TECHNICAL MANUAL

UNIT, INTERMEDIATE DIRECT SUPPORT AND INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL

DRILLING SYSTEM, WELL, ROTARY, TRUCK MOUNTED, AIR TRANSPORTABLE, 600 FEET CAPACITY MODEL LP-12 NSN 3820-01-246-4276

Approved for public release; distribution is unlimited.

This technical manual is an authentication of the manufacturer's commercial literature and does not conform with the format and content requirements normally associated with Army technical manuals. This technical manual does, however, contain all essential information required to operate and maintain the equipment.

HEADQUARTERS, DEPARTMENT OF THE ARMY
8 MAY 1989

CHANGE No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C.4 October 1989

UNIT, INTERMEDIATE DIRECT SUPPORT AND
INTERMEDIATE GENERAL SUPPORT MAINTENANCE MANUAL

DRILLING SYSTEM, WELL, ROTARY
TRUCK MOUNTED, AIR TRANSPORTABLE,
600 FEET CAPACITY
MODEL LP-165F299
NSN 3820-01-246-4276

Approved for public release; distribution is unlimited.

TM 5-3820-256-24-5, 8 May 1989 is changed as follows.

1. Title is changed as shown above.

2. Retain this sheet in front of manual for reference purposes.

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

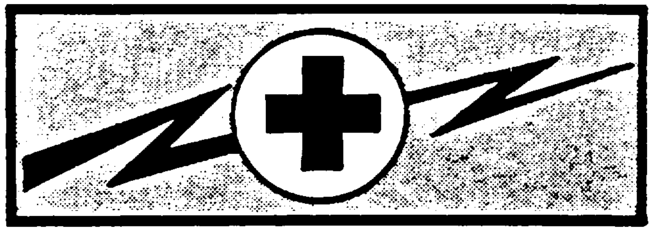
Official:

WILLIAM J. MEEHAN, II
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:
To be distributed in accordance with DA Form 12-25A, Unit, Direct Support and General Support Maintenance requirements for Drilling Machine, Well, Combination Rotary/Percussion, Semitrailer Mounted Diesel, 1500 Ft. Model CF-15-S

***U.S. GOVERNMENT PRINTING OFFICE 1989 - 654-030/00357** **PIN: 066265-001**

WARNING



MI 131637

ELECTRIC POWER LINES CAN KILL

Never raise mast or crane, or operate drill unit with less than 25 feet working clearance to any electrical power line.

Do not touch live electrical parts.

Check for buried utility lines before drilling.

WARNING

Crane and drilling operations have inherent hazards that cannot be mechanically safe guarded. Operator and maintenance personnel are required to wear hard hats and safety shoes.

Compressed air used for cleaning can create airborne particles that may enter the eyes. Pressure will not exceed 30 psig. Eye protection required.

Never operate engine in enclosed areas. Exhaust gases, particularly carbon monoxide, may build up. These gases are harmful and potentially lethal.

Cleaning solvent (PD-680, Type II) is toxic to skin, eyes and respiratory tract. Skin and eye protection required. Avoid repeated or prolonged contact. Good general ventilation is normally adequate.

Welding operations produce heat, highly toxic fumes, injurious radiation, metal slag and airborne particles. Protection equipment consisting of welding goggles with proper tinted lenses, apron or jacket, and welder’s boots required. Good general ventilation is normally adequate.

Exercise care when using sharp or pointed tools to prevent injury to personnel.

Personnel will be trained in safe climbing practices. Climbing devices will be used on mast at all times. Safety climbing devices will be inspected prior to each use to insure good working order.

For Artificial Respiration, refer to FM 21-11.

WARNING

NOISE HAZARD

exist for all personnel within 15 Feet of an operating drilling unit. Personnel must wear approved ear protection equipment. Failure to do so may result in impairment or loss of hearing.

1. SCOPE

This manual covers the 600 Feet Capacity Well Drilling System, Model LP-12, NSN 3820-01-246-4276. This manual consists of six volumes.

2. DRILLING SYSTEM

The Drilling System consists of three main components; a well drilling machine; a support vehicle (rig tender); and a well completion kit. Government furnished (GFE) incorporated as part of the system include a trailer mounted power unit and 3,000 gallon, collapsible, fabric water tank.

3. DRILLING MACHINE - VOLUME 1

The drilling machine is a truck mounted rotary well drilling machine consisting of a 32 foot mast, three drum drawworks assembly, rotary table, mud pump and air compressor. The components of the drilling machine are powered by the truck engine.

4. SUPPORT VEHICLE - VOLUME 2

The support vehicle is a truck mounted vehicle consisting of a 1,000 gallon water tank, hydraulically driven water pump, an electric fuel pump and fuel dispensing nozzle, a welder-generator assembly, and an electro-hydraulic crane. The support vehicle also provides a storage area for transport of drill pipe, collars, hand tools, operating and accessory equipment for the drilling machine, and the well completion equipment.

5. TRUCKS - VOLUMES 3, 4 and 5

The drilling machine and support vehicle are mounted on truck chassis of the same model. The drilling machine truck has a special design low profile cab. The truck is a diesel engine powered, 6x6 vehicle with a transfer case to transfer engine power to truck mounted components.

6. WELL COMPLETION - VOLUME 6

The well completion kit consists of equipment necessary for completion of a 600-ft. water well.

7. OPERATION INSTRUCTIONS

Refer to TM5-3820-256-10 for Operation, Preventive Maintenance and Lubrication of the Well Drilling System.

8. REPAIR PARTS

For repair parts refer to TM5-3820-256-24P, Repair Parts and Special Tools List.

9. APPENDIXES - VOLUME 6

Maintenance Allocation Chart is contained in Appendix A; Torque Requirements are contained in Appendix B.

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ENGINE

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FORWARD

This manual is part of a series of manuals intended to assist service technicians in maintaining International® Engines in accordance with the latest technical advancements.

Due to a commitment of continuous research and development, some procedures, specifications and parts may be altered to improve International® products and introduce technological advances.

Periodic revisions may be made to this publication and mailed automatically to "Revision Service" subscribers. The following literature, supporting International® Diesel Engines, is available from:

Forward Requests to:

International Harvester Company
Printing, Procurement and Distribution
807 Blackhawk Drive
Westmont, Illinois 60559

400 SERIES ENGINES

Form No.	Description
CGGES-185	300/400 Series Engine Service Manual
CGES-200	UTDS Model 100 Fuel Injection Pump Manual
CGES-375	Robert Bosch "MW" Injection Pump Manual
CGED-390	400 Series (w/UTDS Model 100 Pump) Performance Analysis Guide
CGED-365	400C Series (w/Robert Bosch MW Pump) Performance Analysis Guide

SERVICE DIAGNOSIS

Service diagnosis is a systematic procedure of investigation to be followed in order to locate and correct an engine problem. The engine is first considered as a complete unit in its specific application and then the problem is localized to components or systems; intake, exhaust, cooling, lubrication or injection. Testing procedures will then help analyze the source of the problem.

PREREQUISITES FOR EFFECTIVE DIAGNOSIS:

1. Knowledge of the principles of operation for both the engine and application systems.

2. Knowledge to perform and understand all procedures in the diagnostic and service manuals.

3. Availability of and the ability to use gauges and diagnostic test equipment.

4. Have available the current Guideline Data for the engine application.

Although the cause of an engine failure may be apparent, very often the real cause is not found until a repeat failure occurs. This can be prevented if specific diagnostic action is taken prior to, during and after engine disassembly and during engine reassembly.

It is also very important that specific diagnostic tests follow engine reassembly prior to and after the engine is placed back into service.

Identification of the symptoms which lead to engine failure is the result of proper service diagnosis. Effective service diagnosis requires use of the following references:

1. Appropriate Diesel Engine Service Manual.

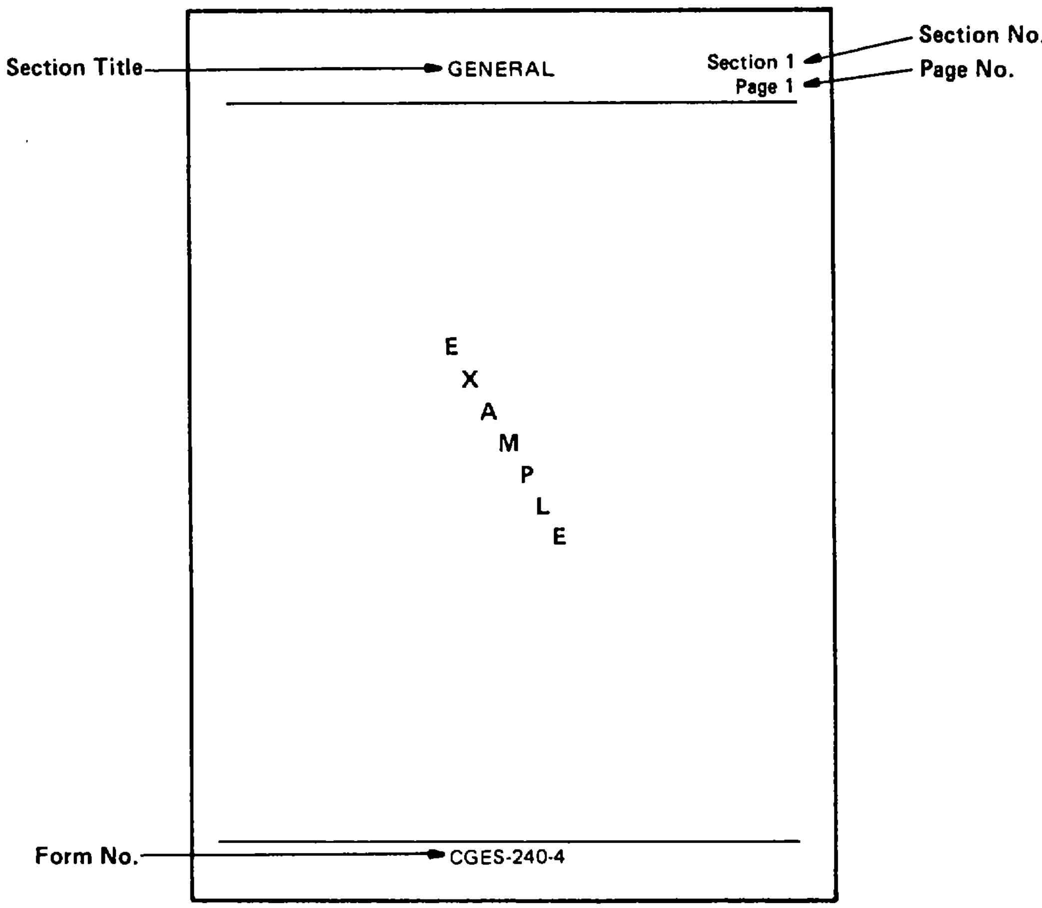
2. Performance Analysis Guides.

3. Fuel Injection Pump and Nozzle Service Manuals.

4. Service Bulletins.

This manual is arranged in sections, with the pages numbered consecutively in each section. Any photos or artist renderings are also numbered consecutively in each section. Included at the top of each page is the Section Title, Section Number and Page Number. The bottom center of each page will show the Manual Form Number (i.e. CGES-240-4).

NOTE: The dash four (-4) indicates the number of times the basic manual has been revised. (See Example.)



An index arranged according to sections will be found at the beginning of this manual.

INTRODUCTION

The engine data contained in this manual is to be used as guidelines for analyzing basic engine performance of INTERNATIONAL® ON-HIGHWAY and OEM Diesel Engines.

If data obtained is NOT within the guidelines shown on the "PERFORMANCE DATA GUIDELINE" sheets located in the rear of each section, "DIAGNOSTIC ANALYSIS" in Section 2 must be followed to determine the problem source before removal of any functional component, such as nozzles, injection pump or turbocharger, etc.

DIAGNOSTIC ANALYSIS

- DEFINITION -

Diagnostic analysis involved certain checks that are simple and easily performed. These checks usually reveal the most frequently encountered causes of faulty operation. The data obtained must be related to the complaint. A failure may be due to a chain of conditions that no one thought important enough to report. The repair must include the discovery of the true cause of the complaint and the corrective measures necessary to correct the condition.

The key to successful diagnostic analysis is the mental matching of the information of the condition with a complete knowledge of how the engine and all its components operate and their inter-relationship.

DIAGNOSTIC ANALYSIS PROCEDURES FOR

. . . OIL CONSUMPTION

When analyzing a lube oil consumption problem proceed as follows:

1. Visually inspect for external leaks and correct.
2. Check for air cleaner restriction, air induction system leaks and excessive crankcase pressure as specified in Section 5.

NOTE : On turbocharged engines, change oil filter elements and inspect for turbocharger damage if lube oil is drawn into the engine.

If items 1 and 2 are NOT the cause, continue analysis.

3. Verify the Problem -

a. Change the oil (using the recommended API Specification and viscosity for the ambient temperature). See NOTE.

b. Determine initial oil consumption rate and trend at

1000 miles/50 hours
or
5000 miles/250 hours

c. Record the amount of make up lube oil added during the test period.

NOTE: Verify engine is equipped with proper dipstick. Wrong dipstick may result in erroneous reading.

4. If oil consumption was excessive, determine the cause of the problem.
   - a. Abnormally heavy loads pulled by the vehicle. (Above the specified GVW).
   - b. Improper operation (i.e. allowing the engine to lug in the incorrect gear range) resulting in oil consumption.
   - c. Plugged air cleaner element causes high intake vacuum which will pull over oil through the crankcase breather tube. (Clean element).
   - d. Plugged crankcase breather element. (Clean element) .
   - e. Faulty air compressor.(If compressor piston rings are worn, oil can leak into the air system).
   - f. Worn engine valve guides. (Clean, inspect and replace if required).
   - g. Worn rings and/or bores due to dirt passing air cleaner.

. . . FUEL CONSUMPTION

1. When excessive fuel consumption is suspected, verify the problem.
   - a. Compare the actual rate of consumption in gallons per hour or miles per gallon against normal expected fuel usage in subject vehicle.
   - b. If excessive fuel consumption is confirmed determine the cause of the problem.
2. Check entire fuel system (tank to injection pump) for leaks.
3. Investigate possibility that engine is not in proper specs for the application by conducting diagnostic tests indicated in text.
4. Review driver’s habits to be sure he is not lugging or overspeeding engine.
5. Inspect engine per the "PERFORMANCE DATA GUIDELINES" in the rear of each Engine Section for the particular application.

. . . HIGH COOLANT TEMPERATURE (Temperature above 200° F to 210° F)

1. Verify problem:
   a. Determine operating conditions when overheating occurs.
   b. Check temperature indicators for accuracy.
   c. Refer to guideline temperature data in the "PERFORMANCE DATA GUIDELINES" located in the rear of each Engine Section.
2. Verify operation:
   a. Operator’s habits - running improper range.
   b. Vehicle specifications - check guideline data if correct for vehicle and job.
   c. Accessory equipment - approved?
3. Engine Maintenance:
   a. Clean, no oil leaks, no external coolant leaks.
   b. Belt adjustments correct (use Krikit gauge).

Refer to the following Maintenance Manuals for belt adjustment specifications:

Engine	Manual No.
DT-466 1	1 171 478 R1
DT/DTI-466B	1 171 562 R1
DT/DTI-466C	1 171 585 R1
400 Series OEM	1171 581 R1
9.0 Liter (All Model Years)	1171 584 R1
6.9 Liter (A Model)	1171 569 R1
6.9 Liter (B Model)	1171 577 R1

4. Inspect Cooling System:
   a. Coolant clean and properly inhibited for season.
   b. Radiator caps operative. Use pressure test kit. Check restriction at water pump inlet. Should not exceed 10 kPa (3 in Hg) without pressure cap and engine at high idle.
   c. Hoses - correct type and properly clamped.
   d. Radiator clean and unobstructed by bent fins, pinched tubes, etc.
   e. Radiator correct. Check repair history or use of "stop leaks." Check specifications of radiator for vehicle.
   f. Fan - proper specification for vehicle, proper fit in shroud. Properly installed.
   g. Shutter control (if equipped) operative and correct set.
5. Inspect Engine:
   a. Water pump condition.
   b. Thermostat and seal - proper specifications and operating correctly.
   c. Engine static timing and advance unit operation.
   d. Oil cooler(s) proper flow both oil and water.
   e. Engine power correct.
   f. Coolant aeration from head gasket or nozzle sleeve leakage ("Pop bottle" test).

      "Pop Bottle Test"

      1. Fill bucket and pop bottle with water.
      2. Run engine until operating temperature is reached.
      3. Immerse filled pop bottle in bucket of water with neck facing bottom of bucket.
      4. Insert cooling system overflow line into pop bottle neck.
      5. Observe pop bottle for aeration (bubbles) or in extreme cases the water in the pop bottle will be blown out.

NOTE: Bubbles or expulsion of water from bottle indicate head gasket or nozzle sleeve leakage.

. . . EXCESSIVE SMOKE

1. Excessive visual smoke can occur under two general conditions:
   a. During acceleration.
   b. During full load operation.
2. Smoke during acceleration can be caused by a malfunctioning fuel modulator or improper operation of vehicle. For example, the driver must keep engine speed within the range specified for the transmission and rear-end drive ratio or intake manifold pressure will drop and allow fuel modulator to actuate.
   (400 Series, D-Series and 9.0 Liter only)
3. If smoke under Full Load Operation is not within recognized limits, follow the "PERFORMANCE ANALYSIS GUIDE" CGED-390 for 400-Series with UTDS* Model 100 Fuel Injection Pump, CGED-365 400 C-Series with Robert Bosch Model MW Fuel Injection Pump or CGED-335-2 for 9.0 Liter diesel engine to determine the cause of the problem.

NOTE: A smoke sampling kit can be used to test smoke intensity as described in Section 5. Sampling Kit is not used on 6.9 Liter.

4. Smoke color can indicate particular problems
   a. BLUE SMOKE - could indicate lube oil is being burned in the cylinders.

*United Technologies Diesel Systems (formerly AMBAC)

- If turbocharged, inspect compressor housing for signs of oil leakage.
- Inspect the cooling system, overcooling can sometimes cause blue smoke.
- Check the "AIR INDUCTION SYSTEM."

b. GRAY SMOKE depending on the specific level, can be caused by the injection nozzle condition and/or air induction system. Gray smoke will exceed specified levels:

- If air cleaner restriction is high or
- If injection system does not meet "PERFORMANCE DATA GUIDELINE" specifications.

Remove and test nozzles.

c. BLACK SMOKE must be immediately corrected. All areas of appropriate "PROBLEM ANALYSIS GUIDE" (CGES-390, 365, 335-2, or 355-3) must be investigated to determine cause.

- If problem cannot be resolved by analysis, remove injection pump for a test stand analysis.

d. WHITE SMOKE - generally indicates

- Excess fuel on starting with
- Insufficient cranking speed or
- Defective nozzles.

These conditions result in misfiring with warm engine.

5. In general, any excess smoke problem can be resolved by following the procedures in the appropriate "PERFORMANCE ANALYSIS GUIDE".

EVALUATING NORMAL EXHAUST SMOKE (6.9 Liter Diesel only)

BLUE-WHITE SMOKE CAN BE OBSERVED

- At engine start up at all engine temperatures and at all ambient temperatures.
- At low idle speeds after cold engine start up this smoke will clear up soon after the vehicle is driven.
- After the engine warm up period due to extended idling time (ten minutes or more).

DARKER SMOKE CAN BE OBSERVED

- When pulling hard, such as going up a steep grade.
- Heavily loaded, such as pulling a trailer or operating with a heavy load in the truck bed.
- During acceleration.

NOTE: Black smoke under the above conditions will be much more pronounced at higher altitudes.
High altitude fuel adjustment instructions are available through IH dealers in those areas, as well as CGES-345 6.9L Fuel Injection Pump Service Manual.

VERY IMPORTANT: DO NOT OPERATE ENGINE ABOVE RATED SPEED.

Operating above rated speed at no load high idle or light load conditions will result in:

- WHITE - BLUE/WHITE SMOKE.
- GOVERNOR HUNTING - SURGE.
- SPUTTERING OR MISFIRE.

These conditions occur because at W.O.T. the face cam is in the full retard position and the min-max. governor is cutting fuel delivery back to idle quantities, which causes:

- SPEED VARIATION AND VERY RETARDED VARIABLE TIMING.

. . . LOW POWER

1. Verify problem:
   a. Determine how power or performance is checked.
   b. Compare to identical units in same type operation.(Refer to "PERFORMANCE DATA GUIDELINES" in the rear of each Engine Section).
2. Determine cause of problem:

   a. Check fuel type and grade. Refer to appropriate "OPERATION AND MAINTENANCE" manual.

b. Inspect all linkage for full travel from high idle stop to low idle stop under all conditions of operation. Make certain operation of vehicle is not changing these adjustments. Verify high idle.

c. Inspect override at wide open throttle. (See NOTE).

NOTE: Throttle override is the adjustment made at the throttle lever which compensates for wear that occurs in throttle linkage and for chassis movement. If throttle override is not maintained, full throttle and consequently, maximum performance will not be available.

d. Measure transfer pump pressure .
- Change filters
- Check for fuel inlet restriction or
- Replace transfer pump if necessary.

e. Measure air cleaner restriction.

- Service air cleaner element(s) as necessary.

f. Check injection pump timing and correct injection pump on engine.
- 400-SERIES with UTDS Model 100 Pump visual check/Flow Time and Dynamic check using (3005, 3005A or SE-2783) CREATIVE TOOL TACH/ TIME KIT w/14 mm split-nut transducer or Sun TACH/TIME KIT (PLT-301 or SE-2528)
- 400-SERIES with Robert bosch MW Pump - visual pointer inspection.
- 9.0 LITER - visual pointer inspection/ Flow Time.
- 6.9 LITER visual check/Dynamic check using SE-4142 Kent-Moore TACH N' TIME TM , Creative Tool SE-2783 or Design Technology Tech-Time Model 3354.

g. Loss of one cylinder.
- Check for plugged injection line.
- Check nozzle operation.

h. 400 SERIES (Turbocharged Engines only)

- Pressurize intake system and inspect for leaks at line between intake manifold or crossover and injection pump aneroid. Air leakage may occur at line connectors or pump or manifold. During engine operation leaks at the connectors can cause manifold pressure to be reduced at the aneroid which allows injection pump to operate in "cut back" or reduced power level. However, slight manifold pressure leakage is allowable on pressure side of the intake system, such as at the turbocharger compressor housing, as long as manifold pressure meets Performance Data Guidelines.
- Test aneroid diaphragm by applying (15 psi max.) air pressure, using D-100 Test Kit, for 30 seconds. If leakage occurs, replace diaphragm. Low power and low manifold pressure will result if diaphragm leaks because injection pump will stay in "cut back" position.

end of the cable to the threaded plug on the panel. Connect the transducer cord to the push-turn plug on the panel.

NOTE: Before proceeding with a running check, it is recommended that an injection pump static (engine stopped) timing check be made.

5. Start the engine and check for fuel leaks.

6. Attain operating temperature.

7. Perform the speed and timing checks as follows: (See OPERATION, this section).

   a. Turn power on by moving the "TACH-OFF T. LIGHT" to the "TACH" position. Red power supply light will be on.

   b. Check calibration as described in OPERATION, this section.

   c. Put "TACH. ADVANCE" switch to "TACH." position. Adjust engine speed to indicate 700 RPM as shown in PERFORMANCE DATA GUIDELINES, Section 6.

   d. Put the "TACH-OFF T. LIGHT" switch to the "T. LIGHT" position. Move the "TACH. ADVANCE" switch to the "ADVANCE" position. Rotate "ADVANCE" knob as directed in OPERATION, this section, to obtain timing.

   e. Switch the "TACH-OFF T. LIGHT" and "TACH. ADVANCE" to the "TACH" positions. Adjust engine speed to specified total pump timing speed for the particular application (see PERFORMANCE DATA GUIDELINES, Section 6).

   f. Move the "TACH-OFF T. LIGHT" and "TACH ADVANCE" switch to "T-LIGHT" and "ADVANCE" respectively. Rotate "ADVANCE" knob as directed in OPERATION, this section, to obtain injection pump timing (Degrees of Advance). Compare readings with specifications.

IMPORTANT

IF THERE IS A QUESTION OF TIMING LIGHT ACCURACY FLOW TIME THE PUMP AS DESCRIBED IN SECTION 5. FLOW TIMING IS ACCOMPLISHED WITH- OUT REMOVING THE PUMP DELIVERY VALVE.

CREATIVE TOOL MODEL CT4000 DIESEL TIMING AND TACHOMETER INSTRUMENT (SE-2783) OR (3005A)' CURRENT MODEL

DESCRIPTION

The diesel timing and tachometer instrument (Figure 5) is a solid state electronic instrument used to dynamically measure fuel injection pump timing and automatic advance in degrees. This instrument also reads engine RPM from cranking to high idle speeds. The 14 mm Split-Nut Transducer No. CT-4000-13 is used for 400 Series On- Highway and OEM Engines.

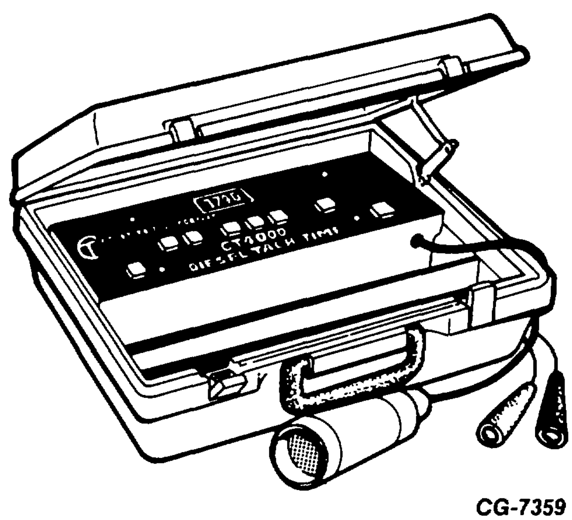


Figure 5. Diesel Timing and Tachometer Instrument (SE-2783 or 3005A)

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CREATIVE TOOL MODEL CT4000 DIESEL TIMING AND TACHOMETER INSTRUMENT (SE-2783 OR (3005A) CURRENT MODEL (Continued)

KEYBOARD DESCRIPTION

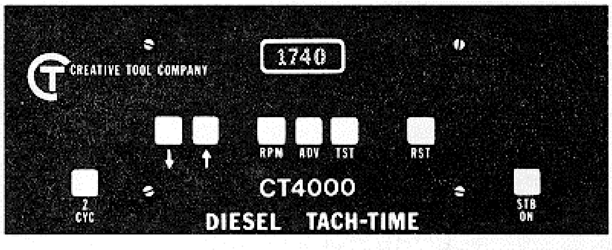

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Figure 6. Control Keyboard

The following is a description of SE-2783's or 3005A's Control Keyboard. From this keyboard, each function of SE-2783 or 3005A can be selected. ONCE A KEY HAS BEEN DEPRESSED, IT MAY BE RELEASED. With the possible exception of the "↑" and "↓" keys, it is not necessary to hold the key depressed. SE-2783 or 3005A reacts as soon as the key is depressed, and remains in that mode until another key has been depressed.

"RST"

The Reset Key will place the SE-2783 or 3005A in the "power-up" mode. Often times when an engine is cranked, the battery voltage will drop below the 9 volt minimum required to operate the SE-2783 or 3005A. To place the instrument into proper operation after this has happened, release and de- press the "RST" Key.

NOTE: The "RST" key is a latching key and will remain down until depressed again - to release it. The key must be depressed when the instrument is in operation.

"2 CYC"

This key is a latching key used on 2 cycle engines. It should be depressed for 2 cycle engines and released for 4 cycle engines.

"TST"

This test key has two functions. Each time the SE-2783 or 3005A is connected to a power source, this key MUST be depressed before any other function can be selected. This places the SE-2783 or 3005A in an operational mode.

Additionally, each time "TST" is depressed, the SE-2783 or 3005A checks to see if a signal is being received from the transducer. If a signal is being received "8888" appears in the lighted display. If the display shows "- - - - ," a problem exists.

"RPM"

This key when depressed, places the SE-2783 or 3005A in the rpm mode. Engine speed will be displayed on the digital readout.

"ADV"

This key, when depressed, places the SE-2783 or 3005A in the ADVANCE mode so injection timing can be easily measured as described in the "OPERATING PROCEDURES" section.

"STB ON"

This key operates the remote strobe light unit. To turn on the strobe light, depress "STB ON" key. To turn the light off, depress and release the key. The timing light can be turned on whether in "RPM" or "ADV" mode of operation.

" ↑"

This key functions during the "ADV" mode. In the ADVANCE mode, it will increase or increment the advance angle by one if it is depressed and re- leased quickly. If it is depressed and held for greater than one-half second, the advance angle will be incremented by one; then at the end of one- half second, it will begin to slew or increase at a rate of four degrees per second for as long as the key is depressed. When the key is released, the display shows the accumulated advance angle.

"↓"

This key is identical to the "↑" key in operation, but when depressed, it decreases or decrements the display in the same manner as the "↑" increased it.

NOTE: It will not go below O in the "ADV" mode.

OPERATING PROCEDURES

NOTE: It is important that the following sequence of events be stricly adhered to.

1. Clean the area of the injection pump where the transducer is to be installed (at #1 or #6 fuel outlet). Do NOT install at the nozzle end of the line.

2. Install the 14 mm Split-Nut Transducer No. CT-4000-13 as follows:

   a. Remove the fuel line connector nut (1, Figure 7) and slide it up the pipe. Secure the displaced nut with tape to prevent bouncing of the nut and possible erratic readings.

   b. Install the 14 mm Split-Nut Transducer (2, Figure 7) over the fuel line by slipping the slotted portion of the transducer on the line and tighten the Split-Nut Transducer to allow slight fuel leakage at the split-nut when the engine is started. Tighten the split-nut only until leakage stops. Use of this method will allow you to achieve the required torque of 23.5 N•m (17.5 lb. ft).

NOTE: When applying or removing the Split-Nut Transducer always make sure the short coaxial (white) cable (3, Figure 7) is not caught up in the lines. Pulling apart of the short white cable from the transducer damages the ground, causing erratic readings.

3. Check static timing (engine stopped).

NOTE: Static timing must be checked before any timing checks are made with the timing light.

4. Mark the TDC dot on the crankshaft pulley and the front cover pointer with white paint or similar product so a clear reading can be obtained when the strobe light is used.

5. Connect power leads to any 12 or 24 volt negative ground electrical system. The power leads are not color coded. Connect either lead to the positive (+) side of the battery and the other to a good ground. continued on next page

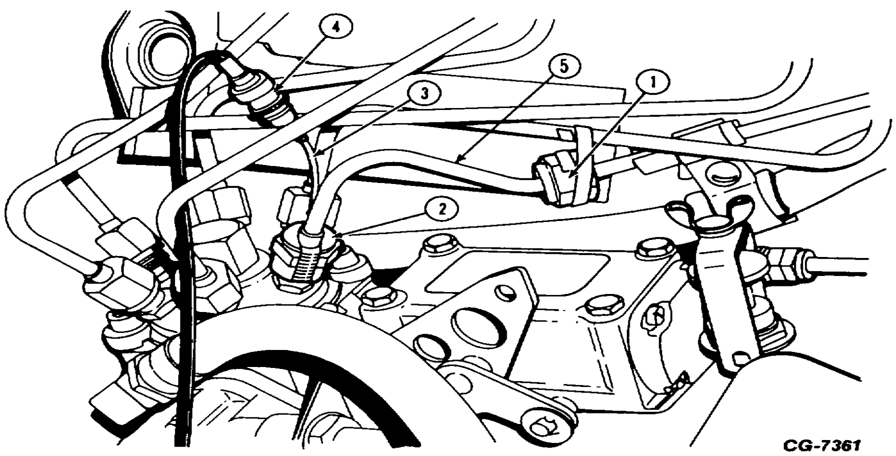


Figure 7. 14 mm Split-Nut Transducer Installed
UTDS Model 100 Pump Shown*

1. Displaced Fuel Line Connector Nut (Taped on Fuel Line)
2. 14 mm Split-Nut Transducer
3. Short Coaxial (White) Cable
4. Lead to Coaxial Cable From SE-2783 or 3005A Unit. Attach Using BNC (Bayonet) Connector.
5. No. 6 Fuel Injection Line. (No. 1 may be used)

*United Technologies Diesel Systems (formerly AMBAC)

CREATIVE TOOL MODEL CT-4000 DIESEL TIMING AND TACHOMETER INSTRUMENT (SE-2783) OR (3005A) CURRENT MODEL (Continued)

OPERATING PROCEDURES (Continued)

6. Connect the lead (4, Figure 7) provided to couple the tachometer and timing light unit (SE-2783) or (3005A) to the white coaxial cable at the 14 mm Split-Nut Transducer (2, Figure 7).
7. Start the engine. Check for fuel leaks.
8. Perform the speed and timing checks as follows: (See KEYBOARD DESCRIPTION, this section).

   a. Depress the "RST" (Reset) key.

NOTE: If it is already depressed, release and depress. SE-2783 or 3005A should be "powered up" at this point, as indicated by the "- - - -" appearing in the digital display.

   b. Depress and release the "TST" (TEST) key on the keyboard to place the SE-2783 or 3005A in the operational mode. "8888" appearing in the digital display indicates the unit is operational and a signal is being received from the transducer. "- - - - -" on the digital display indicates:

      1. The transducer is disconnected.
      2. The unit is NOT functioning properly.
      3. The appearance of any other character or number at this time means the unit is not functioning properly.

NOTE: Once the SE-2783 or 3005A has been placed in the operational mode, any of the functions can be selected.

   c. Depress and release the "RPM" key. The instrument is now in the RPM mode. Engine speed will be displayed on the digital readout. Adjust engine speed to 700 RPM as shown in the PERFORMANCE DATA GUIDELINES, Section 6.

   d. Depress and release the "ADV" key. The instrument is now in the ADVANCE mode. Set ADVANCE mode to double zero (00). Depress "STB-ON" key to activate the strobe light. Aim the strobe light and increase advance mode (by one increment at a time) using the " ↑ " key until TDC mark and front cover pointer align. When the marks are in alignment, release the " ↑ " key. The actual timing will be shown on the display.

IMPORTANT

WHENEVER CHANGING ENGINE SPEEDS, DEPRESS THE " ↓ " BUTTON TO REACH DOUBLE ZERO (00) ON THE DISPLAY BEFORE PROCEEDING.

   e. Depress the "RPM" key and increase engine RPM to total pump timing speed, as specified in PERFORMANCE DATA GUIDELINES, Section 6.

   f. With the ADVANCE mode reset to double zero (00), increase the ADVANCE mode (by one increment at a time) using the " ↑" key until the TDC mark and front cover pointer align. When marks are in alignment, release the " ↑ " key. The injection pump timing (Degrees of Advance) will appear on the digital display. Compare readings with specifications.

NOTE: Do not exceed specified maximum total pump timing speed (RPM).

IMPORTANT

IF THERE IS A QUESTION OF TIMING LIGHT ACCURACY FLOW TIME THE PUMP AS DESCRIBED IN SECTION 5. FLOW TIMING IS ACCOMPLISHED WITH- OUT REMOVING THE PUMP DELIVERY VALVE.

KENT-MOORE TACH-N-TIME™ DYNAMIC TIMING METER SE-4142 (FOR 6.9 Liter Diesel)

DESCRIPTION

The SE-4142 TACH-N-TIME™ from Kent-Moore uses the latest in microprocessor technology to quickly and accurately measure fuel injection pump timing.

The pump pulse is picked up by a piezoelectric transducer that clamps on the No. 1 fuel injection line.

Crankshaft location is picked up with a magnetic probe. The probe offset is automatically computed by the SE-4142 TACH-N-TIMETM.

Using the pump pulse signal and the crankshaft location signal, a microprocessor gives a digital display of exact engine RPM and injection pump timing in degrees.

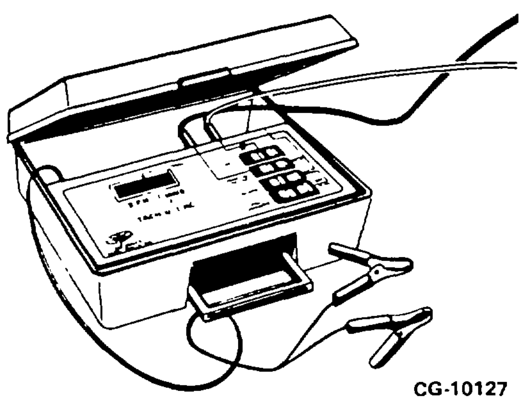


Figure 8. TACH-N-TIMETM INSTRUMENT SE-4142

OPERATING PROCEDURES

1. Select the ¼ in. transducer (black).

2. Clamp-on the ¼ in. piezoelectric transducer to the No. 1 fuel injection line (See Figure 9) at the injection nozzle end.

IMPORTANT

- **THE TRANSDUCER MUST BE PLACED ON A STRAIGHT SECTION OF THE FUEL LINE WITHIN 4 IN. OF THE INJECTION NOZZLE.**
- **CLEAN THE FUEL LINE WITH ABRASIVE CLOTH OR STEEL WOOL TO REMOVE ALL PAINT PRIOR TO AFFIXING THE TRANSDUCER.**
- **DO NOT ALLOW THE TRANSDUCER TO CONTACT THE INJECTION LINE NUT.**
- **DO NOT OVERTIGHTEN THE TRANSDUCER ON THE FUEL LINE. A "SNUG" FIT IS ALL THAT IS NECESSARY FOR PULSE DETECTION.**

3. Connect ground clip from transducer harness to an appropriate ground as shown in Figure 9.

4. Connect the remaining wire from the transducer harness to the plug in receptacle on the SE-4142 body labeled "SENSOR SIGNAL".

IMPORTANT

TRANSDUCER MUST BE DRY. WET CONDITIONS CAN CAUSE ERRATIC READINGS. IF ERRATIC READINGS ARE OBSERVED, REMOVE TRANSDUCER, WIPE LINE AND TRANSDUCER WITH A CLEAN, DRY CLOTH AND SPRAY TRANSDUCER, ON ALL SURFACES, WITH A WATER DISPLACING SUBSTANCE, SUCH AS WD-40® AND RECLAMP ON THE FUEL LINE.

5. Set "SENSOR SIGNAL" toggle switch to the "CLAMP ON" position.

6. 6.9 Liter Diesel uses magnetic probe method for determining crankshaft position.

- **MAGNETIC PROBE METHOD -CRANKSHAFT MONITORING 6.9 LITER DIESEL ONLY**

1. Insert the magnetic probe into the magnetic pick-up access hole located on engine. (See Figure 9).

2. Plug probe terminal into the receptacle on the SE-4142 body labeled "MAGNETIC PICK-UP".

3. Set toggle switch to "MAGNETIC PICK-UP" position.

4. Connect the SE-4142 battery leads to the vehicle battery (red to "+", black to "-"). Display should light up and read (Set ...... 20.0).

CAUTION!

Do not connect to battery system with a "floating ground". The SE-4142 should be powered from a source with a "fixed ground".

5. Set timing offset degrees to 20° for 6.9 Liter "S" Series applications. To set, hold "OFF-SET ADJUSTMENT" rocker switch down while simultaneously depressing either "INCREASE" or "DECREASE" on the rocker switch immediately above it, until you reach the 200 offset angle. Release both switches. Display should now read all zeros.

6. Make sure all cables and wires are clear of fan, belts or any other moving parts. Keep wires away from exhaust manifolds.

7. Start engine. Sensor light on SE-4142 should be blinking regularly, indicating proper function of connectors. Allow engine to reach operating temperature.

8. Check initial dynamic timing and advance by adjusting engine RPM and actuating housing pressure solenoid as directed in Section 5.

9. Engine RPM and timing angle can be read directly from the SE-4142 display.

10. Repaint the scraped fuel line when timing operation is complete to protect the line against corrosion.

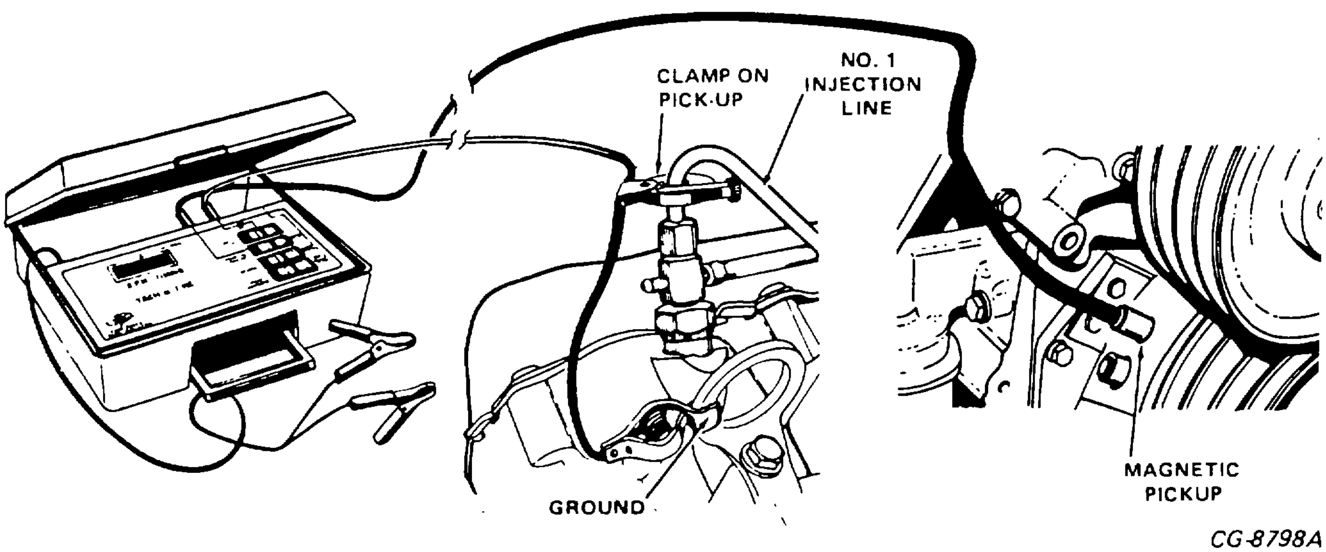


Figure 9. KENT-MOORE TACH-N-TIME^{TM} SE-4142 CONNECTIONS.

DESIGN TECHNOLOGY "TECH TIME" Model 3354 Dynamic Timing Meter (For 6.9 Liter Diesel)

DESCRIPTION OF FRONT PANEL AND ATTACHMENTS (All Reference Nos. refer to Figure 10)

- The Function Control Switch (1) has four positions:
  - LIGHT - Selects the timing method of crankshaft monitoring.
  - PROBE - Selects the magnetic probe method of crankshaft monitoring for engines equipped with a probe holder over the vibration damper, as in the 6.9 Liter Diesel.
  - OFFSET - When in this position, the "Degree Display" will indicate the number of degrees after TDC that the magnetic probe access hole is located.
  - AVE. - Controls the number of seconds over which RPM pulses are averaged. When switched to this position, the unit will display "AVE. 1.4". This represents the initial 1.4 second averaging time set in when power is first applied. To change this number [with switch in AVE. position] tap either the ↓ or ↑ "Adjust" button to decrease or increase the averaging time. Each tap of the button will change the time by 0.1 second. Total adjust range is 0.1 to 6 seconds. This adjustment allows the operator to monitor engine speed variation to whatever response time is desired. For most purposes, an averaging time of 1 to 2 seconds gives a steady reading.

- SOCKET (2) to connect timing light.

- JACK (3) to connect magnetic probe.

- PICK-UP (4) for bayonet connector to connect clamp-on transducer.

- ADJUST BUTTONS (5) used to change the offset of the timing unit to agree with the off-set of the magnetic probe access hole on the engine, or to change the averaging time of the display.

- TRIGGER POINT SWITCH (6) used to select the point on the fuel pressure curve at which the timing unit will trigger.

IMPORTANT

USE HIGH TRIGGER SETTING ONLY FOR THE 6.9 LITER.

- POWER SOURCE CLIPS (7) to be connected to vehicle battery RED to "+", BLACK to " - ".

CAUTION!

Observe polarity, the timing unit itself is protected against reverse polarity, however, damage to the cables may result!

- CLAMP ON TRANSDUCERS (8) available in three sizes: 1/4 in (black), 6 mm (green) and 5 mm (red).

- TRANSDUCER CONNECTING CABLE (9).

- TIMING LIGHT (10).

- DISPLAY (11): Left side shows RPM, right side indicates DEGREES OF ADVANCE, PROGRAMMED OFFSET and AVERAGING TIME.

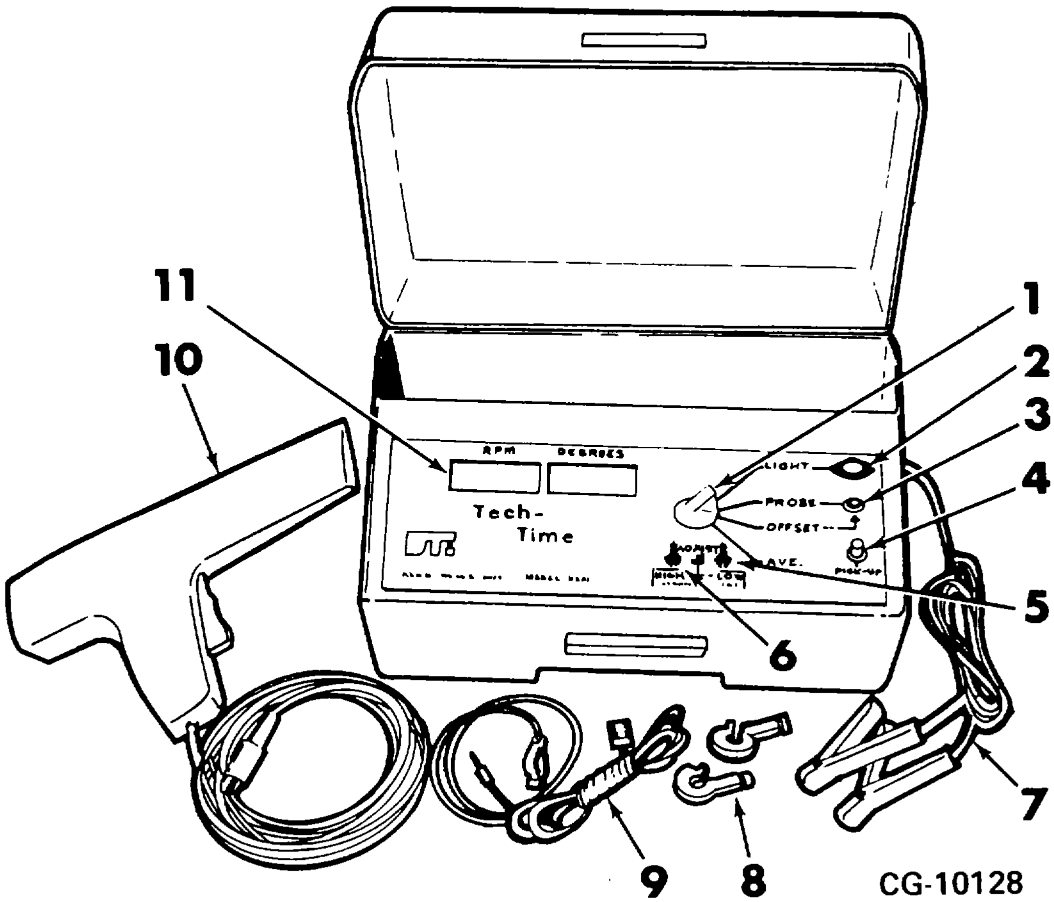


Figure 10. Design Technology "Tech Time" Model 3354 Components.

