2. Select a clean used injector of known leakage. Store in a clean, secure place for periodic checking of the 3375375 over extended periods of use.

3. Drain the sediment from the air inlet as required. If the yellow indicator appears in the upper bulb, remove the filter and clean in solvent.

4. Be sure the flowmeter vent is not obstructed in anyway. Oil or mist entering the flowmeter will cause the float to stick.

5. All fittings must be kept tight and free from air leaks.

6. Drain the separator regularly and clean its sintered filter in solvent twice a year.

7. Change the dry type filter twice yearly under normal operating conditions.

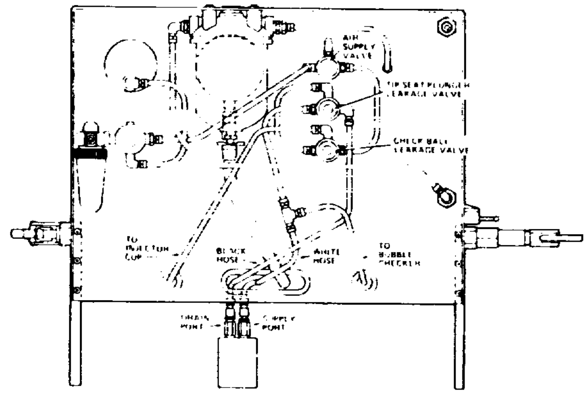


Figure 16H-41. 3375375 Leakage Tester Valve Arrangement (Rear of Panel)

ALTITUDE COMPENSATION. The 3375375 is an attitude sensitive device. When it is used to check barrel to plunger or body leakage, the unit readings should be corrected to allow altitude variations. For every 1,000 feet (305 m) of altitude rise above 600 feet (183 m), 0.2 units should be subtracted from the unit reading. See Table 16H-3.

PLE: If your shop is 6,600 feet (2012 m) above /el, you should subtract 1.2 (6 x 0.2) unit from your unit measurement. Altitude does not affect cup to plunger leakage check.

Table 16H-3. Leakage Tester Altitude Compensation

Altitude	**Units of Compensation**
sea level	add 0 012 units
600 ft.	none
1100 ft.	subtract 0.1 units
1600 ft.	subtract 0 2 units
2100 ft.	subtract 0.3 units
2600 ft.	subtract 0.4 units
3100 ft.	subtract 0.5 units
3600 ft	subtract 0 6 units
4100 ft.	subtract 0.7 units
4600 ft.	subtract 0.8 units
5100 ft.	subtract 0.9 units
5600 ft.	subtract 1.0 units
6100 ft.	subtract 1.1 units
6600 ft.	subtract 1.2 units
7100 ft.	subtract 1.3 units
7600 ft.	subtract 1.4 units
8100 ft	subtract 1 5 units
8600 ft.	subtract 1.6 units
9100 ft	subtract 1.7 units
9600 ft.	subtract 1 8 units
10100 ft.	subtract 1.9 units
10600 ft.	subtract 2.0 units

INJECTOR INSTALLATION. Install the injector as follows

1. Remove the balance orifice clip and screen.

2. Select the appropriate adapter pot. The pot for K-Series injectors is stamped "K" or 3375440.

3. Lubricate the O-rings and insert the injector into the adapter pot.

NOTE
Damaged O-rings can cause false readings.

4. Place the 3375401 Adapter over the injector top with the largest diameter against the injector flange.

5. Insert the 3375398 Link without the 3375397 Adapter. Install the entire assembly into the injector guide, link end first. Secure in place with the locking lever, Figure 16H-42.

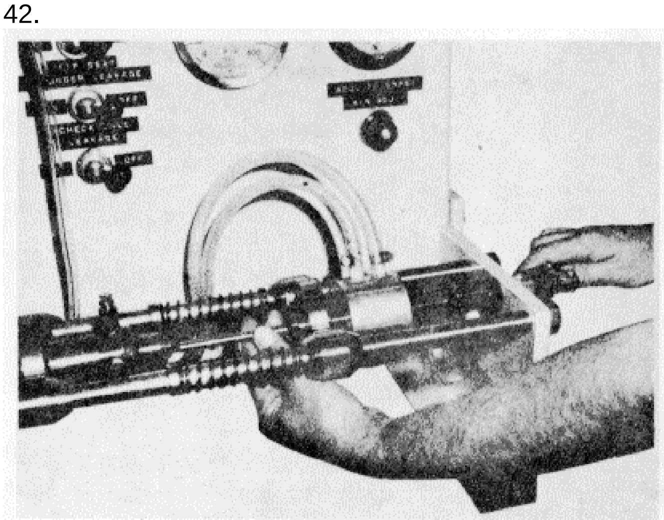


Figure 16H-42. Installing the Injector in the Leakage Tester

6. Install the supply and drain hoses to the fittings on the adapter pot. The white hose should be toward the injector cup.

NOTE
The white hose is the supply. The black hose is the drain.

CHECKING PROCEDURE. Check the injectors as follows:

Cup to Plunger Tip Test

1. Adjust the air pressure to 60 psi (414 kPa). See Step 2 under "Installation." Perform this step if not previously done. Normally, Step 2 is only required on the first set up.

2. Adjust the hand crank to show 200 pounds on the load cell gauge.

CAUTION
Never "peg" the load cell gauge; accuracy may be lost.

3. With the air supply valve OFF, turn the tip seat plunger leakage valve ON.

NOTE

The air supply valve must be off whenever the other valves are switched either on or off. Otherwise, the rush of air may blow oil from the bubble checker.

4. Turn the air supply valve ON and look for bubbles in the bubble checker. If no bubbles appear within 10 seconds, or if the time between bubbles is more than 5 seconds, the cup to plunger seating is acceptable, Figure 16H-43. If unacceptable, retorque the cup.

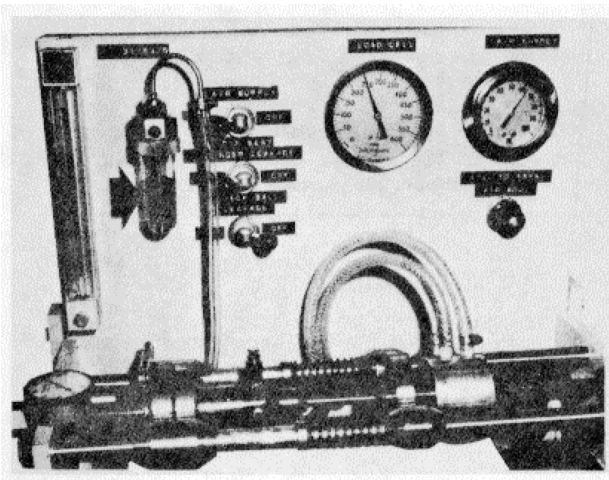


Figure 16H-43. Checking the Cup to Plunger Seating

5. Turn the air supply valve OFF before removing the injector.

NOTE

If the test results are acceptable, proceed with the "Barrel to Plunger Test." Barrel to Plunger Test 1. Adjust the air pressure to 60 psi (414 kPa).

2. Adjust the hand crank to show 200 pounds on the load cell gauge.

NOTE

Never "peg" the load cell gauge; accuracy may be lost.

3. Zero the dial indicator.

4. Back out the hand crank 0.047 inch (1.19 mm) as measured on the indicator.

NOTE

Keep a light pressure on the load cell plunger toward the indicator while turning the crank.

5. With the air supply OFF, turn the tip seat plunger leakage valve ON.

6. Turn the air supply valve on.

7. Gently rotate the injector plunger in small increments, and watch the flowmeter for the highest reading, Figure *16H-44.*

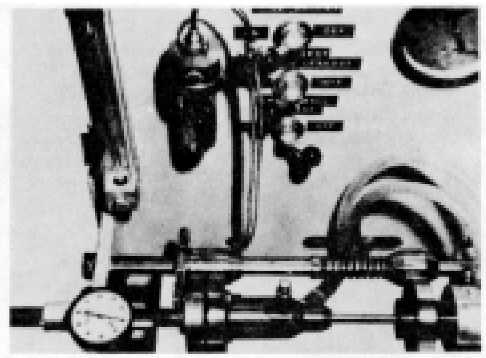


Figure 16H-44. Measuring the Plunger to Body or Barrel Leakage

NOTE
A zero reading on the flowmeter indicates no leakage.

If the leakage exceeds 4.5 units, mark the injector for plunger replacement.

8. Turn the air supply valve OFF before removing the injector.

NOTE
If the leakage is within the specifications, proceed with the "Check Ball Leakage Test.".

Check Ball Leakage Test

1. With the plunger still in the retracted position (0.047 inch (1.19 mm) on indicator), and the tip seat plunger leakage valve and the air supply valve OFF, turn the check ball leakage valve ON.

2. Turn the air supply valve ON and adjust the air pressure to 80 psi.

3. Observe the flowmeter, Figure 16H-45. In some cases, replacing the check ball is all that is required to correct the leakage.

NOTE
If the lowest reading on your flowmeter is 1, that is one unit. If your lowest reading is 10, that is one unit.

4. If the leakage is acceptable, turn the air supply and the check ball leakage valve off before removing the injector.

5. Remove and reassemble the injector.

TROUBLESHOOTING. Occasionally the tip seat plunger leakage valve may leak air pressure through the bubble checker and the flowmeter causing inaccurate assessment of the injector quality. A quick method for checking this failure is to remove the white line from the injector pot and hold your thumb over the disconnect. If bubbles appear in the bubble checker or the ball in the flowmeter rises, the

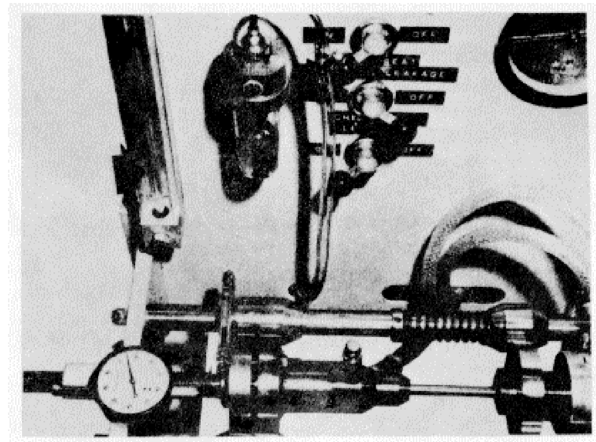


Figure 16H-45. Reading the Flowmeter for Check Ball Leakage

valve is leaking. Take appropriate repair or replacement action.

CUP SPRAY PATTERN CHECK

CHECK INJECTOR SPRAY PATTERN ST-668

1. Locate the ST-668 on or near the ST-790 Injector Test Stand, Figure 16H-46 (or other source of 22 psi (152 kPa) constant fuel pressure). The injector inlet connection of the test stand must reach the injector spray checker. Use injector test oil or fuel oil to perform this test.

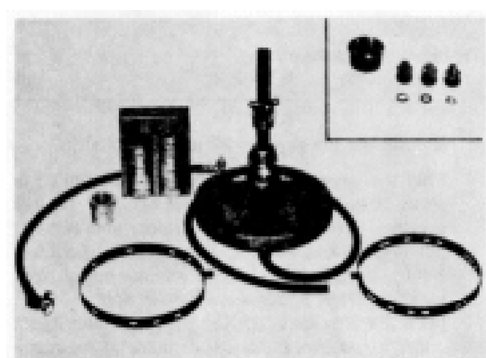


Figure 16H-46. ST-668 Spray Test Fixture

2. Attach a drain hose to ST-668 Base and place the loose end in ST-790 Drain Pan.

3. Assemble the applicable cup seat spacer (see Table 1 6H4) to the seat bracket bore.

4. Check the cup part number as shown in Figure 16H-22 1 (9-0085-10 indicates 9 holes, 0.0085 inch diameter and 10

degree spray angle). See Table 16H-5 for the cup holes and size.

5. Check Table 16H-5 for the number of spray holes (9) and place the applicable target ring in the base of ST-668. Target rings are marked on the "handle" (6 and 9 holes or 5, 7 and 8 holes).

6. Insert the injector in Service Tool ST-1254 Adapter, Figure 16H-47.

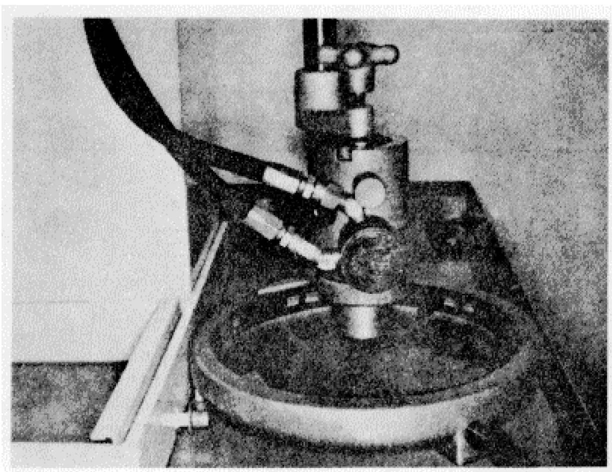


Figure 16H-47. PT (Type D) Injector in ST-668

NOTE

Use plunger bore plug assembly injectors.

7. Remove the plunger assembly and spring from the injector.

8. Select the correct size plunger bore plug and rubber seal and install it in the injector plunger bore. Protect the injector plunger from dirt or damage during tests.

9. Install the solid knurled plug in the injector drain opening.

10. Place the injector in the ST-668 Seat and adjust the holddown bracket into the position required, then tighten the thumb screw.

11. Tighten the knob against the plug and seal in the plunger bore so it seals thoroughly.

12. Attach the fuel inlet line from ST-790 or other pressure source to the injector inlet of ST-1254 Adapter.

13. Start the ST-790Test Stand or other source of fuel and set the pressure to 22 psi (152 kPa).

14. Shift the target ring in the base of the tool so one spray stream hits the center of No. 1 or the index window. This is the tallest window and is next to the target slide handle. On 1974 and later injectors i2 degrees tolerance must be maintained on all streams.

15. Each spray stream must hit a window in the target ring.

Table 16H-4. ST-668 Cup Seat Spacers		
Cup Spray Angle	**Spacer Marking**	**Spacer Height Inch [mm]**
10 deg. [14.30/14.45]	H-10	0.563/0.569

16. If a stream hits above, below, left or right of a small window, shift the target ring so No. 1 window is at that stream. If the stream is still outside No. 1 window, the cup is defective or the spray hole is dirty. Clean the spray holes with compressed air and recheck the cup. If the spray pattern is still defective, check to make sure the proper target ring is being used, or discard the cup.

NOTE

For a cup to be acceptable no more than one stream must require the increased tolerance of the No. 1 window.

17. After testing, assemble the plunger with the spring in the body or adapter and store it in a clean place until ready for the flow test.

FLOW TESTING INJECTORS ON ST-790

FLOW TESTING ADJUSTABLE DELIVERY INJECTORS ON ST-790 The ST-790

Test Stand is used to flow test the complete injector assembly by measurig the fuel delivery. The injector is actuated under controlled conditions closely simulating actual operating conditions. The test stand counts injection strokes and supplies fuel at a specified pressure. Delivery is measured in a glass graduate.

Remove the master injector ST-1262 from the test stand after calibrating the test stand. Install the .026 restrictor orifice in the cup seat. See Table 1 6H-5, Figure 16H-48, and tighten to 6 in. lb. (0.7 N.m). The 0.026 inch (0.66 mm) orifice has one notch.

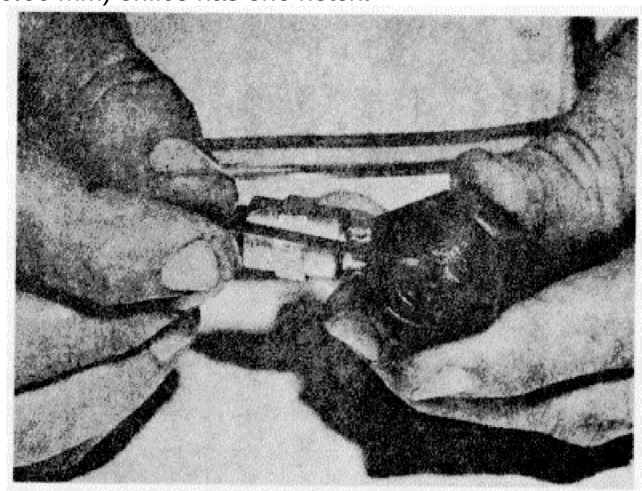


Figure 16H-48. Installing the Restrictor Orifice

Table 16H-5. PT (Type D) Injectors - Delivery Values (ST-790 Test Stand and Master Injector)

Table 16H-5. PT (Type D) Injectors — Delivery Values (ST-790 Test Stand and Master Injector)

Cup Spray Holes No. - Size X Angle	Delivery No. cc @ PSI at 1000 Strokes	Test Stand Seat Orifice	Approx. Orifice Size Before Burnishing	Top Stop Set.	Notes
9 - .0085 x 10 deg	**184-185 @ 120 psi-AK	.026	.027-.028		Direct Feed Barrel

The ST-1262 Master Injector will check the ST-790 delivery flow at approximately 800 strokes.

COMPARING INJECTOR FLOW WITH ST-1 129

A new flowmeter, ST-1129, is available to provide a quick comparative indication of injector flow on the ST-790 Test Stand without running through a complete test cycle. However, this flowmeter is in no way meant to replace the present method of measuring the injector delivery, Figure 16H-49.

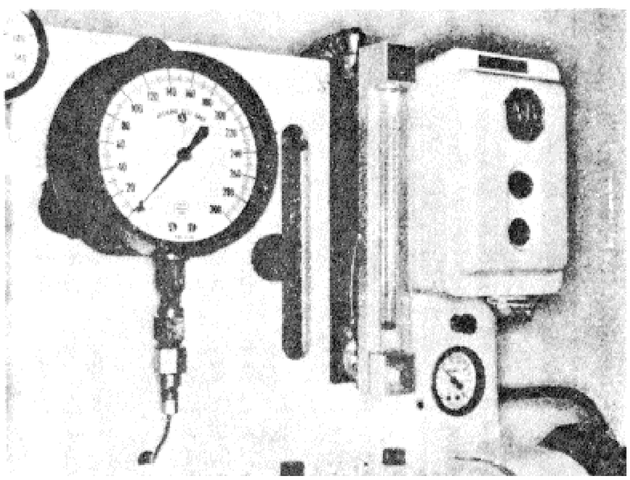


Figure 16H-49. Front View of ST-790 with ST-1129 Installed

OPERATING INSTRUCTIONS

1. Assemble the first injector, of the set to be flowed, into the ST-790 stand per normal procedure and complete the calibration.

2. Before removing the injector from the ST-790, note the flowmeter value.

3. Install the second injector, start the test stand and observe the flow value. Do not hit the flow stand button. Compare it with the previous injector and burnish or replace the orifice until the reading is slightly below the first injector.

4. Complete the calibration of the injector.

A little practice with the flowmeter will save considerable time in "burnishing in" the injectors to reach the correct flow value.

Table 16H-6. Injector Orifice Plugs

Table 16H-6. Injector Orifice Plugs

Flanged Part Number	Inside Diameter Inch [mm]
177292	0.024 [0.61]
177293	0.025 [0.64]
177294	0.026 [0.66]
177295	0.027 [0.68]
177296	0.028 [0.71]
177297	0.029 [0.74]
177298	0.030 [0.76]

NOTE

A very useful tool for checking the orifice inside diameter is ST-1332. The tool is especially helpful if the orifice plugs become mixed. Measure the orifice at the base end (not the wrench end) as shown in Figure 16H-50.

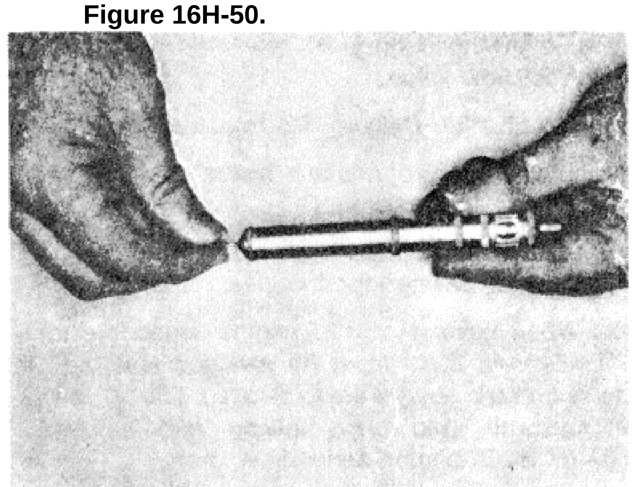


Figure 16H-50. Checking Orifice with the Orifice Size Gauge

FLOW TESTING INJECTORS

The ST-790 Test Stand is used to flow test the complete injector assembly by measuring the fuel delivery. The injector is actuated under controlled conditions closely simulating the actual operating conditions of the engine. The test stand counts the injection strokes and supplies fuel at a specified pressure. Injector delivery is measured in a glass graduate.

1. Calibrate all injectors with the K cam in the test stand.

2. Lubricate the inside of Service Tool ST-1254 Body with test oil so the injector O-rings will slide into the adapter without damage to the O-rings.

3. Seat the injector in the body so the injector inlet aligns with the body inlet holes, Figure 16H-51. Tighten the locating screw, Figure 16H-52.

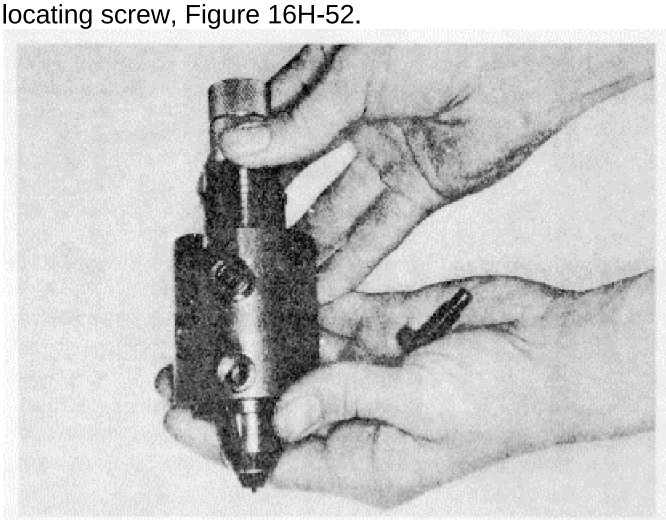


Figure 16H-51. Centering the Injector Inlet in the St-1508 Inlet Hole

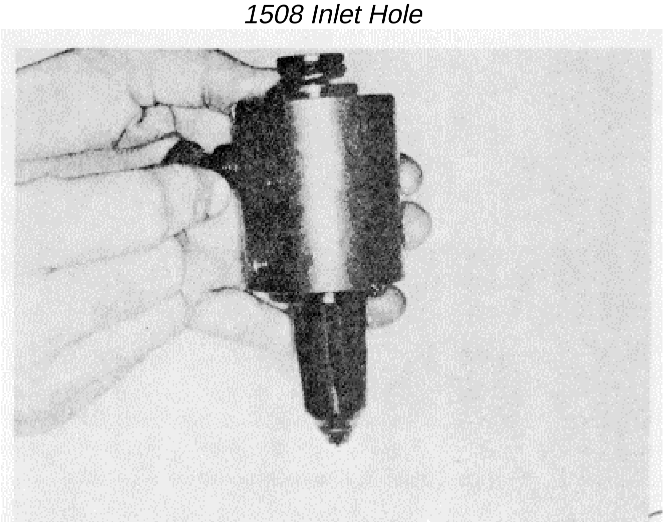


Figure 16H-52. Tighten the ST-1058 Locating Screw

4. Remove the spring and plunger from the injector adapter. Leave the spring off and install the plunger.

5. Perform the ball valve seating check on 3375375 or a converted ST-990 before calibrating the injector. An alternate method of checking the ball seat is as follows:

A. Attach the test stand inlet pressure line to the drain connection of Service Tool ST-1254 Body.

B. Hold the injector plunger down against its seat in the injector cup with the injector in a vertical position. The assembly may be held by hand. Do not place it in the test stand holding device, Figure 16H-53.

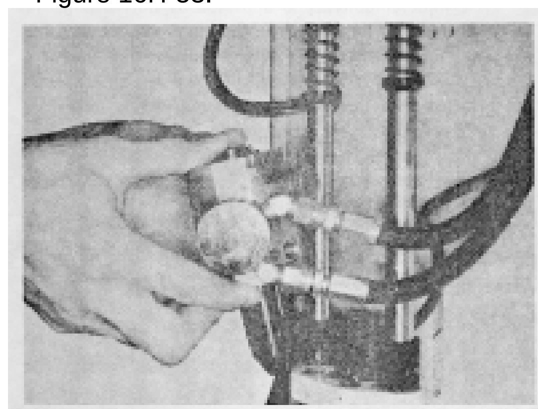


Figure 16H-53. Checking Leakage at the Inlet Port

NOTE

Be sure the ST-708-1 Needle is retracted.

C. Turn on the test stand, and adjust the pressure to 150 psi (1034 kPa).

D. Check the orifice plug inlet opening of Service Tool ST1 254 Body for leakage past the ball valve.

NOTE

Make sure the plunger is seated in the cup.

E. If leakage is observed, the ball must be replaced. Slight seepage is not harmful.

6. Disconnect the inlet pressure line from the drain connection of the body.

7. Remove the injector plunger.

8. The location screw must seat in the hole of the adapter.

9. Check to be sure the injector inlet is centered in the body inlet hole, to prevent breaking ST-708-1 Burnishing Tool point when it is installed later.

10. Install the spring and plunger into the injector.

11. Assemble the retainer plate over the injector with the pins engaged in the body.

12. Position the injector in the test stand with the correct adapter link. The link is 6.3 inches (160 mm) long, marked ST-790-362.

NOTE

All tests on the test stand are performed without a screen on the injector.

13. Assemble the ST-708 Burnishing Tool into the test stand injector inlet connector, Figure 16H-54. Retract the needle by pulling out the small knob. With the needle retracted, the ST-708 Tool may be left in the connector during all test operations.

NOTE

The injector delivery is adjusted by burnishing the inlet orifice plug with ST-708 instead of changing the plug. The replaceable needle point, ST-708-1, is the burnishing member, Figure 16H-55.

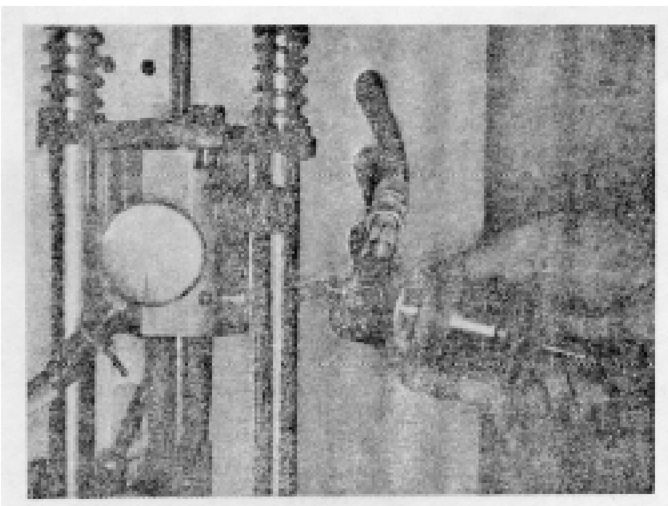


Figure 16H-54. ST-708 Installed in the Inlet Connection

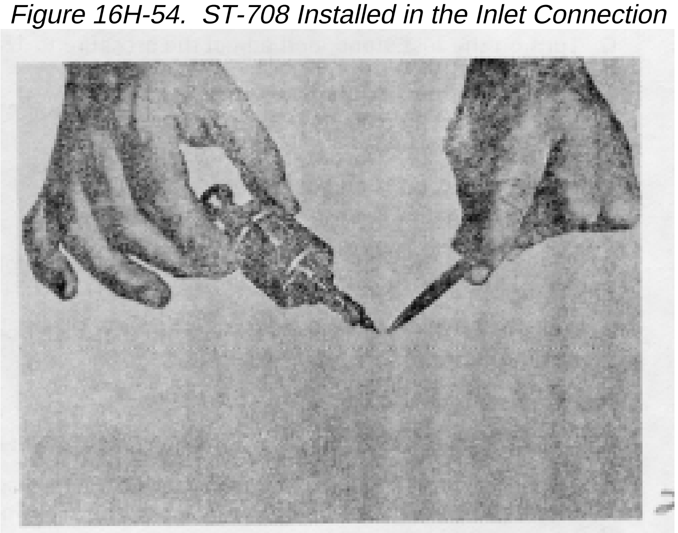


Figure 16H-55. ST-708 Burnishing Tool

14. Install the connector and ST-708 Tool into the Service Tool ST1254 Body inlet by screwing in the large knob section, Figure 16H-54.

15. Install the drain connection.

Run the injector through a test cycle and check the cc delivery. If the delivery is lower than the specifications given in Table 16H-5, turn the knob with the indicator point until it is

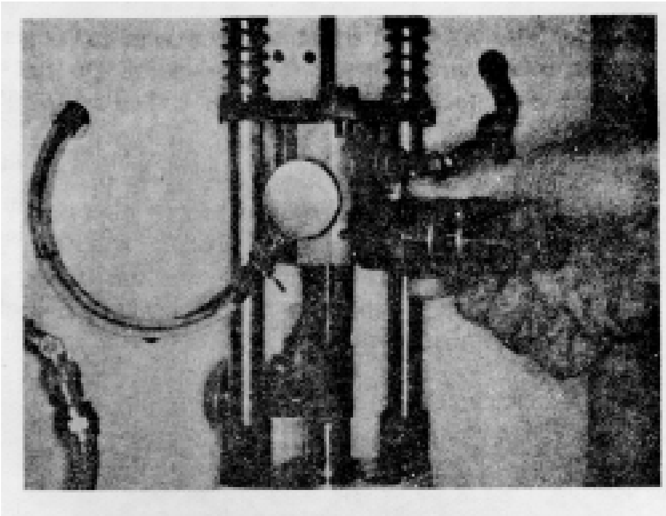


Figure 16H-56. Assembling the ST-708 Tool to the Adapter Pot

spaced 3/8 inch (9.5 mm) from the large knob, Figure 16H57.

CAUTION

The ST-708-1 must be used with extreme caution when sizing the hi-flow injectors. Do not damage the injector body under the orifice plug.

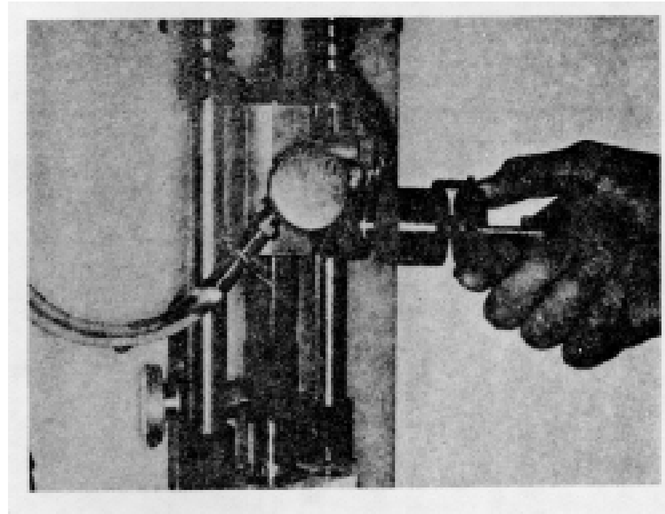


Figure 16H-57. Knob Spacing of ST-708

16. Slowly push the small knob in until you feel the needle enter the orifice plug inside diameter. Then turn the knob counterclockwise to lock the needle shaft to the larger knob with the indicator. Turn the indicator knob in until you feel the needle contact the plug. Index the indicator with a mark on the largest knob and advance one mark, Figure 16H-58.

NOTE

The test stand must be running while burnishing the orifice with ST-708.

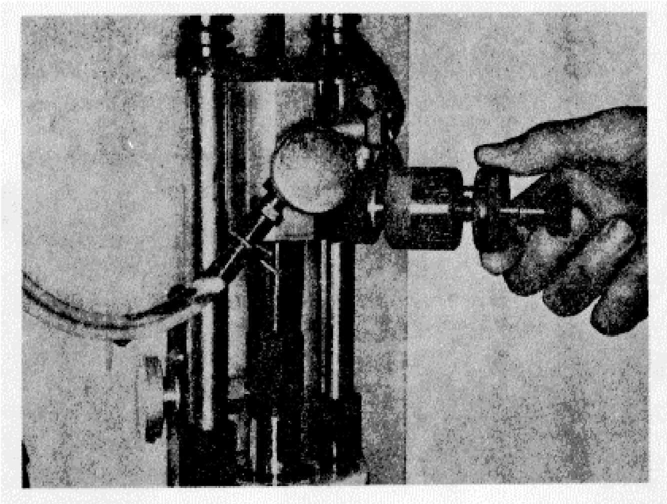


Figure 16H-58. Burnishing Operation

17. Back off the adjusting screw and retract the needle. Check the delivery.

18. If the delivery is more than specified in Table 16H-5 a new adjustable orifice must be installed in the injector. See Table 16H-6. Tighten the orifice plug to 8 to 10 in. lb. (0.9 to 1.1 N.m) torque with an ST-1090.

NOTE

Orifice plugs have flanges and require a gasket between the flange and the adapter.

19. New inlet orifice plugs contain enough stock in the inside diameter so a small displacement of metal, by burnishing, will increase the delivery. The amount of displacement is limited so several orifice plugs are required to cover the delivery for all the engine models from low to high horsepower. See Table 16H-2.

20. After each four cycles, reclamp the injector to ensure maximum accuracy. When the delivery is correct, remove the inlet and drain connection.

21. Remove the injector from the test stand.

22. Remove the adapter plate and body from the injector adapter.

23. Insert the disc screen over the orifice and assemble the retainer ring to hold the screen in place.

24. Insert the link in the plunger coupling and store in a clean place until needed.

STU-790 INJECTOR COMPARATOR

The STU-790 Injector Comparator (made in the U.K.) is used in some shops rather than the ST-790 Injector Test Stand. This manual is written around the ST-790. The method of reading the injector output varies with the two machines; however, an instruction manual is included with the STU790 Injector Comparator explaining the differences.

Following are the conversion factors necessary if an -A (80 percent strokes), or -B (60 percent strokes) or -C (80 percent strokes @ 80 psi) injector is being calibrated.

1. Master the machine with the master injector as described in STU-790 Instruction Manual. If injectors are being calibrated on a comparator built before 1974, a K cam conversion kit must be installed.

2. The delivery values using -A code (80 percent of 1000 strokes) are calculated by multiplying the required flow by 5/4.

EXAMPLE: A 185-A coded injector should produce

$\frac{185 \times 5}{4}$ = 231.2 cc on STU which

will appear on the indicator as 23.12. See Table 16H-7.

Table 16H-7. STU-790 Indicator Reading

Injector Code	Strokes (% 1000)	Equivalent Indicator Reading On STU-790
185A	80%	23.12 (231.25 cc)

INJECTOR RECHECK SPECIFICATIONS

The acceptable variance between the ST-790 injector test stands is +1 or -2 cc from the published calibration flow code or the code stamped on the injector.

EXAMPLE: An injector stamped with a flow code of 185 would be acceptable if it flows 183 to 186 cc on a stand other than the one used to calibrate the injector.

Troubleshooting

PT (type D) Injector Troubleshooting

The following list of problems is of importance when troubleshooting PT (type D) injectors:

Check 1 -- Unable to get the Correct Plunger to Cup Alignment

Cause

Defective or dirty cup.
Improper assembly techniques.
Defective plunger.
Defective barrel face surfaces.
Damaged retainer cup seating shoulder or threads.
Improper cup alignment.

Correction

Test the cup spray pattern on an ST-668. Clean, inspect and repair.
Assemble with correct tools and procedure.
Clean and inspect.
Clean, inspect and repair.
If the damaged areas cannot be cleaned up, replace the part.
Check the cup to plunger alignment.

Check 2 - Defective Barrel to Adapter Seal

Cause

Adapter or barrel face is damaged.
Roll pins or spiral pins are damaged which prevent the barrel and/or gasket from seating properly.

Correction

Lap the surface.
Inspect and replace if interference occurs.

Check 3 - Fuel Leaking Around Retainer

Cause

Barrel cracked.
Leaking barrel plugs.
Defective barrel to cup seal.

Correction

Inspect and replace with a barrel plunger assembly.
Stake plugs with a punch.
Lap the surface.

Check 4 - Plunger Sticks or Scuffed

Cause

Cup to plunger misalignment.
Mounting capscrews not torqued evenly.
Water or dirt in the fuel.

Carbon build up on the plunger.

Injector cup is over torqued.

Correction

Assemble correctly.
Check the capscrew torque.
Change the filter and drain the water from the bottom of the fuel tank and check for dirt in the tank.
Clean and adjust the injector travel. See Check 8. Install chrome plated plunger injectors.
Check the cup torque.

Check 5 - Loose or Broken Plunger Coupling Swage Joint

Correction
Attempt to rotate by hand - replace if defective.

Cause

Coupling not swaged deep enough into the plunger.
Wrong spring used.

J and C injector springs could be mixed with the PT (type D) springs PT (type D) springs are 1/16 inch [1.59 mm] longer, have 0 187 inch [4.75 mm] diameter wire with a slightly larger outside diameter.

Check 6 - Excessive Link Wear

Cause

New link placed in old socket.

Correction

Mark links when removed

Check 7 - Bright Polished Spots at Top and Bottom of Plunger 180 Degrees Apart

Cause

Bearing pattern on plunger.

Correction

This is normal wear. 'Unless metal is displaced or wear is measurable, plunger may be reused.

Check 8 - Carbon Inside of Injector Cup and on Lower Plunger

Cause

Loose injector adjustment.
Plunger not seating completely in cup.
Low fuel octane rating, water or sulfur in fuel.
Air in cup

Correction

Clean and adjust injectors.
Clean and retorque cup retainer.
Clean and reassemble the injectors. Fill the tanks with correct fuel.
Install direct feed barrel and plunger assemblies.

Check 9 - Injector Cup Cracked

Cause

Injector adjusted too tight.
Injector or fuel pump over-fueled.

Carbon in cup seat.
High exhaust temperature.

Correction

Replace the cup and install properly
Replace the cup, check the injector and fuel pump calibration.
Replace the cup See Check 8.
Check the exhaust back pressure.

Check 10 - Cup Tip Failure

Cause

Injector overfueled or excess carbon.
Plunger not seated in cup.
Plunger not seated in cup.
Injector loose in head.
Cup tip flattened.
Cup cleaned with wire brush.

Correction

Replace the cup, check the injector and fuel pump calibration.
Correct the installation.
Adjust the plunger travel.
Check the installation.
Handle carefully.
Clean with Ultra-sonic cleaning tank. Service Tool 3375000.

Check 11 -- Plunger Tip Shoulder (at top of cone angle) Destroyed

Cause

Plunger tip cleaned with crocus cloth.

Correction
Clean in Service Tool 3375000. Lap plunger in the cup.

Check 12 - Injector O-rings Damaged

Cause

Injector installed in head wrong.
Injector O-rings twisted.

Correction
Snap injector into the bore, don't pull down with the mounting capscrews.
Install the O-rings correctly.

3375317 INJECTOR TEST STAND INTRODUCTION

The 3375317 Injector Test Stand must be purchased as 3375410 Injector Calibration Kit. The Service Tool Catalog contains a complete parts breakdown of this test stand. The 3375366 Test Stand Audit Kit is not included in 3375410, Figure 16H-59.

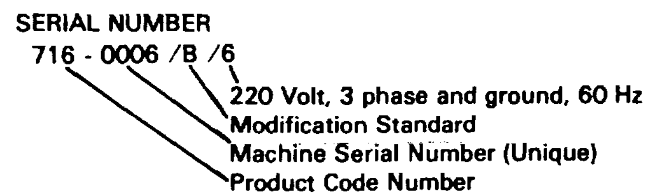
3375410 Injector Calibration Kit
This kit contains:
3375408 Injector Burnishing Tool
3375365 Calibration Fluid (30 Gal.)

3375421 Injector Calibration Test Stand Kit
This kit contains:
3375317 Injector Test Stand
3375367 Installation and Training Kit
This kit contains:
Installation of the test stand
On site test stand training
Test stand operation manual
Audit kit manual

1. The 3375317 Injector Test Stand was designed and developed to test and measure the flow of all Cummins injectors. This test stand is faster, quieter and more accurate than the ST-790 Injector Test Stand.

2. Burnishing the injector orifice is the only way to adjust the injector fuel delivery on 3375317. The test stand is the reference standard and the master injectors are not required.

3. In order to ensure that the test stand remains accurate, an audit kit is used to check the functions which will affect the injector flow. The procedures for using the audit kit are explained after this section.



The serial number of the test stand appears on the identification plate on the left side of the base and should be listed in any parts or service request. A typical serial number with an explanation is given above.

TEST STAND REQUIREMENTS

LOCATION. The location selected for the test stand should be clean and free of dust or dirt. Cleanliness is essential in all matters relating to testing, calibrating and servicing of fuel injection equipment. This not only applies to the location, but also to the cleaning facilities, tool and accessories used and to the handling of component parts. The location must be flat and level.

MAIN ELECTRICITY SUPPLY. The electrical supply to the test stand must be 220 or 460 volts + 10%, 3 phase and ground 50 or 60 Hz. Internal connections can be made to adapt the test stand to the available voltage.

Wire size must be at least No. 12 with 3 wires and ground (12-3 w/ground).

Conduit entry is from the left or right side through a 7/8 inch (22 mm) diameter hole in console.

COOLING WATER SUPPLY. The cooling water supply inlet temperature must be below 800F (27C).

The inlet water pressure must be above 40 psi (276 kPa).

The water outlet is drained by gravity.

External pipe size is to be at least 3/8 inch (10 mm) outside diameter nylon pipe.

AMBIENT AIR TEMPERATURE. The air temperature in the test room should be 60 to 900F (15 to 32C). The company cannot be held responsible for any calibration errors which occur if the test stand environment does not meet the foregoing specification.

INSTALLATION. The 3375317 Injector Test Stand must be installed by a factory authorized service man. The service man will also run the test stand through a complete testing procedure with the audit kit.

The following items may be completed before the service man arrives.

1. Level the test stand.
   A. Place the test stand in position on the rubber feet provided. Remove the front cover.
   B. Place the steel plates under the test stand feet until the deadweight dashpot tops are horizontal both from left side to right side and front to back of machine. Use a level, placed on top of the deadweight dashpots, to level the test stand. Replace the front cover, Figure 16H-60.

2. Fill the fuel tank with test oil by pouring the oil into the top tray at the right hand side of the clamp cylinder. The oil level in the tank should be approximately 1/2 inch (13 mm) below the top of the sight gauge. The tank will hold about 10 gallons (8 Imp. gallons) (38 liters).

CAUTION

Use only oil to SAE Specifications J967D. Cummins Part No. 3375364, in 55 gal. drums and 3375365 in 30 gal. drums. Calibration errors will occur if other test oil is used.

3. Connect the cooling water supply and drain using 3/8 inch (10 mm) outside diameter nylon tube. Tube nuts and sleeves are supplied with the machine.

4. Fill the cambox with SAE 30grade automotive engine oil until the level just covers the datum cam follower link. Place a few drops of oil on the exposed part of the tappet.

5. The electrical supply line may be run up to the test stand. Do not connect the electricity to the test stand. The service man must inspect the motors, transformers, heater and other internal electrical connections before connecting the electrical supply line to the test stand.

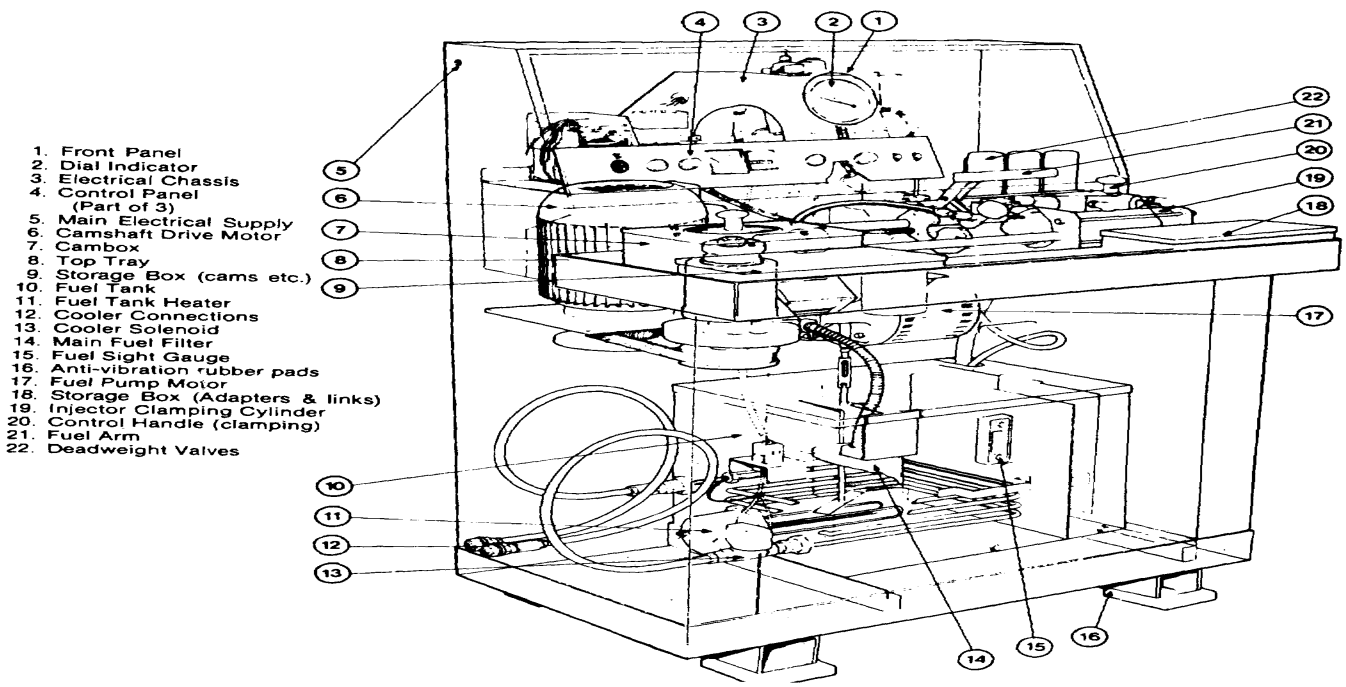


Figure 16H-59. The 3375317 Injector Test Stand

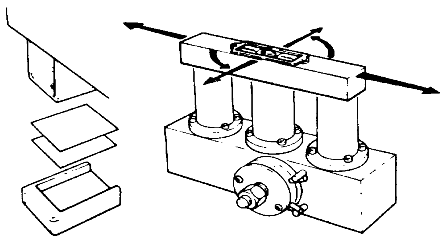


Figure 16H-60. Leveling the Test Stand

DESCRIPTION OF THE 3375317 TEST STAND PARTS

CAMBOX, CAMS AND INDEXING. The cast iron cambox contains a vertically mounted camshaft held in the heavy duty taper roller bearings.

The injector cam is mounted on the upper end of the camshaft on a non-stick taper and is driven by a key and key ways. Cam changes can be made easily and quickly, and any number of cams can be used.

A transparent cambox lid enables the type of cam on the camshaft to be identified.

Injector cam indexing occurs automatically when an injector is unclamped. This is achieved by means of a heart shaped cam on the bottom of the camshaft and a hydraulic cylinder and cam follower. The indexing mechanism also provides a means of holding the camshaft when the injector cam changes are made.

The heart shaped cam is a dynamically balanced flywheel and provides the signal for the electronic stroke counter by means of a peg and magnetic pick up.

CAMSHAFT DRIVE. The motor is a 1-1/2 horsepower synchronous motor, totally enclosed and fan cooled. Electrical characteristics are determined by the location.

The camshaft is driven by a timing belt and toothed pulleys on the motor and camshaft. The ratio of the pulleys is such that the camshaft has a running speed of 1050 rpm.

TANK. The tank has a capacity of 10 U.S. gallon (38 liters) with a heater, cooler, stirrer, thermistor, sight glass, drain plug, float level switch and a sludge compartment with a magnetic filter bar.

The tank is supported on two channels in the base and can be pulled on to a pallet placed in front of the machine for draining and cleaning.

A solid state controller, in the tank, automatically controls the test oil temperature of 1040F (400C) at the injector.

FILTER. The filter on model D and later test stands is Cummins Part No. 154709 (FF105) fuel filter. The pleated paper filter, on models A, B and C, is totally submerged and has a 15 micron absolute filter.

TEST OIL PUMP AND MOTOR CLOSE COUPLED. The gear pump delivers 1.68 gpm (6.36 lpm) at 1800 rpm with a 1 horsepower induction motor, 3 phase with overload protection. The stirrer drive is taken from the motor shaft by a pair of cross helical gears having 3:1 reduction producing a stirrer speed of 600 rpm.

INERTIA DAMPER. The inertia damper is a coil of 24 inches (609 mm) long, 3/32 inch (2.4 mm) diameter bore and 1/4 inch (6.3 mm) outside diameter steel capillary tubing. This coil of tubing acts as an inertia damper to reduce pump teeth and pump cyclic pressure variations.

DEADWEIGHT PRESSURE CONTROL VALVES. Test oil is supplied to a deadweight valve block by the inertia damper where three separate valves operate in series. They generate pressures of 100, 74 and 12 psi (689, 510, 83 kPa) which are used as follows

100 psi: (689 kPa)	Injector fuel supply Seal cylinder providing sealing force Unclamp cylinder providing unclamping force
74 psi: (510 kPa)	PT injector clamping force
12psi: (83 kPa)	Not currently used

PLENUM CHAMBER. A 1 quart (1 liter) capacity steel plunum chamber is teed into the line connecting the 1 00psi (689 kPa) supply to the injector orifice. Its purpose is to minimize pressure fluctuations due to the injector metering cycle.

ROTARY CONTROL VALVE. A rotary control valve is used to control the indexing, clamping and sealing functions. It is fed with two of the three hydraulic pressures from the deadweight valve block.

PRESSURE SELECT VALVE. The pressure select valve, on the front face of the deadweight valve block, is set at 74 psi (510 kPa) clamp pressure. This pressure is piped to the clamping rotary control valve. The 12 psi (83 kPa) is not used.

FUEL ARM. The fuel arm is an over center toggle clamp which connects a self-sealing valve to the injector orifice.

INJECTOR SEALING AND CLAMPING. The injector is held horizontally in the test stand. A dual piston clamp head assembly provides independent sealing and clamping loads on the injector body and plunger respectively. The clamp head is hydraulically operated by the pressures generated in the fuel system and is controlled by means of the rotary clamping control valve.

SEALING FORCE. The injector cup is constantly loaded against the nylon seal in the nose cone assembly with a force of 167 lb. (75 kg).

CLAMPING FORCE. The combined injector, nose cone and sealing assembly are loaded against the indexed injector cam by the injector link and cambox tappet.

A clamping force of 380 lb. (172 kg) is provided by the deadweight control valve.

CLAMPING FORCE DATUM SPOOL VALVE. A spool valve, driven by a link from a fixed cam on the cambox camshaft, permits the clamping load to be relocated every cycle. This occurs during top dwell (outer base circle) for PT injectors.

It ensures that the relative positions of the injector cam and injector body are the same every cycle which means that the injector fuel metering cycle is maintained constant.

NOSE CONE ASSEMBLY. A plate type non-return valve simulates cylinder back pressure and prevents back flow of injected fuel into the injector during plunger retraction.

A replaceable conical nylon seat provides the seal between the injector cup and nose cone assembly.

INJECTOR LOCATION AND ADAPTERS. Ring adapters are provided for all types of cylindrical injectors. The injectors are located in the adapters such that the balance orifice is always aligned with the self-sealing valve in the fuel arm.

Links are provided for all types of cylindrical injectors.

METERING SYSTEM. The metering system is a positive piston displacement system with a dial indicator display of injector output. Injector output is measured over 50 injections.

Capacity 500 cc/1000 strokes

(1 cc/1000 strokes = 1 mm^3/stroke)

Resolution
+ 0.1 cc/1000 strokes

The solid state electronic stroke counter is a proprietary item. The start and end of metering are phased to the camshaft flywheel which provides the signal by means of a peg and magnetic pick-up. Injection chopping is therefore eliminated.

GENERAL. Storage boxes are provided on the left and right sides of the top tray for storage of cams, adapters and links.

Refer to the manual in the test stand for a more detailed parts explanation.

3375317 INJECTOR TEST STAND TROUBLESHOOTING

Complaint	**Probable Cause**	**Solution**
Low Flow 3-5 cc or scattered	Dirty Nose Cone	Disassemble, clean valve plates Lap if necessary to pass audit check
3-5 cc or scattered	Fuel arm nozzle O-ring covering injector orifice (deteriorated)	Replace O-ring
2 cc	Fuel filter in tank plugged	Replace filter
2 cc	Inline filter to metering unit dirty	Clean in sonic cleaner
2-10 cc low	Shot counter circuit erratic	Wiggle PL2 wire
	Gear pump pressure low	Check pressure replace gear pump as required
	Gear pump drive slipping	Tighten drive coupling setscrew
2 cc	Weak fuel arm spring	Tighten collar or replace spring
3-10 cc or scattered	Worn cam drive key	Replace key
2 cc	Fuel arm worn at pivot points	Replace fuel arm assembly
2 cc	Metering head filter plugged	Clean in sonic cleaner
Scattered	Stand unlevel	Level stand recheck deadweights 100 psi and 74 psi (689.5 and 510.2 kPa)
Scattered	Deteriorated fuel arm supply hose	Replace hose
	Wrong cam	Replace as required
	Wrong link	Replace as required
10-20 cc low on top stop injectors	Trying to flow top stop without removing top stop.	Remove top stop to calibrate injector.

3375317 INJECTOR TEST STAND TROUBLESHOOTING

Complaint	Probable Cause	Solution
Stand running hot	Temperature indicator out of adjustment	Check fuel temperature with thermometer and adjust temperature indicator accordingly
	Water inlet solenoid valve stuck closed	Disassemble valve and clean and replace
	Temperature control reostat improperly adjusted	Adjust as required
	All above fails to correct problem	Replace printed circuit board or heat sink.
Clamping index mark does not line up	Wrong cam	Replace as required
	Wrong link	Replace as required
	Datum valve sticking	Observe datum valve position and correct sticking problem clean as required
	Datum valve cam follower roller deteriorated	Remove and replace with new roller
Clamp cylinder will not clamp or clamps slowly or link is loose when clamped	Datum valve sticking	Observe datum valve position and correct sticking problem clean as required
	Datum valve cam follower roller deteriorated	Remove and replace with new roller
	Rotary clamp valve restriction	Remove and clean
	74 psi (510.2 kPa) deadweight not working properly	Clean and adjust with trim washers as required
	Seals leaking in clamp cylinder	Replace seals
	Datum valve leaking	Replace with new parts
Counter quit working	Broken electrical signal circuit board	Wiggle PL2 wire on printed Broken electrical signal Magnetic pickup on heart cam not adjusted properly
	Metering inlet solenoid valve sticking or inoperative	Check voltage to coil re- place coil as required or correct cause
Counter dial hand does not repeat	Dial hand slipping on spindle or sticking	Replace dial indicator assembly
	Metering inlet solenoid valve sticking or inoperative	Check voltage to coil or replace coil as required or correct cause
Deadweights bouncing	Air in system	Tighten all suction connections
Deadweight jumps too high when pump is turned on, knocks can off, squirts fuel	Air in system	Bleed piston by pouring test oil on top of piston and work piston up and down by hand (pliers, etc.)
	Rough mating surface of bottom of piston and valve plate	Disassemble and lap surfaces together reassemble and repeat step just above to bleed air

3375317 INJECTOR TEST AND TROUBLESHOOTING

Complaint	Probable Cause	Solution
Main drive motor will not run	Fuel arm gap excessive	Reset to 0.080"-0.100" (2.032-2.54 mm)
	OL1 or OL2 kicked out	Reset or replace if reset is ineffective
	Start switch defective	Repair or replace
	No 3 phase power	Find fault
	No 24 volts to switches	Find fault
	Bad contractor(s)	Replace
Stand running cold	Cooling solenoid stays on (energized) Water running continuously out the drain.	Replace heat sink and/or PCB

FLOW TESTING INJECTORS ON 3375317

INJECTOR INSTALLATION

1. Check the test oil tank level daily. Add test oil if necessary to about 1/2 inch (13 mm) below top of sight gauge. Use only the type specified by Cummins.

2. Turn on the main switch on the control panel, Figure 16H-59.

3. Press the fuel system ON button. The system will automatically bring the test oil temperate up to 1040F (400C). This is the proper operating temperature.

4. Select the correct cam for the injector to be tested. The chart on the inside of the cam storage box lid identifies the cam to be used, 9, Figure 16H-59.

5. Move the clamping control handle to the unclamp position, 20, Figure 16H-59. Remove the transparent cambox lid. Rotate the tappet away from the camshaft. Use the box wrench and T-bar, Figure 16H-61.

6. Remove the cam nut from the top of the camshaft. Turn it counterclockwise with the same wrench. Remove the washer and cam, and replace the cam with the correct cam.

7. Tighten the nut only until the camshaft begins to turn. Loosen the tappet with the box wrench and T-handle. Replace the lid.

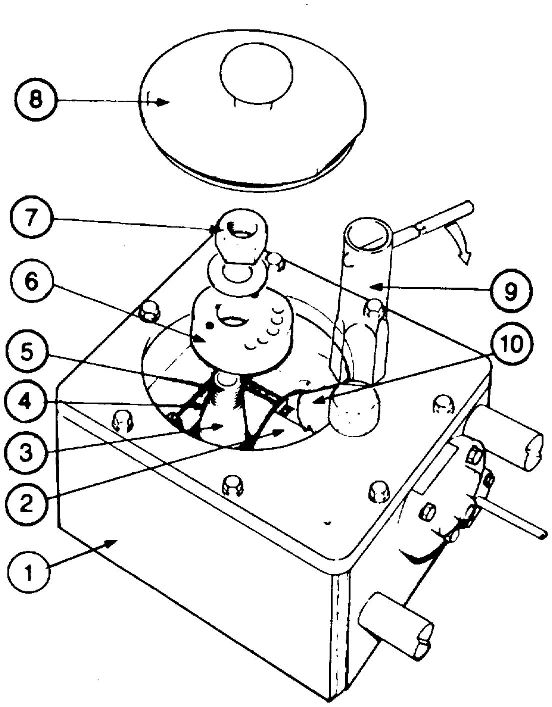
LOADING THE INJECTOR

1. Select the correct injector adapter and link from the storage box. The chart on the inside of the lid identifies the parts to be used with each type of injector, 18, Figure 16H-59.

2. Assemble the adapter to the injector, Figure 16H-62.

3. To load the injector, raise the guard. Place the injector and link in position, Figure 16H-63.

4. The two milled cut-outs in the adapter must register with the two parallel bars that protrude from the clamp plate. The nose of the injector should be supported by the vee block which is attached to one of the parallel bars. The link should rest in the vee support plate between the cambox tappet and the back of the clamp plate.

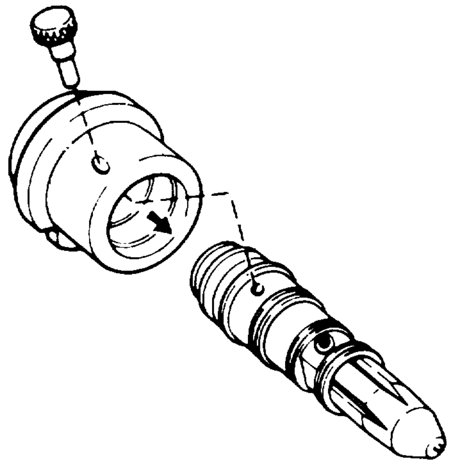


1. Cambox
2. Tappet
3. Taper
4. Key
5. Camshaft
6. Cam
7. Cam Nut
8. Lid
9. Box Wrench
10. Tappet Lifter

Figure 16H-61. Installing an Injector Cam in the Cam Box

5.· Lower the guard.

CLAMPING THE INJECTOR · Pull the clamping valve handle toward you until it is against its stop. This will automatically cause the correct sealing and clamping loads to be applied to the injector.



All PT (Type D) Injectors

Figure 16H-62. Adapter Used on the Injectors

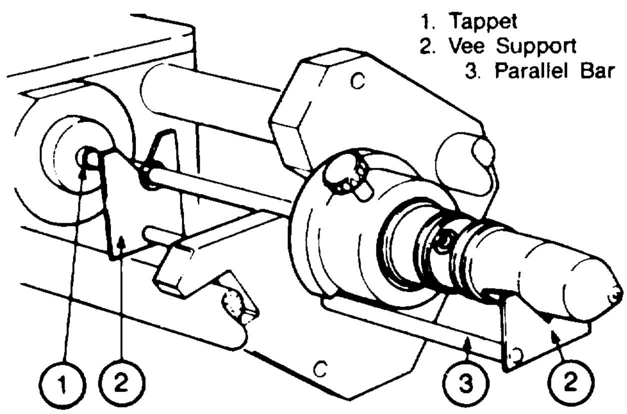


Figure 16H-63. Loading the Injector into the Test Stand

2. The clamping control valve lever, in the clamp position, prevents the guard from being raised.

3. Check the test stand parts alignment. A stamped line on the seal cylinder flange and a square notch cut out of the steel strip which covers it, must be within tolerance. The line must be positioned within the width of the notch. Change the combination of cam, link, adapter and injector to correct the alignment, Figure 16H-64.

CAUTION

Do not proceed further until the correct combination is installed in the machine as indicated by the cylinder flange line.

FLOW TESTING INJECTORS

LOWERING THE FUEL ARM. Lower the fuel arm as follows:

1. Check to be sure the O-ring, in the self-sealing valve in

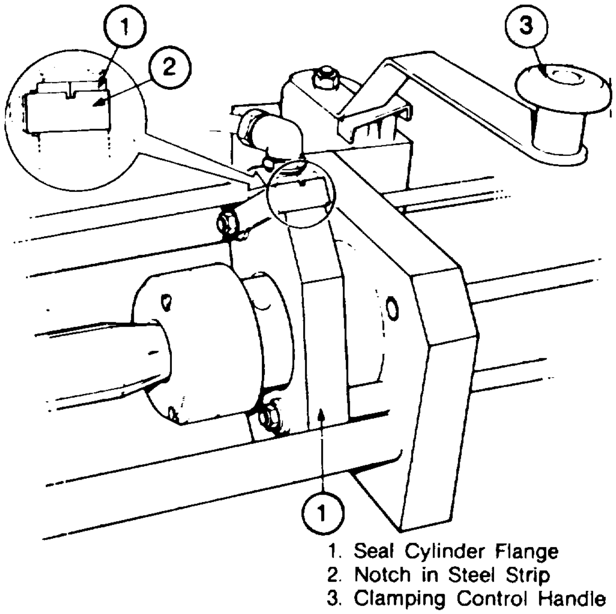


Figure 16H-64. Checking the Parts Alignment

the fuel arm, is in position. This O-ring seals against the fuel inlet orifice when the fuel arm is lowered, Figure 16H-65.

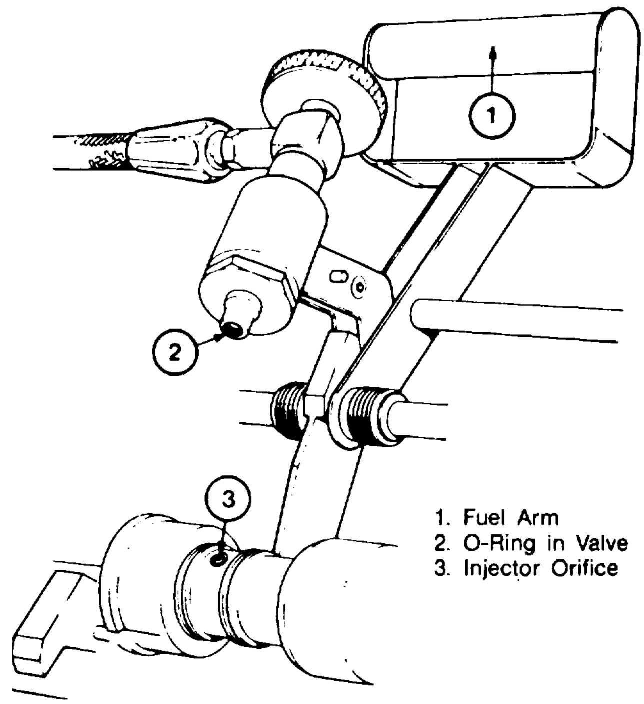


Figure 16H-65. Fuel Arm and Supply Valve for Cylindrical Injectors

2. The adapter positions the injector orifice correctly for the self-sealing valve in the fuel arm.

3. When the fuel arm is lowered, the self-sealing valve will lift off of its seat and 100 psi (689 kPa) test oil is fed to the injector orifice

4. Lower-the fuel arm. Lock it in position with the over center locking action. Test oil will flow from the injector drain port.

NOTE Be certain the fuel line valve is open.

START THE MAIN DRIVE. Press the main drive start button and the cambox will be driven at 1050 rpm by the main motor.