1. Function Control Switch
2. Socket
3. Jack
4. Pick-Up
5. Adjust Buttons
6. Trigger Point Switch (Must be @ High Setting
7. Power Source Clips
8. Clamp on Transducer
9. Transducer Connecting Cable
10. Timing Light
11. Display

OPERATING PROCEDURES

1. Select the 1/4 in. transducer (Black).

2. Clamp on the 1/4 in. transducer to the No. 1 fuel injection line (See Figure 11) at the injection nozzle end.

> **IMPORTANT**
>
> - **THE TRANSDUCER MUST BE SECURELY ATTACHED ON A STRAIGHT SECTION OF THE FUEL LINE WITHIN 4 IN. OF THE INJECTION NOZZLE.**
> - **CLEAN THE FUEL LINE WITH ABRASIVE CLOTH OR STEEL WOOL TO REMOVE ALL PAINT PRIOR TO AFFIXING THE TRANSDUCER.**
> - **DO NOT ALLOW THE TRANSDUCER TO CONTACT THE INJECTION LINE NUT.**
> - **DO NOT OVERTIGHTEN THE TRANSDUCER ON THE FUEL LINE. A "SNUG" FIT IS ALL THAT IS NECESSARY FOR PULSE DETECTION.**

3. Connect ground clip from transducer to an appropriate ground as shown in Figure 11.

4. Connect transducer to timing unit PICK-UP (4, Figure 10) using transducer connecting cable (9, Figure 10).

> **IMPORTANT**
>
> **TRANSDUCER MUST BE DRY. WET CONDITIONS CAN CAUSE ERRATIC READINGS. IF ERRATIC READINGS ARE OBSERVED, REMOVE TRANSDUCER, WIPE LINE AND TRANSDUCER WITH A CLEAN, DRY CLOTH AND SPRAY TRANSDUCER, ON ALL SURFACES, WITH A WATER DISPLACING SUBSTANCE, SUCH AS WD-40® AND RECLAMP ON THE FUEL LINE.**

5. Connect the POWER SOURCE CLIPS (7, Figure 10) to the vehicle battery terminals or 8 to 28 volt supply [red to "+", black to "-"] OBSERVE POLARITY OR DAMAGE TO CABLES MAY RESULT!

6. 6.9 Liter Diesel uses magnetic probe method for determining crankshaft position.

- MAGNETIC PROBE METHOD - CRANKSHAFT MONITORING 6.9 LITER DIESEL only.

1. Connect the magnetic probe (Figure 11) to the timing unit by inserting plug into probe JACK (3, Figure 10).

2. Insert the magnetic probe into the magnetic pick-up access hole located on the engine (Figure 11).

3. Turn the Function Switch (1, Figure 10) to "OFFSET". With power applied to the timing unit, the DEGREE DISPLAY should light up and read "SET 20.0".

NOTE: The 6.9L Diesel has a 20° OFFSET thus no OFFSET adjustment is required.

4. Turn FUNCTION CONTROL SWITCH TO "PROBE". The RPM display should read 0 and the DEGREE DISPLAY should read 0.0.

5. Set timing unit to "HIGH TRIGGER" mode.

> **IMPORTANT**
>
> **HIGH TRIGGER MODE <u>MUST</u> BE USED WITH THIS METER. USE OF THE LOW TRIGGER SETTING WILL RESULT IN FAULTY TIMING READING.**

6. Start engine and observe the displayed reading. The left display indicates RPM, the right the actual number of degrees off TDC. Allow engine to reach operating temperature.

IMPORTANT
IF THE MAGNETIC PROBE IS NOT CLOSE ENOUGH TO THE VIBRATION DAMPER OR IS NOT CONNECTED PROPERLY TO THE UNIT, THE TIMING UNIT WILL DISPLAY THE CORRECT RPM BUT THE DEGREES SHOWN WILL BE THE NEGATIVE VALUE OF THE OFFSET PROGRAMMED INTO THE UNIT. RECHECK CONNECTIONS AND POSITION OF PROBE.

7. Check initial dynamic timing and advance by adjusting engine RPM and actuating housing pressure cold advance solenoid (HPCA).

8. Repaint the scrapped fuel line when timing operation is complete, to protect the line against corrosion.

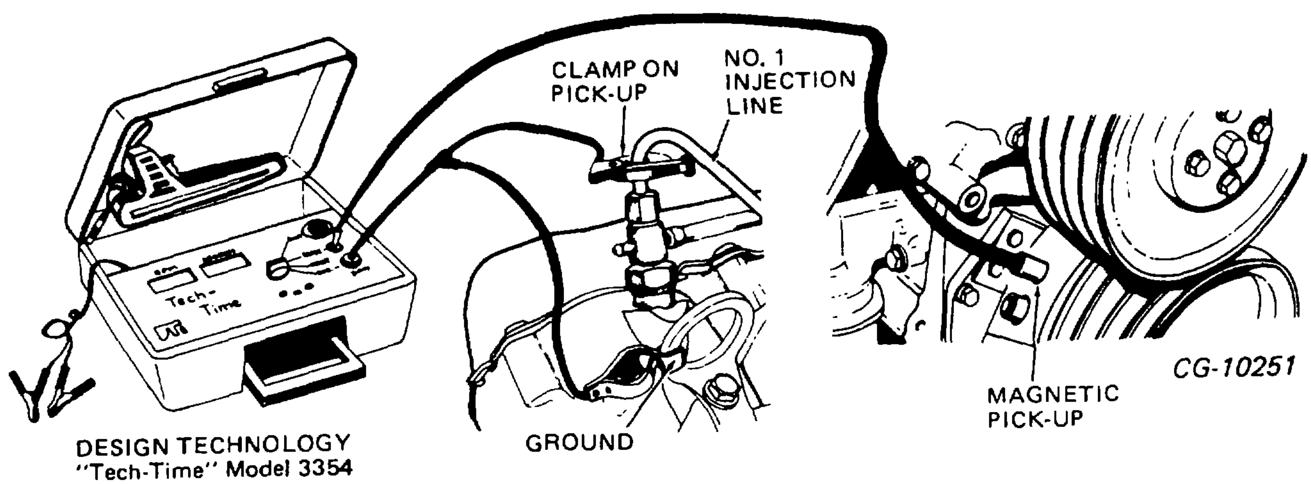


Figure 11. Design Technology Tech-Time Model 3354 Connections

BEYERS MODEL 100 PRESSURE TEST KIT (SE-2239)

DESCRIPTION

The Pressure Test Kit (Figure 12) can be used to measure intake manifold (boost) pressure, fuel pressure, air cleaner restriction, exhaust back pressure and crankcase pressure, however, because of the low maximum limit of crankcase pressure, the use of this kit is not recommended. It may also be used to check the radiator cap and to test the accuracy of the gauges within the kit.

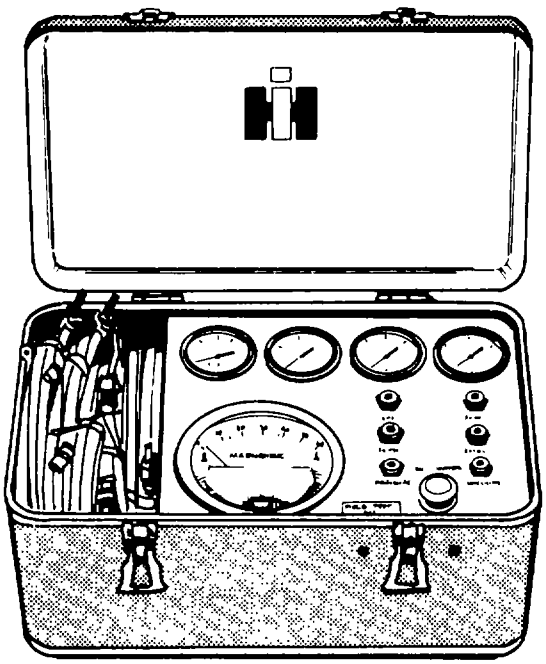


Figure 12. Pressure Test Kit

The 0-15 psi gauge may be used to check the radiator cap. The hand operated pump is usually connected to the 0-15 psi gauge. By rerouting the tubing under the panel, it may also be used for testing the accuracy of the gauges.

The 0-30 psi gauge may be used to check intake manifold (boost) pressure and fuel modulator diaphragm (Aneroid) leakage test. Refer to SLF- 78-19 (ESB-78-10) when performing leakage test.

The 0-60 inches of water (magnahelic) gauge may be used to measure air cleaner restriction and exhaust back pressure. Although crankcase pressure is measured in inches of water, the low maximum limit prohibits the use of this 0-60 inches of water gauge. The water manometer is recommended for measuring crankcase pressure

The 0-160 psi gauge is normally used to check fuel pressure.

The 0-300 psi gauge is not normally used for any engine diagnostic check.

MAINTENANCE AND GAUGE ACCURACY TEST

1. Remove cover of pressure test kit and inspect for damage to gauges such as broken cover glass, bent gauge needles, and for missing pressure connectors and nylon tubing. Replace damaged or missing parts so that the kit will operate when needed.

2. Remove the screws holding gauge panel to carrying case and lift panel from carrying case. If any liquids are found in the tubing behind the panel, loosen the connections and blow out the liquids. Tighten all connectors as required and reassemble gauge panel.

3. The hand operated pump is directly connected to 0-15 psi gauge when the kit is received. If a gauge accuracy test is desired, proceed as described under "CALIBRATING THE PRESSURE KIT (SE-2239) using the Dwyer Slack Tube® Manometer," in this section.

OPERATING INSTRUCTIONS

Connect tubes between the test ports on the panel and the test points shown in Section 5.

CAUTION!

The quick disconnects have shut-off valves in the panel connectors not in the plug. DO NOT connect or disconnect lines while under pressure.

NOTE: When using the inches of water, magnahelic gauge, be sure to use the proper panel connector. Exhaust back pressure uses the "Pressure" connector and air cleaner restriction uses the "Vacuum" connector. In both cases, the opposite connector MUST be vented to the atmosphere by installing a quick connective plug in the port.

DWYER SLACK TUBE® MANOMETER

DESCRIPTION

The manometer (Figure 13) is a "U" shaped tube with a scale mounted between the legs of the "U". Where the portability of the SE-2239 is not required, this manometer can be used to measure either low pressure or vacuum and may be filled with water or mercury. The Dwyer Manometer filled with mercury can be used to calibrate the 0-30 psi gauge of the SE-2239.

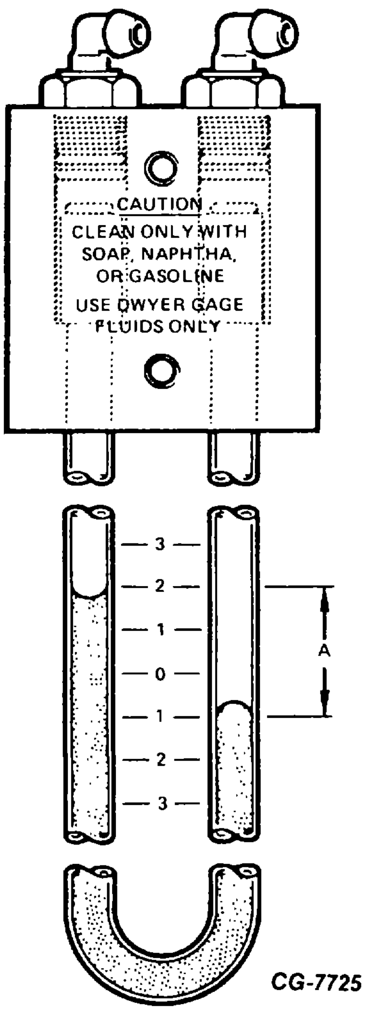


Figure 13. Slack Tube Manometer
"A" Dimension Indicates Total Fluid Column
Dwyer No. 121148

Order from: Dwyer Instruments, Inc.
P.O. Box 373
Michigan City, Indiana 46360
Phone: (219) 872-9141

FILLING

The manometer may either be filled with water, when checking very low pressures, or with mercury, when checking slightly higher pressures. Refer to the Performance Data Guideline pages in Section 6 to determine whether water or mercury should be used.

When filling with water, use only good drinking water without additives except for some colored water vegetable dye which enables the tester to read the scale easier. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

When using mercury, the quantity of fluid needed may be found in the Operating Range and Mercury Fill Chart. Use triple distilled mercury to minimize tube discoloration.

IMPORTANT

NEVER USE AN ANTI-FREEZE SOLUTION, SODA POP, TONIC, ETC. THE INCREASE IN DENSITY CAUSES FALSE READINGS.

OPERATING RANGE AND MERCURY FILL CHART

Tool No.	Operating Range	Required Ounces of Mercury
Inches of Water or Mercury		
Dwyer No. 1211-48	24"-0-24"	22-1/2

INSTALLING AND READING

1. Support the manometer in a vertical position. Be sure the fluid is at the zero mark on the scale.

2. Connect one leg of the manometer to the source of the pressure or vacuum. Be sure the other leg is open to atmosphere.

3. Start the engine and when the engine is in the proper operating condition as specified in Performance Data Guideline pages, observe the manometer.

4. After about two minutes, record the average position the fluid level is above and below the zero mark. Add the two figures together. The sum of the two is the total column of fluid.

NOTE: At times both columns of the manometer will not travel the same distance. This is of no concern to the tester as long as the leg not connected to the pressure or vacuum source is open to the atmosphere.

5. If it is necessary to convert from the column of fluid to psi or kPa, refer to the "Metric Conversion Factor Chart" in Section 11.

CLEANING

1. Wash the tube thoroughly with a little pure soap and water. Avoid liquid soaps and solvents.

2. Dry thoroughly before refilling with mercury.

CALIBRATING THE PRESSURE TEST KIT (SE-2239) USING THE DWYER SLACK TUBE® MANOMETER

1. The hand operated pressure pump on the SE-2239 is directly connected to the 0-15 psi gauge when the test kit is received. Remove the nylon line connecting the pressure pump to the 0-15 gauge and reconnect the line to 0-30 psi gauge. Connect the 0-15 gauge to the 0-15 panel connector.

   Now the hand operated pump is directly connected to the 0-30 gauge. When the pump is operated and no leaks are present at the tubing connectors, panel quick disconnects, or within the pump, a pressure will build on the gauge. If the gauge shows a pressure build-up and then falls off, a leak is present and must be corrected before proceeding. Replace gauges with bent needles, broken cover glass, or gauges that do not operate when pressure is applied.

2. Prepare the manometer for use by removing the manometer from its carrying case and attaching the manometer to a steel surface. Magnets at the back of the manometer will hold the manometer in a vertical position. Note that the manometer has a 90 degree fitting at the top of each column.

   Remove one 90 degree fitting, check valve, and cork to fill the manometer with mercury. Loosen the other 90 degree fitting to vent the opposite column to the atmosphere. Add sufficient mercury to approximately reach the zero mark in both columns. Slide the center measuring scale up or down until the zero mark on the scale is at the top of both columns of mercury. This will "zero" the manometer for reading pressure or vacuum. Since mercury has a high surface tension, always read the manometer column at the highest point of the mercury. If water were used in the manometer, always read the manometer column at the lowest point of the water. Install the removed 90 degree fitting, check valve, and cork but do not tighten completely. The 90 degree fitting must be loose enough to keep the column vented to the atmosphere to measure accurately.

3. To determine the accuracy of the 0-30 gauge, connect a quick disconnect at the 0-30 gauge panel opening. Attach tubing to the quick disconnect and hook up tubing to one side of the mercury manometer. At this point, both 90 degree fittings are loose. One fitting is connected to the tubing and one side is vented to atmosphere.

   Check to see that the manometer is still zeroed. Operate the hand pump and pressure will be read on the 0-30 gauge and also on the mercury manometer. Test for air leakage in the tubing and connectors by watching the manometer and the gauge. A drop off in the manometer reading or gauge indicates an air leak which must be corrected before proceeding.

4. Read manometer as follows:

   Operate the hand pump until the gauge reads exactly six pounds. Read the corresponding mercury manometer pressure by adding the heights of the two columns of mercury. A difference in the height of the columns caused by slight variations in the tubing diameter does not effect the accuracy of the manometer.

   7.65 inches of mercury plus 7.5 inches of mercury equals 15.15 inches of mercury.

continued on next page

CALIBRATING THE PRESSURE TEST KIT (SE-2239) USING THE DWYER SLACK TUBE® MANOMETER (Continued)

4. Read manometer as follows: (Continued)

Use the conversion factor one inch of mercury equals 0.4912 psi to determine the actual pressure in pounds per square inch.

15.15 x 0.4912 = 7.44 psi

Read the gauge pressure again to determine if any air leakage has reduced the gauge pressure from six psi. If the gauge pressure still reads 6 psi, we have determined that the gauge reads 1.44 psi lower than the actual pressure.

Record the gauge pressure, corresponding mercury manometer reading, and convert the manometer reading to psi for each gauge psi from 6 to 22 psi. Repeat the calibration test from 6 psi to 22 psi to double check for air leaks and accuracy of gauge and manometer readings.

Gauge PSI Reading	Inches of Mercury	Conversion	Actual PSI
6	7.65+ 7.50= 15.15	15.15x0.4912=	7.44
7	8.65+ 8.45= 17.10	17.10x0.4912=	8.39
8	9.70 + 9.45 = 19.15	19.15 x 0.4912 =	9.40
9	10.80+ 10.40 = 21.20	21.20 x 0.4912 =	10.41

From the above information, make up a correction chart for the gauge and place it on the gauge panel.

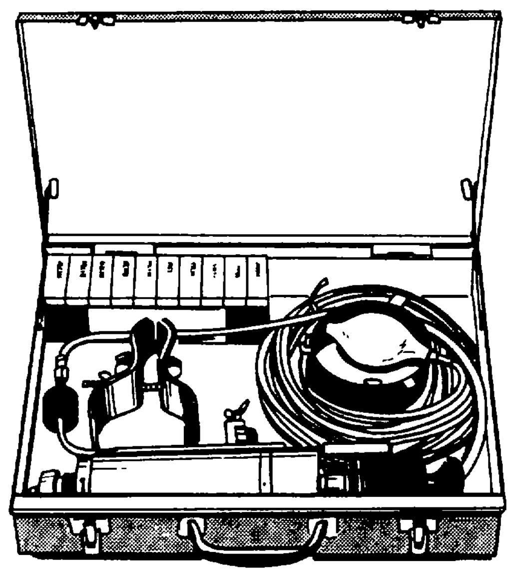
Gauge PSI Reading	Actual PSI
6	7.4
7	8.4
8	9.4
9	10.4

Guideline intake manifold pressures for each engine horse power rating are printed on the "PERFORMANCE DATA GUIDELINE" pages at the rear of each Engine Section. Each pressure has a +1.5 psi range. For example, the DTI-466B rated at 210 HP at 2600 RPM pressure of 125 + 10 kPa (18 + 1.5 psi) at 2600 RPM. An engine operating with 117-138 kPa (17-20 psi) pressure will produce the rated horsepower at the flywheel. Using this calibration procedure to test the accuracy of the 0-30 psi gauge before measuring engine pressure will assist you in evaluating engine performance. Using an accurately calibrated boost gauge along with the diagnostic procedures in this manual, will allow you to determine if the engine is producing rated horsepower and eliminate unnecessary engine component changes.

ROBERT BOSCH SMOKE SAMPLING KIT (SE-2580)

DESCRIPTION

The smoke sampling kit (Figure 14) is used for reading smoke density at the exhaust stack at rated load and speed only to determine acceptability of smoke emission.



CG-5878

Figure 14. Smoke Sampling Kit

OPERATION

In the smokemeter, a sampling pump draws off a certain amount of exhaust gas from the exhaust pipe of the respective engine and then sucks it through a filter paper disk. The filter paper disk, in turn, darkens during this process and thus gives the measure of the soot content of the exhaust gases.

Refer to the appropriate engine section for operation and maintenance instructions.

CRANKCASE PRESSURE ORIFICED RESTRICTOR (SE-4039) w/1103 cm [0.406 in.] ORIFICE [For 400 Series, and 9.0 Liter Diesel Engines.]

DESCRIPTION

The restrictor is used to measure combustion gas flow out of the engine breather and is used with Pressure Test Kit (SE-2239).

IMPORTANT

PRESSURE READINGS OBTAINED WITH THIS RESTRICTOR MUST NOT BE USED AS THE MAIN SOURCE OF ENGINE CONDITION. OIL CONSUMPTION TREND DATA MUST ALSO BE USED IF THE PRESSURE READINGS ARE BEYOND THE SPECIFIED LIMITS. NEITHER CHANGES IN OIL CONSUMPTION TRENDS NOR CRANKCASE DIAGNOSTIC PRESSURES TRENDS CAN ESTABLISH A SPECIFIC COMPONENT PROBLEM BUT ARE ONLY INDICATORS THAT SOME PROBLEM EXISTS.

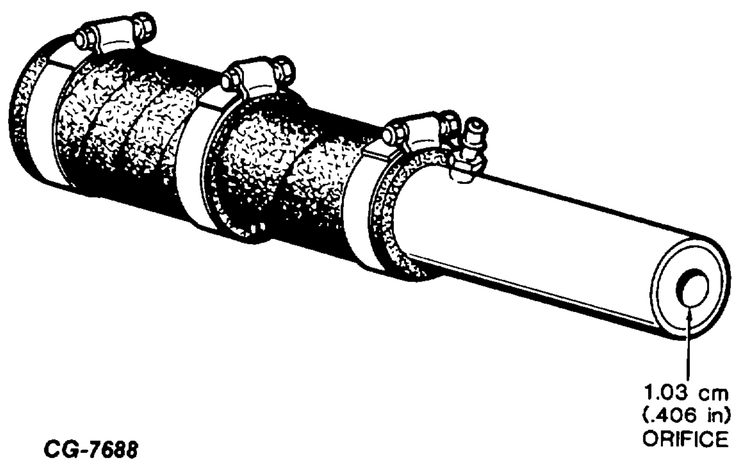


Figure 15. Orificed Restrictor Tool SE-4039 (For 400 Series, and 9.0 Liter Diesel Engines.)

CRANKCASE PRESSURE ORIFICED RESTRICTOR TOOL (SE-4146) [6.9 Liter Diesel Only}

DESCRIPTION

This restrictor has an integral oil fill cap, which provides nearly effortless set-up, when performing a crankcase pressure test on the 6.9 Liter Diesel Engine. The SE-4146 Orificed Restrictor Tool, like its cousin the SE-4039 used on 400 Series, D-Series and 9.0 Liter Diesel Engines, a

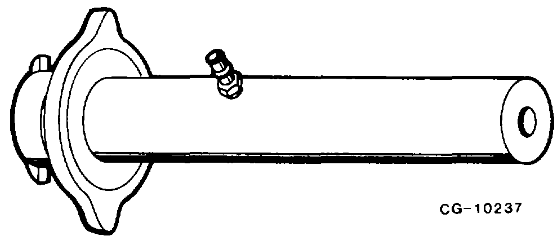


Figure 16. Orificed Restrictor Tool SE-4146 (For 6.9 Liter Diesel Only)

CGED-365 DIAGNOSTIC ANALYSIS GUIDE FOR 400 C SERIES DIESEL ENGINES WITH ROBERT BOSCH MW INJECTION PUMP

–SIDE ONE–

ENGINE DIAGNOSTICS
INTERNATIONAL 400 SERIES
DIESEL ENGINES WITH R BOSCH MODEL MW
INJECTION PUMP
DIAGNOSTIC ANALYSIS GUIDE

REGION	BRANCH/DEALER	ALTITUDE	AMBIENT AIR TEMP	DATE

CHASSIS MODEL	VIN	ENGINE MODEL	ENGINE HP	RATED SPEED	COMPLETE ENGINE SERIAL NUMBER TRUCK MILEAGE	HOURS

PUMP SERIAL NUMBER 1ST CHECK	PUMP SERIAL NUMBER 2ND CHECK	MILEAGE ON PUMP	HOURS	MILEAGE ON ENGINE	HOURS

TESTS

SUFFICIENT CLEAN FUEL

1 FREE OF WATER - ICING - CLOUDING - CORRECT GRADE

METHOD	1st CHECK	2nd CHECK
VISUAL CHECK ☐		

EXTERNAL LEAKAGE

2 ☐ FUEL ☐ OIL ☐ AIR ☐ COOLANT
RECORD LOCATION OF LEAKS IN "COMMENTS"

METHOD	1st CHECK	2nd CHECK
VISUAL CHECK ☐		

ACCELERATOR LINKAGE

3 A ADJUSTED TO OBTAIN OVERRIDE AT FULL THROTTLE
See Illustration – Reverse Side

METHOD	1st CHECK	2nd CHECK
VISUAL CHECK ☐		

SHUTOFF CABLE OR ELECTRIC SHUTOFF *See Illustration – Reverse Side*

4 ADJUSTED TO ALLOW FULL RUN POSITION

METHOD	1st CHECK	2nd CHECK
VISUAL CHECK ☐		

LOW IDLE (RPM)*

5 A MANUAL TRANSMISSION - NEUTRAL
B AUTOMATIC TRANSMISSION - DRIVE
C MIXER - DRUM ENGAGED

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
MASTER TACHOMETER			

HIGH IDLE RPM (NO LOAD)*

6 THROTTLE IN OVERRIDE POSITION AND AT MAXIMUM (HIGH IDLE) STOP
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
MASTER TACHOMETER			

AIR CLEANER MAXIMUM RESTRICTION*

7 A MEASURE AT FULL LOAD AND RATED SPEED
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

SUPPLY PUMP PRESSURE (MEASURE AT HIGH IDLE) (NO LOAD)*

8 A 1 TEST AT FINAL FUEL FILTER VENT PLUG
See Illustration Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
PRESSURE GAUGE (160 PSI RANGE)			

IF PRESSURE REMAINS LOW AFTER REPLACING FUEL FILTERS PERFORM STEP B

B TEST SUPPLY PUMP INLET RESTRICTION 6 HG (MAX) VACUUM MEASURE AT FULL LOAD AND RATED SPEED
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
VACUUM GAUGE			

INJECTION PUMP INITIAL TIMING (ENGINE STOPPED)

9
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
1 VISUAL POINTER INSPECTION			

INTAKE MANIFOLD PRESSURE*

10 A MEASURE AT FULL LOAD AND AT SPECIFIED SPEEDS
B SELECT TRANSMISSION GEAR TO ACHIEVE FULL LOAD (AUTOMATIC TRANSMISSION – STALL RPM & LOAD)
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
PRESSURE GAUGE (30 PSI RANGE)			

CRANKCASE PRESSURE*

11 A LATE MODEL TURBO WITH VALVE COVER MOUNTED BREATHER
1 Measure @ breather tube with orifice restrictor tool, SE 4039, PLT 554 or 15 533 5
2 Measure – High Idle (no load) RPM

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

STOP! READ THIS INSTRUCTION
IF GUIDELINE DATA IS OBTAINED DURING THE FIRST 11 TESTS CONTINUE! - WITH TESTS 12, 13, 14, 15 AND 16 IF GUIDELINE DATA IS NOT OBTAINED

TEST INJECTION NOZZLES

12 A SPRAY CONDITION
B VALVE OPENING PRESSURE
C LEAKAGE

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
HAND TEST PUMP (NOZZLE TESTER) (SE 2002, PLT 360 or 15-71A)			

ANEROID DIAPHRAGM

13 PRESSURE TEST DIAPHRAGM (20 PSI MAX – FOR 30 SECONDS)
NO LEAKAGE PERMISSIBLE
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
D-100 PRESSURE KIT (SE 2239 or PLT 300)			

EXHAUST BACK PRESSURE

14 A MEASURE AT POINT 3 TO 6 IN AFTER ELBOW OR STRAIGHT PIPE EXHAUST EXTENSION FLANGE
B MEASURE AT FULL LOAD & RATED SPEED
See Illustrations – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

MEASURE SMOKE INTENSITY*

15 MEASURE AT FULL LOAD & RATED SPEED (RPM)

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
SMOKE SAMPLING KIT (SE 2580 OR PLT 308)			

INTAKE AND EXHAUST VALVE CLEARANCE

16 ENGINE OFF – HOT OR COLD

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
FEELER GAUGE			

-IMPORTANT-
† All operating data is obtained from "PERFORMANCE DATA GUIDE-LINE" for specified application listed in "DIESEL ENGINE DIAGNOSTIC MANUAL "CGES-240-1 (or later).

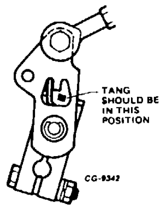
*ENGINE MUST BE AT NORMAL OPERATING TEMPERATURE

COMMENTS

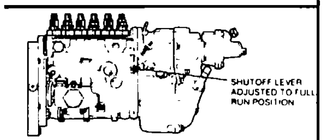
SERVICE TECHNICIAN	DATE /
BRANCH/DEALER SERVICE MANAGER	DATE /
REPLACEMENT AUTHORIZED BY	DATE /

CGED-365

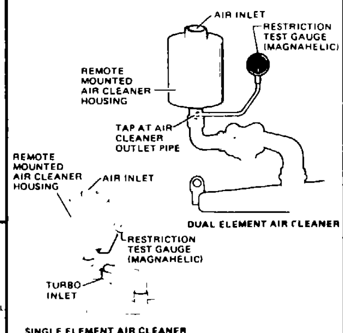
CGED-365 DIAGNOSTIC ANALYSIS GUIDE FOR 400 C SERIES DIESEL ENGINES WITH ROBERT BOSCH MW INJECTION PUMP -SIDE TWO-



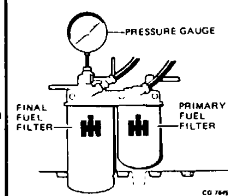
ACCELERATOR LEVER OVERRIDE TEST
TEST 3 and 6



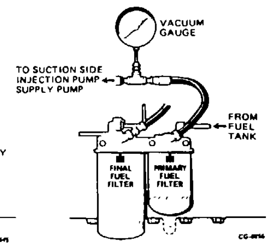
SHUT OFF TEST
TEST 4



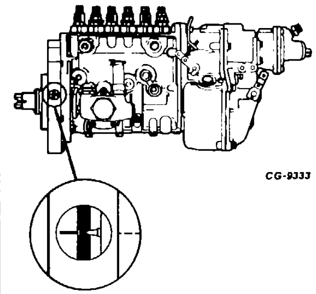
AIR CLEANER RESTRICTION TEST
TEST 7



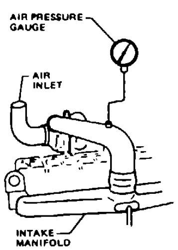
FUEL SUPPLY PUMP PRESSURE TEST
TEST 8A



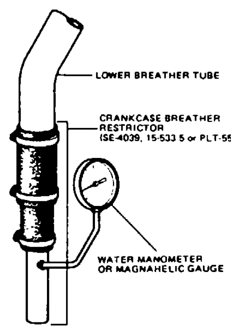
FUEL INLET RESTRICTION TEST
TEST 8B



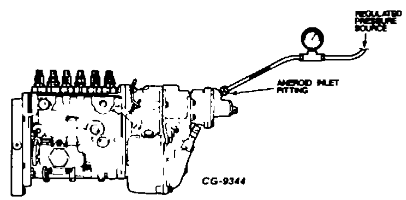
INJECTION PUMP TIMING
TEST 9



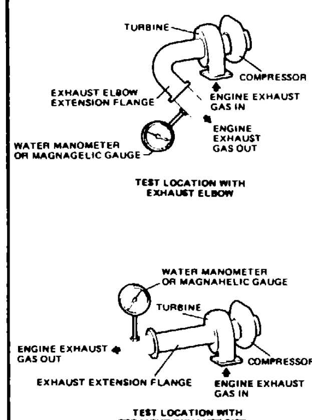
INTAKE MANIFOLD PRESSURE TEST
TEST 10



CRANKCASE PRESSURE TEST
TEST 11



ANEROID DIAPHRAGM LEAKAGE TEST
TEST 13



EXHAUST BACK PRESSURE TEST
TEST 14

FORM NO. CGED-365

SUFFICIENT CLEAN FUEL		
FREE OF WATER - ICING - CLOUDING - CORRECT GRADE OF FUEL		
METHOD	**1ST CHECK**	**2ND CHECK**
VISUAL CHECK		

• **Sufficient Clean Fuel**

If fuel is satisfactory, enter OK in 1st check box. Drain water or remove foreign substances as required. Record any corrective action taken in the comments section at the bottom of the form.

Fuel Quality

Fuel must be of proper grade, clean, undiluted and free of air.

1. CHECK FOR AIR IN FUEL: Check for leaks in the supply line from the tank to the fuel pump. If in doubt, connect a piece of clear plastic tubing from the filter to the injection pump inlet. Run engine and watch for air bubbles - THERE SHOULD BE NO AIR BUBBLES.
2. CHECK FOR QUALITY: By-pass the fuel system. Run the engine with a can of fuel known to be of good quality. Observe engine performance. If engine performance is improved with the use of the sample fuel, clean the system and refill with proper, clean fuel.

Cold weather can cause fuel waxing of certain grades of diesel fuel which result in fuel filter plugging.

Refer to the appropriate Engine Operation Manual for fuel specifications:

Engine	**Operation Manual Form No.**
DT/DTI-466C	1171 585 R1

FORM NO. CGED-365

EXTERNAL LEA■AGE	■		■ ☐	■ ☐
	FUEL	OIL	AIR	WATER
RECORD LOCATION OF LEAKS IN "COMMENTS"				
■	**METHOD**	**1ST CHECK**		**2ND CHECK**
☐	VISUAL CHECK			
	PRESSURE CHECK			

- **External Leakage**

Inspect fuel, oil, air or coolant leaks. If no leaks are found, enter OK in 1st check box. Upon visual inspection, check all hoses and look for water stains, oil stains and wetness at the water pump. Record the location of leaks in the comments section.

Leakage can be the reason for complaints of poor fuel economy, or high oil consumption. A leak in the air intake system can shorten engine life, especially under dusty conditions. A coolant leak can result in a complaint of engine overheating.

If coolant and air leaks are observed, but the source not readily identified, the service technician may utilize the following test procedures to pin point the coolant or air leak:

I. ENGINE COOLANT LEAKAGE TEST

General

Too often attempts to correct complaints of external and/or internal water leakage reflect an arbitrary replacement of oil to water coolers and/ or a complete engine teardown for a visual inspection. Components such as cylinder heads, coolers, etc., are either sent out for inspection and/or replaced as the result of a guess. THIS IS NOT A RECOMMENDED APPROACH AND IN MOST CASES LEAVES MUCH DOUBT IF ALL LEAKAGE AREAS HAVE BEEN IDENTIFIED.

THE PROCEDURE DESCRIBED BELOW IDENTIFIES THE MOST COMMON POINTS OF LEAKAGE and describes the step-by-step procedure to use to implement the test.

Leakage Test Procedure

1. Drain all lube oil and coolant from engine and radiator.
2. Disconnect the radiator from the engine and cap off all the engine connections (with hose clamps and plugs).
3. Disconnect the unit's cab heater connections at the engine and plug engine openings.
4. Disconnect and remove air discharge pipe from turbocharger to intercooler (if equipped).
5. Disconnect and leave open oil supply return line to crankcase from air compressor (if equipped).
6. Remove all valve covers, push rod or valve lifter side inspection covers, lube oil pan and oil drain plug from lube oil cooler.

CAUTION

Do not loosen or remove any injection nozzles from the cylinder head while the cooling system is under pressure.

7. Fill the engine with water and attach an air line connection coupled with a regulator assembly to water drain in cylinder block.
8. Pressurize the crankcase cooling system to 40 psi. Pressure must be maintained until leakage location is evident.
9. It is essential that all points of leakage be identified prior to teardown and repair. NO EXTERNAL OR INTERNAL LEAKAGE IS ALLOWABLE.

Possible Location of Leakage

a. Cracked or porous cylinder head, blown head gasket (engine).
b. Cracked or loose injector nozzle sleeves.
c. Cracked or porous crankcase.
d. Damaged or eroded cylinder sleeve "O" rings or crankcase area.
e. Cracked or porous power cylinder sleeve.
f. Cracked or loose tubes in oil cooler.
g. Cracked or loose tubes in intercooler (if equipped).
h. Cracked or porous cylinder head, blown head gasket (air compressor).

II. AIR INDUCTION SYSTEM PRESSURE TEST

General

The most common cause of engine failure is dirt. Even though an air cleaner element itself is properly serviced per the specific Operation and Maintenance Manual, there are other areas in the induction system which must be maintained. The importance of pressure testing the air induction system cannot be emphasized enough with present- day high speed diesel engines. An air induction leak on the suction side, no matter how small, can cause an engine failure and must not be tolerated. Test for leakage in the air induction system using a manually regulated compressed air supply, 0-103 kPa (0-15 psi) pressure test gauge, tube fittings, duct tape, paint brush and soap solution.

Test Procedure

1. Block off air inlet pipe or completely mask off the outer diameter of air cleaner element air inlet with duct tape.

NOTE: Air systems having air cleaners with reverse flow must be blocked at the air intake pipe.

2. Disconnect the air cleaner restriction indicator or tubing at the air cleaner. Install a tee and connect the indicator or tubing and the pressure test gauge.
3. Remove a pipe plug from the intake manifold. Connect the manually regulated compressed air supply to the manifold.
4. Introduce air to establish that 34 kPa (5 psi) pressurization has been achieved by reading the pressure gauge. If improper pressure is seen, adjust the regulator. A constant supply of air is needed to compensate for air loss out open exhaust valves.
5. Coat the following areas with the soap solution and check for leaks. Leaks will cause air bubbles to form.
   a. Air cleaner body surface around the outlet pipe.
   b. Air cleaner outlet pipe to air cleaner body junction.
   c. Fitting and line connection from air cleaner outlet to restriction indicator including the bottom of the indicator.
   d. All clamped hose and gasket connections between air cleaner outlet and intake manifold. This includes connections at turbocharger, when applicable.
   e. Surface of all air induction piping and hoses between air cleaner and intake manifold including the manifold gasket area.
   f. When applicable, the air compressor air inlet piping from the air cleaner tube to and including the fitting and the gasket.
   g. When applicable, the piping to the intercooler.
6. No leakage is permitted between air cleaner and turbocharger (suction side) in turbocharged applications. If leakage at the joints is detected, tighten hose clamps. If leakage still persists, remove the parts to determine the cause. Replace parts as necessary using the latest clamps and torques specified. Retest the corrected area.

NOTE: Any leaks found in air induction system could have allowed dirt to enter engine. Dirt entering engine can cause high oil consumption because of badly worn or broken piston rings, excessive blue smoke, turbocharger compressor wheel pitting and erosion. If any leaks are found in the air intake system, you can check the internal condition of the engine by running a crankcase pressure check.

Visually inspect the following:

1. Inspect air cleaner housing externally for damage or distortion which could allow unfiltered air to enter the engine. Also, inspect to see that the unloader valve is in place and not plugged by foreign material.

2. Inspect air cleaner housing internally for damage to baffles, end seal movement indicated by polishing where end seal contacts the air cleaner housing. End seal movement indicates dirt may have passed the air cleaner element and entered the engine.

3. Inspect air cleaner element for holes, damaged seals, element sooting, end cap denting because of overtightening or damage during servicing.

4. Inspect hoses and clamps for tightness and positioning over sealing beads.

- **Accelerator Linkage - 400 Series On-Highway (with Robert Bosch MW Fuel Injection Pumps)**

FROM FORM CGED-365

3	**ACCELERATOR LINKAGE**		
	A. ADJUSTED TO OBTAIN OVERRIDE AT FULL PEDAL DEPRESSION		
	METHOD	**1st CHECK**	**2nd CHECK**
	VISUAL CHECK ☐		

Inspect Throttle Linkage

1. With accelerator pedal at full depression, visually inspect tang in outer control lever. Tang should be in "override" position, Figure 1.

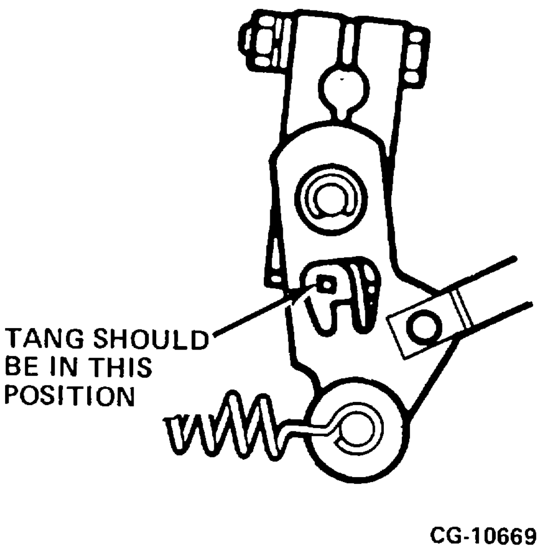


Figure 1a. Control Lever Override (Linkage View Without Bellcrank)

NOTE: High idle speed and maximum engine horsepower will be obtained when control lever is rotated fully counterclockwise (CCW) and inner control lever contacts high idle stop. Override position ensures that slight wear can occur in the throttle cable and the control lever will still contact the high idle stop.

2. If the control lever was in override position at full pedal depression,-enter OK in the 1st check box. If required, adjust throttle cable to achieve override and indicate correction in the Comments Section of the Diagnostic Analysis Guide.

3. If required, adjust throttle linkage to achieve override. Refer to the Linkage Adjustment Procedure.

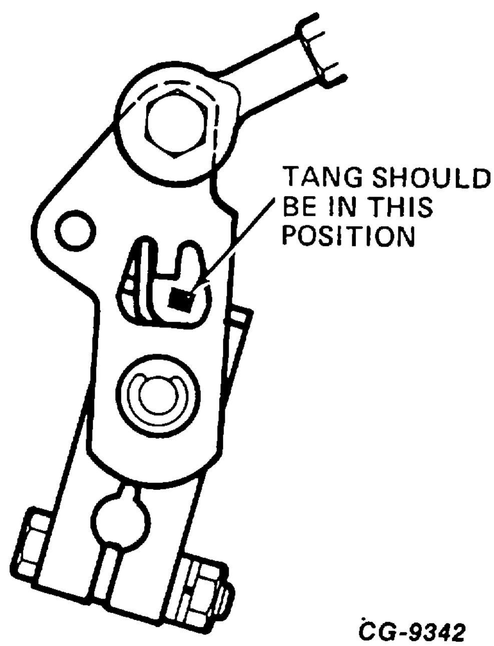


Figure 1b. Control Lever Override (Linkage View With Bellcrank)

Accelerator Linkage Identification

Two different types of linkages exist, (without Bellcrank) and (with Bellcrank). These two types of linkages have differnet versions as follows:

Without Bellcrank (Figures 2a and 2b)

- Version "I" Linkage used with the RQV standard regulation governor.
- Version "II" Linkage used with the RQV close regulation governor.

With Bellcrank (Figures 3a - 3c)

- Versions "I" and "II" Linkage used with the RQV standard regulation governor.
- Version "III" Linkage used with the RQV close regulation governor.

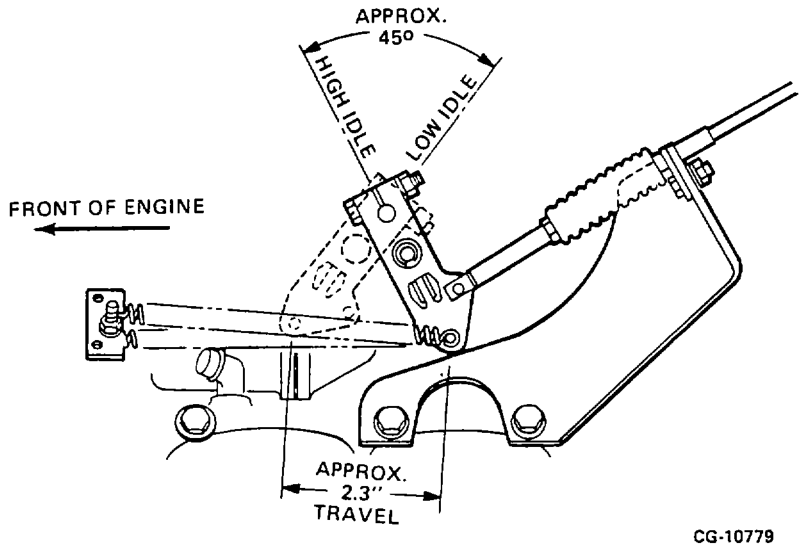
Visual identification of linkage used with standard regulation and close regulation governors can be accomplished by measuring control lever movement. Refer to Figures 2a-2b and 3a-3c.

Standard Regulation Governor

The control lever will rotate about 45° from low to high idle position and travel approximately 2.3 inches.

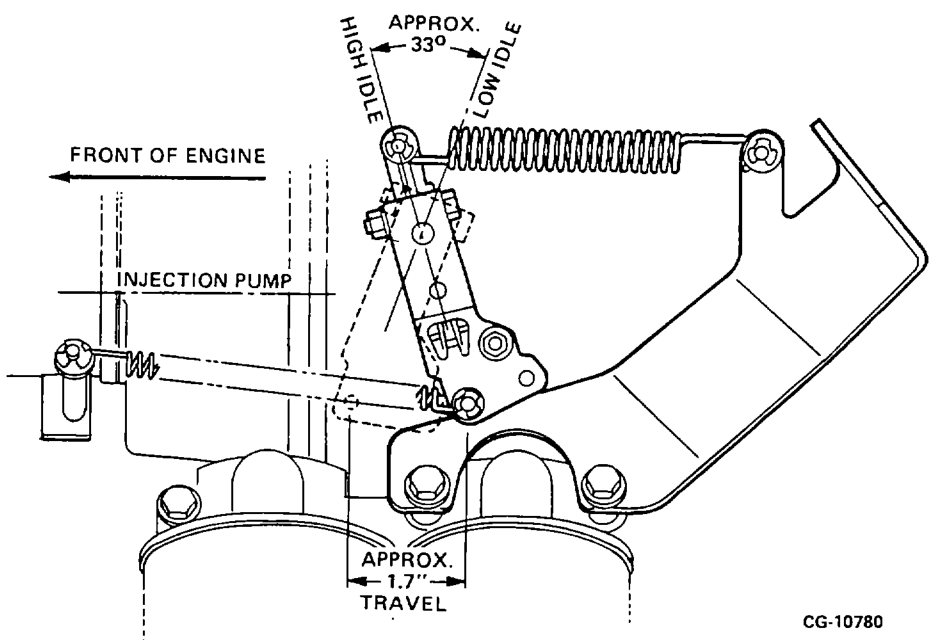
Close Regulation Governor

The control lever will rotate about 33° from low to high idle position and travel approximately 1.7 inches.



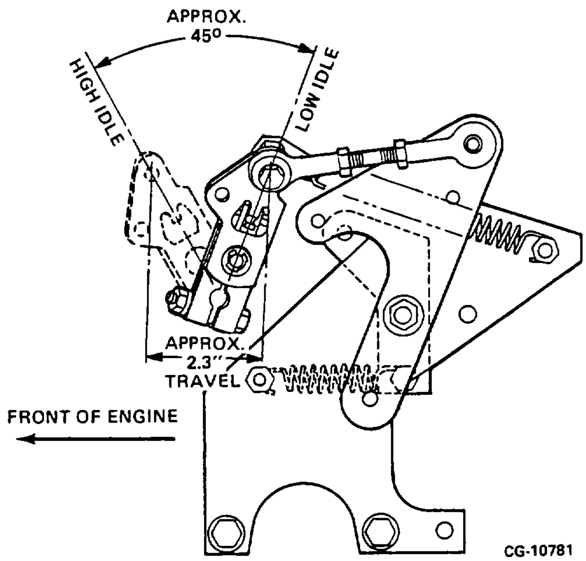
VERSION "I" LINKAGE WITHOUT BELLCRANK USED
WITH RQV STANDARD REGULATION GOVERNOR

Figure 2a. Linkage Identification
Standard Regulation Governor



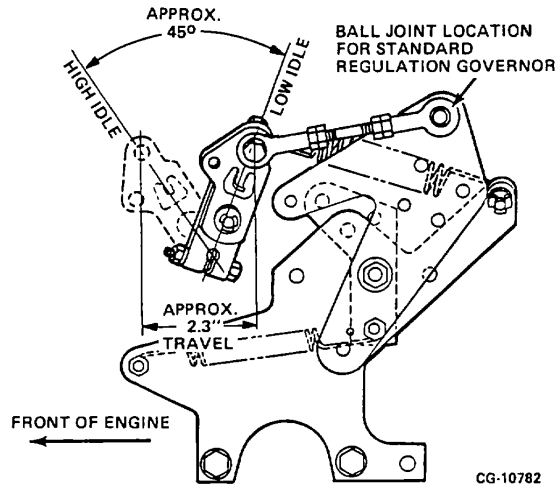
VERSION "II" LINKAGE WITHOUT BELLCRANK USED
WITH RQV CLOSE REGULATION GOVERNOR

Figure 2b. Linkage Identification
Close Regulation Governor



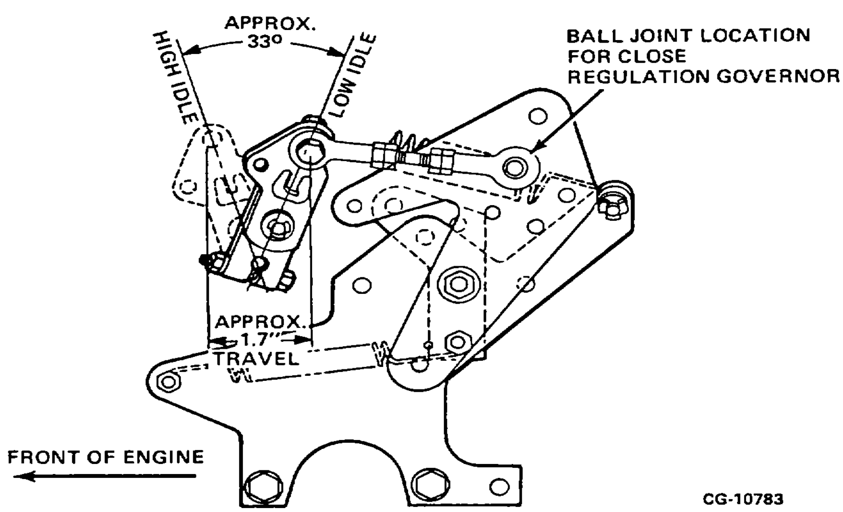
VERSION "I" LINKAGE WITH BELLCRANK USED WITH RQV STANDARD REGULATION GOVERNOR

Figure 3a. Linkage Identification Standard Regulation Governor



VERSION "II" LINKAGE WITH BELLCRANK USED WITH RQV STANDARD REGULATION GOVERNOR

Figure 3b. Linkage Identification Standard Regulation Governor



VERSION "III" LINKAGE WITH BELLCRANK USED WITH RQV CLOSE REGULATION GOVERNOR

Figure 3c. Linkage Identification Close Regulation Governor

LINKAGE ADJUSTMENTS: (Without Bellcrank) Refer to Figure 4a for Version "I" Linkage [Standard Regulation Governor], Figure 4b for Version "II" Linkage [Close Regulation Governor]

1. Hold the (cast) inner throttle lever in high idle position. Move the outer (sheet metal) throttle lever to the 5.20"/5.68" dimension for Version "I" (Figure 4a) or 5.20"/5.45" dimension for Version "II" (Figure 4b). Use a ruler to measure the gauge dimension.

2. Change the mounting position of the lever on the throttle shaft until gauge dimension is obtained.

3. Tighten bolts as specified in Figure 4c.

IMPORTANT

DO NOT POSITION LEVER IN SHAFT GROOVE AND DO NOT FORCE LEVER INTO "OVERRIDE" FOR THIS POSITIONING.

4. Depress accelerator pedal to floor of cab.

5. Move injection pump lever to high idle stop. Do not force lever into over-travel for this positioning.

6. Rotate ball joint coupling on end of accelerator cable until the ball stud can be inserted in the lever hole.

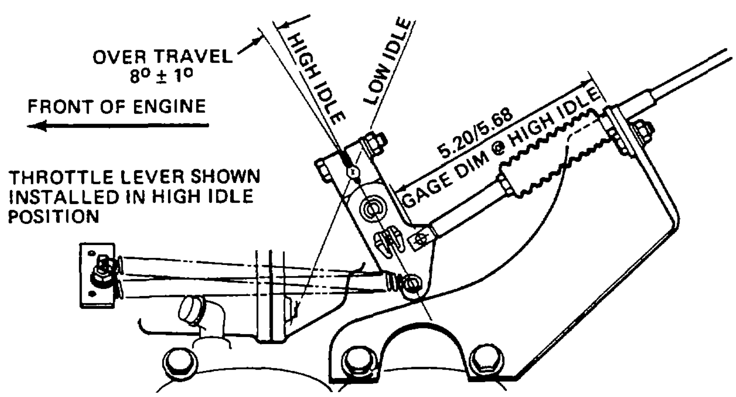
7. Remove stud from hole and rotate ball joint on cable two turns in the direction which shortens the cable.

8. Release accelerator and attach ball joint to pump lever.

9. This procedure should result in pump lever over-travel of one half the available movement (8° + 1°) when the accelerator pedal is pressed to the floor. If this does not result from the first adjustment repeat procedure until the proper override is accomplished.

IMPORTANT

BEFORE STARTING THE ENGINE, ENTER THE OPERATOR'S COMPARTMENT AND DEPRESS THE THROTTLE PEDAL SEVERAL TIMES TO CHECK FOR SMOOTH ACTION AND FULL RETURN OF THE THROTTLE LEVER & THROTTLE PEDAL. THIS MUST BE DONE ANYTIME COMPONENTS ARE REPLACED, REASSEMBLED OR ADJUSTED.



HOLD THE INJECTION PUMP LEVER STOP AT HIGH IDLE' POSITION AND INSTALL THE INJECTION PUMP THROTTLE LEVER WITHIN THE DIMENSION SHOWN. CHASSIS PEDAL TRAVEL AND/OR PEDAL STOP TO BE ADJUSTED SO THAT INJECTION PUMP LEVER OVERTRAVEL IS LIMITED WITH PEDAL AGAINST STOP OR FLOOR. OVERTRAVEL AT PUMP LEVER SHOULD NOT EXCEED 9°.

CG-10670

Figure 4a. "S" Series Version "I" Linkage (Without Bellcrank)
(Robert Bosch MW Pump With Standard Regulation Governor)

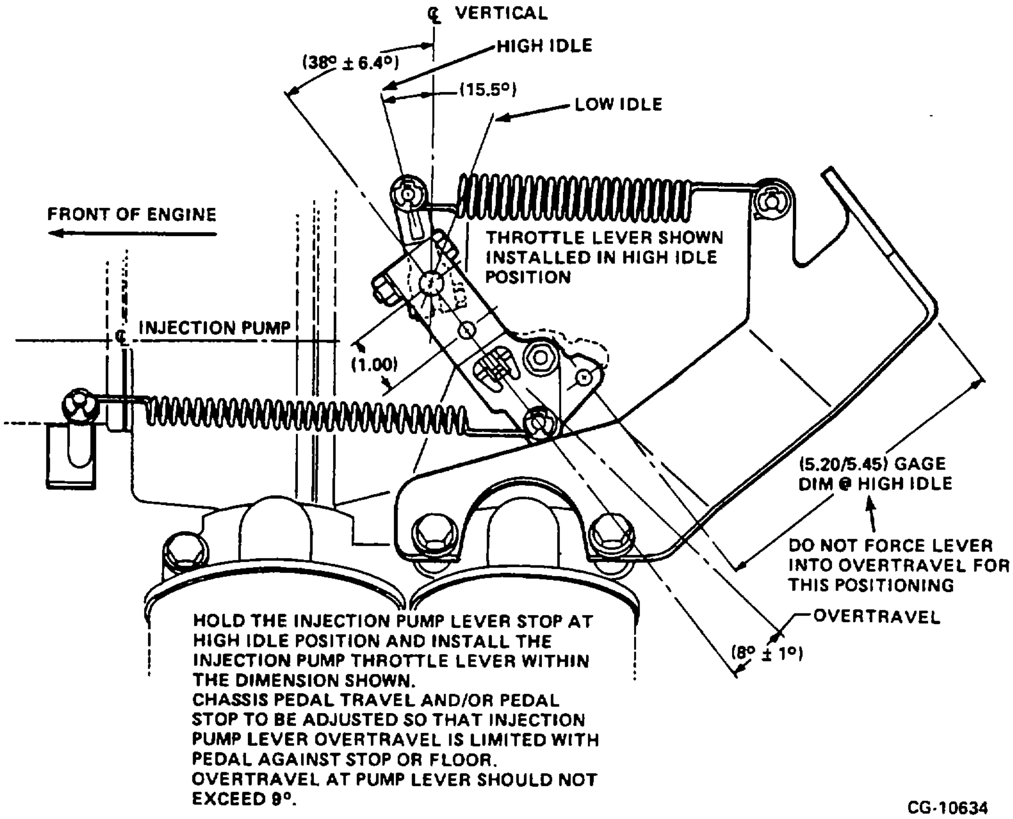


Figure 4b. "S" Series Version "II" Linkage (Without Bellcrank)
(Robert Bosch MW Pump With Close Regulation Governor)

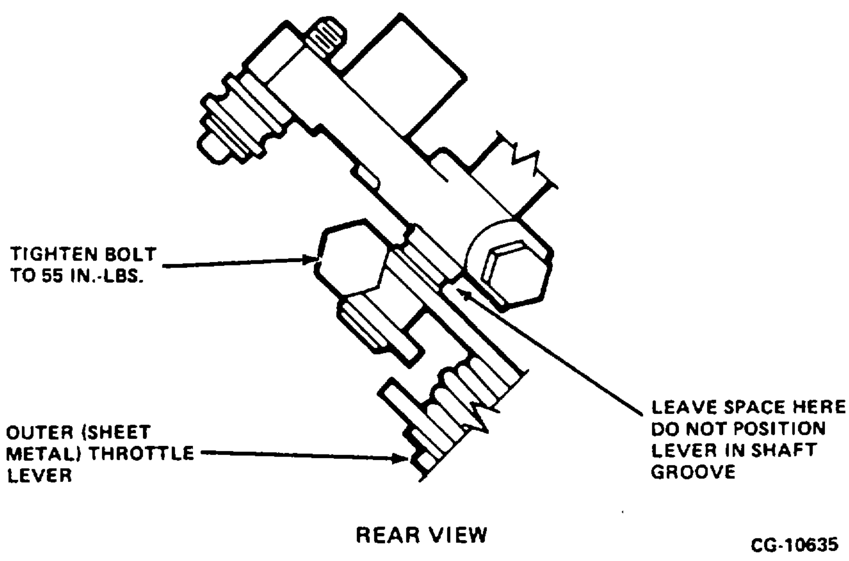


Figure 4c. Inner and Outer Throttle Lever Assembly (Without Bellcrank)
(Version "I" and "II")

NOTE: Tighten bolt to 55 in-lbs. after correct gauge dimension is achieved as shown in Figures 4a and 4b.

LINKAGE ADJUSTMENT: (With Bellcrank) Refer to Figure 5a for Version "I" Linkage, Figure 5b for Version "II" Linkage and Figures 5b and 5c for Version "III" Linkage.

IMPORTANT
BALL JOINTS AND BELLCRANK SHAFT MUST ROTATE FREELY WITHOUT BINDING OR STICKING. THE BALL JOINTS, BELLCRANK SHAFT, BORE AND BUSHING INSERTS MUST BE FREE OF PAINT, GREASE, OIL, DIRT, RUST, OR ANY OTHER FOREIGN MATERIAL. CLEAN OR REPLACE PARTS IF NECESSARY.

IMPORTANT

MAKE THE FOLLOWING ADJUSTMENTS AFTER ENGINE HAS BEEN RUN-IN AND INJECTION PUMP HAS BEEN SET.

Version "I" Linkage With Standard Regulation Governor (Figure 5a)

1. Postion bellcrank bracket and control lever as follows:
   a. Locate bellcrank shaft centerline 15.82" ± 0.06" from front finish of flywheel housing (cranking motor pad). Loosen bracket mounting hardware for this adjustment if required.

   b. Insert 3/16" dia. (1.875" drill) gauge pin through the holes (17, Figure 5a) of the bellcrank bracket and control lever.

2. Assemble throttle lever on pump shaft. Do NOT position lever in shaft groove.

   a. With pump shaft in low idle position, relocate the pump lever to gauge dimension shown in Figure 5a.
   Do not force lever into over-travel for this positioning (Figure 5b).

   b. Spacer (23, Figure 5a) must be installed on the lever clamping bolt inside the lever slot to prevent lever breakage. Tighten clamping bolt to 55 Ibf-in. (27, Figure 5a).

3. Install control rod assembly as follows:
   a. Hold injection pump lever against low idle stop (do not force pump lever into over-travel position).

WARNING
Exposed threads above either control rod nut must not exceed 0.42 in. (29, Figure 5a).

   b. Position the control rod ends so that the ball joint banjo face is aligned parallel with lever mounting face. Then tighten the control rod nuts.

   c. Remove gauge pin.

4. Observe operation of linkage:
   a. Rotate control lever counterclockwise from low idle to high idle and past high idle to max. over-travel.
   b. Observe max. over-travel at the injection pump lever. The injection pump lever tang bottoms in the lever slot when max. over-travel is reached. DO NOT force beyond this point. Pump lever, pump, or linkage components will be damaged if excessive force is used.
   c. Release the control lever and let the springs return the linkage to low idle.
   d. Repeat 4a thru 4c two more times. If linkage has been properly adjusted, the linkage will return to low idle position. The gauge holes will be aligned and the injection pump lever tang will be centered in the slot.

IMPORTANT
BEFORE STARTING THE ENGINE, ENTER THE OPERATOR'S COMPARTMENT AND DEPRESS THE THROTTLE PEDAL SEVERAL TIMES TO CHECK FOR SMOOTH ACTION AND FULL RETURN OF THE THROTTLE LEVER & THROTTLE PEDAL. THIS MUST BE DONE ANYTIME COMPONENTS ARE REPLACED, REASSEMBLED OR ADJUSTED.

LINKAGE ADJUSTMENT (With Bellcrank) - (Continued)

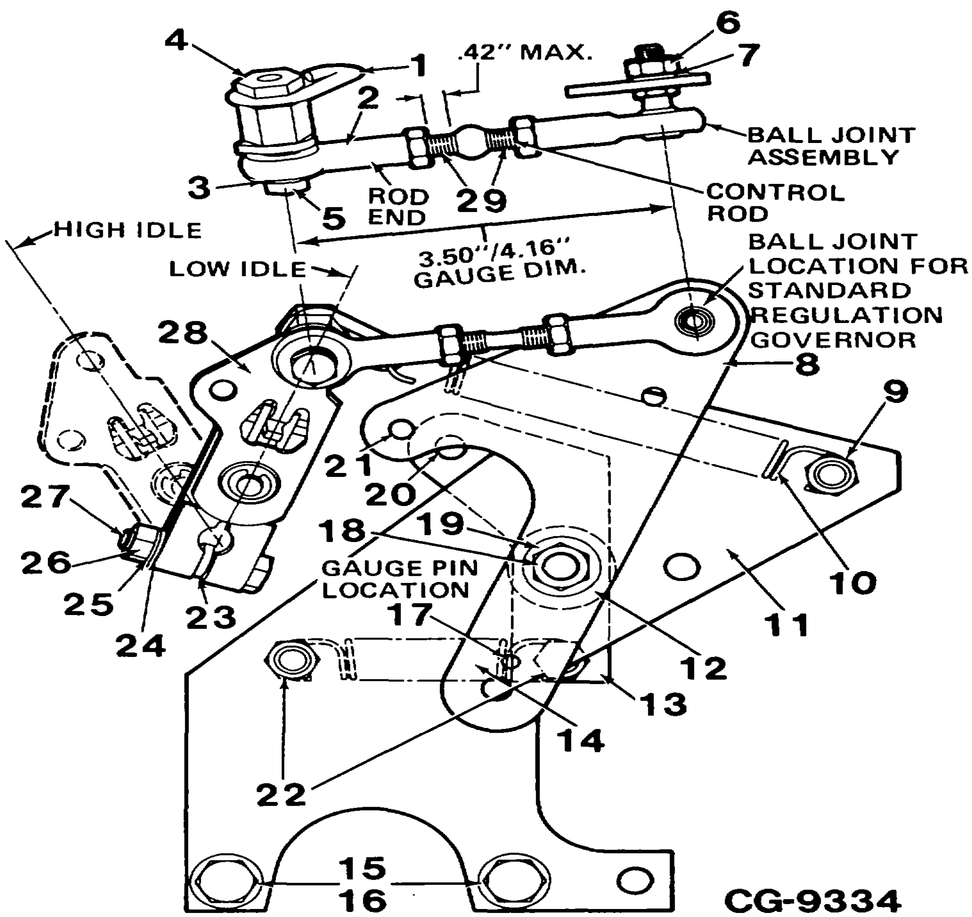


Figure 5a. Version "I" Bellcrank Linkage
(Robert Bosch MW w/Standard Regulation Governor)

LEGEND FOR FIGURE 5a

1. Spring Extension Hook
2. Bellcrank Rod Assembly Consisting of:
   Ball Joint w/o Stud
   Ball Joint w/Stud LH
   Control Rod RH/LH
3. 1/4 Lockwasher
4. Return Spring Nut
5. Bolt 1/4-28 x 1/25
6. Hex Nut 1/4-28
7. 1/4 Lockwasher
8. Engine Control Lever
9. Spring Anchor
   Hex Nut 1/4-28
   5/16 Lockwasher
10. Return Spring
11. Bellcrank Bracket Assembly
12. Nylon Bushings (2)
13. Auxiliary Spring Lever Assembly
14. Return Spring
15. Hex Hd Bolt 3/8-16 x 4.50
16. 3/8 Hardened Washer
17. Insert 3/16 Diameter Drill here to set low idle lever position
18. Hex Hd Lock Nut
19. 3/8 Hardened Washer
20. Paystar Accelerator Attachment Location
21. Cargostar Accelerator Cable Attachment Location
22. Spring Anchor
    5/16-18 Hex Nut
    5/16 Lockwasher
23. Spacer
24. Flat Washer
25. Lockwasher
26. Nut
27. Bolt
28. Throttle Lever
29. Exposed Threads

LINKAGE ADJUSTMENT (With Bellcrank) - (Continued)

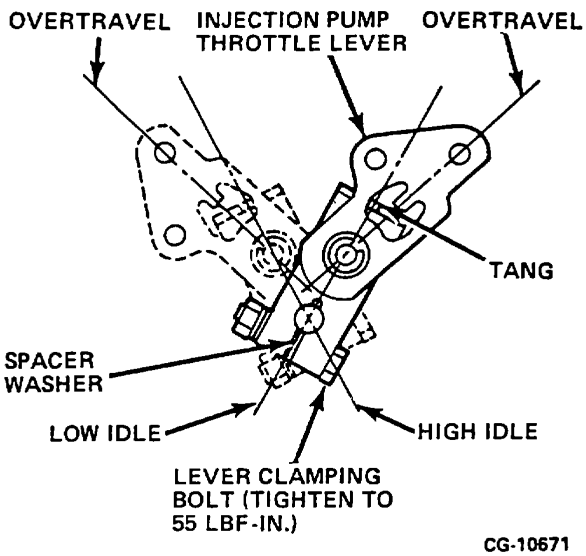


Figure 5b. Overtravel For Version "I" Linkage w/Standard Regulation Governor (With Bellcrank)

Version "II" Linkage w/Standard Regulation Governor (Figure 5c)
Version " 111" Linkage w/Close Regulation Governor (Figure 5d)

1. Position control lever as follows:

   a. Insert 3/16" dia. (1.875" drill) gauge pin through the holes of the Bellcrank bracket and control lever.

2. Assemble throttle lever on pump shaft (Figure 5c). Do not position lever in shaft groove.

   a. With pump shaft in low idle position, re-locate the pump lever to gauge dimension shown in Figure 5c for Version "I" Linkage or Figure 5d for Version "I 1" Linkage.

   Do not force lever into over-travel for this positioning (Figure 5c).

   b. Spacer washer (Figure 5c) must be installed on the lever clamping bolt inside the lever slot to prevent lever breakage. Tighten clamping bolt to 55 Ibf-in.

3. Install control rod assembly as follows:

   a. Hold injection pump lever against low idle stop (see Figure 5c for Version "II" Linkage or Figure 5d for Version "III" Linkage). Do NOT force pump into over-travel position (Figure 5e).

WARNING
Exposed threads above either control rod nut must not exceed .42 in. (Figure 5c).

   b. Position the control rod ends so that the ball joint banjo face is aligned parallel with the lever mounting face. Then tighten the control rod nuts (Figure 5c).

   c. Remove the gauge pin.

4. Observe operation of linkage:
   a. Rotate control lever counterclockwise from low idle to high idle and past high idle to max. overtravel.
   b. Observe max. over-travel at the injection pump lever. The injection pump lever tang bottoms in the lever slot when max. overtravel is reached. DO NOT force beyond this point. Pump lever, pump, or linkage components will be damaged if excessive force is used.
   c. Release the control lever and let the springs return the linkage to low idle.
   d. Repeat 4a thru 4c two more times. If linkage has been properly adjusted, the linkage will return to low idle position. The gauge holes will be aligned and the injection pump lever tang will be centered in the slot.

IMPORTANT
BEFORE STARTING THE ENGINE, ENTER THE OPERATORS COMPARTMENT AND DEPRESS THE THROTTLE PEDAL SEVERAL TIMES TO CHECK FOR SMOOTH ACTION AND FULL RETURN OF THE THROTTLE LEVER AND THROTTLE PEDAL. THIS MUST BE DONE ANYTIME COMPONENTS ARE REPLACED, REASSEMBLED OR ADJUSTED.

LINKAGE ADJUSTMENT (With Bellcrank) - (Continued)

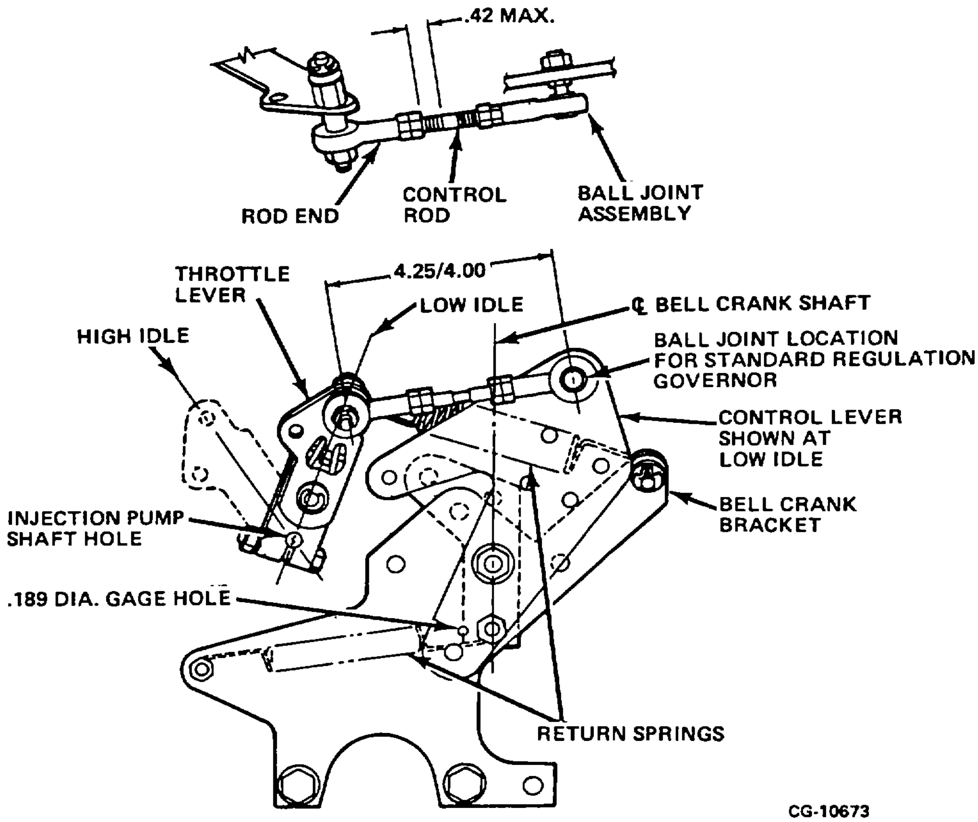


Figure 5c. Version "II" With Bellcrank - Linkage Adjustment (Robert Bosch MW w/Standard Regulation Governor)

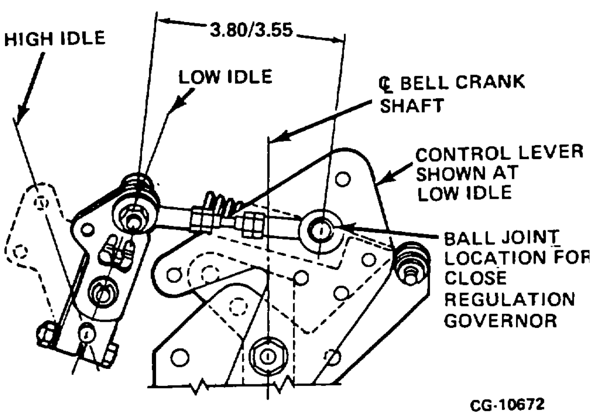


Figure 5d. Version "III" With Bellcrank - Linkage Adjustment (Robert Bosch MW w/Close Regulation Governor)

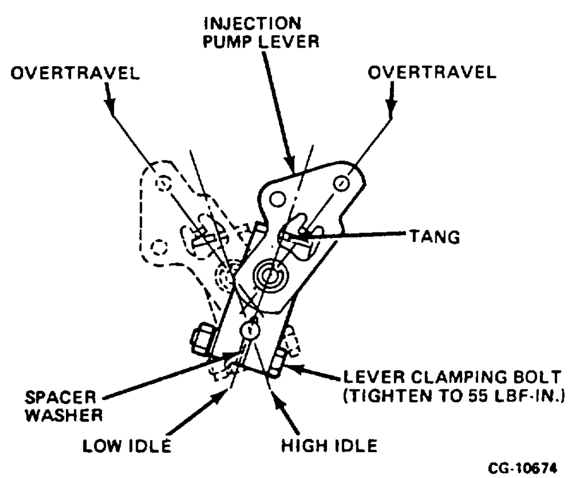


Figure 5e. Overtravel for Versions "II" and "111" Linkage Assemblies (With Bellcrank)

- **SHUTOFF CABLE/ELECTRIC SHUTOFF 400 Series On-Highway (with Robert Bosch MW Pumps)**

FROM FORM NO. CGED-365

4	**SHUTOFF CABLE OR ELECTRIC SHUTOFF**		
	ADJUSTED TO ALLOW FULL RUN POSITION		
	METHOD	**1st CHECK**	**2nd CHECK**
	VISUAL CHECK ☐		

NOTE: If the shutoff cable is properly adjusted and electric shutoff is properly adjusted and functional, enter OK in 1st check block. As necessary, adjust linkage or solenoid and indicate correction in Comments Section.

I. SHUTOFF CABLE (MANUAL SHUTOFF)

Visual Check

The injection pump shutoff lever is spring loaded to the run position. With the shutoff cable pulled out to stop the engine, the shutoff lever must contact the shutoff screw, as shown in Figure 6.

Adjustment

To ensure that the control rack is not restricted by the shutoff lever during engine operation, adjust the shutoff cable so it can be attached to the shutoff lever when the cable knob is fully sealed against the dash and the shutoff lever is turned fully counterclockwise (Full Run Position).

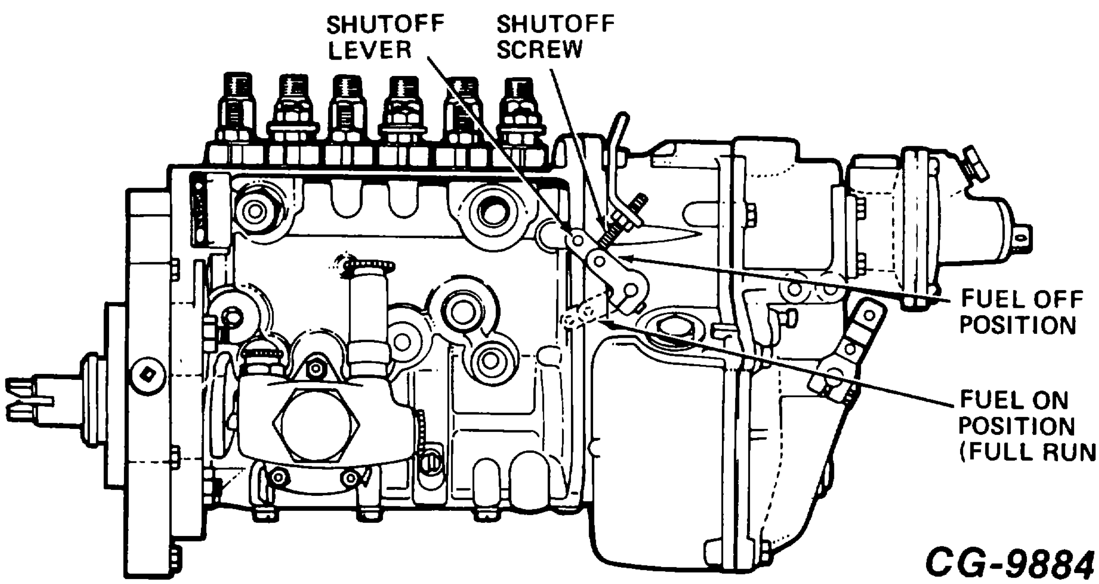


Figure 6. Shutoff Test (466 w/Robert Bosch MW Pump)

II. ELECTRIC SHUTOFF (AUTOMATIC SHUT-OFF)

A. ENGINE WILL CRANK, BUT WILL NOT START START

CAUTION!

Place transmission in neutral with parking brake on.

IMPORTANT

VERIFY ELECTRIC SHUTOFF IS INOPERABLE AS FOLLOWS: OBSERVE SHUTOFF LEVER (1, FIGURE 1) AND TURN IGNITION SWITCH TO "IGNITION" POSITION. SHUTOFF LEVER SHOULD ROTATE COUNTERCLOCKWISE (CCW) AND SOLENOID PLUNGER SHOULD MOVE DOWNWARD. IF NOT, FOLLOW PROCEDURES 1 THRU 8 TO DETERMINE CAUSE AND REMEDY.

1. **Fuse** - Inspect electric shutoff solenoid fuse. If burned out, replace with a 15 amp fuse. Refer to Figure 8 for S-Series Wiring diagram and Figure 9 for Cargostar diagram.

2. **12 V Supply** - Check for 12 volts between positive and negative terminals of solenoid with the 15 amp fuse in place. Turn ignition switch key to "Ignition" position. Minimum voltage required for solenoid to pull in is 9 volts.

CAUTION!

Do NOT "jump" or bypass the fuse.
Do NOT allow voltmeter negative test lead to short between the (-) negative and smaller "AUX" terminal on the solenoid, if this occurs, fuse or solenoid failure may result [See Figure 7 for terminal location] .

NOTE: "AUX" terminal is present only on early model solenoids.

IMPORTANT

IF VOLTAGE AVAILABLE TO SOLENOID IS UNDER 12 V DC, CHECK BATTERY CONDITION, WIRING AND CONNECTIONS, IGNITION SWITCH AND ELECTRIC SHUTOFF RELAY (IF APPLICABLE). REPLACE ANY STAR TYPE LOCKWASHERS FOUND ON SOLENOID TERMINALS WITH SPLIT TYPE LOCKWASHERS.

3. **Rubber Boot** - The rubber boot seals the core from dirt, water, etc.
   - Verify that boot is firmly attached to solenoid body.
   - Replace any boot that is torn.
   - Replace any boot that becomes hard and inflexible in cold temperatures (-1 0°F or below) that may hinder "pull in" of the solenoid plunger.

4 **Solenoid Worn** - Inspect as follows:
   - Inspect for evidence of dust, dirt, brass power, or blackened deposits in solenoid core.
   - Inspect for wear on the inside diameter of the lower portion of the return spring. This condition will result in binding of spring coil on plunger causing slow or no plunger "pull in".

NOTE: If evidence of a worn solenoid is found, as described above, solenoid condition is marginal and may not "pull in" quickly or consistently.

5. Measure resistance (ohms) across the positive and negative terminals of the solenoid as follows; (refer to Figures 10, 11 and Internal Switch Description.)
   - Turn off power supply to solenoid. Remove plunger and connect test ohmmeter to (+) positive and (-) negative terminals.
   - With plunger removed, 0.2-0.3 ohms resistance should be observed.
   - Depress switch button in bottom of solenoid core (using a clean wooden dowel rod), read ohmmeter, 18-20 ohms resistance should be observed.

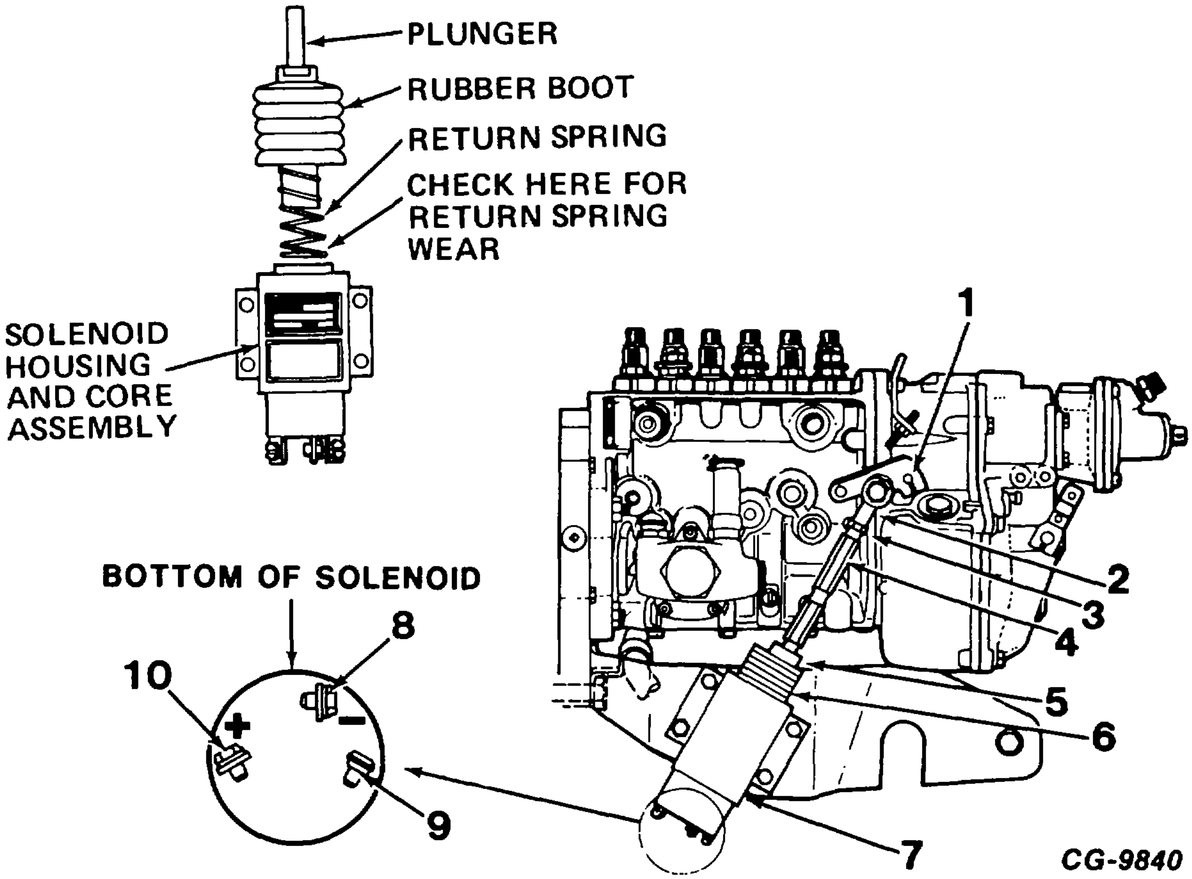


Figure 7. Electric Shut-Off Control On Robert Bosch "MW" Pump

1. Shut-Off Lever
2. Ball Joint
3. Lock Nut
4. Adjusting Rod
5. Solenoid Plunger
6. Rubber Boot (Surrounds Return Spring & Plunger)
7. Solenoid Core With Housing
8. Negative Terminal
9. Auxiliary Connection* (Not Used)
10. Positive Terminal

*"AUX" terminal is present only on early model solenoids.

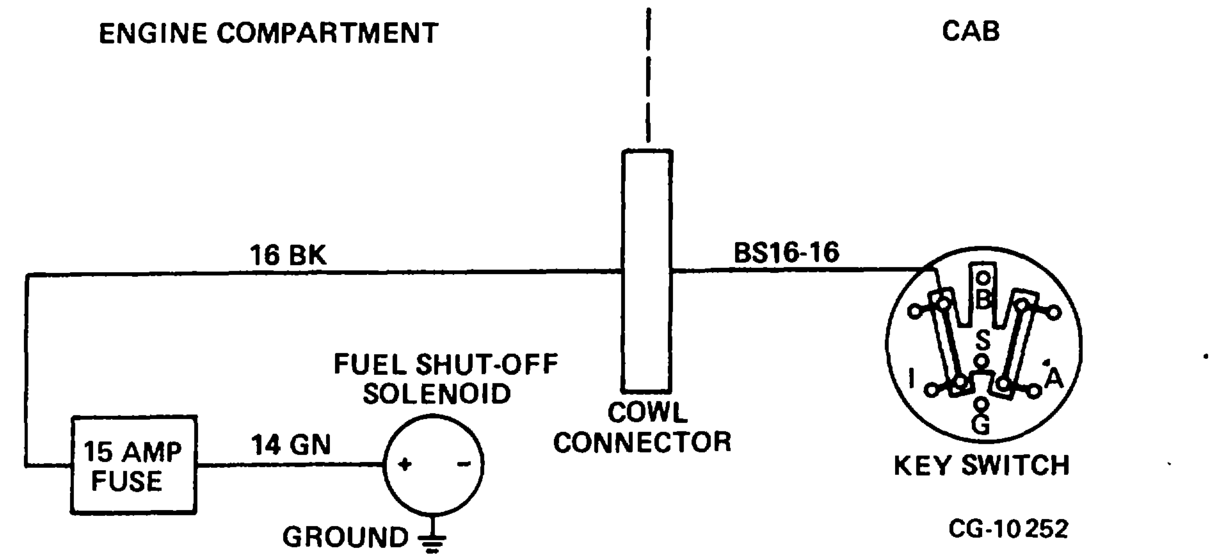


Figure 8. S-Series Electric Shut-Off Wiring

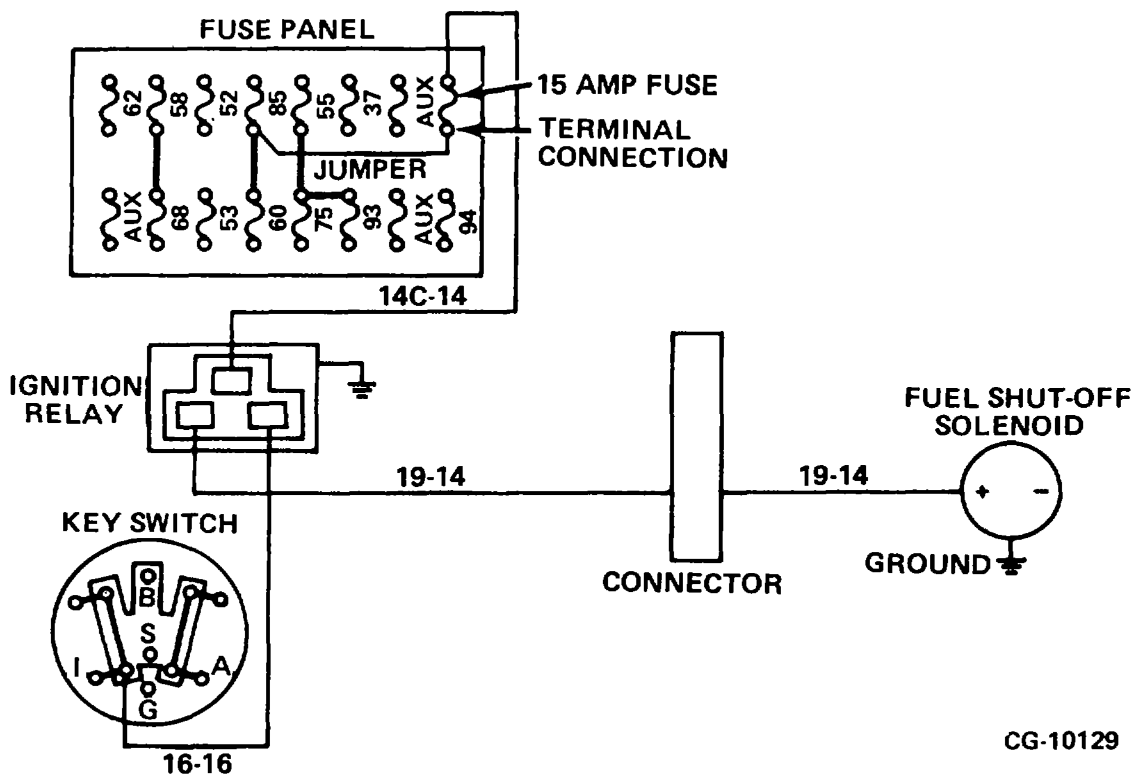
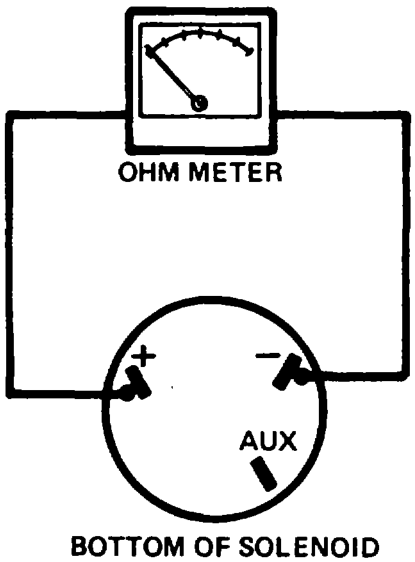


Figure 9. Cargostar Electric Shut-Off Wiring



-IMPORTANT-

IF THESE RESISTANCE SPECIFICATIONS ARE NOT MET, REPLACE THE SOLENOID.

RESISTANCE CHECK
(NO POWER TO SOLENOID IGNITION SWITCH OFF)

PLUNGER POSITION	OHMS
OUT	0.2-0.3
IN	18-20

CG-9838

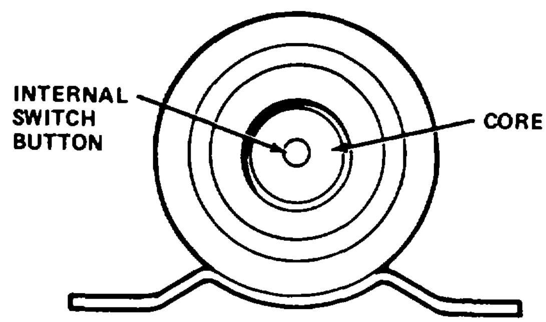
Figure 10. Solenoid Resistance Check

NOTE: " AUX" terminal is present only on early model solenoids.

INTERNAL SWITCH DESCRIPTION
(Refer to Figure 11)

The solenoid contains a built-in switch that is activated when plunger nears the bottom of its stroke. The switch button extends from the bottom of the solenoid end cap into the core.

The switch should completely return to the "out" position when plunger is out. If switch does not rapidly return to the "out" position, debris has fouled the switch and solenoid must be replaced.