Injected fuel will now be passing through the nose cone assembly and the metering unit body.

STABILIZING INJECTOR FLOW. Stabilize injector flow as follows:

1. Press the main drive start button.

2. Press the metering button; do not hold in. The dial indicator will display the flow of the injector in cubic centimeters per stroke.

NOTE

Take several readings until the flow stabilizes. When the metering unit or the injector is cold, the readings will vary.

3. When the readings stabilize, stop the main drive by raising the fuel arm. After the motor has stopped, press the metering button. Then set the dial indicator to zero with the adjusting screw, Figure 16H-66.

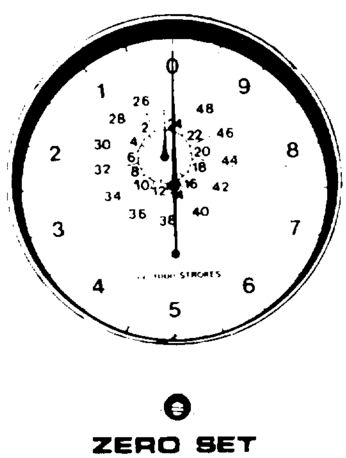


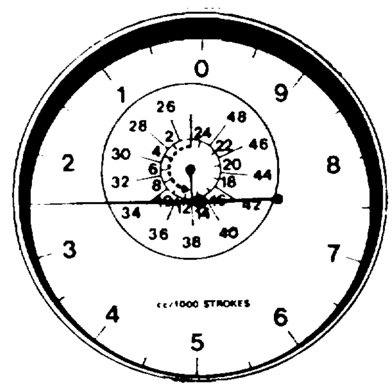
Figure 16H-66. Zero the Dial Indicator Gauge

CHECKING INJECTOR FLOW. Check injector flow as follows:

1. Lower the fuel arm to restart the drive, and press the metering button Watch the small hand on the dial to see if it turns more than one revolution.

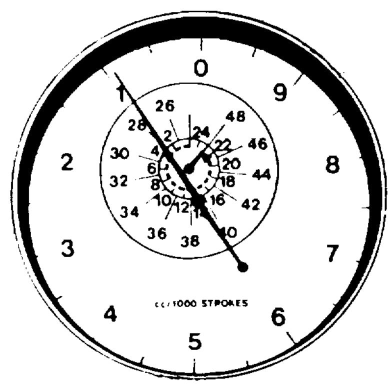
2. Read the output flow of the injector. The small hand makes one revolution for each 250 cc of output flow per 1000 strokes, and the large hand makes one revolution for 10 cc of output flow per 1000 strokes. (1 cu. mm/stroke = 1 cc/1000 strokes.)

If the small hand has made less than one revolution, use the inner ring figures (2 to 24) and multiply by 10. Add the reading of the large hand, Figures 16H-67 and 16H-68.



Small Dial 13
13 X 10 = 130
Large Dial 2.5 + 2.5
Total Flow 132.5 cc

Figure 16H-67. Reading 132.5 cc Injector Flow



Small Dial 23
23 X 10 = 230
Large Dial .9 +.9
Total Flow 230.9 cc

Figure 16H-68. Reading 230.9 cc Injector Flow

If the small hand has made more than one revolution, use the outer ring of figures (26 to 48) and multiply by 10. Add the reading of the large hand, Figures 1 6H-69 and 1 6H-70.

3. If the delivery is greater than that specified in Table 1 6H8, a new orifice plug must be installed in the injector. If the delivery is less than specified, it may be adjusted with the use of 3375408 Burnishing Tool. See the instructions for using that tool.

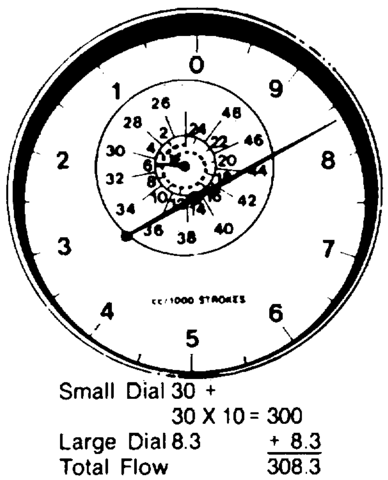


Figure 16H-69. Reading 308.3 cc Injector Flow

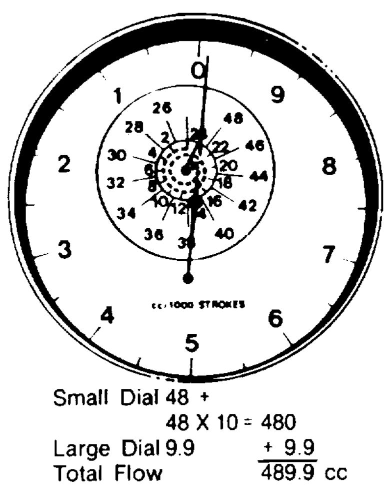


Figure 16H-70. Reading 489.9 cc Injector Flow

CAUTION

Do not unclamp the injector until the main drive has stopped. However, do not leave the injector clamped more than one minute after stopping the main drive. Damage to the injector test stand could result.

4. Measurement of the orifice plug diameter may be taken with ST-1332 Orifice Size Gauge. Table 16H-6 lists injector orifice plugs with a range of orifice diameters from 0.015 inch (0.38 mm) to 0.070 inch (1.78 mm) for all Cummins injector applications.

BURNISH INJECTOR TO INCREASE THE FLOW

1. Cummins specifies a setting tolerance for each type and model of injector. The injector orifice is burnished using burnishing tool 3375408, until the correct output is obtained. This burnishing tool point is shorter than ST-708 tool point.

WARNING

If you use ST-708-1 Burnishing Tool Point on the large hole orifice plugs, you must grind off the end. If the end is not ground off, you will punch a hole through the adapter into the plunger area. This will cause lubricating oil dilution.

2. The test stand is designed to permit burnishing without having to remove the injector from the test stand.

3. Having taken a reading, raise the fuel arm to stop the main drive and reveal the injector orifice. If the flow is low, burnish the orifice. If the flow is high, change to a smaller orifice.

4. Insert the burnishing tool point in the orifice and push in on the tool until it clicks. Burnishing tool, 3375408, is adjustable. The tighter the spring is screwed down, the harder the point hits, the more fuel flow increases, Figure 16H-71

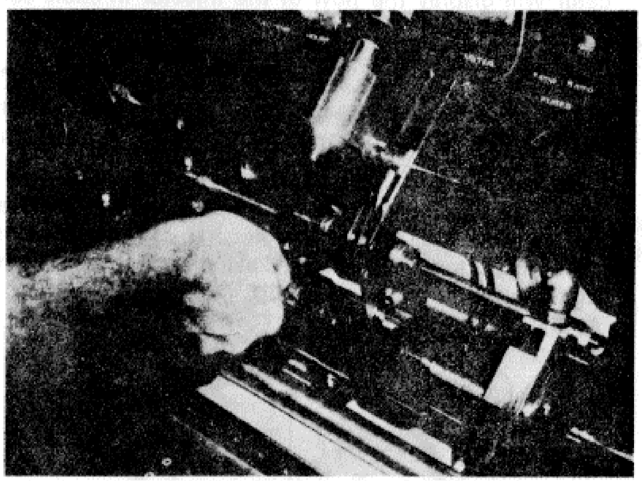


Figure 16H-71. Burnishing the PT Injector

5. Lower the fuel arm to restart the main drive. Check the delivery. When the correct output flow is achieved, remove the injector from the test stand.

REMOVE INJECTOR FROM TEST STAND

1. To remove the injector, raise the fuel arm, push the clamping control valve to the "unclamp" position and raise the guard. The injector with the adapter and link can now be removed.

CAUTION

Wait until the main drive has stopped turning before unclamping the injector.

2. Remove the adapter and link from the injector.

CORRELATION OF ST-790 AND 3375317 INJECTOR TEST STAND FLOW VALUES

The injector flow values are different between injector test stand number ST-790 and 3375317. The flow of ST-790 is measured in cc (cubic centimeters). The flow of 3375317 is measured in MM3/stroke (millimeters cubed per stroke). This is the amount of fuel, injected into the cylinder, each time the plunger seats on the cup. The tabulations in Table 16H8 are calibration values by injector type and flow code for quick correlation between the two test stands.

CAUTION

1. Only lower the fuel arm when the injector is correctly clamped.

If you try to lower the fuel arm when the injector is not clamped correctly and the self-sealing valve does not align with the injector orifice, YOU WILL GET SPRAYED WITH TEST OIL.

2. Do not leave the injector clamped for longer than one minute after stopping the main drive.

If you do and the camshaft has not stopped at the index position, the very slight leakage past the datum spool valve will cause the clamp piston to move towards the cambox. When the clamping control valve is moved to the "unclamp" position or when the main drive is restarted, the injector plunger will "bottom" in the cup before the injector cam has reached a full lift.

Table 16H-8. Injector Flow on 3375317 Test Stand

ST-790 Flow in cc	3375317 Flow in mm3/Stroke
185AK	214.5-216.5

This will probably break the link, may cause permanent damage to the test stand and may scrap the injector.

3. Do not unclamp the injector until the main drive has stopped.

If, having raised the fuel arm to stop the main drive, you unclamp before the camshaft has stopped turning, you will cause the indexing mechanism to engage with a rotating heart cam.

This will damage the indexing mechanism and may make your test stand unuseable.

4. Use only the flanged type "button head" injector balance orifice plugs.

The fuel arm O-ring will not seal against the straight type orifice plugs.

5. Do not exceed specified service intervals.

The service intervals, expressed as hours of fuel system running time, are shown in the section headed Maintenance Schedule. Do not exceed these limits.

INJECTOR REMOVAL AND INSTALLATION IN THE HEAD

REMOVAL

1. Remove the injector hold-down plate or yoke.
A. Use ST-i297, 3375161 or 3375181 to remove the injectors from the cylinder head.
B. You may insert a 3/8"-16 capscrew in the tapped hole in the hold-down plate and lift the injector from the head.

2. Remove all carbon from the injector copper sleeves in the cylinder head. Replace the seal seat.
A. Do not use anything metal to scrape the sleeves.
B. Use a wooden stick with a clean cloth wrapped round the end.

INSTALLATION

1. Lubricate the O-rings with 20 to 30 weight lubricating oil. Do not use Lubriplate.

2. Start the injector into the bore. Guide it by hand until it is aligned in the bore and is not binding. It is not required to line up any plugs or rotate the injector to any position. The injector will perform at any position.

3. Place a clean blunt object on the injector body and "seat" the injector by giving it a quick hard push. A snap should be heard and felt as the cup seats in the copper sleeve. The "K" type injector will contact the cylinder head bore.

NOTE

Do not use a wooden hammer handle or similar tool to install the injectors. Dirt or splinters from the handle may drop into the plunger link seat, causing early failure of the link or plunger socket.

CAUTION

If the injector is not completely seated, the O-rings may be damaged if they are pulled down by the mounting capscrews.

4. Install the hold-down plates or yokes, lockwashers and capscrews.

CAUTION

Be certain the plates or yokes do not contact the crosshead stems.

5. Torque the capscrews in alternate steps to 11 to 12 ft-lb (15 to 16 N.m).

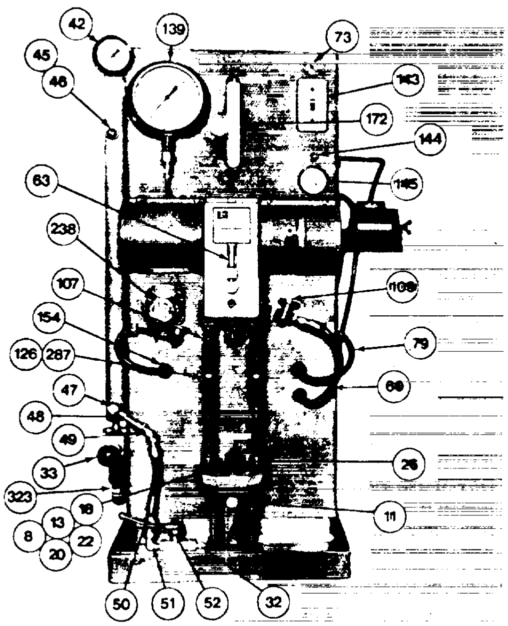
6. Test the injector plunger for movement after torquing the hold-down capscrews. If the plunger is not free, retorque the capscrews. If the plunger still binds, remove the injector and rotate it in the head. Torque down the capscrews and recheck the plunger.

ST-790 INSTALLATION AND CALIBRATION

INJECTOR TEST STAND -- ST-790

The ST-790 Injector Test Stand is used for testing and calibrating Cummins injectors. The test stand must be properly installed and calibrated to obtain the highest accuracy possible.

The ST-790 Injector Test Stand, Figure 16H-72 is used to test all Cummins PT injectors. ST-790 flow tests the complete injector assembly by measuring fuel delivery. The injector is actuated under controlled conditions, closely simulating actual operating conditions. The test stand counts injection strokes, supplies fuel at a specified pressure, and measures the delivery in a glass graduate.



ST-790-8	Orifice Screw (.013)	ST-790-73	Vial Light Switch
ST-790-11	Exhaust Muffler	ST-790-79	Inlet Hose
ST-790-13	Seat Block	ST-790-107	Tie Rod Spring
ST-790-18	O-ring	ST-790-108	Cover Assembly
ST-790-20	Orifice Screw (.011)	ST-790-109	Inlet Connection
ST-790-22	Check Valve Spring	ST-790-126	Tie Rod Bushing
ST-790-26	Tie Rod Spacer	ST-790-139	Fuel Pressure Gauge
ST-790-32	Hex Nipple	ST-790-143	Start & Stop Switch
ST-790-33	Air Valve	ST-790-144	Flow Start Switch
ST-790-42	Air Gauge	ST-790-145	Temperature Gauge
ST-790-45	O-ring	ST-790-154	Hose Grommets
ST-790-46	Hyd Oil Level Sight Gauge	ST-790-172	Vial Graduate
ST-790-47	Elbow	ST-790-238	Pressure Regulator
ST-790-48	Hyd Fluid Sight Glass	ST-790-287	Tie Rod
ST-790-49	Elbow	ST-790-323	Air Valve
ST-790-50	Hose Assembly	ST-790-335	Orifice (.020)
ST-790-51	Valve Elbow	ST-790-338	Counter
ST-790-52	Hydraulic Valve	ST-790-363	Orifice (.026)
ST-790-60	Inlet Hose		
ST-790-63	Sight Glass		

Figure 16H-72. Injector Test Stand ST-790

FUEL PUMP AND INJECTOR TEST STAND AUDIT KIT, 3375187

The Audit Kit is used to master check the performance of the ST-790 and ST-848 Test Stands, Figure 16H-73.

The kit includes one ST- 1210 132CC, one ST-1 262 185A, one ST- 1306 1 78A CC Master Injectors for the ST-790Test

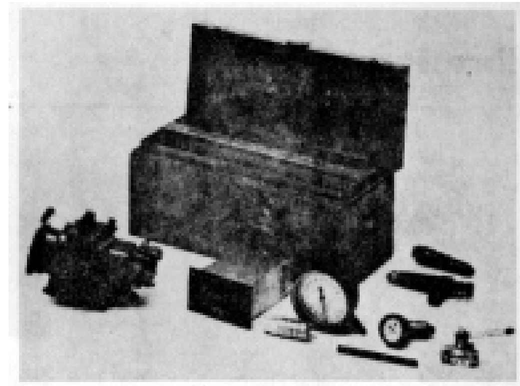


Figure 16H-73. 3375187 Stand Audit Kit

Stand, and a master fuel pump for the ST-848 Test Stand. Also included are the spare parts for both of the test stands, consisting of those which most frequently require replacement. In addition, a master gauge used in checking the test stand gauge calibration is a part of the kit. This kit is currently available through the Cummins Service Tools Center.

TEST STAND INSTALLATION - ST-790

The ST-790 must be located near hot and cold water connections. Water temperature controlled by a mixing valve, is used to maintain the test oil at a 90 to 950F (32 to 350C) temperature range. If the temperature exceeds 950F (35°C), increase the cold water flow. If the temperature exceeds 1350F (75°C), drain and replace with new test oil.

1. Fill the test oil tank 3/4 full of test oil and maintain this level or higher during the test. Test oil capacity is approximately five gallons. It is available from the Service Tool Center of Cummins Engine Company, Inc. as Part No. 3375364 in 55 gallon (205 I1) drums or Part No. 3375365 in 30 gallon (113 I)drums. This oil meets SAEJ967d standard.

2. Fill the hydraulic fluid reservoir to half the level in the sight bulb with clean Type A automatic transmission fluid. Be careful not to allow oil to enter the standpipe in the center of the reservoir.

3. Fill the cambox with SAE 30 non-detergent lubricating oil to the top of the sight glass. Refill when the oil level gets low in the sight glass.

4. Plug the electrical connection into a receptacle carrying the necessary voltage to operate the test stand.

DESCRIPTION OF OPERATION - ST-790

1. A motor driven shaft and a cam are housed in the cambox. The cam actuates the vertical push rod at the bottom of the housing.

2. The push rod is connected to the injector by a link so the injector plunger will be actuated by the cam action just as it is in the engine, Figure 16H-74.

3. Injectors are clamped in the test stand by hydraulic pressure from the cylinder, piston rod and injector seat. The in-

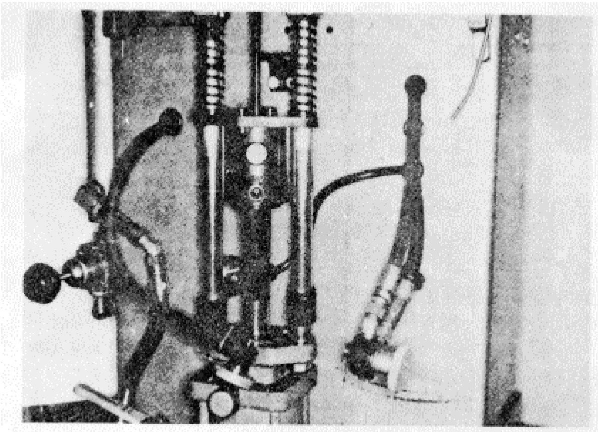


Figure 16H-74. Link and Injector in Position

jector seat contains a removable orifice to restrict the metered fuel flow and causes a back pressure simulating the compression pressures as found in the engine. Be sure to use the correct size orifice, Figure 16H-75.

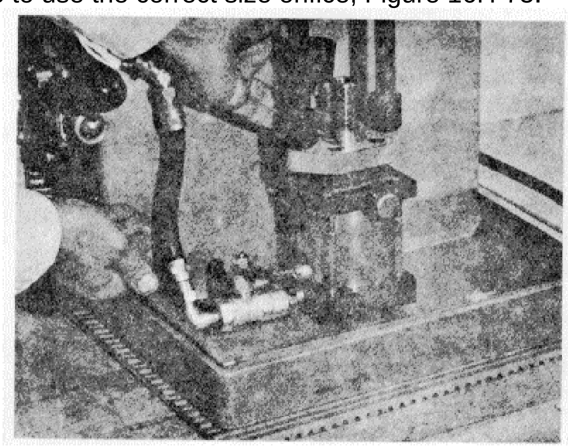


Figure 16H-75. Clamping Cylinder and Seat

4. Before clamping the injector in the test stand, the cam must be timed by rotating the timing wheel so the wheel mark and pointer are aligned, Figure 16H-76.
5. Shop air pressure, regulated by an air regulator, is used to apply a balanced force on the hydraulic system, Figure 16H-77 The air gauge at the top of the hydraulic reservoir is used as a reference indicating that pressure has not changed, after being set when using a load test cell during the test stand calibration.
6. When the air valve is opened, air travels up the pipe in the center of the tube type hydraulic reservoir and exerts a downward pressure against the column of hydraulic fluid.
7. When both the air valve and the hydraulic valve are opened, hydraulic fluid is admitted under the piston in the

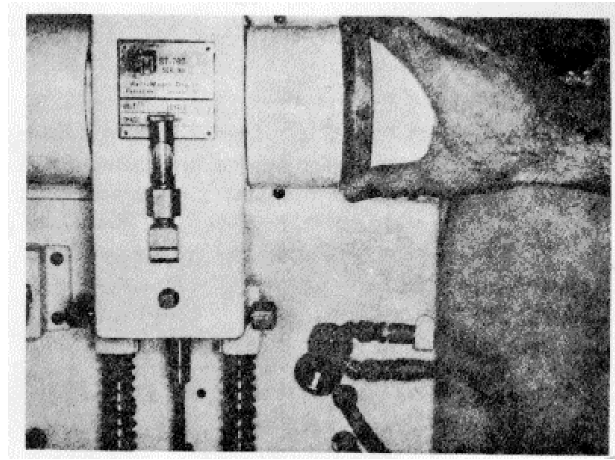


Figure 16H-76. Aligning Timing Wheel Mark

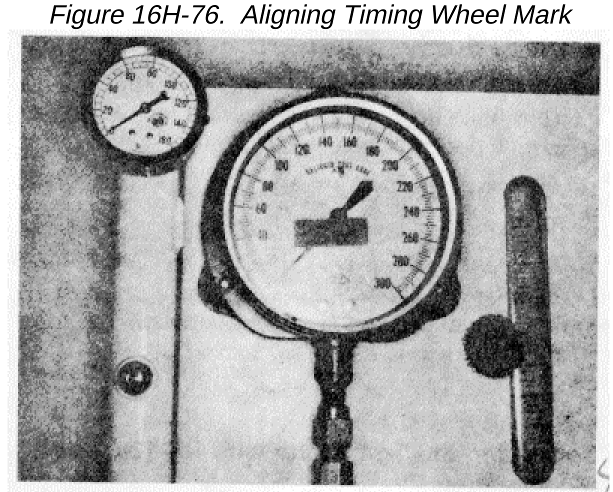


Figure 16H-77. Air Pressure and Fuel Pressure Gauges

cylinder and lifts the injector into the clamped position. Any leak in the hydraulic clamping system will directly affect the injector loading and must not be permitted, Figure 16H-78.

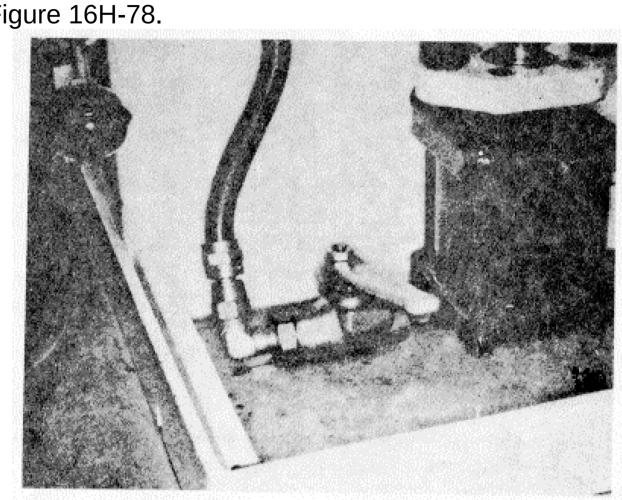


Figure 16H-78. Hydraulic Valve

8. In the clamped position and with the appropriate link in place, tension on the injector is the same as it is in the operating engine. Use of the improper link will affect the clamp load and upset the delivery values.

9. Fuel is delivered to the injector through the inlet connector. Fuel pressure here is controlled at this point by a connecting line and a pressure regulator, Figure 16H-79.

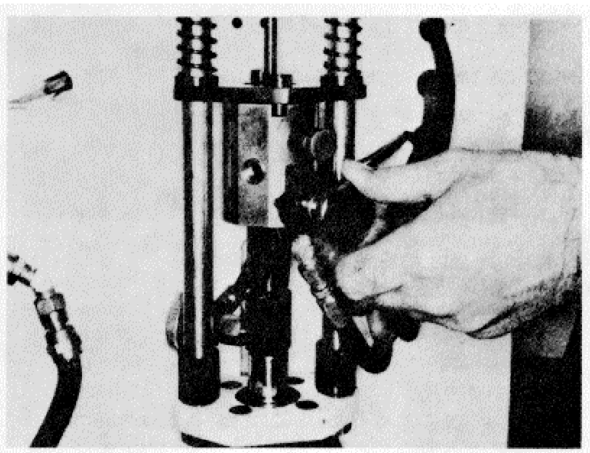


Figure 16H-79. Attaching the Fuel Inlet Connector

10. The second connection, with the clear plastic line, is the injector drain connection which carries the drain fuel from the injector back to the tank.

11. During the test stand operation, the operator starts a test cycle which diverts fuel to the vial so the amount of fuel being injected can be measured, Figure 16H-80.

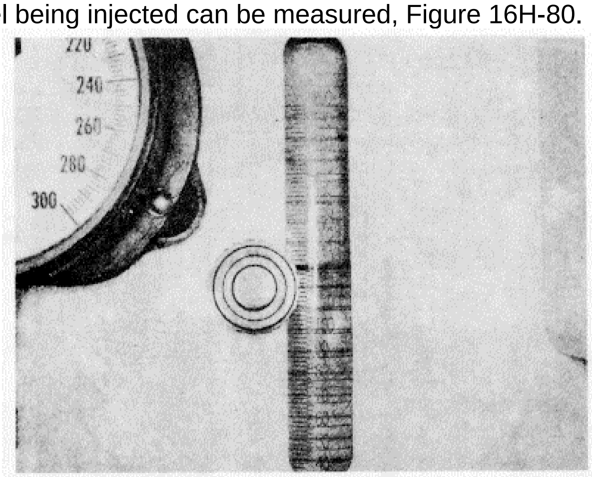


Figure 16H-80. Measuring Fuel in Vial

12. Fuel is delivered to the vial during a measured number of strokes as recorded by the counter.

13. A master injector which has been previously calibrated at the factory is used in setting the test stand priorto adjusting the other injectors for fuel delivery. The master injector must never be tampered with.

INJECTOR TEST STAND MAINTENANCE - ST-790

To obtain the best service life from the ST-790 Injector Test Stand, the following maintenance practice must be observed.

1. The roller tappet and cam assembly will wear, just as any moving assembly, and will require maintenance.

2. If the tappet is worn, it should be replaced as soon as possible to prevent excessive wear on the cam. An improved tappet has been used in test stands built after Serial No. 0576. It uses a needle bearing roller instead of the former bronze bushed roller.

3. Do not assemble a new tappet with a scuffed cam. If the scuffing cannot be removed with a fine hone, the cam must also be replaced.

4. If the cam is worn into the shaft by more than 0.002 inch (0.051 mm), the shaft must also be replaced. This condition will cause undue loading on the cam, tappet and bearings.

5. Align the cam to track 100 percent on the tappet roller.

6. Torque the clamp type ring to 8 to 10 ft-lb (16 to 20 N.m) or tighten the setscrew in the cam hub securely and install a second setscrew on top of the original one as a "jam screw.

CONVERTING THE TEST STAND
WITH ST- 1 261

The "K" Series Engines have a new engine camshaft profile. This engine camshaft has a 0.200 inch (5.08 mm) long stroke on the PT (Type D) Injector. The change in the stroke of the injector made the former cam in the ST-790 unsuitable for use with the "K" injector. If a new cam is required for your ST-790 or the need to calibrate a "K" Injector occurs, you must purchase an ST-1261 Conversion Kit to adapt the ST-790 to the dual cam. The single cam is no longer available.

CAM REMOVAL FROM ST-790. Remove the cam as follows:

1. Remove the covers from the gear pump, drive belt, and cambox.

2. Remove the counter from the mounting bracket. Do not disconnect electrically.

3. Loosen the setscrew (A), Figure 16H-81, to remove the counter clutch assembly.

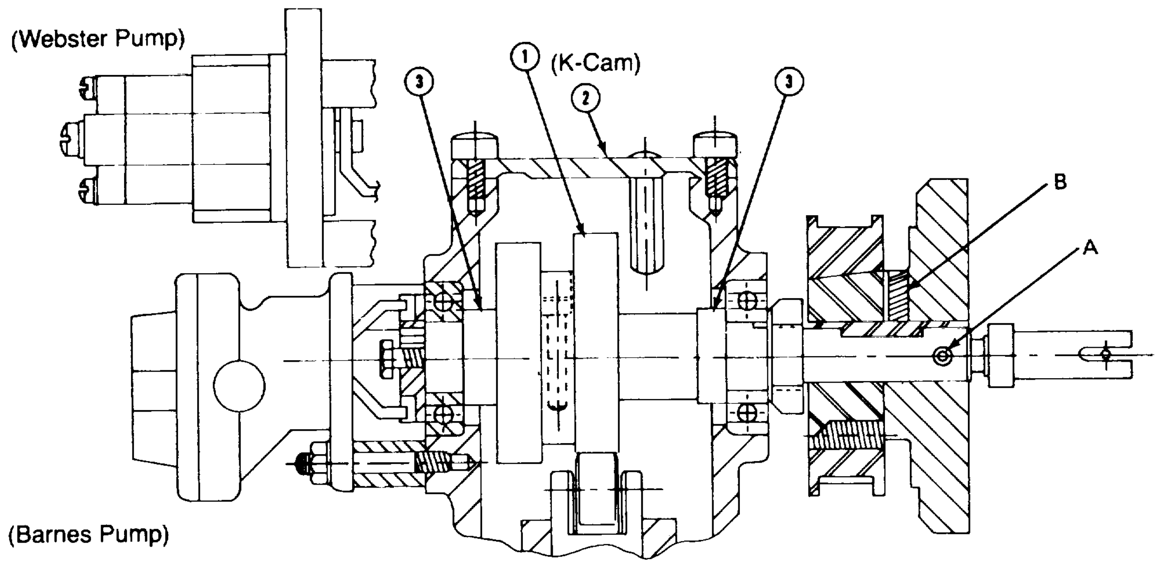
4. Remove the counter clutch arm (D), Figure 16H-83, (see "Clutch Arm Removal" in succeeding paragraphs).

5. Loosen the setscrew (B), Figure 16H-81, to remove the cam set wheel.

6. Loosen the motor mounting screws and remove the drive belt.

7. Remove both setscrews located on the side of the drive pulley, insert one of the setscrews into the third tapped hole and tighten it until the pulley and bushing separate.

8. Remove the gear pump and gear pump drive coupling, which is retained by one screw at the end of the camshaft.



A. Set Screw
B. Set Screw

1. "K" Cam
2. Cover Assembly
3. Cam Spacers

Figure 16H-81. Dual Cam Installed in ST-790 Injector Test Stand

9. Clamp the cam follower in the down position using vise grips at the outside of the housing.

10. Remove the camshaft, driving it out from the fuel pump side. The left hand bearing will remain in the housing as the shaft and the right hand bearing are driven out. To avoid damage to the shaft or bearing, use an intermediate piece of brass or soft steel while driving against the shaft end. The cam may be lifted out as the shaft is withdrawn.

DUAL CAM INSTALLATION. Install the cam as follows: The cam part number and the letter "K" appear on the side of the "K" cam. See the cambox illustration for the proper assembly orientation.

1. Remove the cam drive key from the camshaft and slide a spacer (3), Figure 16H-81, to the bearing end of the shaft and replace the key.

2. With the camshaft partially inserted in the cambox, install the cam and second spacer on the shaft. ("K" cam on the right side.) See Figure 16H-82.

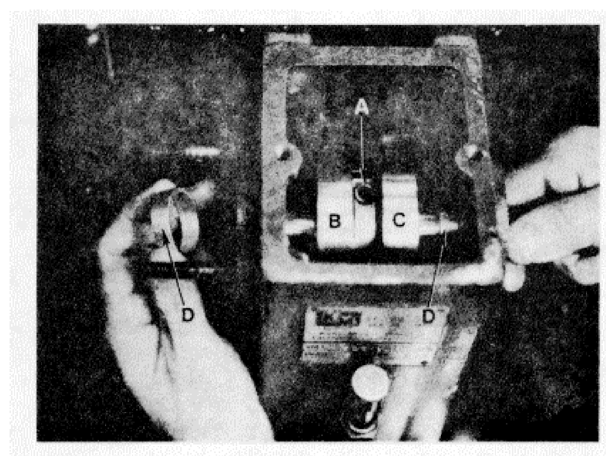
3 Align the camshaft with the left hand bearing bore and tap in a circular pattern on the outer race of the right hand bearing until it is fully seated.

4. Install the gear pump drive coupling on the end of the camshaft. Tighten the screw and lockwasher securely.

NOTE

End play of the camshaft assembly is 0.010 to 0.020 inch (0.254 to 0.508 mm).

5. Replace the gear pump and drive fork.



A. Cam Lock Screw at Top Facing Installer
B. Standard Cam
C. "K" Cam
D. Cam Spacers

Figure 16H-82. Cam and Spacer Installation

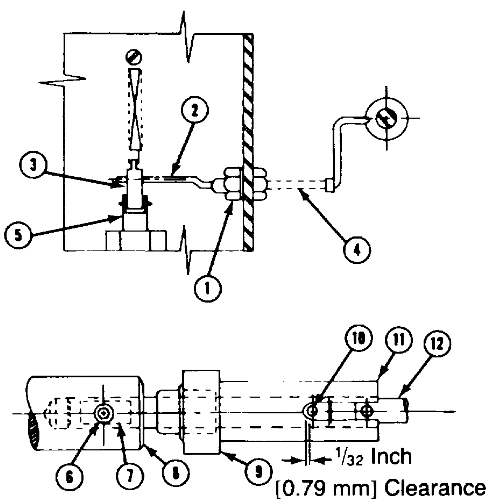
6. Replace the drive pulley, belt, cam set wheel, clutch arm, clutch and counter in the reverse order of disassembly. Adjust the cam set wheel to the original position. See "Clutch Adjustment," in succeeding paragraphs, for the final setting of the counter clutch. Replace the pump and pulley covers.

CAM SELECTION. Set the index mark on the cam set wheel at the pointer on the pulley cover. Slide the cam fully right or left to place the desired cam in the operating position. Hold the cam firmly against the spacer and tighten the cam locking screw to 15 ft-lb (20 N.m) torque using a deep well socket and torque wrench.

When replacing the cambox cover, note that the designation stamped on the front of the cover indicates which cam is in operating position. When the cam is shifted to the other position, the cover is reversed. The projection on the cover prevents incorrect assembly.

The 0.026 inch (0.66 mm) injector seat restrictor orifice must be used when calibrating "K" injectors and all other injectors over 150 cc flow.

CLUTCH ARM REMOVAL. Remove the nut (1), Figure 16H-83. Slide the arm (2), Figure 16H-83, out of the plunger link (3) and guide the clutch arm assembly (4) out through the front of the panel.



1. Nut	5. Plunger	9. Collar
2. Clutch Arm	6. Set Screw	10. Cross Pin
3. Plunger Link	7. Clutch Shaft	11. Driver
4. Clutch Arm	8. Camshaft Shaft	12. Counter Shaft

Figure 16H-83. Clutch Arm Removal and Clutch Adjustment

CLUTCH ADJUSTMENT. Manually engage the clutch by fully depressing the solenoid plunger (shown in "Clutch Arm Removal Procedure"). With the clutch held in this position, the cross pin (10) Figure 16H-83, should clear the driver V-slot by approximately 1/32 inch (0.79 mm), as shown in Figure 16H-83. Tighten the setscrew (6) Figure 16H-83, against the flat provided on the clutch shaft (7).

GAUGE DAMPING AND MOUNTING

Fuel pressure gauge stability will increase the compatibility between the factory and the field test stands. Erratic action of the gauge hand is a result of one or both of the following factors:

1. Hydraulic pulsations being carried into the gauge because the damping valve is not properly adjusted. With the adjustable damping valve it is impossible to ensure that all test stands can be adjusted to the same degree of damping.

2. Mechanical vibration being transmitted into the gauge as a result of one of the following conditions.

A. Operation of the test stand with the gauge mounts broken.

B. Gauge line positioned so it "pulls" or "pushes" on the gauge and in effect becomes a rigid member between the gauge and the test stand frame.

C. Gauge line contacting the frame or other member of the test stand, thereby transmitting mechanical vibration into the gauge.

REMOVING AIR FROM THE FUEL PRESSURE GAUGE. Remove air from gauge as follows:

1 Remove the gauge from the test stand. Remove the snubber from the gauge stem, Figure 16H-84.

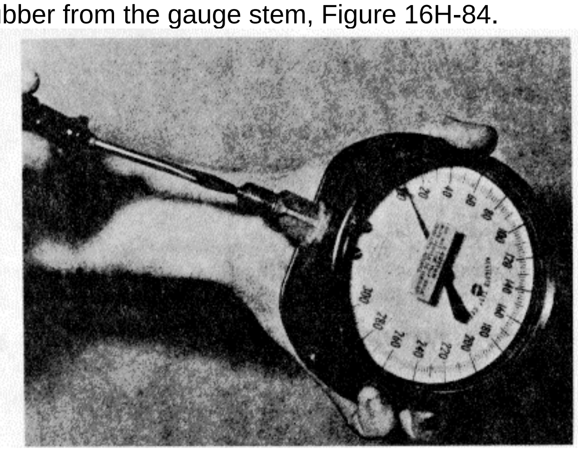


Figure 16H-84. Removing the Snubber from Gauge Stem

2. Fill the gauge filling tube with gauge oil or injector test oil and screw it into the gauge stem. Hold the gauge in a position so the 210 psi (1448 kPa) graduation is the lowest point on the dial face. While holding the gauge in this manner, squeeze the tube and release it. When the tube is squeezed the gauge hand will be actuated indicating fuel is entering the gauge. When the tube is released, air bubbles will come up through the fluid contained in the tube, indicating air inside the gauge is being displaced by the fluid. Continue to squeeze and release the tube several times. After the air bubbles cease to appear, an additional 5 cycles will ensure the gauge is completely filled with fluid, Figure 16H-85.

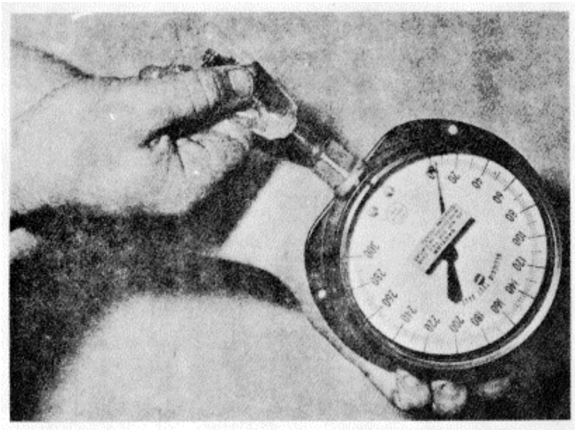


Figure 16H-85. Filling the Gauge to Remove Air Bubbles

3 Turn the gauge so the stem is in an up position and remove the gauge filling tube. Continue to hold the gauge stem upright and finish filling the internally threaded portion of the gauge stem with fluid.

NOTE

The gauge must be held with the stem in the upright position until installation of the gauge on the test stand.

4. Screw the snubber back into the gauge stem.
5. Place an injector into the operating position in the test stand. Start the test stand. When solid fuel begins to flow from the snubber, turn the gauge upright quickly and assemble to the snubber. Let the test stand run while the gauge is tightened securely to the snubber.
6. Assemble the gauge to the mounts and secure it with machine screws and nuts, Figure 16H-86.

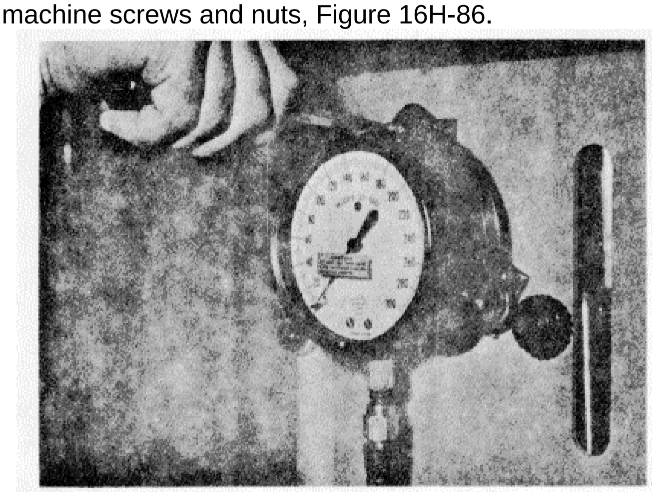


Figure 16H-86. Installing the Gauge to Mounts

7. Start the test stand and observe the gauge hand rise from 0 to 120 psi (0 to 827 kPa). It should take approximately 2 to 3 seconds for the hand to rise to 120 psi (827 kPa). If the gauge hand is slow to rise and fall, carefully repeat Steps 1 through 6.
8. Check for gauge hand vibration; it should not occur if the copper line is properly routed and adjusted.

A. Tubing must be adjusted so it is neither "pulling" or "pushing" on the gauge.
B. Tubing on the gauge must not contact any member of the test stand such as the frame, motor or gear pump cover.
C. Contact of the tubing to any member of the test stand will transmit mechanical vibration into the gauge and defeat the purpose of snubbers and gauge mounts.

CHANGING THE OIL AND FILTER

When changing the oil and filters in the test stand, adjust the regulator to lowest possible pressure during pump pickup to prevent air from being forced into the gauge line. If a slow gauge hand response does occur, it is an indication that air entered the system and the bleeding process Steps 1 through 6 must be performed.

CALIBRATING THE ST-790 TEST STAND

1. Before operating the test stand make sure that the cambox is filled to the top level of the sight glass with clean SAE 30 non-foaming lubricating oil, Figure 16H-73.
2. Fill the hydraulic fluid reservoir to the bulb level with clean Type A automatic transmission fluid. Be careful not to allow oil to enter the standpipe in the center of the reservoir, Figure 16H-73.
3. The test oil tank on the stand must be kept at least ¾ full of Cummins 3375364 test oil.
4. Align the timing mark, Figure 16H-76, and open the hydraulic valve. Place the load cell, ST-790-5111, in the test stand and clamp it in place by opening the air valve, Figure 16H-87.

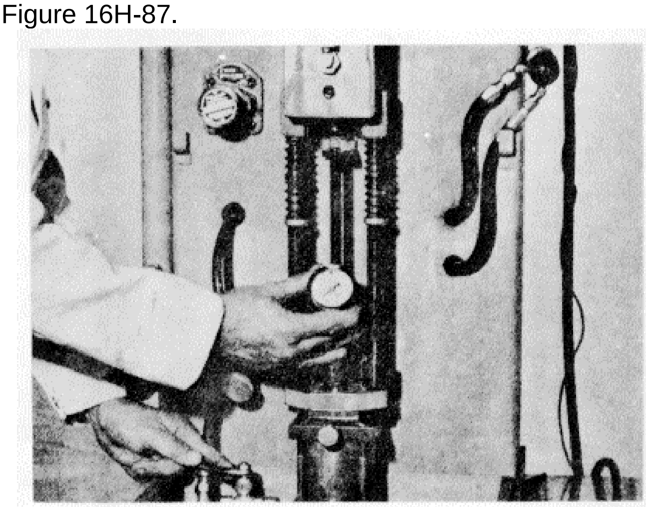


Figure 16H-87. Installing the ST-789 Load Cell

NOTE

Never operate the test stand with the load cell in position.

5. Adjust the air pressure by turning the knurled button on the air regulator until the load cell indicates within the marked band on the load cell gauge. Lock the knurled button in place with the locknut. Note the air gauge pressure (gauge at top of Hydaulic Reservoir), Figure 16H-88. The load cell should read between 370 and 390 when adjusted within the marked band on the dial.

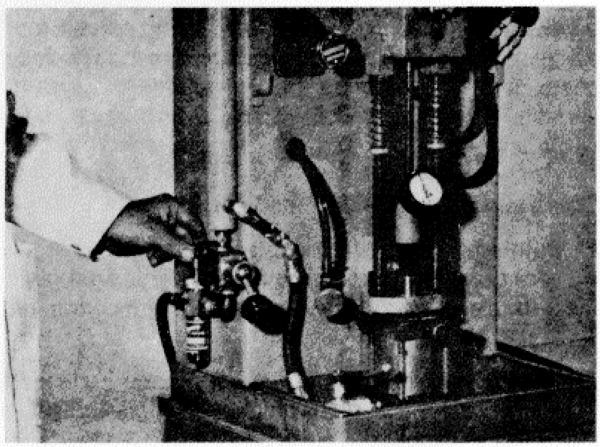


Figure 16H-88. Adjusting the Air Pressure

6. Remove the load test cell by returning the air valve knob to the center position. With the cylinder rod in the down position, check to make sure the hydraulic fluid shows in the hydraulic oil level.

7. Open the air valve. While the cylinder rod is at the top of its travel, check to make sure there is no air in the hydraulic fluid sight glass, Figure 16H-89.

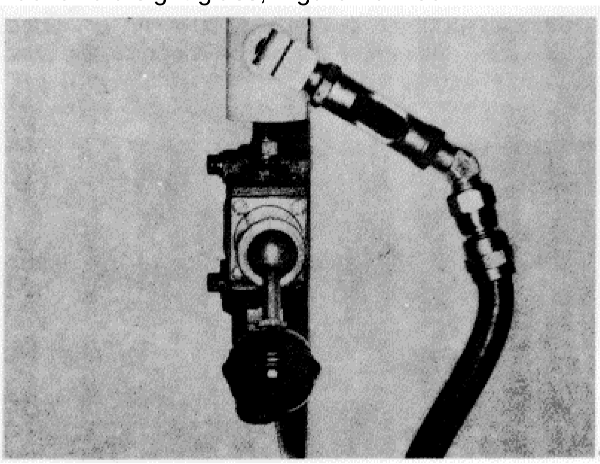


Figure 16H-89. Hydraulic Fluid Sight Glass

8. Make sure the injector seat contains a 0.020 inch (0.51 mm) restrictor orifice when calibrating the test stand with a 132 cc flow injector. Use a 0.026 inch (0.66 mm) orifice when calibrating the test stand with a 178A or a 185A cc flow injector, Figure 16H-90.

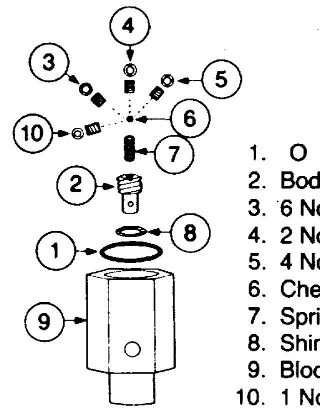


Figure 16H-90. Injector Seat Restrictor Orifice

9. Place the adapter plate over the master injector, ST-768, ST-1210, ST-1262 or ST-1306, and engage the locator in the injector mounting holes. Make sure the seat is retracted and the timing marks are aligned at the timing wheel, Figure 16H-76.

10. Position the test stand link (marked NVH, NH, H) over the injector plunger link and place the assembly in the injector seat, tip the assembly back until the link is below the machine push rod. If necessary, adjust the bracket so the link is aligned but not rubbing.

11. Open the air valve and as the injector goes in the clamped position, make sure the link is properly aligned and engaged, Figure 16H-91.

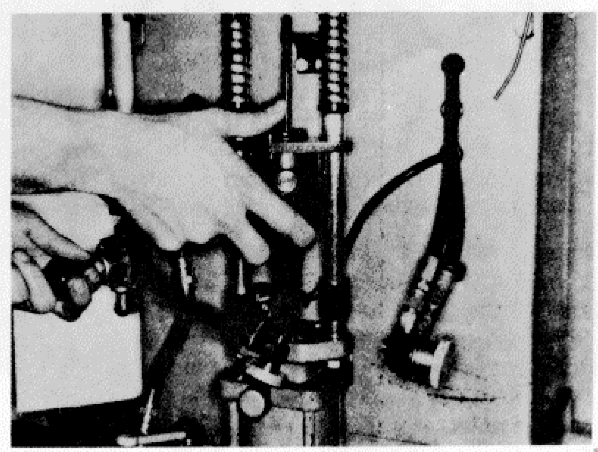


Figure 16H-91. Positioning the Assembly in the Test Stand

12. Check the air pressure gauge at the top of the hydraulic reservoir as originally established with the load test cell. Close the hydraulic valve to lock the injector in the clamped position. Connect the inlet and drain connectors to the injector, Figure 16H-92.

CAUTION

To avoid damage to the master injector, do not use the ST-708 Burnishing Tool when setting up the test stand.

13. Start the test stand motor.

NOTE

Test oil must be a minimum of 900F(320C). If the temperature is not up to 900F (320C), the test stand must be warmed up on a standard injector, not the master injector. If the temperature exceeds 950F (350C), increase the cold water flow. If the temperature exceeds 135°F (570C), drain and replace with new test oil.

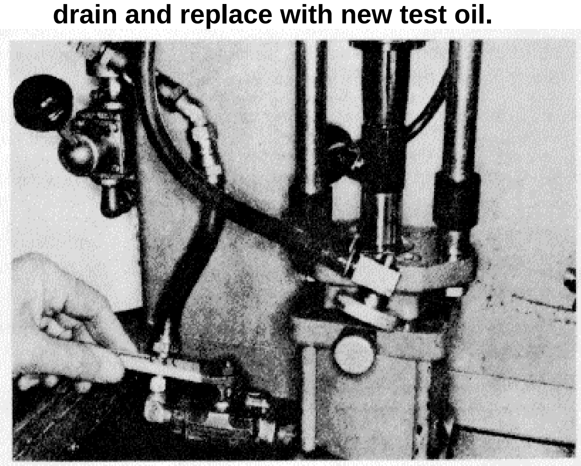


Figure 16H-92. Closing the Hydraulic Valve to Clamp the Injector

14. Adjust the fuel pressure by turning the regulator knob until the pressure gauge shows 120 psi (827 kPa). If this pressure cannot be achieved, the trouble is probably due to a sticking regulator, or to a worn gear pump, Figure 16H-93. Pressure [120 psi (827 kPaimust be maintained at all times during the calibration and testing.

15. All of the counter wheels must be set at zero as a starting point, Figure 16H-94.

16. Shift the silver-colored counter wheels to the right, rotate as necessary then release them to indicate 1020 strokes. Rotate the empty vial into position by turning the vial knob.

NOTE

Some test stand counters are of a different design.

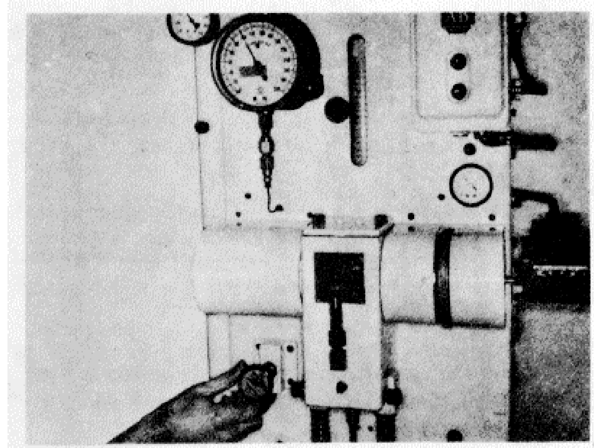


Figure 16H-93. Adjusting the Fuel Pressure to 120 psi

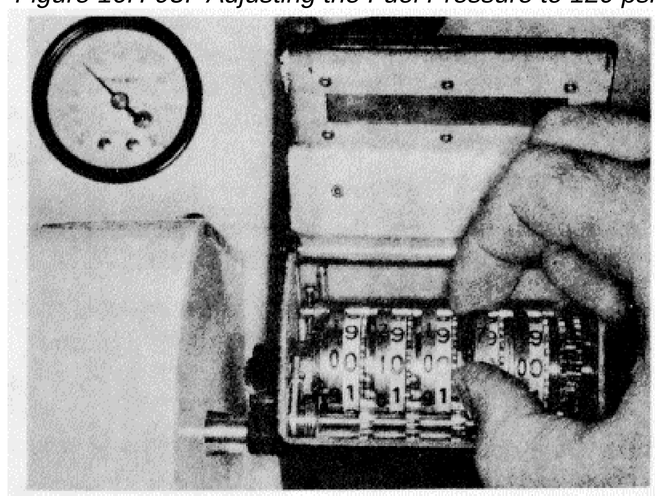


Figure 16H-94. Start Counter at Zero

17. Clear the counter by rotating with the thumb screw for one complete revolution. All white counter wheels must show zero, Figure 16H-95.

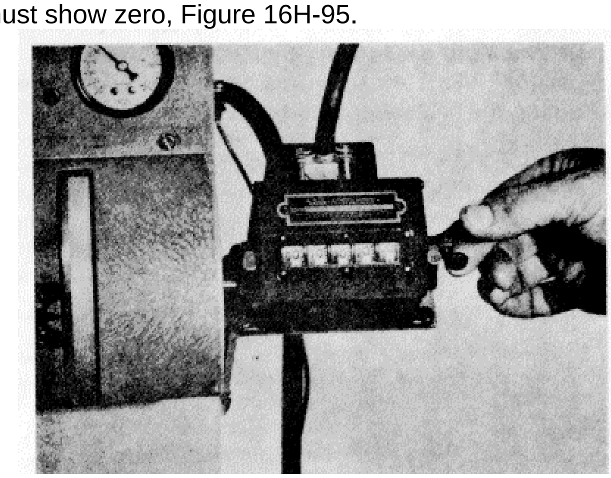


Figure 16H-95. Clearing the Stroke Counter

18. Engage the counter and divert the fuel to the vial for measurement by pressing and releasing the red flow start switch.

19. Stir the fuel with a rod to settle out the foam; then, check the amount collected in the vial at the end of the 1020 count strokes.

20. Look directly into the vial at the fuel level to avoid parallax. If this reading shows 129 cc which is 3 cc below the correct injector master delivery specifications(1 32 cc at 120 psi) or another value, repeat the test, Figure 16H-96.

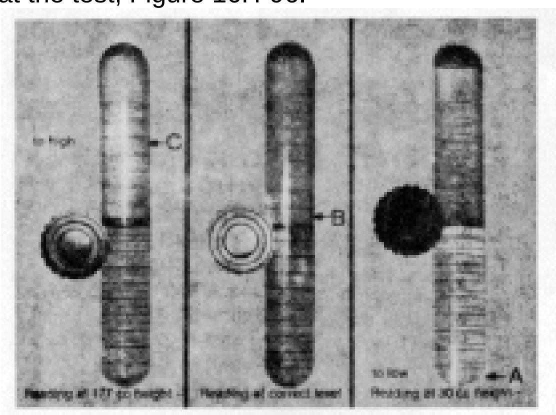


Figure 16H-96. Read the Vial Fuel Level at the Correct Height

21. Dump the fuel from the vial and repeat the test at least twice to ensure consistent results.

22. If 3 cc low, it will be necessary to set the counter up to approximately 1043 strokes or about 7 to 8 strokes for each cc. Roll the counter back. All white counter wheels must show zero.

NOTE

If the counter is set beyond 1050 strokes, it is a good indication the test stand is not properly installed or calibrated.

23. Repeat the tests and adjust the counter as necessary, to obtain 132 cc delivery at 120 psi (827 kPa) with the fuel temperature at 90 to 950F (32 to 350C), while the master injector is in the test stand. Check the readings for three cycles to ensure repeatability. After each four cycles, reclamp the injector to ensure maximum accuracy. At this point, the test stand is correctly calibrated.

NOTE

In reading the level of fuel in the vial, be certain to read it at the fuel level, Figure 16H96. When reading at the "C" height, you are too high. The reading at "B" is the correct height. You are not looking up or down at the fuel level, thereby avoiding parallax. Read the correct cc at the point where the fuel appears to change color.

ST-790 TROUBLESHOOTING/MAINTENANCE

GENERAL

This material should be fully understood by the Injector Test Stand operator. Through this knowledge he should be able to correct the test stand problems and produce a properly calibrated injector.

The ST-790 Injector Test Stand is used to calibrate Cummins injectors. This test stand will provide accurate balancing and testing of Cummins injectors in order to produce the desired engine performance.

Injector calibration on the ST-790 Injector Test Stand combined with the fuel pump calibration on Cummins Fuel Pump Test Stands - with flowmeters - has produced widespread acceptance of fuel system accuracy. There have been reports of erratic results, but investigators have revealed that the cause for such problems falls into three basic categories.

1. Mechanic and/or Tester Error. (Not confined to injector calibration alone. Includes the pump calibration, engine and chassis dynamometer checks, etc.)

A. Calibrating a specific injector model to the wrong flow value.

B. Calibrating a specific fuel pump model to the wrong value.

C. Lack of familiarity with this bulletin and/or Bulletin No. 3379068, 3379182, 3379101, 3379084 and No. 983533.

D. Use of the wrong injector assembly in a specific engine model.

E. Use of camshaft and pistons other than those shown in the CPL.

F. Restricted intake air to the engine.

G. Excessive exhaust back pressure.

H. Restricted fuel supply to the engine.

I. Aerated fuel supply to the engine.

J. Excessively high oil level in the engine crankcase.

2. Instrumentation Errors. (Range all the way from the gauge used on the cup-to-plunger seat check, to the load indicator on the chassis dynamometer.)

A. Erroneous fuel manifold pressure gauges on the engine and/or chassis dynamometer.

B. Erroneous flowmeters.

C. Erroneous dynamometer load indicators.

3. ST-790 Maintenance Status.

A. Use of hose lengths, diameters, and resiliencies other than those which are specified.

CAUTION

Do not replace any hose or lines on the ST-790 Test Stand with other than the correct ST hose as specified in the tool catalog. Hose on the ST-790 should be replaced periodically since rubber in the hose hardens with age causing resonance variables.

B. Fuel routing which is not to specifications.

C. Filter assemblies which have a different dampening effect on the system.

D. Critical components of the test stand such as the check valve, gauge and hydraulic injector clamping, poorly maintained.

TROUBLESHOOTING THE ST-790

Injector calibration problems are discovered by inconsistent results in the service injectors or the inability to flow injectors which have been calibrated at the factory, or at other locations, to the proper specifications. When an injector calibration problem is indicated, the following troubleshooting guide is to be used in the diagnosis and correction of the problem. All injector calibration complaints have been found to fall into the five basic categories as follows:

1. Stand repeatability. Stand will not repeat consistently on any given injector.

2. Poor results on all injector models. Injectors do not perform well in the engine and do not correlate with injectors calibrated on the other stands.

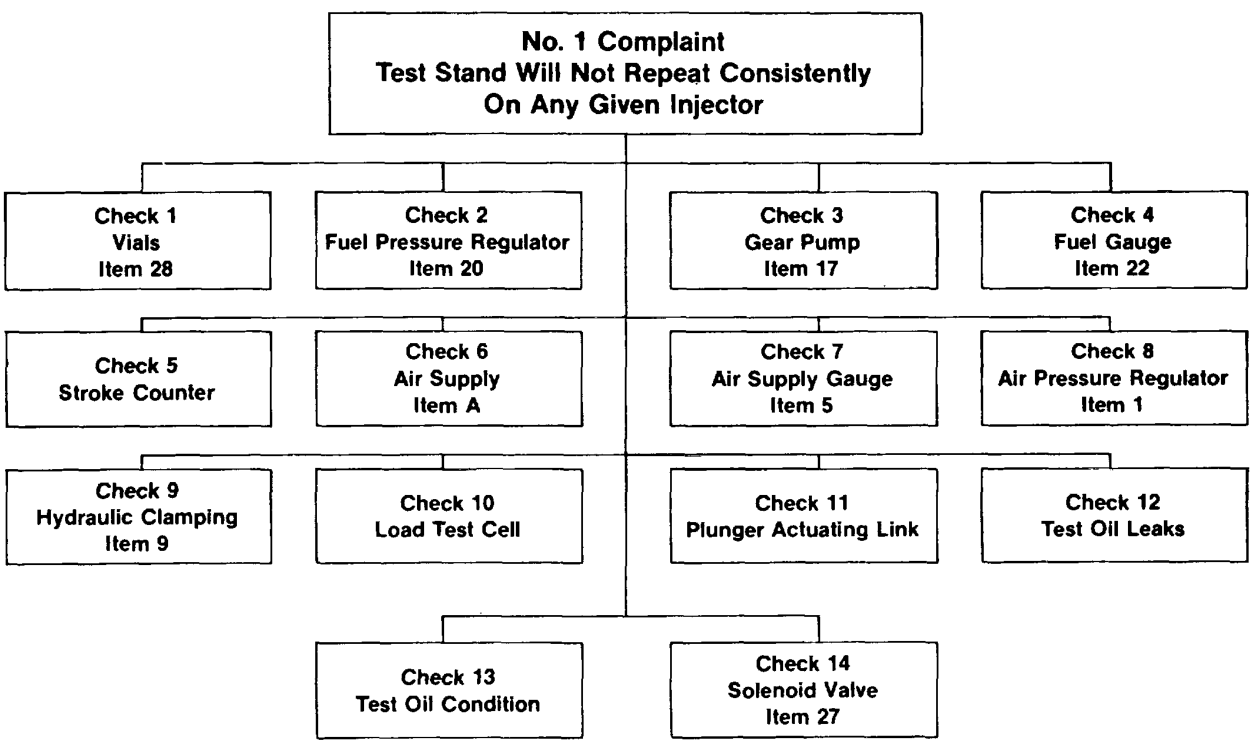
3. 800 stroke injectors heavily overfueled. 1000 stroke injectors slightly underfueled. Reasonable results on all other injectors.

4. All injectors overfueled.

5. All injectors underfueled.

COMPLAINTS AND CORRECTIONS

Charted on the following pages are the complaints, showing the items to check for correction of the complaints. Each check is numbered, and the item numbers from Figure 1 6H-97 are given for quick location, so you may go immediately to the tabulated description of the causes and correction action as necessary.



Check 1 - Vials

Cause	Correction
Differential of 1 cc or more between the vials.	Remove the vials and check their relative accuracy by filling one to various levels and pouring into the other vial. If there is significant variation between the two vials, mark the vials (spot of paint on one) and record the relative variation for future reference in troubleshooting. If the differential is significant at 1 32 cc, choose one vial (the one marked with a spot of paint above) for machine calibration use and when troubleshooting the machine. Replace with correctly calibrated vials as soon as possible.
Metered fuel partially misses the vials.	Adjust the solenoid outlet line so that 100 percent of the metered fuel enters the vials. (For minimum fuel foam, direct the stream of fuel against the side of the vial.)
Foam prevents the accurate reading of the fuel delivery in the vials.	Foam will settle in approximately one minute. To prevent this time loss, a 1 inch diameter hole may be cut in the top panel (with the panel removed) and the foam may be stirred with a wire or rod.

Check 2 - Fuel Pressure Regulator

Cause	Correction
Regulator sticking. (Indicated fuel pressure erratic.)	Clean and/or replace the regulator as required to maintain the pressure at 120 psi (827 kPa).
Regulator is not plumbed into the fuel circuit per the con-version instructions.	Change the plumbing to the right size and length.

Check 3 - Gear Pump

Cause	Correction
Pressure regulator is operating properly but the pressure in excess of 120 psi (827 kPa) cannot be obtained with an 800 stroke injector installed.	Change the gear pump as required. (For gear pump delivery specifications and gear pump checking procedure see Complaint No. 21.

Check 4 - Fuel Gauge

Cause	Correction
Excessive gauge vibration due to machine vibration carrying through the gauge mounts.	Install new gauge mounts.
Hydraulic pulsations being carried into the gauge because the damping valve is not properly adjusted.	Adjust the adjustable damping valve, Figure 16H-97, item No. 21.
Excessive gauge hand vibration due to improper damping in gauge line.	With ST-1262 Master Injector running in the test stand, adjust the needle valve in the gauge line until the gauge hand flutter is eliminated but the gauge hand is responsive to any change in the pressure. This adjustment should be made only with the ST-1262 Master Injector and before the machine is calibrated with the master.
Gauge out of calibration.	Check with a dead weight tester or a master gauge at 120 psi (827 kPa), which is the operating pressure. Adjust the dial hand with the adjusting screw.
Improper plumbing.	Make sure the plumbing agrees with Figure 16H-97. Do not add extra fittings, lines, etc.