CG-9839

Figure 11. Solenoid Internal Switch Button Located in Bottom of Solenoid Core

- **LOW IDLE (RPM)**
  400 Series On-Highway (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

	LOW IDLE (RPM)*			
5	A. MANUAL TRANSMISSION- NEUTRAL B. AUTOMATIC TRANSMISSION - DRIVE C. MIXER- DRUM ENGAGED			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	MASTER TACHOMETER			

*Engine must be at normal operating temperature.
† Refer to "Performance Data Guidelines", in this section.

Measure Low Idle Speed

1. Assure linkage is adjusted as specified in Operation 3.

2. Set the control lever on the pump to low idle position, Figure 10, by moving the lever fully towards the governor housing. The lever must contact the low idle stop screw.

IMPORTANT

PARKING BRAKE MUST BE ENGAGED WITH MANUAL TRANSMISSION IN NEUTRAL, AUTOMATIC TRANSMISSION IN GEAR AND MIXER DRUM ENGAGED (IF APPLICABLE).

3. With the engine running check low idle speed using an accurate tachometer. See "Performance Data Guidelines" in this section for specifications.

4. If adjustment is required, proceed as directed in Low Idle Adjustment Procedure.

Low Idle Speed Adjustment

1. Loosen the lock nut with a 10 mm wrench and raise or lower the low idle stop (bolt) with an 8 mm wrench.

2. Raise the stop to increase speed, lower to decrease speed.

3. Tighten the lock nut when the specified speed is reached.

NOTE: To compensate for parasitic loads which affect low idle speed, the low idle speed should be set slightly higher so engine speed will be within specifications when the load is applied. Examples of major parasitic loads are mixer drums and automatic transmissions.

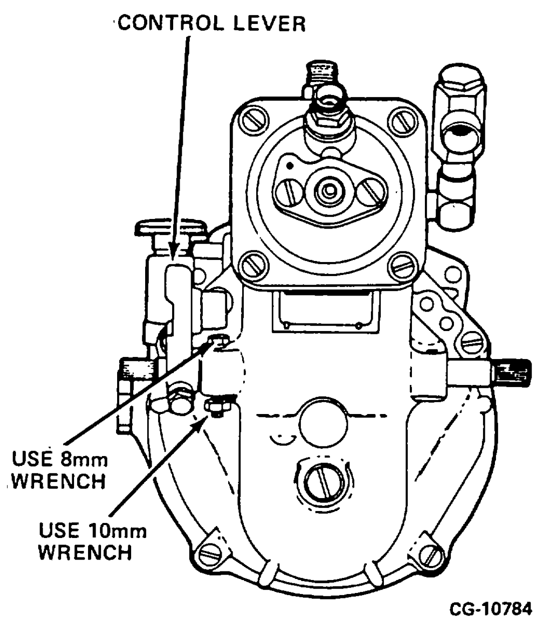


Figure 12. Low Idle Adjustment For Robert Bosch MW Pump

- **HIGH IDLE RPM (NO LOAD)**
  400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

	HIGH IDLE RPM (NO LOAD)*			
6	THROTTLE IN OVERRIDE POSITION AND AT MAXIMUM (HIGH IDLE) STOP			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	MASTER TACHOMETER			

*Engine must be at normal operating temperature.
† Refer to "Performance Data Guidelines", in this section.

1. Assure that accelerator linkage is adjusted properly so outer control lever tang (Figure 13a and b) is in override position. (Refer to Operation 3 "Accelerator Linkage", this Section.)

2. With throttle control lever in override position and at maximum (High Idle) stop, use master tachometer; determine high idle speed.

3. Engine speed on tachometer should be within specifications, outlined in "PERFORMANCE DATA GUIDELINES", in this Section.

4. Enter the observed RPM in the 1st check box.

IMPORTANT

THE HIGH IDLE SPEED IS SEALED. RESOLVE AN INCORRECT HIGH IDLE CONDITION BY FOLLOWING WARRANTY PROCEDURES.

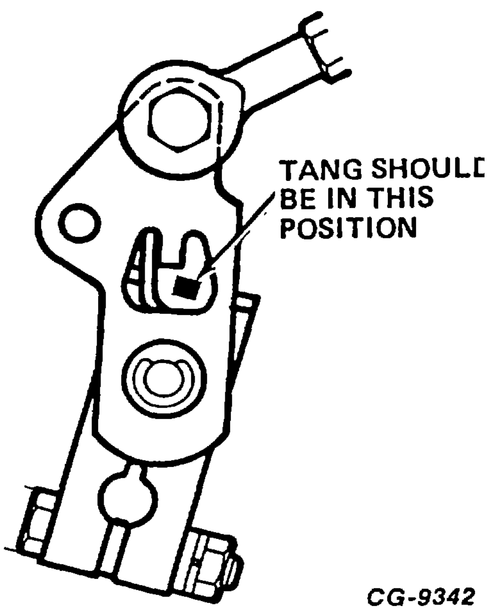


Figure 13a. MW Throttle Lever (View w/Bellcrank Linkage)

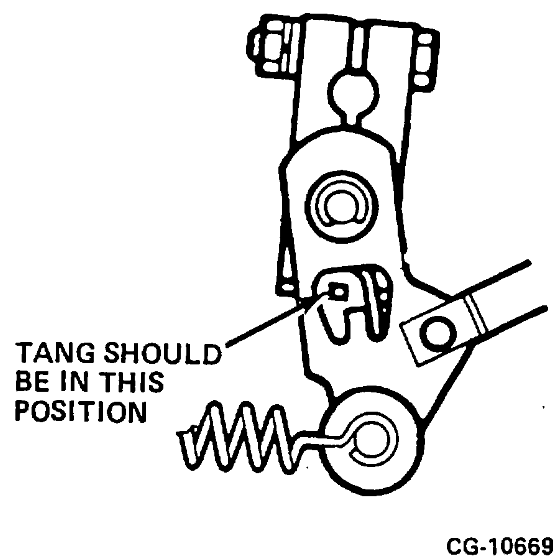


Figure 13b. MW Throttle Lever (View Without Bellcrank)

- **AIR CLEANER MAXIMUM RESTRICTION**
  400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

	AIR CLEANER MAXIMUM RESTRICTION*			
7	A. MEASURE AT FULL LOAD AND RATED SPEED			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	WATER MANOMETER OR MAGNAHELIC GAUGE			

† Refer to "Performance Data Guidelines", in this section.

NOTE: - Often a low power and poor fuel economy complaint is simply due to a dirty air cleaner. In this test, the gauge probe is inserted in the air intake system downstream of the air cleaner. As the air cleaner accumulates dirt, restriction to air flow increases. If restriction exceeds the guidelines, clean or replace the air cleaner element or elements.

Inspect Air Intake Restriction

1. Refer to appropriate "Operation and Maintenance Manual" "Air Cleaner Restriction Gauge and Indicator," for detailed information.

NOTE: - The air cleaner is to be serviced only when the restriction reaches the maximum allowable limit. The restriction can be measured by a service indicator, vacuum gauge or a water manometer.

2. Inspect the element(s) for damaged gaskets or dents in the element(s). If they exhibit either they should be replaced.

Single Element Air Cleaner

Measure air cleaner restriction as follows:

1. Attach restriction test (vacuum) gauge (4, Figure 14) at air cleaner (3).

2. Run engine at full load and rated speed (for turbocharged engines) and at High Idle speed (RPM) (for N/A engines).

3. Service air cleaner element when vacuum gauge (4, Figure 14) shows 6.2 kPa (25 in. H20) for turbocharged engines.

4. Service air cleaner element when vacuum gauge (4, Figure 14) shows 7.0 kPa (30 in. H20) for turbocharged engines measured at the TurboInlet (2, Figure 14).

5. Maximum air cleaner restriction can only be obtained when engine is running at full load and rated speed. If measuring air cleaner restriction under these conditions is not possible, run the engine at high idle no load. Under these conditions, the reading will be approximately 1/2 the full load reading. Maximum allowable restriction is 6.2 kPa (25 in H20) under full load and rated speed; therefore, the restriction reading at high idle no load should be no greater than 2.9 kPa (12 in H20). Service air cleaner element when maximum air cleaner restriction is reached.

NOTE: - TURBOCHARGED MODELS ONLY High air cleaner restriction can cause turbocharger seals to unseat causing oil to be drawn through seals and into engine.

DUAL ELEMENT CLEANER

The duel element air cleaner provides a large primary (outer) filter element and optional small secondary (inner) filter element. The secondary element should be used in dusty environments such as dump and mixer applications.

The current dual element air cleaner assembly air cleaner restriction connection (1, Figure 15) is located between the primary and the secondary element (2) in the bottom of the air cleaner housing (3). This arrangement allows only the primary (outer) element to be sensed by the restriction indicator or dash mounted vacuum gauge. **THE INNER ELEMENT IS NOT RECORDED ON THE RESTRICTION INDICATOR OR DASH MOUNTED VACUUM GAUGE.**

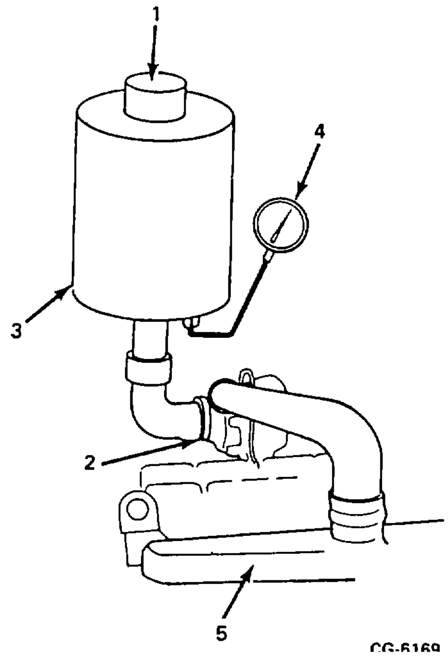


*Figure 14. Checking Air Cleaner Restriction 400-Series On-Highway and OEM Only (Turbocharged Application Shown)**

1. Air Inlet
2. Turbo-Inlet
3. Remote Mounted Air Cleaner
4. Restriction Test Gauge (Magnehelic)
5. Intake Manifold

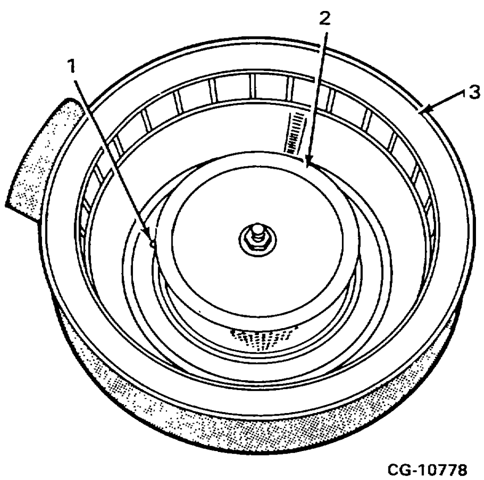


Figure 15. Top View of Dual Element Air Cleaner

1. Air Cleaner Restriction Connection
2. Secondary (Inner) Element
3. Air Cleaner Housing

Test the restriction of the secondary (inner) element as follows:

Refer to Figure 16.

1. Remove and tap the air cleaner outlet pipe (1 approximately 3 inches below the air clean housing (2). Always tap in a straight section o pipe+ and clean tap thoroughly and reinstall Do not allow debris to enter air intake system

+ Cover intake piping to prevent entrance of foreign material into the engine.

2. Attach restriction test gauge (magnahelic) (3) to air cleaner outlet pipe tap.

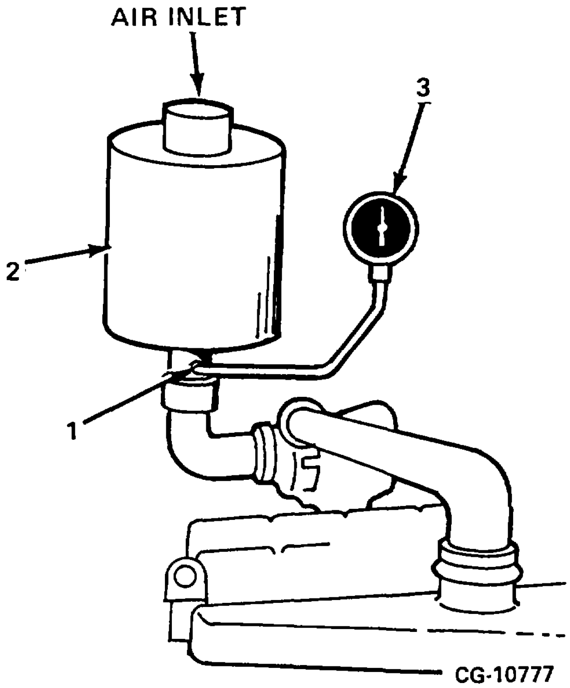
3. Test restriction with both the primary and secondary elements installed in the housing. Maximum allowable restriction is 6.2 kPa (2E in. H20) under full load and rated speed for turbocharged engines.

4. If maximum restriction is exceeded, remove outer element* and recheck restriction to determine useful life of inner element.

*Primary (outer) element is serviceable. (Can be cleaned). The primary element must be replaced after six cleanings or annually whichever occurs first.

5. Secondary (inner) element is not serviceable and must be replaced if maximum restriction is sensed.

NOTE: A low air cleaner restriction reading or a lack of movement by the air cleaner restriction indicator could be a plugged sintered fitting. There are two different types of this fitting (Figure 17). The first fitting has a filter screen in the fitting. This screen can become plugged and not allow a correct air cleaner restriction reading to be taken. If this type of fitting is found, drill center of screen with a 1/32" size drill. This fitting is welded in place and is not a serviceable part. The other type of fitting has a 0.51 mm (0.020 in) orifice fitting. This type of fitting can be easily cleaned with a fine piece of wire. Reworking the first type fitting and cleaning the second type fitting before running (diagnostic tests will eliminate false air cleaner restriction readings.



AIR CLEANER RESTRICTION TEST

*Figure 16. Air Cleaner Restriction Test Location
Dual Element Air Cleaner
400 Series On-Highway*

1. Tap At Air Cleaner Outlet Pipe
2. Air Cleaner Housing
3. Restriction Test Gauge (Magnahelic)

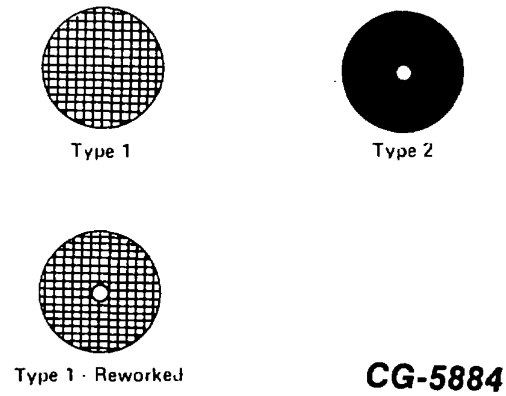


Figure 17. Filter Screen

- **SUPPLY PUMP PRESSURE**
  400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

SUPPLY PUMP PRESSURE	**(MEASURE AT HIGH IDLE) [NO LOAD] ***		
8 **A.** 1. HEADER w/VENT PLUG TEST @ FINAL FUEL FILTER VENT. 2. HEADER w/o VENT PLUG TEST @ FINAL FUEL FILTER OUTLET.			
INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
PRESSURE GAUGE (160 PSI RANGE)			
IF PRESSURE REMAINS LOW AFTER REPLACING FUEL FILTERS, PERFORM STEP B			
B. TEST SUPPLY PUMP INLET RESTRICTION: 6 HG. (MAX.) VACUUM. **MEASURE AT FULL LOAD AND RATED SPEED**			
INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
VACUUM GAUGE			

* Engine must be at normal operating temperature.
† Refer to "Performance Data Guidelines", in this Section.

A. SUPPLY PUMP PRESSURE

1. Remove final filter vent plug on top of fuel filter header (if equipped). If no vent plug is available refer to Figure 18b.

2. Connect 1/8 in. fitting to the vent plug orifice, with a line to a 0-160 psi pressure gauge [(SE-2239) Beyers Model 100 Pressure Test Kit].

3. Measure supply pump pressure at high idle RPM, no load (Figure 18a).

4. Record the pressure in the 1st check block.

5. If the pressure less than the guideline data shown in this Section, PERFORMANCE DATA GUIDELINES, replace the primary and final fuel filter.

6. If pressure is still low, perform inlet Restriction Test.

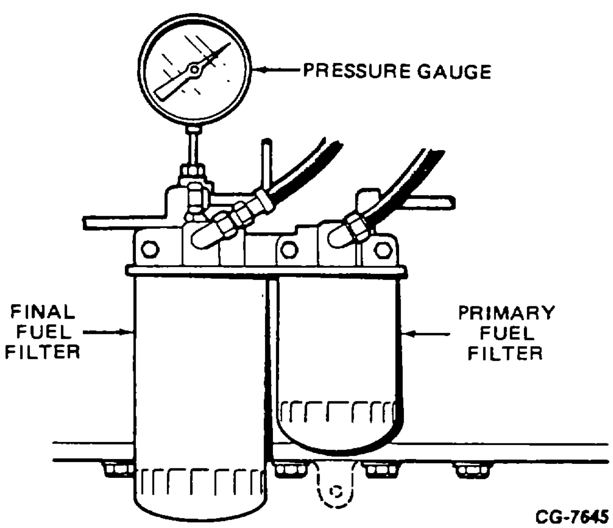


Figure 18a. Fuel Supply Pump Pressure Test (With Vent Plug)

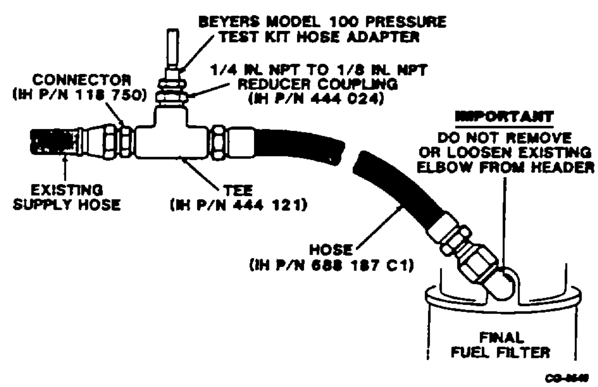


Figure 18b. Fuel Supply Pump Pressure Test (Without Vent Plug)

- **SUPPLY PUMP PRESSURE**
  400 Series On-Highway
  (with Robert Bosch MW Pumps) (Continued)

INLET RESTRICTION TEST

1. Connect a tee fitting at the outlet of the primary fuel filter and connect the line to a vacuum gauge (Figure 19).

2. Run engine at full load and rated speed.

3. Measure and record the restriction in the 1st check block.

4. If restriction exceeds 6 in. Hg., locate the restriction in the fuel lines to the fuel tank.

NOTE: The supply pump is very reliable and seldom the cause of low supply pump pressure. Verify that the specified fuel return hose with orificed fitting is installed.

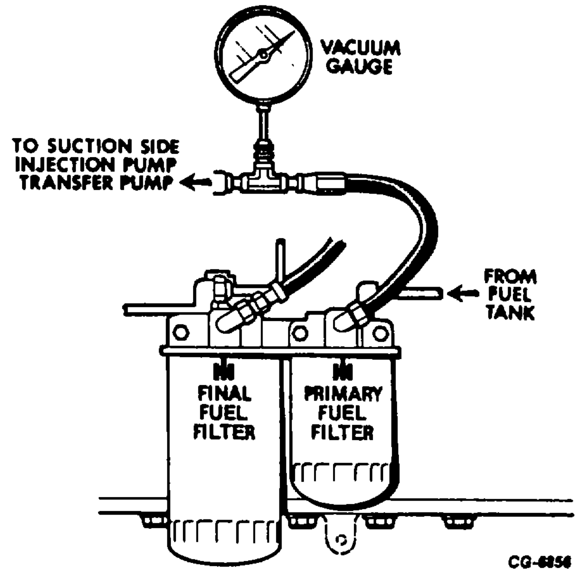


Figure 19. Fuel Inlet Restriction Test

- **INJECTION PUMP INITIAL TIMING (ENGINE STOPPED)**
  400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGES-365

	INJECTION PUMP INITIAL TIMING (ENGINE STOPPED)			
9	A. TIMING VERIFICATION			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	1. VISUAL POINTER INSPECTION			

+Refer to "Performance Data Guidelines", in this Section.

Visual Check

1. Remove injection pump timing pointer access plug from left side of pump mounting adapter.

2. Rotate the engine in normal operating direction until the injection pump hub mark is aligned with the injection pump timing pointer. (Refer to Figure 20.)

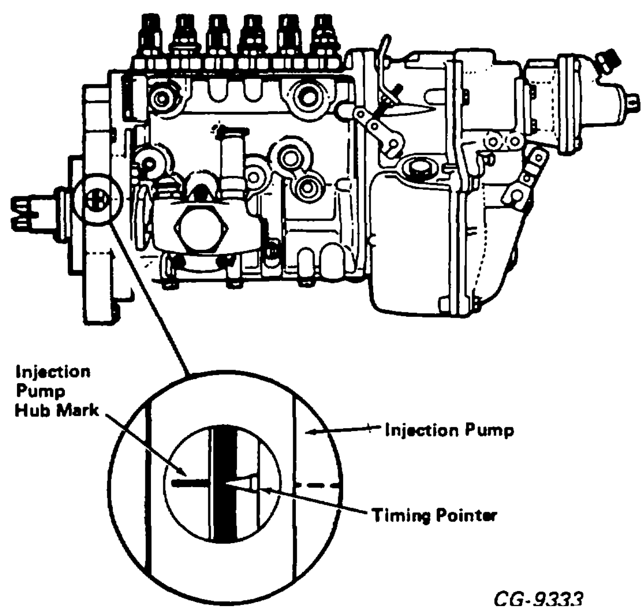


Figure 20. MW Initial Timing

3. Observe engine front cover timing pointer and crankshaft pulley degree alignment (Figure 21).

4. To ensure an accurate reading, view the pointer straight on. The engine should now be positioned at the specified static pump to engine timing as indicated in PERFORMANCE DATA GUIDELINES.

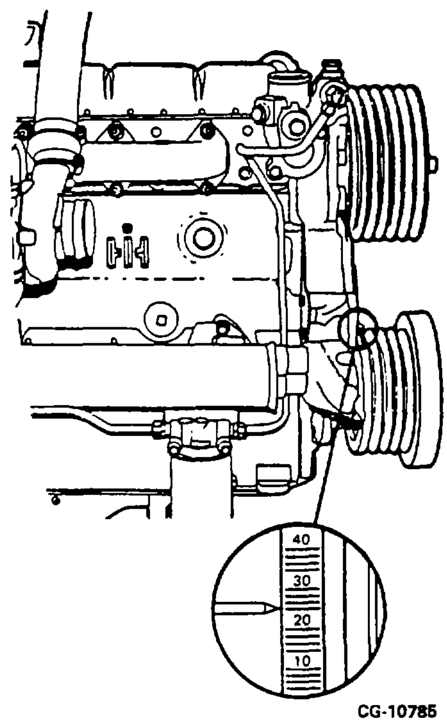


Figure 21. Static Pump to Engine Timing

5. Enter the observed pump to engine timing in the 1st check box of CGED-365-1.

- **INJECTION PUMP INITIAL TIMING (Continued)**
  400 Series On-Highway
  (with Robert Bosch MW Pumps)

If static timing is NOT within specifications, adjust pump to engine timing as follows:

1. Rotate engine to correct crankshaft position (static timing) as specified in PERFORMANCE DATA GUIDELINES, in this Section.
2. Loosen injection pump drive gear bolts and washers to injection pump hub (Figure 22).

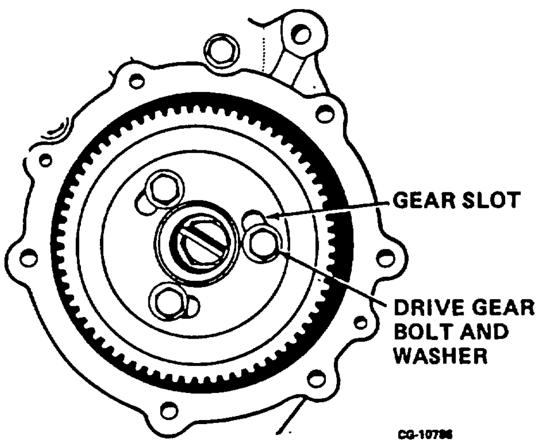


Figure 22. MW Injection Pump Drive Gear

3. Rotate pump clockwise (as viewed from drive gear end) until timing mark on pump drive hub is aligned with timing pointer in adapter hole (Figure 20).
4. Rotate loosened pump drive gear in counterclockwise direction (as viewed from drive gear end) to 3/4 of full extent of drive gear bolt slots.
5. With injection pump in position, secure pump adapter to front plate with bolts, nuts and washers. Tighten bolts and nuts to 33 N•m (24 lbf-ft) torque.
6. Verify alignment of pump timing pointer to hub mark through mounting adaptor opening. Rotate pump drive hub as required for proper alignment. Tighten pump drive gear to 47 N•m (35 lbf-ft).

- **INTAKE MANIFOLD PRESSURE**
  - 400 Series On-Highway Engines
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

	INTAKE MANIFOLD PRESSURE*			
10	A. MEASURE AT FULL LOAD AND AT SPECIFIED SPEEDS. B. SELECT TRANSMISSION GEAR TO ACHIEVE FULL LOAD. (AUTOMATIC TRANSMISSION - STALL RPM & LOAD).			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	PRESSURE GAUGE (30 PSI RANGE)			

*Engine must be at normal operating temperature.
† Refer to "Performance Data Guidelines", in this Section.

1. Check intake manifold pressure as follows:

   a. DT and DTI: Remove the 1/4 in. NPT pipe plug from the air discharge pipe and install a connector and plastic tubing (Figures 23a and b).

   b. Connect the other end of the tubing to the pressure gauge kit panel (SE-2239).

   c. Operate the engine under load until the engine reaches normal operating temperature. Measure intake manifold pressure at full load and rated speed and at full load and the specified lower speed. Refer to the "PERFORMANCE DATA GUIDELINES" at the end of this section.

   d. Enter the observed manifold pressure in the 1st check box. If intake manifold pressure is within the specifications shown in the PERFORMANCE DATA GUIDELINES, engine power is acceptable.

- **INTAKE MANIFOLD PRESSURE - (Continued)**

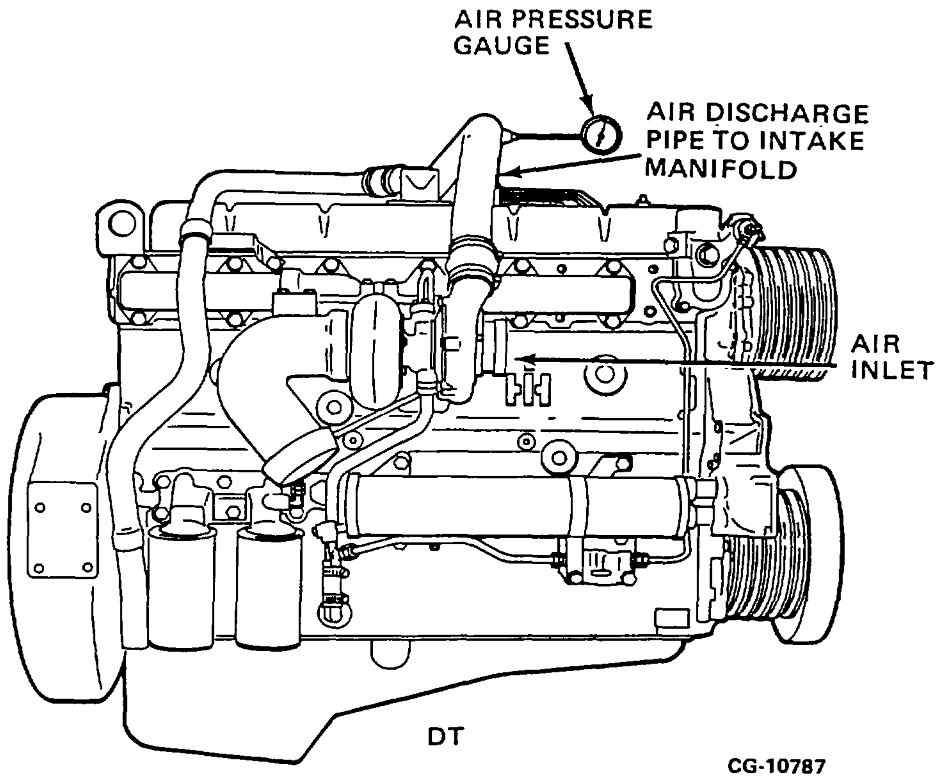


Figure 23a. Intake Manifold Pressure Test (DTI-Shown)

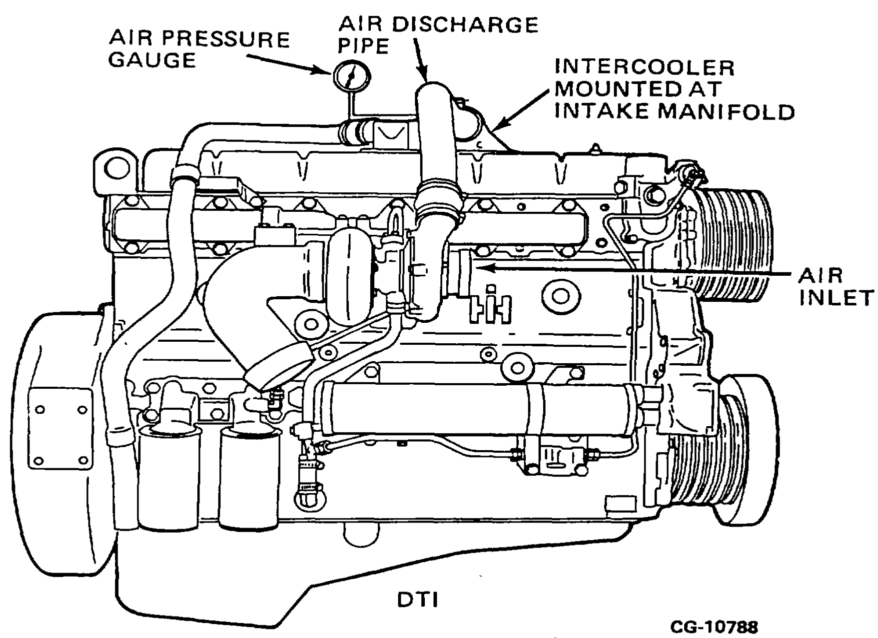


Figure 23b. Intake Manifold Pressure Test (DTI-Shown)

- **CRANKCASE PRESSURE**
  400 Series On-Highway

  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

	CRANKCASE PRESSURE*			
11	A. LATE MODEL TURBO WITH VALVE COVER MOUNTED BREATHER: 1.Measure @ breather tube with orifice restrictor tool, SE-4039. 2.Measure - High idle (no load) RPM.			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	WATER MANOMETER OR MAGNAHELIC GAUGE			

*Engine must be at normal operating temperature.
† Refer to "Performance Data Guidelines", in this Section.

1. Measure crankcase pressure, using breather restrictor tool SE-4039, as follows: (See Figure 24).

   a. Park vehicle on level ground.
   b. Insure breather tube and element are free of dirt.
   c. Insure engine oil level is not above full mark.
   d. Connect a line from the restrictor tool to a water manometer or magnehelic gauge (SE2239).
   e. Run engine at high idle (no load) RPM.
   f. Test must be made with engine specified oil and water temperatures as shown in the PERFORMANCE DATA GUIDELINES, at the end of this section.
   g. Record crankcase pressure in 1st check box on Form CGED-365.
   h. Crankcase pressure guidelines are as follows:
   •T/DTI-466C . . . . .5.5 in. H20 (max.)

IMPORTANT

DO NOT PLUG THE BREATHER TUBE DURING THE CRANKCASE PRESSURE TEST AS RESTRICTING THE TUBE CAN CAUSE CRANKSHAFT AND TURBOCHARGER SEALS TO LEAK.

2. Excessive crankcase pressure with oil consumption trend data indicates:

   a. Badly worn or broken rings and/or
   b. Badly worn or scored cylinder sleeves.

3. Review the recorded results of the crankcase pressure test. If there is any difference between the guideline data and the 1st check box, correct as necessary and repeat the test.

4. If results obtained during the above tests are within guidelines, engine operation is satisfactory.

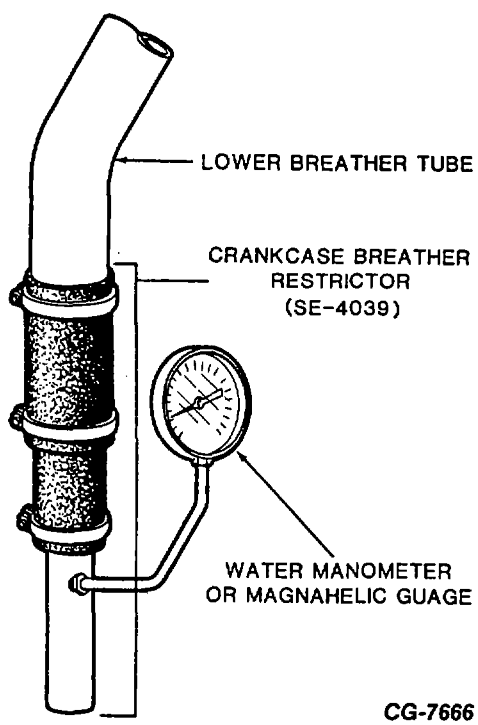


Figure 24. Crankcase Pressure Test

- **TEST INJECTION NOZZLES**
  - 400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

12	**TEST INJECTION NOZZLES** A. SPRAY CONDITION B. VALVE OPENING PRESSURE C. LEAKAGE			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	HAND TEST PUMP [NOZZLE TESTER] (SE-2002)			

† Refer to "Performance Data Guidelines", in this section.

This is a functional test of injection nozzle performance. Nozzles must be removed from the engine and tested for SPRAY CONDITION, VALVE OPENING PRESSURE and LEAKAGE.

NOTE: If proper tools and facilities are not available to test or repair nozzles, and nozzles are the suspected problem; replace all nozzles with new or renewed nozzles.

IMPORTANT

IN OUTLINING THE PROCEDURE FOR INSPECTION OF INJECTION NOZZLES, THE NECESSITY OF CLEANLINESS CANNOT BE OVER-EMPHASIZED. A CLEAN WORKBENCH, CLEAN WASHING FLUID AND CLEAN TOOLS ARE ALL ESSENTIAL TO PRODUCE SATISFACTORY RESULTS. THE USE OF SUITABLE TOOLS FOR THIS TYPE OF WORK IS EQUALLY IMPORTANT.

1. Injection Nozzle Removal:

   a. Detach high-pressure tubing and leak-off lines, covering their opening ends with plastic, cloth or paper caps to protect against the entrance of dirt.
   b. Remove mounting bolt and clamp, where applicable. Pull nozzle assembly from the cylinder head being careful not to strike the end of the nozzle against any hard surface. If the assembly seems to be stuck, break it loose from carbon deposits to facilitate removal.
   c. Cover nozzle openings with protector caps to prevent the entrance of dust. Also protect nozzle tip, with protective caps.
   d. Remove injector nozzle gasket from nozzle bore with suitable tool, discard and replace with new gasket.

- **TEST INJECTION NOZZLES (Continued)**

2. Injection Nozzle Testing

The prime requirements for a satisfactory nozzle assembly are: pressure tight seats; no excessive valve stem leakage; satisfactory spray and automization characteristics.

a. After removal from engine, test nozzles for spray condition, opening pressure and leakage on a hand test pump SE-2002.

Figure 24 shows an injection nozzle mounted for testing on the hand test pump.

IMPORTANT

IT IS ADVISABLE TO TEST NOZZLES BEFORE CLEANING THEM. AFTER TESTING PLACE NOZZLES IN A COLD DECARBONIZING SOLUTION FOR AT LEAST ONE HOUR. AFTER REMOVING NOZZLES FROM SOLUTION, WASH OFF THE OUTSIDE SURFACES.

b. Prepare pump for making tests. Fill pump reservoir with Viscor 1487C calibration fluid. Open pump valve slightly and operate pump handle to expel air from pump and outlet pipe. Operate pump until solid fluid (without air bubbles) flows from end of outlet pipe. Close pump valve.

c. Connect injection nozzle to test pump. Avoid "cross-threading". Tighten connector nut securely with open end wrench.

d. Bleed air from nozzle. Open pump valve and operate pump for several quick strokes to expel (bleed) air from injection nozzle. Fluid should spray from the spray holes in nozzle tip.

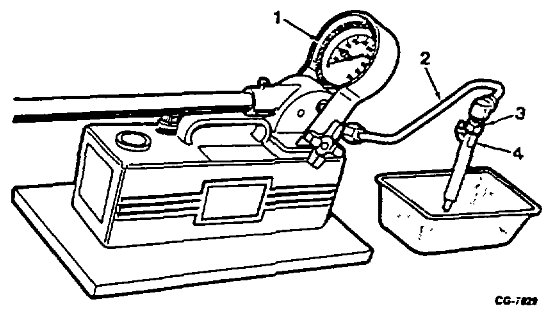


Figure 24. Typical Nozzle Assembly Mounted in the Hand Test Pump

1. **Pressure Gauge**
2. **Nozzle Tube Assembly (SE-2004-13)**
3. **90 Adapter (SE-2757)**
4. **Nozzle Assemblies**

IMPORTANT

KEEP HANDS AWAY FROM NOZZLE SPRAY. FLUID SPRAYING FROM THE NOZZLE UNDER HIGH PRESSURE CAN PENETRATE THE SKIN AND CAUSE INFECTION. MEDICAL ATTENTION SHOULD BE PROVIDED IMMEDIATELY IN THE EVENT OF SKIN PENETRATION.

e. OBSERVE SPRAY PATTERN. Operate test pump in smooth, even strokes and observe pattern of fluid spraying from nozzle tip spray holes. The spray should be well atomized in an even pattern, free from solid streams and dribbling. Examples of good and bad spray patterns are shown in Figure 25.

f. CHECK NOZZLE OPENING PRESSURE. Open gauge valve, operate test pomp in slow smooth, even strokes and observe gauge pressure to determine pressure at which nozzle opens (sprays fluid). Nozzle should operate within specified opening pressure range.

• **TEST INJECTION NOZZLES (Continued)**

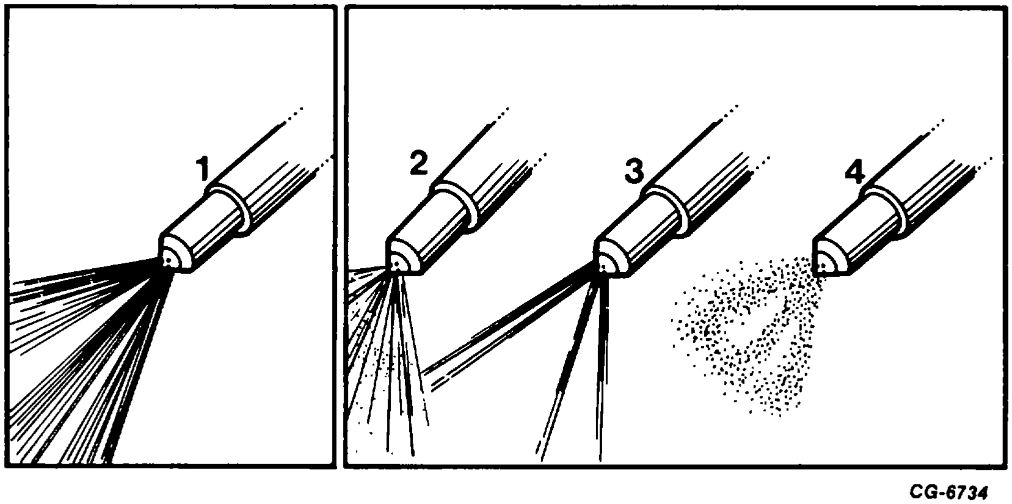


Figure 25. Typical Nozzle Spray Patterns (For Orifice Type Nozzles.)

SPECIFIED VALVE OPENING PRESSURE CHART

- **400 Series On-Highway and OEM Robert Bosch "MW" Pumps**

"MW" Pumps

New or rebuilt . . 25,337 kPa + 517 kPa (3675 psi + 75 psi)
Minimum Permissible (Used) . . . . . 20,000 kPa (2,900 psi)

g. CHECK FOR TIP LEAKAGE. Blow nozzle tip dry using filtered compressed air. Operate test pump to maintain pressure at about 689 kPa (100 psi) below opening pressure. Nozzle tip should remain dry without an accumulation of fluid drops at spray holes. A slight wetting after about 5 seconds is permissible if no droplets are formed. Refer to Figure 26.

IMPORTANT

DO NOT WIPE TIP WITH FINGERS AS THIS WILL TEND TO DRAW THE FLUID PRESENT IN THE SAC HOLE THROUGH THE ORIFICES AND FALSELY INDICATE A LEAK AND REJECTION OF A GOOD VALVE.

h. CHECK FUEL LEAK-OFF. Operate test pump in quick strokes and observe for flow of fluid from leak-off part of nozzle. A very slight leak-off is normal. If an excessive amount of fluid is expelled or if fluid surges from leak-off port when test pump is operated, nozzle is faulty. Conversely, if no fluid is present at the leak-off port the nozzle is faulty.

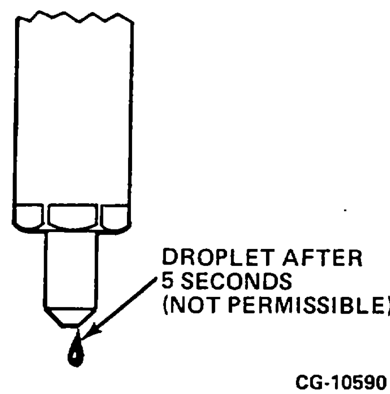


Figure 26. Unacceptable Nozzle Tip Leakage

If nozzle passes above tests, it is suitable for further service in the engine following cleaning and removal of accumulated carbon. Nozzles showing irregular spray pattern, leakage at nozzle tip spray holes, excessive fluid leak-off or opening pressure below minimum permissible limit should be replaced or serviced (disassembled, cleaned and rebuilt).

- **TEST INJECTION NOZZLES (Continued)**

3. Injection Nozzle Installation

   a. Thoroughly clean nozzle bore in cylinder head before reinserting nozzle holder assembly. Pay particular attention to seating surfaces, in order that no small particles or carbon will cause assembly to be cocked or permit blow-by of combustion gases. Don't use hard or sharp tools for cleaning. A round piece of brass properly shaped or a round steel bristle brush is permitted if used with care. Nozzle bores on 6.9 Liter Diesel Engines should use Nozzle Seat Cleaner (SE-4139).

   b. Install injection nozzle washer, seal and gasket (where applicable) on injector assembly. Use new mounting gasket every time injector nozzle is removed.

NOTE: Make sure old nozzle gasket is not left in bore.

   c. Install nozzle assembly carefully into its bore so that nozzle tip does not strike against recess wall. Tighten to specified torque.*

   d. Install clamp, mounting bolt and attach high pressure tubing and leak-off lines, as required. Tighten to specified torque.*

* Refer to appropriate service manual.

   e. Operate engine and check for fuel or combustion gas leakage.

- **FUEL ANEROID DIAPHRAGM**
  400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

13	**ANEROID DIAPHRAGM**			
	PRESSURE TEST DIAPHRAGM (20 PSI MAX - FOR 30 SECONDS) NO LEAKAGE PERMISSIBLE.			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	D-100 PRESSURE KIT (SE-2239)			

† Refer to "Performance Data Guidelines", in this section.

Test for leakage as follows:

1. Remove intake manifold to aneroid line at aneroid.
2. Connect fitting and plastic tubing to Pressure Test Kit (SE-2239). Use 0-30 psi gauge.
3. Pressurize diaphragm housing to 20 psi max. for 30 seconds. (See Figure 27.)
4. No leakage is acceptable. Record whether aneroid leaks. Injection pump must be removed if diaphragm leaks because full load stop must be set on injection pump test bench.

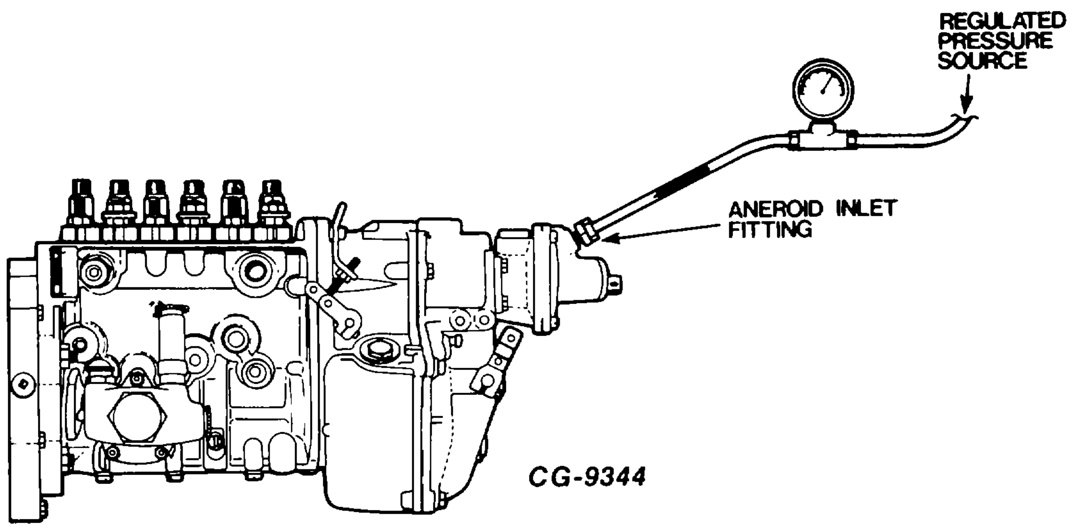


Figure 27. Aneroid Diaphragm Leakage Test For Robert Bosch MW Pump

- **EXHAUST BACK PRESSURE**
  - 400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

	EXHAUST BACK PRESSURE			
14	A. MEASURE AT POINT 3 TO 6 IN. AFTER ELBOW OR STRAIGHT PIPE EXHAUST EXTENSION FLANGE. B. MEASURE AT FULL LOAD & RATED SPEED.			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	WATER MANOMETER OR MAGNAHELIC GAUGE			

† Refer to "Performance Data Guidelines", in this section.

Measure exhaust back pressure as follows:

1. Connect pressure test kit (SE-2239) in a straight section of exhaust pipe approximately 3 to 6 inches after the turbocharger exhaust elbow extension flange, as shown in Figure 28 or 3 to 6 inches after the turbocharger straight pipe exhaust extension flange, as shown in Figure 29.

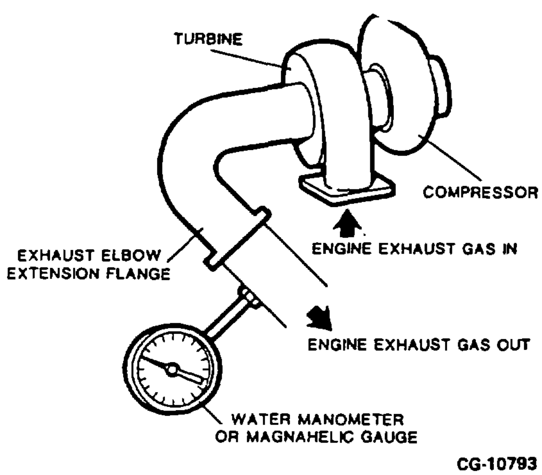


Figure 28. Exhaust Back Pressure Test Location with Exhaust Elbow

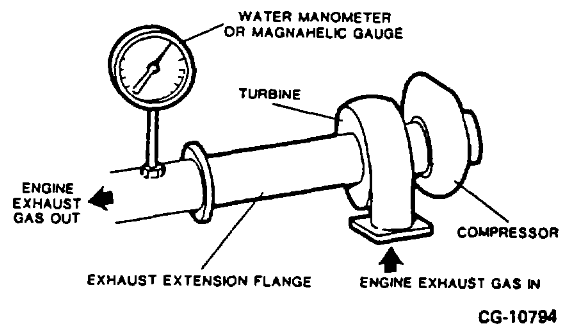


Figure 29. Exhaust Back Pressure Test Location with Straight Exhaust Pipe

2. Obtain the data at rated speed and normal operating temperatures on the chassis dynamometer or fully loaded on the highway. Specifications as noted in the Performance Data Guidelines in Section 6 are 0-6.7 kPa (0-27 in H20.

3. If pressure exceeds guidelines, reduce restriction by replacing muffler or exhaust piping as required.

- **MEASURE SMOKE INTENSITY**
  - 400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

	MEASURE SMOKE INTENSITY*			
15	MEASURE AT FULL LOAD & RATED SPEED (RPM)			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	SMOKE SAMPLING KIT (SE-2580)			

*Engine must be at normal operating temperature.

† Refer to "Performance Data Guidelines", in this section.

General Description

The smoke sampling kit (SE-2580) is used to measure smoke levels at the exhaust stack at full load and rated speed.

The smoke sampling kit (SE-2580) sampling pump draws off a precise amount of exhaust gas from the exhaust pipe of the respective engine and then sucks it through a filter paper disk.

The filter paper disk, in turn, darkens during this process and thus gives the measure of the soot content of the exhaust gases. The filter disk is then compared to the Bacharach Oil Burner Smoke Scale (Chart C). The Bosch smoke number is then determined and compared to the standards given in the Performance Data Guidelines, in this section.

- **MEASURE SMOKE INTENSITY (Continued)**

Operating Instructions

NOTE: To make sure that there are no soot particles of previous tests in the sampling probe or hose which might influence the measuring results, hose and sampling probe have to be blown out with compressed air before the test. A check should be made by pumping fresh air through a filter disk. The disk must not darken.

1. Install the sampling probe as follows:
   a. When used with an open exhaust stack, the probe must be used with the standard probe shield and inserted axially into the end of the pipe, keeping away from the wall. Normally, it will be convenient to use the furnished clamp to position and fasten probe in stack.
   b. For closed stack installations, the standard probe with the tip shield removed can be inserted through a snug fitting hole in the side of the stack. Care must be taken to keep the probe at 90° with the flow, to eliminate velocity effects.

2. If samples are taken from the exhaust systems operating at pressure over 2.5 kPa (10 inches H20) from barometeric pressure, then correction must be made for density of the sample. A typical correction chart is furnished with the smoke meter.

3. Insert sampling probe (1, Figure 30) into exhaust pipe. When possible, avoid locating near a bend.

4. Cock the pump (3, Figure 30) by pushing plunger knob (5) all the way in until latch holds spring compressed.

5. Unscrew cap nut (2, Figure 30) to allow insertion of clean filter disc and clamp filter by moderate tightening of cap nut.

6. Release suction stroke by squeezing rubber bulb (4, Figure 30).

7. Loosen cap nut and remove filter discs.

8. Repeat Steps 4, 5, 6 and 7 until three uniformly darkened discs are obtained.

9. Compare sample discs with "Bacharach Oil Burner Smoke Scale," represented in Chart C.

IMPORTANT

DO NOT COMPARE SAMPLE DISCS WITH SMOKE SCALE REPRESENTED IN CHART C. USE ONLY THE ACTUAL BACHARACH SCALE.

Order Bacharach Oil Burner Smoke Scale from:

A. A. Englehardt Company
6117 North Elston Avenue
Chicago, I L. 60646

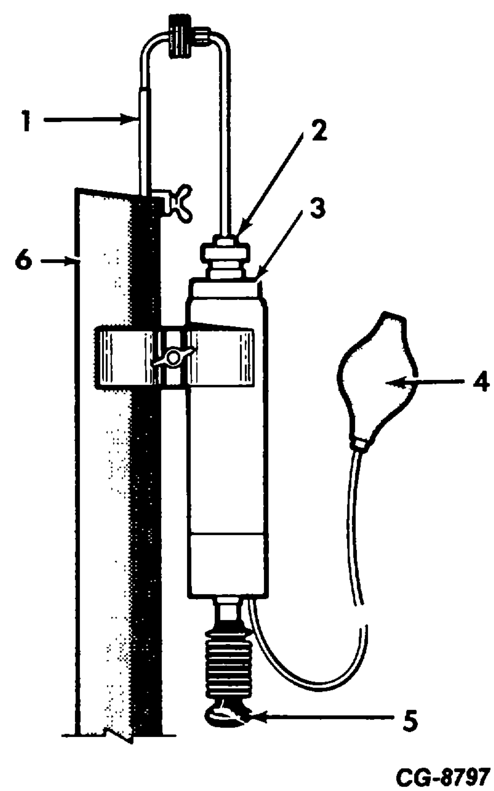


Figure 30. Obtaining Smoke Sample with SE-2580

1. Sampling Probe	**4. Rubber Bulb**
2. Cap Nut	**5. Plunger Knob**
3. Pump	**6. Exhaust Stack**

- **MEASURE SMOKE INTENSITY (Continued)**

10. Determine Bosch smoke number and compare with Bosch number specified in Performance Data Guidelines.

11. If smoke emission sample exceeds published limit correct as required.

NOTE: Filter discs to be evaluated should show no signs of water drops or soot spots. Avoid excessive handling and particularly touching darkened surface as much as possible.

Smoke Meter Maintenance

1. Soot deposits must be periodically cleaned from sampling hose and probe, depending on use and smoke densities encountered. Detach sampling hose from pump by loosening knurled nut. Blow compressed air through hose and probe.

2. Periodically inspect for leakage around filter clamping surfaces:

    a. Remove shield from probe and seal off end and side holes with a short piece of tight-fitting hose which is plugged on one end.
    b. Insert and clamp a filter disc in place.
    c. Cock the pump and release in the normal manner.
    d. Time plunger movement for its full stroke. A time of 10 seconds or longer indicates filter clamping is satisfactory.

3. Periodic inspection of pump seal:

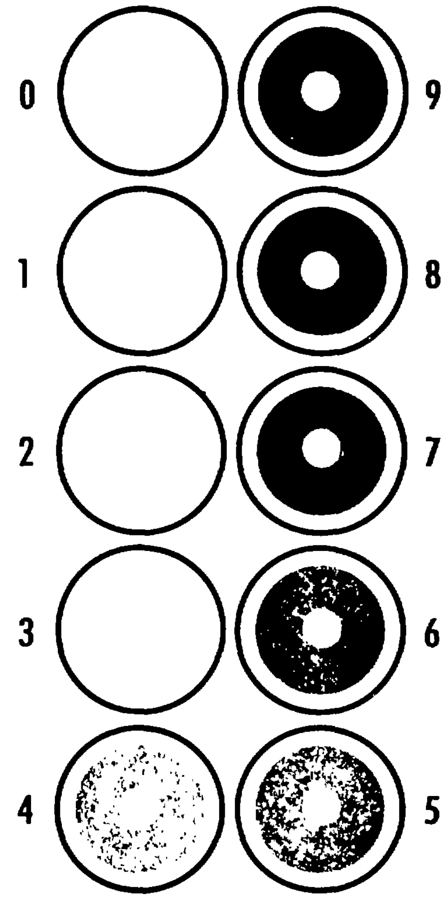
    a. Insert and clamp a rubber disc in filter holder.
    b. Cock and release pump, making sure to maintain pressure on rubber bulb. No perceptible movement of pump piston indicates satisfactory pump seal.

4. Periodic pump cleaning.

    a. Abnormal force required to operate pump indicates need for cleaning.
    b. Disassemble, clean, lubricate pump cylinder, reassemble and check for leaks.

CHART C*
Representation of:

BACHARACH
OIL BURNER SMOKE SCALE
DEVELOPED IN COOPERATION WITH
SHELL DEVELOPMENT COMPANY



This scale is based on a test flue gas volume of 2250 cubic Inches per square inch of filtering area, which is equivalent to 6 full strokes for models RZB and RAC Testers **and 10 full strokes for Models RCC and RCC-B** Testers. For motor operated smoke meter see instructions for sampling period.

This Scale Conforms to ASTM D 2156-63T

Bahoroach Instrument Co. SCALE No. RR776
Pittsburgh Pa., U.S.A. Made in U.S.A.

*Chart C compares darkness of filter paper to Robert Bosch Smoke Number.

- **MEASURE SMOKE INTENSITY (Continued)**

International®
Smoke Nomograph for Service

For those service technicians utilizing other smoke testing methods, the International Harvester Company Smoke Nomograph (Chart D) is used to convert the Bosch No. (used by IH) to four other common smoke scales.

The five diesel smoke testing methods and scales are:

1. The Robert Bosch Smoke Number:

This number is determined by drawing .3 litre of smoke into a cylinder. The smoke is drawn at a uniform rate through a filter paper. The darkness of the paper determines the Robert Bosch number. No adjustment is necessary for stack size.

2. The USPHS Number (United States Public Health Service):

This number is determined by installing a device at the end of the exhaust stack. As smoke passes through device, percent opacity is measured. The percent opacity will vary depending on stack size.

3. Celeso Model 101:

This number is determined similar to the USPHS number. It will also vary depending on the size of the stack.

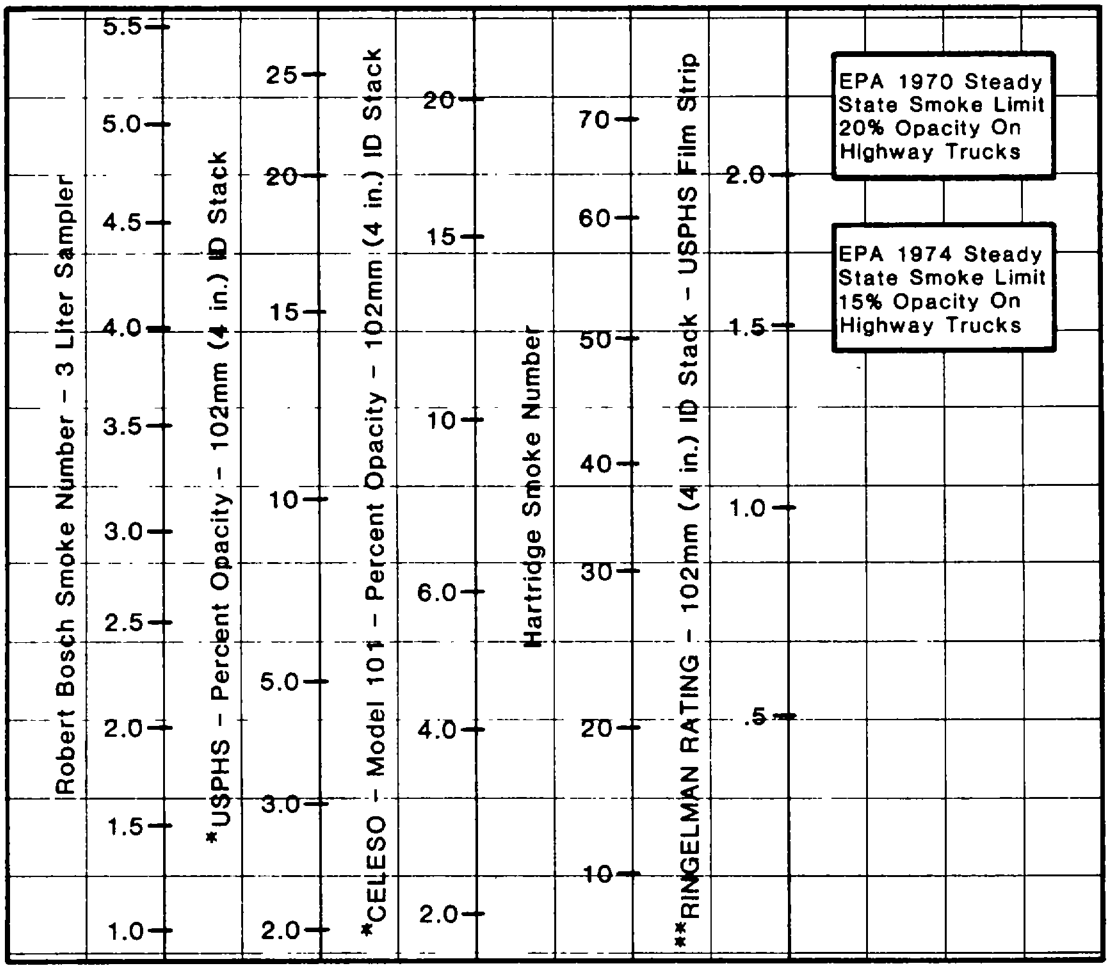
4. Hartridge Smoke Number:

This number is determined by drawing a measured amount of smoke into a cylinder. A light passing through smoke measures opacity of sample. No adjustment is necessary for stack size.

5. The Ringleman Rating:

These are derived by viewing smoke from the stack and comparing it to a standard. Naturally, these values will vary depending upon the observer, background and point of observation.

CHART D
INTERNATIONAL® SMOKE NOMOGRAPH



USE CHART D TO CONVERT FROM ONE SMOKE SCALE TO ANOTHER

CG-7642

*Good for given stack size only. For a different stack size (see example) read percent, then add or subtract the following correction factor.

Percent Opacity	5%	10%	15%	20%	25%
Sample taken from a 127 mm (5 in) stack - Subtract from reading	1.0	2.0	3.0	4.0	5.0
Sample taken from a 76 mm (3 in) stack - Add to reading	1.0	2.0	3.5	4.5	5.5

Example-With a 127mm (5 in) stack, a reading of 10% is obtained using a Celeso Model 101. To correct percent, subtract 2.0 giving a corrected number of 8%. This would be approximately a 3.2 on the Robert Bosch scale.

**This value will vary depending upon observer, background and point of observation.

- **INTAKE AND EXHAUST VALVE CLEARANCE**
  - 400 Series On-Highway
  (with Robert Bosch MW Pumps)

FROM FORM NO. CGED-365

16	INTAKE AND EXHAUST VALVE CLEARANCE			
	ENGINE OFF -HOT OR COLD			
	INSTRUMENT	**GUIDELINE DATA†**	**1st CHECK**	**2nd CHECK**
	FEELER GAUGE			

† Refer to "Performance Data Guidelines", in this section.

- 400 Series On-Highway and OEM
(with AMBAC Model 100 and
Robert Bosch MW Pumps)

- **INTAKE AND EXHAUST VALVE CLEARANCE**

400 Series On-Highway with Robert Bosch MW Pumps

Adjust valve lash as follows:

1. Remove valve cover.

2. Turn crankshaft until number one piston is on compression stroke and timing pointer on front cover is in line with TDC mark (pin) on the pulley.

NOTE: Insure number one piston is on compression stroke by turning both push rods by hand to determine that both valves are closed. Valves are closed when push rods are loose and can be turned easily.

3. Six valves are adjusted when No. 1 piston is at TDC (compression) and remaining six are adjusted when No. 6 piston is at TDC (compression). As depicted in Figure 31 odd numbered valves are intake valves; and even numbered valves are exhaust valves.

4. Valve tappet clearance (lash) is specified in Valve Lash Adjustment Chart.

NOTE: All valves are adjusted by cranking the engine twice.

When tightening head bolts, place a .005 in. Feeler gauge between the outside brackets and the rocker levels to prevent binding.

DO NOT adjust valves with the engine running.
Severe damage can result from inserting feeler gauge between valve and valve lever due to close clearance of valve to piston.

5. Replace valve cover. Use new rubber rings under valve cover bolt washers to avoid oil leaks at this point. Check that the valve cover gasket makes an oil tight seal with the cylinder head.

Use a new gasket is necessary.

• INTAKE AND EXHAUST VALVE CLEARANCE (Continued)

WITH	ADJUST VALVES											
No. 1 Piston at T.D.C. (Compression)	INT 1	EXH 2	INT 3			EXH 6	INT 7			EXH 10		
No. 6 Piston at T.D.C. (Compression)				EXH 4	INT 5			EXH 8	INT 9		EXH 11	NIT 12

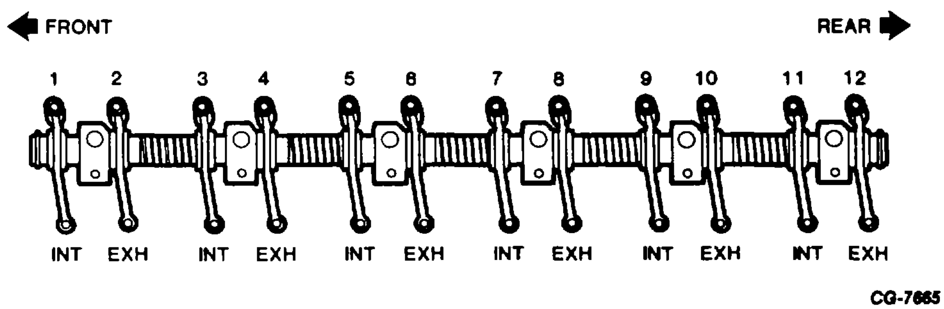


Figure 31. Valve Arrangement

VALVE LASH ADJUSTMENT CHART
(On-Highway and OEM)

Engine	Engine Serial No.	Intake mm (In.)	Exhaust mm (In.)
DT-466C & DTI-466C	400001 and above	.635 (0.025)	.635 (0.025)

DT466C/195 HP - 2600 RPM w/Bowden Wire Shut-Off or Electric Shut-Off
(Federal)

Engine/Model DT-466C/B195F

Engine Rating ....195 BHP @ 2600 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 802 897 C1) with .062" dia. orifice fitting]
Original Equipment 1 802 643 C91

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia. orifice fitting]
Original Equipment 1 802 643 C92
ReNEWed 735 188 C91

Turbocharger No 684 596 C91
A/R Ratio 1.32
Turbocharger No 1 806 077 C91
A/R Ratio 1.15

Injection Nozzle Part Number
Original Equipment 688 840 C91

Nozzle Code .... N

Nozzles Valve Opening Pressure
New or Reconditioned .... 2482025, 855 kPa (3600-3750 psi)
Minimum Valve Opening
Pressure Before Replacement ....20, 000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) ....23°±1°BTDC (Static)

High Idle Speed - RPM ....2925 ±25

Low Idle Speed - RPM ....650 ± 25
- Manual transmission - Neutral
- Automatic Transmission - Drive
- Mixer- Drum Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake ....635 mm (.025")
Exhaust ....635 mm (.025")
Fuel Pressure*

(Check @ High Idle Speed - No Load) ....138 kPa (20 psi) minimum

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

.... 110 kPa ±10 kPa (16 psi ± 1.psi) @ 2600
Intake Manifold Pressure* ....65 kPa ±10 kPa (9.5 psi ± 1.5 psi) @ 1800

DT-466C/195 HP @ 2600 RPM w/Bowden Wire Shut-Off and Electric Shut-Off - Continued (Federal)

Exhaust Back Pressure After Turbocharger* .... 0-6.7 kPa (0-26 in.H20)

Smoke Level* - Bosch Number .... 2.4 @ Rated Speed

Crankcase Pressure* - Min.- Max .... 5.5" H_2O Max.2" H_2O Min.

+Air Cleaner Restriction* - Min.- Max. .... 2.5-7.5 kPa (10-30 in.H_20)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.

Lube Oil Temperature (Oil Pan)*.* .... 110°C (230°F) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**
Low Idle (Min.) .... 69 kPa (10 psi)
High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
+Measure at inlet to turbocharger. Use 6.2 kPa (25 in H20) maximum if measured at outlet of air cleaner.
**Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.

DTI-466C/195 HP @ 2600 RPM w/Bowden Wire Shut-Off or Electric Shut-Off (California)

Engine/Model DTI-466C/B195C

Engine Rating .... 195 BHP @ 2600 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia. orifice fitting]
Original Equipment 1 806 227 C91

Turbocharger No 684 698 C91
A/R Ratio 1.32
Turbocharger No 1 806 078 C91
A/R Ratio 1.15
Injection Nozzle Part Number
Original Equipment 688 840 C91
Nozzle Code .... N

Nozzle Valve Opening Pressure
New or Reconditioned .... 24, 820-25, 855 kPa (3600-3750 psi)

Minimum Valve Opening
Pressure Before Replacement .... 20, 000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) .... 18°+ 1° BTDC (Static)

High Idle Speed- RPM .... 2750 ± 25

Low Idle Speed- RPM .... 650 ± 25
- Manual Transmission - Neutral
- Automatic Transmission - Drive
- Mixer- Drum Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake .... 635 mm (.025")
Exhaust .... 635 mm (.025")

Fuel Pressure*
(Check @ High Idle Speed - No Load) .... 138 kPa (20 psi) minimum

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

124 kPa ± 10 kPa (18 psi ± 1.5 psi) @ 2600
Intake Manifold Pressure* .... 78 kPa ±10 kPa (1115 pi ± 15 psi) @ 1800

DT-466C/165 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off - Continued (California)

Exhaust Back Pressure After Turbocharger* .... 0-6.7 kPa (0-26 in.H_2O)

Smoke Level* - Bosch Number .... 2.3 @ Rated Speed

Crankcase Pressure* - Min.- Max .... 5.5" H_2O Max./2" H_2O Min.

+Air Cleaner Restriction* - Min.- Max.. 2.5-7.5 kPa (10-30 in.H_2O)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.

Lube Oil Temperature (Oil Pan)** .... 110°C (230°F) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**
Low Idle (Min.) ....69 kPa (10 psi)
High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
**Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.
+Measured at inlet to turbocharger. Use 6.2 kPa (25 in H20) maximum if measured at outlet of air cleaner.

DT-466C/210 HP @ 2600 RPM w/Bowden Wire Shut-Off or Electric Shut-Off (Federal)

Engine/Model DT-466C/B210F

Engine Rating ....210BHP @ 2600 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 802 897 C1) with .062" dia.orifice fitting]
Original Equipment 1 802 604 C91

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia.orifice fitting]
Original Equipment 1 802 604 C92

Optional Injection Pump Part Number (For conversion to Refuse Packer Application)
Original Equipment 1 806 264 C91

Turbocharger No 684 596 C91
A/R Ratio 1.32

Turbocharger No 1 806 077 C91
A/R Ratio 1.15

Injection Nozzle Part Number
Original Equipment 688 840 C91

Nozzle Code .... N

Nozzles Valve Opening Pressure
New or Reconditioned .... 24, 820-25, 855 kPa (3600-3750 psi)

Minimum Valve Opening
Pressure Before Replacement ....20, 000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) ....23° ± 1° BTDC (Static)

High Idle Speed - RPM ....2935 ± 25

Low Idle Speed - RPM ....650 ± 25

- Manual Transmission - Neutral
- Automatic Transmission - Drive
- Mixer - Drum Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake .... 635 mm (.025")
Exhaust .... 635 mm (.025")

Fuel Pressure*
(Check @ High Idle Speed - No Load) ....138 kPa (20 psi) minimum

DT466C/210 HP @ 2600 RPM w/Bowden Wire Shut-Off and Electric Shut-Off - Continued (Federal)

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

Intake Manifold Pressure* .... 124 kPa ± 10 kPa (18 psi ± 1.5 psi) @ 2600
76 kPa ± 10 kPa (11 psi ± 5 psi) @ 1800

Exhaust Back Pressure After Turbocharger* .... 0-6.7 kPa (0-26 in.H_20)

Smoke Level* - Bosch Number .... 2.6 @ Rated Speed

Crankcase Pressure* - Min.- Max .... 5.5" H_20 Max./2" H_20 Min.

+Air Cleaner Restriction* - Min.- Max. .... 2.5-7.5 kPa (10-30 in. H_20)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.

Lube Oil Temperature (Oil Pan)** .... 110°C (230°F) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**
Low Idle (Min.) .... 69 kPa (10 psi)
High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
** Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.
+Measure at inlet to turbocharger. Use 6.2 kPa (25 in H_20) maximum if measured at outlet of air cleaner.

DTI-466C/210 HP @ 2600 RPM w/Bowden Wire Shut-Off or Electric Shut-Off (California)

Engine/Model DTI-466C/B210C

Engine Rating .... 210 BHP @ 2600 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 802 897 C1) with .062" dia. orifice fitting]
Original Equipment 1 802 608 C91

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia. orifice fitting]
Original Equipment 1 802 608 C92

Turbocharger No 684 698 C91
A/R Ratio 1.32

Turbocharger No 1 806 078 C91
A/R Ratio 1.15

Injection Nozzle Part Number
Original Equipment 688 840 C91

Nozzle Code .... N

Nozzle Valve Opening Pressure
New or Reconditioned .... 24, 820-25, 855 kPa (3600-3750 psi)

Minimum Valve Opening
Pressure Before Replacement .... 20, 000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) .... 18°±1° BTDC (Static)

High Idle Speed - RPM .... 2945 ± 25

Low Idle Speed - RPM 65025
• Manual Transmission - Neutral
• Automatic Transmission - Drive
• Mixer- Drum Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake .... .635 mm (.025")
Exhaust .... .635 mm (.025")

Fuel Pressure*
(Check @ High Idle Speed - No Load) .... 138 kPa (20 psi) minimum

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

Intake Manifold Pressure* .... 134 kPa ± 10 kPa (19.5 psi ± 1.5 psi) @ 2600
92 kPa ± 10 kPa (13.5 psi ± 1.5 psi) @ 1800

DTI-466C/210 HP @ 2600 RPM w/Bowden Wire Shut-Off and Electric Shut-Off - Continued (California)

Exhaust Back Pressure After Turbocharger* .... 0-6.7 kPa (0-26 in. H_2O)

Smoke Level* - Bosch Number .... 2.4 @ Rated Speed

Crankcase Pressure* - Min.- Max .... 5.5"H_2O Max./2" H_2O Min.

+Air Cleaner Restriction* - Min.- Max. .... 2.5-7.5 kPa (10-30 in. H_2O)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.

Lube Oil Temperature (Oil Pan)*.* .... 110°C (230°F) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**
Low Idle (Min.) ....69 kPa (10 psi)
High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
** Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.
+Measure at inlet to turbocharger. Use 6.2 kPa (25 in H20) maximum if measured at outlet of air cleaner.

DT-466C/180 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off (California) -

Engine/Model DT-466C/B 180C

Engine Rating .... 180 BHP @ 2400 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 802 897 C1) with .062" dia. orifice fitting]
Original Equipment 1 802 607 C91

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia. orifice fitting]
Original Equipment 1 802 607 C92

Turbocharger No .... 684 698 C91 or 684 937 C91
A/R Ratio 1.32

Turbocharger No 1 806 078 C91 or 1 806 079 C91
A/R Ratio 1.15

Injection Nozzle Part Number
Original Equipment 691 348 C91

Nozzle Code .... R

Nozzle Valve Opening Pressure
New or Reconditioned .... 24, 820-25, 855 kPa (3600-3750 psi)

Minimum Valve Opening
Pressure Before Replacement .... 20, 000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) .... 1 7° ± 1° BTDC (Static)

High Idle Speed - RPM .... 2725 ± 25

Low Idle Speed - RPM .... 650 ±25
- Manual Transmission - Neutral
- Automatic Transmission - Drive
- Mixer- Dr6m Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake .... 635 mm (.025")
Exhaust .... 635 mm (.025")

Fuel Pressure*
(Check @ High Idle Speed - No Load) .... 138 kPa (20 psi) minimum

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

Intake Manifold Pressure* .... 117 kPa ± 10 kPa (17 psi ± 1.5 psi) @ 2400
555 kPa ± 10 kPa (8 psi ± 1.5 psi) @ 1700

DT-466C/180 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off - Continued (California)

Exhaust Back Pressure After Turbocharger* .... 0-6.7 kPa (0-26 in. H_2O)

Smoke Level* - Bosch Number .... 2.4 @ Rated Speed

Crankcase Pressure* - Min. - Max ....5.5"H_2O Max./2" H_2O Min.

+Air Cleaner Restriction* - Min. - Max. .... 2.5-7.5 kPa (10-30 in. H_20)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.

Lube Oil Temperature (Oil Pan)*.* ....110°C (230°F) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**
Low Idle (Min.) ....69 kPa (10 psi)
High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 800F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
** Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.
+Measure at inlet to turbocharger. Use 6.2 kPa (25 in H20) maximum if measured at outlet of air cleaner.

DT466C/180 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off (Federal)

Engine/Model DT-466C/B180F

Engine Rating ....180 BHP @ 2400 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 802 897 C1) with .062" dia. orifice fitting]
Original Equipment..1 802 605 C91

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia. orifice fitting]
Original Equipment 1 802 605 C92

Turbocharger No ....684 698 C91 or 684 937 C91
A/R Ratio 1.32

Turbocharger No ....1 806 078 C91 or 1 806 079 C91
A/R Ratio 1.15

Injection Nozzle Part Number
Original Equipment 1 802 769 C91

Nozzle Code ....S

Nozzle Valve Opening Pressure
New or Reconditioned ....24, 820-25, 855 kPa (36003750 psi)

Minimum Valve Opening
Pressure Before Replacement ....20, 000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) ....21° ± 1° BTDC (Static)

High Idle Speed - RPM ....2750 ± 25

Low Idle Speed - RPM ....650 ± 25
• Manual Transmission - Neutral
• Automatic Transmission - Drive
• Mixer- Drum Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake ....635 mm (.025")
Exhaust ....635 mm (.025")

Fuel Pressure*
(Check @ High Idle Speed - No Load) 138 kPa (20 psi) minimum

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

Intake Manifold Pressure* ....103 kPa + 10 kPa (15 psi ±1.5 psi) @ 2400
55 kPa ± 10 kPa (8 psi ± 1.5 psi) @ 1600

DT-466C/180 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off - Continued (Federal)

Exhaust Back Pressure After Turbocharger* .... 0-6.7 kPa (0-26 in. H_2O)

Smoke Level* - Bosch Number .... 1.5 @ Rated Speed

Crankcase Pressure* - Min.- Max .... 5.5" H_2O Max./2" H_2O Min.

+Air Cleaner Restriction* - Min.- Max. .... 2.5-7.5 kPa (10-30 in.H_20)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.,

Lube Oil Temperature (Oil Pan)** .... 110C (230°F) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**
Low Idle (Min.) ....69 kPa (10 psi)
High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
** Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.
+Measure at inlet to turbocharger. Use 6.2 kPa (25 in H_20) maximum if measured at outlet of air cleaner.

DT-466C/165 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off (Federal) -

Engine/Model DT-466C/B 165F

Engine Rating ....165 BHP @ 2400 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 802 897 C1) with .062" dia. orifice fitting]
Original Equipment 1 802 606 C91

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia. orifice fitting]
Original Equipment 1 802 606 C92

Turbocharger No ....684 698 C91 or 684 937 C91
A/R Ratio 32
Turbocharger No ....1 806 078 C91 or 1 806 079 C91
A/R Ratio 15
Injection Nozzle Part Number
Original Equipment 1 802 769 C91

Nozzle Code ....S

Nozzle Valve Opening Pressure
New or Reconditioned .... 24, 820-25, 855 kPa (3600-3750 psi)
Minimum Valve Opening
Pressure Before Replacement ....20, 000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) ....21°±1°BTDC (Static)

High Idle Speed - RPM ....2730 ± 25

Low Idle Speed - RPM ....650 ± 25
- Manual Transmission - Neutral
- Automatic Transmission - Drive
- Mixer- Drum Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake ....635 mm (.025")
Exhaust ....635 mm (.025")

Fuel Pressure*
(Check @ High Idle Speed - No Load) ....138 kPa (20 psi) minimum

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

Intake Manifold Pressure* .... 90 kPa ± 10 kPa (13 psi ± 1.5 psi) @ 2400
48 kPa ± 10 kPa (7 psi ± 1.5 psi) @ 1600

DT466C/165 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off - Continued (Federal)

Exhaust Back Pressure After Turbocharger* .... 0-6.7 kPa (0-26 in. H_20)

Smoke Level* - Bosch Number .... 1.4 @ Rated Speed

Crankcase Pressure* - Min.- Max .... 5.5"H_2O Max./2" H_20 Min.

+Air Cleaner Restriction* - Min.- Max .... 2.5-7.5 kPa (10-30 in. H_20)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.

Lube Oil Temperature (Oil Pan)*.* .... 1100C (230OF) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**

Low Idle (Min.) .... 69 kPa (10 psi)

High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
** Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.
+Measured at inlet to turbocharger. Use 6.2 kPa (25 in H_20) maximum if measured at outlet of air cleaner.

DT466C/165 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off (California)

Engine/Model DT-466C/B165C

Engine Rating 165 BHP @ 2400 RPM

Injection Pump Part Number [uses Fuel Return Hose (1 802 897 C1) with .062" dia. orifice fitting]
Original Equipment 1 802 995 C91

Injection Pump Part Number [uses Fuel Return Hose (1 806 503 C1) with .046" dia. orifice fitting]
Original Equipment 1 802 995 C92

Turbocharger No 684 698 C91 or 684 937 C91
A/R Ratio 32

Turbocharger No 1 806 078 C91 or 1 806 079 C91
A/R Ratio 15

Injection Nozzle Part Number
Original Equipment 691 348 C91

Nozzle Code .... R

Nozzle Valve Opening Pressure
New or Reconditioned .... 24,820-25,855 kPa (36003750 psi)

Minimum Valve Opening
Pressure Before Replacement .... 20,000 kPa (2900 psi)

Injection Pump Initial Timing (Engine Stopped) .... 17°±1° BTDC (Static)

High Idle Speed- RPM .... 2730 ± 25

Low Idle Speed - RPM .... 650 ± 25

• Manual Transmission - Neutral
• Automatic Transmission - Drive
• Mixer- Drum Engaged

Intake and Exhaust Valve Clearance (Engine Off - Cold)
Intake .... 635 mm (.025")
Exhaust .... 635 mm (.025")

Fuel Pressure*
(Check @ High Idle Speed - No Load) .... 138 kPa (20 psi) minimum

The following data to be taken at rated engine speeds on chassis dynamometer or fully loaded on highway.

Intake Manifold Pressure .... 103 kPa ± 10 kPa (15 psi ± 1.5 psi) @ 2400
52 kPa ± 10 kPa (7.5 psi ± 1.5 psi) @ 1700

DT466C/165 HP @ 2400 RPM w/Bowden Wire Shut-Off or Electric Shut-Off - Continued (California)

Exhaust Back Pressure After Turbocharger* ....06.7 kPa (0-26 in. H_2O)

Smoke Level* - Bosch Number .... 2.4 @ Rated Speed

Crankcase Pressure* - Min.- Max .... 5.5"H_2O Max./2" H_2O Min.

+Air Cleaner Restriction* - Min.- Max. .... 2.5-7.5 kPa (10-30 in. H_2O)

The following data to be taken after engine reaches stablized operating temperature and under normal load conditions.

Lube Oil Temperature (Oil Pan)"" .... 110°C (230°F) Max.

Lube Oil Pressure at Operating Temperature (SAE 30)**
Low Idle (Min.) ....69 kPa (10 psi)
High Idle (Min./Max.) .... 276-448 kPa (40-65 psi)

Measure water temperature differential across the radiator with engine on a chassis dynamometer, at full load and ambient temperature of 80°F or above.

Water Temperature Differential Across Radiator .... 3.3-6.6°C (6-12°F)

*Engine must be at normal operating temperature.
** Required to accurately measure crankcase pressure at oil fill or dipstick gauge tubes.
+Measured at inlet to turbocharger. Use 6.2 kPa (25 in H_2O) maximum if measured at outlet of air cleaner.

METRIC CONVERSION FACTOR CHART

UNIT	MULTIPLY BY	TO GET	MULTIPLY BY	TO GET
		HEAT		
British thermal unit (Btu)	1.055056	kilojoule (kJ)	0.9478170	(Btu)
	1055.056	joule (J)	0.0009478170	(Btu)
Btu per hour* (Btu/h)	0.2930711	watt (W)	3.412141	(Btu/h)
Btu per minute* (Btu/min)	17.58427	watt (W)	0.05686902	(Btu/min)
Btu per gallon (Btu/gal)	0.2787163	Kilojoule per litre (kJ/I'	3.5878777	(Btu/gal)
*Heat flow rate. Also see POWER.				
		LENGTH		
	25.4	millimetre (mm)	0.03937008	(in)
inch (in)	2.54	centimetre (cm)	0.3937008	(in)
	0.0254	metre (m)	39.37008	
		MASS (WEIGHT)		
	28.34952	qram (q)	0.03527397	(oz)
ounce (oz)	0.02834952	kilogram (kg)	35.27397	(oz)
grain	0.06479891	gram (g)	15.43236	grain
pound (lb)	0.4535924	kilogram (kg)	2.204622	(lb)
short ton (2000 lb)	907.1847	kilogram (kg)	0.001102311	short ton
	0.9071847	megagram (Mg)	1.102311	short ton
long ton (2240 lb)	1016.047	kilogram (kg)	0.0009842064	long ton
	1.016047	megagram (Mg)	0.9842064	long ton
		POWER		
horsepower(hp)	0.7456999	kilowatt ((kW)	1.341022	(hp)
	745.6999	watt (W)	0.001341022	(hp)
Btu per hour* (Btu/h)	0.2930711	watt (W)	3.412141	(Btu/h)
Btu per minute* (Btu/min)	17.58427	watt (W)	0.05686902	(Btu/min)
*Also heat flow rate. See HEAT.				
		PRESSURE		
pound-force per	2.036	inch of mercury (in Hg)	0.4912	(psi)
square inch (psi)	27.68	inch of water (in H_2O)	0.036125	(psi)
inch of mercury (in Hg)	13.6	inch of water iin H_20)	0.0735	(in Hg)
pound-force per	6.894757	kilopascal (kPa)	0.1450377	(psi)
square inch (psi)	0.006894757	megapascal (MPa)	145.0377	(psi)
inch of mercury (in Hg)	337685	kilopascal (kPa)	0.296134	(in Hg)
inch of water (in H20)	0.24884	kilopascal (kPa)	4.0186	(in H_2O)
bar	100	kilopascal (kPa)	0.01	(bar)
		TEMPERATURE		
degree Fahrenheit (°F). 1.8	(F - 32)÷1.8	degree Celsius (°C)	(1.8 x °C) + 32	(°F)
		TORQUE		
pound-force foot (lb ft)	1.355818	newton metre (N•m)	0.7375621	(ft lb)
pound-force inch (Ibf in)	0.1129848	newton metre (N•m)	8.850748	(in lb)
ounce-force inch (ozf in)	0.007061552	newton metre (N•m)	141.6119	(ozf in)

CONVERSION TABLE -- INCH FRACTIONS AND DECIMALS TO MILLIMETER EQUIVALENTS											
INCHES		mm	INCHES		mm	INCHES		mm	INCHES		mm
Fract	Dec		Fract.	Dec		Fract.	Dec		Fract	Dec	
-	.0004	.01	-	3	7620	-	.7874	20	-	1 969	50
-	.001	.0250	5/16	3125	7.938	51/84	7969	20 241	2	2 000	50.8
-	.039	.10	-	3150	8	13/16	8125	20 638	21/6	2.125	54
-	.005	.127	21/64	3281	8.334	-	8286	21	-	2.165	55
-	0079	.2	-	.3346	85	53/64	8281	21.034	21/4	2250	57.2
-	0098	.25	11/32	3438	8 731	27/32	8438	21431	-	2362	60
-	01	.254	-	3543	9	55/64_	8594	21 828	23/8	2.375	603
-	.0118	.3	23164	.3594	9128	-	8662	22	21/2	2.500	63 5
1/64	0158	.397	-	3740	95	7/8	8750	22 225	-	2559	65
-	0157	.4	3/8	375	9525	57/64	8906	22622	2 5/B	2625	66.7
-	.0197	.5	25/64	.3906	9 922	-	9	22.860	23/4	2.750	69.9
-	.0236	.6	--	3937	10	-	9055	23	-	2.756	70
-	025	.836	-	4	10160	29/32	9063	23019	2 7/8	2875	73
-	0276	.7	13/32	4062	10 319	59/84	9219	23 416	-	2 953	75
-	0295	75	-	4134	105	15/16	9375	23813	3	3000	762
1/32	.0313	.794	27/64	4219	10716	-	9449	24	-	3150	80
-	.0315	’ 8	-	.4331	11	61/64	9531	24 209	31/4	3 250	826
-	0354	9	7/16	4375	11113	31/32	.9688	24 606	-	3346	85
0394	1		29/64	4531	11.509	-	9843	25	31/2	3 500	88 9
3/64	.0469	1.191	15/32	.4688	11906	1	1000	25400	-	3543	90
-	0472	1.2	-	4724	12	-	1024	26	-	3 740	95
-	05	1270	31/64	4844	12 303	1 1116	1062	26 988	33/4	3 750	95 3
-	0551	14	-	4921	12.5	-	1063	27	-	3937	100
-	0591	15	1/2	5	12 700	-	1102	28	4	4000	101 6
1/16	0625	1588	-	5118	13	1 1/8	1125	28575	-	4331	110
-	.0669	17	33/64	5156	13097	-	1 142	29	4 1/2	4500	114.3
-	075	1905	17/32	5326	13494	-	1181	30	-	41 724	120
5/64	0781	1984	-	5315	135	1 3/16	188	30 16	5	5000	127
-	0787	2	35/64	5469	13891	-	1221	31	-	5118	130
-	0906	23	-	.5512	14	I 1/4	1250	31 75	5 1/2	500	139 7
3/32	0938	2381	9/16	5625	14 288	-	1260	32	-	5512	140
-	.0984	25	-	571	14 5	-	1299	33	-	5906	150
-	1 .	2540	37/64	.5781	14 684	1 5/16	1312	33 34	8	6000	1524
-	1024	26	-	5906	15	-	1339	34	-	6299	160
7/64	1093	2776	19/32	5938	15 081	1 3/8	375	34 93	61/2	6500	1651
-	1181	3	-	6	15240	-	1378	35	7	7000	177 8
1/8	125	3175	39/64	6094	15478	-	1417	36	-	7087	180
-	1378	35	-	6103	155	1 7/16	1438	36 51	7 1/2	7500	1905
9/64	.1406	3572	5/6	6250	15875	-	1457	37	-	7874	200
5/32	.1563	3 969	-	6299	16	-	1496	38	8	6 000	203 2
-	1575	4	41/64	6406	16 272	1 1/2	1500	3810	81/2	6500	2159
11/64	1719	4.366	-	6496	165	-	1535	39	-	8661	220
-	.1772	45	21/32	.6563	16 669	I 9/16	1562	39 69	9	9000	2286
3/16	.1675	4.763	-	.6693	17	-	1575	40	-	9449	240
-	.1969	5	43/64	.6719	17 066	-	1614	41	91/2	9 500	241.3
-	2	5.080	11/16	6875	17 463	¶ 5/8	1625	41 28	-	9843	250
13/64	2031	5159	-	6890	17.5	-	1654	42	10	10000	254
-	2165	5.5	-	7	17 780	I 11/16	1688	4286	-	10 236	260
7/32	.2188	5556	45/64	.7031	17859	-	1693	43	11	11.000	279.4
15/64	2344	5953	-	7087	18	-	1732	44	-	11.024	280
-	.2362	6	23/32	7186	18256	1 3/4	1750	4445	-	11811	300
1/4	.25	6 350	-	.7283	185	-	17 2	45	12	12.000	3048
-	.2559	65	47/64	.7344	18 653	-	1811	46	13	13 000	330.2
17/64	.2656	8.747	-	.7480	19	1 13/16	1813	46 04	-	13 780	350
-	2756	7	3/4	75	19050	-	1850	47	14	14000	3556
9/32	2813	7.144	49/64	7656	19447	1 7/8	1 875	47 63	15	15.000	381
-	.2953	75	-	7877	195	-	1890	48	-	15748	400
19/64	2969	7.541	25/32	7813	19 844	-	1929	49	16	16 000	406 4

To The Owner:

This Service Manual is published to assist the reader in overhaul and maintenance instructions on the 400 Series Diesel Engines. The manual is divided into two basic parts which are:

- Introductory Section
- Component Sections

Introductory Section:

This part of the manual covers general areas which should be read before engine disassembly. It will also be used for reference during disassembly, repair and assembly operations. The introductory section covers the following areas:

- Engine Features
- Safety Suggestions
- Torque Values and Information
- Sealing Compounds
- Engine Application Charts
- General Engine Specifications
- General Diagnostic Procedures
- Problem Analysis Guide
- Mounting Engine on Stand

Component Sections:

This part of the manual covers each component of the engine providing the following exploded diagram, general description, specifications, removal procedure, cleaning procedure, inspection and repair of the component, reassembly procedure and installation procedure.

-IMPORTANT-

THIS ENGINE SERVICE MANUAL APPLIES TO ALL CONSTRUCTION EQUIPMENT, TRUCK, AGRICULTURAL EQUIPMENT AND OEM APPLICATIONS USING 400 SERIES DIESEL ENGINES.

COMPONENT

SECTION INDEX

This manual is divided into major sections covering various components of the 400 Series Diesel Engine.

Section identification is also contained in the upper corner of each page.