1. Air Regulator and Filter
2. Filter Drain
3. Air Valve
4. Hydraulic Reservoir
5. Air Pressure Gauge
6. Hydraulic Oil Level Gauge
7. Sight Glass
8. Hydraulic Lock Up Valve
9. Hydraulic Loading Cylinder
10. Piston
11. Piston Rod
12. Piston Return Spring
13. Cylinder Breather
14. Bleed Plug
15. Fuel Tank
16. Fuel Strainer
17. Gear Pump
18. Fuel Filter (Part No. 105204)
19. Injector Inlet Connector
20. Pressure Regulator
21. Dampening Valve
22. Fuel Pressure Gauge
23. Injector Seat Assembly
24. Restrictor Orifice
25. Check Ball
26. Spring
27. Solenoid Valve
28. Vials
29. "O" Ring (Goshen Part No. GRG-27-12) (Parket Part No. 2-114) (Linear Part No. 11-114)
30. 0.035 Orifice
31. Secondary Check Valve
32. Filter Drain Cock

A. Air In.
B. Hydraulic Fluid
C. Fuel From Tank To Pump
D. Fuel From Pump To Filter Inlet (Stratoflex No. 213 M.H.P. No. 4 21″ Length)
E. Fuel From Injector Inlet To Pressure Regulator (Stratoflex No. 213 M.H.P. No. 4 21″ Length)
F. Fuel From Pressure Regulator To Pressure Gauge (3/16 x 18″ Copper Tubing)
G. By-Pass Fuel From Pressure Regulator (3/16 I.D. x 3/8 O.D. x 9½″ Long Clear Vinyl Tubing)
H. Metered Fuel To Vials (3/16 I.D. x 5/16 O.D. x 40″ Long Clear Vinyl Tubing)
I. By-Pass Fuel From Solenoid Valve (3/16 I.D. x 3/8 O.D. x 7″ Long Clear Vinyl Tubing)
J. Drain Fuel (5/16 I.D. x ½ O.D. x 14″ Long Clear Vinyl Tubing
K. Injector Return Fuel (5/16 I.D. x ½ O.D. x 22″ Long Clear Vinyl Tubing)
L. Fuel From Filter Outlet To Injector Inlet Connector (Stratoflex No. 213 M.H.P. No. 4 37½″ Length)
M. Fuel From Solenoid To Vial (1/8 x 2¼″ Long Copper Tubing)
X. Original Plumbing (Omit)

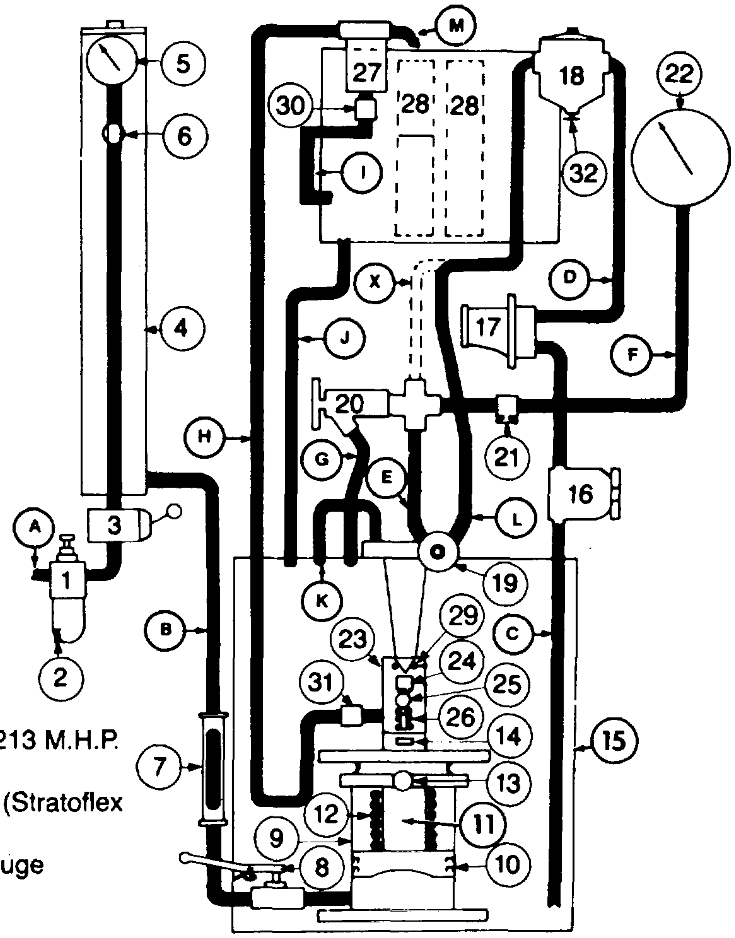


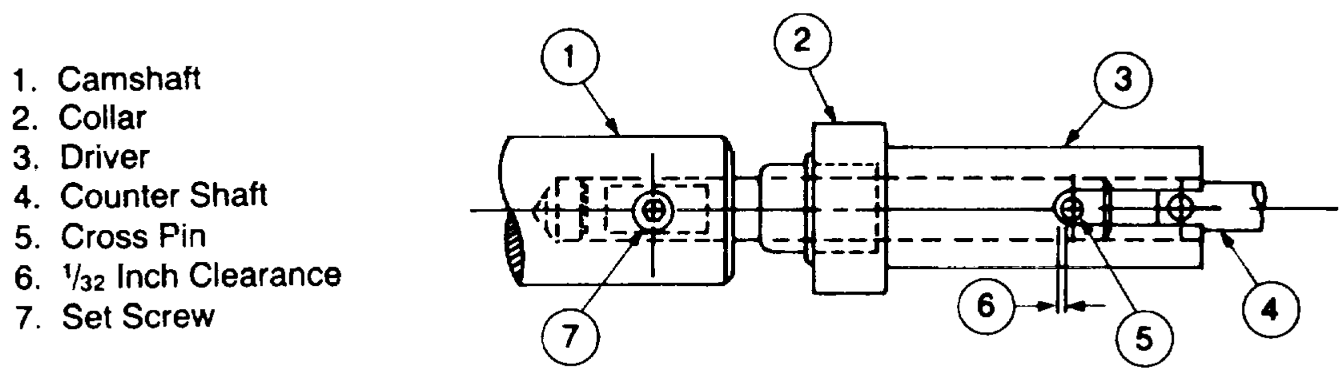
Figure 16H-97. Test Stand Hydraulic System

Check 5 - Stroke Counter

Cause	Correction
Stroke counter improperly set.	Counter wheels must be set and locked for the correct number of strokes. The numbers must then be cleared to "0" by rotating the thumb screw for at least one complete revolution.
Stroke counter engagement faulty.	Align the countershaft with the drive shaft. See Figure 1 6H-98.
Stroke counter fails to disengage.	Increase the tension on the counter return spring at the rear of the panel.
Stroke counter gears damaged or worn.	Check visually while holding the cover back and correct as required.

Check 6 - Air Supply

Cause	Correction
Shop air pressure of less than 80 psi (552 kPa).	Supply air pressure of 80 psi (552 kPa) or more.
Air supply is on common line with other air actuated equipment which causes intermittent pressure drop.	Rearrange the equipment so that the ST-790 is on a circuit which has constant air pressure.



If 1/32 inch clearance has been affected because of loose setscrew or any other condition, the following steps should be taken to obtain proper clearance.

1. Loosen setscrew so that shaft slides freely in housing.

2. Manually engage clutch by fully depressing solenoid (inside main housing). With clutch held in this position, the cross pin in the clutch shaft should be positioned to clear the end of the "U" slot in clutch driver by approximately ’/32 inch.

3. Tighten setscrew against flat on clutch shaft.

4. Check operation, if solenoid is noisy (loud hum or chatter) recheck Step No. 2.

Figure 16H-98. Position of Collar and Drive Clutch Assembly

Check 7 - Air Supply Gauge

Cause	Correction
PSI setting does not agree with the load test cell reading.	Check both the air gauge and load test cell when the rela-ionship between the gauge and cell changes by more than 3 psi (21 kPa).
Air gauge hangs up at a certain point regardless of regulated pressure.	Clean and adjust the hand to clear the face or replace as necessary.
Air gauge is erratic. It does not repeat consistently when actuated several times at the same pressure.	Check the inlet for obstruction, gauge hand for hanging up and correct or replace as necessary.

Check 8 - Air Pressure Regulator

Cause	Correction
Excessive moisture.	Drain the regulator bowl each day by releasing the spring loaded valve. Clean the filter by removing the bowl, wash in solvent and air dry.
Regulated pressure "creeps."	Remove the top housing, valve seat and valve assembly. In-spect the disc and seating surface of the valve seat. Inspect the valve guide and valve guide recess for foreign particles. Clean all parts thoroughly. While the top housing is removed for the preceding step, check the diaphragm and slip ring and replace the faulty parts.

Check 9 - Hydraulic Clamping

Cause	Correction
Leaks (hydraulic clamping system). This may be verified by the following check:	(See below for specific corrections.)
1. Clamp the load cell in the stand.	
2. If after 3 minutes the load cell reading should change position by more than 20 lbs. (9.07 kg).	Check for leaks at the bleed plug and correct as required.
3. Dry all plumbing connections and watch for seepage with the air valve closed and with it open.	Correct as required.
4. If no external seepage is indicated and the condition still persists, one of the following exists:	
A. Leakage past the piston sealing rings. (This is accompanied with a loss of fluid from the reservoir and the appearance of oil out of the cylinder vent when the piston is actuated to the top travel.)	Replace the sealing rings as required. (See Figure 16H-99 for assembly instructions.)
B. Hydraulic lock-up valve leaking. (This may be checked by placing the valve in a closed position and applying air pressure. Indicated travel of the piston rod verifies a leaking hydraulic lock-up valve.)	Repair or replace as required.

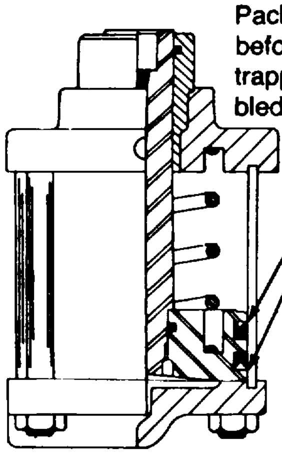


Figure 16H-99. Hydraulic Loading Cylinder

Check 10 - Load Test Cell

Cause	Correction
The gauge on the load cell has become miscalibrated as a result of mishandling such as dropping or excessive loading.	Check the load cell on a valve spring tester at 380 lbs. (172 kg) load. The load cell should read 380 lbs. (172 kg). Correct the gauge with the recalibration screw on the gauge face.

Check 11 - Plunger Actuating Link

Cause	Correction
Use of the wrong injector model link causing the hydraulic piston return spring to be worked at a height other than that when checking the load cell.	Use correct link for the injector being calibrated.
Plunger actuating link binding on link guide bracket.	Inspect the link visually and during running of the stand and replace if necessary.
Plunger actuating link distorted or cracked on the socket and causing cocking during the operation of the stand.	Align the link guide bracket so that it does not contact the link at any point.

Check 12 - Test Oil Leaks

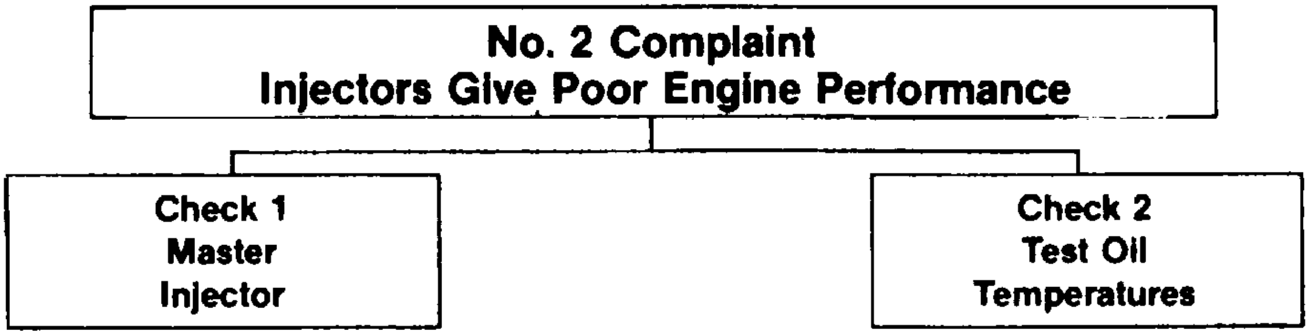
Cause	Correction
Cup seat O-ring leaking. (Leak may appear as mist.)	Replace the O-ring with a new one. If an O-ring of a larger crosscut diameter is used, the injector may bounce on the cup seat and thus affect transfer groove and metering orifice timing. Any bouncing of the injector on the cup seat must be corrected.
Cup seat block-to-solenoid line (line H in Figure 16H-97) leaking in between the tank and front panel. (To check this, route line H temporarily in front of the panel and operate test stand.)	Correct as necessary, remove the rear panel.
Visual leaks.	

Check 13 - Test Oil Condition

Cause	Correction
Improper fuel or dilution.	Keep the tank 3/4 full of Cummins 3375364 Test Oil. Use of oil not meeting these specifications or diluted until the viscosity or specific gravity values are affected will cause improper calibration.
Fuel brown in appearance.	New oil is clear in appearance and becomes amber during use, never use when brown.
Dirty fuel.	Based on 8 hours per day, clean the filter and change the oil monthly or after 160 hours of operation.
Fuel aerated.	It is normal for the drain on flange type injectors to appear "milky." The drain should normally be clear. Fuel in the cup seat block-to-solenoid line (line H, Figure 16H-97) must always appear clear with all injector models. It must be possible to disconnect the injector inlet lines immediately after shutting off the test stand without evidence of any compressed air in the system.
Low oil level in tank.	Fill tank to 3/4 full or above.
Air not completely expelled from system after the filter change or after having the lines disconnected for other reasons.	Without breaking the fuel line connections, remove the filter assembly from its mounting bracket. With the filter assembly in the inverted position and the test stand running at low pressure, bleed the filter at the drain cock until the oil is free of air.
Air leak between the supply tank and gear pump suction. 1. Strainer cap loose or cap gasket missing. 2. Air leaks in strainer-to-gear pump section line or at connections.	Correct as required.

Check 14 - Solenoid Valve

Cause	Correction
Solenoid leaking fuel into the bypass line during the test cycle.	Check for foreign particles and pitted valve or seat. Clean, repair or replace as necessary.
Improperly installed solenoid valve (incoming fuel line connected to the discharge port and the vial line connected to the inlet port) causing excessive restriction on the metered fuel.	Check identification on the solenoid valve inlet port to which line from the injector cup tip must be connected is stamped IN. Directly opposite is the discharge port which must be connected to the vial line. Correct if necessary.
Solenoid valve sticks and fails to divert the fuel to the vials at the instant the counter actuating switch is depressed.	Clean the valve until it operates freely or replace.
The 0.035 inch (0.89 mm) orifice below the solenoid is partially clogged with foreign particles. This causes excessive restriction, which expands the injector-to-solenoid line (line H, Figure 16H-97), while the fuel is being bypassed but regains normal size and empties excess fuel into the vial when the test cycle is started.	Clean as required.

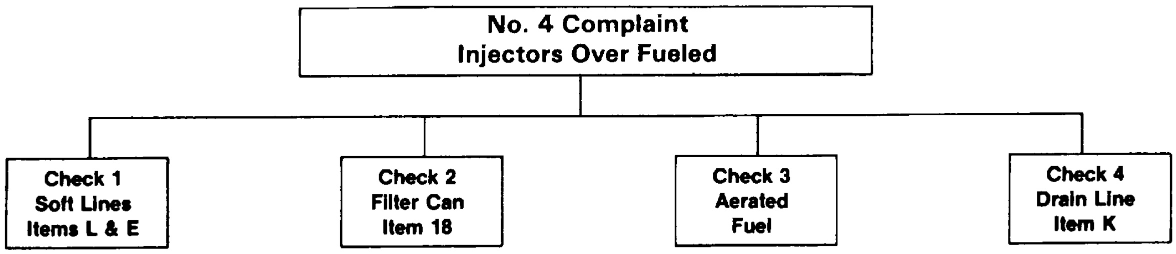


Check 1 - Master Injector

Cause	Correction
Master injector out of calibration	This can be substantiated or disproved by calibrating a set of injectors at 132 cc and engine testing them. If the fuel rate vs. manifold pressure relationship i- not within specifications, a miscalibrated master injector is verified. During this check the utmost accuracy is required in weighing the fuel and recording the manifold pressure. The correct camshaft and pistons as listed on the CPL must be used during this test. Replace the faulty master with a new master ordered from the Factory. Clean and correct the faulty master after it has been taken apart or changed in any way.

Check 2 - Test Oil Temperature

Cause	Correction
Test oil at excessively high or low temperature.	Setting up the test stand or calibrating injectors while the test oil is at excessively low or excessively high temperatures. Check the test oil temperature indicator against a master thermometer and compensate as necessary for any existing differential. It may be necessary to connect cold or hot water lines to the heat exchanger at the back of the tank to maintain the test oil temperature at the required 90to95°F (32 to 350C). If temperature exceeds 95°F (350C), increase the cold water flow. If temperature exceeds 1350F (570C), drain and replace with new test oil.



Check 1 - Restrictor Orifice Threads

Cause

Leakage around the restrictor orifice threads.

Correction

Torque the resistor orifice into the check valve body at 6 in. lb. (0.7 N.m).

Check 2 - Check Valve Body Threads

Cause

Leakage around the check valve body threads.

Correction

Use a gasket (0.030 inch (0.76 mm) throttle adjusting shim) under the check valve body. Torque the check valve body into the cup seat block at 10 to 12 in. lb. (1.1 to 1.4 N.m).

Check 3 - Check Ball Travel

Cause

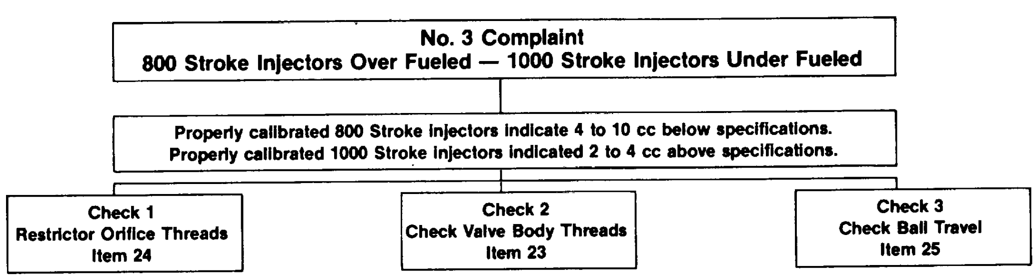
Loss of ball travel caused by overtightening of the restrictor orifice and consequent stripping of orifice threads.

CAUTION

Never try to attain the proper ball travel by loosening the orifice as this will cause leakage around the threads and defeat the purpose of the restrictor orifice and check valve.

Correction

Orifice must be replaced if the threads are damaged. Orifice torque is 6 in. lb. (0.7 N.m). Ball travel is 0.020to O.030 inch (0.51 to 0.76 mm)with the orifice torqued in position (for assembly diagram refer to Figure 16H-90).



Check 1 - Soft Lines

Cause

Use of a filter-to-injector and injector-to-regulator lines (lines L and E in Figure 16H-97) which are softer and more resilient than those supplied with test stand.

Correction

Install lines of material and length shown in Figure 16H-97.

Check 2 - Filter Can

Cause

Original filter has been replaced with one which is larger or has a softer can, such as a Cummins throw-away filter.

Correction

Replace with a standard filter per Figure 16H-97.

NOTE

Be sure that the filter is installed in the correct location in the circuit.

Check 3 - Aerated Fuel

Cause

Aerated fuel.

Correction

See "Causes and Corrections" under Check 13 of "Test Stand will not repeat consistently on any given injector".

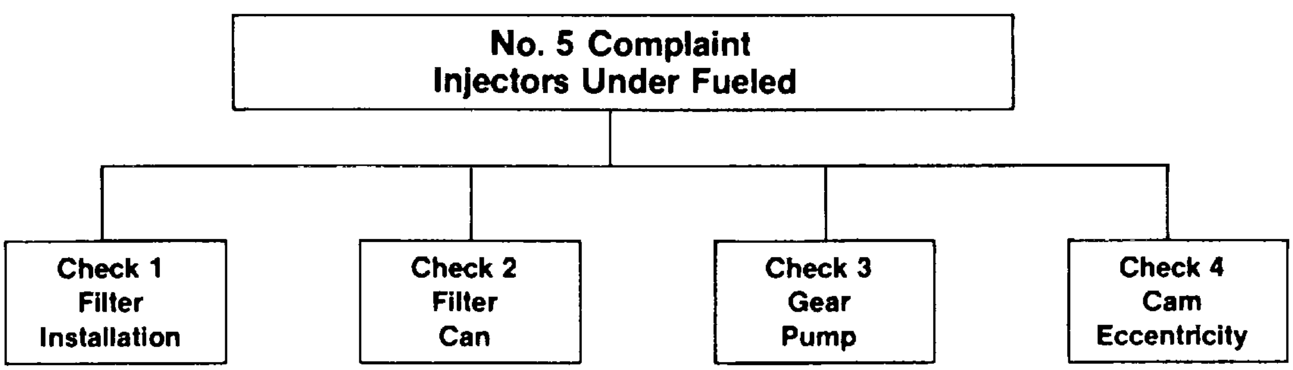
Check 4 - Drain Flow Lines

Cause

Use of a line with less than 5/16 inch (7.95 mm) I.D. or crimp caused by a sharp bend in the drain line.

Correction

Replace per line K in Figure 16H-97.



Check 1 - Filter Installation

Cause	Correction
Removal of the filter assembly from the circuit.	Install the filter.
Installation of the filter assembly in the suction side of the gear pump.	Filter assembly must be in the specified location as shown.

Check 2 - Filter Can

Cause	Correction
I Installation of a smaller or more rigid than standard filter can.	Filter must be of the specified type.

Check 3 - Gear Pump

Cause	Correction
Low gear pump delivery.	With the pressure regulator bypass line (line G, in Figure 1 6H-97) completely blocked, check the gear pump against a 0.045 inch (1.14 mm) orifice installed in line L. The gear pump is acceptable if it delivers 80 to 120 psi (552 to 827 kPa) during this check. If the gear pump delivers less than 80 psi (552 kPa), check the fuel strainer for clogging. Check pump suction restriction and clean if necessary. The gear pump may need replacing.

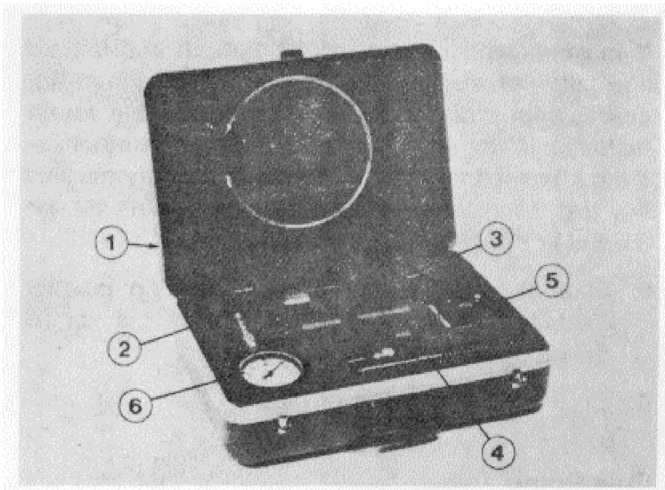
Check 4 - Cam Eccentricity

Cause	Correction
Cam base circle eccentricity.	Check as follows: 1. Align the timing wheel mark and pointer. 2. Install the ST-790-51 11 load cell with the regulated air pressure set to 380 lbs. (172 kg) load. Repeat the clamping several times to assure that the setting of the clamping load is correct. 3. Close the hydraulic valve while the load cell is clamped in position and turn the timing wheel slowly by hand. 4. f the load cell indicates more than 50 lbs. (22.7 kg) increase above the clamping load, the cam and/or shaft and/or cam follower must be replaced.

3375366 INJECTOR TEST STAND AUDIT KIT

GENERAL

The 3375366 Injector Test Stand Audit Kit is used to check the calibration of a 3375317 Injector Test Stand. The test stand must be periodically checked to ensure the reliability of the output display. Master injectors are not used to check a 3375317 Injector Test Stand, Figure 16H-100.



1. Case (Only
2. Viscometer
3. Thermometer
Chart
4. Dummy Injector Link,
& Spring
5. Dead Weight Tester
Baseplate
6. Pressure Gauge (0-600)
7. Fuel Drain Adapter Kit
Time-Viscosity

Viscosity-Temperature
Chart

Figure 16H-100. 3375366 Audit Kit

The instructions below include the data required to prepare the Injector Test Stand, conduct tests and make adjustments as required. Follow all of the instructions in the outlined sequence.

PREPARING 3375317 INJECTOR TEST STAND

1. Install a 178A cc Injector and run the test stand for approximately 30 minutes.

2. Remove the front panel from the test stand.

TEST OIL TEMPERATURE CHECK

The purpose of this check is to establish test oil temperature and calibrate the temperature display green band to cover a range of 1030 to 1050F (39.50 to 40.50C). The injector test stand must be operating during this check.

1. Fill the thermometer well with test oil and insert the audit kit thermometer, Figure 1 6H-1 01. Allow five minutes for the temperature to stabilize.

2. If the stabilized temperature is other than 1040F (400C) rotate the potentiometer screw (1), Figure 16H-102, as required to increase or decrease the indicated temperature.

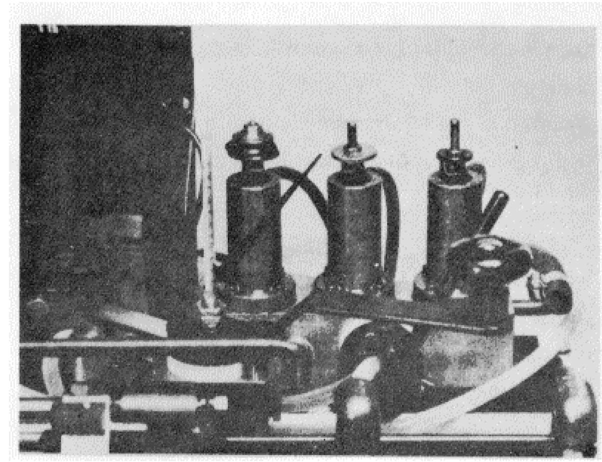


Figure 16H-101. Thermometer Well

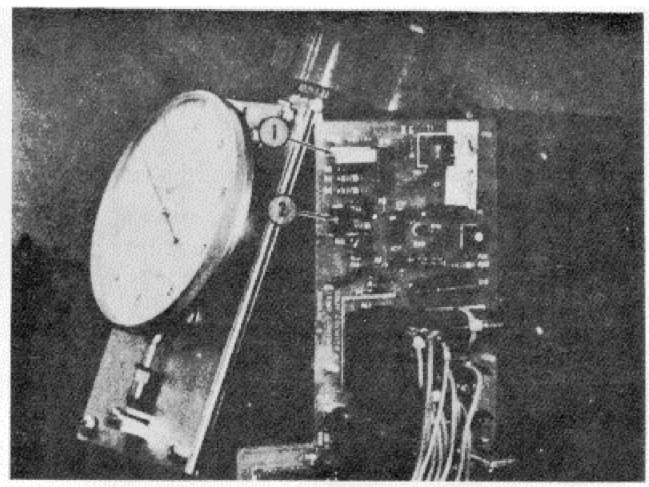


Figure 16H-102. Temperature Control Circuit Board

Rotate the screw clockwise to increase, or counterclockwise to decrease the temperature. Allow 15 minutes for the temperature to stabilize.

3. Adjust the potentiometer (2), Figure 16H-102, to center green band on temperature display.

OIL VISCOSITY CHECK

The purpose of this check is to determine the test oil viscosity. The oil temperature check must be completed before making this check.

Use the Viscometer Cup (in the Audit Kit)and a stop watch (not included in the Audit Kit).

NOTE

The Injector Test Stand must be stopped while this check is being performed.

1. Unplug the heater cord. Remove the reservoir holding pins and lift stir rod coupling. Slide the reservoir to the front of the stand and remove the reservoir cover.

2. Submerge the viscometer cup into the test oil in the reservoir. Allow 10 minutes for the cup and test oil temperature to stabilize.

3. Raise the cup, by the handle, from the test oil by a smooth rapid motion. Use care to keep the cup level.

4. Start the stop watch when the top of the cup breaks the test oil surface.

NOTE

The cup must be held steady until the oil level falls below the cup lip.

5. Stop the stop watch when the last drop of test oil drains through the cup drain hole.

NOTE

The difference between the times should be within one second.

6. Repeat steps 2, 3, 4 and 5 and average the times required for the oil to drain from the cup

NOTE

Chart I, Time Viscosity, and Chart II, Viscosity Temperature, are included in the Audit Kit. The kit charts are specifically prepared for the viscometer Included in the kit and assigned the same serial number as the kit. The serial number is stamped on the lower right corner of each chart. The boxed in number on the upper right corner is the Cummins Test Oil number.

7. Locate the average time point (step 6) on the left side (Efflux Time-Seconds) of Chart I. Follow the related line to the right to the point where it intersects the diagonal line. Follow the intersection point downward to the bottom line (Viscosity Centistokes) and read the viscosity.

8. Locate the viscosity point established in step 7 on the left side (Kinematic Viscosity, Centistokes) of Chart II. Follow the related line to the right. Locate the 104°F (40°C) point on the bottom line (Temperature, Degrees Fahrenheit) and follow the related line upward to the point where it intersects the line extended from the left side.

NOTE

Only the 104°F (40°C) point can be used for this check since that was the test oil temperature set during step 2 of the Test Oil Temperature Check.

If the intersection point of the bottom and left side line falls between the minimum and maximum fluid specifications diagonal lines, and no visible foreign matter is in the oil, the oil is suitable for further use. If the intersection point falls outside the diagonal lines, the test oil must be replaced. Replace the oil with 3375364 or 3375365 Cummins Test Oil.

9. Slide the reservoir into the operating position. Replace the bottom cover. Replace the stir rod drive coupling and the holding pins.

10. Connect the tank heater plug.

FUEL PUMP TEST

1. Remove the 6 mm plug from the fuel junction block. Connect a nylon hose to the junction block with an SAE compression fitting and a 6 mm fitting.

2. Connect the Pressure Gauge in the audit kit, adapter and valve to the nylon hose. Close the valve, Figure 16H-103.

3. Start the fuel system. Open the valve and check the indicated pressure. The pressure should be 440-500 psi (3033-3447 kPa).
4. If the indicated fuel pressure is below 440 psi (3033 kPa), perform the following checks and take corrective actions as required.

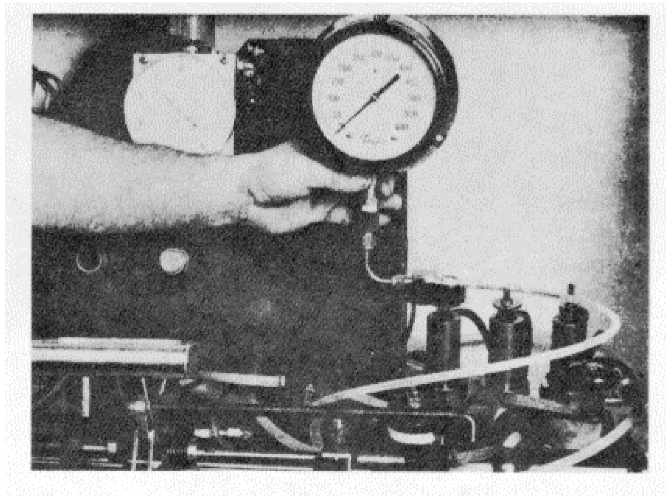


Figure 16H-103. Gear Pump Test Hook-Up

A. Check fuel supply. Add fuel if required.

B. Bleed any trapped air from the nylon hose by loosening the hose connection at the gauge sufficiently so fuel seeps from the loosened connection. 7ighten the connection.

C. Check the gear pump drive for slippage. Make repairs as required.

D. Check that the motor wires are properly and securely connected.

E. Check the gear pump motor electric circuit. Replace the motor if required.

F. Check the tank filter for restriction or make sure the filter is submerged in the tank.

NOTE

If the fuel pressure is still below 440 psi (3033 kPa) replace the gear pump.

5. When the fuel pump pressure is within the limits, remove the gauge, adapter, valve, nylon hose and fittings. Install the plug in the fuel injection block.

ASSEMBLING THE DEAD WEIGHT TESTER

Tools required: Dummy Injector and Link (4), Figure 16H-100, Dead Weight Tester (5), Pressure Gauge (6), 3/8 inch Adapter Pot, Dead Weights and Metric Open End Wrench Set (not included in the Audit Kit).

1. Place the dead weight tester base plate on a solid surface.

2. Place the 11 .5 psi (79 kPa) deadweight and stem into the barrel in the center of the base plate, Figure 16H-104.

NOTE

The 11.5 psi (79 kPa) dead weight and stem are used for all pressure checks. Additional weights are placed on the 11.5 psi (79 kPa) dead weight for higher pressure checks.

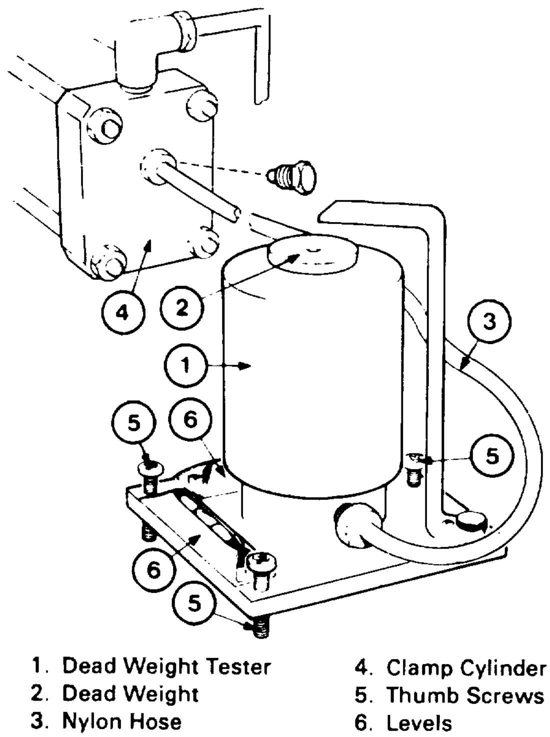


Figure 16H-104. The 3375450 Dead Weight Tester is Connected to the End Plate

3. Remove the brass thumbscrew from the base plate corner. Install the dead weight retainer by inserting the thumbscrew through the retainer hole and screwing the thumbscrew into the base plate.

4. Connect the nylon hose SAE compression fitting to the fitting in the base plate.

5. Remove the 6 mm plug from the clamp cylinder end plate and connect the nylon hose 6 mm fitting from the dead weight tester base plate to the plug port. Place the dead weight tester on the work tray.

12 PSI (83 kPa) CLAMP PRESSURE CHECK
(FOR FUTURE INJECTORS)

The test stand is set for 74 psi (510 kPa). This check can only be made by the Cummins authorized service man. The test stand and the main drive must be off before starting this check.

1. Level the dead weight tester by turning the three socket head screws, as required, to center the level gauge bubbles. Spin the dead weight and stem to relieve friction.

NOTE

This dead weight and stem must float freely in the barrel.

2. Move the clamp plate selection valve to the extreme left, 12 psi (83 kPa) or PTE position.

3. Remove the dummy link from the Dummy Injector. Install the injector into a 3/8 inch PT (Type D) pot and install the positioning pin furnished with the test stand.

NOTE

This series of tests is performed with the dummy link removed.

4. Install a K or PT (Type D) cam furnished with the test stand.

5. Install the 6 mm plug removed from the cylinder clamp (step 5, Assembling Dead Weight Tester) end clamp in the dummy injector.

6. Check that an O-ring is installed in the dummy injector (normally the injector orifice cavity). Start the fuel pump drive motor. Clamp the dummy injector in the test stand. Engage the fuel arm and start the test stand main drive.

NOTE

Apply slight hand pressure to the dead weight to keep it stable while air is being purged.

7. Bleed the air from the hose.

8. Place the 1 psi (6.9 kPa) trim weight (included in Audit Kit) on the roll pin in the dead weight stem. The dead weight and stem should fall. If not, the 12 psi (83 kPa) clamp pressure is high. Decrease the clamp pressure by removing enough trim weights from the top hanger bracket so the dead weight and stem fall.

9. Remove the 1 psi (6.9 kPa) trim weight. The 11.5 psi (79 kPa) dead weight and stem should float free. If not, the 12 psi (83 kPa) clamp pressure is low. Increase the clamp pressure by adding enough trim weights to the top hanger bracket so the 11.5 psi (79 kPa) dead weight and stem float free.

10. When steps 9 and 10 are completed, the 12 psi (83 kPa) clamp pressure is accurately adjusted at 12 psi (83 kPa).

11. Lift the fuel arm up. Stop the test stand main drive.

12. Remove the plug from the dummy injector. Disconnect the hose from the clamp cylinder. Install the plug removed from the dummy injector into the clamp cylinder.

74 PSI (510 kPa) CLAMP PRESSURE CHECK

NOTE

This check is required for all injectors. The test stand must be off before starting this test.

1. Loosen the dead weight retainer thumbscrew. Remove the retainer and add the 73.5 psi (506 kPa) dead weight (included in Audit Kit)to the dead weight stem. Replace the retainer and tighten the retainer thumbscrew.

2. Level the Dead Weight Tester by turning the three socket head screws as required to center the level gauge bubbles. Spin the dead weight and stein to relieve friction.

NOTE

The dead weight and stem must float freely in the barrel.

3. The clamp plate selection lever (1), Figure 1 6H-105, is set at the extreme right, 74 psi (105 kPa) or PT position.

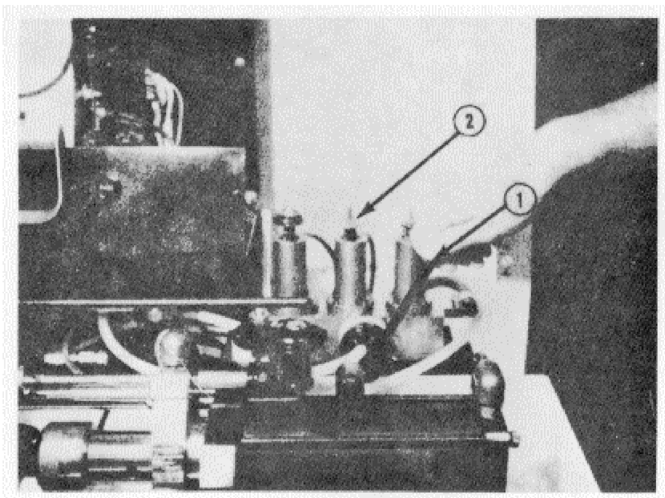


Figure 16H-105. Clamp Pressure Selection Lever is Set at the 74 psi Position

4. Remove the dummy link from the Dummy Injector (4), Figure 1 6H-100. Install the injector into a 3/8 inch pot and install the positioning pin furnished with the test stand.

5. Install the K or PT (Type D) cam furnished with the test stand.

6. Remove the 6 mm plug from the clamp cylinder.

7. Install the 6 mm plug removed from the clamp cylinder end plate (step 5, Assembling Dead Weight Tester) in the dummy injector.

8. Check that an O-ring is installed in the dummy injector. Start fuel system drive motor. Clamp the dummy injector in the test stand. Engage the fuel arm and start the test stand main drive.

NOTE

Apply slight hand pressure to the dead weight to keep it stable while air is purged.

9. Bleed air from the hose.

10. Place the 1 psi (6.9 kPa) trim weight (included in Audit Kit) on the roll pin in the dead weight stem. The dead weight and stem should fall. If not, the 74 psi (510 kPa) clamp pressure is high. Decrease clamp pressure by removing enough trim weights from the top hanger bracket (2), Figure 16H-105, so the dead weight and stem fall.

11. Remove the 1 psi (6.9 kPa) trim weight. The 73.5 psi (506 kPa) dead weight and stem should float free. If not, the 73.5 psi (506 kPa) clamp pressure is low. Increase pressure by adding enough trim weights to the top hanger bracket (2), Figure 16H-105 so the 73.5 psi (506 kPa) dead weight and stem float free.

12. When steps 9 and 10 are completed, the 74 psi (510 kPa) (PT) clamp pressure is accurately adjusted at 74 psi (510 kPa).

13. Lift the fuel arm up. Stop the test stand main drive.

14. Remove the plug from the dummy injector. Disconnect the hose from the clamp cylinder. Install the plug removed from the dummy injector.

100 PSI (689 kPa) INJECTOR SUPPLY PRESSURE

Tools required: Dummy Injector and Link (4), Figure 16H-100, Dead Weight Tester (5), Pressure Gauge (6), 3/8 inch Adapter Pot and Metric Open End Wrench Set (not included in Audit Kit).

1. Loosen the dead weight retainer thumbscrew and remove the retainer. Remove the 73.5 psi (506 kPa) dead weight.

NOTE

The 11.5 psi (79 kPa) dead weight should not be removed.

2. Add the 99.9 psi (688.7 kPa) dead weight (included in Audit Kit) to the dead weight stem. Replace the retainer and the retainer thumbscrew.

3. Connect the dead weight tester 6 mm fitting and dummy injector in connection with the nylon hose, Figure 16H- 106.

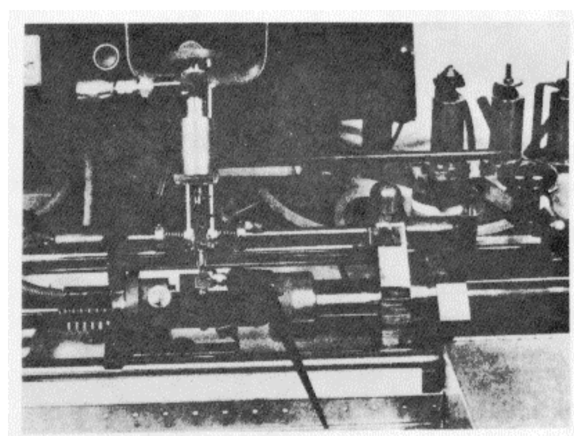


Figure 16H-106. Dummy Injector Connections

4. Level the dead weight tester by turning the three socket head screws, as required, to center the level gauge bubbles. Spin the dead weights and stem to relieve friction.

NOTE

The dead weight and stem must float freely in the barrel.

5. Check that a K or PT (Type D) cam, installed during the clamp pressure test, is still installed. Start the fuel system motor. Clamp the dummy injector in the test stand.

6. Lower the fuel arm and start the main drive.

NOTE

Apply slight pressure to the dead weight to keep it stable while the air is being purged.

7. Check that the fuel is flowing from the injector drain.

8. Place the 0.2 psi (1.4 kPa) trim weight (included in Audit Kit) on the roll pin in the dead weight stem. The 99.9 psi (688.7 kPa) dead weight and stem should fall. If not, the 100 psi (689 kPa) supply pressure is high. Decrease pressure by removing enough trim weights from the top hanger bracket, Figure 16H-107.

9. Remove the 0.2 psi (1.4 kPa) trim weight. The 99.5 psi (686 kPa) dead weight and stem should float free. If not, the 100 psi (689 kPa) supply pressure is low. Increase pressure by adding enough trim weights to the top hanger bracket so the 99.5 psi (686 kPa) dead weight floats free.

10. When steps 8 and 9 are completed the supply pressure is accurately adjusted at 100 psi (689 kPa).

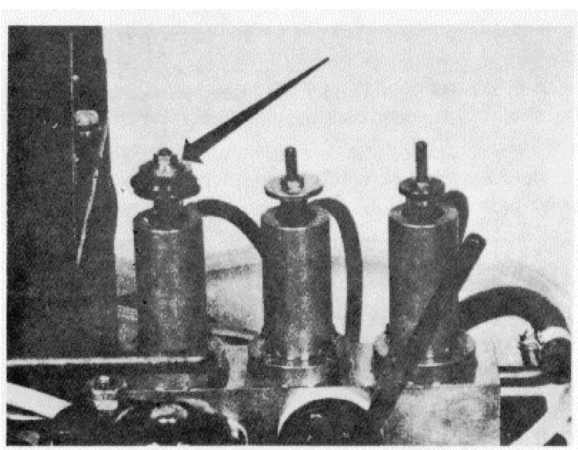


Figure 16H-107. 100 psi Supply Pressure Valve

ASSEMBLING NOSE CONE FOR CHECKS

Tools required: Dummy Injector and Link (4), Figure 16H-100, Pressure Gauge (6), tubes and fittings for making a tee and connecting the gauge. Tubes and fittings are included in the Audit Kit.

1. Disconnect the nose cone outlet pipe.

2. Remove the 6 mm plug from the fuel junction block. Connect a nylon hose to the junction block with an SAE compression fitting and a 6 mm fitting.

3. Install the 6 mm plug removed from the fuel junction block in the dummy injector connection No. 1.

NOTE CONE LEAK CHECK

1. Assemble a tee, tubes, valve and 0-600 psi (4136 kPa) pressure gauge, Figure 16H-108.

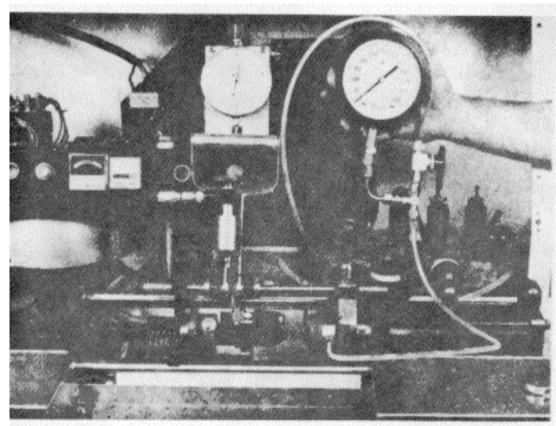


Figure 16H-108. Nose Cone Leak Test Hook-Up

2. Connect the nylon hose to the valve.

3. Install a 6 mm fitting in the nose cone outlet. Connect this fitting and the tee with a nylon hose and SAE compression fittings.

4. Close the valve and start the fuel system. f

5. Open the valve and check for external leaks at the plate valve, joints, seals, etc.

6. Close the valve. If the gauge pressure falls below 350 psi (2413 kPa) in 60 seconds, the leak rate is excessive. If the leak is past the valve plate, disassemble the nose cone, lap as necessary, clean and reassemble. If leak(s) occur at other points repair as necessary.

NOSE CONE FLOW PRESSURE CHECK

1. Close the valve and remove the hose from the nose cone outlet and the tee connected to the pressure gauge. Install nylon SAE compression to SAE compression and adapter between tee and outlet in dummy injector, Figure 16H-109.

2. Start test stand and clamp dummy injector in test stand.

NOTE

Be sure the nose cone is positioned to drain fuel into tray.

3. Open the valve and check the indicated pressure. The pressure should be 350 + 25 psi (2430 ± 172 kPa).

4. If the pressure is not within limits, remove nose cone end cap and adjust the pressure.

PLATE VALVE LEAKAGE TEST

NOTE

A plate valve leakage test should only be made after the nose cone flow pressure check is completed

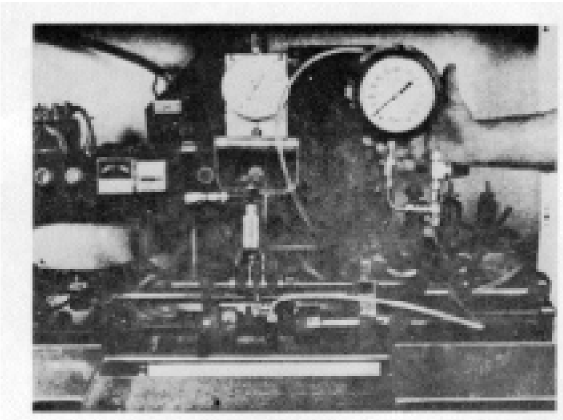


Figure 16H-109. Flow Pressure Check Hook-Up

1. Start the test stand and clamp the dummy injector in the test stand.

NOTE

Be sure the nose cone is positioned to drain the fuel into tray.

2. Close the valve and check the indicated pressure. The pressure should remain above 150 psi (1034 kPa) for a minimum of 30 seconds.
3. If the pressure does not meet the specification, open and close the valve several times to flush the dirt from the nose cone and repeat test.

4. If nose cone still will not hold pressure, disassemble, lap the plate valve and seat separately, clean and reassemble.

CLAMP HEAD/DATUM VALVE LEAKAGE TEST

1. Remove the injector link support.

2. Install the dummy injector, link and spring (4), Figure 16H-100.

3. Remove the plug from the clamp cylinder end plate.

4. Install 6 mm to SAE connector in end plate plug port. Connect the nylon hose to the connector.

5. Connect the 0-600 psi (4136 kPa) pressure gauge (2), Figure 16H-1 10 and adapter to the other end of the hose.

6. Turn the fuel system motor on. Clamp the dummy injector. Check the pressure gauge. Rotate the cam 1800 by hand and observe the pressure gauge.

7. Turn the fuel system off. If the indicated pressure remains above 35 psi (241 kPa) for 60 seconds, the datum valve is satisfactory. If the indicated pressure falls below 35 psi (241 kPa) in less than 60 seconds check for datum valve leaks. If no leaks are apparent check the clamp piston seal, clamp cylinder end gaskets and fittings for leaks. Repair as required.

MAINTENANCE OF THE AUDIT KIT TOOLS

Clean the kit tools after each use. Place the tools in the case and store the case in a dry location.

MAINTENANCE SCHEDULE OF 3375317 INJECTOR TEST STAND

AFTER EACH 200 HOURS OF OPERATION:

1. Change the test oil - use oil to SAE Spec. J967D. Cummins Part No. 3375364 in 55 gal. drums or 3375365 in 30 gal. drums.

NOTE

Test oil may be used longer if the viscosity is between 2.4 and 3.2 centistokes.

2. Change the test oil filter.

3. Clean the magnetic filter bar.

4. Clean the metering unit filter. This filter is located in line between the nose cone and the metering unit.

5. Replace the fuel arm shut-off valve O-ring.

6. Apply grease to the stirrer drive shaft gears and bushings.

7. Lightly oil the stirrer drive shaft bushings.

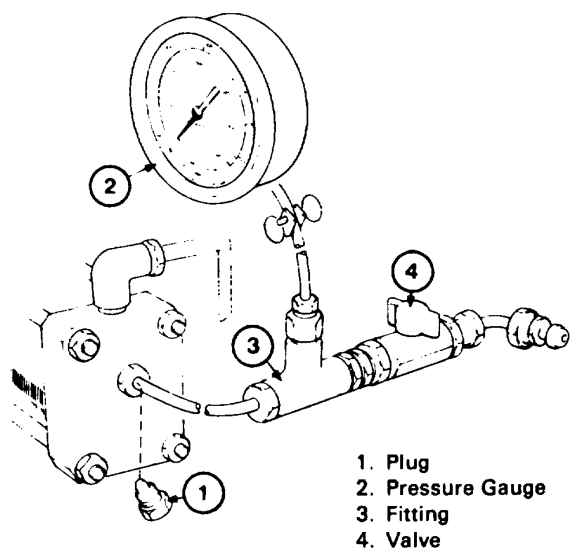


Figure 16H-110. The Pressure Gauge and Control Valve Connected to the Clamp Cylinder

AFTER EACH 1000 HOURS OF OPERATION:

1. Change the cambox oil, use Automotive Engine Oil SAE 30W.

2. Adjust the drive belt tension. There should be about ½ inch (13 mm) deflection of the belt when pressed by thumb at the midpoint between pulleys. Adjust the tension by loosening the motor capscrews and sliding the motor.

3. Lightly oil the index lever roller bearings.

4. Lightly oil the index lever pivot.

5. Lightly oil the index cylinder pivot bushings.

6. Lightly oil the fuel arm pivot points.

NOTE

To check the datum valve, the camshaft must be at the index position. Hold the rod to be certain the lever roller is in contact with the camshaft when adjusting the datum valve.

7. Check the datum valve adjustment. The spool shaft should be flush + 0.010 inch with its housing when viewed from the right side of the test stand. To adjust, remove the spring retainer from the datum valve, loosen the spool locknut and rotate the spool to adjust. Tighten the locknut, read- just the spring and tighten the spring retainer.

8. Check the magnetic pickup to the heart shaped camshaft peg clearance. Adjust until the clearance is 0.005 to 0.010 inch (0.13 to 0.24 mm).

9. Check the fuel arm center line position relative to the adapter plate. Adjust if the fuel arm nozzle repeatedly fails to align with the injector balance orifice. The fuel arm center line should be 2.50 to 2.54 inch (63.5 to 64.5 mm) from the adapter plate.

10. Check the minimum clearance between the index roller and the heart shaped cam at the index position. Clearance is 0.005 to 0.015 inch (0.13 to 0.38 mm). The nylon roller should spin freely by hand when the cam is in the index position. Adjust by loosening the index piston rod locknut and rotating the piston rod. The fuel pump must be switched off for easier adjustment.

NOTE

Do not damage the piston rod.

AFTER 5000 HOURS OF OPERATION:

The test stand should be completely checked out for a possible major overhaul.

SUBSECTION 161

LUBRICATING SYSTEM

DESCRIPTION

Lubricating system group contains oil pump, oil pan, pan adapter, dipstick, filters, bypass filter, lines and oil coolers.

TOOLS

The following service tools or tools of comparable quality are necessary to repair or rebuild the components of the lubricating system as outlined in this group

Essential Service Tools (Or Equivalent)	
Service Tool Number	**Tool Name**
3375206	Lube Oil Pump Boring Tool
Desirable Service Tools (Or Equivalent)	
ST-1134	Dowel Pin Extractor

LUBRICATING OIL PUMP

DISASSEMBLY

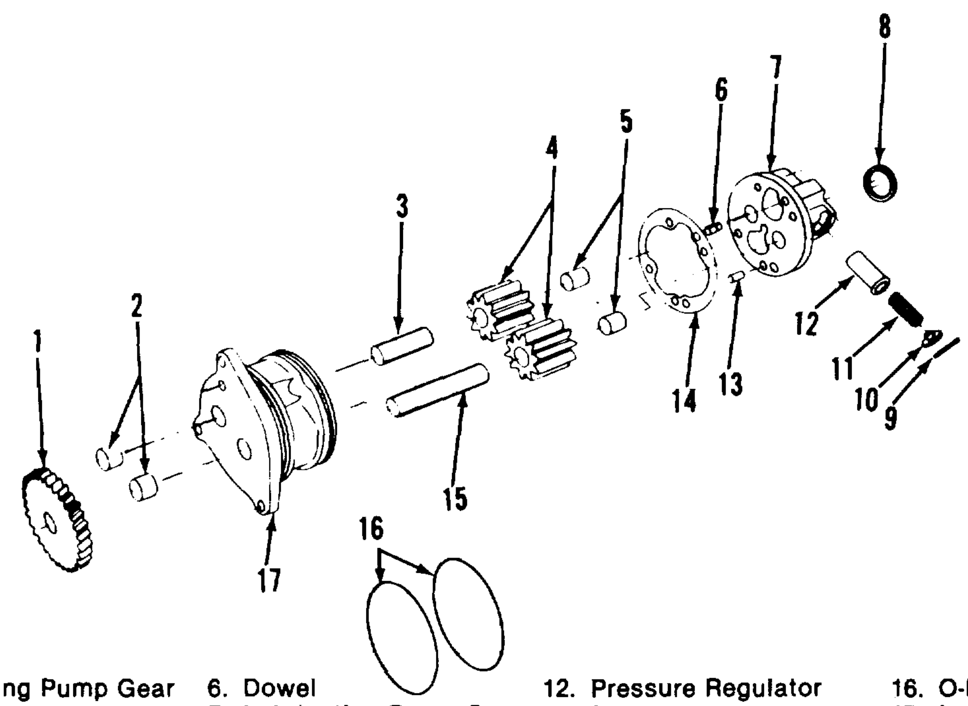
1. Remove the cover (7), Figure 161-1, from the pump body, (17). Use a soft hammer to loosen from the dowels (6 and 13).

2. Remove the idler gears (4) and the shafts(3 and 15)from the pump body (17).

3. Use a puller to pull the pump gear (1) from the shaft and body.

4. Remove the roll pin (9), stop (10), spring (11) and pressure regulator (12) from cover (7).

5. Clean all parts in an approved cleaning solvent. Dry with compressed air.



1. Lubricating Pump Gear
2. Lubricating Pump Bushings
3. Idler Shaft
4. Idler Gears
5. Lubricating Pump Bushings
6. Dowel
7. Lubricating Pump Cover
8. Rectangular Sealing Ring
9. Roll Pin
10. Pressure Regulator Stop
11. Pressure Regulator Spring
12. Pressure Regulator Plunger
13. Dowel
14. Gasket
15. Lubricating Pump Drive Shaft
16. O-Rings
17. Lubricating Pump Body

Figure 16I-1. Lubricating Oil Pump

NOTE

The new style regulators have either a roll pin and plug or a solid dowel that cannot be removed with the pump in the engine.

INSPECTION

1. Inspect the drive shaft (3) and idler shaft (15). Mark for replacement if badly scratched or worn smaller than 0.874 inch (22.20 mm). See Table 161-1 (2).

2. Inspect the idler gears (4). Mark for replacement if the teeth are chipped, cracked, badly scratched or show excessive wear.

3. Measure the bushings in the body (17) and cover (7). Mark for replacement if worn larger than 0.8785 inch (22.314 mm). See Table 161-1 (1).

4. Check the pressure regulator valve for free movement in the pump cover.

REPAIR

1. If the bushings in the body or the cover were marked for replacement, remove and press the new bushings flush to 0.020 inch (0.51 mm) below surface of the body or cover with the ST-0000 Bushing Mandrel.

NOTE

Use the 3375206 Bushing Boring Tool to machine the bushings in the body and cover to 0.8765 to 0.8775 in. (22.263 to 22.289 mm) after the bushings are installed.

2. If the drive shaft or driven gear were marked for replacement, press the gear from the shaft. When assembling replacement parts, press the drive shaft through the driven gear to 1.665 to 1.685 inch (42.29 to 42 80 mm) shaft protrusion from the end of the gear.

3. If the idler or idler gear were marked for replacement, press the gear from the shaft. When assembling the replacement parts, press the idler shaft through the idler gear to 1.085 to 1.105 inch (27.56 to 28.07 mm) shaft protrusion from the end of the gear.

ASSEMBLY

1. Put the drive shaft (3) and the idler gear (4), Figure 161-1 through the bushing in the pump body (17).

2. Put the assembly on the end of the drive shaft and then press the pump gear (1)onto the shaft with a 0.1 30 toO.150 inch (3.30 to 3.81 mm) clearance between the gear and pump body. See Table 161-1 (3). After the pump gear is pressed into position, the drive shaft is to have 1.030 to 1.050 inch (26.16 to 26.67 mm) protrusion above the cover surface of the pump body. See Table 161-1 (4).

3. Put the other idler gear(4) and the idler shaft (15) into the pump body and bushing.

4. Install the cover (7) to the pump body (17). Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque.

5. Install the pressure regulator valve (12) spring (11) and stop (10) and secure with the snap ring (old style). New style regulators that use a roll pin instead of a snap ring must have the short plug pressed in flush with the pump cover gasket surface. New style pumps that use a long solid dowel instead of the roll pin do not need the short plug. It is important that the roll pin or solid dowel be seated in the spring retainer slot.

6. Rotate the shaft. Check for movement. Measure the drive shaft end clearance. See Table 161-1 (5).

LUBRICATING OIL PAN AND ADAPTER

INSPECTION

1. Visually check the oil pan and adapter and cover for cracks or, if a leak is suspected, use a dye penetrant to inspect it.

A. Spray the area with dye penetrant. Allow the penetrant to dry for fifteen minutes.

B. Spray the area with a dye developer and check for crack indications.

2. Check the thread inserts. If damaged, replace. Check all the threaded holes for damaged threads.

REPAIR

1. Replace the damaged thread insert. Use an insert extractor tool to remove the damaged inserts. Condition hole and install a new insert.

2. Repair the small cracks in the pan by welding. Do not weld finished surfaces.

LUBRICATING OIL DIPSTICK

The dipstick has been calibrated for a certain oil level when used with a specific oil gauge tube and with engine in a certain position. Too high an oil level will cause foaming, excessive oil temperature and power loss. Too low an oil level will result in oil pressure fluctuation and possible loss of oil pressure. In the event a dipstick should be lost or damaged a new dipstick is required.

Finished dipsticks are no longer available for purchase. Unmarked dipsticks are available and will require fabrication by measuring and marking.

Make the finished dipstick high and low oil level markings according to the instruction sheet contained in the service assembly dipstick package.

For the proper marking identification, etch with an electrical pencil to a depth of 0.005 to 0.010 inch (0.13 to 0.25 mm).

LUBRICATING OIL FILTER HEAD - FULL-FLOW

DISASSEMBLY AND INSPECTION

1. Inspect the filter head for damage to the sealing ring area. Replace all parts which are not serviceable.

2. The filter bypass and pressure control valves normally require no servicing. Check to see that the valves open and close freely. If the valves do not open and close freely:

A. Remove the pipe plugs (2, 8 and 11), Figure 161-2, pressure regulator stops (7 and 14), springs (5 and 12) and plunger (4 and 10) from filter head (3). Discard the 0-rings (6 and 13).

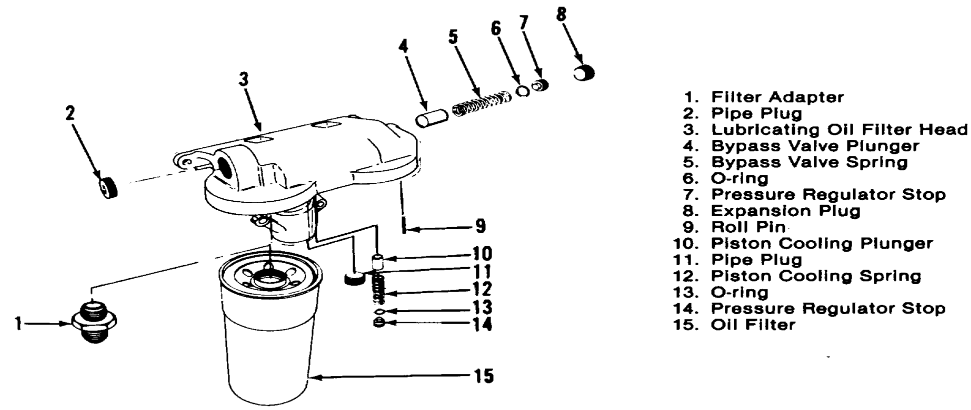


Figure 16I-2. Lubricating Oil Filter

B. Clean all the parts in approved cleaning solvent and dry with compressed air. Vent hole in the piston cooling plunger must be open. Inspect for wear or distortion. Discard and replace all parts which are not serviceable.

ASSEMBLY

1. Lubricate the plungers, springs, pressure regulator stops and O-rings with clean engine lubricating oil; position the O-rings on the regulator stops.

2. Put the bypass valve plunger (4), Figure 161-2, into the bore of the filter head (3). Install the spring (5) and the pres-sure regulator stop (7).

3. Put the piston cooling valve plunger (10) into the bore of the filter head (3). Install the spring (1 2) and the pressure regulator stop (14).

4. Coat the pipe plugs(2, 8 and 11)with sealing tape or lead sealer. Install in the filter head. Tighten to 50 to 55 ft-lbs torque (68-75 N.m).

BYPASS FILTER

DESCRIPTION

A bypass filter can be used with a full-flow filter. Never use a bypass filter instead of a full-flow filter.

DISASSEMBLY

1. Remove the coupling half(1), Figure 161-3, and lift off the cover (2) and O-ring (3).

2. Remove the upper support assembly (4, 5, 6). Lift out the filter (7).

INSPECTION

1. Inspect the upper support assembly and seal drain plug connections and filter cover. Replace if damaged.

2. Clean the orifice in the standpipe. The orifice controls the amount of oil flow through the bypass filter and so must be kept clean.

ASSEMBLY

1. Install the new filter element (7), Figure 161-3.

2. Install the spring (6) and the O-ring (5).

3. Replace upper support holddown (4) on the filter and tighten to stop.

4. Position the O-ring (3) on the cover (2).

5. Install the cover (2) and coupling (1). Tighten the cap-screws until the clamps come together.

FLOW CHARACTERISTICS AND SPECIFICATIONS

With a 1800F (820C) oil temperature and with engine at high idle, oil flow through the bypass filter is to be a minimum of 1-1/2 to 3 gallon (5.7 to 11.4 lit) per minute to be sure maximum filtration and adequate oil pressure are available.

HOSE SIZE

1. The supply and drain hoses are Number 6 (5/16 inch (7.9 mm) inside diameter) flexible hose up to 10 ft (3 m) in length. For hose over 10ft (3 m), use Number 8(13/32 inch (10.3 mm) inside diameter). All fittings in the bypass circuit should be no less than 1/4 inch (6.4 mm) pipe size.

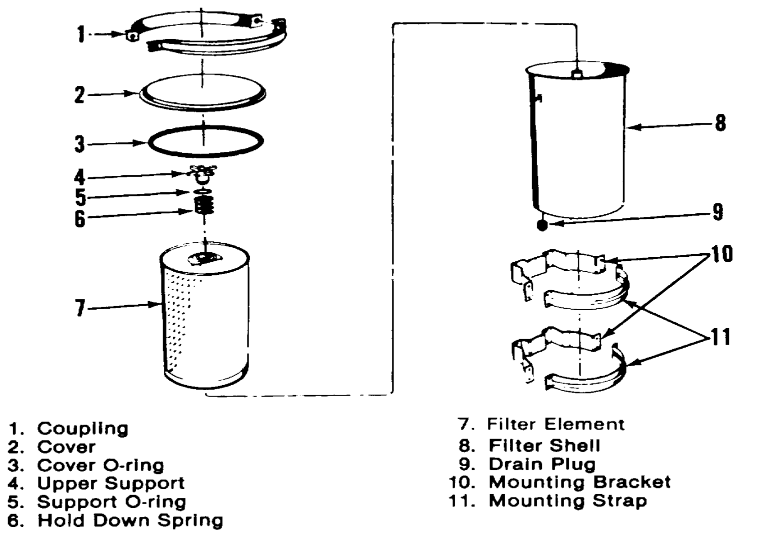


Figure 16I-3. Lubricating Oil Bypass Filter

2. The drain hose should discharge below the oil level in the oil pan to prevent foaming.

3. Supply hose should be connected to the oil circuit be-tween the oil pump and full-flow filter.

FUEL AND LUBRICATING OIL HOSES

HOSE SPECIFICATION

The hose must be either Teflon lined strengthened with corrosion resistant wire braid or a multiple ply construction consisting of a seamless Buna N synthetic rubber inner tube reinforced with one fabric or synthetic rubber and at least one wire braid layer, with an oil resistant cover of impregnated fabric braid.

The particular size hose must be rated by the manufacturer as suitable for a temperature range of at least -400F to +2750F and a working or operating pressure of a minimum of 250 psi (1723.8 kPa).

In addition, it must be certified by the manufacturer to have the following minimum burst pressures:

Hose Size	Min. I.D. In. (Ref.)	Min. Burst Press.-PSI
-6	5/16	1000
-8	13/32	1000
-10	1/2	1000
-12	5/8	1000
-16	7/8	1000
-20	1-1/8	1000
24	1-3/8	750

ASSEMBLY

Replace the hose and worn or cracked connections with new parts. The average life of flexible oil hose is 100,000to 200,000 miles (160,900 to 321,000 km) or 3200 to 6400 hours. Time depends on the amount of bend and temperature to which the hose is subjected. Shops which make up new hose from bulk hose, follow the steps below to insure proper fitting installation.

1. Use a hacksaw to cut the hose to length. The cut is to be square within 5° and smooth so that the inner liner will not be damaged.

2. Position the socket in the jaws of a vise. Check all fittings to make sure of fit.

3. Hold the hose so that it enters the socket straight, Figure 161-4. Rotate the hose counterclockwise while push-ing it into the socket.

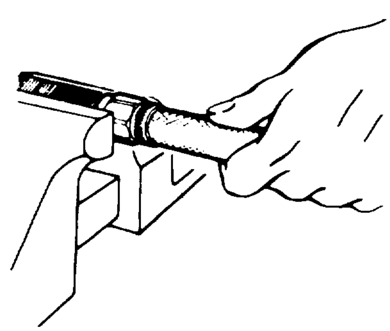


Figure 16I-4. Install the Hose into the Socket

4. Turn the hose into the socket until it bottoms. Check to be sure that it does not collapse in on the inside from being pushed in too far.

5. Put the socket and hose assembly in the jaws of a vise. (Clamp on the socket.) Apply lubrication on the nipple, Figure 161-5 and the inside of the hose for assembly.

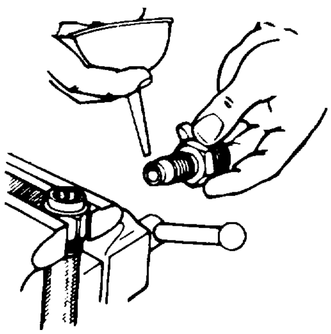


Figure 16I-5. Lubricate the Nipple

6. Hand assembly tools are available for assembling the nipple assemblies into the hose socket assembly. The ST-1 160 Assembly Tool Kit, includes an assembly mandrel for each hose Size 4, 5, 6, 8, 10, 12 and 1 6. In an emergency, a brass fitting can be tightened enough in the swivel nut to enable turning the flare seat (nipple) into the hose and socket, Figure 161-6.

7. After assembly, always look carefully inside the fittings and hose for possible hose damage. A cut in the inside diameter to the hose lining can plug the hose bore when the flow of fluid goes through the hose.

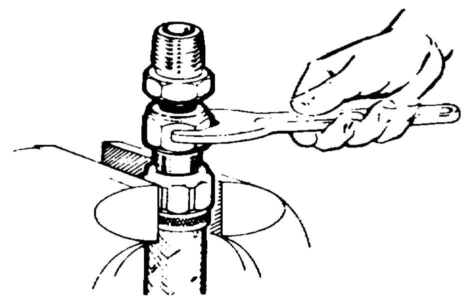


Figure 16I-6. Assemble the Hose Nipple and the Socket

LUBRICATING OIL COOLER
DISASSEMBLY

1. Ream out the capscrew from the oil cooler cover (6) and housing (3), Figure 161-7.

2. Remove capscrews attaching the element (9) to the cooler housing (3). Remove elements.

3. Discard gaskets (2, 5 and 10) and O-rings (7 and 11).

CLEANING

To prevent hardening and drying of foreign material, clean the elements immediately with an approved cleaning solvent. Make sure solvent will not harm copper.

INSPECTION

1. Inspect the housing (3) and the cover (6) for cracks or damage.

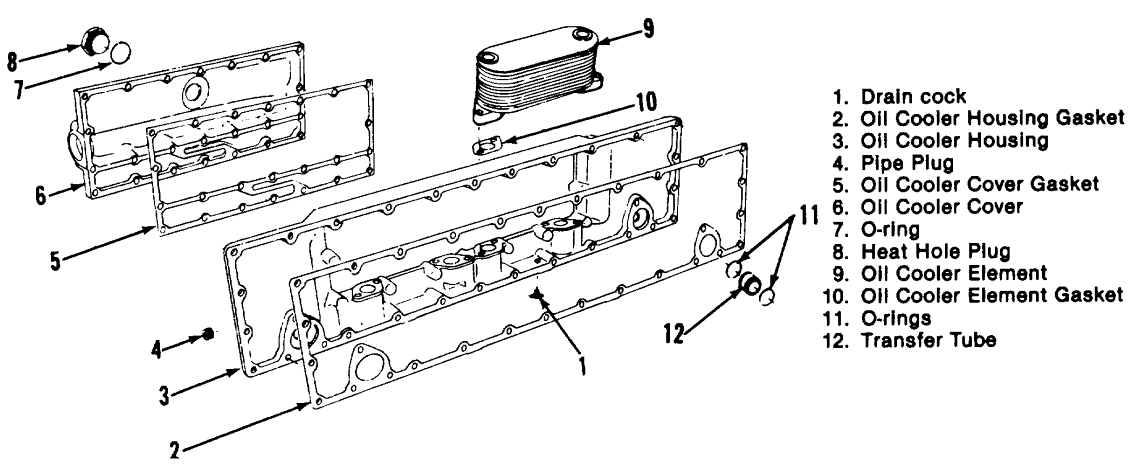


Figure 16I-7. Lubricating Oil Cooler

2. Use adapters to plug the openings in the elements. Test the elements in a water tank.

3. Apply 60 psi (413.7 kPa) of air pressure to the element.

4. Inspect for air leaks. Replace defective parts.

ASSEMBLY

1. Use new gaskets (2, 5 and 10), Figure 161-7, and the 0-rings (7 and 11).Lubricate the O-rings with clean engine lubricating oil. Install the elements (9) in the housing (3).

NOTE

If the retainer holddown clamps are used, hand tighten capscrews at this time. Tighten capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque.

2. Install the plugs (8) with an O-ring (7) into the housing and cover. Tighten to 50 to 55 ft-lb (95 to 108 N.m) torque.

3. Install the cover with nine capscrews and washers as shown in Figure 161-8. Install the drain cock (1) in the bottom of the housing. Tighten to 5 to 10 ft-lbs (7 to 14 N.m) torque.

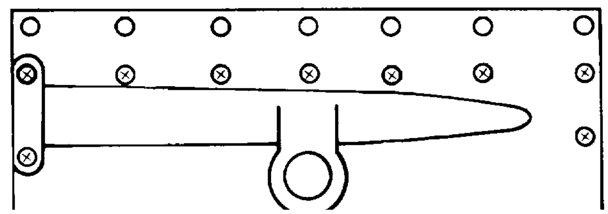
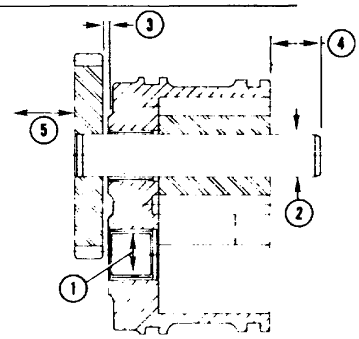


Figure 16I-8. Installation of the Cover to the Lubricating Oil Cooler Housing

Table 16I-1. Lubricating Oil Pump Specifications – Inch (mm)

Table 161-1. Lubricating Oil Pump Specifications — Inch (mm)

Ref. No.	Measurement	Worn Limit	New Minimum	New Maximum
	Bushing			
1.	Inside Diameter	**0.8785 [22.324]**	0.8765 [22.263]	0.8775 [22.289]
	Idler and Drive Shaft			
2.	Outside Diameter	**0.874 [22.20]**	0.8745 [22.212]	0.8750 [22.225]
	Drive Gear to Body			
3.	Clearance		0.130 [3.30]	0.150 [3.81]
	Shaft Protrusion Above			
4.	Cover Mounting Surface		1.030 [26.16]	1.050 [26.67]
	Drive Shaft			
5.	End Clearance		0.0025 [0.064]	0.0065 [0.165]



SUBSECTION 16J

COOLING SYSTEM

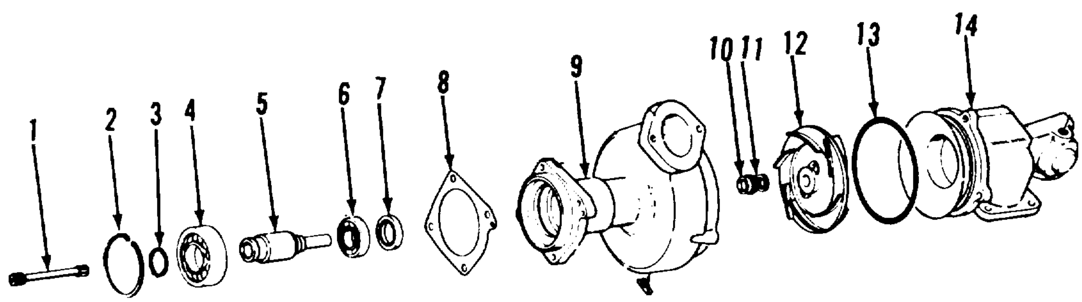
DESCRIPTION

The cooling system group contains engine water pump, fan hub and thermostats.

TOOLS

Service Tools Required (Or Equivalent)

Service Tool Number	Tool Name	Standard Tools
ST-647	Puller	Snap Ring Pliers (Large and Small)
ST-657	Bearing Mandrel	Arbor Press
3375265	Pulley Impeller Puller	Grease Gun
3375320	Seal Driver	Bearing Packer
3375326	Bearing Separator	5/16-18, 3/8-16, 7116-14 Taps
3375448	Seal and Seat Mandrel	Feeler Gauge Set
3375705	Spring Compressor Plate	0-1, 1-2, 2-3 Micrometers
		Telescoping Gauges
ST-1314	Drive Bushing Mandrel	
3375411	Thermostat Seal Driver	
3375692	Oil Seal Driver Mandrel	
3375707	Seal and Pulley Assembly Tool	
3375693	Bearing Race Driver	
3375694	Bearing Race Driver	
3375695	Bearing Driver	
3375704	Bearing Race Driver	
3375697	Wear Sleeve Driver	



1. Drive Shaft
2. Retaining Ring
3. Retaining Ring (small)
4. Outer Bearing
5. Shaft
6. Inner Bearing
7. Oil Seal
8. Gasket
9. Water Pump Housing
10. Face Seal
11. Cup Seat
12. Impeller
13. O-ring
14. Water Inlet Housing

Figure 16J-1. Water Pump

WATER PUMP

DISASSEMBLY

1. Remove the capscrews and lockwashers securing the water inlet housing (14) to the water pump housing (9). Discard the O-ring.

2. Use a 3375265 Puller to remove the water pump impeller (12) from the shaft (5), Figure 16J-2.

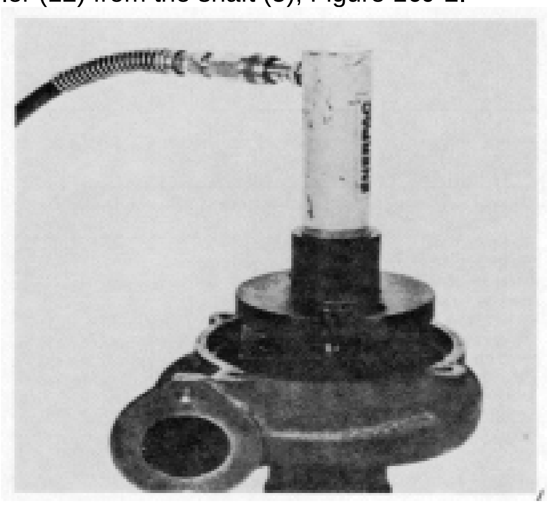


Figure 16J-2. Remove the Impeller

3. Remove the retaining ring (2) holding the bearing and the shaft assembly (4, 5, 6) in the water pump housing.

4. Support the water pump housing at the drive end. Press the shaft and bearing assembly from the housing by apply-ing pressure to the impeller end of the shaft, Figure 16J-3.

5. Remove the seat (11), drive the oil seal (7) and the face seal (10) from the housing. Discard the seat and seal.

6. Remove the retaining ring (3) retaining the outer bear-ing (4) from the shaft, Figure 1 6J-4. Support the outer bear-ing with a 3375326 Bearing Separator and press the shaft (5) from the bearing.

7. Use a 3375326 Bearing Separator supporting the inner bearing (6) to press the shaft from the inner bearing.

INSPECTION

1. Inspect the water pump bearings. Rough or worn races indicate possible damage to the shafts outside diameter and the pump housing bore. *Discard the bearings.*

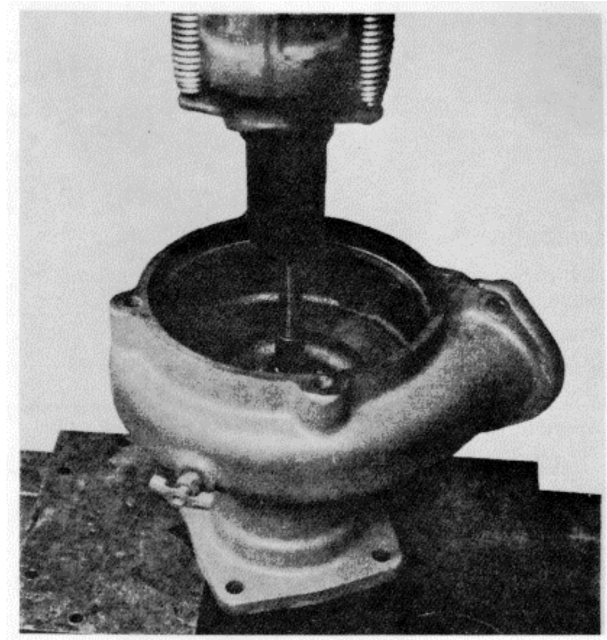


Figure 16J-3. Press the Shaft Assembly from the Housing

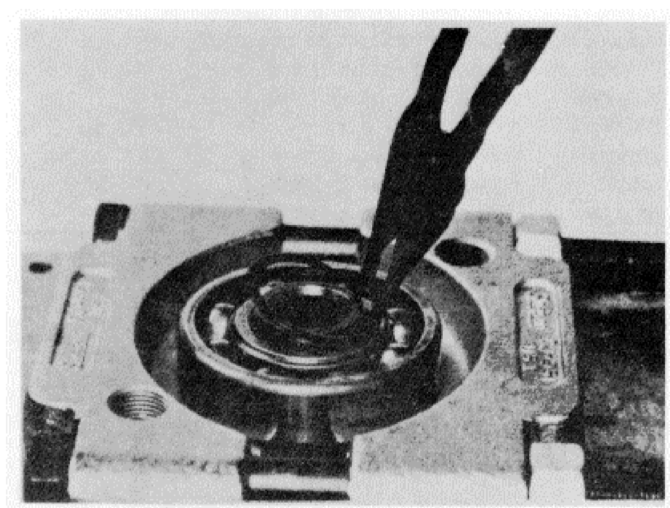


Figure 16J-4. Remove the Retaining Ring

2. Visually inspect the water pump housing and inlet housing for cracks, corrosion and excessive wear. Measure the water pump housing bore, Figure 1 6J-5; if larger than maximum specifications, replace the housing. See Table 16J-1.

3. Inspect the water pump impeller for cracks or erosion to the extent that it will retard coolant circulation.

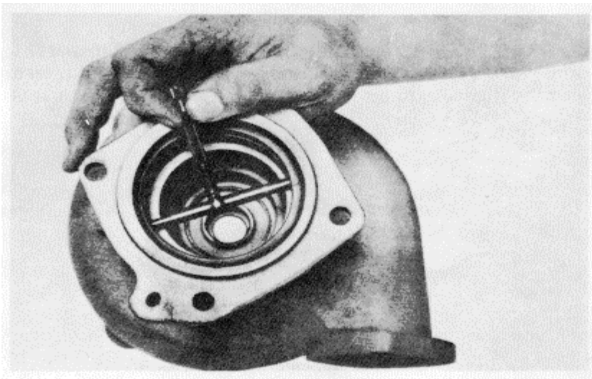


Figure 16J-5. Measure the Housing Bore

4. Measure the impeller bore and the shaft diameter. There should be a minimum of 0.001 inch (0.03 mm) press fit be-tween the bore and the shaft mating surface. See Table 16J-1.

5. Inspect the shaft for straightness and galling on the diameter surfaces that are press fit.

6. Inspect the water pump drive shaft for wear or distortion.

7. Clean all the parts in an approved cleaning solvent and dry with moisture free compressed air. Discard all the parts that do not meet inspection criteria

ASSEMBLY

1. Lubricate the shaft bearing surfaces with a thin coat of clean lubricating oil. Use a ST-657 Bearing Mandrel to sup-port the inner bearing (6), to press the impeller end of the shaft (5) through the inner bearing until the shaft shoulder seats tightly against the bearing inner race, Figure 16J-6.

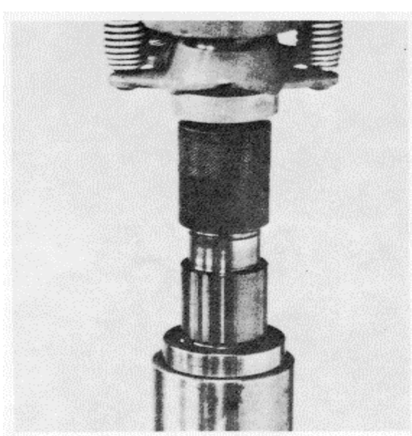


Figure 1 6J-6. Press the Shaft into the Small Bearing

2. Use a 3375318 Bearing Mandrel to support the outer bearing (4) and press. Press the drive end of the shaft (5) through the outer bearing until shaft shoulders seat against the bearing inner race. Secure the outer bearing with a re-taining ring (3), beveled side away from the bearing, Figure 16J-7.

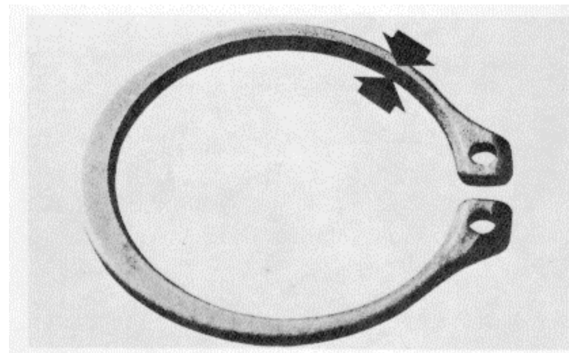


Figure 16J-7. Beveled Edge of the Retaining Ring

3. Support the water pump housing (9) at the impeller end. Use the 3375320 Seal Driver to press the oil seal (7) into the bore. Seal the lip up toward the bearing, until it is even with the shoulder of the inner bearing surface.

4. Apply a thin coat of Loctite 601 to the bearing(s) outer race only, Figure 1 6J-8. Lubricate the shaft seal mating surface. Position the bearing and the shaft assembly(3, 4, 5, 6) into the water pump bore and press it into the housing until the outer bearing (4) seats. Use a 3375318 Bearing Mandrel to support the bearing outer race.

CAUTION
Take care not to damage the oil seal.

5. Install the large retaining ring (2) to hold the bearing assembly in place.

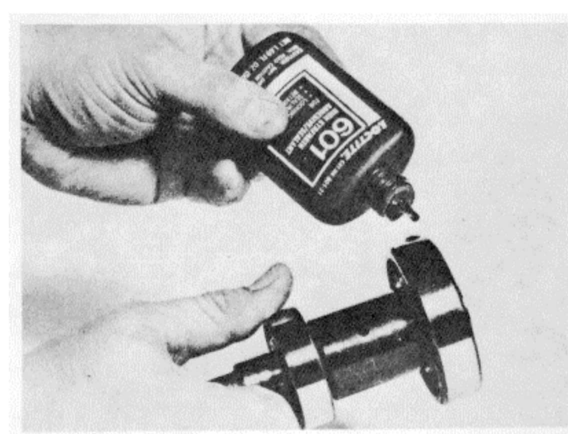


Figure 16J-8. Apply Loctite to the Bearings

6. Apply a thin coat of Loctite 3375066 to the brass case on the face seal (10) Figure 1 6J-9. Use a 3375448 Mandrel to support the water pump on the drive end of the housing - not on the shaft - and press the face seal into the housing until it seats, Figure 16J-10.

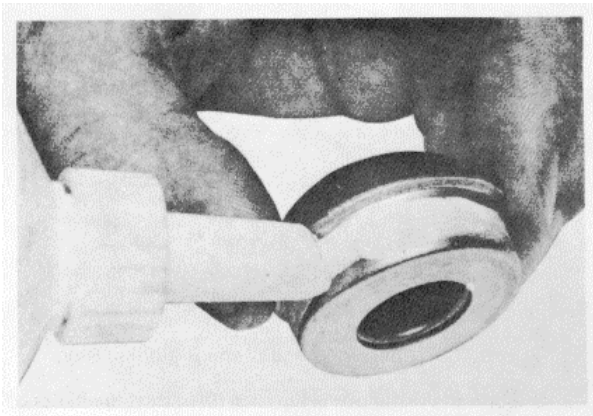


Figure 16J-9. Apply Pipe Sealant to the Seal

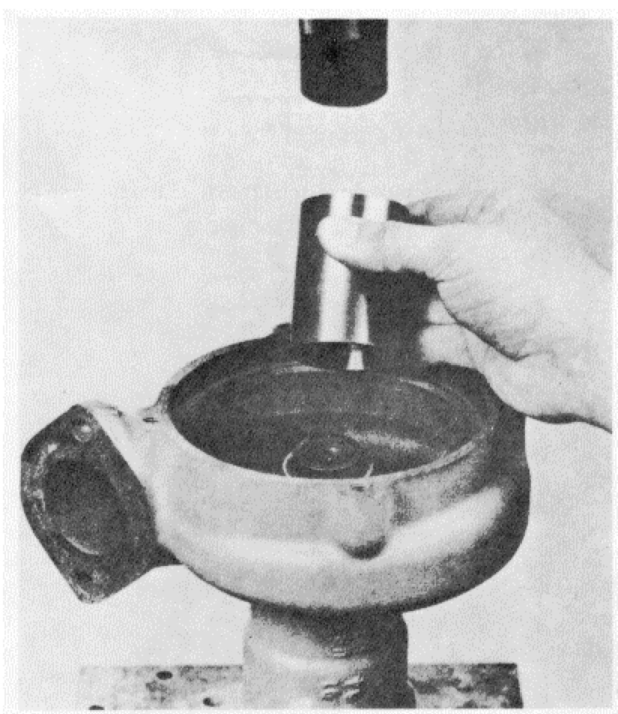


Figure 16J-10. Press the Carbon Face Seal in the Housing

7. Use a 3375448 Mandrel to press the new cup seat (11) into place on the shaft. A 3375448 Mandrel is designed to put the cup seat to an exact location against the face seal, Figure 16J-11.

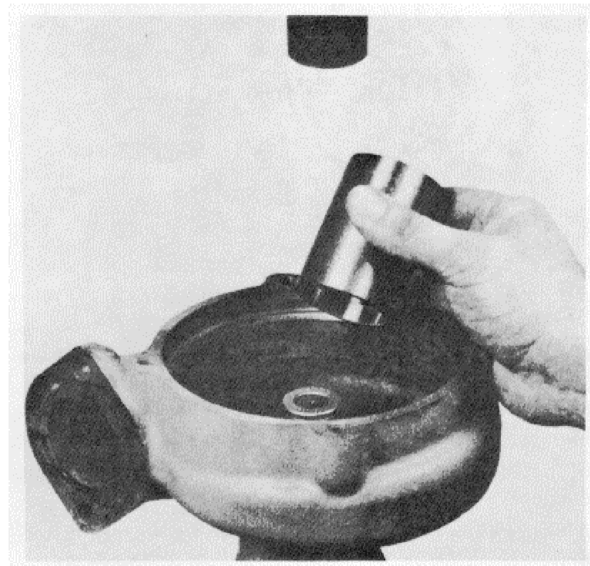


Figure 16J-11. Install the Cup Seat

8. Apply one drop of Loctite 290 to the cup seat at the shaft, Figure 16J-12.

CAUTION

If an excess amount is applied, the face seal and seat could become locked together.

Figure 16J-12. Apply Loctite to the Shaft Behind the Seat

9. Apply a thin coat of Loctite 601 to the impeller bore and press on the shaft maintaining 0.013 to 0.020 inch (0.33 to 0.51 mm) clearance between the impeller and the housing. Use a feeler gauge through the water discharge port in the housing to check the clearance, Figure 16J-13.

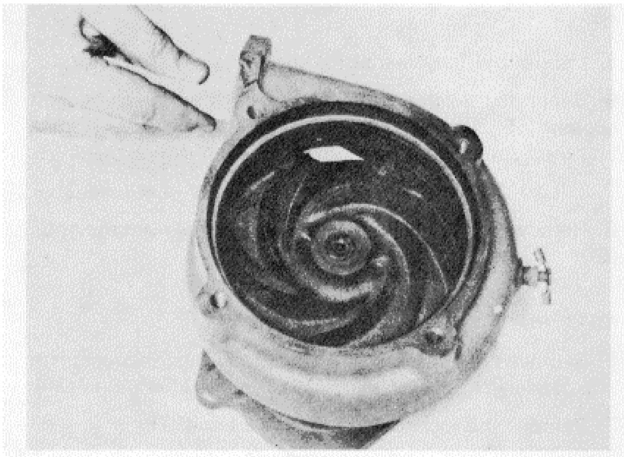


Figure 16J-13. Check the Impeller Clearance

10. Apply a thin coat of clean lubricating oil to the O-ring (13) and put it in the groove on the inlet housing.

11. Put the inlet housing to the water pump housing in the correct position. Secure the water inlet housing to the water pump housing with capscrews and lockwashers.

FAN HUB AND IDLER ASSEMBLY

DISASSEMBLY

1. Lock the bracket end of the hub (15), Figure 1 6J-14, in a vise so the hub is parallel with the floor. Remove the pipe plug (7).

2. Remove fan hub cover (9) and O-ring (6). Discard the O-ring.

3. Wipe excess lubricant from the hub and shaft and re-move the hub locknut (5) and washer (14).

4. Keep the hub and pulley (3, 8) parallel with the floor, so the front roller bearing (1) will not fall out, remove hub and pulley from shaft. Remove the bearing and bearing cone spacer (12) from the hub.

5. Turn the hub over and pry out the oil seal (11) and dis-card. Remove the rear half of the bearing (1) and spacer(13).

6. Remove capscrews and washers (2, 4) and lift off pulley.

7. The roller bearing cups (1) can be removed with a suit-able flat bottom brass punch and a plastic hammer. Strike each side alternately until the cups drop out.

8. The snap ring (10) need not be removed.

CLEAN AND INSPECTION

1. Clean the parts with an approved solvent and dry with compressed air.

2. Inspect the pulley if cracks or pits are found, mark for re-placement. Should rust be found in belt contact area, re-move with emery cloth.

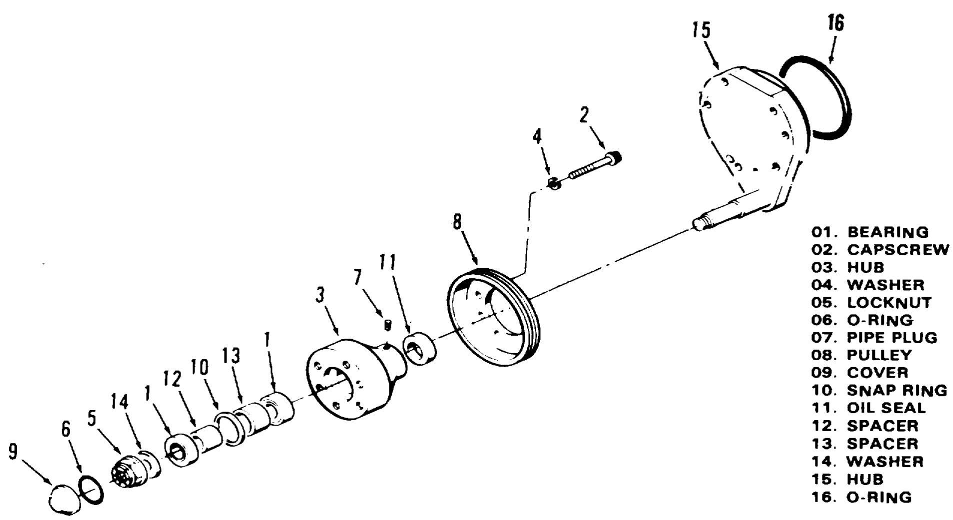


Figure 16J-14. Fan Hub

3. Inspect the bearings, cups, and fan hub shaft. Mark parts for replacement if rough or worn.

4. Inspect the parts for stripped or crossed threads or cracks, replace as necessary.

ASSEMBLY

NOTE

Install new bearings in complete sets. Do not mix new and used components. Pre-pack the bearings with Aeroshell No. 5 or an equivalent lubricant before installation.

1. Install the bearing cup spacer (13) Figure 16J-14, into the back side of the fan hub until spacer bottoms on snap ring (10). Press the bearing cup (1) until it is seated against the spacer.

2. Install the bearing cup spacer (12) into the front side of the fan hub (3); press the outer bearing cup into the hub until it is seated against the spacer.

3. Position the rear bearing (1) into the fan hub (3). Fill the area between the bearing and seal with 0.25 ounces(7.1 g) of lubricant.

4. Press the seal (11) in with a suitable mandrel flush with rear of the hub bore. The spring loaded lip of the seal goes next to the bearing.

5. Place the hub on a table with the seal "up." Slide the shaft through the bearing and seal; do not damage the seal.

6. Install the bearing spacer (12) and front bearing (1)onto the shaft.

NOTE

Fill the fan hub assembly with 1.75 to 2.0 ounces (49.6 to 56.7 g) of Aeroshell No. 5 lubricant (or the equivalent).

7. Install the washer (14) and hub locknut (5); tighten the locknut finger tight. Lock the hub in a vise, so the hub is parallel with the floor and tighten the hub locknut to 145 to 155 ft-lb (197 to 210 N.m) torque. Fill the area of the bore with lubricant.

8. Check the fan hub end clearance; it must be 0.003 to 0.012 inch (0.08 to 0.25 mm). The fan hub must rotate freely.

9. Install pipe plug (7), using sealant or Teflon tape and torque to 5 to 10 ft-lbs (7 to 14 N.m).

10. Coat a new O-ring (6) with clean engine oil, install on cover (9). With a suitable mandrel, press cover and O-ring into fan hub, do not damage the O-ring seal.

11. If pulley was removed, position pulley (8) to fan hub and secure with capscrews (2) and washers (4); torque to 70 to 75 ft-lbs (95 to 102 N.m).

BACKSIDE FAN HUB IDLER ASSEMBLY

IDLER LEVER DISASSEMBLY

1. Remove the shock absorber (19) Figure 16J-15.

2. Place a box end wrench over the flats on the idler lever cap (3) and lift up.

3. Remove the capscrew (1) from the idler lever cap (3), allow the cap to rotate counterclockwise to relieve spring tension. Align the roll pins (9) with the slots and remove the cap.

4. Remove the capscrew (4) from the pivot shaft support (15).

5. Lift out the flat washer (5) and thrust washer (7).

6. Separate the fan idler pivot arm (10) from the pivot shaft support (15) by holding the support with your index fingers and pressing on the pivot arm shaft with thumb pressure.

7. Lift off the torsion spring (13) from the idler lever (10).

8. Remove the pivot arm shaft bushings (8) from the shaft (6).

IDLER PULLEY DISASSEMBLY

1. Remove the two capscrews (35) securing the cover plate (33). Remove the cover plate (33) from the idler pulley (29).

2. Remove the locknut (31) from the shaft (26).

CAUTION

The locknut (31) has left hand threads.

3. Remove the idler pulley (29) from the idler shaft (26).

4. Press the seal (27) from the backside of the idler pulley (29).

5. Lift out the roller bearings and press the race from the pulley, turn the pulley over and press the remaining race from the pulley.

6. Should the shaft (26) appear to be damaged or worn in the seal area, remove the jam nut (20) and press the shaft from the idler pulley bracket (22).

INSPECTION

1. Inspect the shaft (6), bushings (8), thrust washers (7), bearings and bearing races (30 and 28) for wear. Discard and replace as required.

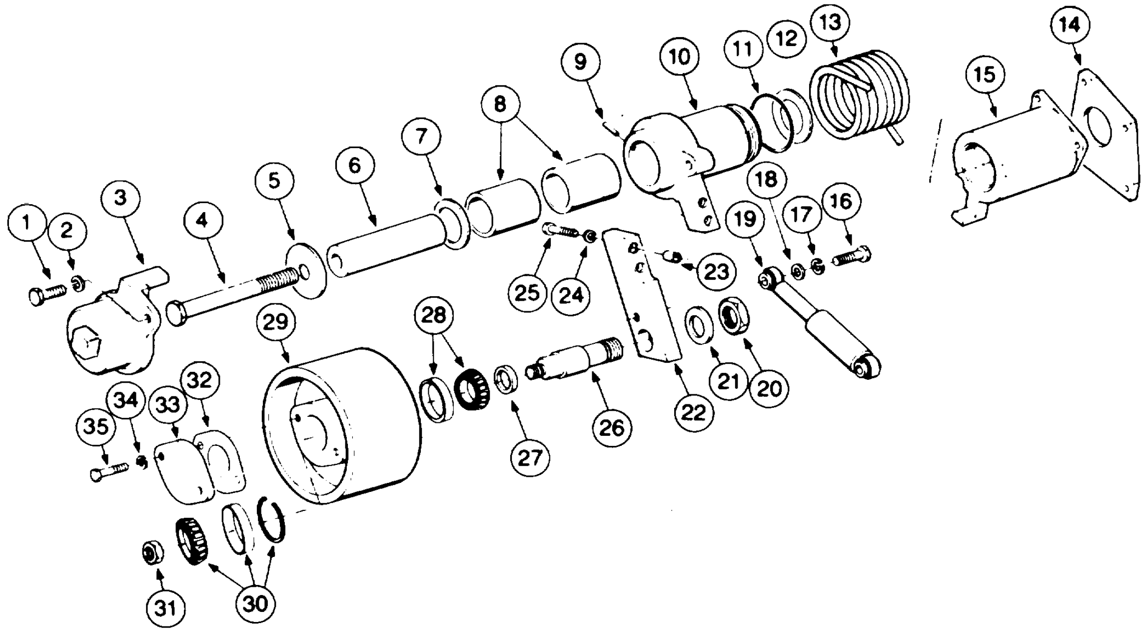
2. Inspect the pulley (29), if cracks or pits are found, mark it for replacement. Should rust be found in the belt contact area, remove with an emery cloth.

3. Inspect the shaft (26) for wear in the seal contact area, replace the shaft if worn or defective.

4. Inspect the shock absorber (19) for leakage and internal wear by manually extending and compressing the shock absorber. (Force required to extend should be greater than that required to compress.)

IDLER PULLEY ASSEMBLY

1. If removed, press the shaft (26) into the bracket (22), in-stall the jam nut with washer (20) and (21). Tighten to 145 to 155 ft-lbs (197 to 210 N.m) torque.



01. CAPSCREW
02. LOCKWASHER
03. CAP
04. CAPSCREW
05. WASHER
06. SHAFT
07. THRUST WASHER
08. BUSHING
09. ROLL PINS
10. PIVOT ARM
11. O-RING
12. WASHER
13. SPRING
14. PLATE
15. SUPPORT
16. CAPSCREW
17. LOCKWASHER
18. WASHER
19. SHOCK ABSORBER
20. JAM NUT
21. WASHER
22. BRACKET
23. LOCKWASHER
24. LOCKWASHER
25. CAPSCREW
26. SHAFT
27. SEAL
28. BEARING
29. PULLEY
30. BEARING
31. LOCKNUT
32. GASKET
33. COVER PLATE
34. LOCKWASHER
35. CAPSCREW

Figure 16J-15. Exploded View of the Fan Hub Idler Assembly

2. With the pulley part number down, install the "C" clip contained in bearing the assembly (28 and 30) into pulley bore (groove approximately halfway down the length of the bore).

3. Press bearing race into the bore, seat it against the "C" clip, install the inner bearing. Press in the seal (27), flush with the lip on the pulley. Turn the pulley over and insert the small diameter spacer ring (contained in the bearing as-sembly (28 and 30)). Press in the remaining bearing race.

NOTE

The bearings should be packed before assembly with Aeroshell No. 5 lubricant or equivalent.

4. Install the pulley (29) over the shaft (26), install the remaining bearing, tighten the locknut (31) to 145 to 155 ft-lbs (197 to 210 N.m) torque.

CAUTION

The locknut (31) has left hand threads.

5. Fill the idler pulley cavity with approximately 1 oz. Aeroshell No. 5 or equivalent lubricant.

6. Install the cover plate (33) with gasket (32) using two capscrews (35) and tighten to 20 ft-lb (27 N.m) torque.

IDLER LEVER ASSEMBLY

1. Lubricate the new O-ring (11) and install with the torsion spring (13) on the fan idler pivot arm (10).

2. Coat the thrust washer (12) with lubriplate and insert it in the pivot shaft support (15).

3. Coat the bushings (8) with lubriplate and insert them into the pivot arm (10), insert the idler pivot arm (10) into the pivot shaft support (15).

NOTE

The ear of the torsion spring should be on the top side of the spring lug on the pivot shaft support (15).

4. Install the pivot arm shaft (6) through the idler pivot arm (10), and pilot into the counterbore in the pivot shaft sup-port (15).

5. Place the flat washer (5) onto the capscrew (4) followed by the remaining thrust washer (7) (coated with lubriplate).

6. Insert the capscrew (4) through the pivot shaft (6) and into the pivot shaft support (1 5), tighten to 145 to 155 ft-lbs (197 to 210 N.m) torque.

7. Locate the lever cap (3) over the rollpins (9), and with a box end wrench over the flats on the cap (3) rotate it until the capscrew holes line up. Install the capscrew (1) with lock-washer (2) and tighten to 20-25 ft-lbs (27 to 34 N.m)torque.

8. Install the shock absorber (19) to the fan idler arm (22) and fan hub support with capscrews (16), lockwashers (17) and flat washers (18). Tighten to 70 ft-lbs (95 N.m) torque.

THERMOSTAT AND HOUSING

DESCRIPTION

Thermostats cannot be repaired, but are to be checked to ensure they are opening and closing at the correct temperatures.

DISASSEMBLY

Remove the thermostat housing (7). Remove the seal (5) and the theromstat (4) from the housing support (3), Figure 16J-16.

INSPECTION

1. Check the theromstats for opening and closing at the correct temperature.

A. Put the thermostats and thermometer in water.

B. Heat the water to the thermostat operating temperature, which is normally marked on the thermostat.

C. Compare the thermostat operation with the thermometer.

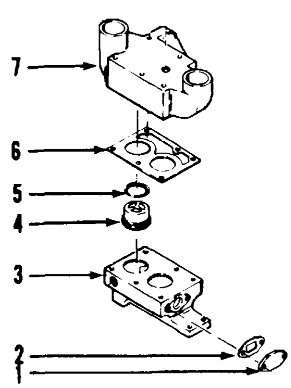
D. Thermostats start opening at 170°F (77°C) and are fully open at 185°F (85°C).

2. Discard the thermostats if they do not operate in correct range.

ASSEMBLY

1. Use the 337541 1 Seal Mandrel to install the new seals (5) into the thermostat housing support (3). Seals must be installed with the part number or metal flange of the seal up and toward the mandrel during installation.

2. Install the new or tested thermostats (4) into the housing support (3) with the vent hole at the top. Install the thermostat housing (7).



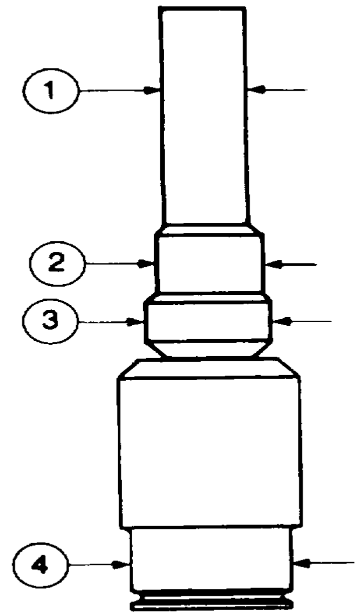
1. Cover
2. Gasket
3. Thermostat Housing Support
4. Thermostat
5. Seal
6. Housing Gasket
7. Thermostat Housing

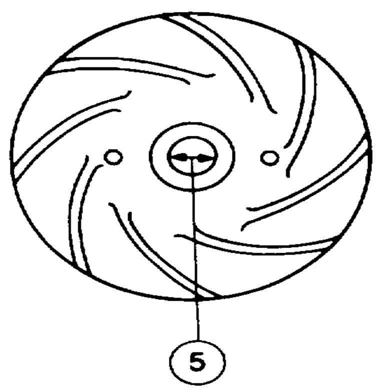
Figure 16J-16. Thermostat Housing

Table 16J. Specifications – Inch (mm)

Table 16J-1. Specifications — Inch (mm)

Ref. No.	Dimension Locations	New Minimum	New Maximum	Worn Limit
	Housing Bore Outer Bearing	2.8345 [71.996]	2.8351 [72.012]	**2.8431 [72.215]**
	Housing Bore Inner Bearing	2.0471 [51.996]	2.0477 [52.012]	**2.0557 [52.215]**
	Housing Bore Oil Seal	1.749 [44.43]	1.751 [44.48]	
1.	**Shaft Diameter** Impeller End and Seat Location	0.6262 [15.905]	0.6267 [15.918]	
2.	**Shaft Diameter** Oil Seal	0.872 [22.15]	0.878 [22.30]	
3.	**Shaft Diameter** Inner Bearing	0.9842 [24.999]	0.9846 [25.009]	
4.	**Shaft Diameter** Outer Bearing	1.1810 [29.997]	1.1814 [30.008]	
5.	**Impeller Bore**	0.624 [15.85]	0.625 [15.86]	
	Impeller to Body Clearance	0.013 [0.33]	0.020 [0.51]	
	Minimum Press-Fit Between Shaft and Impeller	0.001 [0.03]		
	Fan Hub End Clearance	0.003 [0.08]	0.012 [0.30]	
	Bearing to Shaft Press Fit	0.000 [0.00]	0.001 [0.03]	
	Thermostats Operating Range Medium	170°F [77°C]	185°F [85°C]	





SUBSECTION 16K

DRIVE UNIT

DESCRIPTION

The drive units are used to transfer power from engine crankshaft, through camshaft gear, to drive a compressor, fuel pump, water pump and other assemblies. Replace-ment of oil seals, bearings or bushings is the only normal service required.

TOOLS

Essential Service Tools (Or Equivalent)	
Service Tool Number	**Tool Name**
ST-1249	Puller

OIL SEALS

Always check the pulley sleeve surface for wear and replace the sleeve if necessary before installing the new seal.

Before installing oil seals, always lubricate with a clean lubricating oil.

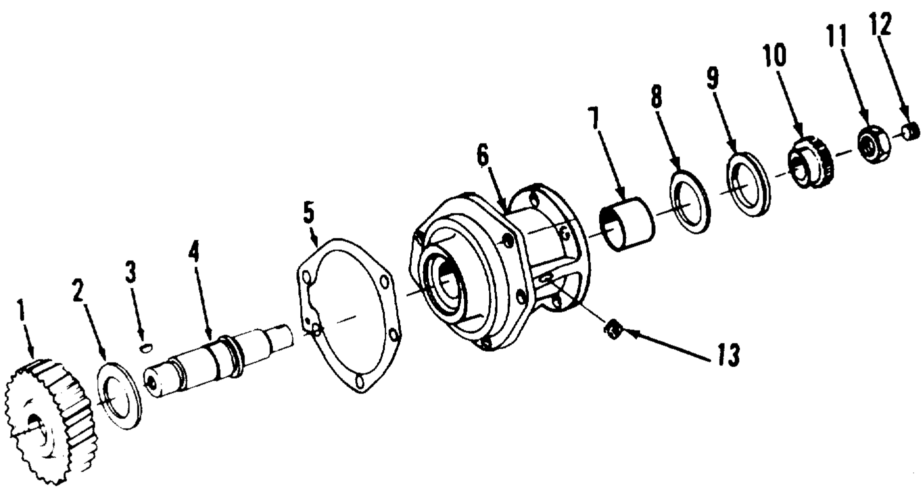
NOTE
Teflon seals are to be installed dry.

BORES IN HOUSING

If the bushings have turned in the bore and damaged the housing, the housing must be discarded. The bore of the housing must be clean before pressing the bearing in position.

THRUST WASHERS

In the installation of thrust washers on accessory drives, the thrust side of the washers is installed away from the



1. Gear
2. Thrust Washer
3. Key
4. Shaft
5. Gasket
6. Housing
7. Bushing
8. Thrust Washer
9. Clamp Washer
10. Coupling
11. Locknut
12. Pipe Plug
13. Pipe Plug

Figure 16K-1. Fuel Pump/Accessory Drive housing. The thrust side contains grooves. Wrong installation of these washers will result in an excessive wear and increased end play, which causes early failure of the accessory drive assembly.

FUEL PUMP DRIVE - UPPER ENGINE:
COMPRESSOR DRIVE - LOWER ENGINE

DISASSEMBLY

1. Remove the drive shaft locknut (11) Figure 16K-1. Use the ST-1249 Coupling Puller to pull the coupling (10) from the shaft (4). Press the shaft and gear assembly from the housing (6). Press the shaft (4) from the gear (1), and re-move the key (3) from the shaft (4).

NOTE

A splined coupling is used on the air compressor drive. A spider coupling is used on the fuel pump drive.

INSPECTION

1. Inspect the bushing (7) in the drive housing. Replace it if worn beyond specifications as shown in Table 16K-1 (3). Replace the thrust washers (2 and 8) if worn or damaged.

2. Inspect the gear (1) for worn or damaged teeth; replace as necessary.

3. Inspect the shaft (4) for wear, chips or sharp edges. Discard the shaft if it is worn smaller than worn limits as shown in Table 16K-1 (1 and 2).

ASSEMBLY

1. Install the shaft (4) through the housing (6) and bushing (7). Install the thrust washer (2) with the face up.

2. Install the key (3) and press it on the drive gear (1).

3. Turn the assembly over. Install the thrust washer (8) (face up) and clampwasher. Install the coupling key, if used.

4. Press on the coupling (10), hub end down. Hold in place with the locknut (11). Install the pipe plug (12), if removed.

5. Rotate the assembly in the housing to check for movement.

6. Check the end clearance which is to be 0.002 to 0.012 inch (0.05 to 0.30 mm) with the unit assembled.

DRIVE PULLEYS

1. Check for cracks and other damage in the hub, web and groove areas and forwear in the grooves and oil seal sleeve. If wear on the sleeve can be seen, remove the worn oil sleeve by cutting with a chisel. Do not damage the pulley hub.

2. Press the new sleeve with mandrel until it is even to 0.015 inch (0.38 mm) below the face of hub. See the latest Parts Catalog for the correct pulley/sleeve combination.

BARRING DEVICE

DISASSEMBLY

1. Remove the retaining ring (2) from the barring device shaft (1). Figure 16K-4.

2. Remove the barring device shaft (1) by pulling out on the shaft. This will remove the spring (5) and the worm gear (4).

3. Remove the barring shaft guide assembly.

INSPECTION

1. Examine the shaft bore for burrs, sharp edges, or dirt in the shaft bore.

2. Clean or repair as required.

ASSEMBLY

1. With the gear cover removed, compress the guide as-sembly bushing (6) for installation into the front cover.

2. Put the slotted end of the barring device shaft (1)over the roll pin (7) in the guide assembly and tap into position, Fig-ure 16K-2.

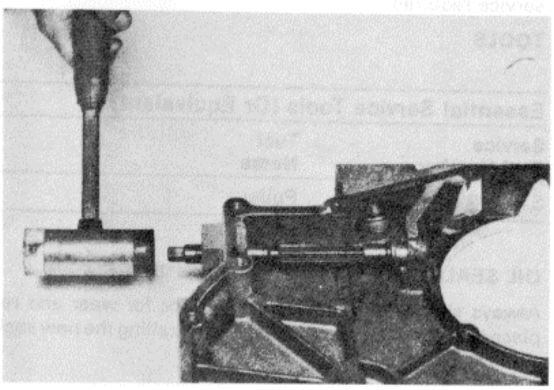


Figure 16K-2. Install the Guide Assembly

3. Remove the barring device shaft (1) and install the 0-ring (3), Figure 16K-4, in the proper location on the shaft.

4. Insert the barring shaft (1) into the shaft bore far enough to expose the splined end of the shaft. Install the worm gear (4) and the spring into position on the shaft.

5. Continue to insert the barring shaft (1) far enough to ex-pose the retaining ring groove and install the retaining ring (2), Figure 16K-4.

6. Refer to Figure 1 6K-3 for a view of the barring device in-stalled in the front cover.

ENGAGEMENT OF BARRING DEVICE WORM GEAR

1. While turning the barring device shaft counterclock-wise, slowly push the shaft into the gear cover. The shaft is in the correct position when the step near the hex portion of the shaft is flush with the front cover.

2. Several additional turns on the barring device shaft will be required to completely engage the worm gear and the camshaft gear. It is important that no force is used to en-gage the gears. Repeat steps 1 and 2 if the gears do not en-gage easily.

3. Approximately 50 ft-lb (68 N.m) torque is required to bar the engine to the desired "set point" positions.

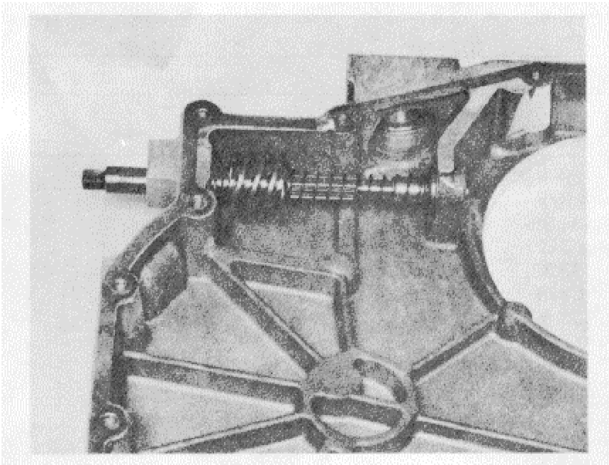


Figure 16K-3. Barring Device Installed

4. To disengage the barring device shaft, rotate the shaft clockwise until the worm gear is free of the camshaft gear.

CAUTION

Do not use an impact wrench on the barring device to rotate the engine. Also do not rotate the engine in a counterclockwise direction when the barring device is engaged.

WATER PUMP DRIVE

DISASSEMBLY AND INSPECTION

1. Use a mandrel to press the new bushings into the support, if removed. Bushings must be even or below the thrust bearing surface of support. The oil hole must be in alignment with the housing oil hole.

2. Press the gear on the shaft, if removed, until the gear bottoms on the shaft stop.

3. Put the thrust washer over the shaft to the gear. Install the shaft and gear assembly into the support.

4. Install the thrust washer and clamping washer over the shaft. Hold in place with a retaining ring. The beveled side of the retaining ring must be out during the installation. The chamfer on the clamping washer must be toward the shaft stop as in (7), Figure 16K-5.

NOTE

The water pump pulley is installed after the pump drive is installed to the gear housing and cover. This pulley is used to drive the alternator.

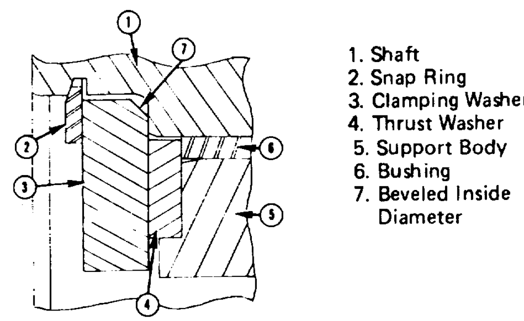


Figure 16K-5. Water Pump Drive Clamping Washer Installation

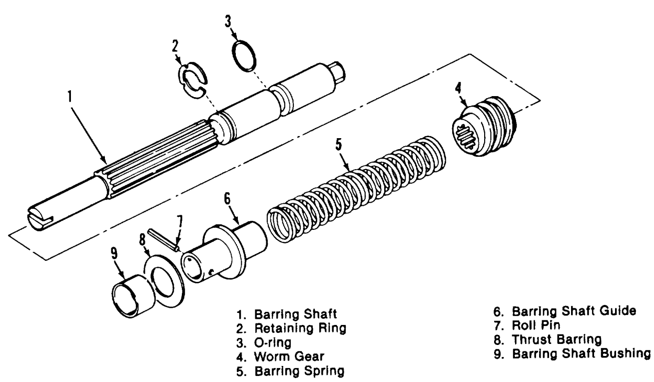
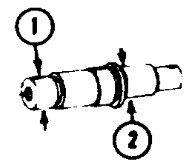
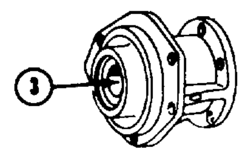


Figure 16K-4. Barring Device

Table 16K-1. Drive Unit Specifications - Inch (mm)

Ref. No.	Measurement	Worm Limit	New Minimum	New Maximum
	Fuel Pump/Compressor Drive			
1.	Shaft Outside Diameter		1.3765	1.377
	At Pulley Location		[34.963]	[34.98]
2.	Shaft Outside Diameter,	**1.310**	1.3115	1.312
	Bushing Wear Area	**[33.27]**	[33.312]	[33.32]
3.	Bushing Inside	**1.320**	1.316	1.319
	Diameter	**[33.53]**	[33.43]	[33.50]
	End Clearance		0.002	0.012
	Assembled		[0.05]	[0.30]
	Water Pump Alternator Drive			
	Bushing Inside	**1.755**	1.751	1.754
	Diameter	**[44.58]**	[44.48]	[44.55]
	Shaft Outside Diameter	**1.748**	1.7485	1.749
	Bushing Wear Area	**[44.40]**	[44.412]	[44.42]
	End Clearance	**0.007**	0.015	
			[0.178]	[0.571]
	Barring Mechanism			
	Bushing Inside	**0.626**	0.624	0.625
	Diameter	**[15.900]**	[15.849]	[15.875]
	Shaft Outside	**.6210**	.6215	.6220
	Diameter	**[15.773]**	[15.786]	[15.80]





AIR INTAKE SYSTEM

DESCRIPTION

The intake air system group contains the intake manifolds, connections, air cleaners, piping and turbochargers. Air cleaners are covered in the operators manual.

INTAKE MANIFOLDS AND CONNECTIONS

Clean the intake manifolds, air crossover connections and tubes with steam.

Inspect for chips, cracks, distortion and damaged threads. Discard all parts which are not usable.

Damaged threads are to be repaired by installing Helli-Coils.

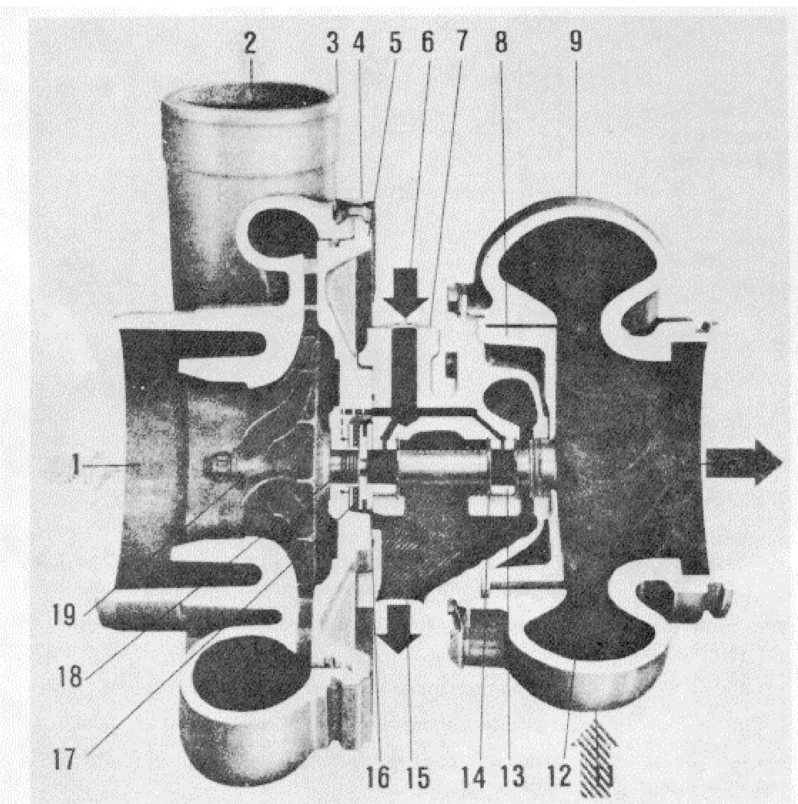
TURBOCHARGER

GENERAL

The turbocharger is a mechanical unit which is driven by exhaust gas. The turbocharger forces more air into the engine cylinder than the engine cylinder receives when operating as a naturally aspirated engine. The additional air and the increased fuel charge helps the engine develop more horsepower and operate more efficienty.

DESCRIPTION

The turbocharger adds a very small percentage to the overall weight of the engine The results of using a turbo-charger is a higher horsepower to weight ratio.



1. Air Inlet
2. Air Outlet
3. Compressor Housing
4. V-band Clamp
5. Back Plate
6. Oil Inlet
7. Center Housing
8. Shroud
9. Turbine Housing
10. Exhaust Outlet
11. Exhaust Inlet
12. Turbine Wheel and Shaft
13. Bearings
14. Snap Rings
15. Oil Outlet
16. Thrust Bearing
17. Thrust Collar
18. Oil Seal Assembly
19. Compressor Wheel

Figure 16L-1. Turbocharger Cutaway

The turbocharger consists of a turbine wheel and a compressor wheel. They are in separate housings, but they are mounted on and rotate with a common shaft. The turbine side mounts to the exhaust manifold outlet flange. The com-pressor side mounts with the intake manifold. The lubrication and cooling for the turbocharger is obtained from the engine oil which circulates through the bearing housing.

The power to drive the turbine wheel, which in turn drives the compressor wheel, is obtained from the energy of the exhaust gases. The speed of the turbine wheel increases as the speed of the engine increases. This gives the engine enough air to burn the fuel for its load requirements.

The part number, serial number, model number, and other information is on the nameplate attached to the turbo-charger.

OPERATION

The compressor working together with the turbine automatically adjusts the speed and the output of the turbo-charger. The turbocharger rotates in only one direction. The direction of the engine rotation has no effect on the turbo-charger.

Under continuous load operation, there will not be very much smoke coming from a turbocharged engine. Fast ac-celeration can cause a turbocharged engine to show exhaust smoke for a few seconds. When the turbocharger rpm catches up with the sudden increase in the fuel supply, the smoke will decrease.

STARTING AND CHECKING THE TURBOCHARGER

1. Before starting the engine, lubricate the turbocharger by pouring clean lubricating oil through the oil inlet fitting. Turn the rotating assembly by hand to coat the bearings with the oil.

2. Start the engine and run at an idle.

3. Disconnect the oil drain to see if the oil is flowing through the turbocharger. Reconnect the line when finish-ed.

4. Remove the air inlet hose from the compressor end of the turbocharger and observe the rotation of the turbo-charger rotor. The rotor must be free of any rotating problems.

5. Stop the engine to see if the rotor stops freely.

6. Restart the engine and check the full speed and the load.

7. Make sure all the connections and the piping are tight. If there are no leaks of any type, the engine is ready for oper-ation.

8. The performance of the turbocharger must be checked at intervals. Data and conditions to be checked are noted in following paragraphs.

STOPPING ENGINE

It is important to idle an engine 3 to 5 minutes before stopping it. This lets the lubricating oil carry the heat away. The turbocharger contains bearings and seals that receive a high degree of heat from the combustion exhaust gases.

While the engine is running, the heat is carried away by the oil circulation. If the engine is stopped suddenly, the turbo-charger temperature can rise as much as 1000F (380C).

A high degree of heat in the turbocharger can cause seizure of the bearings, burned O-ring oil seals and distortion of the bearing housing.

TURBOCHARGER SPEED

The speed of the turbocharger changes automatically with the speed and load of the engine. If the turbocharger runs too fast, the engine fuel rate is too high.

VIBRATION

If a vibration starts in the turbocharger, stop the engine and find the cause. Vibration can be caused by damage to the compressor wheel, shaft or turbine wheel.

INLET AIR RESTRICTION

If the inlet air restriction exceeds 25 inches (635 mm) of water, the air flow to cylinders will not be good enough and a loss of power will occur. Too much exhaust smoke and high exhaust temperatures are joined with a loss of power.

1. Check the inlet air restriction by attaching a vacuum gauge or water manometer in the air intake piping. The adapter must be at a right angle to the air flow and one pipe diameter up-stream from the turbocharger, Figure 16L-2.

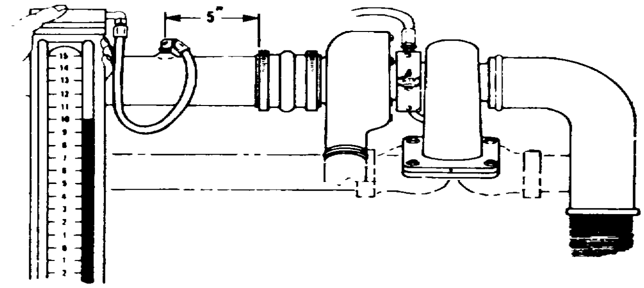


Figure 16L-2. Checking the Air Inlet Restriction

2. Operate the engine until the normal operating temperature is reached.

3. Operate the engine at the rated speed and full-load. Take the reading from the vacuum gauge or manometer.

4. If the air restriction exceeds 25 inches (635 mm) of water:

A. Clean or replace the dry type cleaner element.

B. Replace damaged air piping, rain shield or housing.

C. Remove the extra bends or other source of restriction in the air piping.

5. Air restriction readings can be taken at the air cleaner outlet connection plug. If the reading is taken at air cleaner,

the restriction must not exceed 20 inches (508 mm) of water.

NOTE

Do not use this procedure when checking engines that have a correctly mounted restriction gauge in the air cleaner outlet. Reference the applicable engine maintenance manual for further information.

EXHAUST BACK PRESSURE

High exhaust back pressure can be caused by foreign objects or excessive bends in the exhaust piping. The use of piping smaller than the exhaust outlet of the turbocharger ,an also cause high back pressure. If the exhaust back pressure exceeds 3 inches (76.3 mm) of mercury, you will have poor performance and early engine failure. To check exhaust back pressure:

1. The point of measurement must be as close as possible to the turbocharger outlet flange. The area to be measured must be where there is uniform flow such as a straight section of pipe. Make sure the area to be measured is at least one pipe diameter from any changes in the flow direction. If it is impossible to locate a point of measurement in a straight section, you can measure on the side of a bend. Make sure the flow is uniform and equivalent to the flow in the centerline. Do not measure on the inside or outside radius of a bend. The flow is not uniform at these points, Figure 16L3.

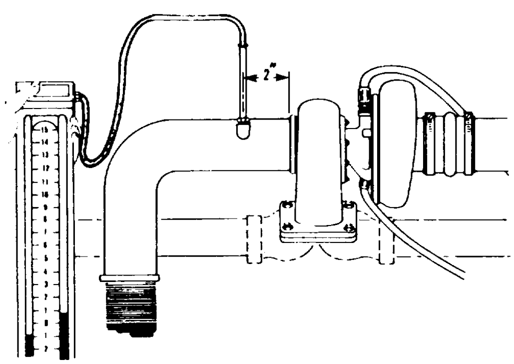


Figure 16L-3. Checking the Exhaust Back Pressure

2. At the point selected, weld a 1/8 inch (3.2 mm) pipe coupling to the exhaust tubing. Drill through the tubing with a 1/8 inch drill. Remove all the burrs on the inside of the pipe and mount a 900 fitting to the coupling. Use 3 feet (0.9 mm) of 1/8 inch (3.2 mm) I.D. copper tubing (to resist the heat) plus 10 feet (3 m) of 3/16 inch (4.8 mm) I.D. soft rubber hose to manometer. The manometer can be mercury filled or water filled.

NOTE

It is important that the line to the manometer be the size and length as given. This will minimize the variation in the reading. A change in the length of the line can cause a change in the manometer reading.