CONTENTS

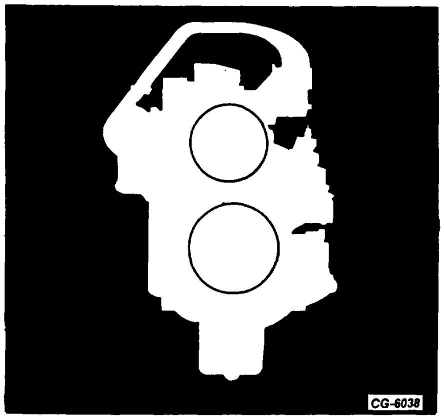
CONTENTS
(Continued)

CONTENTS
(Continued)

CONTENTS
(Continued)

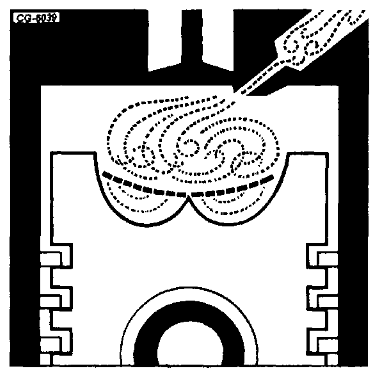
ENGINE FEATURES

DESCRIPTION

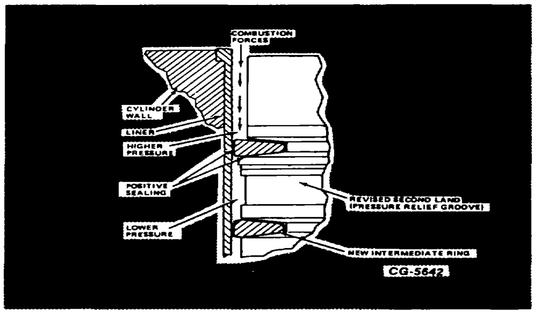


The 300/400 Series comprise a line of premium quality mid-range engines used in various Agricultural Equipment, Construction Equipment, On-Highway Truck and OEM applications.

All are direct starting, valve-in-head type with direct fuel injection.



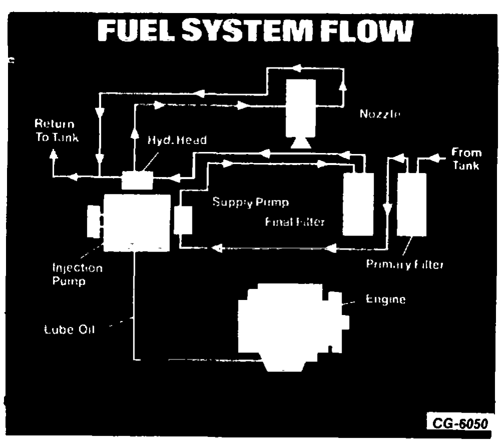
The cylinder head design initiates a swirling motion to the air entering the cylinders from the intake manifold to create high turbulence air-to-fuel mixing, resulting In greater efficiency.



DESCRIPTION

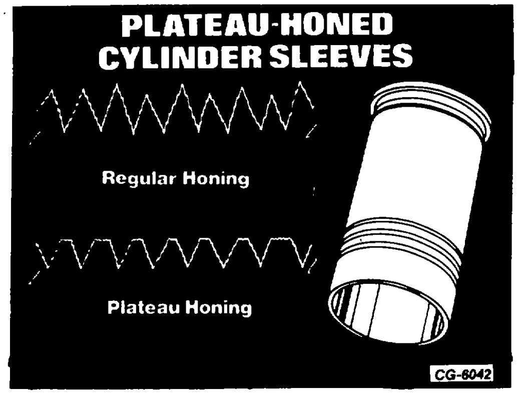
The Turbocharged 400 Series Engines incorporates a "BALANCE PRESSURE" PISTON with a revised second land configuration and top ring groove and a new INTERMEDIATE PISTON RING. These technological advances provide a more positive seal for the top ring against the bottom of the top ring groove and cylinder wall (sleeve). Engine oil control is improved significantly.

For ease of service all 300/400 series engines are equipped with two spin-on, throw-away type oil filters.



A hydraulic fuel system which accurately meters the required amount of fuel for complete combustion, and provides complete governor control for power take off applications without the additional cost of add-on governors.

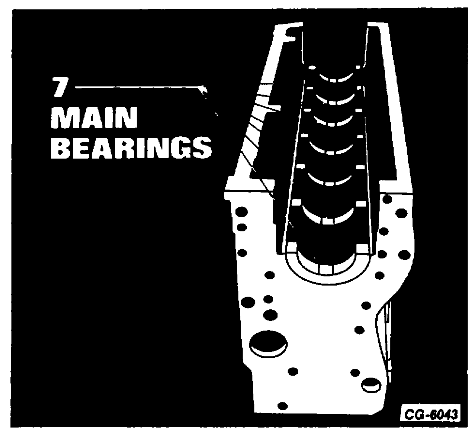
Incorporated in a built-in timing advance and excess fuel control device which allows smooth, quiet, and unaided starting down to 20°F. or below.

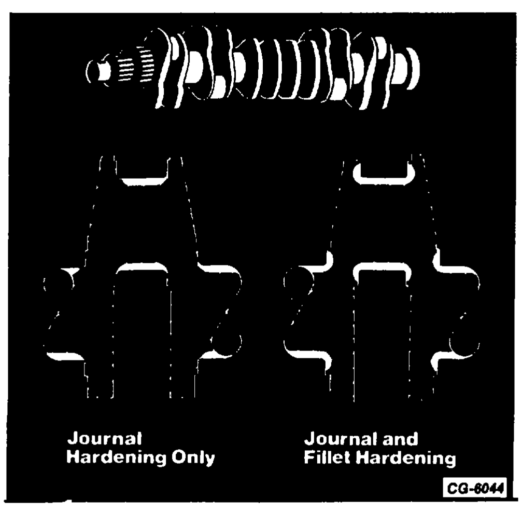


DESCRIPTION

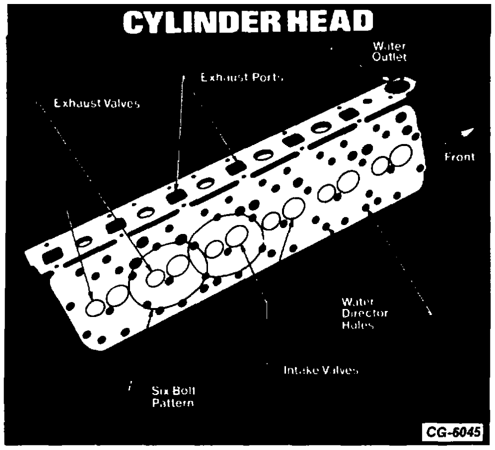
Cylinder sleeves are of the replaceable, wet-type which are surrounded by water to provide immediate positive heat dissipation. The sleeves are machined by a special process called Plateau-Honing. This process provides a sleeve finish which results in rapid engine run-in. Induction hardening of the sleeves I.D. results in low wear rates and long life. (Hardening is used only on certain applications with higher HP ratings).

The block is made of high strength alloy iron which minimizes weight without sacrificing engine rigidity. An outstanding feature of the 400 series engines Is that crankshaft wear is distributed over 7 main bearings rather than 4 main bearings which is common among competitive make engines.





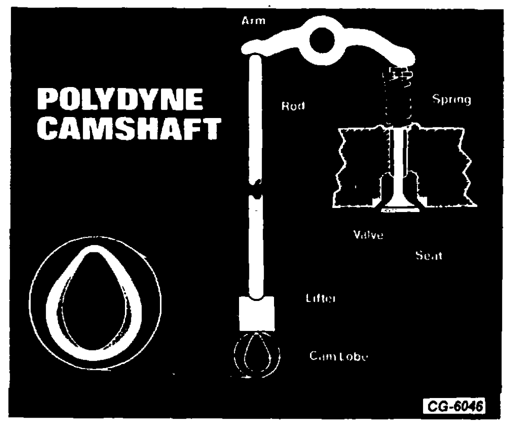
The crankshaft Is constructed of induction hardened forged steel; International not only Induction hardens the journal areas, but the fillet areas as well on 466 Series Engines, since this area is where crankshaft failures often occur.



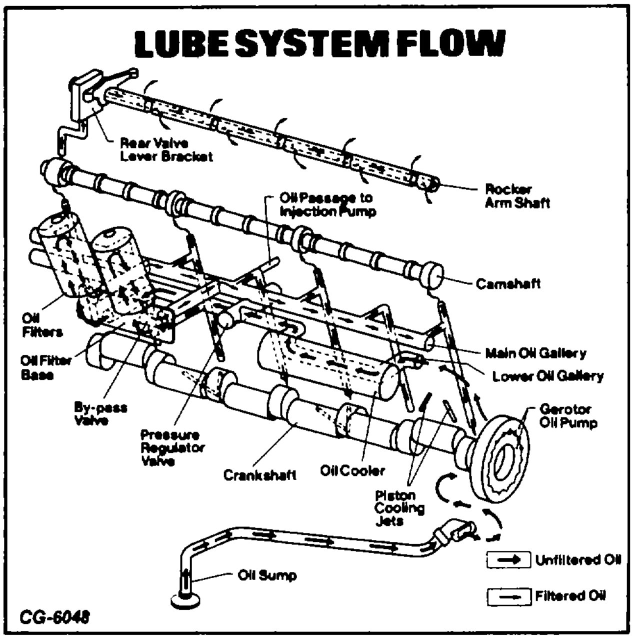
DESCRIPTION

The cylinder head is a one piece, iron alloy casting with a six bolt pattern around each cylinder which assures positive head gasket sealing.

The camshaft is a steel forging with induction hardened lobes. It is a "Polydyne" design camshaft which means that valve travel speed is reduced just before valve seating to allow gentle seating of valves. As a result of this "Polydyne" design camshaft, superior valve life can be achieved.



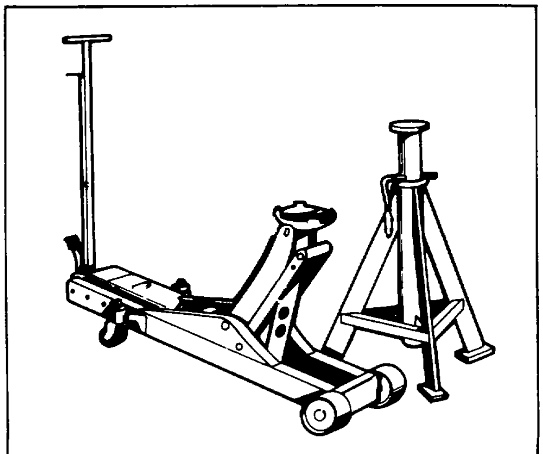
The lubrication system in the Turbocharged 400 series engines addresses the problem of on-the-spot immediate cooling with twelve oil cooling jets installed in the main bearing webs, two per cylinder. These cooling jets facilitate piston and wrist pin cooling, thus eliminating the possibility of heat build-up in these hardworking high friction areas.



DESCRIPTION

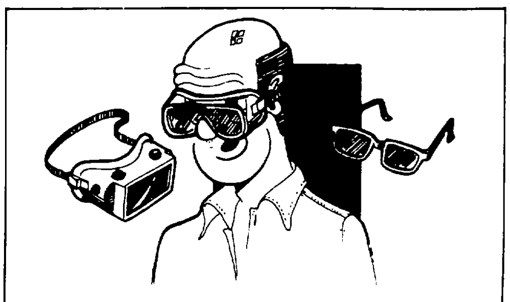
A unique feature of this lubrication system is the pressure regulating valve. It not only controls the pressure and flow of clean oil released from the oil filters going to the main oil gallery and other critical areas of the engine, but this oil regulator controls the flow of unfiltered oil entering the filters. Excess unfiltered oil is dumped back into the oil pan before it can reach the filters. This added control eliminates the possibility of overloading the filters by dumping oil before filtering, thus adding to oil filter life.

SAFETY SUGGESTIONS



CG-6057

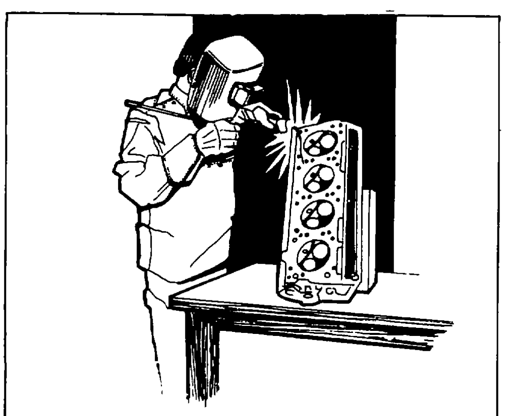
Always use safety stands In conjunction with hydraulic Jacks or hoists. Do not rely on Jack or hoist alone to carry the load; They can fail.



CG-6058

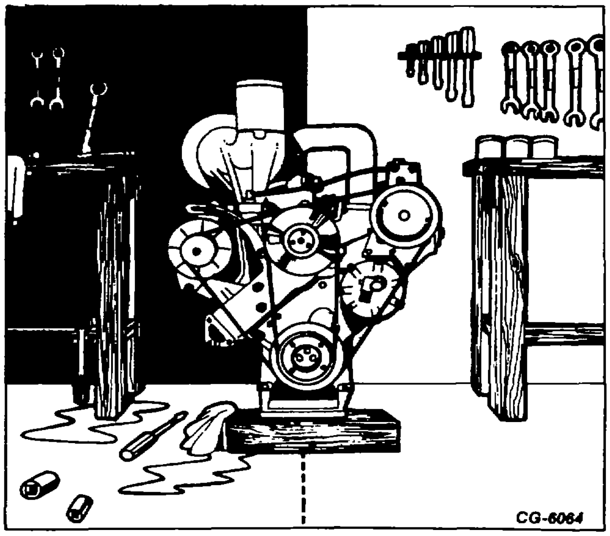
To prevent injury, always select appropriate type safety glasses for the job.

It is especially important to wear safety glasses when using tools such as hammers, chisels, pullers and punches.



CG-6059

When welding or using an acetylene torch, always wear welding goggles and gloves. Insure acetylene and oxygen tanks are separated by a metal shield and are chained to a cart. Do not weld or heat areas near fuel tanks or fuel lines and utilize proper shielding around hydraulic lines.

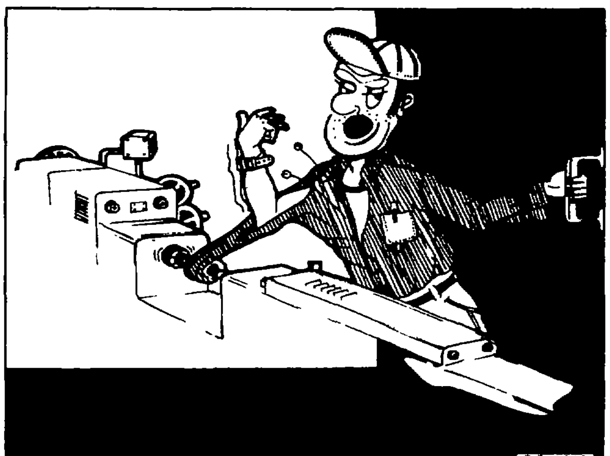


CG-6064

Keep work area organized and clean. Wipe up oil spills of any kind. Keep tools and parts off floor. Eliminate the possibility of a fall which could result in a serious Injury.

Be sure to reinstall safety devices, guards or shields after adjusting and/or servicing the machine.

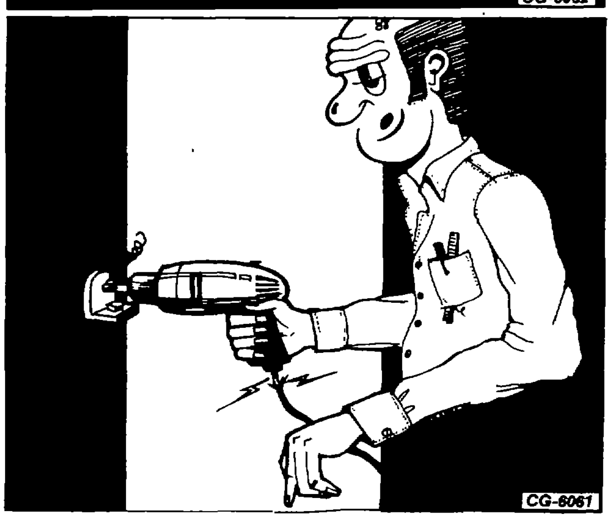
After servicing, be sure all tools, parts, or servicing equipment are removed from the machine.



CG-6062

Be sure to wear safe work clothing. It should be well fitted and in good repair.

Do not wear rings, wrist watches or loose fitting clothing, when working on machinery, they could catch on moving parts causing serious Injury. Wear sturdy, rough-soled work shoes. Never adjust and/or service a machine In bare feet, sandals or sneakers.

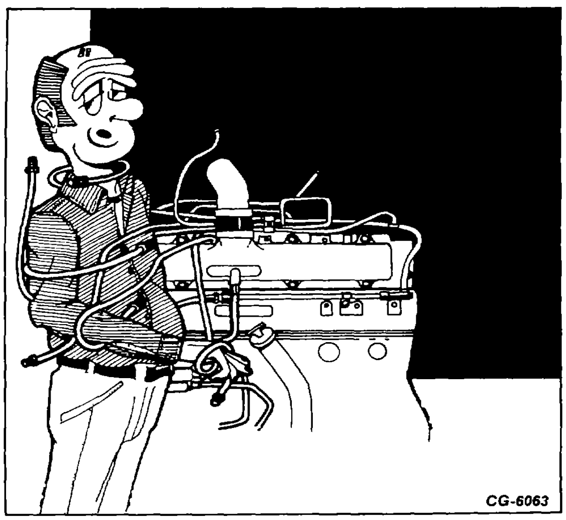


CG-6061

Do not use defective portable power tools. Check for frayed cords prior to using the tool. Be sure all electric tools are grounded.

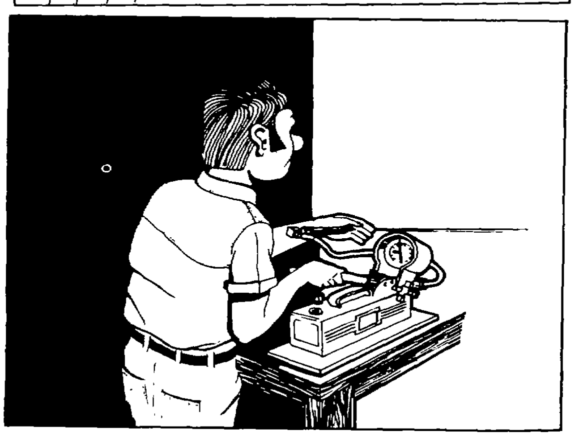
Be careful when using compressed air. Never apply compressed air to any part of the body or clothing, Injury or death can occur.

Use approved air blow guns, do not exceed 30 psi, wear safety glasses or goggles and use proper shielding to protect everyone in the work area.



When removing fuel lines remove them as an assembly, not Individually.

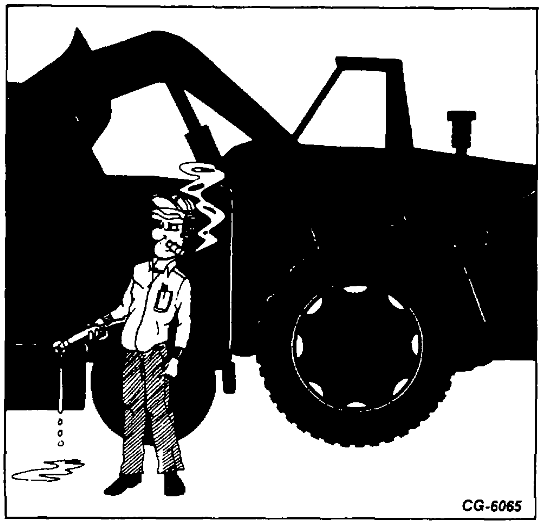
Avoid getting fuel injection lines mixed up as our friend has.



Be extremely careful when dealing with fluids under pressure.

Fluid under pressure can have enough force to penetrate the skin. These fluids may also infect a minor cut or opening in the skin. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can result if medical treatment is not given immediately.

Never put your hands in front of fluid under pressure.



When refueling, keep the hose and nozzle or the funnel and container in contact with the metal of the fuel tank to avoid the possibility of an electric spark ignition the fuel.

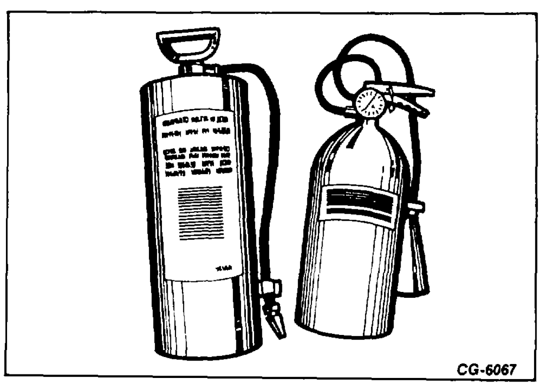
Do not over fill the fuel tank - overflow creates a fire hazard.

Do not smoke when refueling and never refuel when the engine is hot or running.

Electrical storage batteries give off highly Inflammable hydrogen gas when charging and continue to do so for some time after receiving a steady charge.

Do not under any circumstances allow an electric spark or open flame near the battery or explosion may occur.

Always disconnect a battery cable before working on the electrical system.



Keep a "charged" fire extinguisher within reach whenever you work in an area where fire may occur. Also, be sure you have the correct type of extinguisher for the situation:

Type A: Wood, Paper, Textile and-Rubbish

Type B: Flammable Liquids

Type C: Electrical Equipment

CONVERSION TABLE

CONVERSION TABLE — INCH FRACTIONS AND DECIMALS TO MILLIMETER EQUIVALENTS

INCHES		mm	INCHES		mm	INCHES		mm	INCHES		mm
Fract.	Dec.		Fract.	Dec.		Fract.	Dec.		Fract.	Dec.	
—	.0004	.01	—	.3	7.620	—	.7874	20	—	1.969	50
—	.001	.0250	5/16	.3125	7.938	51/64	.7969	20.241	2	2.000	50.8
—	.0039	.10	—	.3150	8	13/16	.8125	20.638	2 1/8	2.125	54
—	.005	.127	21/64	.3281	8.334	—	.8268	21	—	2.165	55
—	.0079	.2	—	.3346	8.5	53/64	.8281	21.034	2 1/4	2.250	57.2
—	.0098	.25	11/32	.3438	8.731	27/32	.8438	21.431	—	2.362	60
—	.01	.254	—	.3543	9	55/64	.8594	21.828	2 3/8	2.375	60.3
—	.0118	.3	23/64	.3594	9128	—	.8662	22	2 1/2	2.500	63.5
1/64	.0156	.397	—	.3740	9.5	7/8	.8750	22.225	—	2.559	65
—	.0157	.4	3/8	.375	9.525	57/64	.8906	22.622	2 5/8	2.625	66.7
—	.0197	.5	25/64	.3906	9.922	—	.9	22.860	2 3/4	2.750	69.9
—	.0236	.6	—	.3937	10	—	.9055	23	—	2.756	70
—	.025	.635	—	.4	10.160	29/32	.9063	23.019	2 7/8	2.875	73
—	.0276	.7	13/32	.4062	10.319	59/64	.9219	23.416	—	2.953	75
—	.0295	.75	—	.4134	10.5	15/16	.9375	23.813	3	3.000	76.2
1/32	.0313	.794	27/64	.4219	10.716	—	.9449	24	—	3.150	80
—	.0315	.8	—	.4331	11	61/64	.9531	24.209	3 1/4	3.250	82.6
—	.0354	.9	7/16	.4375	11.113	31/32	.9688	24.606	—	3.346	85
—	.0394	1	29/64	.4531	11.509	—	.9843	25	3 1/2	3.500	88.9
3/64	.0469	1.191	15/32	.4688	11.906	1	1.000	25.400	—	3.543	90
—	.0472	1.2	—	.4724	12	—	1.024	26	—	3.740	95
—	.05	1.270	31/64	.4844	12.303	1 1/16	1.062	26.988	3 3/4	3.750	95.3
—	.0551	1.4	—	.4921	12.5	—	1.063	27	—	3.937	100
—	.0591	1.5	1/2	.5	12.700	—	1.102	28	4	4.000	101.6
1/16	.0625	1.588	—	.5118	13	1 1/8	1.125	28.575	—	4.331	110
—	.0669	1.7	33/64	.5156	13.097	—	1.142	29	4 1/2	4.500	114.3
—	.075	1.905	17/32	.5326	13.494	—	1.181	30	—	4.724	120
5/64	.0781	1.984	—	.5315	13.5	1 3/16	1.188	30.16	5	5.000	127
—	.0787	2	35/64	.5469	13.891	—	1.221	31	—	5.118	130
—	.0906	2.3	—	.5512	14	1 1/4	1.250	31.75	5 1/2	5.500	139.7
3/32	.0938	2.381	9/16	.5625	14.288	—	1.260	32	—	5.512	140
—	.0984	2.5	—	.571	14.5	—	1.299	33	—	5.906	150
—	.1	2.540	37/64	.5781	14.684	1 5/16	1.312	33.34	6	6.000	152.4
—	.1024	2.6	—	.5906	15	—	1.339	34	—	6.299	160
7/64	.1093	2.776	19/32	.5938	15.081	1 3/8	1.375	34.93	6 1/2	6.500	165.1
—	.1181	3	—	.6	15.240	—	1.378	35	7	7.000	177.8
1/8	.125	3.175	39/64	.6094	15.478	—	1.417	36	—	7.087	180
—	.1378	3.5	—	.6103	15.5	1 7/16	1.438	36.51	7 1/2	7.500	190.5
9/64	.1406	3.572	5/8	.6250	15.875	—	1.457	37	—	7.874	200
5/32	.1563	3.969	—	.6299	16	—	1.496	38	8	8.000	203.2
—	.1575	4	41/64	.6406	16.272	1 1/2	1.500	38.10	8 1/2	8.500	215.9
11/64	.1719	4.366	—	.6496	16.5	—	1.535	39	—	8.661	220
—	.1772	4.5	21/32	.6563	16.669	1 9/16	1.562	39.69	9	9.000	228.6
3/16	.1875	4.763	—	.6693	17	—	1.575	40	—	9.449	240
—	.1969	5	43/64	.6719	17.066	—	1.614	41	9 1/2	9.500	241.3
—	.2	5.080	11/16	.6875	17.463	1 5/8	1.625	41.28	—	9.843	250
13/64	.2031	5.159	—	.6890	17.5	—	1.654	42	10	10.000	254
—	.2165	5.5	—	.7	17.780	1 11/16	1.688	42.86	—	10.236	260
7/32	.2188	5.556	45/64	.7031	17.859	—	1.693	43	11	11.000	279.4
15/64	.2344	5.953	—	.7087	18	—	1.732	44	—	11.024	280
—	.2362	6	23/32	.7188	18.256	1 3/4	1.750	44.45	—	11.811	300
1/4	.25	6.350	—	.7283	18.5	—	1.772	45	12	12.000	304.8
—	.2559	6.5	47/64	.7344	18.653	—	1.811	46	13	13.000	330.2
17/64	.2656	6.747	—	.7480	19	1 13/16	1.813	46.04	—	13.780	350
—	.2756	7	3/4	.75	19.050	—	1.850	47	14	14.000	355.6
9/32	.2813	7.144	49/64	.7656	19.447	1 7/8	1.875	47.63	15	15.000	381
—	.2953	7.5	—	.7677	19.5	—	1.890	48	—	15.748	400
19/64	.2969	7.541	25/32	.7813	19.844	—	1.929	49	16	16.000	406.4

TORQUE - TENSION VALUES FOR STANDARD FASTENERS

This chart provides tightening torque for general purpose applications using original equipment standard hardware as listed in the Parts Catalog for the application Involved. DO NOT SUBSTITUTE. Original equipment standard hardware is defined as IH Type 8, coarse thread bolts and nuts and thru hardened flat washers (Rockwell "C" 38-45), all phosphate coated and assembled without supplemental lubrication (as received condition).

The torques shown below also apply to the following:

1. Phosphate coated bolts used In tapped holes In steel or gray Iron.

2. Phosphate coated bolts used with phosphate coated prevailing torque nuts (nuts with distorted threads or plastic Inserts).

3. Phosphate coated bolts used with copper plated weld nuts.

Markings on bolt heads or nuts indicate material grade ONLY and are NOT to be used to determine required torque.

Nominal Thread Diameter	Standard Torque $\pm$10%	
	N•m	lbf-ft
1/4	10	7
5/18	19	14
3/8	32	24
7/16	51	38
1/2	80	60
9/18	110	80
5/8	155	115
3/4	270	200
7/8	440	320
1	650	480
1-1/8	800	590
1-1/4	1100	830
1-3/8	1500	1100
1-1/2	1900	1400
1-3/4	3100	2300
2	4600	3400

SPECIAL TORQUES

Each application has some non-standard torques which are necessary for proper component function. These are listed under "SPECIAL TORQUES" shown elsewhere in this manual. Typical examples are hose clamps, non-rigid joints (gaskets), non-ferrous fasteners or tapped holes, spanner nuts, fine thread fasteners, jam nuts, and cases where loading or distortion are critical factors.

TORQUE VALUES FOR HOSE CLAMPS

The following chart provides the tightening torque's for hose clamps used in all rubber applications (radiator, air cleaner, operating lever boots, hydraulic system, etc.)

	Torque Plus or Minus 5 Ibf-in (0.6 N•m)			
	Radiator, Air Cleaner, Boots, etc.		Hydraulic System System	
Clamp Type and Size	N•m	Ibf-in	N•m	Ibf-in
"T" Bolt (Any Diameter)	7	60	5	45
Worm Drive - 1-3/4" Open Diameter and Under	3	25	5	45
Worm Drive - Over 1-3/4" Open Diameter	5	45	5	45
Worm Drive - All "Ultra Tite"	11	100	--	--

SPECIAL SERVICE TOOL LIST

Manual Section No.	Tool Description	Agricultural Equipment	Pay Line Equipment	Truck Equipment
ONE	No SPECIAL SERVICE TOOLS REQUIRED	--	--	--
TWO	No SPECIAL SERVICE TOOLS REQUIRED	--	--	--
THREE	Expanding Screw	17-25-4	PLT-509-4	
	Pre-Cup Puller (Intake)	17-25-5	PLT-509-5	
	Pre-Cup Puller (Exhaust)	17-25-6	PLT-509-6	
	Nozzle Sleeve Puller Adapter	17-25-13	PLT-509-12	SE-2587
	Nozzle Sleeve Installing Tool	04-148-3	PLT-510-3	SE-2534
	Valve Guide Remover	046-4		SE-1722
	Valve Guide Installer	04-6-4	-	SE-1943
	Valve Spring Tester	15-233	PLT-100	SE-2241
FOUR	Camshaft Bearing Service Set	04-101	PLT-543	SE-2893
	Thermomelt Stick (3880F)	15-115-1	PLT-118-1	
FIVE	Universal Wet Sleeve Puller	17-22-2	PLT-502-3	SE-2536
	Piston Ring Compressor	04464-2	PLT-500-2	SE-1680
	Piston Groove Wear Gauge Pins	3020*	3020*	3020*
	Piston Ring Clearance Fixture (obsolete)	04-68-3	PLT-501	SE-2206
	Counter bore Depth Gauge	--	1 020 560 R91	SE-2515
	Counter boring Tool (Driver Unit,	--	--	--
	Handle and (3) Tool Bits)	---	1 020 553 R91	SE-2514
	ADAPTER PLATE	-1 020 554 R1	SE-2514	--
	TOOL HOLDER (300 SERIES)	--	1 020 556 R1	Not Applicable
	TOOL HOLDER (400 SERIES)	-1 020 555 R1	SE-2514-2	--
	OIL LEAK DETECTOR	-	--	SE-1632
SIX	Lifting Sling	17-138-1	PLT-120-1	SE-2722
	Wear Sleeve and Oil Seal	--	--	--
	Installing Tool	04-149-3A	PLT-513-4A	--
SEVEN	Puller (For Three-- Hole Vibration	--	--	--
	Damper)	89-10-17	--	--
	Puller (For Four-Hole Vibration	--	--	--
	Damper)	04-33-3	PLT-514	SE-1368
	Crankshaft Pulley Hub Wear Sleeve	--	--	--
	Installing Tool	04-3004	3004	--
EIGHT	No SPECIAL SERVICE TOOLS	--	--	--
	REQUIRED	--	--	--
NINE	No SPECIAL SERVICE TOOLS	--	--	--
	REQUIRED BEYOND THOSE OF	--	--	--
	A WELL EQUIPPED SHOP	---	--	--
	Excess Fuel Device Support Bar	05-500-11	PLT-500-11	Part of
TEN		--	SE-2755	--
	Pressure Test Kit	15-126	PLT-300	SE-2239
	Torque Cam Angle Gauge	05-500-5	PLT-355-5	Part of
		--	--	SE-2755
	Torque Cam Fulcrum Support Block	05-500-12	PLT-355-12	Part of
				SE-2755
	Nozzle Test Pump	15-71-A	PLT-360	SE-2002
	Nozzle Tube Assembly	15-72-1	PLT-360-1	SE-2004-13
	90° Adapter	15-72-2	PLT-360-3	SE-2757

*Kent Moore No. J-29511
Piston Groove Wear Gauge Pins may be ordered from

Kent Moore Tool Div.
29784 Little Mack
Roseville, Michigan 48066

ATTN: Order Department
(313)-774-9500

GENERAL INFORMATION - SEALING COMPOUND USE

LOCTITE RETAINING AND SEALING COMPOUNDS

Compound Description

These products are single component, self- curing, polyester compounds which remain liquid while exposed to air, and harden by chemical action into tough structural solids when confined between closely mated metal parts. These compounds will resist solvents, heat, shock and vibration and are intended to provide a positive seal against leakage, and shear strength resistance to loosening when used in the assembly of threaded, slip fit, or press fitted parts.

Loctite Grades (General Usage)

1. GRADE B (YELLOW) - Straight threaded fasteners.

2. GRADE "AVV" (RED) - Straight threaded fasteners; higher strength for studs, etc.

3. PLASTIC GASKET (RED) - Use as seal between mating surfaces (face sealant).

4. HVV (UNFILLED PIPE SEALANT) - Use on tapered pipe threads.

5. HYDRAULIC SEALANT - Use on fuel fittings with straight pipe threads.

NOTE: Once cured, these compounds have an operating temperature range of -55° C to 150°C (-65 to 300°F) and will resist attack by oils, chemicals, hydraulic fluids and solvents.

Exceptions DO NOT use Loctite:

1. Where other means of retaining the assembly are provided such as, prevailing torque fasteners (fasteners with distorted threads or plastic inserts), lock washers, lock plates and lock wires.

2. On items requiring frequent servicing.

3. When the operating temperature exceeds 150°C (300°F). (Example: Engine Exhaust Systems).

4. On brass fittings and plugs.

SURFACE PREPARATION

Plain and Phosphate Coated Parts

Clean the surfaces where compounds are to be applied to remove heavy coatings of oil grease and dirt (rust or light oil film are not detrimental). Normal shop practice of cleaning or degreasing is adequate. Phosphate and oiled hardware is used in the "as received" condition.

Zinc or Cadmium Plated Parts or for Rapid Hardening

At least one of the mating surfaces should be degreased with a cleaning solution to which concentrated primer has been added. (1 part primer concentrate to 30 parts trichlorethylene or 1-1-1 trichlorethylene). Allow surfaces to dry for 3 to 6 minutes before applying compound.

Drawbar Studs or Special Stud Applications

Degrease parts with a cleaning solution to which concentrated primer has been added. (1 part primer concentrate to 30 parts trichlorethylene or 1-1-1 trichlorethylene). Allow surfaces to dry for 3 to 6 minutes before applying compound. In blind holes be sure to remove all chips and oil.

Face Sealant (Plastic Gasket)

Mating parts must be cleaned as for plain and phosphate coated parts.

APPLICATION

Cap Screws and Pipe Threads

Fill the first 2 to 3 leading threads in area of engagement with compound. For large quantities of cap screws, may also be applied by tumbling method (refer to manufacturer's instructions).

Studs

Apply by hand to individual studs. Fill full length of thread with one strip on diameters up to 25 mm (1 inch), two strips 180° apart on diameters up to 50 mm (2 inches), and three strips 120° apart on diameters over 50 mm (2 inches). In all cases apply one strip into tapped holes.

Blind hole applications - apply enough compound to fill the bottom 2 to 3 threads of engagement, then insert stud. If engagement length exceeds one diameter use proportionally more compound.

For non-seated studs (studs that can go deeper in hole than required) turn stud one turn deeper than required. After bubbling stops, apply a ring of compound around stud at top of hole, then turn back to required height.

Face Sealant (Plastic Gasket)

Spread an even coat 1 cc per 260 cm^2 (40 sq. inches) on one of the mating surfaces. Assemble and tighten bolts.

NOTE: On crawler tractor applications only, when compound is used as a gasket, bolts which attach the parts should be coated with MPL (gear lubricant) to prevent compound from sticking to bolts.

APPLICATION AT LOW TEMPERATURES

1. Without special precautions, these compounds can be applied and will cure at temperatures down to 10°C (50°F), and at that temperature full strength will be obtained within 72 hours.

2. At temperatures from 10° to -18°C (50° to 0°F), the use of primer is recommended.

3. If necessary, the compounds can be applied at temperatures below -180C (0°F), only if heat is used to accelerate the cure as follows:

65°C (150°F) for 60 minutes
93°C (200°F) for 45 minutes
120°C (250°F) for 30 minutes

SETTING TIME (BEFORE PLACING IN OPERATION)

1. Normal time for compound grades without use of any primer - 6 to 24 hours at room temperature with machined carbon steel parts. Higher temperatures will accelerate cure and lower temperatures will retard cure. Other base metals will provide more or less catalytic effect on cure.

2. Primed surfaces - 2 to 6 hours. This may be speeded by pretreating mating surfaces with special primers. Some metals (such as zinc and cadmium plate, anodized aluminum, and passivated stainless steel) are inactive and require heat or primer to cure the compound.

3. A fast curing type primer will fix parts for normal handling in 10 to 15 minutes and will achieve 75 percent of ultimate strength in 1 hour and full cure in 2 to 4 hours.

REMOVAL

Parts difficult to remove can be preheated to 205° to 260°C (400° to 500°F) prior to removal.

ENGINE APPLICATION CHART

AGRICULTURAL EQUIPMENT

TRACTORS

ENGINE	MODEL
D-312	H-70 H-86 F-666GD F-666HS F-686GD F-766
D-360 D-414	F-766GD F-886GD F-966HS F-966HS F-966GD F-1066GD
DT-414	F-1066HS
DT-414B	F-1086 F-1086D H-100
D-436	H-186 F-986 F-3688 F-1466GD F-1486 F-1566GD
DT-436	F-1586 F-1586 F-4166 F-4186 F-1486D F-1i 586D
DT-436B	F-6388 was F-3388 F-6588 was F-3588 F-5088
D-466	F-3488
DT-466	F-4366
DT-466B	F-6788 was F-3788 F-5288
DTI-466	F-4386
DTI-466B	F-4386 F-5488
DT-466C	6788
DTI-466C	5488

COMBINES

ENGINE	MODEL
D-360	453
D-414	815
DT-414	915
D-436	1440
DT-436	1460
	1480
DT-436B	1460 1480
D-466	1440
DT-466B	1480 Rice
	1470 Hillside
DT-466C	1480 Rice 1480 1470

CONSTRUCTION EQUIPMENT

PAYLOGGERS

ENGINE	MODEL
D-360	515 & S8A PS S8A GD
DT-360	S9B S10

PAYLOADERS

ENGINE	MODEL
D-360	H-60E H-515
DT-414	H-515 H-530
DT-414B	H-65C H-530
DT-466	H-65C & H-80B 175C H54D
DT-466B	H-80B 175C H-540

PAYSCRAPERS

ENGINE	MODEL
DT-414	E-200 412
DT-466	433/444 433/444B
DT-466B	412 41 2B 433B 433B 444B

PAYDOZERS

ENGINE	MODEL
D-466	TD-12
DT-466	TD-15 Series C w/AMBAC Pump
DT-466B	TD-15C w/Robert Bosch MW Pump

ON HIGHWAY TRUCK

TRUCKS

ENGINE	MODELS
DT-466	Cargostar - Fleetstar Loadstar - Paystar - "S" Series - 2053 Bus
DT-466B	Cargostar - Fleetstar - Loadstar - Paystar - "S" Series
DTI-466B	Cargostar - Fleetstar - Loadstar -- Paystar - "S" Series - CO-4050-FC-Bus.
DT-466C	Cargostar - Paystar "S" Series - 1853 FC-Bus
DTI-466=C	Cargostar - Paystar "S" Series - 1853 FC-Bus
SEDDON - ATKINSON TRUCKS	
ENGINE	**MODELS**
DT-466	Series 300
DT-466B	Series 300
DTI-466B	Series 300
DT-466C	Series 300
AUSTRALIA	
DT-466B	S & T Series
DT-466C	S & T Series

OEM APPLICATIONS

ENGINE	MODELS
D-414	Standard Engine, Generator Set
DT-414	Standard Engine
DT-414B	Standard Engine, Blackwelders Tomato Harvester (LQ 8), Generator Set Standard Engine, Generator Set, Galion
D-466	T-400A Grader (LQ165 & #165A), Galion T-500A, T-500C Grader (LQ157 & #157A), Galion AT-500C Grader (#167, #167A & #169), Power Unit (SSP LQ 3D).
DT-466	Standard Engine, Galion T-600B, T-600C Grader (LQ 158 & # 158), Galion T-500L, T-500M Grader (LQ 161, LQ 161 A & 161 A)
DT-466B	Standard Engine, Galion T-600B, T-600C Grader (# 158A), Galion T-500L, T-500M Grader (# 161B), Galion AT-500M Grader (LQ 166A, # 166A & # 168), Galion AT-600 (# 170), Generator Set, Solar Turbine Starter (SLR-1).
DTI-466B	Marine

POWER UNITS

ENGINE	MODEL
D-312	UD-312
D-360	UD-360
DT-360	UDT-360
D-414	UD-414
DT-414	UDT-414
DT-414B	UDT-414B
D-466	UD-466
DT-466	UDT-466

SPECIFICATIONS

300/400 ENGINES: **VALUES**

Number of Cylinders.. Six

Type of Cylinder Sleeves..................................Replaceable, Wet

BORE AND STROKE:

D-312.................................. 98.6 x 112.0 mm (3.88 x 4.41 in.)
D and DT-360.......................... 98.6 x 129.3 mm (3.88 x 5.09 in.)
D and DT-414.......................... 109.2 x 120.7 mm (4.30 x 4.75 in.)
D and DT-436.......................... 109.2 x 135.9 mm (4.30 x 5.04 in.)
D and DT-466; DT-466B
DTI-466B, and DT-466C .... 109.2 x 135.9 mm (4.30 x 5.35 in.)