MAINTENANCE

For best turbocharger performance, keep the compressor wheel and the compressor housing clean.

Keep dirt and other deposits from forming on the compressor wheel. These deposits will reduce the compressor efficiency, decrease the balance of the rotor and reduce intake manifold air pressure.

Periodic inspections of these parts will reduce mechanical failure and loss of performance requirements.

Since the rotor is the only moving part, the turbocharger will experience little wear under normal operating conditions. Due to the rotors high speed of rotation and close running clearance, it must be accurately balanced. Make sure the balance and the running clearance of the rotor are maintained.

Operate the engine at rated horsepower and listen for turbocharger noise. If a shrill noise (above the normal turbine noise) is heard, shutdown immediately. A shrill noise indicates turbocharger bearing failure. Remove the turbocharger for an overhaul. Other noises would result from not enough clearance between the turbine wheel and turbine housing. If these noises are heard, the turbocharger must be removed from the engine, disassembled and inspected.

SERVICE PERIODS

1. Clean the turbocharger compressor wheel using the following procedure.

A. Remove the air intake to turbocharger connection. Remove the air inlet piping to the turbocharger and the compressor housing to expose the compressor wheel. Use cleaner, or solvent, and a bristle brush to clean the deposits from the compressor wheel and compressor housing.

CAUTION

Never use a cleaner or solution that will damage the aluminum. Never use a wire brush, scraper or abrasives to clean the compressor wheel.

B. Dry the unit and assemble the compressor housing to the bearing housing. Torque the V-band clamp nuts to the torque specifications. See Specifications.

C. Connect the air piping and fasten with the clamps.

D. Check the compressor wheel for oil sediment build up. Find the cause and correct such items as undersized oil bath air cleaner, air restriction, over filling the oil cup, etc.

2. Check the bearing clearance as shown under "Dimensions and Specifications" in this manual.

MAJOR CLEANING OPERATION

If the turbocharger has heavy carbon deposits, you must take the turbocharger off the engine for a complete cleaning. Disassemble, clean, inspect, repair or replace and assemble the turbocharger as described in the Rebuild Instructions.

TOTAL END CLEARANCE

Check the end clearance as listed in the Checking Procedure below. This can be done without removing the turbocharger from the engine. Use a dial indicator to indicate the total end clearance of the rotor shaft. See Page 16L14.

CHECKING PROCEDURE

1. Remove the exhaust outlet connection and the intake piping from the turbocharger. This will expose both ends of the rotor assembly.
2. Attach a dial indicator to compressor housing. Push the shaft all the way to the rear. Place the indicator point against the end of the rotor shaft and zero the indicator.

Push the shaft from the rear toward the indicator point and check the indicator reading. The total end clearance must be within 0.004/0.009 inch (0.10/0.23 mm).

3. If end clearance is not within these limits, the turbocharger must be removed from the engine and replaced by a new or rebuilt unit.

INSTALLATION

The turbocharger can be mounted in many locations depending on the type of turbine housing and compressor housings. Change the position of the turbine housing and the compressor housing on the bearing housing. This will give you the location of the exhaust inlet and exhaust outlet. Band nuts must be torqued again if they are loose.

In all mounting arrangements of the turbochargers.

1. Check the position of the turbocharger oil drain. This drain must always be down or within 300 of that position when the turbocharger is mounted on the engine, Figure 16L4.

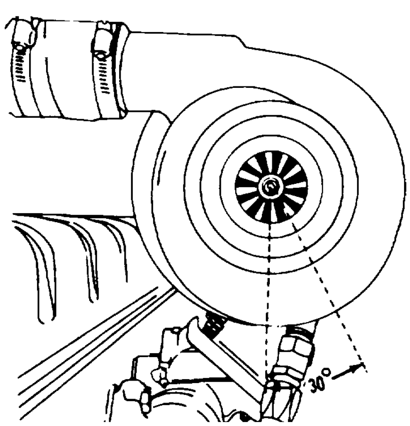


Figure 16L-4. Turbocharger Mounting

2. Install the gasket and position the turbocharger on the exhaust manifold flange. Mount the turbocharger to the exhaust manifold flange with the capscrews.
3. Put Teflon tape on the inlet fitting and the drain fitting. Install these fittings in the bearing housing. The torque for these fittings is listed in Specifications.
4. Install the oil drain line from the bottom of the turbocharger to the boss located on the engine block or oil pan. If the inlet or drain hose needs replacing, refer to the parts catalog.
5. Lubricate the turbocharger before using. Add 2 to 3 oz. (60 cc) of clean engine lubricating oil through the inlet opening.
6. Fill the inlet line with clean lubricating oil (same grade as used in engine) and connect to the turbocharger.
7. Install the hose that connects the air outlet of the turbocharger to the engine intake manifold connection.
8. Install the air cleaner and the exhaust piping.
9. Check the crankcase breather condition. Excessive crankcase pressure will cause turbocharger leakage.

AIR AND EXHAUST PIPE SUPPORTS

The air and the exhaust connections to the turbocharger require support. Make sure these connections are not bent. Too much bending can put stress on the turbocharger housing. There must be a flexible joint between the turbocharger and the support. This will help in movement, misalignment and thermal expansion of the joint.

1. Exhaust Piping

A. The maximum bending moment of unsupported piping at the outlet plane must not exceed 10 ft-lb (14 N.m).

B. A maximum of 12 inches (304.8 mm) of flexible connection or two ball joints must be provided within the first 4 feet (1.22 m) of exhaust piping on turbocharger engines. This will permit thermal growth and help avoid over stressing the turbocharger components.

C. No more than 4 feet (1.22 m) of exhaust tubing or flexible connection without support can be attached to the turbocharger.

2. Air Piping

A. The maximum bending moment of the piping at the compressor inlet plane without support can not exceed 5 ft-lb (7 N.m).

B. A flexible connection must be provided between the turbocharger and the support point of the piping

C. No more than 5 feet 9 inches(1.75 m) of air intake tubing without support can be attached to the turbocharger.

NOTE

One foot pound equals one pound of weight at a distance of one foot.

Table 16L-1. Troubleshooting Turbochargers

Troubleshooting Turbochargers

CAUSES / COMPLAINTS	Engine Low On Power	Black Smoke	Blue Smoke	Too Much Oil Consumption	Too Much Oil Turbine End	Too Much Oil Compressor End	Not Enough Lubrication	Oil in Exhaust Manifold	Damaged Compressor Wheel	Damaged Turbine Wheel	Drag or Bind in Rotating Assembly	Worn Bearings, Journals, Bearing Bores	Noisy	Dirty Center Housing
Dirty air cleaner filter	•	•	•			•							•	
Dirty crankcase breathers				•	•	•	•	•						•
Air cleaner filter missing, leaking, loose connections to turbocharger											•		•	
Restricted air tube before turbocharger	•	•	•			•							•	
Damaged crossover pipe turbocharger to intake	•	•				•							•	
Foreign material between air cleaner and turbocharger	•	•				•				•	•	•	•	
Foreign material in exhaust system (from engine, check engine)	•	•			•			•	•		•	•	•	
Turbocharger flanges, clamps or bolts loose	•	•	•	•	•	•			•	•	•	•	•	
Inlet manifold cracked, gaskets loose or missing, connections	•	•	•			•							•	
Exhaust manifold cracked, gaskets burned out or missing	•	•											•	
Restricted Exhaust System	•	•											•	
Oil lag (oil delay to turbocharger at start up)							•					•		
Not enough lubricating											•	•		
Lubricating oil contaminated											•	•		
Wrong type lubricating oil used							•				•	•		•
Restricted oil feed line					•	•	•				•	•		
Restricted oil drain line				•	•									•
Turbine housing damaged or restricted	•	•							•	•			•	
Turbocharger seal leakage			•	•	•	•		•						
Worn journal bearings	•	•		•	•	•		•	•	•	•	•	•	
Too much dirt buildup in compressor housing	•	•	•			•			•	•	•		•	
Too much carbon buildup behind turbine wheel	•	•	•		•			•	•	•	•		•	
Too fast acceleration at initial start (oil lag)							•					•		
Too little warm-up time							•					•		
Fuel pump malfunction	•	•												
Worn damaged injectors	•	•												
Valve timing	•	•												
Burned valves	•	•						•						
Worn piston rings	•	•						•						
Burned pistons	•	•						•						
Leaking oil feed line							•				•	•		
Too much engine pre-oil			•		•									
Too much engine idle			•	•	•	•		•						
Dirty center housing			•	•	•			•	•	•	•			
Oil pump malfunction												•		
Oil filter plugged			•	•	•	•	•		•	•	•	•		
Oil bath air cleaner (Check all below.)	•	•	•	•		•							•	
Air inlet screen restricted														
Oil pull over														
Dirty air cleaner														
Oil viscosity low														
Oil viscosity high														

DISASSEMBLY

1. Before disassembly of the turbocharger, mark the compressor, turbine and center housings to help in alignment during assembly, Figure 16L-5.
2. Remove the oil drain and the oil supply fittings.

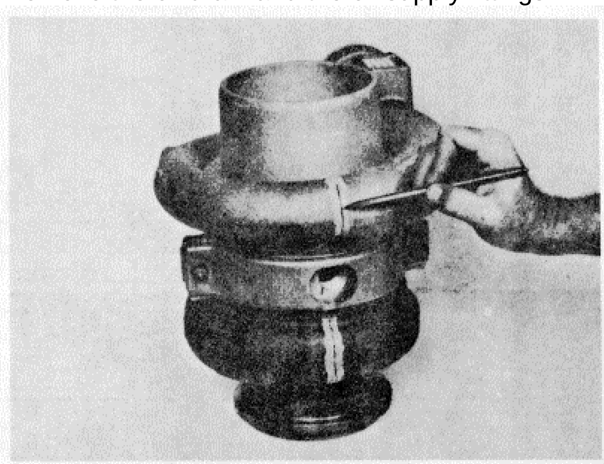


Figure 16L-5. Mark the Components Before Disassembly

3. Remove the locknuts, washers and the bolts which hold the V-band clamps to the turbocharger, Figure 16L-6. Lift off the V-band clamps and discard the locknuts, washers and bolts.

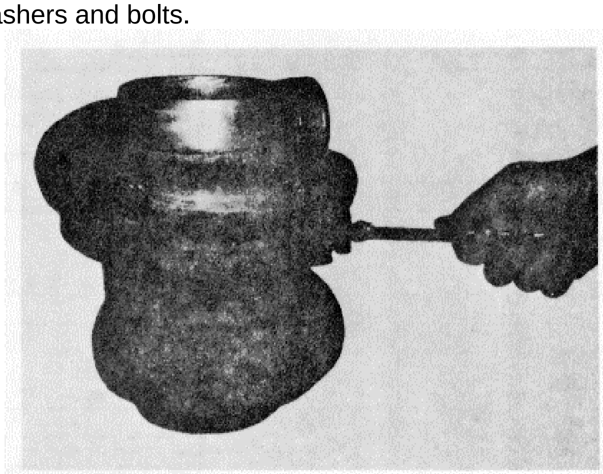


Figure 16L-6. Removing the V-Clamp

4. Remove the compressor housing, Figure 16L-7.

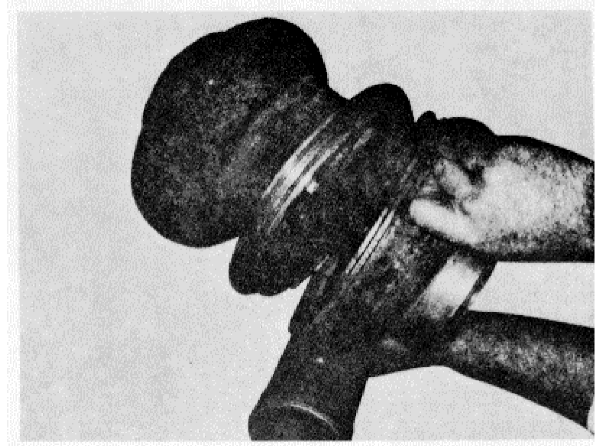


Figure 16L-7. Removing the Compressor Housing

5. Remove all capscrews holding the turbine housing to the center housing, Figure 1 6L-8. Remove the lockplates.

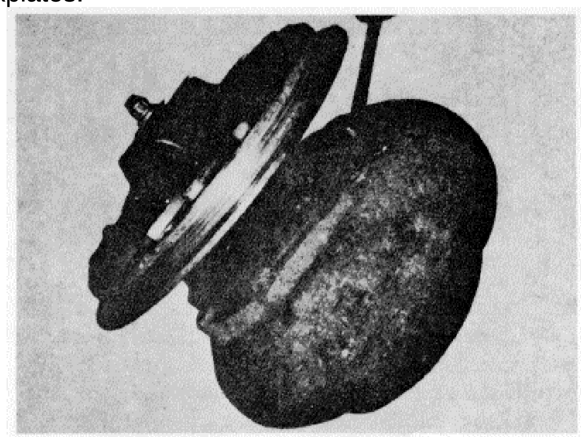


Figure 16L-8. Removing the Turbine Housing Capscrews

6. Separate the turbine housing from the center housing. Lift out the center housing assembly, Figure 16L-9.

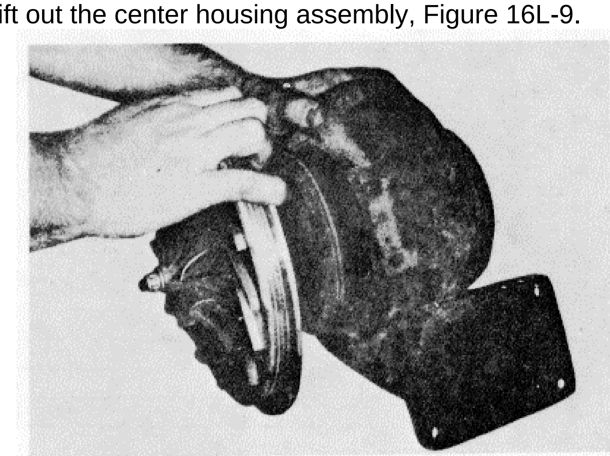


Figure 16L-9. Removing the Turbine Housing

CAUTION

Do not damage the compressor turbine wheel when separating the housings.

7. Place the turbine end of the shaft in a vise. Do not tighten the vise too much. This can cause the shaft to bend. Remove the compressor wheel locknut using a T-handle wrench, Figure 16L10.

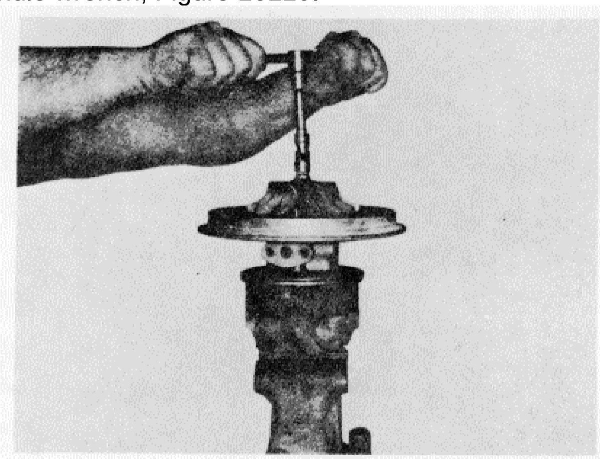


Figure 16L-10. Removing the Impeller Locknut

8. Press the turbine wheel shaft assembly from the compressor wheel. Use an arbor press and support the assembly at the turbine housing mounting face, Figure 16L11.

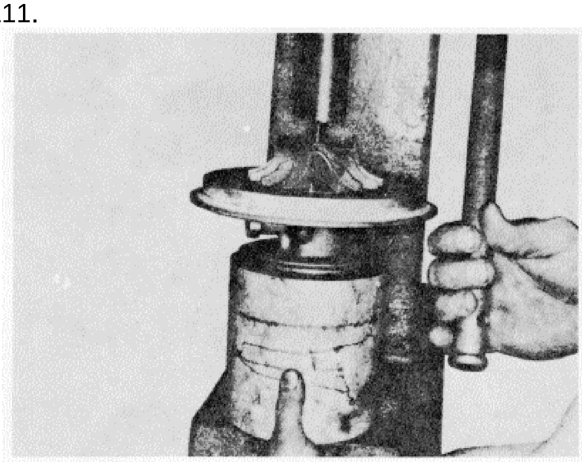


Figure 16L-11. Pressing Out the Turbine Wheel and Shaft

9. Remove the turbine wheel and shaft from the center housing, Figure 1 6L-1 2. Lift off the shroud.

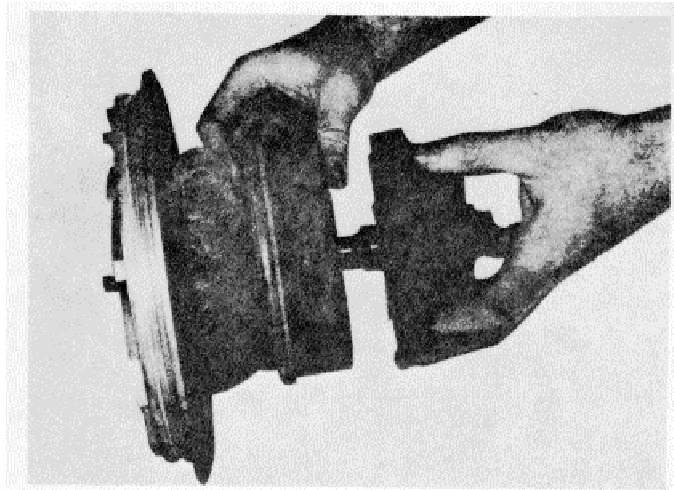


Figure 16L-12. Removing the Turbine Wheel and Shaft

10. Remove the spacer, Figure 16L-13.

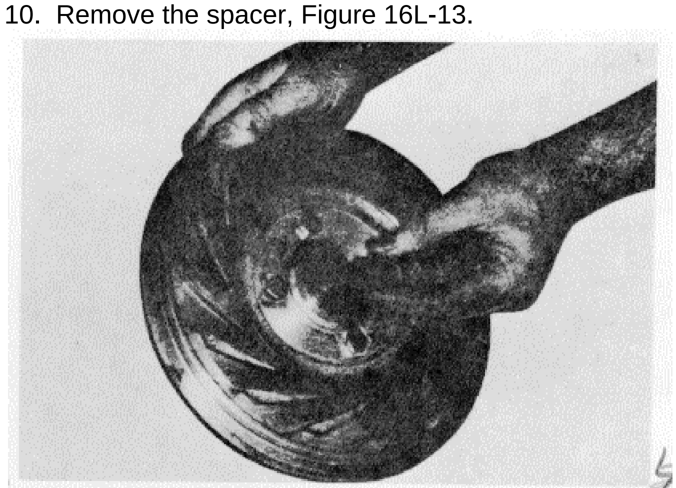


Figure 16L-13. Removing the Thrust Spacer

11. Remove the four capscrews holding the backplate, Figure 16L-14. Lift off the backplate, Figure 16L-15.

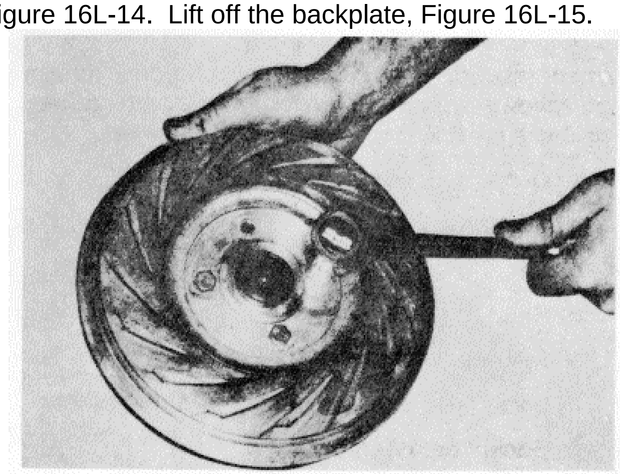


Figure 16L-14. Removing the Back Plate Capscrews

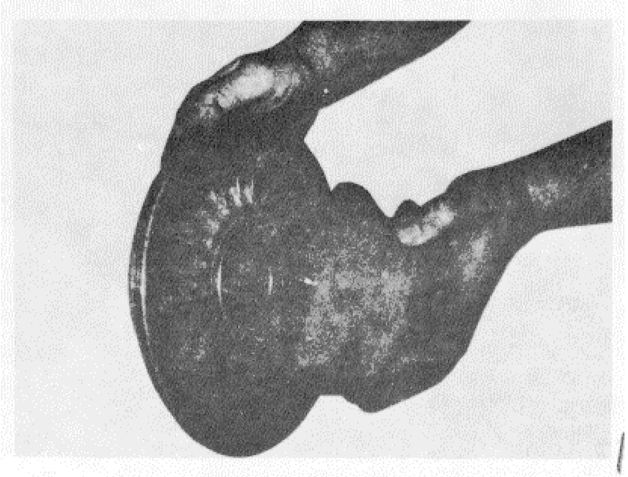


Figure 16L-15. Lift Off the Back Plate

12. Remove the thrust collar and the washer from the center of the housing, Figure 1 6L16. Remove the seal ring, Figure 16L17.

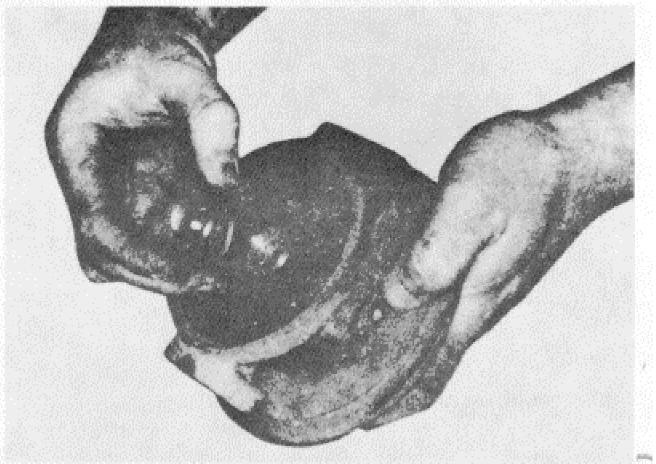


Figure 16L-16. Removing the Thrust Washer and Collar

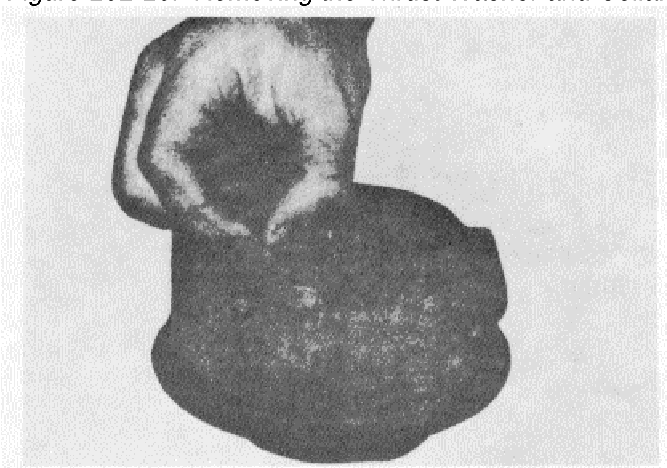


Figure 16L-17. Removing the O-Ring

13. Remove the bearing, bearing washer, and the snap ring from the compressor end of the center housing, Figure 1 6L18.

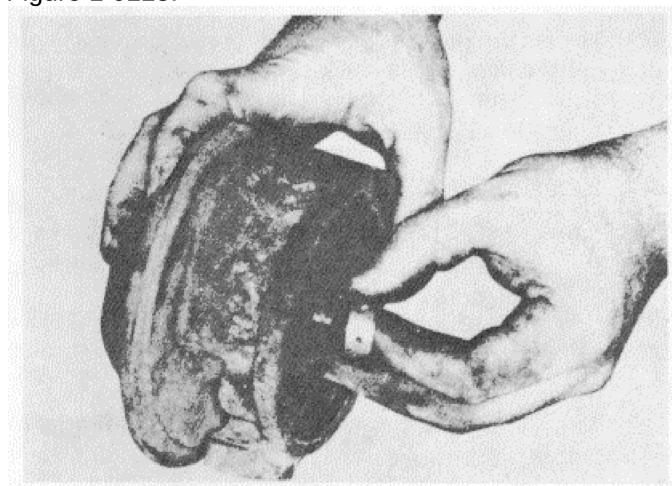


Figure 16L-18. Removing the Bearing and Washer (Compressor End)

14. Remove the outer snap ring, bearing, bearing washer, and inner snap ring from the turbine end of the center housing, Figure 16L19.

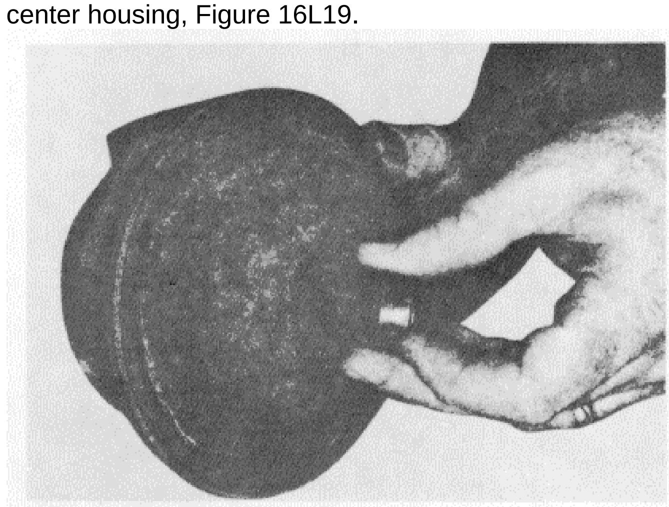


Figure 16L-19. Removing the Bearing and Washer (Turbine End)

CLEANING

Hard carbon deposits will form on the turbocharger parts which are very difficult to remove with ordinary solvents. The cleaner must be capable of removing hard deposits without damaging the metal.

1. Place all parts in a divided wire basket so the part will not be damaged through contact. Do not pile the parts in a basket. Avoid damage to all precision machined surfaces.

2. Do not use a chemical solution or any type solvent that will damage the parts. Use only an approved cleaning solvent. Parts can also be washed in hot water and soap, mineral spirits, or they can be steam cleaned.
3. Use a soft bristle brush to clean the parts. Never use a wire brush or any other type brush with stiff bristles.
4. To remove the dirt loosened by cleaning, you must flush the oil passages in the bearing housing, from the drain end.
A. If time allows, leave the parts in an approved cleaning solvent for 12 to 24 hours.
B. After completion of step A, pump the solvent through the passages again to flush out any loose particles.
5. Drain and steam clean the parts to remove all carbon and grease.
6. Blow off the excess water and dry with moisture free compressed air.
7. Place the parts carefully in a clean basket to avoid damage and dirt

INSPECTION AND REPAIR

GENERAL. When rebuilding a T-18A Turbocharger, replace the following parts. Refer to current parts catalog for these service replacement part numbers

A. O-ring
B. Seal ring
C. Bearing
D. Snap rings
E. Bearing washers
F. Lockplates or new capscrews and washers.
G. Backplate assembly
    (1) Backplate
    (2) Thrust spacer
    (3) Piston rings
    (4) Thrust collar
    (5) Thrust washer

All other parts must be within the specified wear limits. See Table 16L-2 for specifications of these parts.

COMPRESSOR WHEEL. The compressor wheel must show no signs of rubbing or damage from foreign material. It must be completely free of dirt or other foreign material and the bore must not be burned. The seals must show no signs of rubbing the running faces.

TURBINE HOUSING. The turbine housing must show no signs of contact with the rotating parts.

Inspect the turbine housing mounting flange for cracks, distortion and burning Inspect for any external cracks, Figure 1 6L-20.

CENTER HOUSING Inspect the center housing for cracks in the oil passages (inlet and outlet ports), pitting and distortion. Discard if damaged.

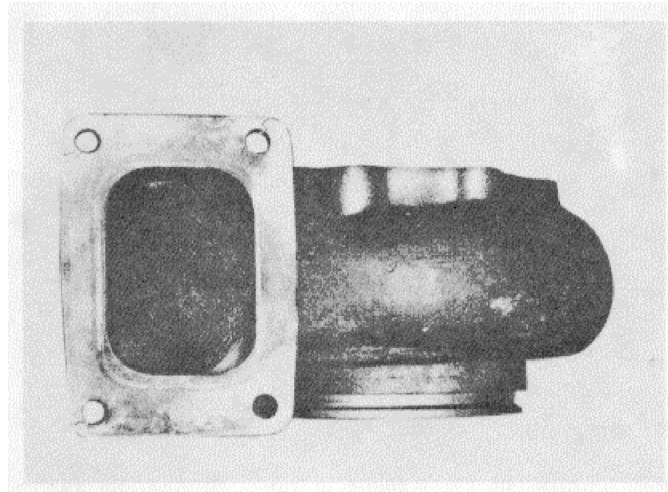


Figure 16L-20. Cracks in the Turbine Housing Mounting Flange

Using gauges, take reading of the bearing bores, Figure 16L-21. Discard the housing if worn more than 0.9835 (24.981) or if there is any evidence of burned areas.

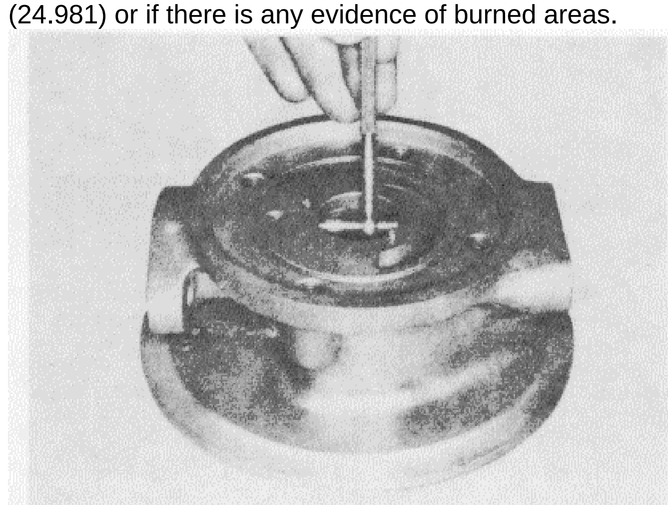


Figure 16L-21. Measuring the Center Housing Bore

TURBINE WHEEL AND SHAFT. The turbine wheel must show no signs of rubbing and the vanes must not be torn or worn to a fine edge. The shaft must show no signs of scoring, scratches, or seizure with the bearings.

Check the turbine thrust shoulder for scoring. Check for turbine wheel cracks with a dry penetrant. Discard the turbine wheel if any cracks are found.

Check the shaft bearing journal diameters for wear, Figure 1 6L-22. The turbine wheel and shaft can be used again if not worn more than 0.6245 (15 862). If the shaft is worn, a new shaft and turbine wheel assembly must be installed.

COMPRESSOR HOUSING. Do not use the compressor housing if there is a great amount of scoring due to contact

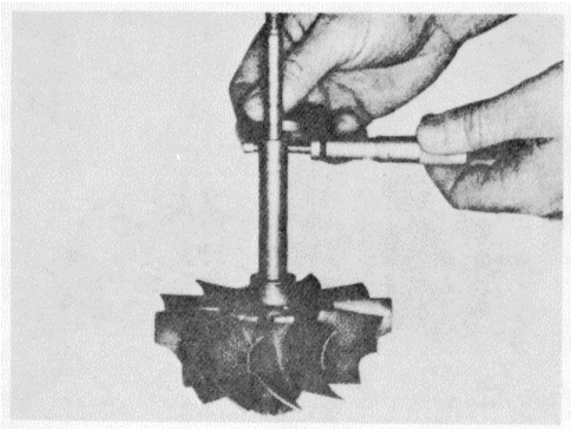


Figure 16L-22. Measuring the Shaft Journals

with the compressor wheel. The compressor housing contour is very important to the turbochargers performance.

If small scratches or chips are found, they can be smoothed out with a crocus cloth. Discard if cracked or distorted.

MISCELLANEOUS. The V-band may be cleaned and used again if they are not damaged.

ASSEMBLY

CAUTION

All parts and the work area must be free of grease, oil and dirt to keep the abrasives out of the turbocharger during assembly.

NOTE

Coat all the bearings, bearing washers, thrust washer, thrust collar and the piston seal with a light coat of clean engine lubricating oil.

1. Install a new snap ring in each end of the center housing, Figures 16L-23 and 16L-24.

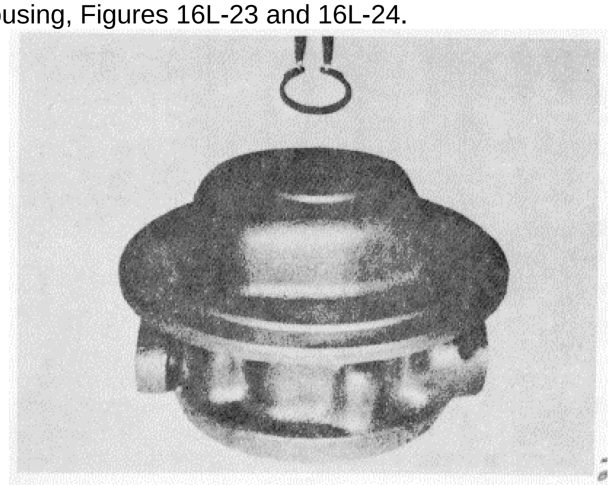


Figure 16L-23. Installing the Snap Ring (Turbine End)

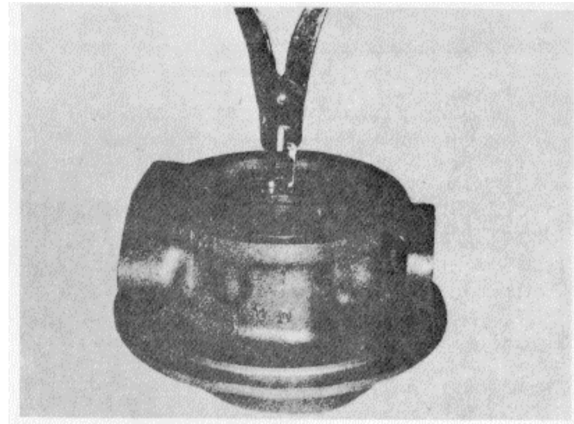


Figure 16L-24. Installing the Snap Ring (Compressor End)

2. Install a new bearing washer against the snap ring (turbine end), Figure 16L-25. Install a new bearing and secure with the outer snap ring, Figure 16L-26.

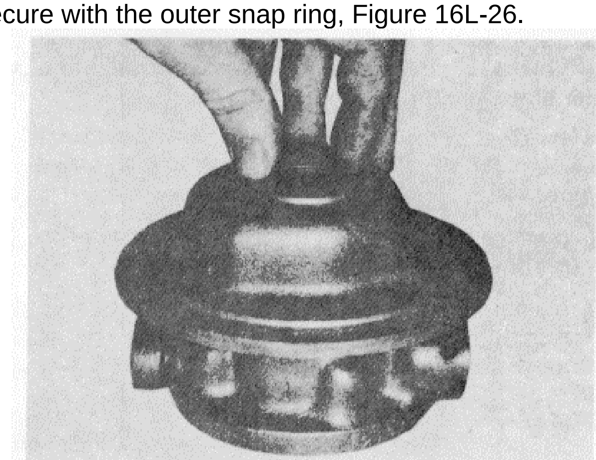


Figure 16L-25. Installing the Bearing Washer (Turbine End)

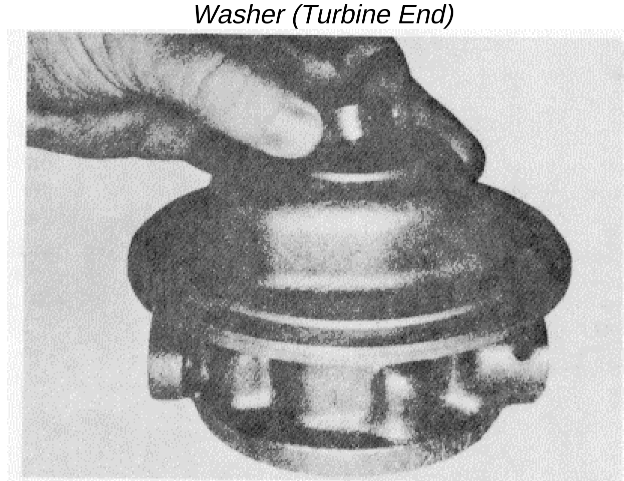


Figure 16L-26. Installing the Bearing (Turbine End)

3. Position the shroud on the center housing, Figure 16L- 27.

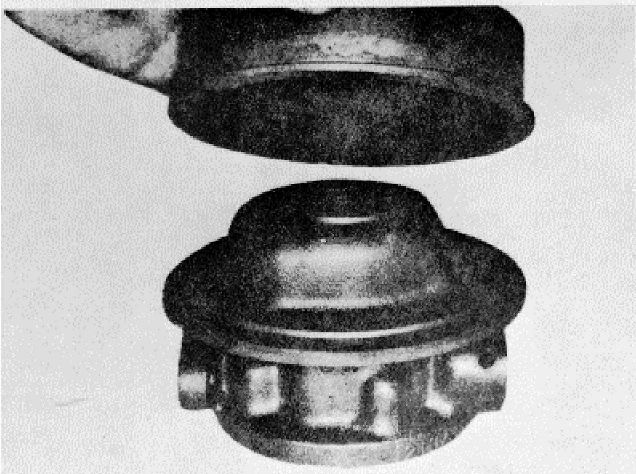


Figure 16L-27. Placing the Shroud on the Center Housing

4. Install a new piston ring on the turbine shoulder, Figure 1 6L-28, and insert the turbine and shaft through the center housing, Figure 16L-29.

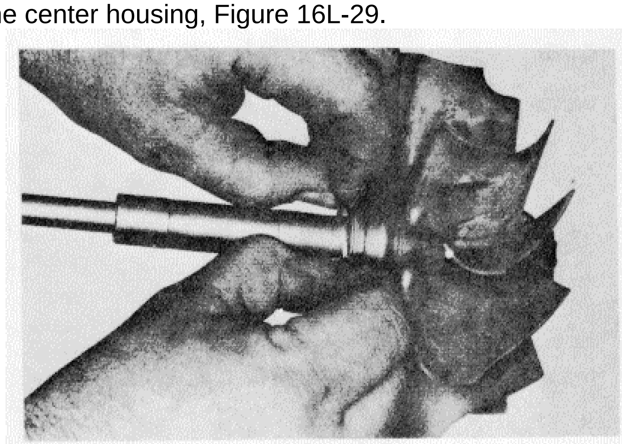


Figure 16L-28. Placing the Ring on the Turbine Shaft

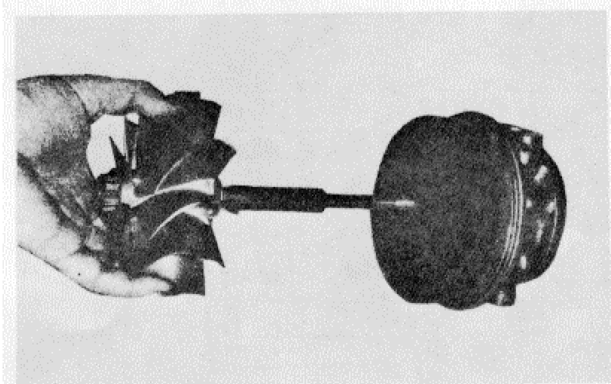


Figure 16L-29. Installing the Turbine Wheel and Shaft

5. Install a new bearing washer over the compressor end of the shaft, Figure 1 6L30, down to the inboard snap ring. Install a new bearing over the shaft, Figure 16L31, down to the bearing washer.

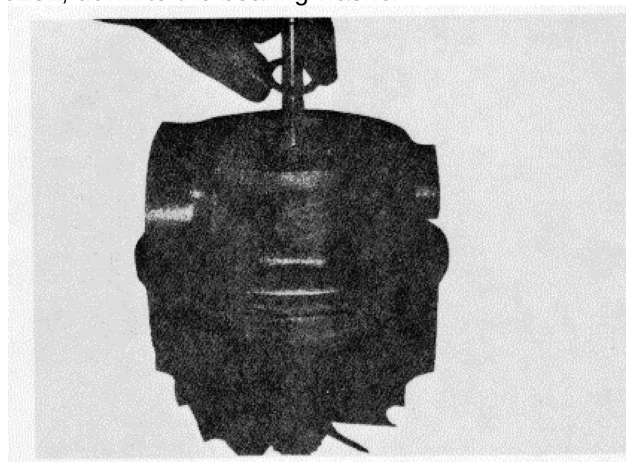


Figure 16L-30. Installing the Bearing Washer (Compressor End)

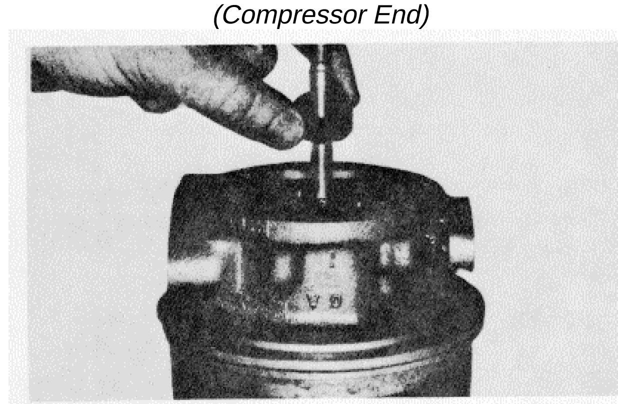


Figure 16L-31. Installing the Bearing (Compressor End)

6. Position a new thrust washer (grooves out), Figure 16L-32, on the center housing. Make sure the hole and cut-out engage the pins in the center housing and the thrust washer is seated flat against the surface of the housing.

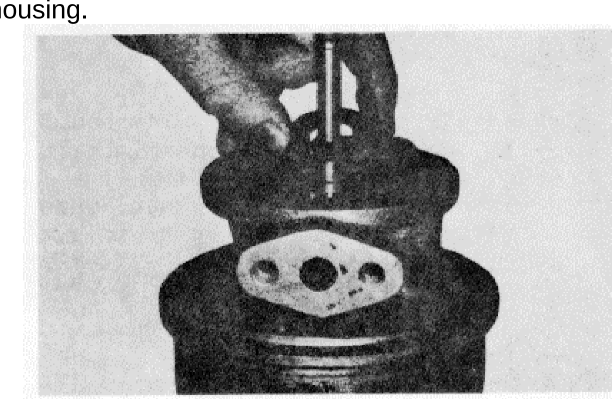


Figure 16L-32. Installing the Thrust Washer

7. Install a new thrust collar over the shaft and tight against the thrust washer, Figure 1 6L-33.

Figure 16L-33. Installing the Thrust Collar

8. Position a new O-ring in the proper groove in the center housing, Figure 16L-34.

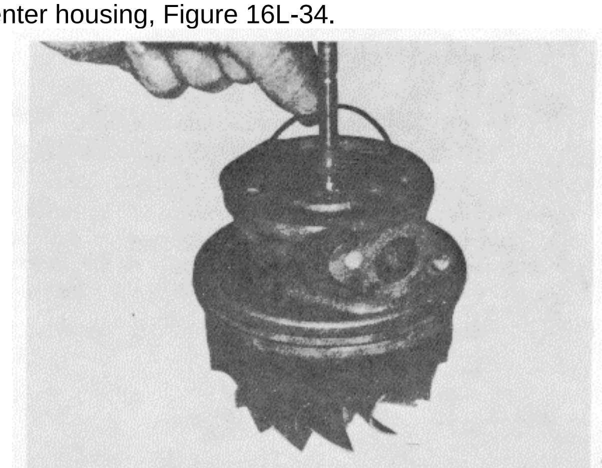


Figure 16L-34. Installing the O-Ring

9. Align the oil feed holes of the center housing and the new back plate. Position the back plate on the center housing. Figure 16L-35. Install the new lockplates and capscrews. Torque the capscrews to 90-110 in-lb (18.1-20.3 N.m) for cast iron, back plates, Figure 16L-36.

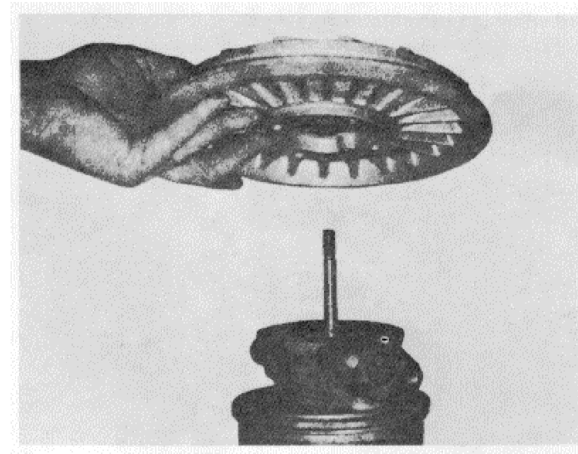


Figure 16L-35. Installing the Back Plate

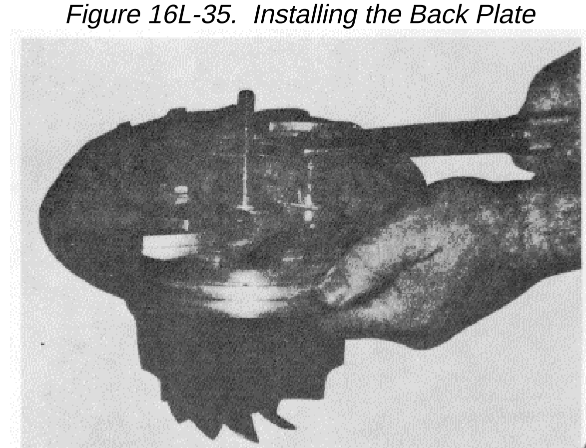


Figure 16L-36. Torquing the Back Plate Capscrews

10. Position a new piston ring in the groove of the new seal spacer. Insert the seal spacer over the turbine shaft and into the bore of the back plate and the thrust collar, Figure 1 6L- 37. Do not force the piston ring seal into place.

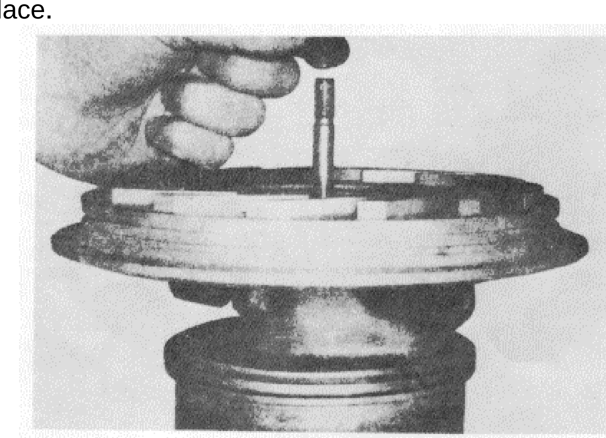


Figure 16L-37. Installing the Seal Spacer

11. Place the impeller, at room temperature, on the shaft, Figure 16L-38.

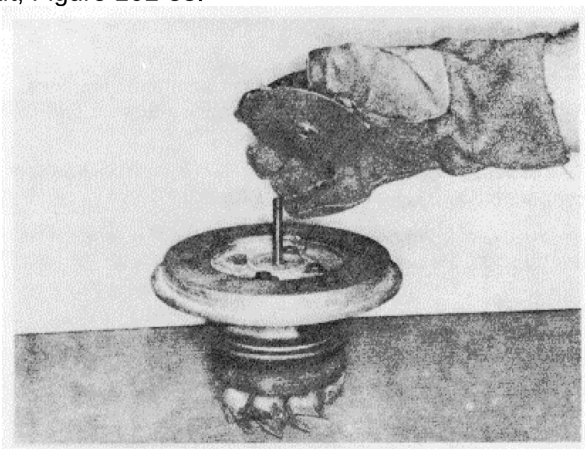


Figure 16L-38. Installing the Impeller on the Shaft

A. Oil the threads and the impeller face that will be under the nut.
B. Install the nut and tighten to 125 to 150 in-lb(14.13 to 16.95 N.m) of torque. This will seat the impeller against the thrust spacer.
C. Loosen the nut and then tighten to 35 to 55 in-lb(3.96 to 6.22 N.m) of torque greater than the drag torque*.

*Drag torque is being defined as the amount of torque required to move the nut on the threaded portion of the shaft before contact with the impeller. Torque values must be in addition to the drag torque.

D. Tighten the nut for shaft stretch of 0.009 to 0.010 inch (0.23 to 0.25 mm). Use aT-handle or a flexible socket to tighten the shaft nut, Figure 16L-39.

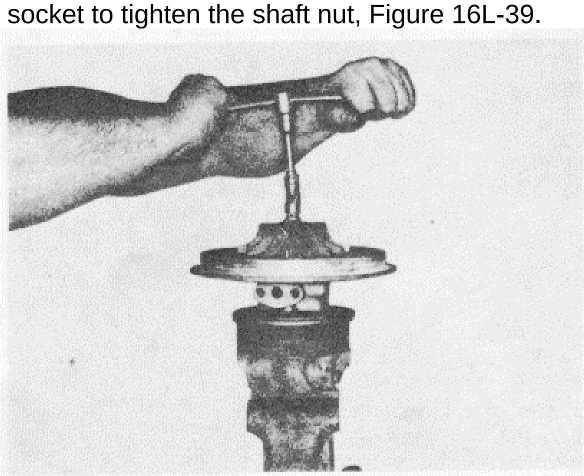


Figure 16L-39. Torquing the Shaft Nut

NOTE

If the equipment is not available to measure the shaft stretch, this alternate method may be used. The procedure is the same up to the point of tightening to achieve the shaft stretch. Instead turn the nut an additional 1100.

12. Position the compressor housing to the center housing, Figure 16L-40. Align the marks, install and tighten the V-band coupling to 40-60 in-lb (4.5-6.8 N.m), Figure 16L-41.

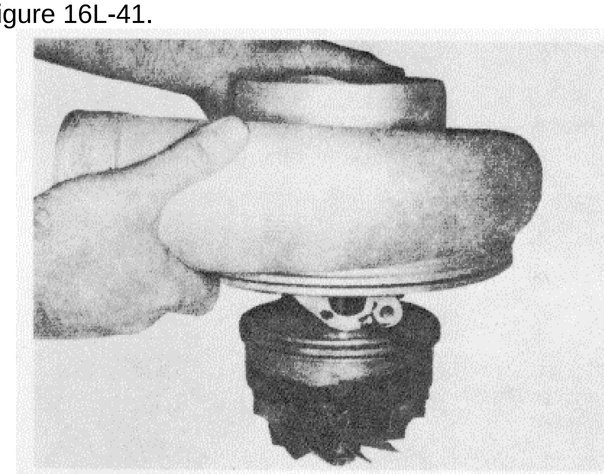


Figure 16L-40. Installing the Compressor Housing

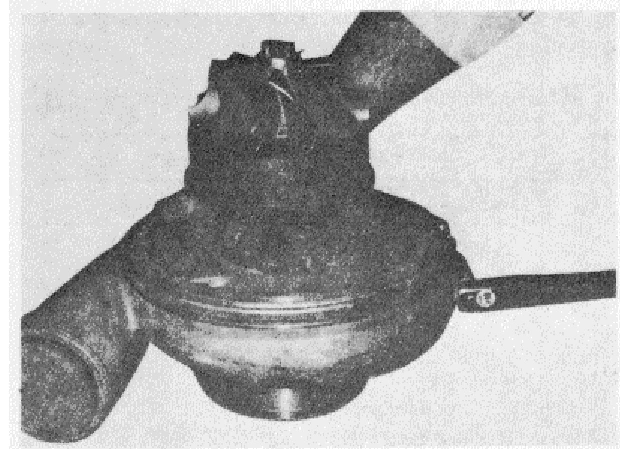


Figure 16L-41. Torquing the V-Band Nut

13. Position the turbine housings to the center housing, Figure 16L-42. Align the marks, Figure 16L-5. Install the clamps, lockplates and bolts Coat the threads of the bolts with an anti-seize compound or the equivalent. Torque to 100-110 in-lb (11.5-12.5 N.m), Figure 16L-43.

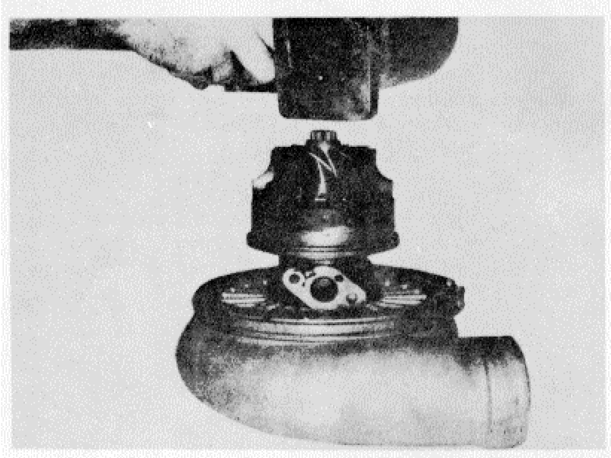


Figure 16L-42. Installing the Turbine Housing

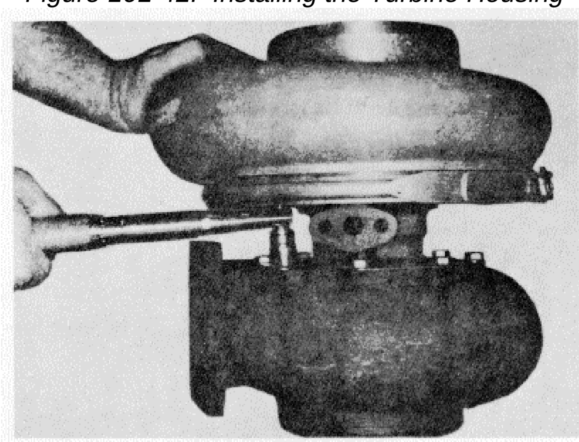


Figure 16L-43. Torquing the Turbine Housing Capscrews

14. After assembly, push the rotating assembly as far as possible from the turbine end, turn and check for binding. Repeat the check pushing from the compressor end of the turbocharger.
15. Use a dial indicator to check the total end clearance, Figure 16L-44. The total end clearance must be within 0.004-0.009 inch (0.10-0.23 mm).
16. Using the new gaskets, install the oil inlet and outlet connections onto the center housing.
17. If the unit is to be stored, lubricate the internal parts and tape all the openings.

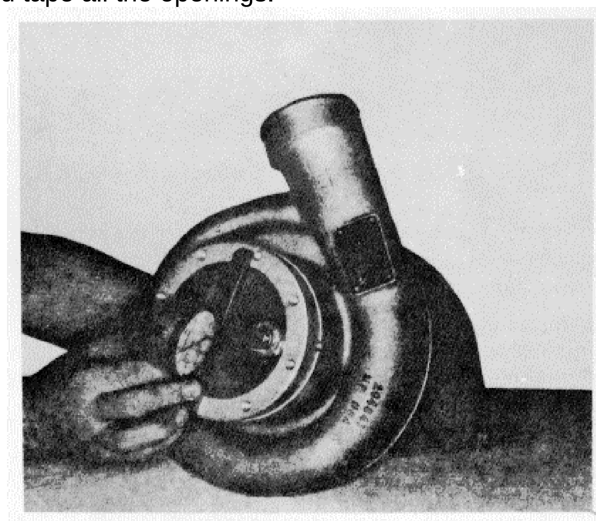


Figure 16L-44. Check the Total End Clearance

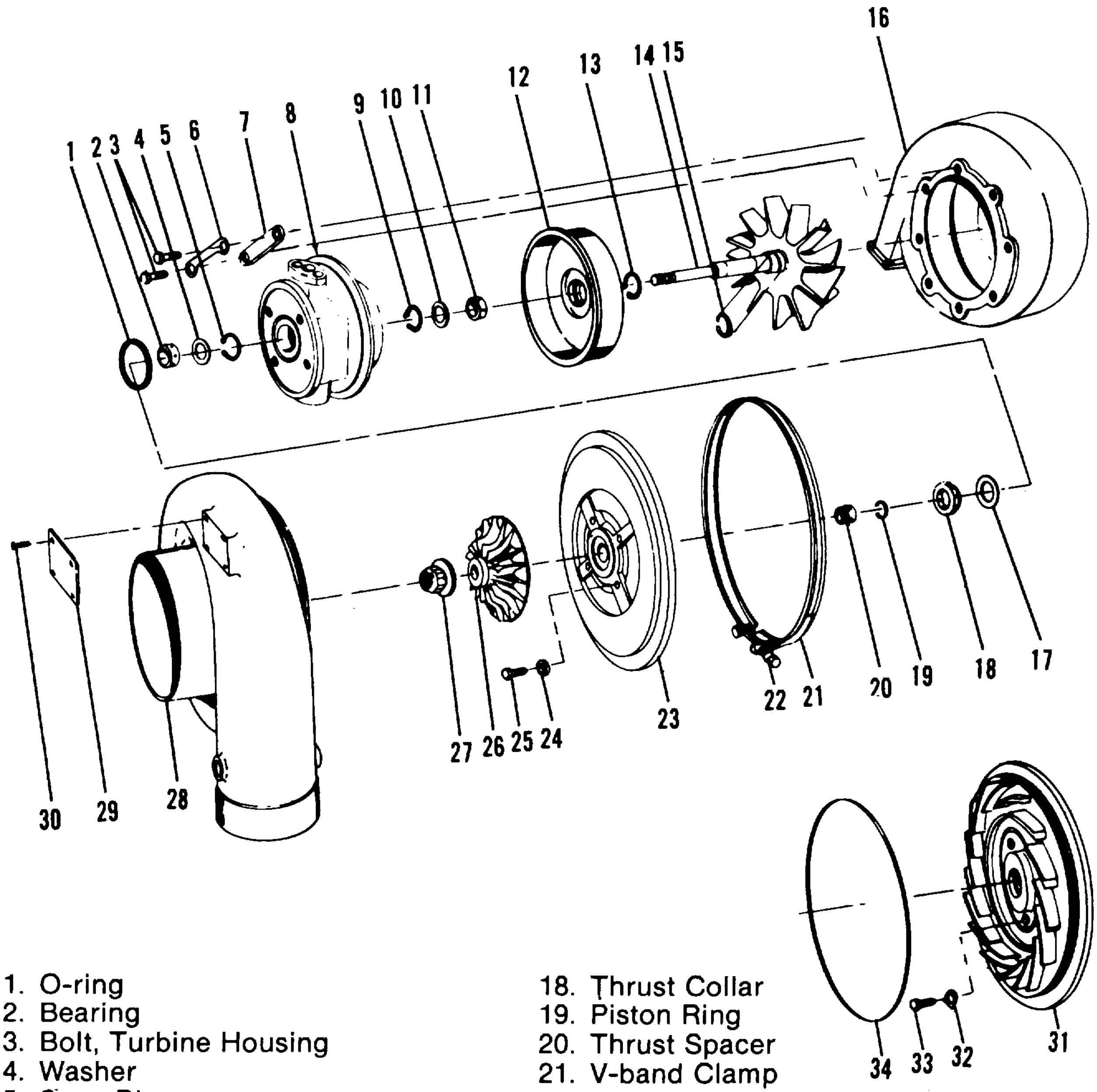
Table 16L-2. Specifications — Inch (mm)

Part or Location	New Part Limits	Worn Limits
Center Housing Bearing Bore	0.9830 [24.968]	0.9835 [24.981]
Bearing I.D.	0.6268 [15.921]	0.6272 [15.931]
Bearing O.D.	0.9782 [24.846]	0.9787 [24.859]
Rotor Shaft Journal O.D.	*0.6250 [15.875]	0.6254 [15.887]
Inboard Thrust Bearing	0.090 [2.29]	0.092 [2.34]
Total End Clearance	0.004 [0.10]	0.009 [0.23]
Bearing Radial Clearance	0.003 [0.08]	0.007 [0.18]

*Replace shaft if worn below .6245 [15.862]

Assembly Torque Specification

V-Band Clamp Tension	40/60 in-lb [4.5/6.8 N•m]
Turbine Housing Mounting Capscrew	100/110 in-lb [11.5/12.5 N•m]
Rotor Assembly Locknut Torque	35/50 in-lb [3.96/5.65 N•m] Above the drag torque plus 110 deg.
Lubricating Oil Drain Fitting	50 ft-lb [68 N•m]
Lubricating Oil Inlet Fitting	20 ft-lb [27 N•m]
Back Plate Mounting Capscrews for (Aluminum)	90/110 in-lb [10.0/12.5 N•m]
Back Plate Mounting Capscrews for (Cast Iron)	160/180 in-lb [18.1/20.3 N•m]



1. O-ring
2. Bearing
3. Bolt, Turbine Housing
4. Washer
5. Snap Ring
6. Lockplate
7. Turbine Housing Clamp
8. Center Housing
9. Snap Ring
10. Washer
11. Bearing
12. Shroud Wheel
13. Snap Ring
14. Wheel and Shaft
15. Piston Ring
16. Turbine Housing
17. Thrust Bearing
18. Thrust Collar
19. Piston Ring
20. Thrust Spacer
21. V-band Clamp
22. Locknut
23. Back Plate
24. Lockplate or Washer
25. Bolt
26. Impeller
27. Rotor Locknut
28. Compressor Housing
29. Nameplate
30. Screw
31. Back Plate
32. Lockplate
33. Capscrew
34. O-ring

Figure 16L-45. Turbocharger-- Exploded View.

SUBSECTION 16M

EXHAUST SYSTEM

DESCRIPTION

The exhaust system group contains the exhaust manifolds, piping and mufflers.

EXHAUST MANIFOLD

Inspect the exhaust manifold for cracks and distortions; discard the defective parts.
When ordering replacement parts, order the same part s used.

SUBSECTION 16N

ENGINE ASSEMBLY AND TESTING

DESCRIPTION

The engine assembly and testing section covers assembly of all units and subassemblies to the cylinder block. Adjustments before and during engine test and break-in, in and out of equipment, are also covered.

TOOLS

Essential Service Tools (Or Equivalent)

Service Tool Number	Tool Name
3376030	Dial Indicator and Sleeve Assembly
3375155	Injector Tip Protrusion Comparator
3376085	Pulley Assembly Tool
ST-1313	Camshaft Pilot
ST-1325	Dial Gauge Attachment
3375932	Pressure Gauge
3375150	Blow-By Checking Tool
ST-547	Gauge Block
3375522	Timing Fixture
3375422	Liner Driver
3375342	Piston Ring Compressor Sleeve
3375004	Injector Indicator Kit

Desirable Service Tools (Or Equivalent)

ST-1319	Tube Driver
ST-1307	Engine Adapter Plate
3375193	Engine Rebuild Stand
ST-386	Pulley Assembly Tool
ST669	Torque Wrench Adapter
3375855	Template Indicator, Level and Angle
ST-1190	Fuel Consumption Measuring Device
ST-1232	Drill Reamer Fixture
ST-1233	Drill Reamer Bushing
ST-1258	Engine Lifting Fixture
ST-1267	Cylinder Liner Hold-Down Tool
ST-1269	Piston Ring Expander
ST-1293	Belt Gauge
3375098	Connecting Rod Guide Pins
ST-1311	Front Crankshaft Seal Installation Tool
ST-1286	Engine Lifting Hook (2 Required)
3375496	Drill Pilot
3375292	Heavy Duty Socket Set
3375707	Seal and Pulley Assembly Tool

Standard Tools - Obtain Locally

0-150 Inch-pound Torque Wrench
0-250 Foot-pound Torque Wrench
0-600 Foot-pound Torque Wrench
Dial Indicator (Starret No. 196A)
Dial Indicator Sleeve (Starret No. 196L)
Manometer (Mercury or Water)
0-1 Micrometer
Impact Wrench
Engine and/or Chassis Dynamometer
Hoist (Power or Chains)
Straight Edge
Feeler Gauge

ENGINE ASSEMBLY

Engine assembly as described in this Group, is with the assumption that all units have been rebuilt to specifications or are new and ready to be installed. Newgaskets, O-rings and lockplates, where used, should be installed as the engine is assembled. Torque values and procedures must be used where specified when tightening capscrews. If the capscrew torque is not specified, refer to Specifications and Wear Limits, Subsection 16Q.

MOUNT CYLINDER BLOCK TO REBUILD STAND

1. Secure the ST-1307 Engine Stand Adapter to the 3375193 Engine Rebuild Stand.

2. Use a suitable block lifting fixture and hoist to put the block to the adapter plate. Secure it with capscrews and lockwashers.

CRANKSHAFT AND MAIN BEARINGS

Before installation, check the crankshaft front and rear counterweights for main and thrust bearing sizes. See Crankshaft, Subsection 16B.