DISPLACEMENT:

D-312......................................5.1 liters (312 cu. in.)
D and DT-360...............................5.9 liters (360 cu. in.)
D and DT-414...............................6.8 liters (414 cu. in.)
D and DT-436...............................7.2 liters (436 cu. in.)
D and DT-466; DT-466B
DTI-466B, and DT-466C ....7.6 liters (466 cu. in.)
Firing Order 1-5-3-6-2-4

COMPRESSION RATIO:

D-312, D-360 and D-436 .... 17:1
DT-360 .... 16:1
D and DT-414.. 16:1
DT-436 .... 16:1
D and DT-466.. 15.4:1
DT-466B, DTI-466B,
and DT-466C... 16.3:1

Engine Speed - RPM..........................Refer to Chassis Manual

INJECTION PUMP TIMING - STATIC (CRANKSHAFT DEGREES)
AGRICULTURAL EQUIPMENT ±1°

H-70 Tractor with D-312 .... 13° BTDC

H-86 Tractor with D-312 .... 13° BTDC

H-100 Tractor with D-436
- Equipped w/injection Pump No. 684 437 C93 .... 12° BTDC
- Equipped w/Injection Pump No. 687 437 C92 .... 180 BTDC

H-186 Tractor with D-436
- Equipped w/Injection Pump No. 687 036 C93 .... 12° BTDC
- Equipped w/injection Pump Nos. 687 036 C91 & C92.......... 18° BTDC

F-666 GD Tractor with D-312
- Equipped w/Injection Pump Nos. 680 345 C91, C92 & C93 .... 18° BTDC
- Equipped w/injection Pump Nos. 684 529 C91 & C92 .... 13° BTDC

F-666 HS Tractor with D-312
- Equipped w/injection Pump No. 680 346 C93 .... 18° BTDC

F-686 GD Tractor with D-312
- Equipped w/Injection Pump No. 684 529 C92 .... 13° BTDC

F-766 Tractor with D-360
- Equipped w/Injection Pump No. 681 238 C92 .... 18° BTDC

F-766 GD Tractor with D-360
- Equipped w/injection Pump No. 684 451 C93 .... 12° BTDC
- Equipped w/Injection Pump No. 684 451 C92 .... 18° BTDC
- Equipped w/injection Pump No. 684 222 C91 .... 18° BTDC

F-886 Tractor with D-360
- Equipped w/Injection Pump No. 687 033 C93 .... 12° BTDC
- Equipped w/injection Pump No. 687 033 C92 .... 18° BTDC

F-966 GD Tractor with D-414
- Equipped w/injection Pump No. 684 224 C93 .... 12° BTDC
- Equipped w/injection Pump No. 684 224 C92 .... 18° BTDC
- Equipped w/Injection Pump No. 680 320 C92 .... 18° BTDC
- Equipped w/Injection Pump No. 681 271 C91 .... 18° BTDC
- Equipped w/injection Pump No. 681 228 C92 .... 18° BTDC

F-966 HS Tractor with D-414 .... 18° BTDC

F-986D Tractor with D 436
- Equipped w/injection Pump No. 687 035 C93 . ... 12° BTDC
- Equipped w/Injection Pump No. 687 035 C92 .... 18° BTDC

F-1066 GD Tractor with DT-414 .... 18° BTDC

F-1066 HS Tractor with DT-414 .... 18° BTDC

AGRICULTURAL EQUIPMENT (Continued) ±**1°**

F-1086 Tractor with DT-414	18° BTDC
F-1086 D Tractor with DT-414B	15° BTDC
F-1466 GD Tractor with DT-436	18° BTDC
F-1466 Tractor with DT-436	18° BTDC
F-1486 D Tractor with D-436	18° BTDC
F-1486 D Tractor with DT-436B	15° BTDC
F- 1566 Tractor with DT-436	15° BTDC
F- 1566 GD Tractor with DT-436	15° BTDC
F- 1586 Tractor with DT-436	18° BTDC
F-1586 D Tractor with DT-436B	15° BTDC
F-6388 was F-3388 Tractor with DT-436B	15° BTDC
F-4166 Tractor with DT-436	18° BTDC
F-4186 Tractor with DT-436	18° BTDC
F-6588 was F-3788 Tractor with DT-436B	15° BTDC
F-6788 was F-3788 Tractor with DT-466B	15° BTDC
F-6788 Tractor with DT-466C	27° BTDC
F-4366 Tractor with DT-466	18° BTDC
F-4386 Tractor with DTI-466	17° BTDC
F-4386 Tractor with DTI-466B	14° BTDC
453 Combine with' D-360	
Equipped w/Injection Pump No. 684 406 C93	12° BTDC
Equipped w/injection Pump No. 684 406 C92	18° BTDC
815 Combine with D-414	
Equipped w/Injection Pump No. 681 256 C94	12° BTDC
Equipped w/injection Pump No. 681 256 C93	18° BTDC
915 Combine with DT-414	18° BTDC

AGRICULTURAL EQUIPMENT (Continued) ±1°

1440 Hydro Combine with D-436
Equipped w/Injection Pump No. 691 038 C93 .... 12° BTDC
Equipped w/Injection Pump No. 691 038 C92 .... 18° BTDC
Equipped w/Injection Pump No. 687 187 C93 .... 12° BTDC
Equipped w/Injection Pump No. 687 187 C92 .... 18° BTDC

1440 Combine with D-466
Equipped w/Injection Pump No. 1 806 012 C92 (Export) .... 12° BTDC
Equipped w/Injection Pump No. 1 806 012 C91 .... 18° BTDC

1460 Combine with DT-436 .... 18° BTDC

1460 Combine with DT-4368 .... 15° BTDC

1460E Combine with DT-466B (Export) .... 15° BTDC

1470 Hillside Combine with DT-466B .... 15° BTDC

1470 Combine with DT-466C .... 27° BTDC

1480 Combine with DT-436 .... 18° BTDC

1480 Combine with DT-4368 .... 15° BTDC

1480 Rice Combine with DT-466B .... 15° BTDC

1480 Rice Combine with DT-466C .... 27° BTDC

F-5088 with DT-436B .... 15° BTDC

F-5288 with DT-466B .... 17° BTDC
F-5488 with DTI-466B .... 17° BTDC

F-5488 with DTI-466C .... 23° BTDC
F-3688 with D-436
Equipped w/Injection Pump No. 1 802 253 C93 .... 12° BTDC
Equipped w/injection Pump No. 1 802 253 C92 .... 18° BTDC
F-3488 Tractor with D-466
Equipped w/Injection Pump No. 691 335 C93 .... 12° BTDC
Equipped w/Injection Pump No. 691 335 C92 .... 18° BTDC

CONSTRUCTION EQUIPMENT

S-8A PS Paylogger with D-360
Equipped w/Injection Pump No. 684 719 C93 .... 12° BTDC
Equipped w/injection Pump No. 684 719 C92 .... 18° BTDC

CONSTRUCTION EQUIPMENT (Continued) **± 1°**

S-8A Paylogger with D-360
Equipped w/Injection Pump No. 684 984 C93 .... 12° BTDC
Equipped w/Injection Pump No. 684 984 C92 .... 18° BTDC

S-9B Paylogger with DT-360 .... 13° BTDC

S-10 Paylogger with DT-360 .... 13° BTDC

H-60E Payloader with D-360
Equipped w/Injection Pump No. 684 421 C93 .... 12° BTDC
Equipped w/injection Pump No. 684 421 C92 .... 18° BTDC

515 Paylogger with D-360
Equipped w/injection Pump No. 684 719 C93 .... 12° BTDC
Equipped w/injection Pump No. 684 719 C92 .... 18° BTDC

H-65C Payloader with DT-414 .... 15° BTDC

H-65C Payloader Komatsu-lnt. with DT-414B .... 18° BTDC

H-65C Payloader with DT-466 .... 18° BTDC

530 Payloader with DT-414 .... 15° BTDC

H-530 Payloader with DT-414B .... 15° BTDC

530 Payloader with DT-414B .... 15° BTDC

H-530A II with DT-466B .... 18° BTDC

H-80B Payloader with DT-466 .... 18° BTDC

H-80B Payloader with DT-466B .... 15° BTDC

540 Payloader with DT-466B .... 15° BTDC

E-200 Payscraper with DT-414
Equipped w/Turbo 680 319 C91 or 684 237 C91 .... 15° BTDC
Equipped w/Turbo 674 985 C91 .... 18° BTDC

412 Payscraper with DT-466 .... 15° BTDC

412 Payscraper with DT-466B .... 15° BTDC

412B Payscraper with DT-466B .... 15° BTDC

433/444 Payscraper with DT-466 .... 18° BTDC

433/444 Payscraper with DT-466B .... 15° BTDC

TD-12 Crawler Tractor with D-466
Equipped w/Injection Pump No. 684 720 C92 .... 12° BTDC
Equipped w/injection Pump No. 684 720 C91 .... 18° BTDC

TD-12 PS and GD with DT-466B
Equipped w/Injection Pump No. 684 720 C92 .... 12° BTDC
Equipped w/injection Pump No. 684 720 C91 .... 18° BTDC

CONSTRUCTION EQUIPMENT (Continued) **± 1°**

TD-15C Paydozer with DT-466
Equipped w/Turbo 680 319 C91 .... 15° BTDC
Equipped w/Turbo 674 985 C91 .... 18° BTDC
Equipped w/MW Pump .... 26° BTDC

ON HIGHWAY TRUCK

DT466 Engines

Fleetstar Models Equipped with Injection Pump No. 682 984 C91 .... 17° BTDC
Paystar, Loadstar, S-Series and 2053 Bus Models
Fleetstar Models (w/Engine No. 16536 and up)
Equipped with Injection Pump No. 684 933 C92 .... 17° BTDC

Carqostar Models
Equipped with Injection Pump No. 684 936 C92 .... 17° BTDC
Equipped with Injection Pump No. 684 405 C91 .... 17° BTDC

Cargostar Models
Equipped with Injection Pump No. 687 194 C91 .... 17° BTDC

Loadstar Models
Paystar Models (Below Engine S/N 16295)
S-Series
Fleetstar Models (Below Engine S/N 16536)
Equipped with Injection Pump No. 687 157 C91 .... 17° BTDC

Paystar Models
Loadstar Models
Fleetstar Models
S-Series Models
Equipped with Injection Pump No. 687 195 C91 .... 17° BTDC

DT-466B Engines

Loadstar Models
Paystar Models
Fleetstar Models
S-Series Models
Equipped with Injection Pump No. 688 881 C91 .... 14° BTDC

Cargostar Models
Equipped with Injection Pump No. 688 882 C92 .... 14° BTDC

Cargostar Models
S-Series Models
Equipped with Injection Pump No. 689 644 C91 .... 16° BTDC

ON HIGHWAY TRUCK
(Continued) **± 1°**

Paystar Models
Cargostar Models
S-Series Models
Equipped with Injection Pump No. 689 645 C91 .... 17° BTDC

S-Series Models
Equipped with Injection Pump No. 689 646 C91 .... 17° BTDC

Cargostar Models
S-Series Models
Equipped with Injection Pump No. 689 647 C91 . ... 17° BTDC

S-Series Models
Equipped with Injection Pump No. 691 156 C91 .... 16° BTDC

Cargostar Models
Equipped with Injection Pump No. 691 341 C91 .... 16° BTDC

S-Series Models
Paystar Models
Equipped with Injection Pump No. 691 344 C91 .... 20° BTDC

S-Series, Paystar and Cargostar Models
Equipped with Injection Pump No. 691 345 C91 .... 20° BTDC

DTI-466B Engines

Loadstar Models
Paystar Models
Fleetstar Models
Equipped with Injection Pump No. 688 842 C91 .... 15° BTDC

Cargostar Models
Paystar Models
Equipped with Injection Pump No. 688 843 C91 .... 15° BTDC

S-Series, F-C Bus, Paystar and CO-4050 Models
Equipped with Injection Pump No. 691 346 C91 .... 20° BTDC

S-Series, Paystar, Cargostar and CO-4050 Models
Equipped with Injection Pump No. 69f 347 C91 .... 20° BTDC

ON HIGHWAY TRUCK
(Continued) **± 1°**

DT-466C ENGINES
S-Series, 1853 FC Bus and Cargostar Models
Equipped with Injection Pump No. 1 802 606 C91 .... 21° BTDC

S-Series and Cargostar Models
Equipped with Injection Pump No. 1 802 995 C91 .... 17° BTDC

S-Series, 1853 FC Bus, Cargostar and Paystar Models
Equipped with Injection Pump No. 1 802 604 C91 .... 23° BTDC

S-Series, 1853 FC Bus and Cargostar Models
Equipped with Injection Pump No. 1 802 605 C91 .... 21° BTDC

S-Series and Cargostar Models
Equipped with Injection Pump No. 1 802 607 C91 .... 17° BTDC

S-Series and Cargostar Models
Equipped with Injection Pump No. 1 802 643 C91 .... 23° BTDC

DTI-466C Engines

S-Series, 1853 FC Bus, Cargostar and Paystar Models
Equipped with Injection Pump No. 1 802 608 C91 .... 18° BTDC

S-Series and Cargostar Models
Equipped with Injection Pump No. 1 806 227 C91 .... 18° BTDC

S-Series and Cargostar Models
Equipped with Injection Pump No. 1 806 227 C91 .... 18° BTDC

OEM:

UD-312 Power Unit with D-312
Equipped with Injection Pump No. 684 530 C92 .... 13° BTDC

UD-312 Power Unit with D-312
Equipped with Injection Pump No. 684 730 C92 .... 13° BTDC

UD-312 Power Unit, Galion LQ-155 & Canadian Car LQ-1 with D-312
Equipped with Injection Pump 684 687 C91 .... 18° BTDC
Equipped with Injection Pump 684 687 C92 .... 13° BTDC
Equipped with Injection Pump 684 687 C93 .... 13° BTDC

UD-312 Power Unit with D-312
Equipped with Injection Pump 675 713 C91 .... 18° BTDC

UD-360 Power Unit with D-360
Equipped with Injection Pump No. 684 439 C92 .... 18° BTDC
Equipped with Injection Pump No. 684 439 C93 .... 12° BTDC

OEM
(Continued) **± 1°**

UD-360 Power Unit with D-360
Equipped with Injection Pump No. 673 573 C92 .... 18° BTDC
Equipped with Injection Pump No. 673 573 C93 .... 12° BTDC

UDT-360 Power Unit with DT-360
Equipped with Injection Pump No. 680 300 C91 .... 13° BTDC

UD-414 Generator Set with D-414
Equipped with Injection Pump No. 684 351 C92 .... 18° BTDC

UD-414 Power Unit with D-414
Equipped with Injection Pump No. 673 572 C92 .... 18° BTDC
Equipped with Injection Pump No. 673 572 C93 .... 12° BTDC

UDT-414 Power Unit with DT-414
Equipped with Injection Pump No. 673 574 C91 .... 15° BTDC

UDT-414 Generator Set with DT-414
Equipped with Injection Pump No. 684 352 C91 .... 15° BTDC

UD-466 Power Unit with D-466
Equipped with Injection Pump No. 675 958 C92 .... 18° BTDC
Equipped with Injection Pump No. 675 958 C93 .... 12° BTDC

UD-466 Power Unit (SSP LQ3D) with D-466
Equipped with Injection Pump No. 684 499 C92 .... 18° BTDC
Equipped with Injection Pump No. 684 499 C93 .... 12° BTDC

UD-466 Power Unit with D-466
Equipped with Injection Pump No. 684 509 C92 .... 18° BTDC
Equipped with Injection Pump No. 684 509 C93 .... 12° BTDC

UD-466 Generator Set with D-466
Equipped with Injection Pump No. 680 430 C92 .... 18° BTDC

UDT-466 Power Unit with DT-466
Equipped with Injection Pump No. 675959 C91 .... 15° BTDC

UDT-466 Generator Set with DT-466
Equipped with Injection Pump No. 684 438 C91 .... 15° BTDC

UDT-466 Power Unit (Min-Max Governor) with DT-466
Equipped with Injection Pump No. 684 525 C91 .... 18° BTDC

UDT-466 Power Unit (Min-Max Governor) with DT-466
Equipped with Injection Pump No. 684 748 C92 .... 15° BTDC

UDT-414 Power Unit and Eaton #1-D with DT-414
Equipped with Injection Pump No. 684 686 C91 .... 15° BTDC

OEM
(Continued) **± 1°**

UDT-466 Power Unit SMI (Snow Blower) with DT-466
Equipped with Injection Pump No. 684 546 C91 .... 17° BTDC

UD-414 Standard Engine
Equipped with Injection Pump No. 673 572 C92 .... 18° BTDC
Equipped with Injection Pump No. 673 572 C93 .... 12° BTDC

UDT-414 Standard Engine
Equipped with Injection Pump No. 673 574 C92 .... 15° BTDC

UDT-414B Standard Engine
Equipped with Injection Pump No. 687 473 C91 .... 15° BTDC

Blackwelders Tomato Harvester (LQ8)
Equipped with Injection Pump No. 691 102 C91 .... 15° BTDC

UD-466 Standard Engine
Equipped with Injection Pump No. 675 958 C92 .... 18° BTDC
Equipped with Injection Pump No. 675 958 C93 .... 12° BTDC

Galion T-400 A Grader (LQ 165, # 165A)
Equipped with Injection Pump No. 691 058 C91 .... 18° BTDC
Equipped with Injection Pump No. 691 058 C92 .... 12° BTDC

D-466 Generator Set 3% Reg. with D-466
Equipped with Injection Pump No. 680 430 C92 .... 18° BTDC

Galion T-500A, T-500C Grader (LQ 157, # 157A)
Equipped with Injection Pump No. 684 509 C92 .... 18° BTDC
Equipped with Injection Pump No. 684 509 C93 .... 12° BTDC

Galion AT-500C Grade (# 167, # 167A, # 169)
Equipped with Injection Pump No. 691 158 C91 .... 18° BTDC
Equipped with Injection Pump No. 691 158 C92 .... 12° BTDC

UDT-466 Standard Engine
Equipped with Injection Pump No. 675 959 C91 .... 15° BTDC

Galion T-600B, T-600C Grade (LQ 158, # 158)
Equipped with Injection Pump No. 684 525 C91 .... 18° BTDC

Galion T-500L, T-500M Grader (# 161B)
Equipped with Injection Pump No. 691 048 C91 .... 15° BTDC

UDT-466B Standard Engine
Equipped with Injection Pump No. 691 025 C91 .... 15° BTDC

Galion T-500L, T-500M Grader (LQ 161, LQ 161A and # 161A)
Equipped with Injection Pump No. 684 748 C92 .... 15° BTDC

OEM
(Continued) **± 1°**

Galion AT-500M Grader (LQ 166A, # 166A, # 168)
Equipped with Injection Pump No. 691 000 C91 .... 15° BTDC

Galion AT-600 Grader (# 170)
Equipped with Injection Pump No. 691 025 C91 .... 15° BTDC

Galion T-600B, T-600C Grader (# 158A)
Equipped with injection Pump No. 691 047 C91 .... 15° BTDC

Solar Turbine Starter (SLR-1)
Equipped with Injection Pump No.691 022 C91 .... 15° BTDC

Marine
Equipped with Injection Pump No. 1 806 060 C91 . ... 17° BTDC

SPECIAL NUT AND BOLT TORQUE DATA*

	N•m	lbf-ft**
Air Compressor Idler Shaft Nut	102	75
Alternator Pulley Nut:		
w/.67 Inch Diameter Shaft	68	50
w/.87 Inch Diameter Shaft	102	75
Camshaft Thrust Plate Bolt	27	20
Connecting Rod Bolts	175	130
Crankcase Front Plate Bolt	27	20
Cranking Motor Mounting Bolts	115	85
Crankshaft Main Bearing Cap Bolt.	155	115
Crankshaft Vibration Damper Retainer Bolts (Pay Line Application) (Rubber Damper)	142	105
Crankshaft Pulley Retainer Bolts	142	105
Long and Short ***Cylinder Head Bolts "Old Style" w/Hardened Washer & "New Style" w/Flange Head and No Washer	225	165
Cylinder Head Valve Cover Bolt	3	26 lbf-in.
Exhaust Manifold Nuts	77	57
Flywheel Bolts:		
Pin	170	125
Phc	150	110
Flywheel Housing Mounting Bolts	142	105
Idler Gear Carrier Bolt	115	85
Idler Pulley Shaft Nut	102	75
Injection Nozzle Crab Bolt	27	20
UTDS† Model 100 Injection Pump Drive Gear Bolts	35	26
Robert Bosch Model MW Injection Pump Drive Gear Bolts	47	35

* All torques are given with bolts, studs and nuts lubricated with SAE 30 engine oil or chassis grease, except as noted.
** Unless otherwise noted.
** To be torqued in steps as shown on the cylinder head torque pattern chart. (Section 3).
†United Technologies Diesel Systems (formerly AMBAC)

SPECIAL NUT AND BOLT TORQUE DATA*
(Continued)

	N•m	lbf-ft**
Injection High Pressure Connectors	40	30
Injection Nozzle Holder Nut (with Nozzle Installed)	45	33
Intake Manifold Bolt	27	20
Oil Filter By-Pass Valve Cap	68	50
Oil Pan Drain Plug	45	33
Oil Pan Bolts	27	20
Oil Pressure Regulating Valve Cap Nut	230	170
Turbocharger Mounting Bolts	47	35
Tachometer Drive Thrust Plate Nuts	27	20
Valve Adjusting Screw Nut	27	20
Vibration Damper Mounting Bolts	47	35
Water Pump Hub Nut (Nut Retained Hub)	203	150 (Regular Nut) †
	237	175 (Flanged Nut) ††

†Use Loctite #242
††Use Oil

* All torques are given with bolts, studs and nuts lubricated with SAE 30 engine oil or chassis grease, except as noted.

**Unless otherwise noted

SERVICE DIAGNOSIS

Service diagnosis is a systematic procedure of investigation to be followed in order to locate and correct an engine problem. The engine is first considered as a complete unit in its specific application and then the problem is localized to components or systems; intake, exhaust, cooling, lubrication or injection. Testing procedures will then help analyze the source of the problem.

PREREQUISITES FOR EFFECTIVE DIAGNOSIS:

1. Knowledge of the principles of operation for both the engine and application systems.

2. Knowledge to perform and understand all procedures In the diagnostic and service manuals.

3. Availability of and the ability to use gauges and diagnostic test equipment.

4. Have available the current Guideline Data for the engine application.

Although the cause of an engine failure may be apparent, very often the real cause Is not found until a repeat failure occurs. This can be prevented if specific diagnostic action is taken prior to, during and after engine disassembly and during engine reassembly.

It is also very important that specific diagnostic tests follow engine reassembly prior to and after the engine is placed back into service.

Identification of the symptoms which lead to engine failure is the result of proper service diagnosis. Effective service diagnosis requires use of the following references:

1. GSS-1460 and GSS-1482 for Agricultural Equipment Applications.

2. ISS-1526 for Pay Line Applications.

3. 1 171 478 R1 for On-Highway Truck Applications.

4. Component Specifications within this Manual.

5. Service Bulletins.

The visual inspections and measurements required will determine not only the need to replace a component but also for salvage such as the crankcase for cylinder sleeve upper and lower bore inserts.

It is recommended that you follow the steps outlined in the areas listed below when the need to perform engine repairs becomes necessary. This will avoid unnecessary repairs, pin-point the cause or causes of failure and eliminate repeat failure.

PRIOR TO REMOVAL OF ENGINE FROM CHASSIS OR PERFORMING IN-CHASSIS DISASSEMBLY.

PRIOR TO ENGINE DISASSEMBLY.
DURING ENGINE DISASSEMBLY.
PRIOR TO ENGINE REASSEMBLY.
DURING ENGINE REASSEMBLY.
PRIOR TO ENGINE START-UP.
ENGINE START-UP.

damage to components such as mounting brackets, fan and shroud, etc.

3. Obtain In-Chassis Engine Performance Data.

4. Pressure test air induction system.

5. Obtain a sample of the crankcase oil and submit for analysis. ***NOTE: If sample Is not submitted under OLA program and local laboratory is used, it will be necessary for you to specify type of analysis required.***

6. Obtain a coolant sample and hold pending inspection of engine components after disassembly, as condition will dictate if this sample should be discarded or analyzed.

PRIOR TO DISASSEMBLY OF ENGINE

1. Pressure check engine cooling system for leaks as follows:

a. Drain all lube oil and coolant from engine and radiator.

b. Disconnect the radiator from the engine and cap off all the engine connections (with hose clamps and plugs).

c. Disconnect the unit's cab heater connections at the engine and plug engine openings.

d. Disconnect and remove air discharge pipe from turbocharger to intercooler (if equipped).

e. Disconnect and leave open oil supply return line to crankcase from air compressor (if equipped).

f. Remove all valve covers, push rod or valve lifter side inspection covers, lube oil pan and oil drain plug from lube oil cooler.

NOTE: DO NOT REMOVE ANY INJECTION NOZZLES FROM CYLINDER HEAD.

g. Fill engine with water and attach an air line connection coupled with a regulator assembly to water drain in cylinder block.

h. Pressurize the crankcase cooling system to 50 psi. Pressure must be maintained until leakage location is evident.

NOTE: NO EXTERNAL OR INTERNAL WATER LEAKAGE IS ALLOWABLE.

DURING ENGINE DISASSEMBLY

1. Measure and record exhaust and Intake valve lash.
2. Measure and record cylinder head bolt (nut) torque using the mark method.
3. Measure and record connecting rod and main bearing cap bolt torque using the mark method.
4. Measure gear backlash if the front cover is removed.
5. Measure and record crankshaft end play.
6. Inspect push rods for straightness and end button looseness.
7. Inspect valve tappets for defects.

PRIOR TO ENGINE REASSEMBLY

1. Pressure test cylinder head(s) for nozzle sleeve leakage and port and/or deck cracking if Magnaflux, Magnaglo or visual inspection did not reveal cracks.
2. Pressure test oil cooler for leakage.
3. Measure cylinder head lower deck flatness.
4. Inspect the valve seat inserts for wear, cracks and looseness.
5. Measure valve guides for excessive wear.
6. Inspect valves for stem and face wear, face burning and cracks.
7. Inspect valve rotators for operation.
8. Measure crankcase deck for flatness.
9. Inspect crankcase deck for cracks.
10. Inspect cylinder sleeve counterbores for cracks.
11. Measure cylinder sleeve counterbores.
12. Inspect lower cylinder sleeve bores for erosion.
13. Measure lower cylinder sleeve bores.
14. Inspect camshaft bearings for wear and looseness.
15. Inspect oil gallery(s) for foreign material.
16. Inspect oil pressure regulating and bypass valves for scuffing and sticking.
17. Inspect turbocharger for oil seal leakage and wheel damage.
18. Measure turbocharger shaft end and radial movement.

19. Inspect oil pump suction and pressure side pipes for cracks, end fretting, gasket and/or "O" ring failure. Inspect screen for damage and restriction.

20. Inspect crankshaft for cracks on the throws and journals. Inspect journals for scuffing and scratching.
21. Inspect water pump for seal, bearing and impeller failure.

22. Inspect oil pump for seal, bearing and gear failure.

23. Flow test injection pump if permitted under injection pump service policy to determine if fuel delivery meets specifications and if repair or replacement is required.

24. Test injection nozzles for orifice plugging, tip leakage and opening pressure. It is suggested that nozzles be disassembled and cleaned or new valves installed or that nozzles be replaced with ReNewed assemblies **See NOTE**).

    NOTE: If nozzle life has been short and if inspection reveals metal chips in orifices, the injection lines (all) should be replaced.

DURING ENGINE REASSEMBLY

1. Measure cylinder sleeve flange protrusion.

2. Measure piston ring gap.

3. Rectangular Rings: Measure piston ring side clearance.

4. Keystone Rings: Measure piston ring drop.

5. Measure connecting rod and main bearing to crankshaft journal clearance.

6. Measure intake and exhaust valve protrusion or recession.

7. Lubricate camshaft and face of valve tappets with Molycote "G-n" paste or Fel-Pro C-670.

8. Lubricate O.D. of tappets with oil.

PRIOR TO ENGINE START-UP

1. Pressurize lubrication system with engine oil to assure adequate lubrication. ***NOTE: Remove valve cover(s) and check for oil flow to rocker arm assembly.***

2. Pre-lube Turbocharger with 4 - 5 oz. of clean IH 30W engine oil.

3. Pressure test air induction system.

ENGINE START-UP

1. Run at low idle and check rocker arm lubrication - reinstall valve cover(s).

2. Inspect visually for coolant and oil leaks.

3. Start engine run-in (See NOTE).

   NOTE: ***Follow specified engine run-in procedures. Failure to do so will result in engine failure such as piston/sleeve scoring and/or excessive oil consumption.***

4. Retorque cylinder heads at specified time period during run-in. Failure to do so will result in head gasket failure.

5. Complete engine run-in.

6. Obtain In-Chassis Engine Performance Data.

7. Retorque all external fasteners (Nuts, bolts and hose lamps).

8. Engine can now be placed back into service.

   NOTE: ***Follow-up should be made per after delivery service for specific application. This follow-up service must be made on engine if complete engine disassembly was necessary.***

PROBLEM ANALYSIS GUIDE

PROBLEM: LOW INTAKE MANIFOLD PRESSURE (POWER COMPLAINT)
REASON OR CAUSE:

1. Operator error...
   a. gauge inaccurate
   b. engine not properly loaded
2. External leakage...
   a. on intake or exhaust manifolds at gasket
   b. at air compressor and turbocharger mounting and housing clamps
   c. at the diaphragm or pressure feed line of the aneroid
3. Excessive...
   a. air cleaner restriction
   b. exhaust back pressure after turbocharger.
4. Incorrect...
   a. engine valve timing
   b. injection pump timing
   c. high idle adjustment (too low)
   d. linkage adjustment
   e. valve adjustment (too tight)
   f. injection pump on engine
   g. turbine housing A/R ratio or nozzle ring
   h. lift to port closure (start of injection)
5. Plugged...
   a. or defective injection nozzles
   b. or restricted fuel filters
   c. or loose fuel bleed valve

6. High vacuum restriction on low pressure fuel system caused by...

    a. fuel hose collapse

    b. incorrectly drilled connectors

    c. or foreign material in the fuel tank

7. Defective...

    a. fuel supply pump

    b. fuel return valve

8. High crankcase pressure caused by...

    a. Plugged crankcase breather element.

    b. worn piston ring sleeves

    c. leaking cylinder head gasket

    d. restricted air induction system

    e. or exceeding oil pan fill capacity

9. Defective...

    a. injection pump (under fueling)

    b. small I.D. fuel inlet supply line

    c. or improperly adjusted injection pump fuel modulator (Aneroid)

    d. or improperly adjusted injection pump fuel shut off cable

10. Defective, misadjusted or worn clutch resulting in slipping.

11. Torque converter slipping, high converter stall speed.

12. Excessive main hydraulic pressure causing low full stall speed.

PROBLEM: HIGH INTAKE MANIFOLD PRESSURE (EXCESSIVE FUEL CONSUMPTION)
REASON OR CAUSE:

1. Overfueling of engine caused by defective or misadjusted fuel injection pump.

2. Incorrect turbine housing (incorrect A/R ratio) or incorrect nozzle ring, small vane gap.

3. Incorrect nozzles - orifice size larger than specified for application.

4. Incorrect Injection lines - I.D. larger than specified for application.

5. Incorrect fuel inlet supply line, filter to injection pump or I.D. larger than specified.

6. Loose delivery valve assembly

PROBLEM: EXCESSIVE ENGINE SPEED (RPM)

REASON OR CAUSE:

1. Inaccurate tachometer.

2. Misadjusted injection pump.

3. Defective injection pump.

PROBLEM: EXCESSIVE CRANKCASE PRESSURE

REASON OR CAUSE:

1. Operator error ...

    a. gauge inaccurate - cross check using water manometer
    b. using wrong specification or test procedure

2. Worn piston or sleeve due to dirt...

3. Dirty or restricted crankcase breather element.

4. Cylinder head gasket leakage.

5. Broken piston rings.

6. Stuck piston rings.

7. Improper maintenance procedures.

PROBLEM: HIGH COOLANT TEMPERATURE

REASON OR CAUSE:

1. Defective...

    a. gauge
    b. radiator (plugged tubes or fins)
    c. radiator cap
    d. water pump

2. Low coolant level.

3. Collapsed coolant hose(s).
4. Stuck thermostats (closed).
5. Shutter stats inoperative or misadjusted.
6. Loose fan belts (slipping).
7. External coolant leakage.
8. Improper coolant treatment.
9. Overfueling

PROBLEM: LOW COOLANT TEMPERATURE

REASON OR CAUSE

1. Defective...
   a. gauge
   b. thermostat seals on thermoostat housing counter bore
2. Incorrect thermostat.
3. Stuck thermostat (open).
4. Shutter stats inoperative or misadjusted.

PROBLEM: COOLANT IN THE LUBE OIL OR ENGINE LUBE OIL IN THE COOLING SYSTEM

REASON OR CAUSE:

1. Cracked cylinder head, crankcase or leaking cylinder head gasket.
2. Leaking injector sleeve.
3. Defective oil cooler and/or intercooler.
4. Defective air compressor.
5. Damaged or eroded cylinder sleeve "O" rings or crankcase lower bore.

PROBLEM: EXCESSIVE EXHAUST SMOKE - BLACK

REASON OR CAUSE:

1. Low power.
2. Excessive air cleaner restriction.

3. Overfueling due to misadjustment.

4. Leakage at the...

   a. intake manifold

   b. turbocharger

   c. aneroid pressure line or diaphragm (if applicable)

5. Defective...

   a. turbocharger

   b. injection pump

6. Plugged nozzles.

7. Fuel aneroid misadjustment or failure.

8. Air in fuel system.

9. Worn piston rings and/or cylinder sleeves (low compression).

10. Broken piston rings (high crankcase pressure).

11. High main hydraulic pressure (low stall speed).

12. Incorrect engine timing on injection pump advance.

13. Operator lugging engine.

PROBLEM: EXCESSIVE EXHAUST SMOKE - GRAY

REASON OR CAUSE:

1. Worn piston rings or cylinder sleeves.

2. Excessive air cleaner restriction.

3. Worn valve guides result if BLUE GRAY smoke.

PROBLEM EXCESSIVE EXHAUST SMOKE - WHITE

REASON OR CAUSE:

1. Overfueling when engine is cold (injection pump stays in excess fuel position).

2. Incorrect timing.

PROBLEM: EXCESSIVE AIR INLET RESTRICTION

REASON OR CAUSE:

1. Operator error

   a. gauge inaccurate
   b. improper consideration of specifications vs. gauge locations
   c. no orifice in sintered fitting in Donaldson valve connection or orifice plugged

2. Dirty element.

3. Damaged element.

4. Incorrect size element

5. Damaged inlet piping.

6. Excessive bends in piping.

7. Rain cap blocks air inlet pipe opening.

8. Air intake and cab air duct misaligned in cab over models.

PROBLEM: ENGINE "MISFIRING" - ERRATIC VISUAL SMOKE

REASON OR CAUSE:

1. Plugged nozzle orifices (holes).

2. Low nozzle valve opening pressure.

3. Improper valve lash adjustment.

4. Valves and/or seat wear (leakage).

5. Cylinder head gasket leakage.

6. Defective injection pump.

7. Incorrect valve timing.

8. Air in fuel system.

PROBLEM: EXCESSIVE BACK PRESSURE AFTER TURBOCHARGER
REASON OR CAUSE:

1. Operator error...

   a. gauge inaccurate

b. test performed inaccurately. **(NOTE:** ***Test hook up should be in a straight section of pipe at least 12" long and not more than 18" from the turbo exhaust outlet).***

2. Damaged or defective muffler.

3. Clogged or wrong muffler.

4. Excessive number of bends in exhaust piping.

PROBLEM: Incorrect oil pressure **(NOTE: Correct should be 290 kPa (42 PSI) to 448 kPa (65 PSI) at rated engine speed with engine at normal operating temperature.)**

REASON OR CAUSE:

1. Lube oil pressure regulating valve assembly working improperly.

2. Clogged or dirty lubricating oil filters.

ELECTRICAL
PROBLEM: DISCHARGING BATTERY

REASON OR CAUSE:

1. Connections loose.
2. Short circuits.
3. Connections dirty.
4. Voltage control unit out of order.
5. Alternator not charging.

PROBLEM: BATTERY OVERHEATING

REASON OR CAUSE:

1. High charging rate.
2. Voltage control unit out of order.

PROBLEM: BATTERIES FULLY CHARGED AND ALTERNATOR CHARGING RATE HIGH

REASON OR CAUSE:

1. Improper voltage regulator setting.
2. Grounded alternator field circuit (in either alternator, regulator or wiring).

PROBLEM: BATTERIES LOW IN CHARGE AND LOW OR NO ALTERNATOR CHARGING RATE

REASON OR CAUSE:

1. Loose connections, frayed or damaged wiring.
2. Defective batteries.
3. Low voltage regulator setting.
4. Oxidized regulator contact points.
5. Defective alternator.

PROBLEM: NO ALTERNATOR OUTPUT

REASON OR CAUSE:

1. Defective alternator.

PROBLEM: AMMETER SHOWS DISCHARGE WITH ENGINE OPERATING

REASON OR CAUSE:

1. Alternator inoperative.
2. Faulty voltage regulator.
3. Short circuits.
4. Alternator has loose or broken belt.

PROBLEM: NOISY ALTERNATOR

REASON OR CAUSE:

1. Loose mountings.
2. Loose pulley.
3. Worn bearings.

PROBLEM: AMMETER POINTER FLUCTUATES RAPIDLY

REASON OR CAUSE:

1. Shortened or loose connections.
2. Alternator defective.
3. Alternator drive belt loose or broken.
4. Low idling speed.

PROBLEM: VOLT-METER SHOWS LESS THAN 26 VOLTS WITH ENGINE AT HIGH IDLE

REASON OR CAUSE:

1. Alternator inoperative.
2. Faulty voltage regulator.
3. Defective connections.

PROBLEM: HIGH VOLTAGE - VOLT-METER POINTER IN RED ZONE

REASON OR CAUSE:

1. Grounded alternator field circuit - in either alternator, regulator, or wiring.
2. Defective regulator.

PROBLEM: CRANKING MOTOR WILL NOT OPERATE OR OPERATES SLOWLY

REASON OR CAUSE:

1. Faulty batteries.
2. Cables or terminals loose, dirty or defective.
3. Starting switch defective.
4. Cranking motor burned out.
5. Commutator worn or dirty.
6. Brushes not making proper contact.
7. Starter solenoid defective.
8. Drive end bearing badly worn.

MOUNTING ENGINE ON STAND

ONE...

Remove crankcase ventilation tube (1, Fig. 1), oil cooler (2), pressure regulator valve (3), Turbocharger oil return elbow (4) and oil filter base (5) with filters from the crankcase. These items are removed to allow installation of the engine on stand.

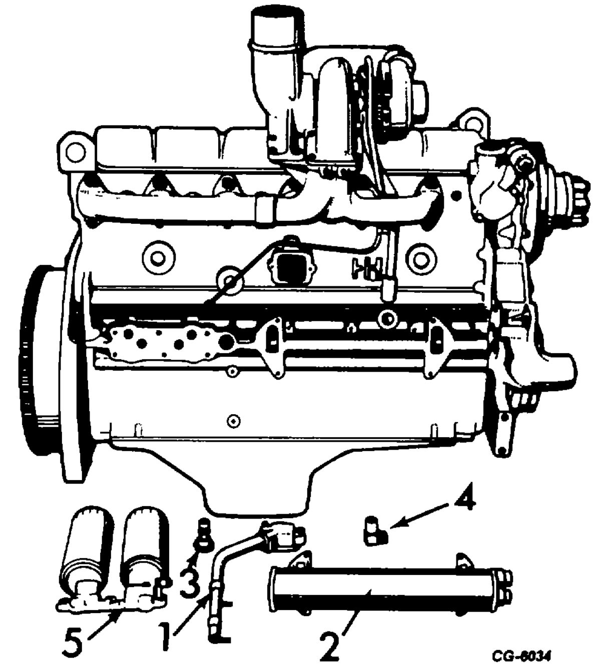


Figure 1.

TWO..

Use a safety catch on the hoist hook (Fig. 2).

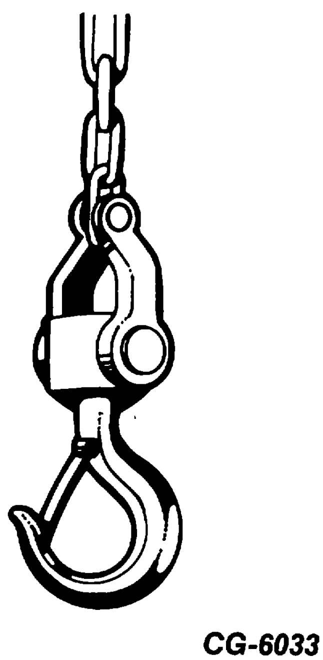


Figure 2.

THREE...

Hoist the engine to the stand. Insert a 2" x 4" board (1, Fig. 3) of appropriate length between the ends of the lifting chains as shown. This will prevent the possibility of the lifting eyes turning and damaging the rocker arm cover. Mount the attaching plate PLT-540-4 or 17-52-14 at crankcase bolt holes (arrows).

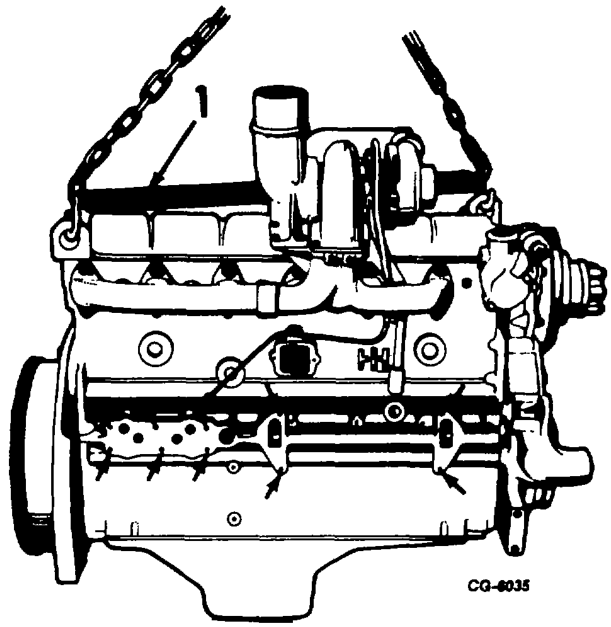


Figure 3.

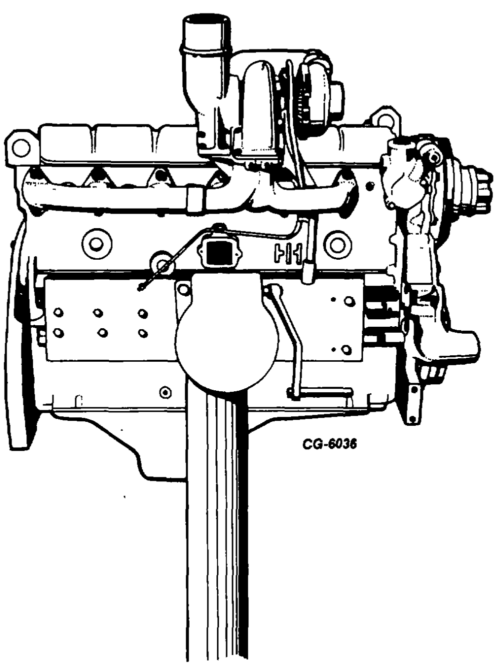


Figure 4.

FOUR...

Mount the engine in the engine stand PLT- 640 or 17-52 as shown (Fig. 4).

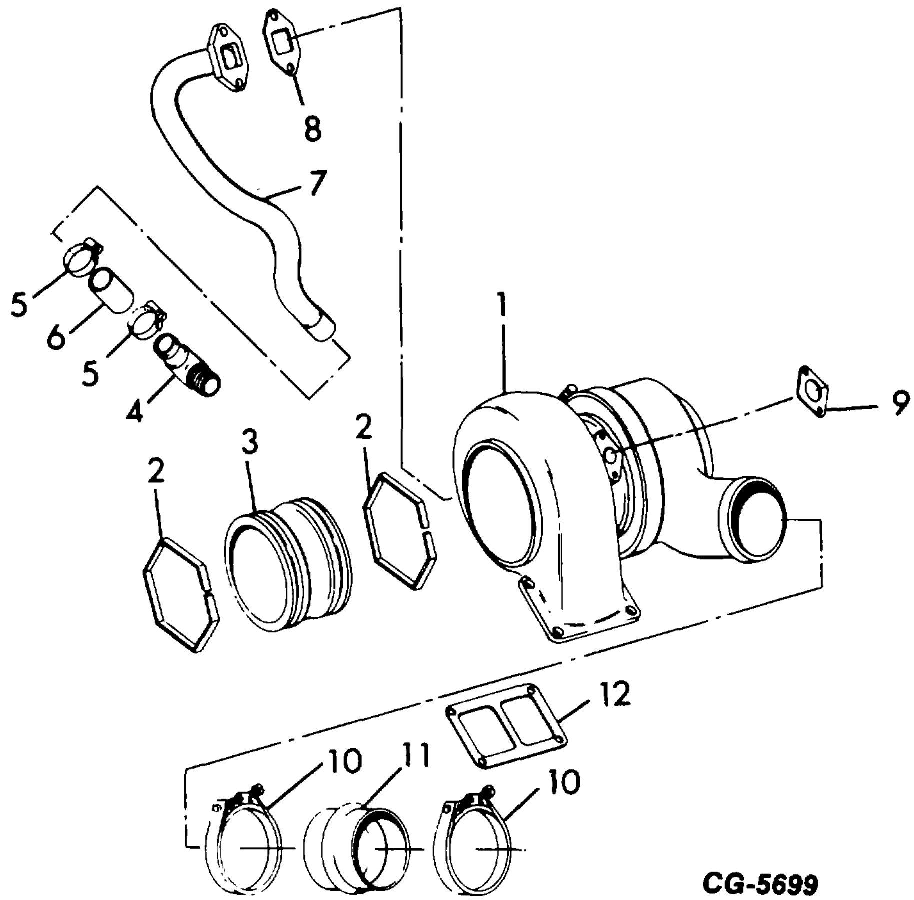


Figure 1. - Typical Turbocharger and Common Parts

1. Turbocharger
2. Seal Ring
3. Turbocharger Exhaust Sleeve
4. Turbocharger Oil Drain Elbow
5. Turbocharger Oil Drain Clamp
6. Turbocharger Oil Drain Hose
7. Turbocharger Oil Drain Tube
8. Turbocharger Oil Drain Tube Gasket
9. Turbocharger Oil Inlet Tube Gasket
10. Turbocharger Air Outlet Pipe Hose Clamp
11. Turbocharger Air Outlet Pipe Hose
12. Turbocharger Gasket

GENERAL

Turbocharger Diagnostic Data:

Prior to servicing the Turbocharger diagnose the problem.

Replace the Turbocharger if:
- The Compressor wheel or Turbine wheel has rubbed on its housing causing heavy damage.

Replace the Core Assembly If:
- The Compressor wheel or Turbine wheel has rubbed on Its housing causing damage to the housings or wheels themselves.

NOTE: ***High spots must be removed from the housings before reuse with a new core assembly.***

If engine and Turbocharger are opperable perform engine diagnostic tests as detailed In appropriate DIAGNOSTIC MANUAL.

NOTE: ***Engine performance problems are usually related to secondary problems in other engine systems:***

Engine Performance Problem: Turbocharger shaft seals leak oil Into the Intake or exhaust manifolds, resulting in black smoke and excessive engine temperatures.

Secondary Problems:

a. Excessive Intake restriction caused by:
   - Dirty Air filters
   - Collapsed Intake pipes or hoses

b. Restricted Turbocharger oil drain system caused by:
   - Plugged hoses
   - Collapsed hoses

c. Excessive crankcase pressure caused by:
   - Dirty crankcase breather.
   - Overfilling crankcase with engine oil.
   - Excessive engine blow by.

Specific diagnostic data may be located in the Turbocharger Manual.

The Turbocharger Is essentially an exhaust driven centrifugal air compressor. Its purpose Is to Increase diesel engine power output by supplying compressed inlet air to the engine.

The Turbocharger consists of the following main parts: (See Fig. 2).

1. Turbine Wheel (2)
2. Bearing (3)
3. Compressor Wheel (4)

The Turbine Wheel is located at one end of the Bearing Housing; the Compressor Wheel is at the other end. A shaft (5) connects the Turbine Wheel with the Compressor Wheel, making It a wheel assembly. The Bearing Housing is oil cooled. Engine oil is circulated through the Bearing Housing which acts as a heat barrier between the hot Turbine and the compressor. Bearings are of the sleeve type and are lubricated by engine oil. Oil is taken directly from the clean oil side of the engine oil filters. Piston ring type seals are used at each end of the shaft.

Turbine Housing (e) and Compressor Housing (7) are located at opposite ends of the core assembly.

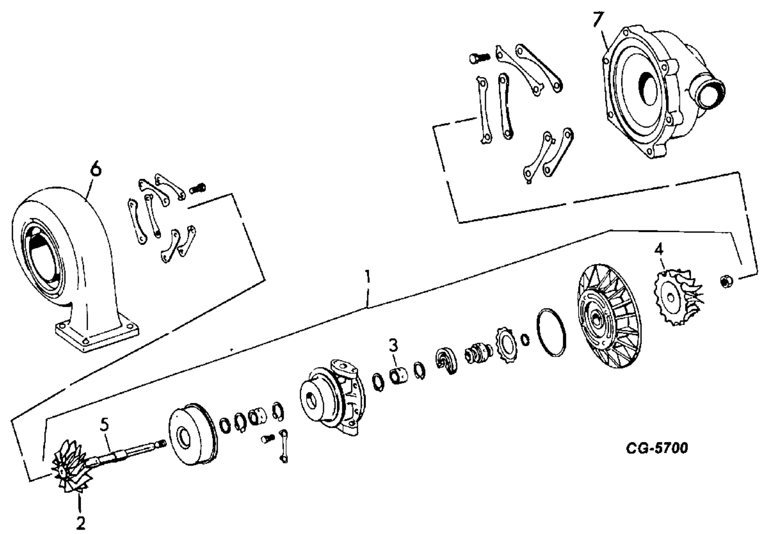


Figure 2. - Turbocharger Core Assembly

1. Core Assembly
2. Turbine Wheel
3. Bearing
4. Compressor Wheel
5. Shaft
6. Turbine Housing
7. Compressor Housing

SPECIFICATIONS

Refer to ISS-1047-2, CTS-2659N or GSS-1427-1 w/Rev. 5 **TURBOCHARGERS FOR INTERNATIONAL DIESEL ENGINES.** Identify the manufacturer and model number of the Turbocharger prior to looking up specification.