1. Be sure that mating surfaces and the main bearing bore are clean.

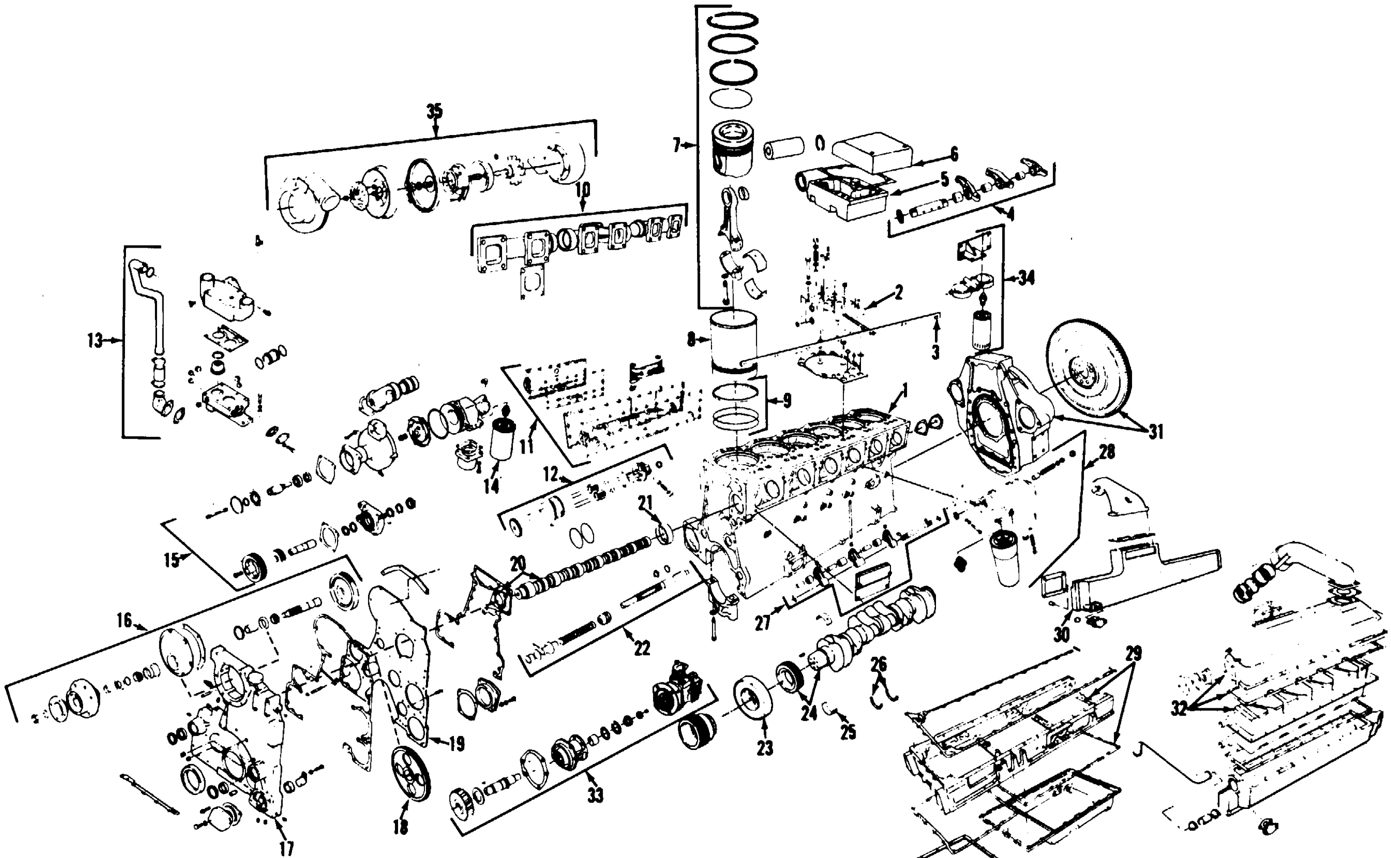
NOTE

As a precautionary measure, clean the main bearing capscrew holes out with compressed air.

2. Put the upper main bearing shells in the block. Hold in position with a tang. The ends of the bearings shells must be flush with the parting face of the block, Figure 16N-2.

NOTE

The upper main bearing shells are grooved and drilled for lubrication. No's. 2, 3, 4, 5 and 6 are interchangeable and No's. 1 and 7 are interchangeable



1. Cylinder Block
2. Cylinder Head
3. Fuel Manifold
4. Rocker Levers and Shaft
5. Rocker Lever Housing
6. Rocker Lever Cover
7. Connecting Rod/Piston Assy.
8. Cylinder Liner
9. Crevice Seal/O-Rings
10. Exhaust Manifold
11. Lub Oil Cooler Assy.
12. Lub Oil Pump
13. Thermostat Hsg./Conn.
14. Water Filter
15. Water Pump/Drive Assy.
16. Fan Hub
17. Gear Cover
18. Camshaft Gear
19. Gear Housing
20. Camshaft/Thrust Plate
21. Camshaft Bushing
22. Barring Mechanism
23. Vibration Damper
24. Crankshaft/Gear
25. Main Bearings
26. Thrust Rings
27. Cam Follower Assy./Cover
28. Lub Oil Filter Assy.
29. Oil Pan/Adapter
30. Intake Manifold
31. Flywheel/Housing
32. After Cooler/Housing
33. Fuel Pump/Accessory Drive
34. Fuel Filter Assy.
35. Turbocharger

Figure 16N-1. Engine

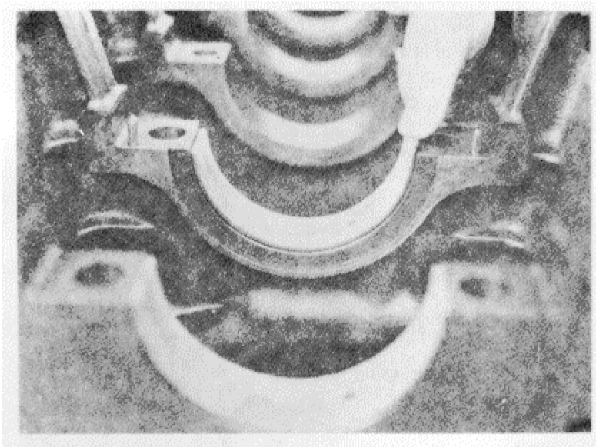


Figure 16N-2. Install the Upper Main Bearing Shells

3. Lubricate the crankshaft journals and upper main bearing shells with a coat of clean engine lubricating oil.

4. Use a hoist and lifting hooks protected with rubber hose or a lifting strap to lower the crankshaft carefully into positin in Figure. 16N-3

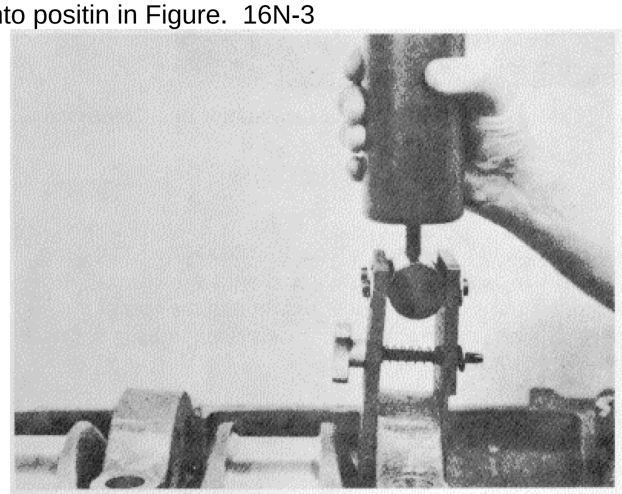


Figure 16N-3. Install the Crankshaft

CAUTION

Avoid cocking the crankshaft during installation.
Damage to bearing shells may result. If the crankshaft cocks, remove and inspect the condition and position of the bearing shells.

5. Lubricate the upper thrust bearing halves and slide into position around the No. 6 main bearing journal, Figure 1 6N4.

NOTE

The grooved face of the thrust bearing must be installed toward the crankshaft flange. The ends of the thrust bearing must be even with the mounting face of the main bearing.

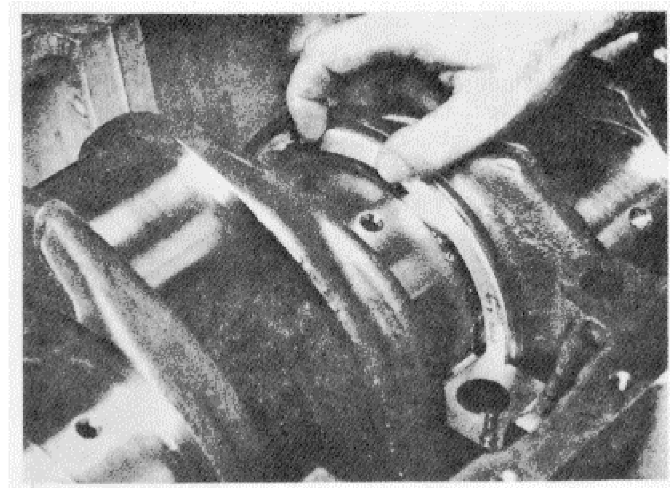


Figure 16N-4. Install the Upper Thrust Bearings

6. Put the lower half of the main bearing shells into the caps. Lubricate the bearing surfaces with a clean engine lubricating oil.

7. Install the main bearing caps as follows:

A. No's. 1 through 7 which are stamped on the main bearing caps must correspond with the numbers stamped on the camshaft side of the block.

B. Put the lower thrust bearing halves over the dowels on the No. 6 bearing cap.

NOTE

The smooth surface side of the thrust bearing goes toward the cap.

C. Care must be taken to align the capscrew holes and cap to the block dowels (No. 6 main bearing cap) when installing the caps to the block, Figure 16N-5.

NOTE

Pull the cap in position by tightening the capscrews alternately and evenly

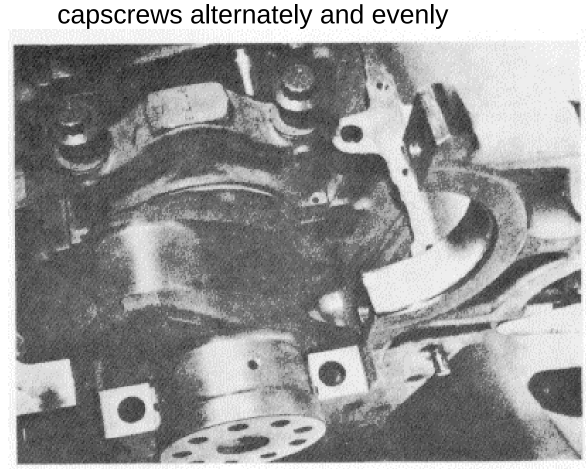


Figure 16N-5. Install the Main Bearing Caps

8. Lubricate the main bearing capscrew threads with a clean engine lubricating oil, Figure 16N-6. Coat under the head of the capscrews and hardened washers with SAE 140W lubricant. Tighten the capscrews in sequence as outlined in Table 16N-1 and Figure 16N-7.

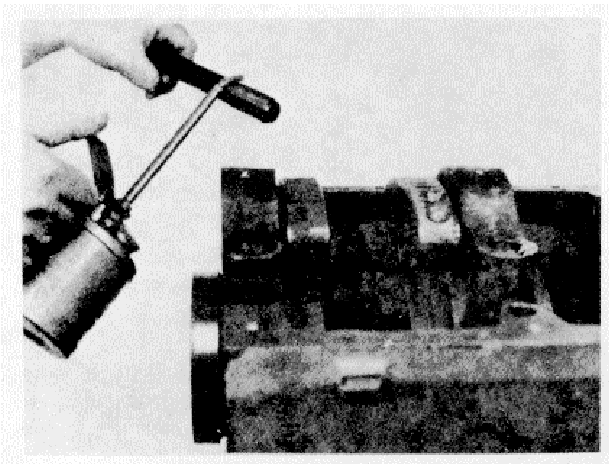


Figure 16N-6. Lubricate the Main Bearing Capscrew Threads

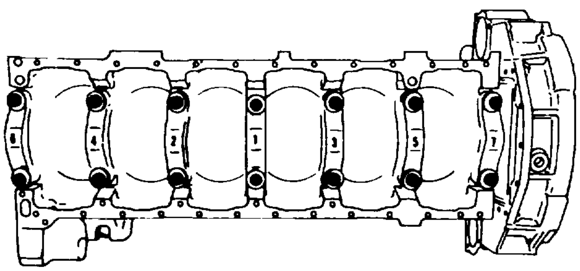


Figure 16N-7. Tighten Main Bearing Capscrews

9. After tightening all the main bearing capscrews to operating tension, the crankshaft must be free enough to turn easily by hand.

Table 16N-1. Main Bearing Capscrew Tightening - Ft-Lb (N.m)

Step	**Torque Reading**
1. Tighten to	190 to 200 ft-lb [258 to 271 N.m]
2. Advance to	440 to 450 ft-lb [597 to 610 N-m]
3. Loosen all capscrews,	remove all tension
4. Tighten to	190 to 200 ft-lb [258 to 271 Nom]
5. Advance to	440 to 450 ft-lb [597 to 610 N-m]

10. Attach a dial indicator gauge securely to the rear of the cylinder block with the contact point of gauge resting on the crankshaft flange end face, Figure 16N-8.

11. Pry the crankshaft toward the front of the engine. Remove the pry bar and set the gauge at "0".

12. Pry the crankshaft toward the rear of the engine. Remove the pry bar. The gauge should indicate 0.004 to 0.016 inch (0.10 to 0.41 mm) end clearance for an engine with a new crankshaft and new thrust bearings.

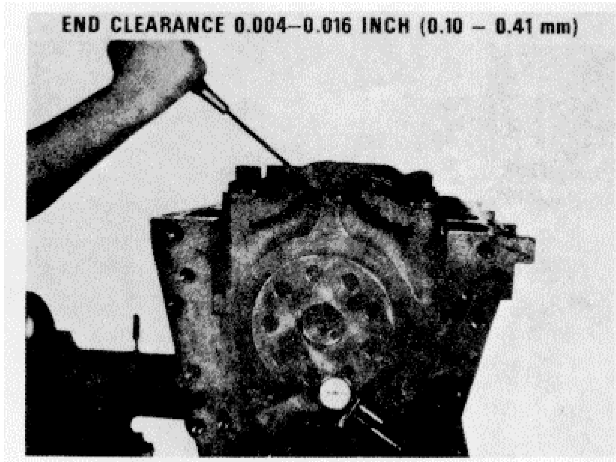


Figure 16N-8. Check the Crankshaft End Clearance

13. If the end clearance is less than 0.004 inch (0.10 mm), loosen the capscrews slightly and shift the crankshaft toward the front of the engine and then to the rear of the engine. Tighten the crankshaft as described in Step 8. Check the end clearance.

NOTE

When an engine is being rebuilt, it may be necessary to bring the crankshaft end clearance to specifications by using a reconditioned crankshaft and oversize thrust bearings as described in Subsection 16B.

CYLINDER LINERS

Before installing cylinder liners, check the liner protrusion. If necessary, install the counterbore shims around liners to maintain 0.003 to 0.006 inch (0.08 to 0.15 mm) liner protrusion as described in Subsection 1 6B.

1. Lubricate the crevice seal and the O-rings with a light coat of clean engine lubricating oil, just prior to installing the liner into block.

2. Put the crevice seal into position on the liner.

3. Roll (black) top O-ring into the groove on the liner.

4. Roll the (red) bottom O-ring into the bottom groove on the liner.

NOTE

Check for twisted O-rings. Use the mold mark on the O-ring as a guide to straighten as required. Do not stretch the O-rings more than required during installation.

5. Lubricate the machined portions of the block on which the O-rings will seat with a light coat of clean engine lubricating oil.

6. Put the liner into the block by hand, being careful to avoid dislodging the O-rings and crevice seal. Drive the liner into position. Use the 3375855 Liner Driver to drive the liner securely into the block, Figure 16N-9.

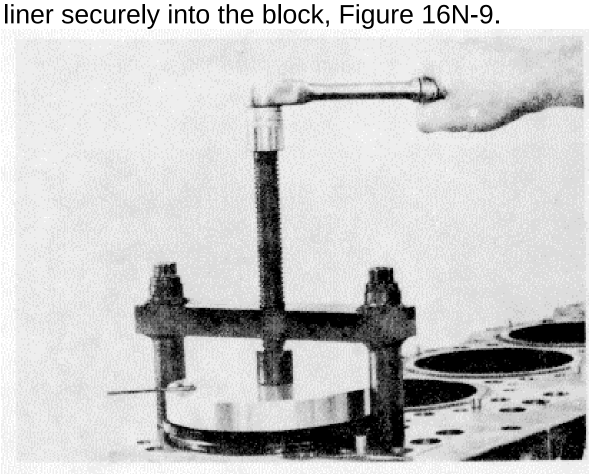


Figure 16N-9. Install the Liner in the Block with a ST-1266

7. Install the ST-1267 Liner Holddown Clamps. Tighten to 50 ft-lbs (68 N.m). Use the ST-547 Gauge Block (at four equidistant points) to determine if the liner protrusion is uniform and 0.003 to 0.006 inch (0.08 to 0.15 mm), Figure 16N-10.

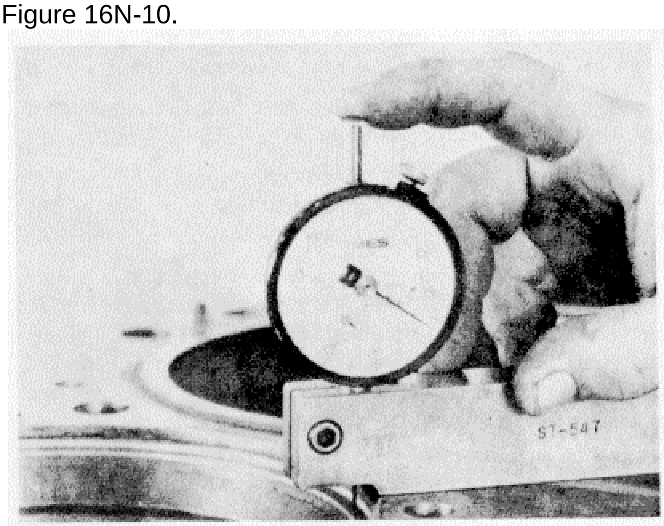


Figure 16N-10. Check the Liner Protrusion with a ST-547

8. Check the liner bore with a precision dial bore gauge for roundness at several points within the range of piston travel. If the liner is more than 0.002 inch (0.05 mm)out-of round in the packing ring area, remove the liner and check the cause of distortion. It is permissible to have 0.003 inch (0.08 mm) out-of-round at the top 1 inch (25.4 mm) of the liner bore.

9. Check the liner to block clearance as described in "Cylinder Liner Lower Bore," Subsection 16B.

CONNECTING RODS AND PISTONS

1. Use the ST-1269 Piston Ring Expander to install the rings on the piston with the "Top Marking" toward the top of the piston, Figure 16N-11.

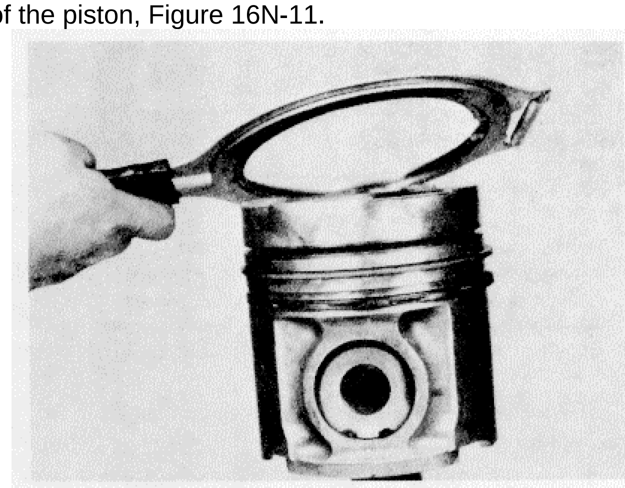


Figure 16N-11. Install the Piston Rings

2. Over expanding a piston ring during installation on the piston can cause distortion which will result in damage leading to ring failure. A ring should be expanded only enough to allow it to pass over the piston. The measured gap should not be expanded more than eight (8) times the nominal radial wall thickness of the ring.

NOTE

The top surface of a piston ring is identified either with the word "TOP," a "Notch" in the ring gap or a "Pip" in the top ring surface. See Figure 16N-12.

3. Stagger the ring gaps so they are not in line with each other or the piston pin. Lubricate the piston and rings with a clean engine lubricating oil.

4. Remove the connecting rod caps and put the bearing shells into the rods and caps. Make sure that the tang on the shell is in the proper position in the milled recess of the rod and cap. Install the rod guide pins to protect the crank journal.

NOTE

Connecting rod caps are not interchangeable and must be kept with the matching rod. Keep the same part number pistons in all cylinders.

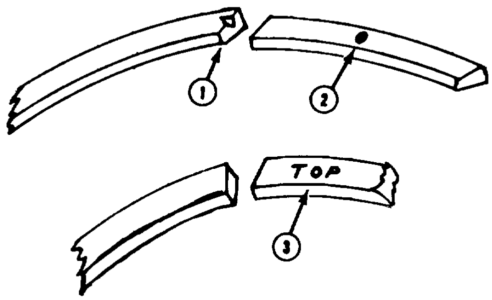


Figure 16N-12. Piston Ring Markings

5. Apply a film of clean engine lubricating oil to the bearing shells and cylinder liner walls.

CAUTION

> The following procedure is necessary due to the width between the crankshaft counterweights and the thickness of the connecting rod cap. Two men maybe required when rotating crankshaft as described in Step 9.

6. Starting with any cylinder, rotate the crankshaft to the top center position.
7. Use the ST1268 or 3375342 Ring Compressor to insert the piston and rod assembly into the cylinder liner with the numbered side of the rod toward the camshaft side of the block. Do not allow the rod to damage the liner wall.
8. Push the piston and rod assembly through the ring compressor into the liner until the top bearing shell is seated on the crankshaft, Figure 16N-13.

CAUTION

> Ring damage can result from improper use of a ring compressor. Rings should pass into the liner smoothly. If a band type compressor is used, make sure that the inner band does not slip and bind the piston.

9. Rotate the crankshaft to the bottom center position while holding the rod and bearing shell against the bearing journal.
10. Install the rod cap:
    - A. Match the number on the cap with the number on the rod.
    - B. Put the cap over the journal, starting it on ring dowels in the rod mating surface, Figure 16N-14.
    - C. Lubricate the rod bolt threads and hardened washers with SAE 140W lubricant.

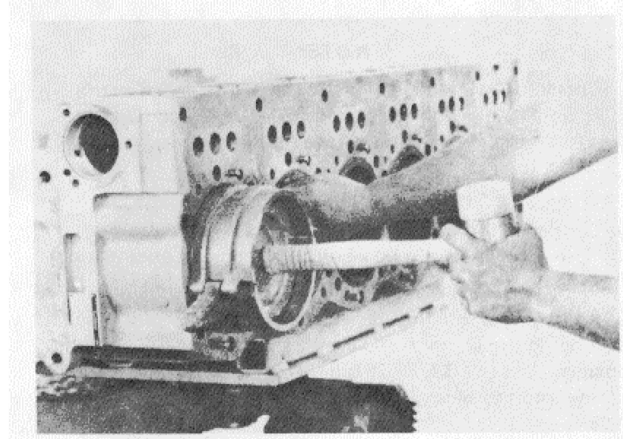


Figure 16N-13. Install the Piston Assembly Using a 3375342

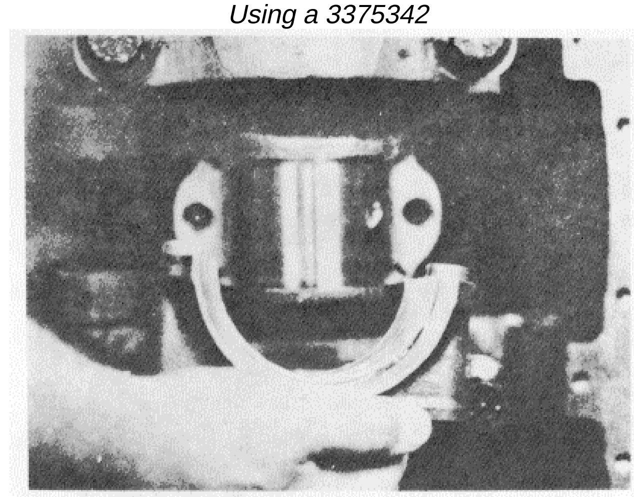


Figure 16N-14. Position the Connecting Rod Cap to the Rod

    - D. Pull the cap and rod together by tightening the bolts alternately and evenly. Do not tighten the bolts to the final torque until all rods and caps are in position.
11. Proceed with the remaining cylinders. Repeat Steps 6 through 10 for each cylinder.
12. Tighten the connecting rod bolts, Figure 16N-15, in sequence 3-4, 1-6 and 2-5, alternately and evenly. See Table 16N-2.
13. Check the connecting rod to crankshaft side clearance, Figure 16N-16. The tightened rod should be free to move sideways on the crankshaft journal. The side clearance is 0.008 to 0.014 inch (0.20 to 0.36 mm). If the rod does not move freely, remove the cap and check for improper bearing size, burrs, dirt, etc.

STEEL PLATE INSTALLATION WITH THE PAN ADAPTER REMOVED

1. Use a suitable gasket adhesive to install the housing gasket to the block.

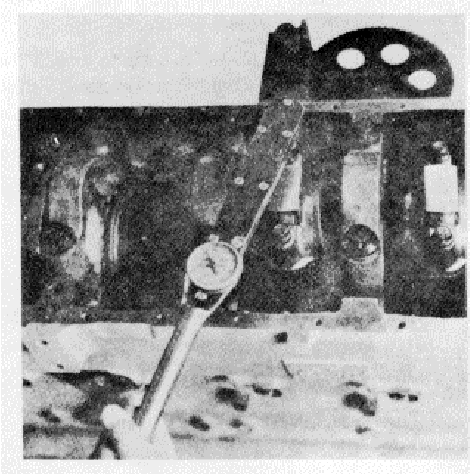


Figure 16N-15. Tighten the Connecting Rod

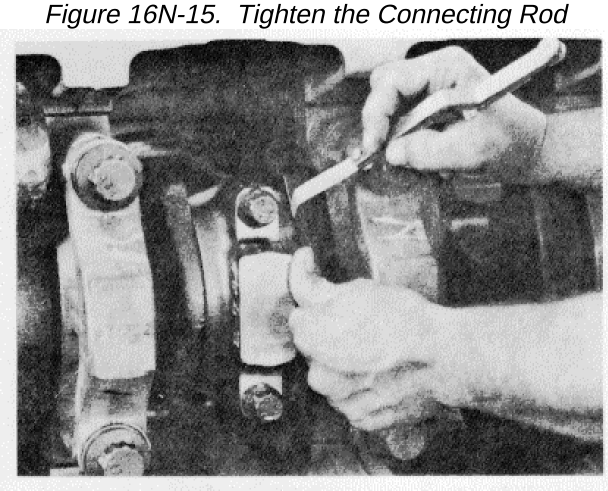


Figure 16N-16. Checking the Connecting Rod Side Clearance

Table 16N-2. Connecting Rod Bolt Tightening Ft-Lb (N.m)

Step	Torque Reading
1. Tighten to	70 to 80 ft-lb [95 to 108 N.m]
2. Advance to	140 to 150 ft-lb [190 to 281 Nom]
3. Advance to	210 to 220 ft-lb [285 to 295 Nom]
4. Loosen bolts,	remove all tension
5. Tighten to	70 to 80 ft-lb [95 to 108 Nom]
6. Advance to	140 to 150 ft-lb [190 to 281 Nom]
7. Advance to	210 to 220 ft-lb [285 to 295 Nom]

2. Install the diamond dowel in the front of the cylinder block. The flats on the diamond dowel must be turned 900 the master dowel. Make sure the dowel is fully seated e bottom of the dowel hole. See Figure 16N-17 for the Il location.

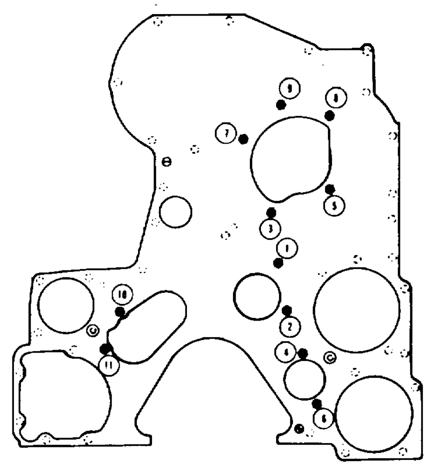


Figure 16N-17. Dowel and Mounting Capscrew Locations

3. Use the eleven capscrews installed in the locations shown in Figure 16N-17 to install the steel plate to the cylinder block.

4. Tighten the two bottom retaining capscrews to 10 in-lb (1 N.m) torque.

5. Put the steel plate so that the bottom side of the plate is flush to -0.002 inch (0.5 mm) with pan rail surface of the cylinder block. Use service tool gauge block, ST-547 to measure the distance, Figure 16N-1l.

6. Tighten the eleven capscrews to 30 to 35 ft-lb (41 to 47 N.m) torque in the sequence shown in Figure 16N-17.

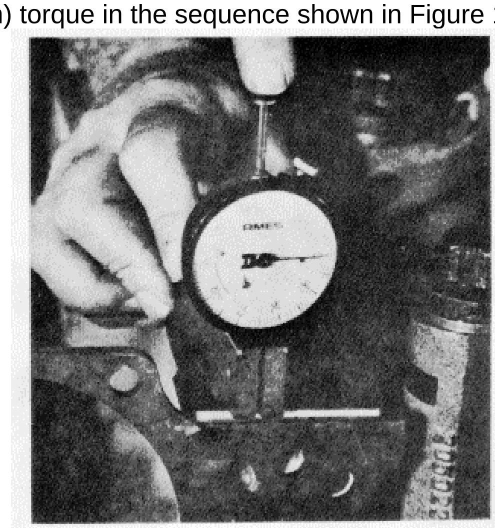


Figure 16N-18. Position the Steel Plate

IDLER GEARS

1. Rotate the crankshaft to put the No. 1 cylinder in the top center position.

2. Put the idler gear on the shafts with the timing marks on the camshaft idler gear (2) out. Align the "O" on the crankshaft gear (4) with the "O" on the camshaft idler gear (2), Figure 16N-19.

3. Mount only the accessory drive gasket and housing into position on the mounting stud.

4. With the crankshaft gear in position, align the timing marks "A" on the camshaft idler gear (2) and "A" on the accessory drive gear (3), Figure 16N-19.

NOTE

Tighten the accessory drive retaining nut finger tight only.

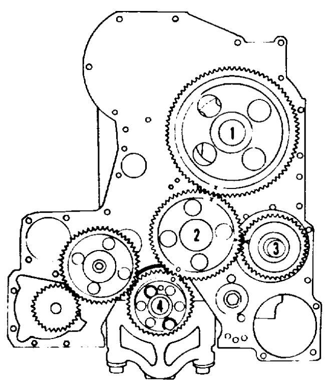


Figure 16N-19. Align the Timing Marks

5. Tighten the idler gear retaining capscrews to 175 to 185 ft-lb (237 to 251 N.m) torque, Figure 16N-20.

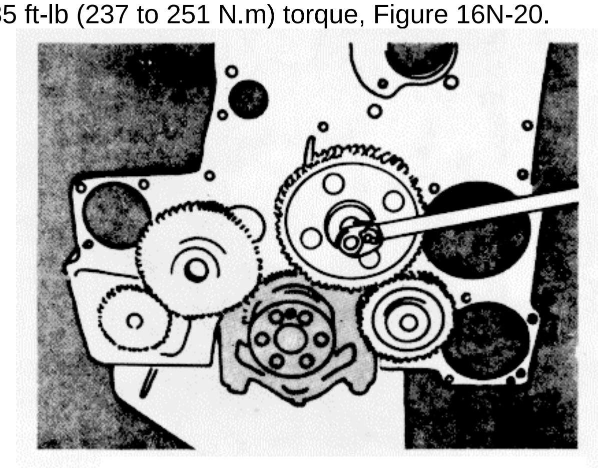


Figure 16N-20. Tighten the Idler Gear Retainer Capscrews

6. Use a dial indicator or feeler gauge to check the end clearance of the idler gears. See "Idler Gears," Subsection 1 6B for end clearance.

NOTE

Because of excess weight, the air compressor and fuel pump should not be installed at this time.

CAUTION

Do not bar engine until camshaft and accessory drive have been installed as misalignment of timing marks will result.

STEEL PLATE INSTALLATION WITH THE PAN ADAPTER INSTALLED

1. Install the diamond dowel in the front of the cylinder block, but do not install the master dowel at this time, Figure 16N-17.

2. Starting at the front of the cylinder block, remove the portion of the pan adapter gasket that was under the front cover and the steel plate. Clean the exposed gasket mounting surface of the pan adapter.

3. Apply sealant to the area where the cylinder block and oil pan adapter meet and install the complete service gasket on the pan adapter.

NOTE

This gasket is marked and can be cut for use when the front cover is the only thing removed.

4. Install the steel plate on the cylinder block. Trim the gasket to fit even with the pan adapter gasket. Apply sealant to the area where the steel plate contacts the oil pan adapter.

5. Tighten the eleven capscrews in sequence to 30 to 35 ft lb (41 to 47 N.m) torque, Figure 16N-17.

IDLER GEARS

1. Rotate the crankshaft to put the No. 1 cylinder in the top center position.

2. Put the idler gears on the shafts with the timing marks on the camshaft idler gear (2) out. Align the "O" on the crankshaft gear (4) with the "O" on the camshaft idler gear (2), Figure 16N-19.

3. Mount only the accessory drive gasket and housing into position on the mounting stud.

4. With the crankshaft gear in position, align the timing marks "A" on the camshaft idler gear (2) and "A" on the accessory drive gears (3), Figure 16N-19.

5. Tighten the idler gear retaining capscrew to 175 to 185 ft-lbs (237 to 251 N.m) torque, Figure 16N-20.

6. Use a dial indicator or feeler gauge to check the end clearance of the idler gears. See "Idler Gears," Subsection 16B for end clearances.

NOTE

Because of excess weight, the air compressor and fuel pump should not be installed at this time.

CAUTION

Do not bar the engine until the camshaft and accessory drive have been installed since misalignment of timing marks will result.

CAMSHAFT AND GEAR

1. Install the ST-1313 Camshaft Pilot for the rear of the camshaft.

2. Lubricate the camshaft lobes and thrust plate with a high pressure lubricant.

3. Install the camshaft in the block. Use the pilot as guide to rotate and lift the camshaft slightly, Figure 16N-21. Take care not to distort the camshaft lobes or journals.

NOTE

Due to weight and length of the camshaft and pilot, two men may be required during camshaft installation.

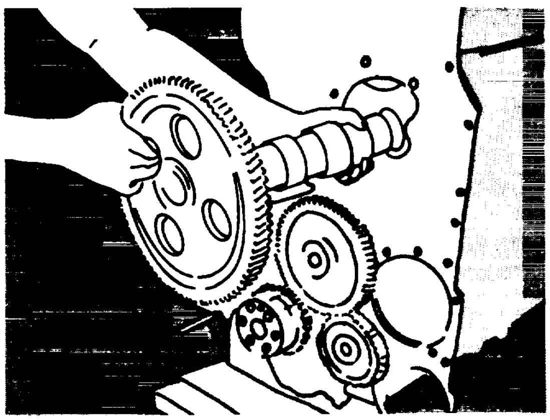


Figure 16N-21. Install the Camshaft

4. Align the "X" marks on the camshaft and idler gear to make sure the timing is correct. See Figure 16N-19.

5. Secure the camshaft thrust plate to the block. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-22. Bend lockplates.

6. Remove the camshaft pilot from the rear of the camshaft. Install the camshaft rear cover.

7. Attach the dial indicator gauge to the housing and check the camshaft end clearance, Figure 16N-23. It must be 0.006 to 0.013 inch (0.15 to 0.33 mm). If the end clearance is not within limits, remove the camshaft and change the thrust plate as outlined in Subsection 16B.

CAM FOLLOWERS

1. Put the cam follower assemblies over the right dowels to the cylinder block.

2. Install the special drilled capscrews, Figure 16N-24.

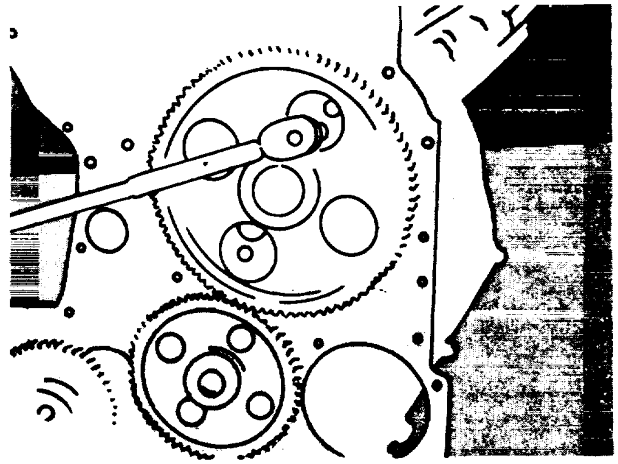


Figure 16N-22. Tighten the Camshaft Thrust Plate

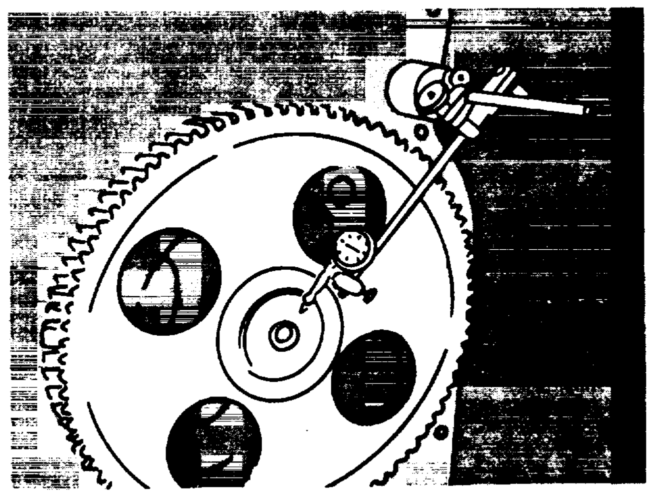


Figure 16N-23. Check the Camshaft End Clearance

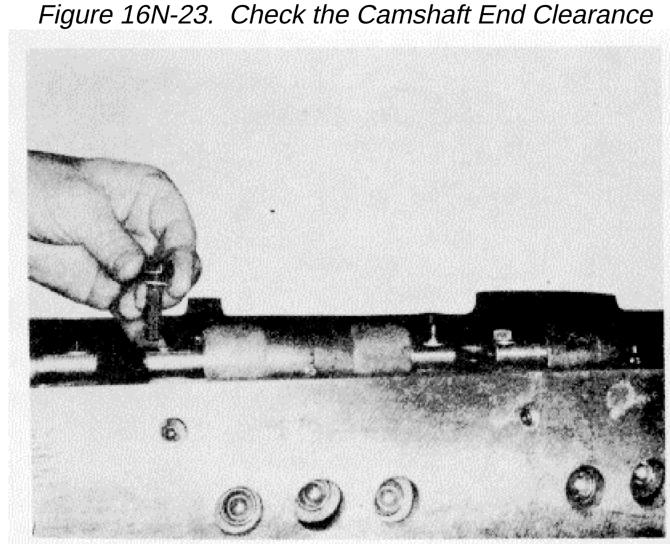


Figure 16N-24. Install the Drilled Capscrews

NOTE

Visually inspect the cross drilled hole in the capscrew shank for evidence of overtightening. Compare the capscrew with the new capscrews. If the drilled holes are out-of-round, replace the capscrews.

3. Tighten the capscrews alternately and evenly to 29 to 31 ft-lbs (39 to 42 N.m) torque, Figure 16N-25.

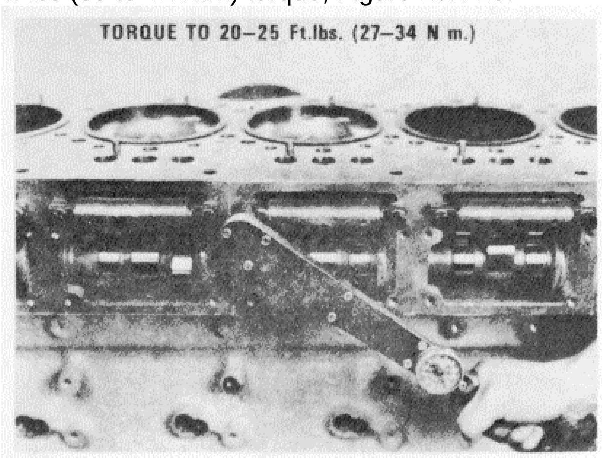


Figure 16N-25. Tighten the Cam Follower Shaft Capscrews

CYLINDER HEADS

1. Put the cylinder head gaskets over the dowels in the block. The word '0OP" on gasket must be visible after the gasket is installed, Figure 16N-26.

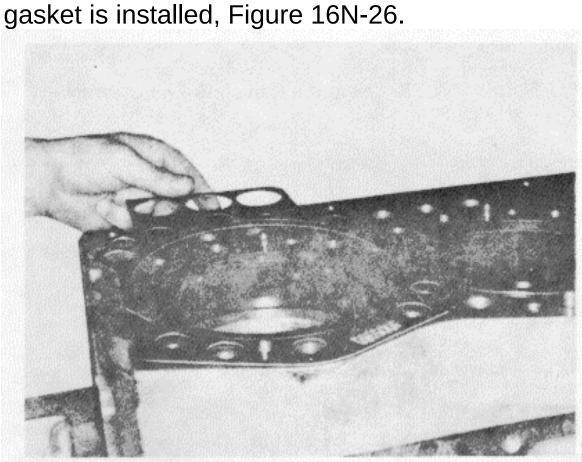


Figure 16N-26. Install the Cylinder Head Gasket

2. Put the water, oil and push rod grommets into position in each cylinder head gasket, Figure 16N-27. One capscrew

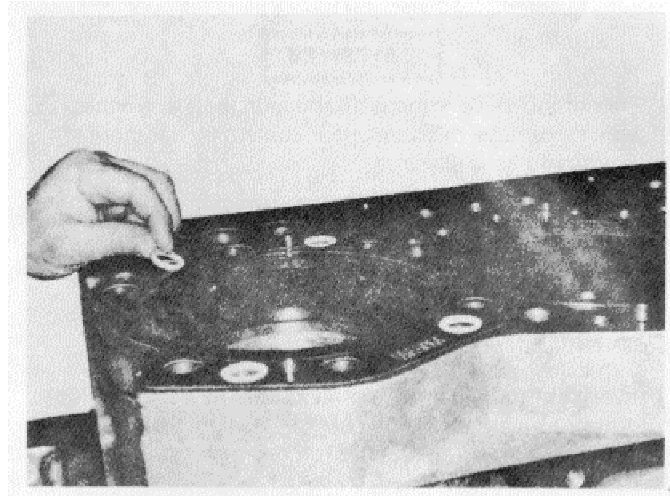


Figure 16N-27. Install the Cylinder Head Grommets

hole in each gasket, on the camshaft side of the engine, requires a grommet.

3. Use a hoist or suitable lifting device to put the cylinder heads over the dowels in block, Figure 16N-28.

NOTE

Exercise care when inserting the rubber water grommets into the head gasket so the rubber bonded to the steel washer does not roll and become pinched when head is finally installed.

4. Lubricate the threads of the cylinder head capscrews with a rust preservative lubricant. Lubricate under the capscrew head and hardened washer with SAE 140W lubricant.

NOTE

Washers must be placed on capscrews with the rounded edges toward the washer surface under the capscrew head.

5. Start the capscrews through the cylinder heads to the block by hand, engaging two (2) or more threads.

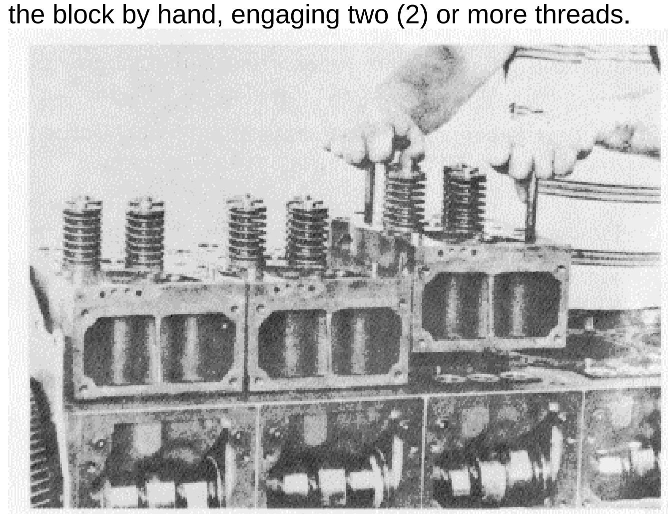


Figure 16N-28. Install the Cylinder Heads

6. Tighten the cylinder head capscrews in sequence as shown in Figure 16N-29 to the torque values as listed in Table 16N-3.

TIMING THE ENGINE

Use the ST-593 Timing Fixture and the ST-593-40 Support Block to obtain the precise timing of the push rod and piston travel. Adjustments to the timing are made by changing the camshaft keys. Timing one cylinder will complete engine timing.

1. Position the ST-593 Timing Fixture in the injector "well." Engage the push rod indicator in the injector push rod socket. Secure with knurled holddowns, tighten evenly by hand.

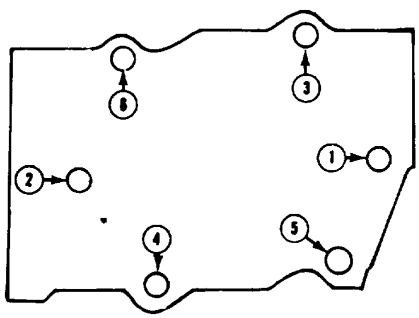


Figure 16N-29. Cylinder Head Torquing Sequence

Table 16N-3. Cylinder Head Torquing Procedure - Ft-Lb (N.m)

Torque Reading Step	**Cadium Plated**
1	40 to 60 ft-lbs [54 to 81 N-m]
2	110 to 130 ft-lbs [149 to 176 Nom]
3	180 to 190 ft-lbs [244 to 258 Nom]
4	250 to 260 ft-lbs [339 to 353 Nom]
Step	**Lubrited**
1	40 to 60 ft-lbs [54 to 81 Nom]
2	140 to 160 ft-lbs [190 to 217 Nom]
3	240 to 260-ft-lbs [244 to 353 Nam]
4	350 to 370 ft-lbs [475 to 502 Nem]

NOTE

If the adapter block as shown in Figure 16N-30, is used, attach the block to the housing and then secure the push rod indicator to the block. Tools must be mounted straight in the cylinder and over the injector push rod. Loosen the indicators in their supports to prevent damage when barring the engine.

2. Use the crankshaft to bar the engine in the direction of rotation. Bring the piston on the cylinder being checked to the top center firing position.

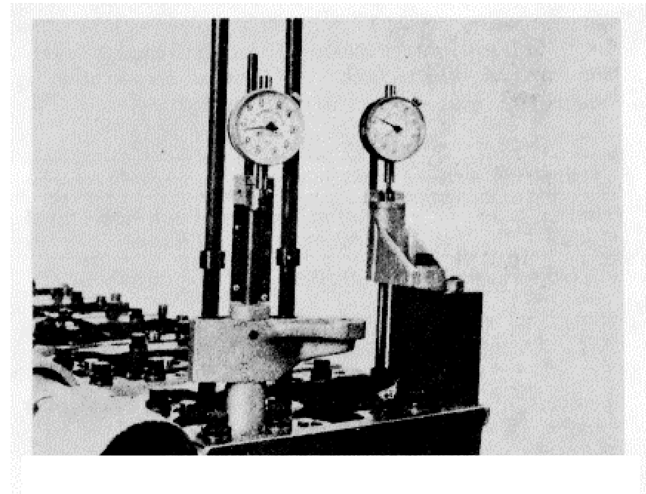


Figure 16N-30. Check the Piston and Push Rod Travel

CAUTION

The crankshaft must be used when barring the engine to check timing. If the regular barring mechanism is used an error in the indicator readings will occur and result in incorrect timing.

3. Put the piston indicator to the compress stem within 0.010 inch of inner travel stop. Secure the indicator.

4. Check the piston to be at exactly top center (1), Figure 16N-31. Turn the indicator dial to zero at this point.

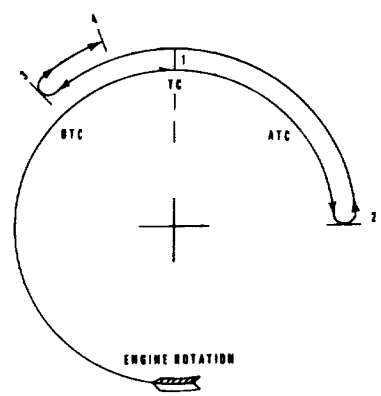


Figure 16N-31. Injector Timing Procedure

5. Bar the crankshaft in the direction of rotation (2) to 90° after top center. At this point, put the push rod indicator on the push rod follower to 0.020 inch from its inner travel stop. Secure the indicator. Turn the indicator dial to zero.

6. Bar the crankshaft in the opposite direction of rotation to a position 45° before top center (3).

7. Rotate the crankshaft in the direction of the rotation (4) until a reading of 0.2032 inch before top center is reached on the piston travel indicator. The exact reading in ten-thousandths must be estimated. Exercise care in bringing the piston travel indicator to this reading.

Table 16N-4. Injection Timing

Timing Code Code	Piston Travel (inches)	Push Rod Travel (inches)
AE Non-Aftercooled	- 0.2032	0.108 t 0.002

8. Read the push rod travel indicator. It should read the push rod travel as indicated in Table 16N-4.

9. If the timing is not within these limits, refer to "Camshaft," Subsection 16B for instructions in changing the key to adjust the timing.

10. Remove the timing fixture.

ACCESSORY DRIVE
(FUEL PUMP, AIR COMPRESSOR)
1. Install the accessory drive over the stud to the housing. Align the "A's" on the accessory drive gear and idler gear.

2. The accessory drive capscrews are installed after the front housing cover installation, Figure 16N-32.

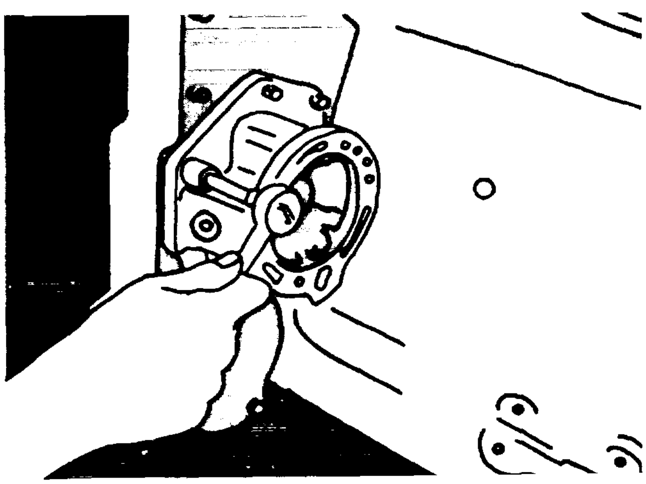


Figure 16N-32. Install the Accessory Drive

LUBRICATING OIL PUMP
1. Lubricate the O-rings with clean engine lubricating oil. Put on the pump body.

2. Coat both sides of the sealing ring with a lubricate and put on the rear (block end) of the pump, Figure 16N-33.

Figure 16N-33. Install the Sealing Ring

NOTE
The sealing ring must stay in position on the pump body during installation.

3. Lubricate the pump bore in the block with a clean engine lubricating oil.

4. Install the pump into the bore. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-34.

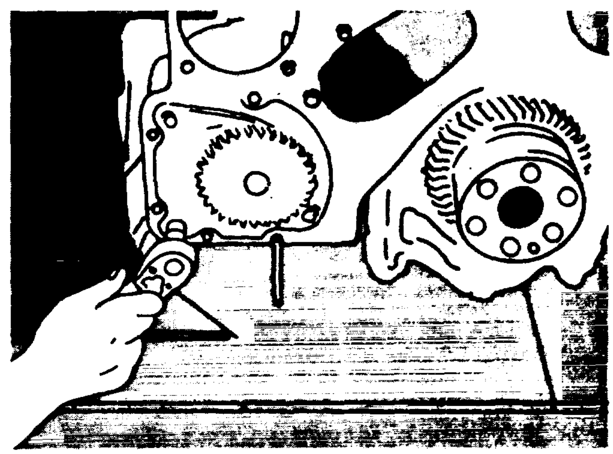


Figure 16N-34. Tighten the Lubricating Oil Pump Capscrews

5. Check the gear backlash. The backlash must be 0.003to 0.012 (0.08 to 0.30 mm). Backlash can be adjusted by loosening the capscrews and rotating the lubricating pump.

6. Visually check the sealing ring through the pump cavity between No. 1 rod and No. 2 main bearing journals) to make sure that the ring is properly seated.

WATER PUMP DRIVE
The water pump drive and water pump assembly with a water filter may be installed as a complete assembly after the front cover installation.

1. Use a suitable gasket adhesive to position the drive assembly gasket to the front cover housing.

2. Put the drive assembly over the stud. Tap into position with a soft hammer. Align the drive gear with the idler gear.

GEAR TRAIN BACKLASH
1. Attach a dial indicator to the gear housing with the plunger on a tooth of the gear to be checked, Figure 1 6N-35.

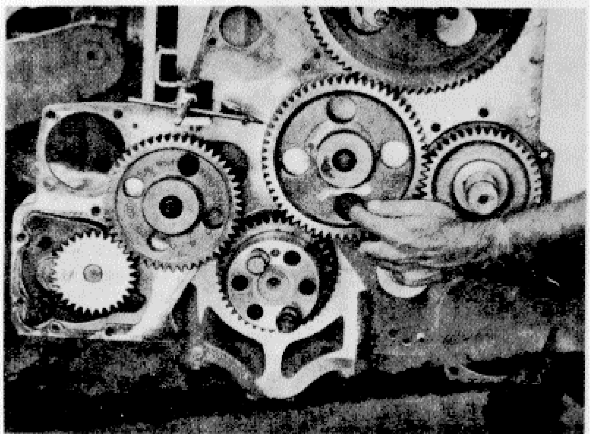


Figure 16N-35. Check the Gear Backlash

2. Lock the mating gear in position. Rotate the gear to be checked as far as it will move to take up the backlash. Turn the indicator to zero.

3. Rotate the gear in the opposite direction. Read the gear backlash travel on the indicator gauge. Backlash travel should be 0.003 to 0.012 inch (0.08 to 0.30 mm) on all gears.

4. Move the dial indicator to the next gear and repeat the procedure.

FRONT COVER INSTALLATION Make sure all bushings, seals and pipe plugs are installed before installation.

1. Use a suitable gasket adhesive, place the front cover gasket to the steel plate.

2. Lubricate the seal inside diameters and shaft outside diameters, crankshaft and fuel pump/compressor, water pump drives (if installed), with a clean lubricating oil.3. Align the cover over the shafts and dowels in the housing and tap into position using a soft hammer, Figure 16N36.

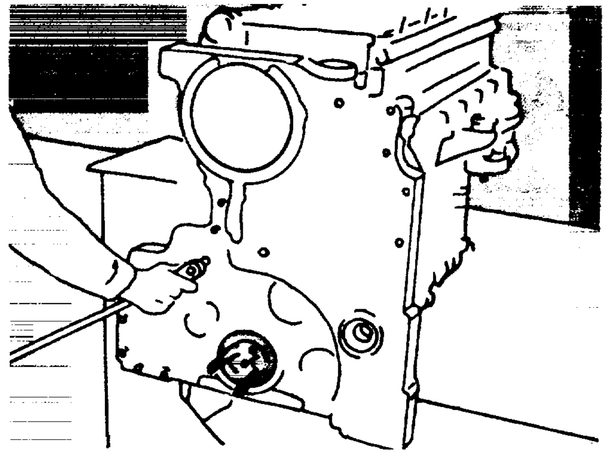


Figure 16N-36. Install the Front Cover

NOTE

Install the master dowel in the cylinder block at this time if the steel plate and front cover were installed with the pan adapter already installed, Figure 16N-37.

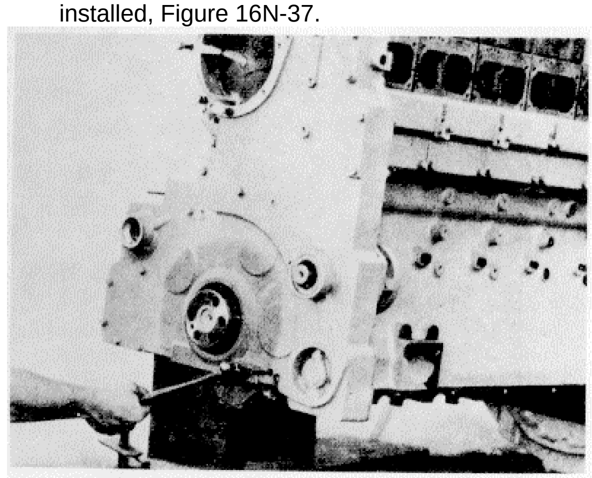


Figure 16N-37. Install the Master Dowel

4. Install and tighten the front cover mounting capscrews in the sequence shown in Figure 16N-38 to 30 to 35 ft-lb (41 to 47 N.m) torque.

5. Trim the excess gasket material from the front cover gasket and the steel plate gasket so that only 0.010 inch (0.25 mm) gasket material protrudes from the lower side of the block, Figure 16N-39.

OIL PAN ADAPTER
Before installing the pan adapter to the block, secure the lubricating oil pump suction tube assembly to the adapter, if not previously installed.

1. Rotate the engine on the rebuild stand until the pan adapter rail is at the top and horizontal.

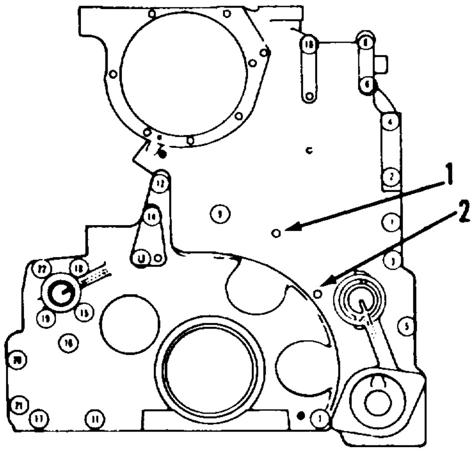


Figure 16N-38. Front Cover Mounting Capscrew Tightening Sequence

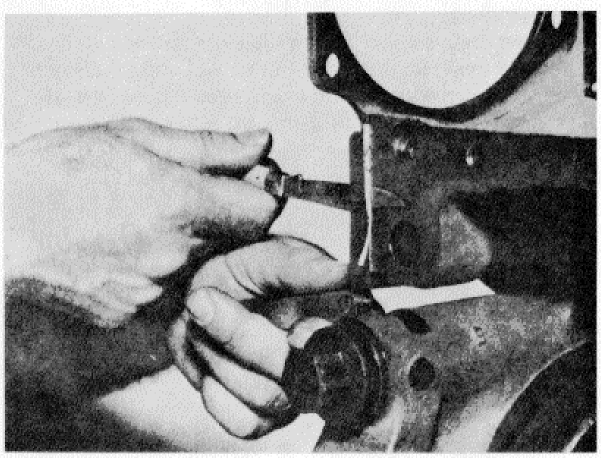


Figure 16N-39. Trim the Excess Gasket Material

2. Install the four (4) guide studs (two on each side spaced evenly) into the capscrew holes in the rail.

3. Install the gasket to the pan rail over the guide studs.

4. Put the adapter over the studs. Start several capscrews by hand to align the adapter to the block. Do not tighten the capscrews. Remove the guide studs.

NOTE

Capscrew installation is to be completed after the flywheel housing is installed.

5. Use a suitable gasket adhesive. Install four (4) bolt seals (1), Figure 1 6N-40, and two(2) rectangular sealing strips(2) to the pan adapter (flywheel end).

NOTE

The adhesive must hold these seals in position during the flywheel housing installation.

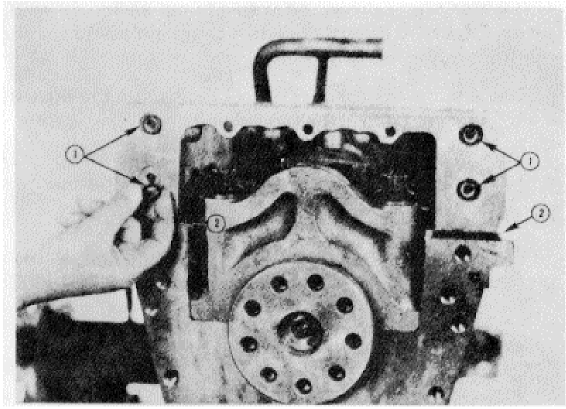


Figure 16N-40. Install the Pan Adapter to the Flywheel Housing Seats

FLYWHEEL HOUSING

1. Inspect the flywheel housing dowels. If looseness or evidence of wear is found, remove the dowels from the block.

NOTE

If a new flywheel housing is being installed, the old dowels must be removed and oversize dowels installed. See "Custom Dowel Flywheel Housing" following.

2. Install two (2) guide studs into the rear of the block to guide and support flywheel housing.

3. Use a suitable gasket adhesive to install a rectangular sealing strip into the groove of flywheel housing. The butt joint should be at the top of the housing.

NOTE

The sealing rings must be installed in the counterbores around the capscrew and dowel holes.

4. Lift the housing into position over the guide studs and use a soft hammer to tap into position over the dowels.

5. Start the capscrews and tighten finger tight, Figure 1 6N41. Remove the guide studs. Install and snug tighten all the capscrews.

CHECK FLYWHEEL HOUSING BORE WITH INDICATOR. The flywheel housing face and seal bores are checked in a similar manner. Both bores should be checked and corrected to meet specifications in Table 16N-5, if necessary.

1. Install the ST-1325 Dial Gauge or a suitable fixture to the crankshaft flange, Figure 16N-42. Turn the indicator to zero on the surface to be checked.

2. Draw chalk marks on the flywheel housing at 12, 3, 6 and 9 o'clock.

3. Check the readings at 9 and 3 o'clock. If the total indicator reading exceeds the specifications, move the housing

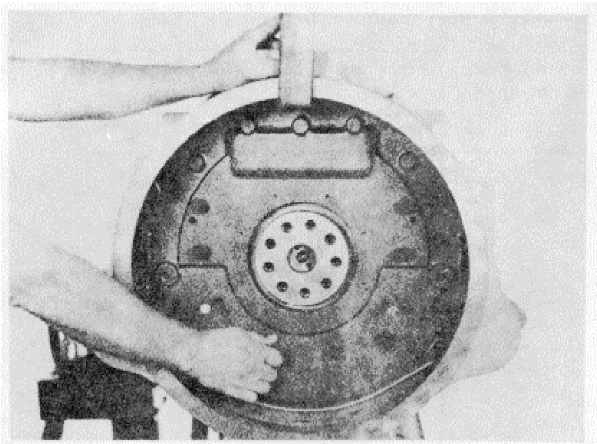


Figure 16N-41. Install the Flywheel Housing Capscrews

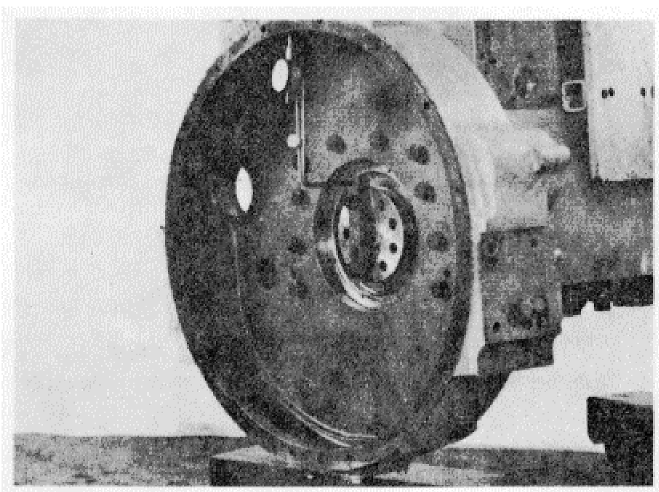


Figure 16N-42. Use the Indicator to Check the Flywheel Housing Bore

one-half the distance of the total indicator reading to center the housing horizontally.

4. Check the readings at 12 and 6 o'clock. If the total runout exceeds the specifications, move the housing up or down, whichever is necessary, one-half the distance of the total indicator reading to center the housing vertically.

CHECKING FLYWHEEL HOUSING FACE WITH INDICATOR. Check flywheel housing face as follows:

1. Move the dial gauge to the face of the housing as shown in Figure 16N-43.

2. Push the crankshaft forward to take up end clearance. Turn the crankshaft to obtain readings on the housing face.

3. The total flywheel housing face run-out must not exceed the specifications in Table 16N-5.

4. To correct housing face run-out, remove the housing and check the sealing strip alignment. Remove any burrs and clean the mating surfaces. Install and align the housing.

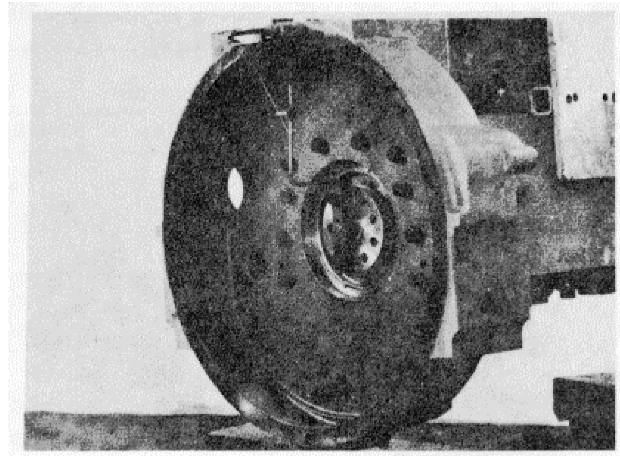


Figure 16N-43. Use the Indicator to Check the Flywheel Housing Face

5. If the readings are within the limits and the dowels were not removed, tighten the capscrews to 140 to 160 ft-lbs (190 to 217 N.m) torque, Figure 16N-44.

6. Install the remaining capscrews in the oil pan adapter. Check the capscrews for proper size and length.

7. Tighten two (2) end capscrews (flywheel housing end)to hold the pan adapter to the block rail.

TORQUE TO 140-160ft.lbs. 190-217 N m

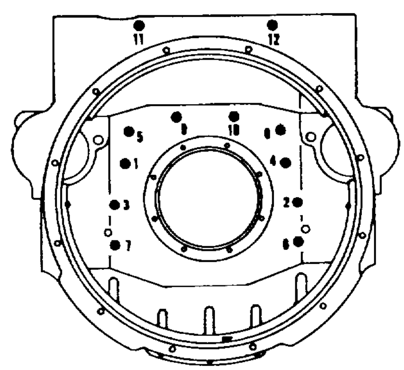


Figure 16N-44. Tighten the Flywheel Housing

8. Starting with the side capscrews securing the buttress end of the adapter to the flywheel housing, tighten the capscrews, Figure 16N-45, alternately and evenly to the values listed in Step 11 following. See "B," Figure 16N-45.

9. Loosen the capscrews tightened in Step 7.

10. Tighten the pan adapter-to-block capscrews in the sequence shown in "A," Figure 16N-45.

11. The pan adapter capscrew torque values are: A. 3/8-16 30 to 35 ft-lbs (41 to 47 N.m) 16N-15

A. 3/8-16 30 to 35 ft-lbs (41 to 47 N.m)

Table 16N-5. Flywheel Housing Specifications Inch (mm)

SAE No.	Bore Diameter	Clutch Bore Tolerance	Face Run-Out Tolerance	Seal Bore Tolerance
1	20.125 to 20.130 (534.27 to 534.40)	0.008 (0.20)	0.008 (0.20)	0.008 (0.20)

B. 7/16-14 40 to 45 ft-lbs (54 to 61 N.m)

C. 9/16-12 60 to 70 ft-lbs (81 to 91 N.m)

CUSTOM DOWEL FLYWHEEL HOUSING. If a new flywheel housing is being used or if the dowels were removed from the block, install oversize dowels as follows:

1. After the dowels are removed from block, install undersize, internally drilled, dummy dowels.

2. Install the housing to block. Tighten the capscrews. The capscrews must be tight enough to hold the housing in position. Remove the dummy dowels.

3. Use the indicator to check the flywheel housing bores and face as described under "Flywheel Housing." 4. After the flywheel housing is in the correct position tighten all the capscrews to 140 to 160 ft-lbs (190 to 217 N.m) torque.

5. Use the ST-1232 Dial and Ream Fixture and ST-1233 Bushing Set to drill and ream the dowel holes to the smallest permissible oversize. See Table 16N-6.

Table 16N-6. Flywheel Housing Dowels

Diameter	Oversize
.501 (12.725)	Standard
.515 (13.081)	0.015 (0.381)
.532 (13.513)	0.030 (0.762)
.547 (13.894)	0.046 (1.168)

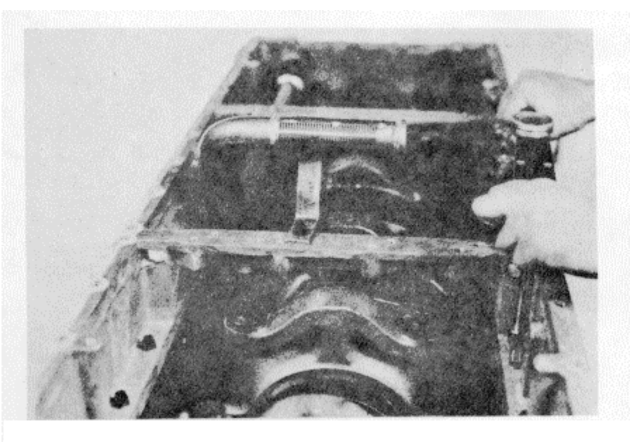
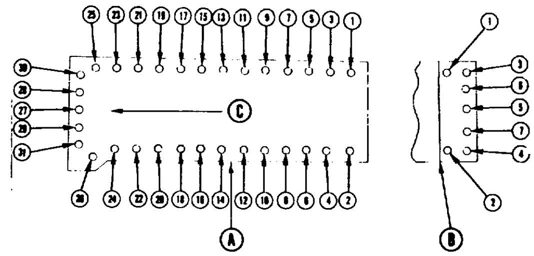


Figure 16N-45. Tighten the Pan Adapter to the Block



A. Adapter to Block
B. Adapter to Flywheel Housing
C. Front of Engine

Figure 16N-46. Oil Pan Adapter Tightening Sequence

NOTE
The crankshaft must be held stationary during the drilling and reaming operation.

6. Remove the drill and ream fixtures. Clean the holes thoroughly.

7. Install the oversize dowels. The dowels must be even or below the surface of the flywheel housing.

REAR CRANKSHAFT OIL SEAL

1. Lubricate the oil seal O-ring with a clean engine lubricating oil. Put the seal over the crankshaft into the bore in the flywheel housing.

2. Put the seal housing over the crankshaft. Align the capscrew holes. Make sure the housing trunnion enters the 0ring evenly.

3. Install the locking (self-sealing) capscrews. Tighten alternately and evenly to 7 to 9 ft-lbs (9 to 12 N.m) torque.

NOTE
Do not apply oil to the LAY DOWN LIP type seal.

FLYWHEEL

1. Install the two (2) guide studs in the crankshaft flange to guide and support the flywheel.

2. Use a suitable lifting device to put the flywheel over the guide studs and against the crankshaft flange, Figure 16N47.

3. Lubricate the place bolt threads with a clean engine lubricating oil. Lubricate the hardened washer faces with SAE 140W lubricant.

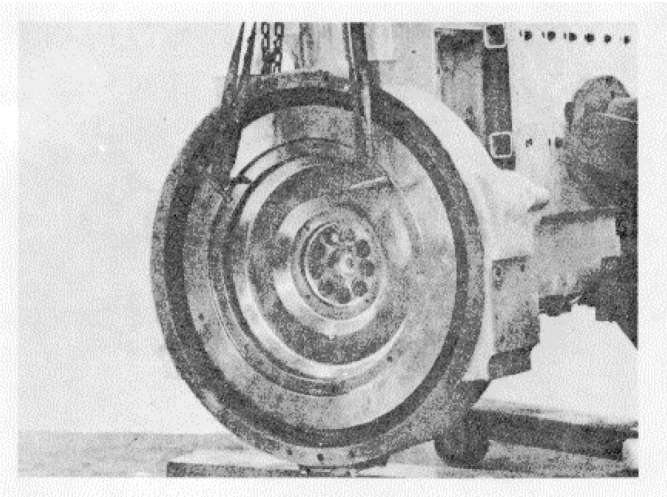


Figure 16N-47. Install the Flywheel

4. Install the seven (7) place bolts and tighten by hand 1 to 1-1/2 turns.

5. Remove the guide studs. Install and tighten the remaining place bolts 1 to 1-1/2 turns by hand.

6. Tighten all the place bolts in sequence as shown in Figure 16N-48 to 100 to 120 ft-lbs (136 to 163 N.m) torque.

7. Repeat the tightening sequence. Tighten to a final torque of 200 to 220 ft-lbs (271 to 292 N.m).

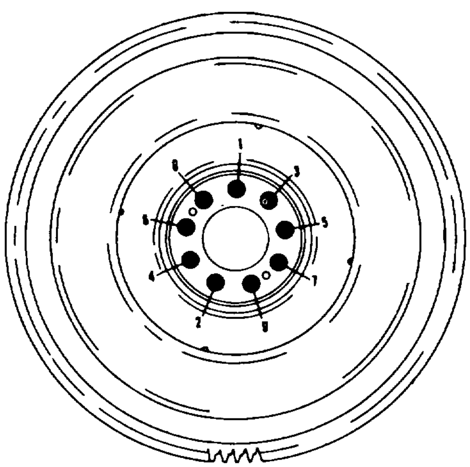


Figure 16N-48. Flywheel to Crankshaft Tightening Sequence

8. Check the clutch pilot bearing bore with an indicator.

A. Attach the indicator gauge to the flywheel housing. Put the point of the indicator into the bore inside diameter.

B. Rotate the flywheel. The total indicator reading must not exceed 0.005 inch (0.13 mm) in one complete revolution, Figure 16N-49.

9. Check the flywheel clutch face with the indicator

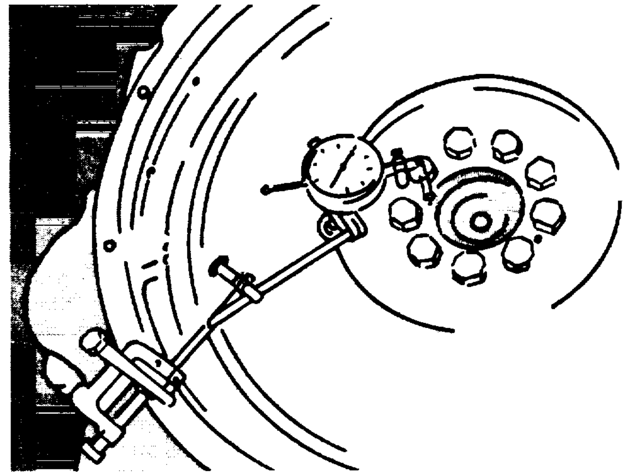


Figure 16N-49. Check the Flywheel Bearing Bore with Indicator

A. Move the gauge to the clutch face of the flywheel, Figure 16N-50.

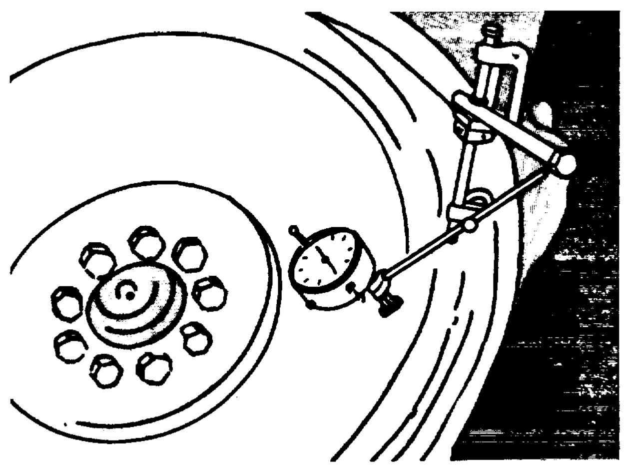


Figure 16N-50. Check the Flywheel Clutch Face with the Indicator

B. Put the crankshaft to the front or rear limit of the thrust clearance. Turn the gauge to zero.

C. Rotate the flywheel. The total indicator reading must not exceed 0.0005 inch (0.013 mm) per inch of the diameter of the outer 1/3 of the clutch face radius.

NOTE

If the total indicator readings exceed the limits listed in 8B and 9C preceding, remove the flywheel. Clean the flywheel and crankshaft flange faces and install the flywheel. Repeat checks.

10. If any place bolts are removed or loosened after final tightening, loosen and tighten all the place bolts and repeat Steps 6 through 9.

OIL PAN AND ADAPTER COVER

1. Use guide studs to put the gaskets to pan adapter in the correct position.

2. Put the sump of the oil pan in the proper position. Put the pan and adapter cover over the guide studs. Start several capscrews. Hand tighten and remove the guide studs.

3. Install the remaining capscrews. Starting at center and alternating from side to side of the oil pan or adapter, tighten the capscrews evenly to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-51.

TORQUE TO 30-35 Ft. lbs. (41-47 N m)

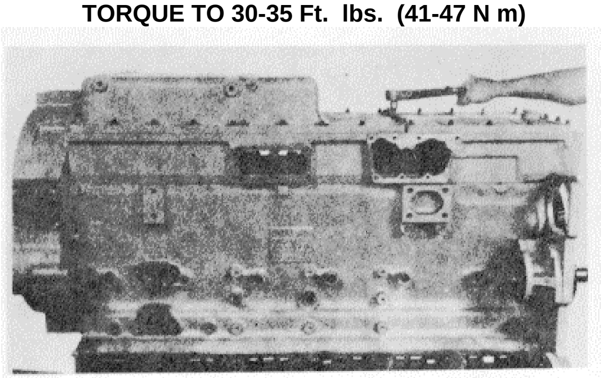


Figure 16N-51. Tighten the Oil Pan Capscrews

PISTON COOLING NOZZLES

1. Lubricate the O-rings with a clean engine lubricating oil; position on the nozzle. Be sure the O-rings are not twisted in groove.
2. Insert the nozzles in the block, Figure 16N-52, and align the notch in the nozzle with the threaded hole in the block.

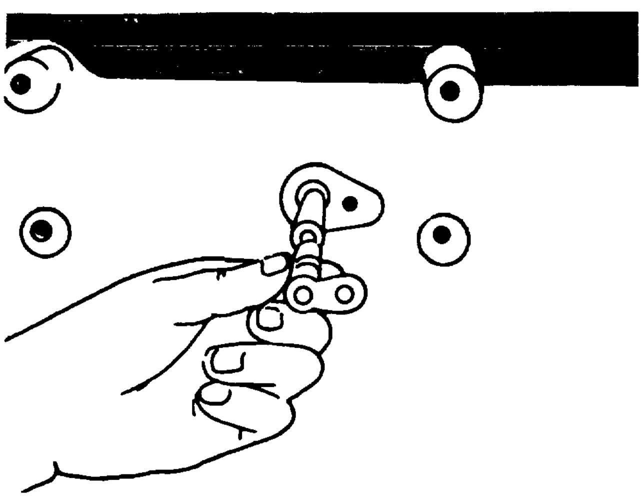


Figure 16N-52. Install the Piston Cooling Nozzle

3. Tighten the nozzle screws to 8 to 10 ft-lbs (1 1 to 14 N.m) torque, Figure 16N-53.

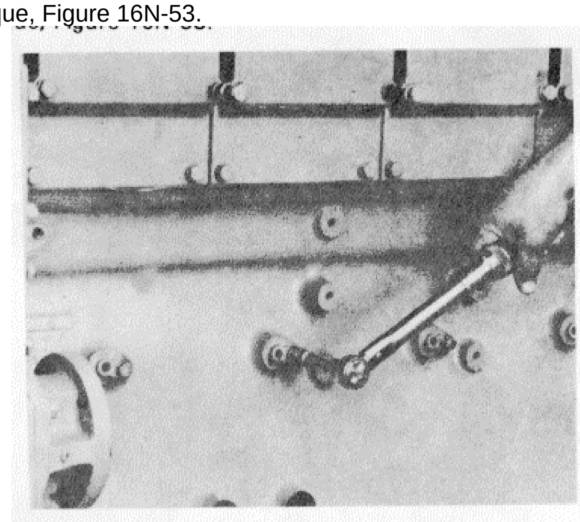


Figure 16N-53. Tighten the Piston Cooling Nozzle Screw

ROCKER HOUSINGS/WATER MANIFOLD

The water manifolds and rocker housings are installed to the cylinder heads at the same time. Passages cast into the housing and transfer tubes sealed with O-rings make up the water manifold.

1. Put the gaskets over the dowels in the cylinder heads.
2. Lubricate the O-rings with a clean engine lubricating oil and put on the water transfer tubes and rear housing plug.
3. Install the front rocker housing to the cylinder head. Put the water transfer tube into the rear of the water passage. Make sure the retaining ring groove is to the front of the engine. Push the tube into the passage until it reaches bottom.
4. Install the second rocker housing. Use the ST-1319 to move the water transfer tube from the water passage in the front housing into position in the passage of the housing being installed. Secure with a retaining ring.
5. Repeat Steps 3 and 4 for the remaining rocker housings, Figure 16N-55.
6. Starting in the center, tighten the capscrews alternately and evenly to 60 to 70 ft-lbs (81 to 95 N.m) torque, Figure 16N-54.
7. Put the plug in the rear of the rear rocker housing and secure it with groove pin.

VALVE CROSSHEAD ADJUSTMENT

1. Put the crossheads over the guides with the adjusting screws toward the water passage in the rocker housing.
2. Loosen the adjusting screw locknuts and back the adjusting screws off one (1) turn, if not previously done.
3. Use light finger pressure at rocker lever contact surface to hold the crosshead in contact with the valve stem near-

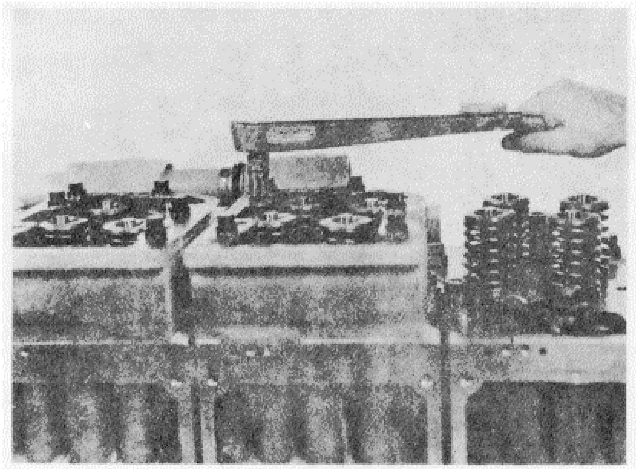


Figure 16N-54. Tighten the Rocker Housing Capscrews

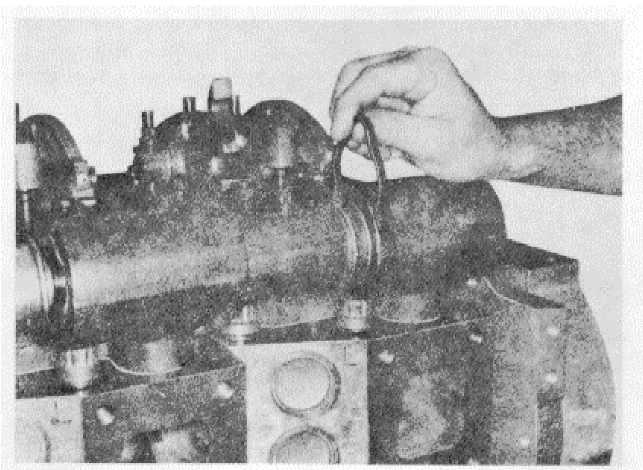


Figure 16N-55. Install the Water Transfer Tube Retaining Ring

est the push rod. Turn the adjusting screw down until it contacts its mating valve stem, Figure 1 6N-56.

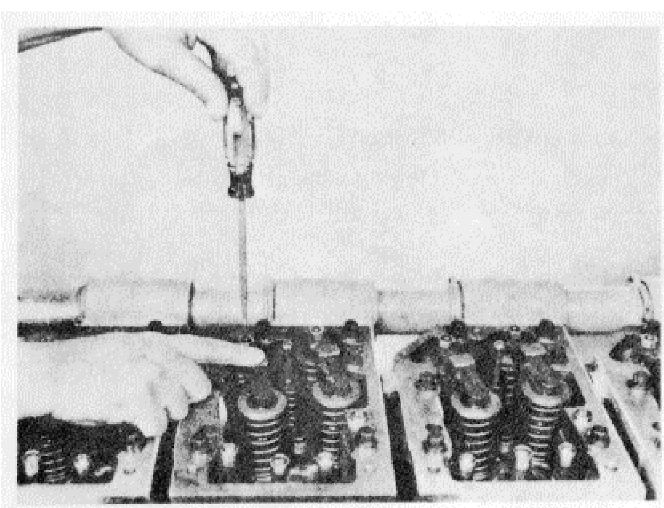


Figure 16N-56. Adjust the Valve Crosshead

4. Use the ST-669 Torque Wrench Adapter to hold the adjusting screw in position. Then tighten the locknut to 22 to 26 ft-lbs (30 to 35 N.m) torque, Figure 16N-57. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver and then tighten locknuts to 25 to 30 ft-lbs (36 to 41 N.m) torque.

5. Check the clearance between the crosshead and the valve spring retainer, Figure 16N-58, with a wire gauge. There should be a minimum of 0.025 inch (0.64 mm) clearance at this point.

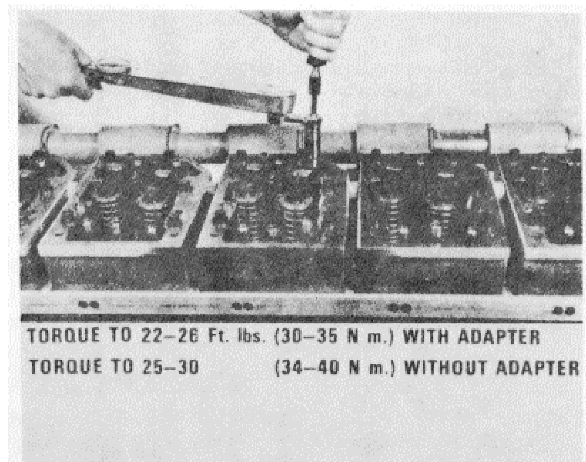


Figure 16N-57. Tighten the Crosshead Locknut

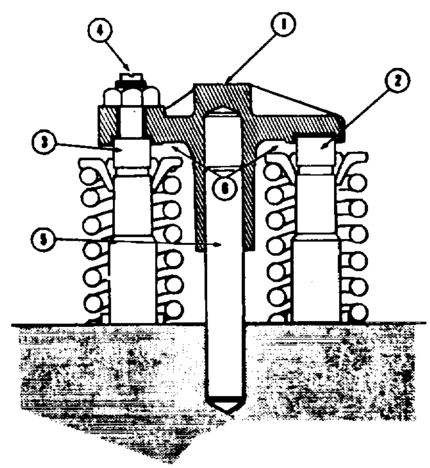


Figure 16N-58. Valve Crosshead

PUSH RODS

The injector push rod has a larger outside diameter than the valve push rods. The injector push rod fits in the middle socket. Lubricate the ball ends with clean engine lubricating oil. Seat push rods firmly in the cam follower sockets.

INJECTORS

1. Lubricate the injector "wells" with clean engine lubricating oil. Install the injector valve seats onto the injector.

NOTE

Only one (1) valve seat is to be installed in each injector "well." 2. Lubricate the injector body O-rings with a light coat of clean engine lubricating oil. Check after installation on injectors for twisted O-rings. Straighten as required.

3. Start the injector into the bore by hand. Then use the ST1297 to push the injector into position.

NOTE

Remove the injector and inspect the O-rings and valve seat if the injector fails to go into position.

4. Put the holddown plate over the injector body. Start the holddown capscrews. Do not tighten.

5. Carefully insert the injector plunger link, Figure 16N-59. Tighten the holddown capscrews alternately and evenly to 11 to 13 ft-lbs (15 to 18 N.m) torque, Figure 16N-60.

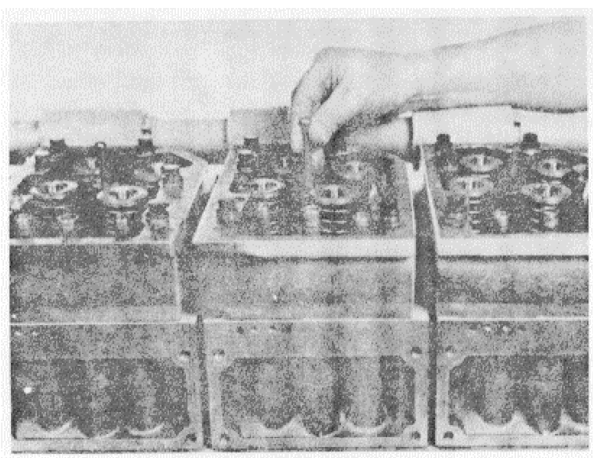


Figure 16N-59. Install the Injector Plunger Link

FUEL MANIFOLD

1. Coat the O-rings with lubriplate and put them into the counterbores on the block side of the fuel manifold.

NOTE

O-rings must stay in position in the manifold counterbores during installation.

2. Carefully put the manifold to the cylinder heads. Align the O-rings with the fuel drillings. Secure with Allen head countersunk screws.

NOTE

Coat the mating surface of the screw head with antiseize compound to aid in removal.

TORQUE TO 11-13 ft. lbs. 15-18N m.

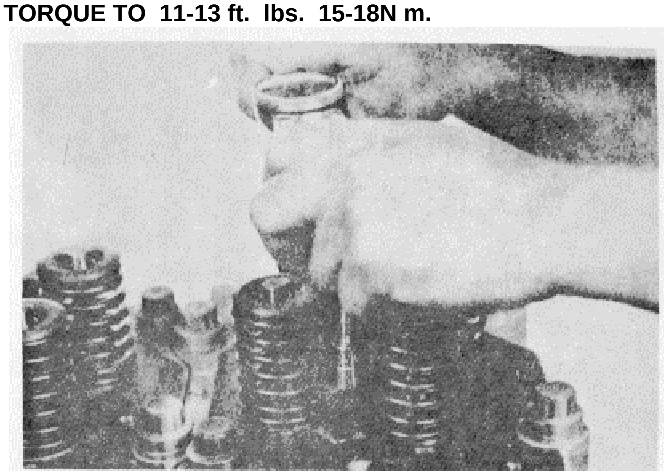


Figure 16N-60. Tighten the Injector Holddown Capscrews

3. Use an Apex adapter and inch-pound torque wrench to tighten screws starting in the center, alternately and evenly to 40 to 45 in-lbs (4.5 to 5.1 N.m)torque, Figure 16N-61.

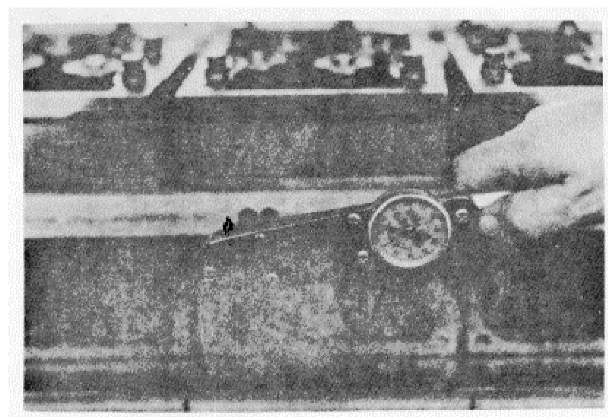


Figure 16N-61. Tighten the Fuel Manifold Screws

ROCKER LEVER ASSEMBLIES

1. Loosen the locknuts and back off the rocker lever adjusting screws two (2) or three (3) turns, if not previously done.

2. Lubricate the push rod sockets and adjusting screws with clean engine lubricating oil.

3. Put the rocker lever assembly to the housing with the ball ends of adjusting screws fitting into their respective push rod sockets.

4. Install the capscrews and washers. The longer capscrew goes through the rear of the housing into the cylinder head. Tighten the capscrews alternately and evenly to 60 to 70 ft-lbs (81 to 95 N.m) torque, Figure 16N-62.

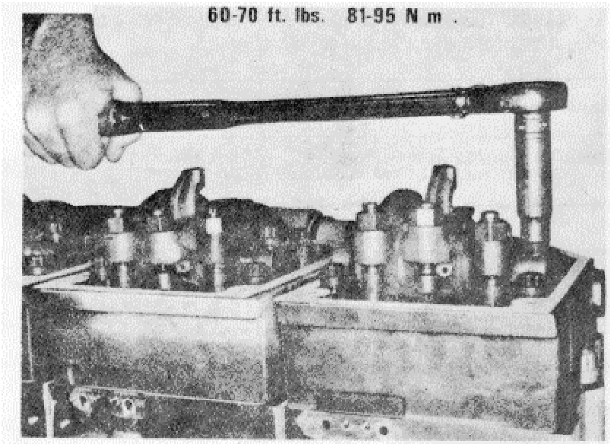


Figure 16N-62. Tighten the Rocker Lever Assembly Capscrews

INJECTOR AND VALVE ADJUSTMENT

Bar the engine in the direction of rotation until the "A" valve set mark on the pulley is aligned with the pointer on the gear housing cover, Figures 16N-63 and 16N-64. In this position the injector plunger for the No. 3 and No. 4cylinder will be at the top of its travel and rocker levers for No. 5 or No. 2 cylinder will be free (valves closed).

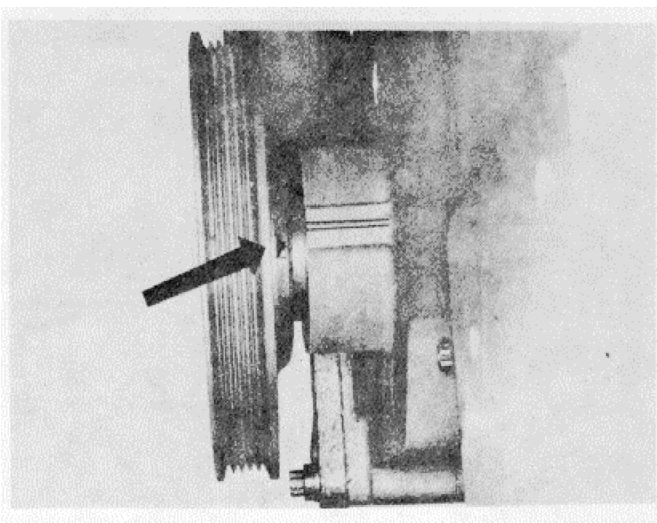


Figure 16N-63. Valve Set Marks

NOTE

The injector and valves on any one (1)cylinder cannot be set at the same time. Example: If the rocker levers on No. 2 cylinder are free (valves closed), the injector plunger travel on No. 4 cylinder is to be adjusted. Then adjust the valves on No. 2 cylinder. See Table 1 6N-7.

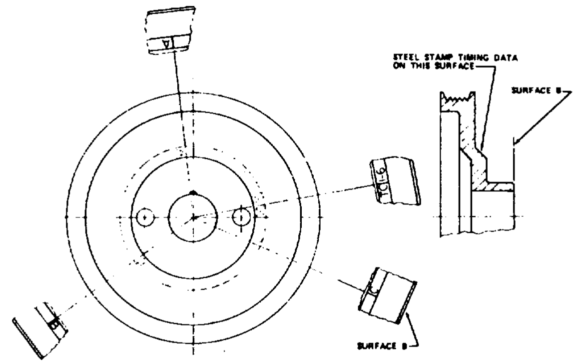


Figure 16N-64. Accessory Drive Pulley Markings

INJECTOR PLUNGER TRAVEL ADJUSTMENT WITH 3375004 KIT

1. Set up the 3375007 Indicator Support with an extension on the injector plunger top at the No. 4 cylinder. Make sure the indicator extension is secure in the indicator stem and not against the rocker lever.

2. Use the 3375010 Rocker Lever Actuator, Figure 16N-65 to depress the injector plunger until the plunger is at the bottom in the cup to squeeze oil film from the cup.

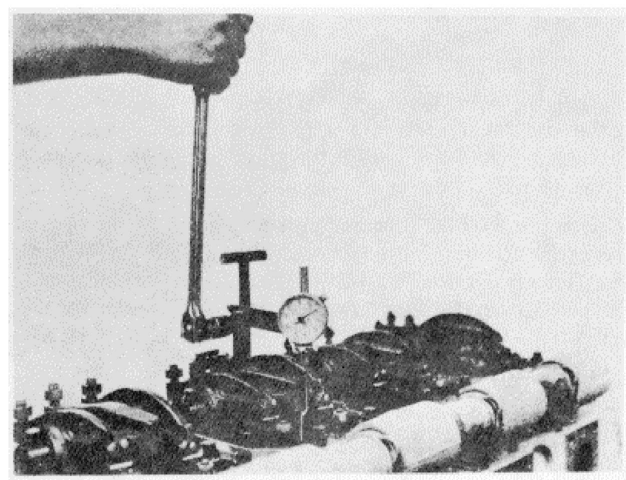


Figure 16N-65. Actuate the Rocker Lever to the Set Dial Indicator

Table 16N-7. Injector and Valve Set Position

Bar in Direction	Pulley Position	Set Cylinder Injector	Valve
Start	A	3	5
Adv. To	B	6	3
Adv. To	C	2	6
Adv. To	A	4	2
Adv. To	B	1	4
Adv. To	C	5	1

Firing Order 1 -5-3-6-2-4

3. Allow the injector plunger to rise and reach the bottom again. Set the dial indicator at zero (0) with the injector plunger at bottom, Figure 16N-65. At this point, check the extension contact with the plunger top.

4. Allow the plunger to rise. Then go to the bottom again to check the zero (0) dial indicator setting.

5. Remove the rocker lever actuator and turn the adjusting screw until the adjustment value, Table 16N-8, is obtained on the dial indicator, Figure 16N-66.

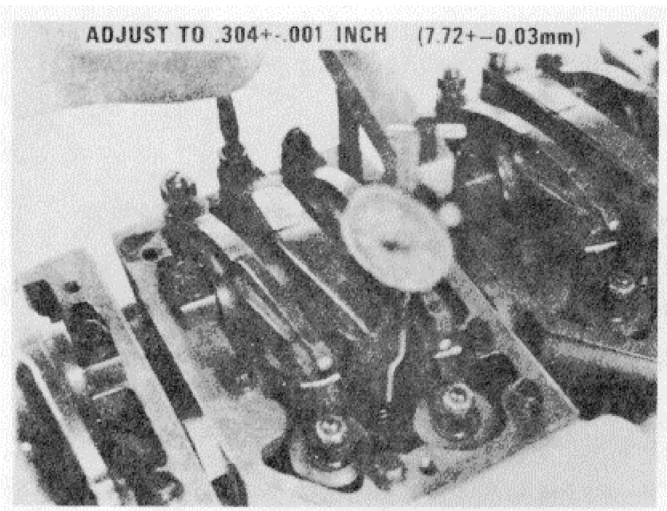


Figure 16N-66. Adjust the Injector Plunger Travel

6. Use the rocker lever actuator bottom plunger again to release the lever. The indicator must show the injector plunger travel to be within the travel range as shown in Table 16N-8.

7. Use the ST-669 Torque Wrench Adapter on the adjusting screw to tighten the locknut to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 1 6N-67. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver and tighten the locknuts to 40 to 45 ft-lbs (54 to 61 N.m)torque.

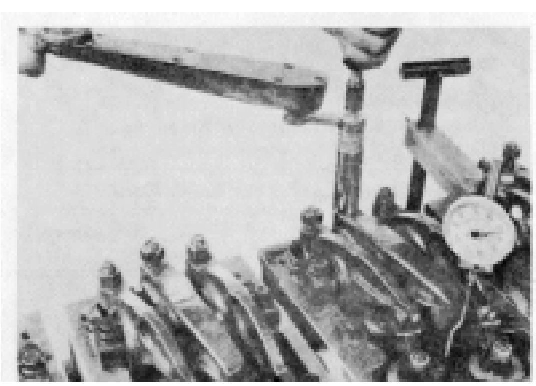


Figure 16N-67. Tighten the Locknut with a ST-669 Adapter

8. Actuate the injector plunger several times as a check of adjustments. Adjust again if necessary.

Table 16N-8. Uniform Plunger Travel Adjustment Limits

Injector Plunger Travel Inch [mm]	**Valve Clearance Inch [mm]**	
Adj. Valve	**Intake**	**Exhaust**
0.304 + 0.001 [7.72]	0.014 [0.36]	0.027 [0.69]

VALVE ADJUSTMENT

Before adjusting the valve on cylinder No. 2, be sure that the crossheads are in proper adjustment.

1. Insert the correct thickness feeler gauge between the rocker lever and crosshead for the valve being adjusted. See Table 16N-8 for valve clearances.

NOTE

The exhaust valves are toward the front of each cylinder head.

2. Turn the adjusting screw down until the rocker lever just touches the feeler gauge, Figure 16N-68. In this position, tighten the locknut to the same value as the injector locknuts.

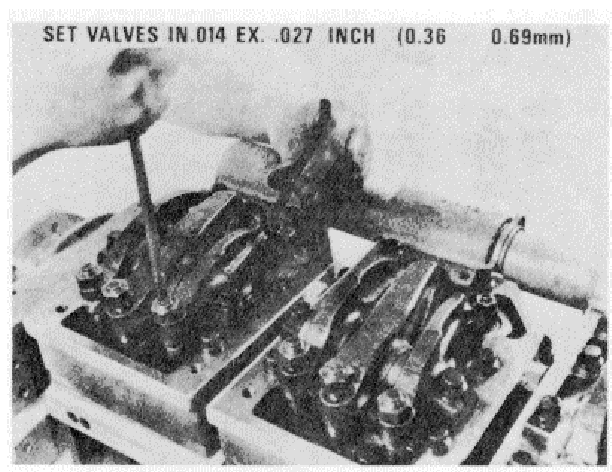


Figure 16N-68. Adjust the Valves

After completing the injector and valve adjustments at the "A" valve set position, bar the engine in the direction of rotation until the next valve set mark on the accessory drive pulley is lined up with the mark on the gear housing cover. Repeat "Injector Plunger Travel" and "Valve Adjustment" procedure as described in Table 16N-7 for each cylinder until all rocker levers are properly adjusted.

VALVE COVERS

Put the valve covers and gaskets to rocker housings. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-69.

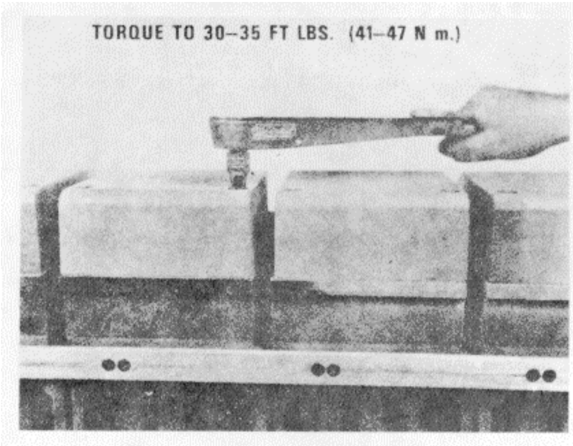


Figure 16N-69. Tighten the Valve Covers

INTAKE MANIFOLD

1. Put the intake manifold to the cylinder heads. Use several guide studs to hold the gasket in position.

NOTE

Be sure the guide studs are long enough to protrude through the intake manifold after installation.

2. Put the intake manifold over the guide studs. Be sure the gasket is not misaligned. Tighten several capscrews finger tight to hold the gasket in position before removing the guide studs.

3. Lubricate the O-ring on the air compressor supply tube (if used) with clean engine lubricating oil. Put the tube into the bore in front of the intake manifold.

4. Install the remaining capscrews. Starting in the center, tighten the capscrews alternately and evenly to 30 to 35 ft lbs (41 to 47 N.m) torque, Figure 16N-70.

CAM FOLLOWER COVERS

1. Install the cam follower covers. Put the covers with the filter tube and breather over cam followers as noted during removal.

2. Tighten the capscrews to 15 to 20 ft-lbs (20 to 27 N.m) torque, Figure 16N-71.

ACCESSORY DRIVE AND ALTERNATOR PULLEYS

The accessory drive and alternator pulleys are installed in a similar manner.

1. Put the oil slinger over the shaft (accessory drive shaft). Install the key. Lubricate the shaft and pulley bore with clean engine lubricating oil.

TORQUE TO 30-35 Ft. lbs. (41-47 N·m.)

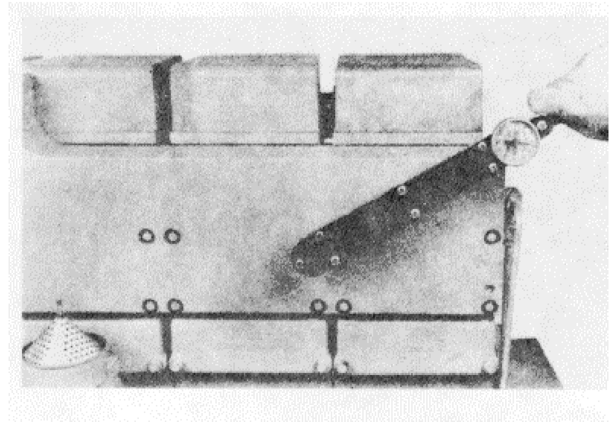


Figure 16N-70. Tighten the Intake Manifold

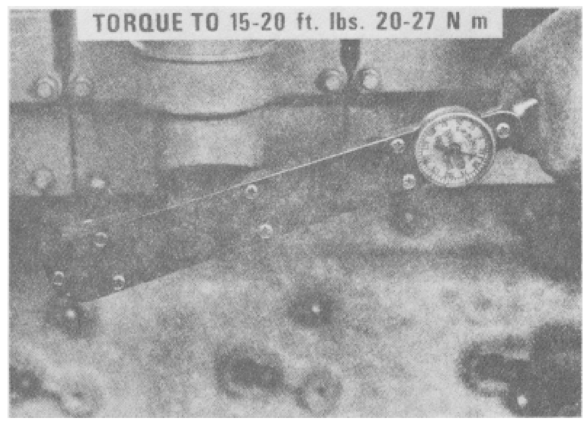


Figure 16N-71. Tighten the Cam Follower Covers

2. Start the pulley on shaft and key (accessory drive shaft); use the ST-386 Pulley Assembly Tool to press into position, Figure 16N-72.

3. Remove pulley assembly tool, install shaft plug (alternator drive pulley), tighten to 65-75 ft-lbs (88-102 N.m) torque.

VIBRATION DAMPER AND CRANKSHAFT ADAPTER

1. Wipe the crankshaft and adapter mating surfaces with a clean, dry cloth. Align the capscrew holes. Put the adapter to the crankshaft.

2. Lubricate the washer faces and capscrew threads with a clean engine lubricating oil. Tighten the capscrews to 160 to 180 ft-lbs (217 to 244 N.m) torque. Repeat the torquing sequence. Tighten the capscrews to a final torque of 320to 340 ft-lbs (434 to 461 N.m), Figure 16N-73.

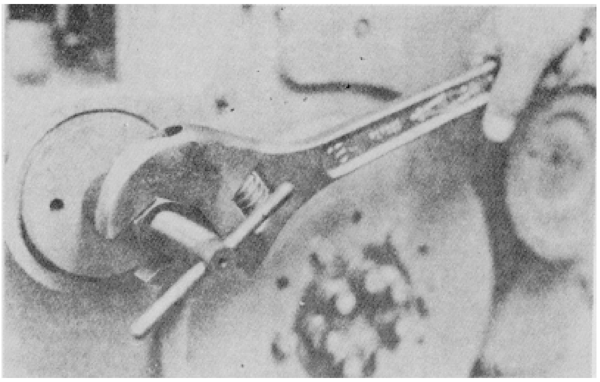


Figure 16N-72. Install the Alternator Drive Pulley

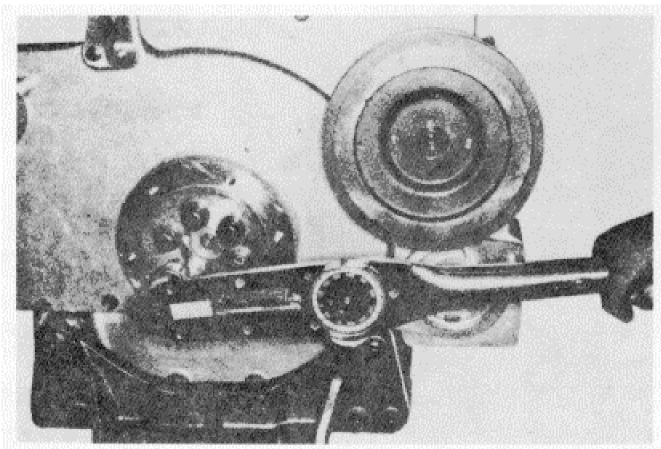


Figure 16N-73. Tightening the Crankshaft Adapter

3. Wipe the mating surfaces of the damper and adapter with a clean dry cloth. Align the capscrew holes. Put the damper to the adapter.

4. Lubricate the washer faces and capscrew threads with a clean engine lubricating oil. Tighten the capscrews alternately and evenly to 65 to 75 ft-lbs (88 to 102 N.m) torque, Figure 16N-74.

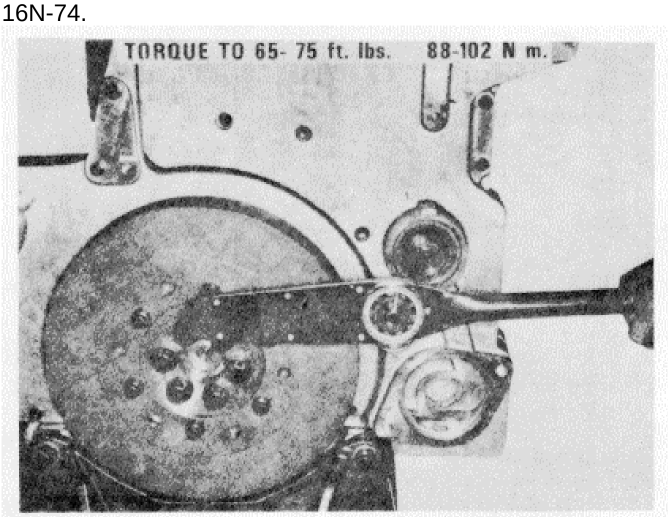


Figure 16N-74. Tighten the Vibration Damper to Crankshaft

5. Check the vibration damper for common centers and wobble as follows:

A. Mount the dial indicator gauge to the oil pan adapter. Turn the indicator to zero on the vibration damper as shown in Figure 16N-75.

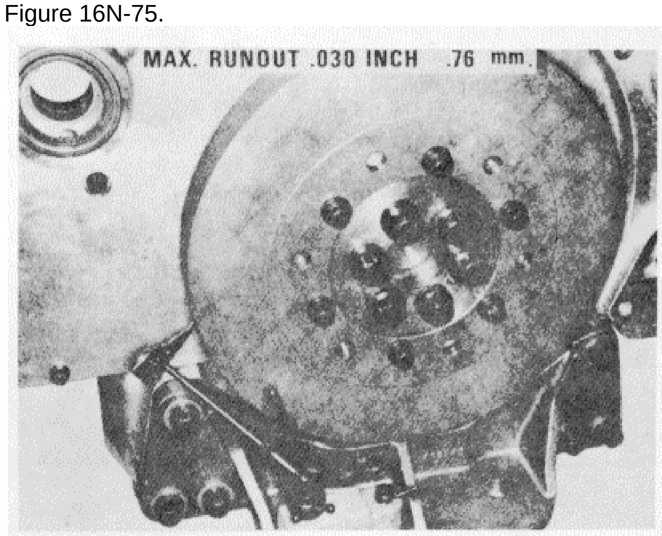


Figure 16N-75. Check the Vibration Damper Common Centers

B. Rotate the engine 360°. The common centers must be within 0.030 inch (0.76 mm).

C. Move the dial indicator gauge to the face of the vibration damper. Put the crankshaft at either the front or rear limit of the thrust clearance. Turn the indicator to zero, Figure 16N-76.

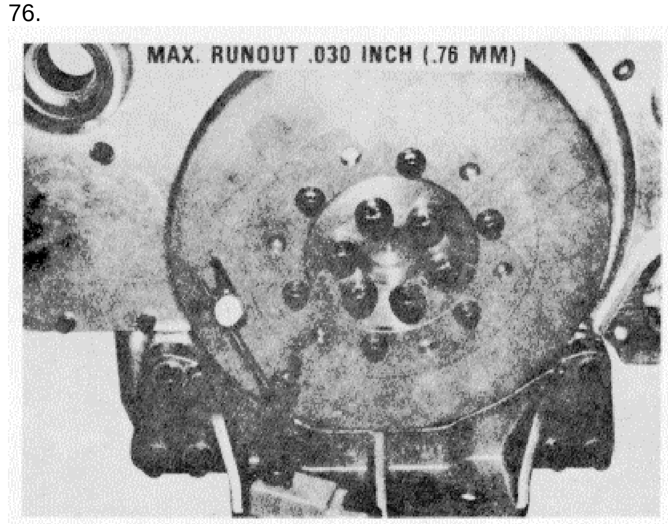


Figure 16N-76. Check the Vibration Damper Wobble

D. Rotate the engine 360°; wobble must not exceed 0.030 inch (0.76 mm).

NOTE

The crankshaft must be kept at either front or rear limit of the thrust clearance while checking the vibration damper for wobble.

FAN HUB AND IDLER ASSEMBLY

FAN HUB. Install fan hub as follows:

1. Position a new O-ring on the fan hub support.

2. Slide the fan hub support over the studs through the gear cover. Be sure the O-ring is in position.

3. Tighten the nuts alternately and (from side to side of the support) evenly to 30-35 ft-lbs (41 to 47 N.m) torque.

IDLER ASSEMBLY. Install idler assembly as follows:

1. Install the pivot arm assembly to the alternator mounting bracket. Tighten the capscrews to 30-35 ft-lbs (41 to 47 N.m) torque, Figure 16N-77.

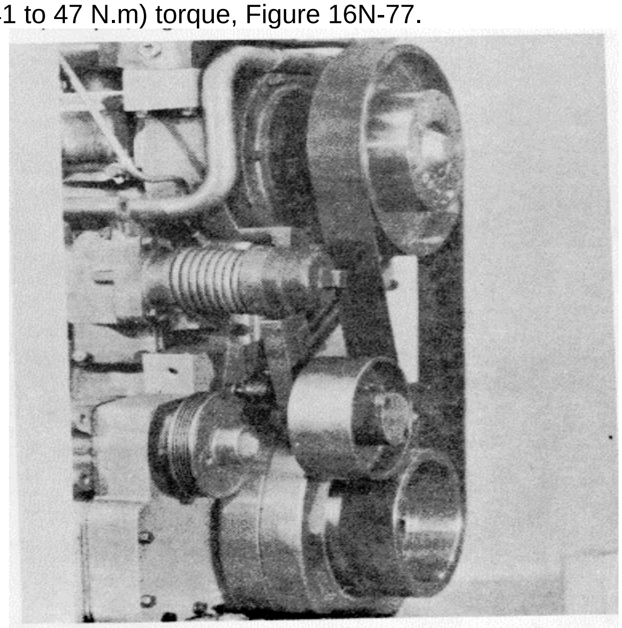


Figure 16N-77. Fan Hub and Idler

2. Install the shock absorber to the fan idler arm and the gear cover. Tighten the capscrews to 30-35 ft-lbs (41 to 47 N.m) torque.

3. Place a box end wrench over flats on the lever cap and lift up.

4. Put a new belt over the crankshaft drive pulley and the fan hub pulley.

5. Release the wrench on the lever cap, the idler pulley will ride on the backside of the fan hub belt.

NOTE

The fan belt idler assembly is self tensioning and will not require periodic adjustment.

FRONT ENGINE SUPPORT

Put the front engine support to the oil pan adapter. Tighten the capscrews alternately and evenly to 140 to 150 ft-lbs (190 to 203 N.m) torque, Figure 16N-78.

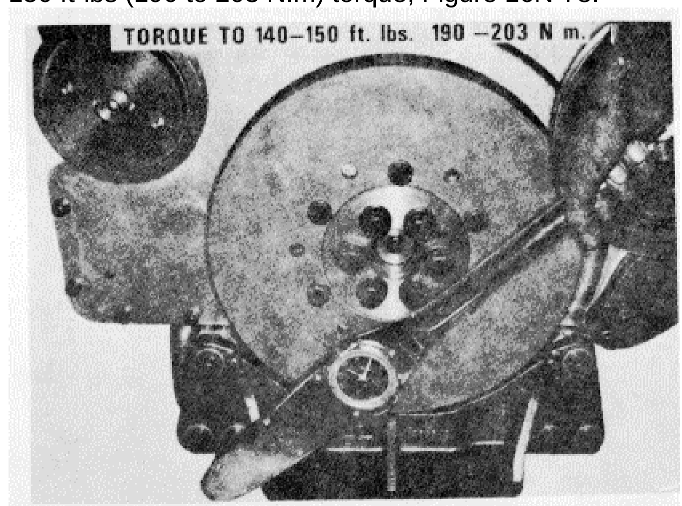


Figure 16N-78. Tighten the Front Engine Support

THERMOSTAT HOUSING

1. Lubricate the O-rings. Put the water transfer tube into the water passage of the rocker lever housing, Figure 16N-79.

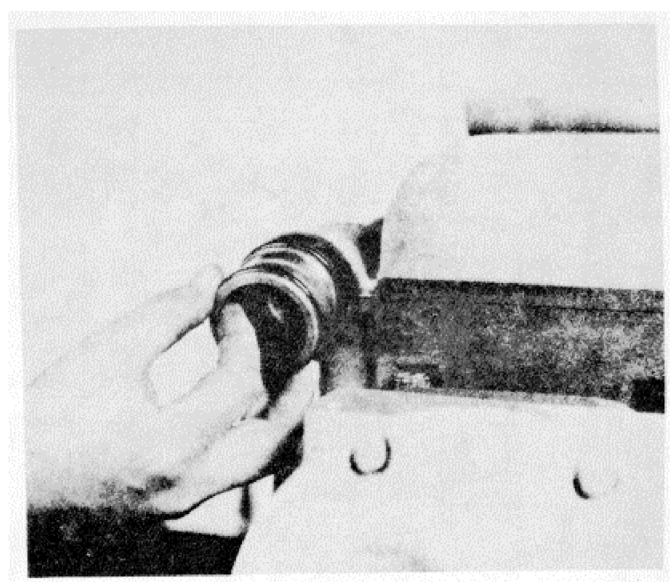


Figure 16N-79. Install the Water Transfer Tube

2. Put the thermostat housing over the water transfer tube and secure to the gear housing front cover.

NOTE

The thermostat housing is secured to the gear housing front cover with two (2) capscrews from the top and two (2) capscrews through the front cover into a bracket mounted to the rear of the thermostat housing, Figure 16N-80.

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Figure 16N-80. Install the Thermostat Housing

AIR COMPRESSOR (LOWER ENGINE)

The air compressor and fuel pump may be installed as an assembly, if so desired.

1. Put the splined coupling on the accessory drive gear.

2. With a new gasket in position, align the air compressor gear with the splined coupling. Tighten the capscrews, Figure 16N-81.

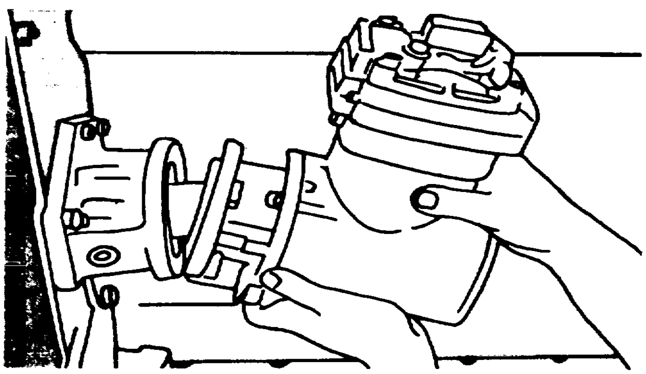

Figure 16N-81. Install the Air Compressor

3. Install the air compressor support bracket to the compressor and cylinder block.

4. Put the fuel pump to the accessory drive of the air compressor with a new gasket and buffer in position.

5. Tighten the capscrews to the following torque values:

NOTE

Use a flat washer between the front support and the lockwasher when assembling the compressor crank-case to the front support.

A. The air compressor to support 40 to 45 ft-lbs (54 to 61 N.m).

B. Mounting bracket to block and air compressor 30 to 35 ft-lbs (41 to 47 N.m).

C. Fuel pump to air compressor support 30 to 35 ft-lbs (41 to 47 N.m).

6. Install the fuel filter to the fuel pump mounted. Coat the seal with a clean engine lubricating oil. Tighten by hand until the seal touches the filter head. Tighten an additional one-half to three-fourths turn.

CAUTION

Mechanical tightening will distort or crack filter head.

7. Install the water inlet and outlet tubes from the air compressor to the thermostat housing and block. Install the air supply connection to the supply tube (installed in intake f manifold). Secure them with hose clamps and capscrews, Figure 16N-82.

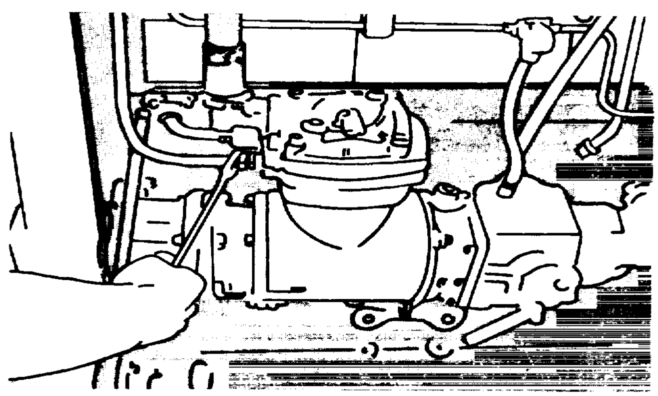

Figure 16N-82. Install the Air Compressor Piping

8. Use new O-rings. Install the fuel connection to the rear of the fuel manifold, if removed.

9. Put the fuel supply tube from the solenoid on the fuel pump to the upper opening and fuel return tube assembly

from the gear pump to the lower opening in the fuel connection starting tube nuts by hand. Secure with clips and tube nuts as illustrated in Figure 16N-83.

NOTE

When installing the fuel tubes to the connection, be sure the sealing sleeves are in position and the tubing is at the bottom in the connection before the tube nuts are tightened.

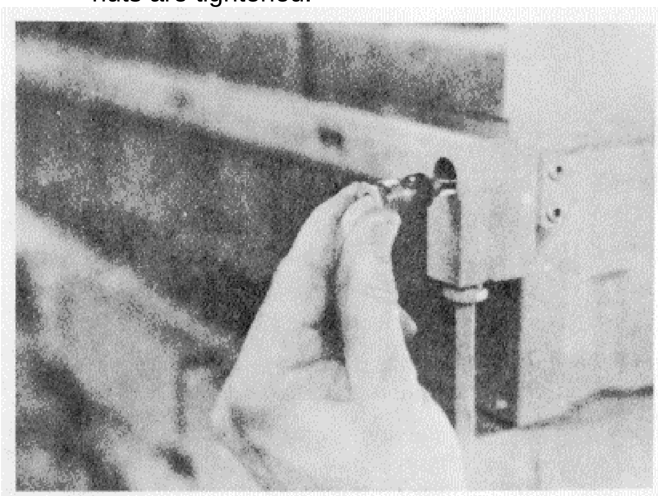

Figure 16N-83. Install the Fuel Tubing

FUEL PUMP (UPPER ENGINE)

1. Position fuel pump to the accessory drive housing with a new gasket and spider buffer.

2. Install capscrews and tighten to 30 to 35 ft-lbs (41 to 47 N.m) torque.

3. Use new O-rings. Install the fuel connection to the rear of the fuel manifold, if removed.

4. Put the fuel supply tube from the solenoid on the fuel pump to the upper opening and fuel return tube assembly from the gear pump to the lower opening in the fuel connection starting tube nuts by hand. Secure with clips and tube nuts as illustrated in Figure 1 6N-83.

NOTE

When installing the fuel tubes to the connection, be sure the sealing sleeves are in position and the tubing is at the bottom in the connection before the tube nuts are tightened.

LUBRICATING OIL FILTERS

1. Install the capscrews through the filter head. Put the gasket over the capscrews.

2. Put the filter head to the block and finger tighten all the capscrews.

3. Start with the inside center capscrews, Figure 16N-84. Tighten the capscrews alternately and evenly to 30 to 35 ft-lbs (41 to 47 N.m) torque.

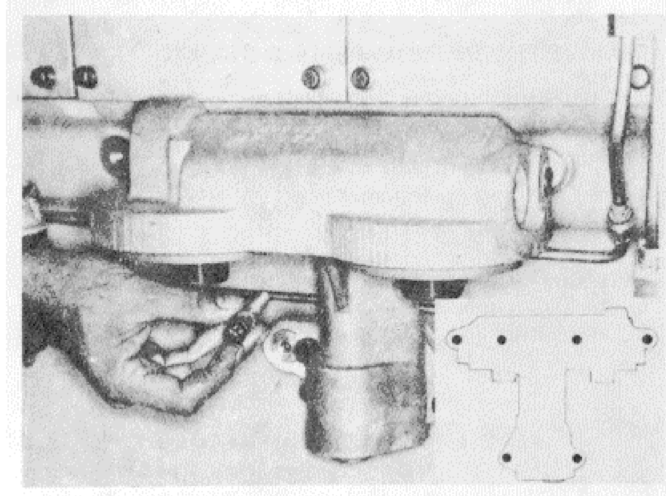

Figure 16N-84. Install the Lube Oil Filter Head

4. Install the throw-away type filter elements, Figure 16N-85. Coat the seal with clean engine lubricating oil. Tighten by hand until the seal touches the filter head and then tighten an additional one-half to three-fourths turn.

HAND TIGHTEN ONLY

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Figure 16N-85. Install the Lube Oil Filter

FUEL FILTER ENGINE MOUNTED (UPPER ENGINE)

1. Install the filter mounting bracket in the desired position. Secure the filter head to the mounting bracket.

2. Coat the seal with a clean engine lubricating oil. Install the element to the filter head. Tighten by hand until the seal

touches the filter head, and then tighten an additional one-half to three-fourths turn.

3. Connect the fuel line between the fuel pump and fitting marked "OUT" on the fuel filter head. Secure with hose clamps.

REMOVE ENGINE FROM REBUILD STAND

1. Attach the lifting arrangement and remove the engine from the rebuild stand.
2. Mount the front and rear supports to the engine; re-move the lifting arrangement.

OIL GAUGE BRACKET AND HAND HOLE COVER

Install the oil gauge mounting bracket and hand hole covers to the oil pan adapter (if removed). Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-86.

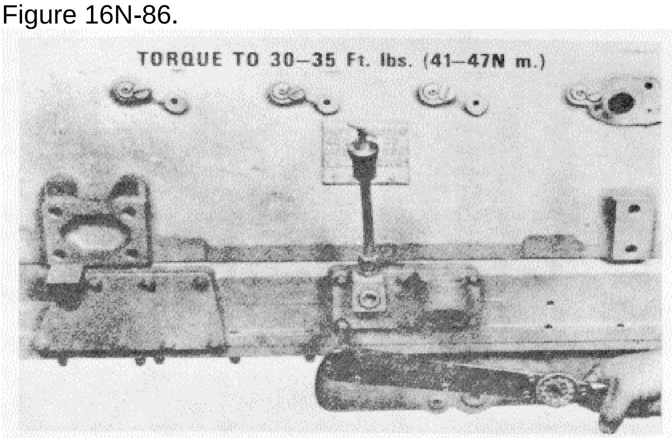

Figure 16N-86. Install the Hand Hole Cover

POWER STEERING PUMP COVER

1. When the power steering pump is not used, install the covers.

2. Lubricate the O-ring with a clean engine lubricating oil. Put on the rear cover. Install the rear cover and gasket to the housing. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque.

3. Install the front cover and gasket to the gear cover. Tighten the capscrews to 65 to 75 ft-lbs (88 to 102 N.m) torque.

LUBRICATING OIL COOLER

1. Lubricate the O-rings with a clean engine lubricating oil. Put the transfer tubes into block until they reach bottom as shown in Figure 16N-87.

2. Install the guide studs at the top and bottom to hold the gasket in position. Put the gasket over the guide studs.

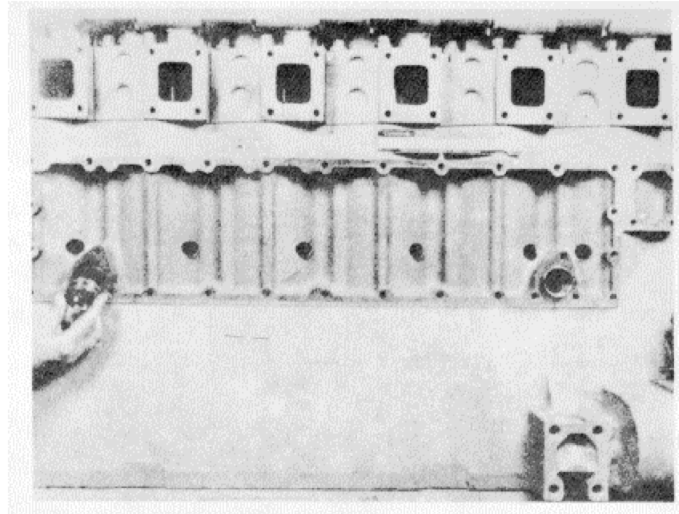

Figure 16N-87. Install the Oil Transfer Tubes

NOTE

The guide studs must be long enough to protrude through the lubricating oil cooler and cover.

3. Put the cooler housing over the guide studs. Install the capscrews finger tight, Figure 1 6N-88, to hold the gasket in position when removing the guide studs.

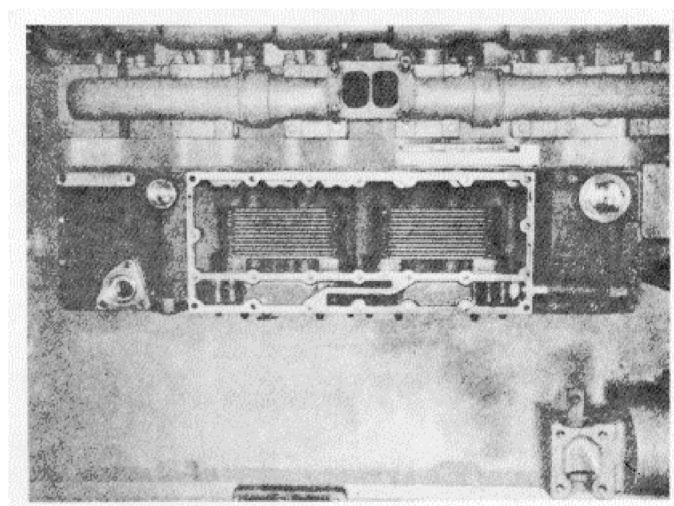

Figure 16N-88. Install the Lubricating Oil Cooler Housing

4. Put the gasket and cover over the guide studs. Remove the guide studs. Tighten all the capscrews.

5. Tighten the capscrews securing the cover to the housing to 25 to 30 ft-lbs (34 to 41 N.m) torque. See Figure 16N-89 for the tightening sequence.

6. Tighten the capscrews securing the cooler housing to the cylinder block to 30 to 35 ft-lbs (41 to 47 N.m) torque,

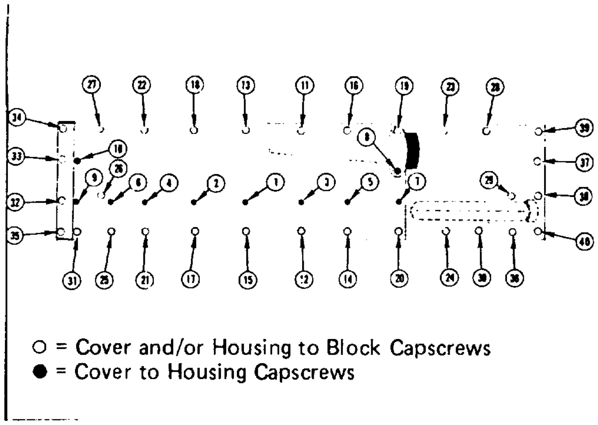

Figure 16N-89. Lubricating Oil Cooler and the Housing Torquing Sequence

Figure 16N-90. See Figure 16N-89 for tightening sequence.

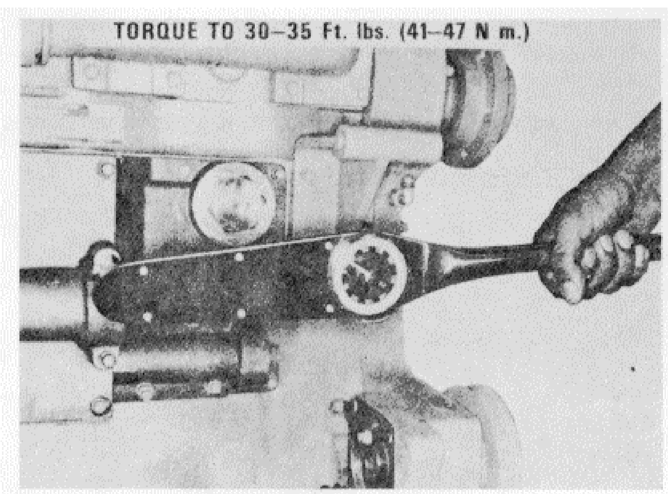

Figure 16N-90. Tighten the Lubricating Oil Cooler to the Cylinder Block

WATER PUMP/WATER FILTER

1. Put the water pump drive shaft into the water pump drive support.

2. Put the water pump assembly with the gasket over the drive shaft and the stud in the water pump support.

3. Install and tighten the capscrews and stud nut alternately and evenly to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-91.

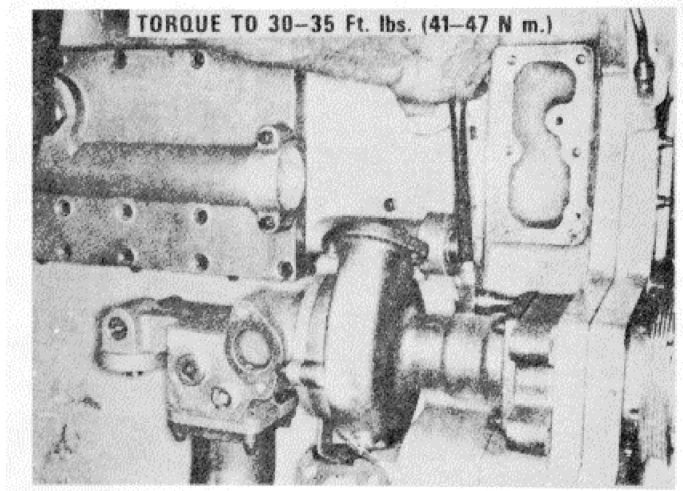

Figure 16N-91. Tighten the Water Pump Capscrews

4. Install the alternator mounting bracket to the block. Make sure the tapped hole is toward the front of the engine. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-92.

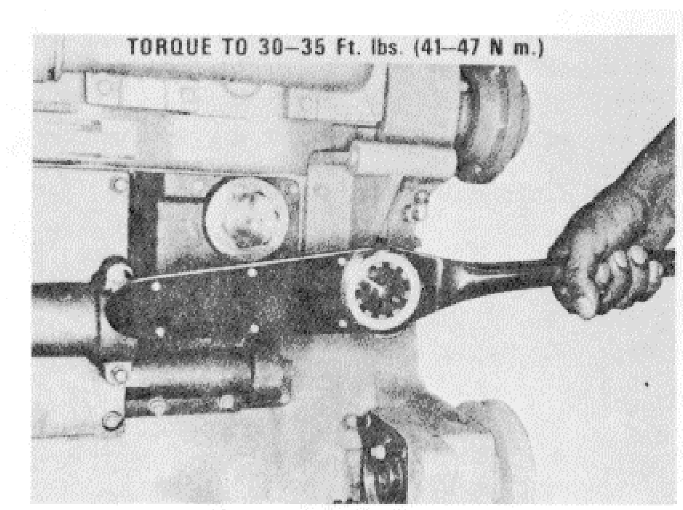

Figure 16N-92. Tighten the Alternator Bracket

5. Use a new gasket, hose and O-ring lubricated with clean engine lubricating oil. Put the water bypass tube to the thermostat housing and the water pump as shown in Figure 16N-93.

6. Install the capscrews. Tighten the flange to the water pump capscrews to 20 to 25 ft-lbs (27 to 34 N.m) torque. Tighten the support to the alternator mounting bracket cap-screw to 30 to 35 ft-lbs (41 to 47 N.m) torque. Tighten the hose clamps.

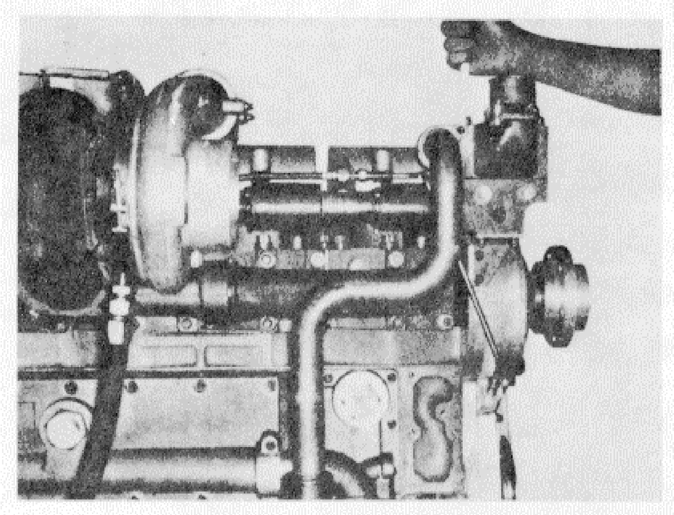

Figure 16N-93. Install the Bypass Tube Assembly

7. Lubricate the O-rings with clean engine lubricating oil. Assemble the water transfer tube into the connector. Do not tighten the capscrew. Put the tube assembly and gasket to the lubricating oil cooler cover and water pump as shown in Figure 16N-94.

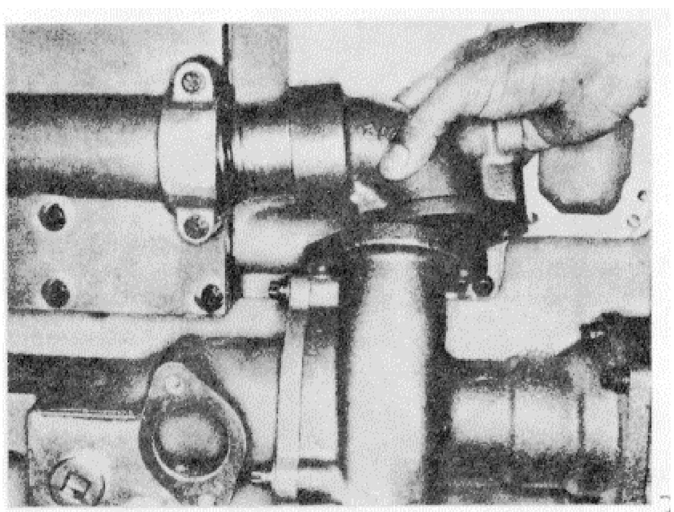

Figure 16N-94. Install the Water Transfer Tube

8. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque.

9. Install the water filter on the rear of the water pump as-sembly, Figure 16N-95. Coat the seal with a clean engine lubricating oil. Tighten by hand until the seal touches the sealing surface. Tighten an additional one-half to three-fourths turn.

10. Turn the shut-off valve on the water pump to the "ON" position.

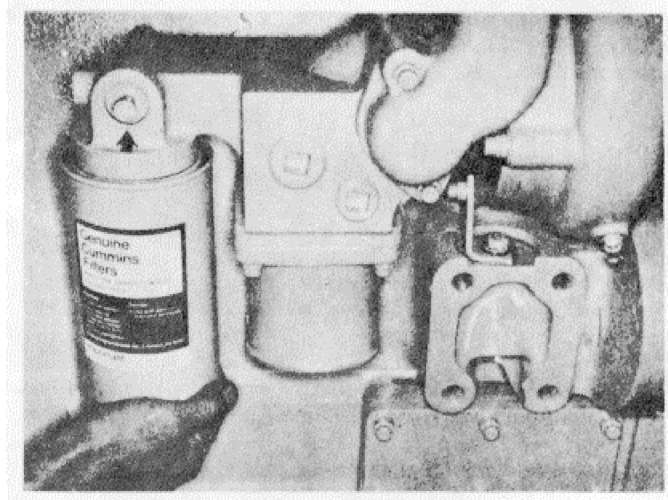

Figure 16N-95. Install the Precharge DCA Water Filter

EXHAUST MANIFOLD

Exhaust manifold sections may be installed separately or assembled and installed as a unit.

1. Install the gaskets to the cylinder block. Use guide studs to hold the gaskets in position. The side of the gasket marked "OUT" must be installed toward the manifold.

2. Put the exhaust manifold over the guide studs. Install and tighten the capscrews in the holes not used for guide studs.

3. Remove the guide studs. Install the remaining capscrews. Tighten all capscrews alternately and evenly to 40 to 45 ft-lbs (54 to 61 N.m) torque, Figure 16N-96.

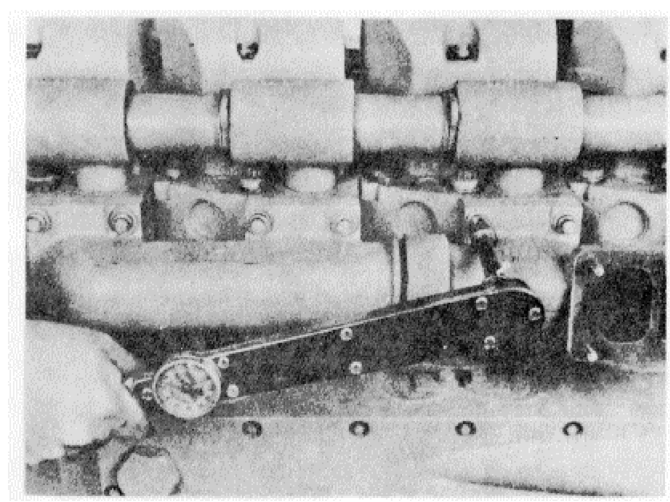

Figure 16N-96. Tighten the Exhaust Manifold Capscrews

TURBOCHARGER AND AIR CROSSOVER

1. Install the turbocharger mounting studs, if removed, as follows:

A. Coat the threads with high temperature "Thread Guard" or the equivalent.

B. Use a stud drive or two (2) nuts and locked together to in-stall the studs at 20 to 25 ft-lbs (27 to 34 N.m) torque until no more than one thread is showing above the gasket mating surface of the exhaust manifold.

2. Install the gasket over the studs. The side of the gasket marked "OUT" must be installed toward the turbocharger, Figure 16N-97.

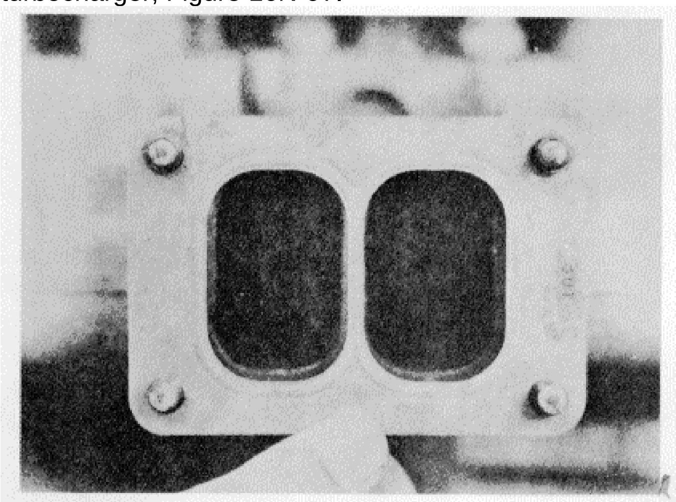

Figure 16N-97. Install the Turbocharger Mounting Gasket

3. Coat the stud threads with high temperature "Thread Guard" or the equivalent. Put the turbocharger over the studs, being careful not to damage the stud threads.

4. Install the locknuts. Tighten alternately and evenly to 22 to 28 ft-lbs (30 to 38 N.m) torque, Figure 16N-98.

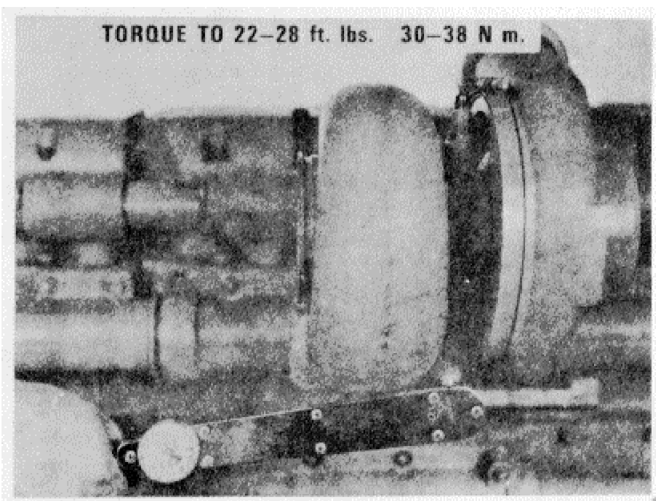

Figure 16N-98. Tighten the Turbocharger Locknuts

NOTE

The round part of the locknut must be toward the turbocharger flange.

5. Install the turbocharger oil drain line. The drain line must be in a vertical or down position or within 300 of that position, Figure 16N-99.

NOTE

If the turbocharger must be loosened to align the oil drain line, tighten the V-band nut to 40 to 60 in-lbs (4.5 to 6.8 N.m). Tighten the turbine housing cap-screws to 100 to 1 10 in-lbs (1 1.3 to 12.4 N.m)torque.

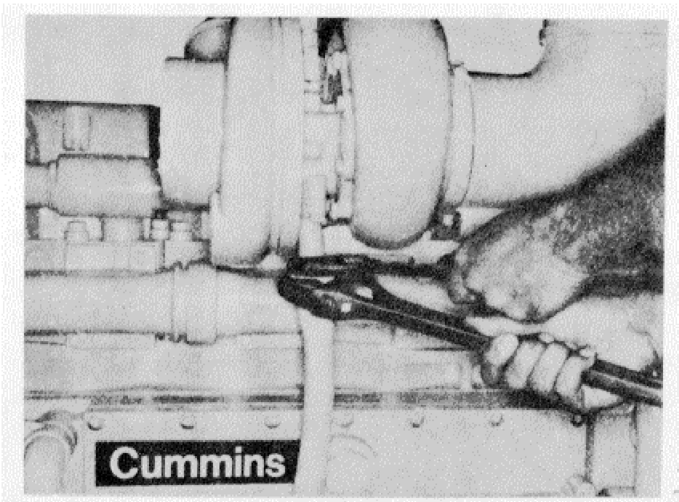

Figure 16N-99. Install the Turbocharger Oil Drain Line

6. Install the turbocharger supply line. Secure it with tube clips and tube nuts, Figure 16N-100.

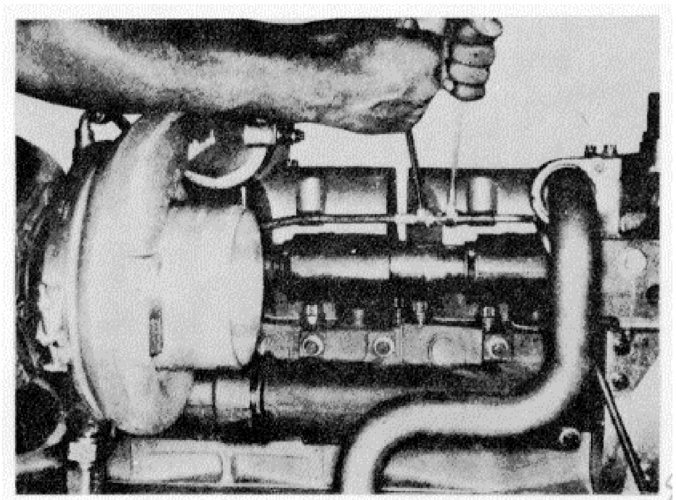

Figure 16N-100. Install the Turbocharger Supply Line

7. Lubricate the O-rings with a clean engine lubricating oil. Put the air crossover tube into the inlet opening or turbo-charger compressor housing, Figure 16N-101.

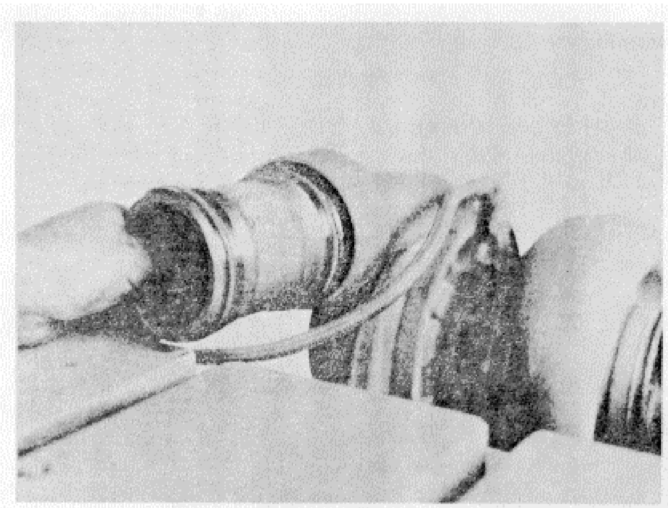

Figure 16N-101. Install the Air Crossover Tube

8. Put the air crossover connection with the gasket over the crossover tube. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 N.m) torque, Figure 16N-102.

CAUTION

The improper use of gaskets, Figure 1 6N-97, could result in damage to the turbocharger or cause exhaust leakage.

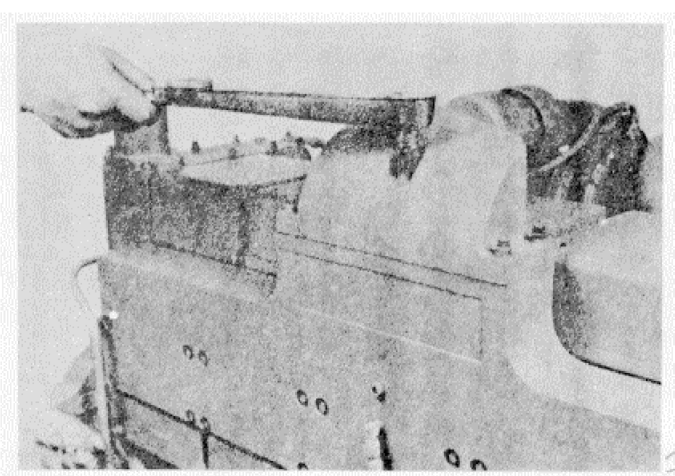

Figure 16N-102. Tighten the Air Crossover Connection Capscrews

ALTERNATOR

1. Put the alternator to the mounting bracket. Loosely assemble the capscrew, hardened washers and spacers, as used, through the alternator lugs and mounting bracket. Do not tighten the capscrew nut.

2. Put the belt over the pulleys. Tighten the adjusting link to the alternator and water pump support.

3. Put the ST-1293 Belt Tension Gauge on the belt as shown in Figure 16N-103. Adjust the belt tension by turning the center section in the alternator adjusting link until a reading of 100 to 110 lbs is obtained on the gauge.

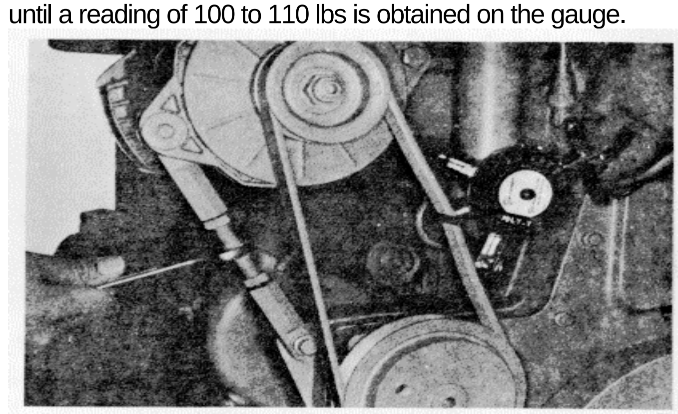

Figure 16N-103. Adjust the Belt Tension

4. Tighten the adjusting link locknuts to 50 to 55 ft-lbs (68 to 75 N.m) torque.

5. Tighten the capscrew nut on the alternator mounting bracket to 65 to 75 ft-lbs (88 to 102 N.m) torque.

6. Tighten the adjusting link to the alternator capscrew to 65 to 75 ft-lbs (88 to 102 N.m) and the adjusting link to the water pump support capscrew to 40 to 45 ft-lbs (54 to 61 N.m) torque. Remove the belt tension gauge.

NOTE

When using the "Krikit" gauge, the correct belt ten-sion reading for the belt tested must be read at the point where the top of the black indicator arm crosses the bottom numbered scale as shown in Figure 16N-104. Put the gauge in the center of the belt between two pulleys. The flange at the side of the gauge should be flat against the edge of the belt.

CRANKING MOTOR

1. Check the cranking motor. See that it is the same type as removed. Cranking motors are designed with different type drives and must be used with a matching flywheel ring gear.

2. Position spacer and the gasket, into the bore of the flywheel housing.

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Figure 16N-104. ST-1 274 "Krikit" Indicator Reading Point

3. Put the cranking motor and gasket into the spacer and flywheel housing bore. Tighten the capscrew to 150 to 170 ft-lbs (203 to 231 N.m) torque, Figure 16N-105.

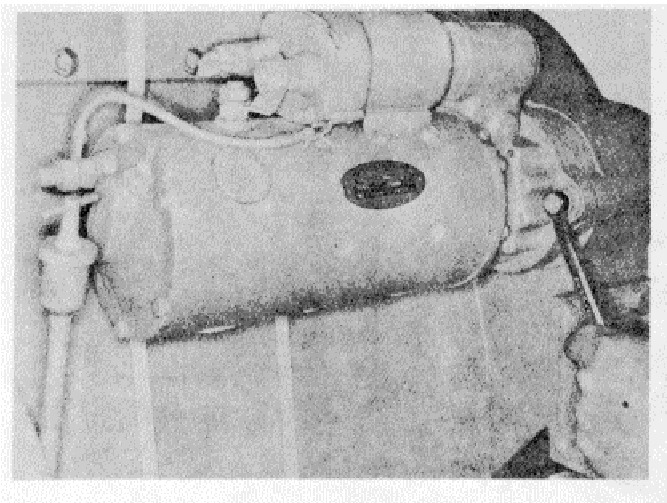

Figure 16N-105. Install the Cranking Motor

ELECTRICAL CONNECTIONS

Secure the electrical connections to the mounted equipment.

FAN INSTALLATION

When installing the fan to the fan hub, 3/8 inch (9.5 mm) capscrews must have 9/16 inch (14.3 mm) thread engage-ment. Fans using 1/2 inch (12.7 mm)capscrews must have 3/4 inch (19.1 mm)thread engagement. Check the decal on fan hub for proper capscrew length. The fan may be in-stalled before or after dynamometer testing.

ENGINE TESTING

GENERAL

Engine break-in and testing are accomplished simultaneously. Break-in on a new or rebuilt engine is necessary be-cause it provides an operating period during which the moving parts acquire their final finish and mating surfaces reach a full seat. Engine testing helps detect possible as-sembly errors, the need for adjustments as the engine breaks in and establishes a period for final adjustments for the best engine performance.

PRIMING THE FUEL SYSTEM

1. Fill the fuel tanks and filter with clean No. 2 diesel fuel oil.

A. With the PT (Type G) fuel pump (lower engine), fill the pump through the plug next to the tachometer with clean fuel. Install plug.

B. With the PT (Type G) VS fuel pump (upper engine), re-move the inlet line and wet the gear pump gears with clean fuel. Connect inlet line.

2. If the injector and valve or other adjustments have been disturbed, be sure they have been properly adjusted before starting the engine.

PRIMING THE LUBRICATING SYSTEM

1. Fill the crankcase to the "L" (low) mark on the dipstick (approximately 9 gal. (34 I1). See Operators Manual. Fill the bypass filter.

2. Remove the oil inlet line from the turbocharger and pre-lubricate the bearing by adding 2 to 3 oz. (60 cc) of clean lubricating oil. Reconnect the oil inlet line.

NOTE

A dipstick oil gauge is located on the side of the engine. The dipstick has an "H"(high) and "L"(low) level mark to indicate the lubricating oil supply. The dip-stick must be kept with the oil pan, or engine, with which it was originally supplied.

3. Remove the plug from the lubricating oil cooler housing to the prime system, Figure 16N-106.

CAUTION

Do not prime the engine lubricating system from the bypass filter.

4. Connect a hand or motor driven priming pump line from the source of clean lubricating oil to plug the boss in the housing. Prime until a 30 psi (2.1 kg/sq cm) maximum pressure is obtained.

5. Crank the engine at least 15 seconds (with the fuel shut-off valve closed or disconnect to prevent starting), while maintaining external oil pressure at a minimum of 15 psi (1.1 kg/sq cm).

6. Remove the external oil supply line and replace the plug.

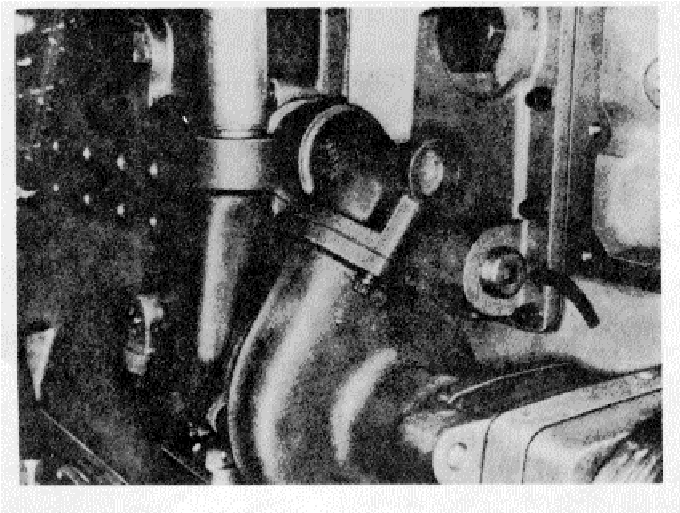

Figure 16N-106. Lubricating System Priming Point

WARNING

Clean the area of any lubricating oil spilled while priming or filling the crankcase.

7. Finish filling the crankcase to the "H" (high) mark on the dipstick.

FUEL PUMP THROTTLE TRAVEL

Use a protractor or the tool shown in Figure 16N-107orST-1162 to set the fuel pump lever idle. Position the centerline at 550 from vertical on the centerline of the fuel pump throttle shaft. Lock the throttle lever screw. Set the centerline of the fuel pump lever in the maximum position 270 from vertical. Lock the adjusting screw. Check the throttle lever centerline travel. It must be 280 between idle and full throttle.

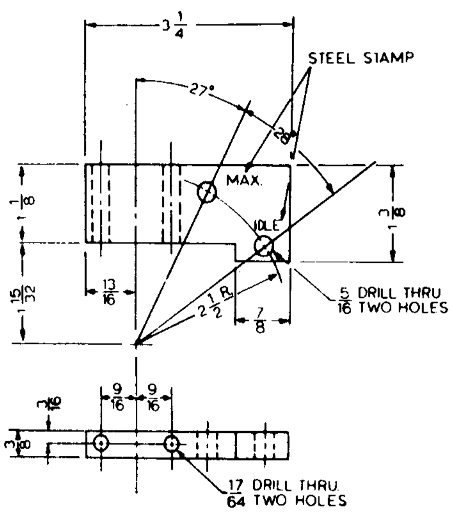

Figure 16N-107. Fuel Pump Throttle Adjustment Template

ENGINE DYNAMOMETER

Check dynamometer capacity. Make sure the capacity is sufficient to allow testing at 96 to 100 percent maximum engine horsepower. If the capacity is insufficient, testing procedures must be modified to prevent damage to dynamometer.

INSTALLATION OF ENGINE

1. Place the engine on the dynamometer test stand. Secure the engine mounting pads to the engine support risers.

2. Put the dynamometer drive shaft flange to the engine flywheel. Follow the manufacturer's instructions for proper alignment.

3. Connect the water supply and return the hose to the water cooling arrangement.

4. Attach the ST-1190 Fuel Consumption Measuring De-vice to the engine.

5. Connect the throttle linkage instruments, exhaust pip-ing and air intake piping to the engine.

6. Install the 3375150 Blow-By Checking Tool in the crank-case breather opening. Use the water manometer and fill to "O" mark at the middle of the scale. Close all openings that would allow blow-by pressure to escape.

7. Start the engine: see "Starting Procedure." Open the coolant supply to the engine water connection. Introduce the water to the dynamometer following the manufacturer's instructions. Check the tubing, hose, lines, fittings and plugs for leaks. Correct as necessary. See "Check Turbocharger Oil Flow" following.

8. For the engine run-in, see "Test Procedure."

CHECK TURBOCHARGER OIL FLOW

1. Disconnect the turbocharger oil drain line.

2. Start the engine and maintain rpm at low idle.

3. Observe the oil drain. Oil should flow in 10 to 15 seconds. If no oil flows in 30 seconds, shut the engine off and correct the fault.

4. Connect the oil drain line when the flow is established.

STARTING PROCEDURE

1. Set the throttle for idle speed. Electric fuel shutoff valves operate automatically.

NOTE

The manual override knob provided on the forward end of the electric shutoff valve allows the valve to be opened in case of electric power failure or if power is not available during testing. To use, open by turning clockwise.

2. Press the starter button or turn the switch key to the "start" position.

CAUTION

Do not crank the engine continuously for more than 30 seconds. If the engine does not fire, wait two to five minutes before repeating to avoid cranking motor damage.

TEST PROCEDURE

HORSEPOWER RATINGS

1. The maximum horsepower ratings at rpm shown in Table 16N-9 "Dynamometer Test Chart," are for engines operating at No. 1 Curve or intermittent-duty applications at sea level, 600F (16°C) intake air temperature and 29.92 inch (760.0 mm) Hg (Mercury) barometric pressure.

2. Turbocharged engines do not require fuel derating be-low maximum altitudes shown in the "Dynamometer Test Chart." Above maximum altitudes, derate at 4 percent for each 1000 ft (304.8 m) additional altitude.

3. New or newly rebuilt engines during dynamometer tests are not required to deliver more than 96 percent of maximum horsepower at power checks.

BREAK-IN RUN

Initial Starting. Start the engine and idle at approximately 800 rpm no load for five to ten minutes. Check the oil pressure and water circulation; look for leaks.

At Each Phase:

1. Apply dynamometer load to (+10%) horsepower at (+5%) speed shown in Table 16N-9, "Dynamometer Chart."

2. Check the crankcase pressure (blow-by) with 3375150. If the pressure continues to drop, reduce run-in time by half; otherwise, run the engine for the time period shown in the dynamometer chart.

Phase 1:

1. Run the engine until normal oil operating temperature has been obtained.

2. Add the lubricating oil to bring level up to "H" mark on dipstick; allow the oil temperature to stabilize.

Phase 2:

Set the engine idle governed speed and fuel rate. Refer to fuel pump calibration.

Phase 3:

If the blow-by rises, reduce load to preceding phase and run for 30 minutes; then return to original phase specifications.

Phase 4:

1. Run at speed and horsepower indicated.
2. Check for leaks and tighten all exposed capscrews.
3. Recheck valves and injectors. Use "Hot Setting," refer to Tables 16N-7 and 16N-8.

NOTE

Readjustment after 1 hour operation is necessary to assure lowest smoke potential and avoid excessive injector train loads.

POWER CHECK

1. Run the engine at rated speed for 5 minutes. It should develop 96 percent of rated horsepower at standard fuel rate. Check the crankcase pressure blow-by. If the pressure exceeds value shown in Table 16N-9, reduce the engine speed and load to preceding phase; run engine 30 to 45 minutes.

2. Repeat procedure described above until the engine develops 96 percent rated horsepower at standard fuel rate within permissible crankcase pressure limit.

3. Reconnect aneroid after the power check is completed.

CHECKS DURING RUN-IN TEST

During the period of engine run-in, the following checks should be made frequently.

Table 16N-9. Dynamometer Test Chart

Engine Model	**HP @ RPM**	**Rated HP @ RPM 500 Ft. Altitude**	**Fuel Rate Lb./Hr.**	**Air Manifold Pressure In./Hg.**	**Altitude Max. HP Alt.**	**Turbo.**	**Crankcase Pressure With 3375150**
KT-1150	450 @ 2100	450 @ 2100	160/167	32/38	12,000	T-18A	12

Phase 1 To Temperature HP @ RPM	**Phase 2 15 Min.** HP @ RPM	**Phase 3 15 Min.** HP @ RPM	**Phase 4 15 Min.** HP @ RPM	**Power Check 5 Min.** HP @ RPM	**Torque Ft./Lb. Sea** Level	**Torque Ft./Lb. 500 Ft.** Altitude
225 @ 1575	338 @ 2100	338 @ 2100	405 @ 2100	432 @ 2100	1300	1300

NOTES:

1. Turbocharged engines do not require fuel derating below altitude shown in column entitled "Rating @ Altitude Maximum." Above maximum altitude, derate at each 1000 ft (304.8 m) additional altitude by 4%.

2. Crankcase pressure with 3375150 is given in inches of water.

3. Reference fuel pump calibration for Rated HP @ RPM and fuel rate.

LUBRICATING OIL

1. Lubricating oil pressure should remain at or near a constant figure at constant engine speed and load (see Table 16N-10) after normal operating temperature has been reached. Abnormally high pressures may indicate blocked lubricating oil lines. Abnormally low pressures indicate an insufficient supply of lubricating oil from the pump or increased oil clearances which may be due to bearing failure.

2. If the oil temperature rises sharply above 225°F (107°C), shut down the engine and correct as necessary.

Table 16N-10. Normal Lubricating Oil Pressure

Idle PSI (kPa)	Rated Speed PSI (kPa)
15 (103.4)	45-70 (310-483)

NOTE: Individual engine may vary from above pressures.

3. New lubricating oil filter elements will absorb oil, there-fore engine must be shut down after five or ten minutes of operation and additional oil added to bring oil level to "H" mark on dipstick. Check oil level every phase during run-in test.

ENGINE COOLANT

After the engine is started, add coolant as necessary to completely fill cooling system and replace entrapped air. Coolant should not exceed 200°F (93°C) or drop below 160°F (71 °C) during engine operation. Do not turn the engine off immediately after a load run. Heat stores in the iron masses will boil coolant in the jackets if air and coolant circulation is immediately stopped while engine is hot. Allow the engine to idle for a few minutes before shutting down.

FUEL PRESSURES

For fuel pressure reading and adjustment, refer to fuel pump calibration.

ENGINE FUEL RATE

ST-1190 Fuel Consumption Measuring Device operates by drawing fuel from fuel tank, then through flowmeter. Re-turn fuel from injector drain is routed through float tank so when float tank is filled, float valve opens and allows return fuel flow to flowmeter. Make up fuel or amount of fuel being consumed by engine will flow through flowmeter thus showing rate of fuel consumption in pounds per hour. See "Fuel Pump Calibration."

BLOW-BY READINGS

1. Manometer readings must be taken frequently during run-in test so mechanic will note any blow-by increase at a given speed and load. If there is any indication of blow-by in-crease, engine speed must be reduced for a few minutes and then brought back to the original settings.

2. During each power check, keep a constant check on the manometer; if pressure rises, more run-in is required. Representative pressure limits for engine running at governed speed and pulling 96 to 100 percent of rated horse-power are given in Table 16N-9.

3. If pressure is greater than values listed at end of testing period, operate 30 minutes extra at 96 to 100 percent rated load and rpm. If there is no rapid change in excess of 2 inches (50.8 mm) of water and reading does not exceed 100 percent of representative pressure, blow-by is acceptable.

NOTE

Manometer readings not exceeding 0.3 inch (7.62 mm) surge are desirable.

CHASSIS DYNAMOMETER TESTS

If the engine is installed in equipment, it may be tested on a chassis dynamometer as follows:

1. Check instruments; follow manufacturer's instructions.

2. Perform all phases of engine dynamometer break-in run. See Table 16N-9.

MAINTENANCE OF DYNAMOMETER

Follow manufacturer's maintenance instructions to service the dynamometer.

CALIBRATING INSTRUMENTS

Keep beam or spring scales properly calibrated. Follow manufacturer's recommendation when recalibrating or instrument adjustment is necessary.

IN-CHASSIS RUN-IN

In-chassis repaired engines should receive run-in equivalent to that on an engine dynamometer. Follow procedure given below after an in-chassis repair or rebuild.

1. Start the engine. Idle at 800 to 100 rpm, no load, for 5 to 10 minutes. Check the oil pressure and the water circulation. Correct any leaks.

2. Operate at 1/4 to 1/2 throttle for first 5 to 10 hours.

3. Operate at 1/2 to 2/3 throttle for next 45 to 50 hours.

4. After 50 hours of operation, do not operate engine at full load and speed in excess of 5 minutes continuously at any time. After 5 minutes full power run, drop back to 3/4 throttle.

5. During the first 100 hours service:

A. Do not idle engine for long periods.

B. Watch instruments closely. Decrease engine rpm if oil temperature reaches 250°F (121°C) or if the coolant temperature exceeds 190°F (88°C).

C. Operate with a power requirement low enough to allow the acceleration to governed speed under any condition.

6. Check the exhaust restrictions (back pressure) as follows:

A. Using a mercury or water manometer, take readings when engine is developing maximum horsepower at maximum engine speed.

B. Maximum permissible back pressure is 3.0 inch (76.2 mm) Hg or 40.74 inches (103.48 cm) of water.

PAINT ENGINE

1. Prior to painting, clean the surface for maximum paint adherence. Dry with compressed air.

2. Cover all openings, pulley grooves, instrument faces and belts. Cover all dataplates, exposed threads, wire terminals, hose fittings and pipe openings with water proof paper or tape.

3. Cover the clutch contact surface on the flywheel with anti-rust compound, if the engine is not going into immedi-ate service.

4. Spray the outside surfaces of the castings and corrodible parts with a primer coat of lacquer to serve as a base for the second coat of engine enamel.

ENGINE STORAGE

GENERAL

On any engine not in service, the unpainted machined surfaces are subject to rust and corrosion. The rate of corrosion varies with climatic conditions. An engine stored in a climate with a high amount of moisture in the air will cor-rode more rapidly than an engine stored in a dry climate.

TEMPORARY STORAGE

If an engine remains out of service for three or four weeks (maximum six months), special precautions should be taken to prevent rust. The operations listed below are required to minimize or prevent damage to temporarily stored engines.

1. The engine must be started and operated until thoroughly warm. Disconnect the fuel lines to the engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil.

2. Start the engine with fuel line to the filter using diesel fuel. The injector drain can flow into the container with diesel fuel. After the engine is running smoothly, switch the fuel line to the container with preservative oil. Operate five to ten minutes on preservative oil. Stop the engine and re-connect at the fuel lines.

3. Drain the oil sump, fuel filters and fuel tank and reinstall the drain plugs. The sump may remain empty until the engine is ready for use. Tag the engine with a warning tag.

4. Disconnect the electrical wiring and turn the fuel pump manual shutoff valve fully counterclockwise to "Off." Spray lubricating oil into the intake manifold and air compressor while cranking the engine slowly.

5. Cover all openings with tape to prevent the entrance of dirt and moisture.

6. Drain the coolant from the cooling system unless it is a permanent type antifreeze with a rust inhibitor added.

7. Store the engine in a dry and uniform temperature area.

8. Bar the engine crankshaft two or three revolutions each three to four weeks.

LONG TERM STORAGE

1. When the engine is to be stored six months or more, the lubricating system, cooling system, fuel system, crankcase and external parts must be protected against rust and corrosion.

2. Start the engine and operate at fast idle until the engine is thoroughly warm. Stop the engine and drain the old oil.

3. Fill the crankcase to full mark on bayonet gauge or dipstick with preservative oil, U.S. Military Specification MIL-L-21260, Type P-10, Grade 2 SAE 30. This specification may be obtained as Shell-Brand Code 66202 or equivalent.

4. Disconnect the fuel lines to the engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil U.S. Military Specification MIL-L-644 Type P9. Preservative oil to this specification is Daubert Chemical Co., Nox-Rust No. 518 or equivalent. The Daubert Chemical address is 2000 Spring Road, Oakville, Illinois.

5. Start the engine with the fuel line to the filter using diesel fuel. The injector drain line can flow into the container with diesel fuel. After the engine is running smoothly, switch the fuel line to container with the preservative oil. Operate five to ten minutes on the preservative oil. Stop the engine and reconnect the fuel lines.

6. Drain the oil sumps of pumps, compressors, coolers, filters and crankcase, etc. Replace all plugs after draining.

7. Remove the intake and exhaust manifolds. Spray all in-take and exhaust ports, including air compressor intake port, with preservative oil. Replace the intake and exhaust manifolds.

8. Inspect the cooling system. If the cooler is contaminated, drain and flush. Fill with rust preventive compound.

9. Brush or spray a film of rust preventive compound on all exposed, unpainted surfaces of the engine. Use a rust preventive conforming to Type P-2, Grade 1 or 2, U.S. Military Specification MIL-C-16173C. Remove the cylinder head covers and spray the rocker levers, valve stems, springs, guides, crossheads and push rods. Replace the cover.

10. Cover all engine openings with heavy paper and tape. Tag the engine to indicate that it has been, treated with preservatives and crankshaft should not be barred over. The tag should show the coolant has been removed, the date of the treatment and that engine is not ready to run.

11. Store the engine in an area where the air is dry and the temperature is uniform.

NOTE

Engines in storage more than 24 months should be flushed out with a suitable solvent or light, hot oil and then be reprocessed with rust preventive materials. Periodically inspect engines for rust or corrosion.
Take corrective action if necessary.

12. Although the preservative materials may be added to and used for the same purpose repeatedly, they must be kept clean. The accumulated deposits should be removed after being allowed to settle.

PREPARING A STORED ENGINE FOR SERVICE

When an engine is removed from storage and put into service, the following operations should be performed.

CLEAN ENGINE. Clean engine as follows:

1. Clean the accumulated dirt from the exterior of the en-gine. Remove covers, tape and wrappings.

2. Use a suitable cleaner to remove the rust preventive compound from unpainted surfaces.

3. Refill the crankcase with clean lubricating oil. Flush and fill the cooling system.

INSPECTION. Inspect the engine as follows:

1. When an engine has been stored for six months or less, it is necessary to adjust the injectors, valves and belt, tighten the cylinder head capscrews and connections, replace the filters and check the air filter and screens.

2. When an engine has been stored for six months or more, the following procedure should be followed:

A. Flush the fuel system with clean fuel oil until all preservative oil is removed.

B. Remove the plug from oil gallery and force hot, light mineral oil through the oil passages to flush away all preservative oil. Bar the engine crankshaft over three or four revolutions during the flushing operation.

C. Replace all filters and clean all screens before the engine is started.

D. After inspecting the engine and part, make sure that all preservative oil and gummed oil has been flushed away. Start the engine as described in "Engine Testing."

SUBSECTION 16P

MOUNTING ADAPTIONS

DESCRIPTION

The mounting adaptations groups consist of the flywheel and flywheel housing.

FLYWHEEL AND RING GEAR

INSPECTION AND REMOVAL

1. Inspect the ring gear for broken or cracked teeth.

2. If replacement is necessary, drive the gear from the fly-wheel with a blunt chisel.

REPLACEMENT

1. If an oven with a heat control is not available, heat the gear with a heating torch - not a cutting torch - from the inside diameter so that the heat travels outward to the teeth.

2. Use a 600°F (316°C) Templistick crayon or equivalent to determine the amount of heat applied. Stroke the gear several times while applying heat. The crayon will leave a chalk mark until temperature is reached and then will leave a liquid smear. Overheating will soften the gear.

3. Place the ring gear on the flywheel and quickly drive on until it is firmly seated.

4. No attempt should be made to remachine flywheels in a shop that is not equipped to maintain factory standards both as to dimensions and static balance. The static balance tolerance of flywheels is 2 inch oz. (144 g cm) maximum. Never reface the flywheel beyond the point where clutch face is less than 5/8 inch (15.88 mm) thick.

SUBSECTION 16Q

WEAR LIMITS, SPECIFICATIONS AND TORQUE

GENERAL

Worn limits as stated in this section indicate that the part may be reused if it is at the worn limit. Discard only if it exceeds the worn limit. All engine models are the same unless otherwise stated. Limits are given in U.S. and Metric measurements. All Metric units are enclosed in brackets ().

Part or Location	Worn Limit	New Minimum	New Maximum
CYLINDER BLOCK			
Installed Camshaft Bushing Inside Diameter	**3.003** **[76.276]**	3.00 [76.2]	3.002 [76.250]
Camshaft Bushing Bore in Block	3.2535	3.2445 [82.638]	 [82.664]
Cylinder Liner Counterbore (Thin Flange) Prior to Engine Serial No. 31121670 (2-16-81)			
Block Upper Counterbore Inside Diameter		7.399 [187.934] 7.409 [188.188]	7.401 [187.985] 7.411 [188.239]
Block Upper Counterbore Inside Diameter		7.419 [188.442]	7.421 [188.493]
Block Upper Counterbore Depth		0.300 [7.62] 0.310 [7.87] 0.320 [8.13]	0.302 [7.671 0.312 [7.92] 0.322 [8.18]
Block Lower Bore Inside Diameter		7.090 [180.086]	7.092 [180.136]
Liner Flange Outside Diameter		7.400 [187.960] 7.410 [188.214] 7.420 [188.468]	7.402 (188.010] 7.412 [188.264] 7.422 [188.518]
Liner Flange Thickness		0.305 [7.747] 0.315 [8.001] 0.325 [8.255]	0.396 [7.772] 0.316 [8.026] 0.326 [8.280]
Liner Lower Outside Diameter		7.093 [180.162]	7.095 [180.213]

Part or Location	Worn Limit	New Minimum	New Maximum
Cylinder Liner Counterbore (Thick Flange) After Engine Serial No. 31121670 (2-16-81)			
Block Upper Counterbore Inside Diameter		7.491 [190.271]	7.493 [190.322]
Block Upper Counterbore Depth		0.521 [13.233]	0.523 YEW (13.284]
Block Lower Bore Inside Diameter		7.090 [180.068]	7.092 [180.1368]
Liner Flange Outside Diameter		7.492 [190.296]	7.494 [190.347]
Liner Flange Thickness		0.526 [13.060]	0.527 [13.385]
Liner Lower Outside Diameter		7.093 [180.162]	7.094 [180.187]
Main Bearing Bore	**5.8465 [149.50]**	5.845 [148.46]	5.846 [148.49]
Main Bearing Capscrew Tightening Ft-Lb [Nom]			
1. Tighten to		190 [258]	200 [271]
2. Advance to		440 [597]	450 [610]
3. Loosen		All	All
4. Tighten to		190 [258]	200 [271]
5. Advance to (Final Torque)		440 [597]	450 [610]
Cylinder Block Height From Main Bearing Bore Center Line	**18.994 [482.45]**	19.004 [482.70]	19.006 [482.75]
From Top of Alignment Bar	**16.07 [408.20]**	16.08 [408.46]	16.084 [408.53]
Cylinder Liner Counterbore Shims			
Part No.	205741	0.0063 [0.160]	0.007 [0.18]
Part No.	205742	0.0072 [0.183]	0.0088 [0.223]
Part No.	205743	0.0081 [0.206]	0.0099 [0.251]
Part No.	205744	0.018 [0.46]	0.022 [0.56]
Part No.	205745	0.028 [0.71]	0.034 [0.86]
Part No.	205748	0.056 [1.42]	0.068 [1.73]

Part or Location	Worn Limit	New Minimum	New Maximum
Cylinder Liner Inside Diameter [158.88]	**6.255 [158.740]**	6.2495 [158.78]	6.251

Note: New cylinder liners dimensions at 60 to 70°F [16 to 21°C]; may be 0.0002 to 0.0006 inch [0.005 to 0.015 mm] smaller than indicated due to lubrite coating.

Part or Location	Worn Limit	New Minimum	New Maximum
Bearings			
Standard Size (Thickness)			
Main Bearing	**0.169 [4.29]**	0.1705 [4.331]	0.1712 [4.348]
Connecting Rods	**0.123 [3.12]**	0.1245 [3.162]	0.125 [3.18]
Journal Clearance			
Main	**0.0085 [0.2161**	0.0026 [0.066]	0.0065 [0.165]
Connecting Rods	**0.0075 [0.19]**	0.002 [0.05]	0.005 [0.13]
Crankshaft Thrust Ring Thickness		0.1505 [6.22]	0.1535 [6.27]
* Use Crankshaft end clearance.			
Crankshaft End Clearance	**0.021 [0.53]**	0.004 [0.10]	0.016 [0.41]
Vibration Dampers			
Wobble and Eccentricity	See Vibration Damper Subsection 16N		
Connecting Rods			
Bolt Tightening Ft-Lb [N*m]			
1. Tighten to		70 [95]	80 [108]
2. Advance to		140 [190]	150 [203]
3. Advance to		210 [285]	220 [298]
4. Loosen		All	All
5. Tighten to		70 [95]	80 [108]
6. Advance to		140 [190]	150 [203]
7. Advance to (Final Torque)		210 [285]	220 [298]
Crankpin Bore	***0.0015 [0.038]**	4.251 [107.993]	4.252 [108.018]
Piston Pin Bushing	**2.4025 [61.023]**	2.401 [60.985]	2.4015 [60.998]
Connecting Rod Length			
Center to Center		11.405 [289.68]	11.407 [289.74]
Connecting Rod Alignment			
Without Bushing	**0.008 [0.20]**		
With Bushing	**0.004 [0.10]**		

As measured 30° either side of parting line; tolerance for inner diameter beyond 30° either side of parting line is same as it is for new rods 4.2517" 4.252"

Part or Location	Worn Limit	New Minimum	New Maximum
Twist			
Without Bushing	**0.020 [0.51]**		
With Bushing	**0.010 [0.25]**		
Rod Dowel Pilot		0.8137 [20.668]	0.8142 [20.681]
Cap Dowel Pilot		[20.676] [20.676]	0.8145 [20.688]
Connecting Rod Bolt Minimum O.D.	**0.600 [15.24]**	0.601 [15.27]	0.605 [15.37]
Ring Dowel Outside Diameter		0.8147 [20.693]	0.8152 [20.751]
Inside Diameter		0.700 [17.78]	0.705 [17.91]
Piston and Piston Rings			
Ring Gap			
Top Ring	**	0.025 [0.64]	0.040 [1.02]
Center Ring	**	0.025 [0.64]	0.040 [1.02]
Oil Ring	**	0.015 [0.38]	0.030 [0.76]
Piston Skirt Diameter at 70°F [21 C]	**6.235 [158.371**	6.238 [158.45]	6.239 [158.47]
Piston Pin Bore at 70°F [21 °C]	**2.399 [60.94]**	2.3985 [60.922]	2.3989 [60.932]
Piston Pin Diameter	**2.398 [60.91]**	2.3988 [60.929]	2.399 [60.94]
Camshaft			
Journal Diameter	**2.995 [76.07]**	2.996 [76.09]	2.997 [76.12]
Thrust Bearing Thickness	**0.359 [9.12]**	0.368 [9.35]	0.372 [9.45]
Gear Housing Cover			
Accessory and Alternator Drive Bushing			
Part No. 132770 Inside Diameter	**1.571 [39.90]**	1.565 [39.75]	1.569 [39.85]
Part No. 132771 Inside Diameter	**1.561 [39.651**	1.555 [39.41]	1.559 [39.60]
Part No. 132772 Inside Diameter	**1.551 [39.40]**	1.545 [39.24]	1.549 [39.34]
Hydraulic Pump			
Drive Bushing			
Inside Diameter	**1.506 [38.25]**	1.501 [38.13]	1.504 [38.20]

Add 0.003 inch [0.08 mm] ring gap to new maximum limit for each 0.001 inch [0.03 mm] wear in cylinder liner wall.

Part or Location	Worn Limit	New Minimum	New Maximum
CYLINDER HEAD			
Height	**4.715 [119.76]**	4.745 [120.52]	4.755 [120.78]
Injector Seal Seat			
Thickness (Std.)		0.0135 [0.343]	0.0165 [0.419]
Injector Tip Protrusion		0.090 [2.29]	0.110 [2.79]
Valve Seat Insert			
Run-out	0.002 [0.05]		
Seat Angle		30 deg.	
Sizes Available		Refer to Table 2-1.	
Valve Crossheads and Guides			
Crosshead Stem Inside Diameter	**0.440 [11.181**	0.434 [11.02]	0.438 [11.07]
Guide Outside Diameter	**0.432 [10.97]**	0.433 [11.00]	0.4335 [11.011]
Guide Assembled Height		2.350 [59.69]	2.370 [60.20]
Valve Stem Pocket Depth in Crosshead		0.110 [2.79]	0.150 [3.81]
Valve, Guides and Springs			
Valve Stem Outside Diameter	**0.4935 [12.535]**	0.4945 [12.560]	0.4955 (12.586]
Valve Guide Inside Diameter Installed	**0.4987 [12.671**	0.4961 [12.60]	0.4971 [12.626]
Valve Guide Outside Diameter	**0.8441 [21.440]**	0.8456 [21.478]	0.8461 [21.491]
Valve Guide Assembled Height		1.175 [29.845]	1.190 [30.225]
Valve Spring Data	Refer to Table 2-1.		
ROCKER LEVERS			
Bushing Inside Diameter	**1.3776 [34.991]**	1.3735 [34.887]	1.3765 [34.963]
Shaft Outside Diameter	**1.371 [34.82]**	1.3720 [34.85]	1.3725 [34.860]
CAM FOLLOWERS			
Shaft Outside Diameter	**0.873 [22.171**	0.8735 [22.187]	0.874 [22.20]
Follower Inside Diameter			
A. Shaft Bore	**0.877 [22.28]**	0.875 [22.23]	0.876 [22.25]
B. Pin Bore	**7503 [19.06]**	7495 [19.04]	7503 [19.06]
Cam Roller			
Inside Diameter	**0.758 [19.20]**	0.754 [19.15]	0.755 [19.18]
Outside Diameter	**1.622 [41.20]**	1.624 [41.25]	1.625 [41.28]
Pin Outside Diameter	**0.7489 [19.081**	0.7505 [19.06]	0.751 [19.08]
Push Tubes			
Ball End Radius		0.623 [15.82]	0.625 [15.87]
Socket (Spherical Inside Diameter)		0.505 [12.83]	0.520 [13.21]

'This dimension is measured where roller rides on pin; a press fit of .0002 to .0015 is always required between the pin and cam flower pin bore; use the pin new max. and min. specifications at the press fit area to determine whether it is reusable.

Part or Location	Worn Limit	New Minimum	New Maximum
LUBRICATING SYSTEM			
Lubricating 011 Cooler		70	80
Heater Plug Torque Ft-Lb [N•m]		[95]	[108]
Lubricating 011 Pan		60	70
Drain Plug Torque Ft-Lb [N•m]		[81]	[95]
Lubricating 011 Pump			
Bushings Inside Diameter	**0.8785**	0.8765	0.8775
	[22.314]	(22.263]	[22.289]
Idler and Drive Shaft Outside Diameter	**0.8740**	0.8745	0.8750
	[22.197]	[22.212]	[22.225]
COOLING SYSTEM			
Water Pump			
Impeller to Shaft Press-Fit	0.001		
	[0.03]		
Impeller Depth In Body		1.200	1.205
		[30.48]	[30.61]
Housing Bore	2.8431	2.8345	2.8351
Outer Bearing	[72.215]	[71.996]	[72.012]
Housing Bore	2.0557	2.0471	2.0477
Inner Bearing	[52.215]	[51.996]	[52.012]
Housing Bore		1.749	1.751
Oil Seal		[44.43]	[44.48]
Impeller to Body Clearance		0.013	0.020
		[0.33]	[0.51]
Fan Hub			
End Clearance		0.003	0.012
		[0.08]	[0.30]
Bearing to Shaft Press-Fit		0.000	0.001
		[0.00]	[0.03]
Thermostats			
Operating Range			
Medium		170 F	185'F
		[77 C]	[85'C]
DRIVE UNITS			
Fuel Pump and Compressor Drive			
Shaft Outside Diameter			
At Pulley Location		1.3765	1.377
		[34.963]	[34.98]
Shaft Outside Diameter			
Bushing Wear Area	**1.310**	1.3115	1.312
	[33.27]	[33.312]	[33.32]
Bushing Inside Diameter	**1.320**	1.316	1.319
	[33.53]	[33.43]	[33.50]
End Clearance			
Assembled		0.002	0.012
		[0.05]	[0.30]

Part or Location	Worn Limit	New Minimum	Now Maximum
DRIVE UNITS CONTINUED			
Water Pump and Alternator Drive			
Bushing Inside Diameter	**1.755** **[44.58]**	1.751 [44.481	1.754 [44.55]
Shaft Outside Diameter			
Bushing Wear Area	**1.748** **144.401**	1.7485 [44.412]	1.749 [44.42]
Barring Mechanism			
Bushing Inside Diameter	**0.826** **115.9001**	0.624 [15.849]	0.625 [15.875]
Shaft Outside Diameter	**0.8210** **115.7731**	0.6215 [15.786]	0.6220 [15.80]
ENGINE ASSEMBLY AND TESTING			
Crankshaft End Clearance		0.004 [0.10]	0.016 [0.41]
Cylinder Liner Protrusion		0.003 [0.08]	0.006 [0.15]
Cylinder Liner Out-of-round			
Top one (1) Inch [25.40 mm]			0.003 [0.08]
Lower Area			0.002 [0.05]
Connecting Rod Side Clearance		0.008 [0.20]	0.014 [0.36]
Gear Backlash - Gear to Gear			
All Gears	**0.020** **[0.50]**	0.003 [0.08]	0.012 [0.30]
Camshaft End Clearance		0.006 [0.15]	0.013 [0.33]
Injection Timing	Refer to Table 16N-5		
Injector and Valve Adjustment	Refer to Section 16N		
Engine Firing Order	Refer to Table 16N-7		
Belt Tension Lb	**70/80 After Run-In**	100	110
Injector Hold-Down Capscrew Ft-Lb [Nem]			
Nyloc Capscrews		11 [15]	13 [18]
Rocker Lever Shaft Ft-Lb [Nom]		60 [81]	70 [95]
Rocker Lever Housing Ft-Lb [Nom]		60 [81]	70 [95]
Rocker Lever Cover Ft-Lb [Nem]		30 [41]	35 [47]

Part or Location	Worn Limit	New Minimum	Now Maximum
Cam Follower Shaft Ft-Lb [N•m]		29 [39]	31 [42]
Cam Follower Covers Ft-Lb [N•m]		30 [41]	35 [47]
Flywheel Housing Capscrews Ft-Lb [N•m]		140 [190]	160 [2171
Flywheel Capscrews Ft-Lb [Nom]		200 [271]	220 [298]
Vibration Damper and Adapter Ft-Lb [N•m]			
Damper to Adapter		65 [88]	75 [102]
Adapter to Crankshaft		320 [434]	340 [461]
Fan Hub Nut Ft-Lb [Nom]		145 [197]	155 [210]
Exhaust Manifold Capscrews Ft-Lb [Nom]		40 [54]	45 [61]
Engine Testing	Refer to Page 16N-9.		
Dynamometer Test Chart	Refer to Table 16N-9.		
Lubricating Oil Pressure			
Idle Speed PSI [kg/sq cm]		15 [1.1]	
Rated Speed PSI [kg/sq. cm]		45 [3.2]	70 [4.9]

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IN ALL PRINCIPAL COUNTRIES OF THE WORLD**

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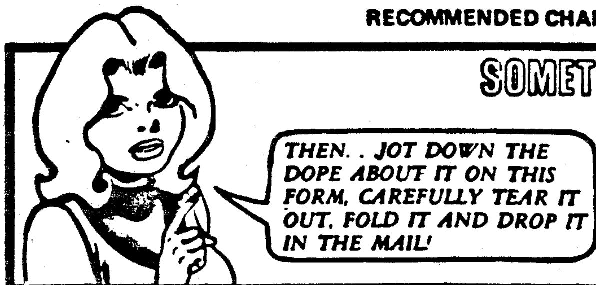

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PREVIOUS EDITIONS ARE OBSOLETE.

P.S.—IF YOUR OUTFIT WANTS TO KNOW ABOUT YOUR RECOMMENDATION MAKE A CARBON COPY OF THIS AND GIVE IT TO YOUR HEADQUARTERS.

THE METRIC SYSTEM AND EQUIVALENTS

'NEAR MEASURE

. Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches
1 Kilometer = 1000 Meters = 0.621 Miles

'EIGHTS

Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces
1 Kilogram = 1000 Grams = 2.2 lb.
1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
1 Liter = 1000 Milliliters = 33.82 Fluid Ounces

SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches
1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet
1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches
1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

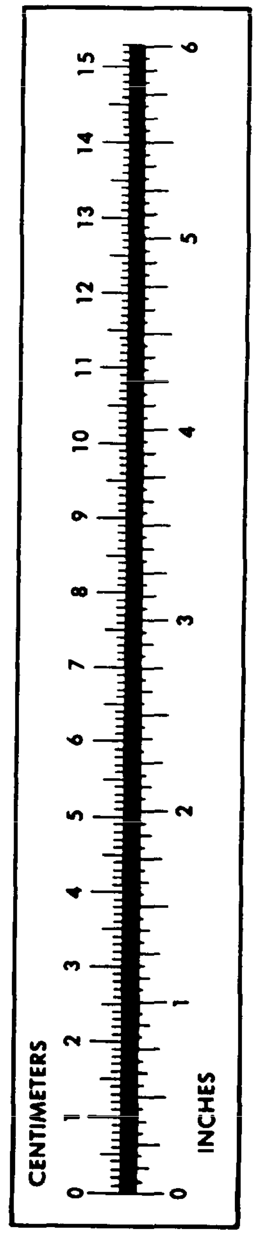
TEMPERATURE

5/9(°F - 32) = °C
212° Fahrenheit is evuivalent to 100° Celsius
90° Fahrenheit is equivalent to 32.2° Celsius
32° Fahrenheit is equivalent to 0° Celsius
9/5C° + 32 =°F

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
ıts	Liters	0.473
arts	Liters	0.946
allons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds per Square Inch	Kilopascals	6.895
Miles per Gallon	Kilometers per Liter	0.425
Miles per Hour	Kilometers per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
'ers	Gallons	0.264
.ms	Ounces	0.035
.ograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pounds-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
'lometers per Liter	Miles per Gallon	2.354
›meters per Hour	Miles per Hour	0.621



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