REMOVAL

Remove the Turbocharger as Follows:

1. Remove the exhaust elbow (1, Fig. 3), (held with hex-head cap screws, nuts and lock washers.)

2. Remove the Turbocharger exhaust sleeve (not shown), located between the exhaust and Turbine housing.

NOTE: ***The exhaust sleeve Is loosely hold and must be supported when removed.***

3. Disconnect the oil Inlet tube (4) and drain tube (5) from the center housing. Remove and discard all tube gaskets.
4. Loosen the clamps and remove the air cleaner hose (pipe) (not shown) from the compressor housing.
5. Loosen the clamps on the air-crossover tube hose (2) at the air compressor housing. Position these parts away from the Turbocharger.
6. Remove all four Turbocharger mounting bolts and lift the Turbocharger from the exhaust manifold (6).
7. Remove the Turbocharger gasket from the exhaust manifold.
8. Cover or plug the exhaust manifold and air tubes.

NOTE: ***Prevent the entrance of foreign materiel by covering or pluging all openings Into the Turbocharger. Covers must remain In place until the Turbocharger Is Installed end all connections are secured (See Fig. 4).***

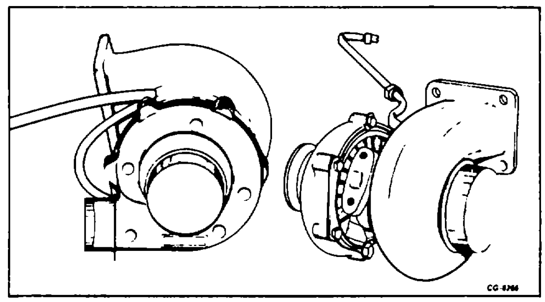


Figure 4. - Turbocharger Properly Capped

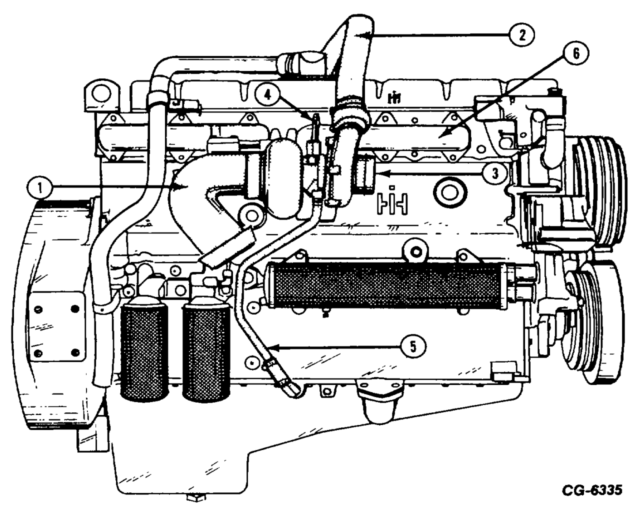


Figure 3. - Turbocharger Removal

1. Exhaust Elbow
2. Air-Crossover Tube
3. Air Inlet
4. Oil-Inlet Tube
5. Oil-Outlet Tube
6. Exhaust Manifold

CLEANING, INSPECTION & REPAIR

CLEANING

Clean the Turbocharger and Related Components as Follows:

1. Thoroughly clean the piping connecting the air cleaner to the Turbocharger.

2. Remove the air cleaner and clean inside the air cleaner element housing. (Important to prevent repeat Turbocharger or engine failures).

3. In the event of a Turbocharger failure, REPLACE the OLD AIR CLEANER ELEMENT with a NEW AIR CLEANER ELEMENT, because foreign material and/or compressor wheel particles may be embeded in the air cleaner element.

NOTE: ***If the air cleaner element is not changed, the foreign material end/or particles may be drawn Into the turbocharger compressor wheel when the engine Is restarted.***

4. Clean the exhaust elbow and manifold, thoroughly.

NOTE: ***Use Bendix Metal Cleaner or Gunk Hydroseal to clean components. DO NOT use a caustic solution.***

5. In case of Turbocharger failure or damage to the wheel assembly, plug the Turbocharger oil Inlet tube and operate the engine without the Turbocharger installed to blowout any foreign material In the engine or manifold.

INSPECTION

Inspect the Assembled Turbocharger as Follows:

1. Visually Inspect the compressor and turbine wheels for damaged blades or evidence of wheel contact with compressor or turbine housings. (see Fig. a & b).

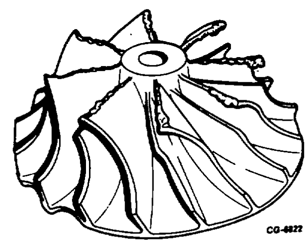


Figure 5a. - Foreign Material Turbo Damage

NOTE: ***View of the turbocharger compressor wheel which has been damaged by foreign material from the air Inlet system.***

Hard dense foreign material such as capscrews or nuts will damage the leading edges of the compressor wheel. Soft foreign material such as shop rags will bend the compressor blades backward.

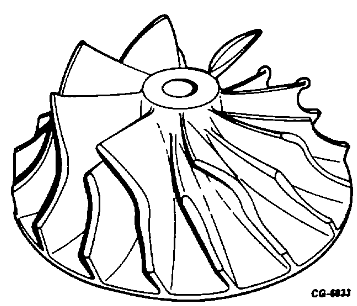


Figure 5b. - Bearing Failure Resulting in Compressor Wheel Damage

NOTE: ***View of turbocharger compressor wheel damaged due to failed bearings. The compressor wheel blades made contact with the compressor housing wail after bearing failure.***

INSPECTION - Cont'd

2. Inspect Turbine and Compressor wheels as follows:
   a. Spin the wheels. They must rotate freely.
   b. The Turbine wheel must NOT rub on the shroud.
   c. The compressor wheel must NOT rub on the backplate.

NOTE: ***Be certain that reused compressor and turbine housing Interiors have not been damaged.***

3. Visually inspect the external parts of the Turbocharger for cracks and oil leaks.

NOTE: For detailed inspection and repair information of external and internal Turbo- charger parts refer to: ISS-1047-2, CTS- 2659N or GSS-1427-1 w/Revision 5 (Section 3 Turbocharger).

INSTALLATION

Install Turbocharger Core Assembly as Follows:

1. Carefully Install the turbine end of the core assembly Into the Turbine Housing (1, Fig 6). (with nozzle ring if so equipped).

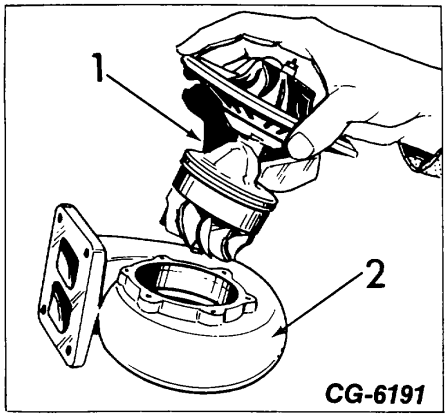


Figure 6. - Installation of Core Assembly Into Housing

1. Core Assembly
2. Turbine Housing

2. Coat the threads of the capscrews with IH "NEVER SEEZ" compound. Install the clamps, lockplates and bolts to hold the assembly together, but with enough slack to allow the core assembly to be rotated relative to the turbine housing.

3. Install the diffuser (if so equipped) into the compressor housing. Carefully insert the core assembly with turbine housing into the compressor housing. Align the marks on the compressor housing with those on the center housing and backplate. Carefully install the compressor housing and secure with bolts and lockplates or clamps, whichever is used on the particular model Turbocharger. Tighten the bolts or clamps in proper sequence and to specified torque. (Fig. 7)

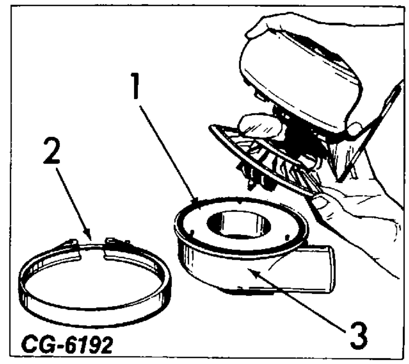


Figure 7. - Compressor Housing Installation

1. Diffuser
2. Clamp
3. Compressor Housing

+FOR SPECIFIED TORQUE VALUES AND SEQUENCE, DETERMINE TURBOCHARGER MODEL AND REFER TO ISS-1047-2, CTS-2659N OR GSS-1427-1 w/REVISION 5 (SECTION 3 TURBOCHARGER).

Install the Assembled Turbocharger as Follows:

1. Keep all Turbocharger openings covered prior to installing the Turbocharger on the engine.

2. Be sure all elbows and hoses are clean before Installing them. Check the air cleaner, air induction system and engine exhaust manifolds for foreign material.

NOTE: ***To minimize service parts Inventories, one basic service Turbocharger Is used to replace many production Turbochargers. It may be necessary to rotate the Compressor Housing and/or Turbine Housing of complete Turbochargers to match the orientation of the Turbocharger removed.***

3. Inspect Turbocharger mounting pad on the manifold for presence of foreign material.

4. Using a new gasket, place the Turbocharger on the exhaust manifold and install the four bolts and nuts. DO NOT torque at this time.

5. Make certain that the oil inlet and oil drain lines are clean. If hoses are used, make certain that they have not hardened and that the Inner lining has not deteriorated or started to flake off. If metal tubing is used, make certain that it is not restricted or collapsed.

6. Install the oil inlet and drain lines to the crankcase and Turbocharger center housing, rotating the Turbocharger center housing to properly align the oil lines.

7. When alignment has been accomplished scribe a mark on the center and turbine housings for reference as shown in Fig. 8.

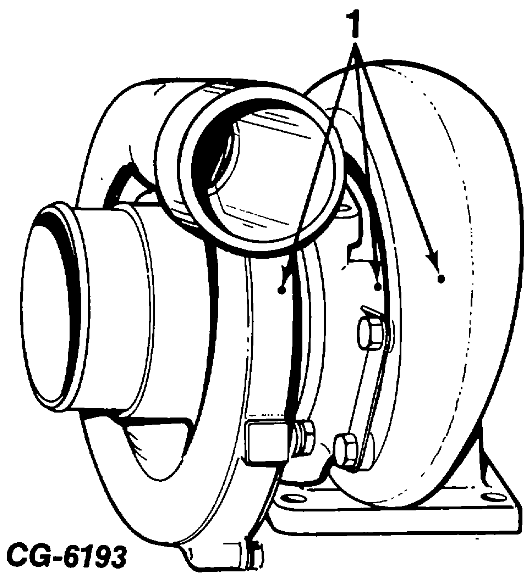


Figure 8. -- Center and Turbine Housing Aligned

1. Scribe Marks

8. Rotate the compressor housing to align the air crossover tube and hoses to the intake manifold.

9. Scribe a reference mark on the center and compressor housing.

10. Remove Turbocharger from the engine and with scribe marks in alignment torque the clamp and all bolts to specifications (consult Turbocharger Service Manual for proper torques) and bend the lock tabs on the lockplates to secure bolts.

11. SPIN the wheels of the Turbocharger. The shaft must rotate with no Interference at either end of the Turbocharger.

12. If the Turbocharger Is not to be Installed immediately, lubricate internally and Install protective covers on all openings.

13. Using the new gasket (from step 4), place the Turbocharger on the exhaust manifold and install the four bolts and nuts (consult the service manual for proper torque).

NOTE: ***Use IH "NEVER SEEZ" compound on the Turbocharger mounting bolts before running the nuts on. This will aid In future removal.***

14. Install the exhaust outlet system.

NOTE: ***Use IH "NEVER SEEZ" to lubricate seal rings on exhaust sleeve, (If so equipped) and all threaded fasteners used.***

15. Remove the covers or plugs from the oil-inlet and outlet parts. Using a new gasket, connect the oil outlet tube.

16. With a squirt can, put four or five ounces of clean IH 30W engine oil into the oil-inlet opening of the Turbocharger. This will provide sufficient lubrication for the Turbocharger bearings until normal engine lubrication is established.

17. Connect the oil inlet tube to the Turbocharger using a new gasket.

18. Connect the air crossover tube and hoses to the compressor housing outlet and tighten the clamps.

19. Connect the air cleaner Turbocharger connecting hardware.

NOTE: ***It is imperative that the air-cleaner service outlined In the Operator's Manual be rigidly followed because of the power losses and oil leakage Into the Intake manifold that can be Incurred with a restricted air cleaner.***

20. To ensure proper sealing of the air intake system an air Induction test Is recommended. Consult your authorized IH Distributor for the proper procedure to be followed.

21. Intake restriction should be measured with the engine under full load (maximum Turbocharger Air Flow) prior to changing a Turbocharger for oil seal leakage and always after turbocharger replacement.

NOTE: ***Maximum allowable Inlet restriction measured under full load varies according to the application but is always less than 30 In.H20.***

22. A plugged crankcase breather element can cause excessive crankcase pressure and prevent oil drainage from the Turbocharger oil seals to "Flood" which results in internal and external oil leakage. CLEAN the CRANKCASE BREATHER element and piping as required. (Refer to Section 6).

Engine Starting Procedure after Installing a Turbocharger:

1. Change the engine lubricating oil with the type specified in the Operator's Manual and at the proper operating level. <u>This is very important if a Turbocharger failure has occurred.</u>

2. Crank the engine without starting until oil pressure is indicated on the oil pressure gauge. This should provide an adequate amount of oil to lubricate the turbocharger.

3. Start the engine and operate at low RPM for a few minutes before loading engine.

NOTE: ***During operation, the Turbocharger should be free from vibration or unusual noises.***

NOTE: ***During shutdown periods or when the unit Is being transported, the exhaust stack must be covered to prevent water from entering and damaging the turbine.***

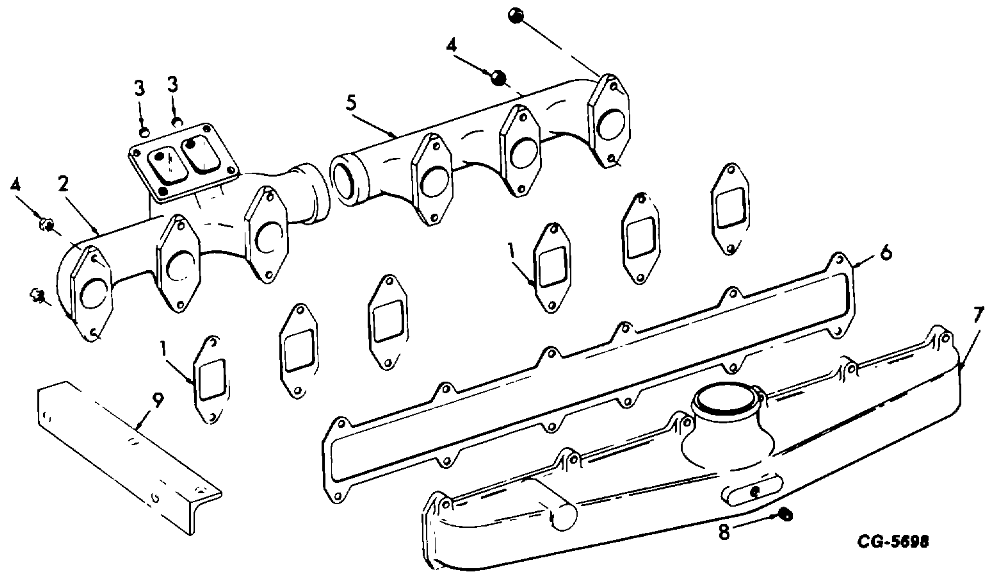


*Figure 1. - Intake and Exhaust Manifold (400 Series Turbocharger for Payline Shown)**

1. Exhaust Manifold Gaskets (6)
2. Front Exhaust Manifold
3. Plug (2)
4. 7/16" Nut & Special Hardened Washer (1 2)
5. Rear Exhaust Manifold
6. Intake Manifold Gasket
7. Intake Manifold
8. Square Head Pipe Plug
9 Either Starting Support

NOTE:** ***Engine application variations exist which may alter the appearance of front exhaust manifold and Intake manifold, from that shown above.

( ) Denotes quantity

GENERAL

INTAKE MANIFOLD

The intake manifold, located on the left side of the engine, serves as a passage for filtered air to enter the combustion chamber. Manifold design and configuration varies with application (Turbocharger vs. naturally aspirated).

EXHAUST MANIFOLD

The exhaust manifold, mounted on the right side of the engine, contains six passages which remove exhaust gases from each cylinder.

Air flows through the intake manifold (with the boost of a Turbocharger on some engine models) into the cylinder head combustion chamber. By special cylinder head design the air swirls to bring about high turbulent air-to fuel mixing.

Correct torque values are necessary when installing manifolds so efficient fuel-air mixing results.

PATCH TYPE INTAKE MANIFOLD MOUNTING BOLTS

A prevailing torque type bolt with plastic patch (Fig. 2) has replaced the standard intake manifold mounting bolt. The new patch type bolt provides a more secure retention with the intake manifold and cylinder head.

In the event of intake manifold repair, the standard type bolt should be replaced by the patch type bolt.

IMPORTANT: Refer to appropriate parts catalog for the particular application when ordering bolts so the correct length(s) are obtained.

SPECIFICATIONS

Intake Manifold bolt
Torque Data .... 27 N•m (20 lbf-ft)

Exhaust Manifold Nut
Torque Data .... 77 N•m (57 lbf-ft)

Exhaust Manifold
Flange Thickness .... 19.05 mm (.75 in)

Other specifications are not applicable for service.

INTERCOOLER

The intercooler is a heat exchanger that removes heat generated by compression of air in the turbocharger and transfers the heat to the cooling system. Cooling the air intake charge reduces the formation of oxides of nitrogen. Use of such a device enables certain engines to meet California Emission Standards.

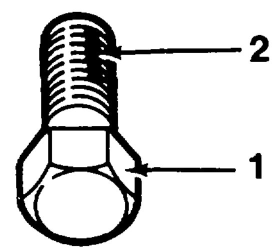


Figure 2. - Patch Type Bolt

1. Bolt
2. Plastic Patch

REMOVAL AND DISASSEMBLY

Remove Manifolds as Follows:

INTAKE MANIFOLD - (D and DT Engines)

1. Disconnect Turbocharger crossover tube (2, Fig. 3 or Fig. 3a) (if equipped) from intake manifold (1).

2. Remove fuel lines (as an assembly) as follows:

   a. Disconnect fuel lines (3, Fig. 3 or 3, Fig. 3a) at injection nozzles and pump.

   b. (Engines equipped with UTDS* Model 100 Fuel Injection Pump only) Loosen clamp (4) securing fuel lines to the hose connecting final fuel filter to injection pump.

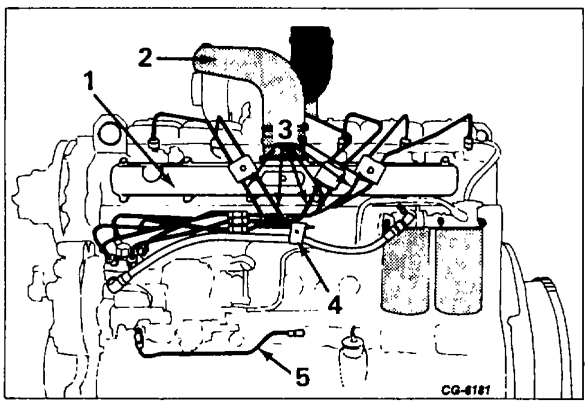


Figure 3. - Left Side View DT-466 (w/UTDS Model 100 Fuel Injection Pump)*

1. Intake Manifold
2. Outlet Pipe
3. Fuel Lines
4. Clamp
5. Lube Oil Tube

*United Technologies Diesel Systems (formerly AMBAC)

   c. After removing fuel lines cap all Injection nozzle openings, pump and line openings to prevent dirt from entering.

3. Remove cap screws securing Intake manifold to cylinder head; then remove manifold and manifold gasket.

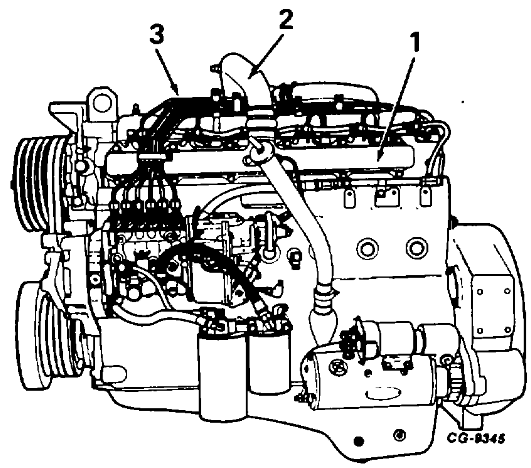


Figure 3a. - Left Side View DT466C (w/Robert Bosch Model MW Fuel Injection Pump)

1. Intake Manifold
2. Outlet Pipe
3. Fuel Lines

Intake Manifold - (DTI Engines)

1. Remove turbocharger to intercooler pipe (1, Fig. 4 or 4a).

2. Disconnect water inlet (2) and outlet hoses (3) at intercooler.

3. Remove fuel lines (as an assembly) as follows:

   a. disconnect fuel lines at injection nozzles and pump.

   b. (Figure 4 only) loosen clamps (4 and 5) which secure fuel lines to the intercooler.

   c. (Figure 4a only) disconnect fuel return line (4).

   d. remove fuel lines and cap all openings.

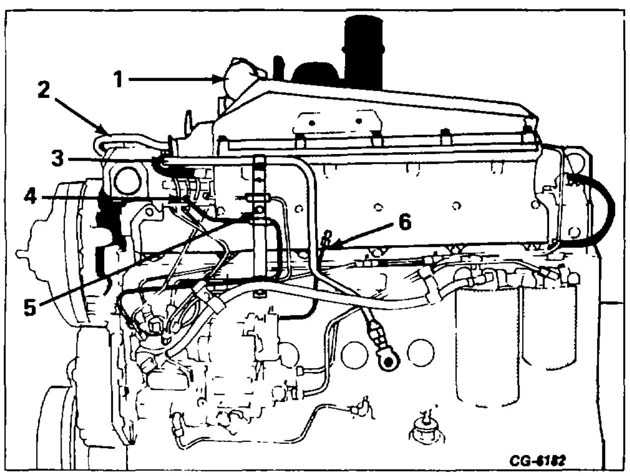


Figure 4. - Left Side View (DTI-466B) (with UTDS Model 100 Fuel Injection Pump)*

1. Turbo Outlet Pipe 4. Clamp
2. Water Inlet Pipe 5. Clamp
3. Water Outlet Tube 6. Aneroid Tube

*United Technologies Diesel Systems (formerly AMBAC)

4. Remove aneroid tube (6, Fig. 4 or 5, Fig. 4a) and cap openings.

5. Remove bolts securing intercooler to cylinder head; then remove intercooler gasket.

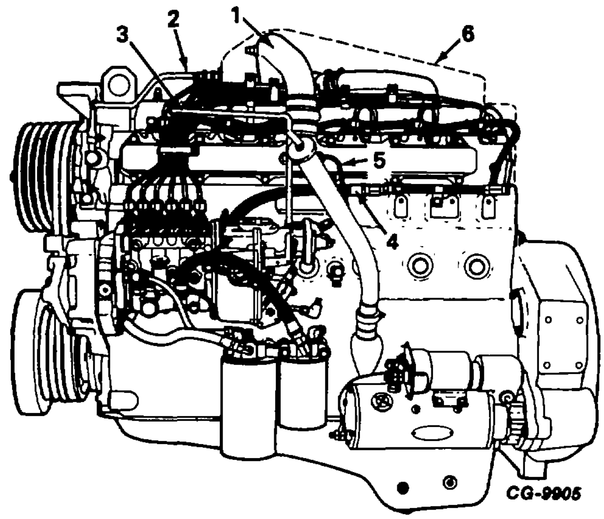


Figure 4a. - Left Side View (DTI-466C) (with Robert Bosch Model MW Fuel Injection Pump) [With Intercooler]

1. Turbo Outlet Pipe 4. Fuel Return Line
2. Water Inlet Pipe 5. Aneroid Tube
3. Water Outlet Tube 6. Intercooler (outline)

Exhaust Manifold - (D, DT and DTI Engines)

1. Remove Turbocharger (If equipped). Refer to Section 1.

2. Remove stud nuts and washers securing the exhaust manifold to the cylinder head.

3. Remove manifold and manifold gaskets.

Disassemble Intercooler as Follows:

1. Remove flange (1, Fig. 5a), gaskets (2) and "O" rings on the intercooler coolant inlet 3 and outlet hoses (4).

2. Remove the cover bolts (7) then remove the cover (8) and gasket (9).

3. Remove the housing bolts (10) to disassemble the core (Fig. 5b) from the housing (11).

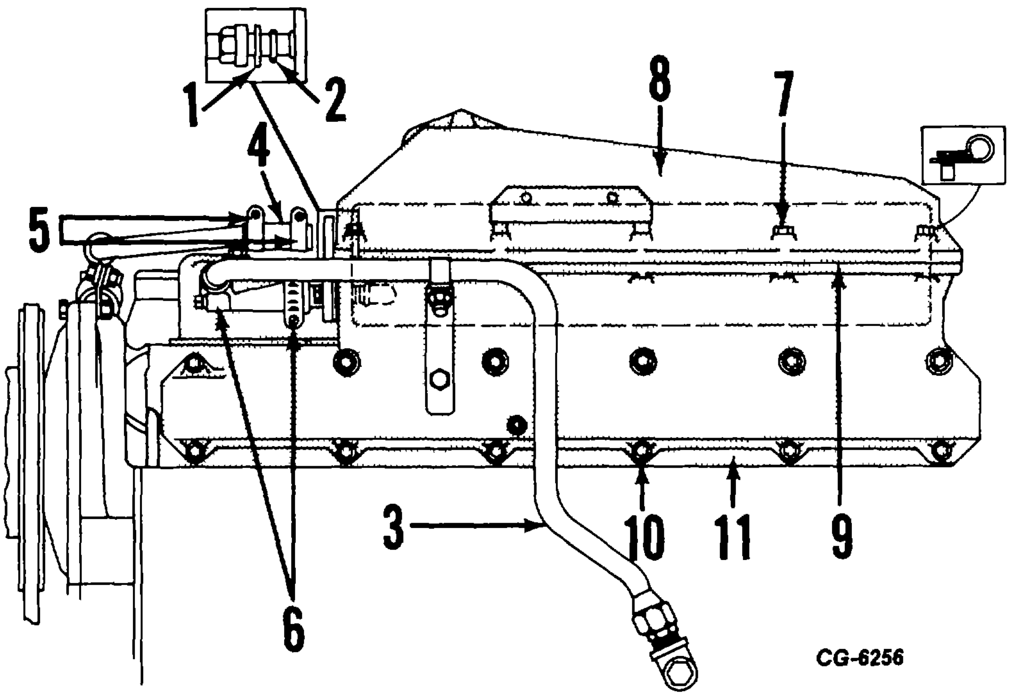


Figure 5a. - Intercooler Disassembly Sights AE Application Shown (Others Similar)

1. Intercooler Water Flange
2. Intercooler Flange Gasket
3. Water Inlet Hose
4. Water outlet Hose
5. Outlet Hose Clamps
6. Inlet Hose Clamp
7. Intercooler Cover Bolts
8. Intercooler Cover
9. Intercooler Cover Gasket
10. Intercooler, Housing Bolts
11. Intercooler Housing

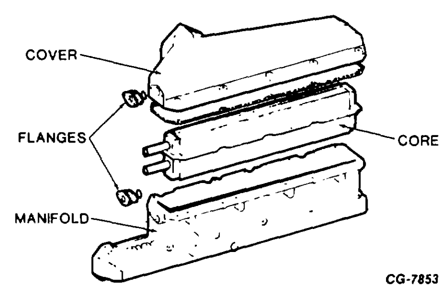


Figure 5b. - Intercooler Disassembly

CLEANING, INSPECTION & REPAIR

Clean Manifolds as Follows:

1. Steam clean intake or intercooler and exhaust manifolds (after removal and disassembly) to dislodge dirt and carbon deposites.

Inspect and Repair Manifolds as Follows:

1. Inspect the Intercooler or Intake manifold and exhaust manifold bodies and flanges for CRACKS and DISTORTIONS. Replace damaged parts.

2. Replace old gaskets with new gaskets at all mating surfaces.

3. DTI ENGINE ONLY: After disassembly, pressure check intercooler core for leaks at 380 kPa (55 psi) core leak check pressure.

4. Inspect exhaust manifold gasket flange for warpage as follows:

   a. Install all cleaned exhaust manifold sections (as a unit) to the cylinder head without gaskets. Tighten with washers and nuts. Torque to 81 N•m (60 Ibf-ft).

   b. Measure gap between cylinder head and exhaust manifold gasket flange face with a 6 mm (1/4") wide feeler gauge. If 0.38 mm (0.015") feeler gauge will pass gap in region shown in Figure 6, resurfacing of exhaust manifold gasket flanges must be performed with all sections of manifold assembly together. A maximum of 0.84 mm (0.025") material can be removed.

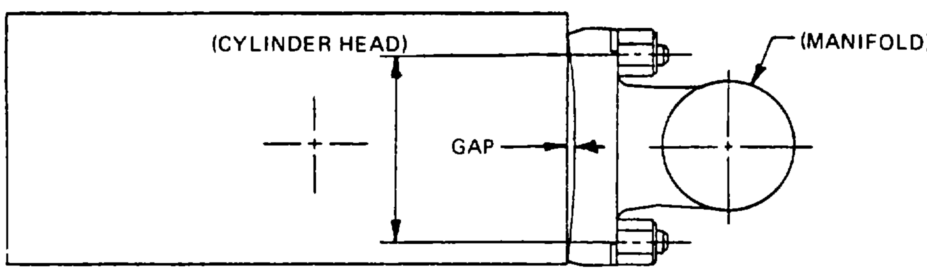


Figure 6. - Exhaust Manifold Warpage

Resurface Exhaust Manifold Gasket Flanges as Follows:

1. Assemble ALL exhaust manifold sections.
2. Grind a maximum of 0.64 mm (0.025 in) material from gasket flanges.
3. After grinding, wash all mating surfaces with solvent to remove loose material.

INSTALLATION

D and DT ENGINES ONLY

Install Manifolds as Follows:

1. Install Intake manifold with NEW gasket. Be sure manifold bolts are properly Indexed with each gasket bolt hole. Failure to follow this procedure can result In gasket misalignment.

2. Secure intake manifold bolts with a torque of 27 N•m (20 Ibf-ft).

3. Install exhaust manifold with NEW gasket.

4. Use only specially hardened washers between manifold studs & nuts. Manifolds may loosen if non-specified washers are used. Torque manifold stud nuts to 77 N•m (57 Ibf-ft).

5. Reconnect fuel lines (3, Fig. 3 or 3, Fig. 3a) to injection nozzle and pump. Torque fuel line fittings to 47 N•m (35 Ibf-ft).

6. Install the Turbocharger and outlet pipe (if equipped).

DTI ENGINES ONLY

Reassemble Intercooler as Follows:

1. Install core Into housing.

2. Install cover onto housing.

3. Install flanges onto water Inlet and outlet ports, using new gaskets.

Install Intercooler and Exhaust Manifolds as Follows:

1. Install Intercooler to cylinder head, using new gaskets.
2. Install aneroid tube (6, Fig. 4 or 5, Fig. 4a) and fuel injection lines.
3. Install exhaust manifold with a new gasket. Torque bolts to 77 N•m (57 Ibf-ft).
4. Install the Turbocharger and outlet pipe. Refer to Turbocharger Section 1.

NOTE: ***IH "NEVER SEEZ" is to be used on all exhaust system bolts, studs, fasteners, etc.***

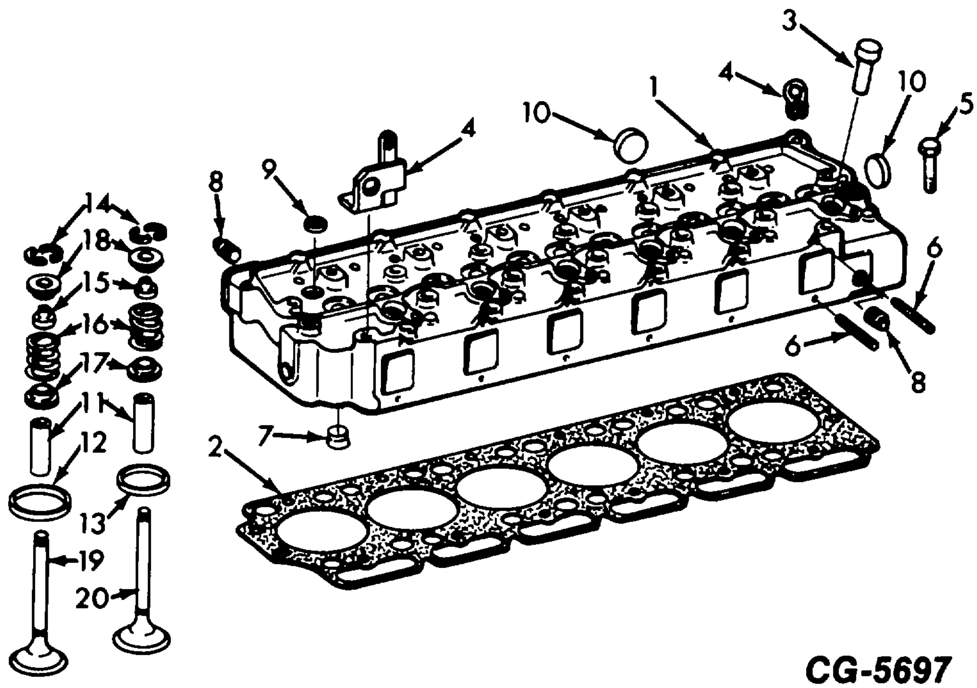


Figure 1. - Cylinder Head and Valves

CYLINDER HEAD PARTS

1. Cylinder Head Assembly
2. Cylinder Head Gasket
3. Injector Sleeve (6)
4. Lifting Eye (2)
5. Cylinder Head Short Bolt (20)
6. Exhaust Manifold Stud (12)
7. Water Director (12)
8. 1/2 Inch Pipe Plug
9. 1-1/8 Inch Cup Plug (6)
10. 1-1/2 Inch Cup Plug (6)
11. Valve Guide (12)
12. Intake Valve Insert
13. Exhaust Valve Insert

VALVE PARTS

14. Valve Spring Lock (24)
15. Oil Shield (12)
16. Valve Spring (12)
17. Valve Spring Seat (12)
18. Rotator (12)
19. Intake Valve (6)
20. Exhaust Valve (6)

( ) Indicates quantity

GENERAL

These engines are the overhead valve type with two valves per cylinder. All turbocharged engines are built with "STELLITE" exhaust valves, which have special wear characteristics.

NOTE: ***DO NOT use an exhaust valve from a naturally aspirated engine in a turbocharged engine. non-stellite exhaust valves are used in naturally aspirated engines.***

VALVE ROTATORS are used on all valves to prolong valve life.

The VALVE ARRANGEMENT in the cylinder head is intake-exhaust, intake-exhaust and so on, starting from the front of the engine.

The exhaust VALVE FACE ANGLES are ground at 45 degrees and the intake at 30 degrees.

400 SERIES engines use valve seat inserts on both the intake and exhaust valves.

The VALVE LEVER and SHAFT ASSEMBLY is mounted to the cylinder head. The valve lever shaft is lubricated from a drilled passage in the crankcase through the rear stud hole of the cylinder head.

Valve levers and valve lever shaft are subject to frictional wear and hammering. During engine overhaul check these parts against "Specifications". Correct installation of valve lever shaft is important to valve train lubrication.

The Cylinder Head Is Identified as follows:

NATURALLY ASPIRATED ENGINES have a recessed letter "H" cast into the intake manifold side of the cylinder head, which designates "High Swirl."

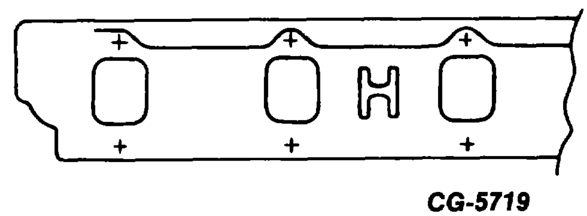


Figure 2. - "H" (High Swirl)

TURBOCHARGED ENGINES (except "B"& "C" Series) have NO markings, which designate "Low Swirl."

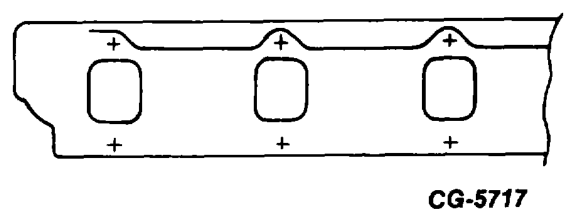


Figure 3. - No Markings (Low Swirl)

TURBOCHARGED "B" & "C" SERIES ENGINES have a recessed cross "+" cast into the side of the cylinder head, which designates "Intermediate Swirl."

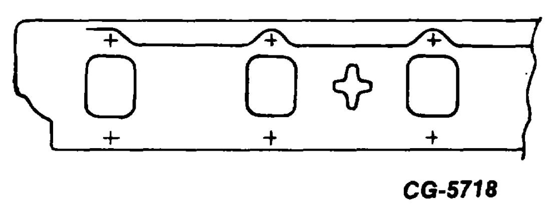


Figure 4. - "+" (Intermediate Swirl)

The cylinder head, cylinder head gasket and cylinder head coolant directors have been revised for all 400 Series Engines. The 12 coolant holes in the bottom deck of the cylinder head have been enlarged from 19.05 mm (.750 in.) to 23.80 mm (.937 in.) in diameter (Refer to Fig. 5)

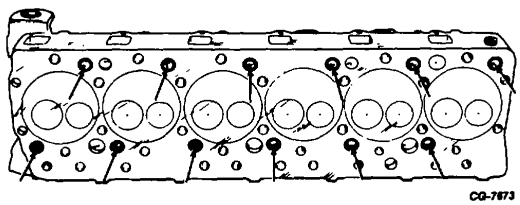


Figure 5. - Cylinder Head Bottom View of Deck With Coolant Hole Locations

The outer diameter of the press-fit coolant directors used in these coolant holes has also been increased in size from 19.15 mm (.754 in.) to 23.90 mm (.941 in.).

The twelve cylinder head gasket coolant holes have been enlarged to accommodate the larger coolant hole size.

IMPORTANT: The new style cylinder head gasket (IH Part No. 676 108 C2) and cylinder head gasket package (IH Part No. 674 398 C95) may be used with either the old or new style cylinder head. The old style cylinder head gasket (IH Part No. 676 108 C1) and cylinder head gasket package (IH Part No. 674 398 C94) can only be use with the old style cylinder head.

The new style cylinder head can be identified by the casting number (see chart) located on top of the cylinder head at intake side between number four and five nozzle locations (Refer to Figure 6).

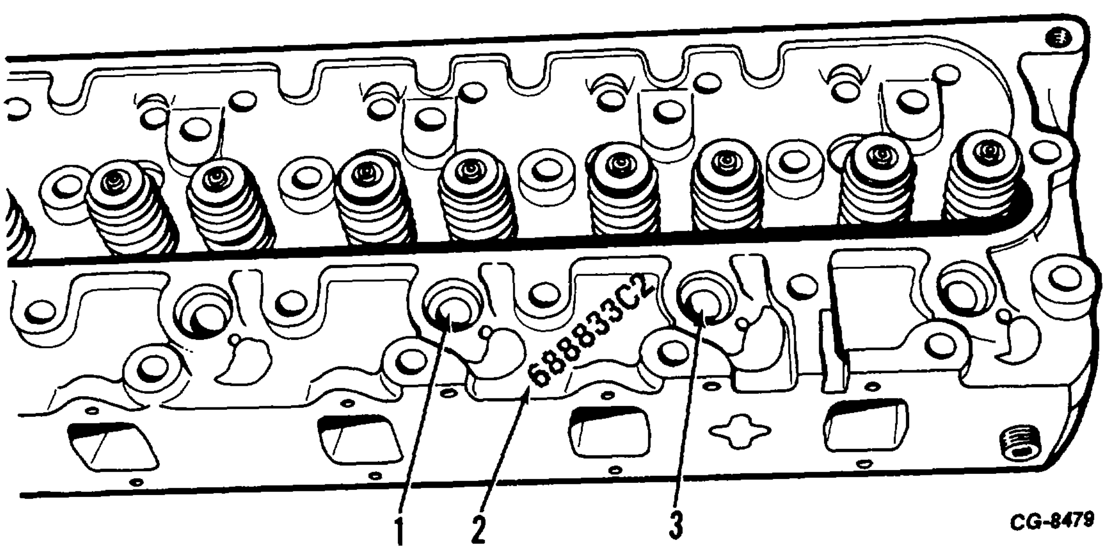


Figure 6. - Cylinder Head Production Part No. Location

1. Number Four Nozzle Bore
2. Casting Number Location
3. Number Five Nozzle Bore

NEW STYLE CYLINDER HEAD CHART

Production Part No.	Engine Type
688 833 C2*	Turbocharged "B" and "C" Engines
680 426 C2*	Turbocharged "NON-B or C" Engines
680 427 C2*	Naturally Aspirated Engines.

The old style cylinder head can be identified by the casting number (see chart) located on top of the cylinder head at intake side between number four and five nozzle locations (Refer to Figure 6).

OLD STYLE CYLINDER HEAD CHART

Production Part No.	Engine Type
688 833 C1 *	Turbocharged "B" Engines
680 426 C1 *	Turbocharged "NON-B or C" Engines
680 427 C1 *	Naturally Aspirated Engines.

*NON-SERVICEABLE Part Numbers.

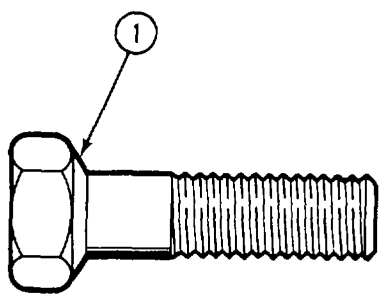
NEW INJECTOR CRAB AND INJECTOR CRAB BOLT.

INJECTOR CRAB BOLT

The new style injector crab bolt (IH Part No. 691 105 C1) [Refer to Figure 7A] eliminates the hardened washer (IH Part No. 684 496 C1) and injector crab washer (IH Part No. 675 677 C1) [Refer to Figure 7B] with a full radius fillet [Refer to 1, Figure 7A].

IMPORTANT: DO NOT USE DISPLACED STYLE WASHERS WITH NEW STYLE BOLT. THE NEW BOLT MUST BE USED WITH NEW CRAB ONLY. DISPLACED BOLT MAY BE USED WITH NEW OR DISPLACED CRAB.

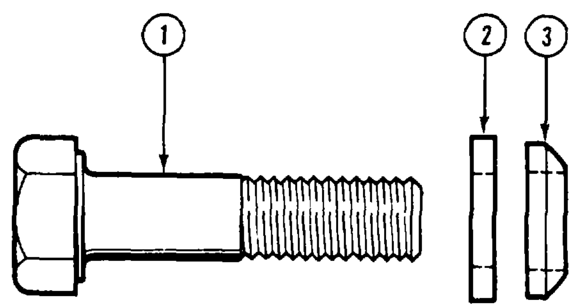
IMPORTANT: The torque remains the same for the new style and displaced style bolts, 27 N•m (20 Ibf-ft).



NEW STYLE
(IH PART NO. 691105C1)

Figure 7A.

1. Full Radius Fillet Shown on New Style Injector Crab Bolt (691 105 C1)



DISPLACED STYLE

CG-6868

Figure 7B.

1. Injector Crab Bolt (684 497 C1)
2. Hardened Washer (684 496 C1)
3. Injector Crab Washer (675 677 C1)

INJECTOR CRAB

The new style injector crab provides an improved injector crab seating contact area resulting from the following changes:

1. Increased through hole diameter from 0.344 in. on the displaced style injector crab to 0.375 in. on the new style injector crab (Refer to Figures 8A and 8B).

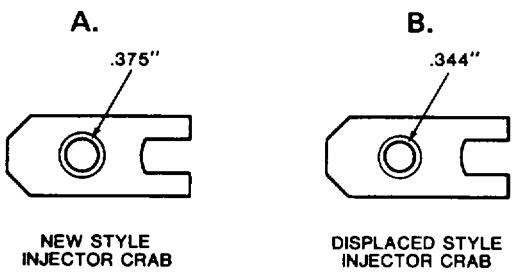


Figure 8A. - Through Hole Diameter
Figure 8B. - Through Hole Diameter

NEW CYLINDER HEAD BOLT AND TORQUE

Revised long and short cylinder head bolts with flange type heads (Figure 9a) have replaced the old style cylinder head bolts (Figure 9b) which required the use of a hardened washer (I H Part No. 252 018 R 1).

Use of the new style flange type long and short cylinder head bolts results in the following changes:

New Style Cylinder Head Bolt	Old Style Cylinder Head Bolt
(IH P/N 691 475 C1 - Long)	(IH P/N 676 119 C1 - Long)
(IH P/N 691 476 C1 - Short)	(IH P/N 676 120 C1 - Short)
1. Washer NOT Required	1. Washer Required.
2. Final Torque 225 N•m (165 lbf-ft)	2. Final Torque 225 N-m (165 lbf-ft)

IMPORTANT: Do not intermix old and new style cylinder head bolts.

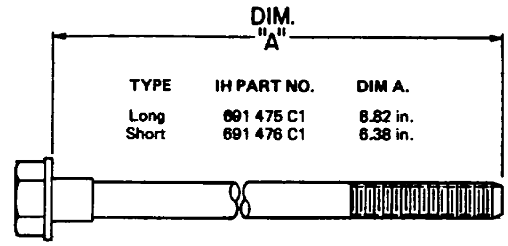


Figure 9a. - "New Style" Cylinder Head Bolt (Flange type) (Washer not required

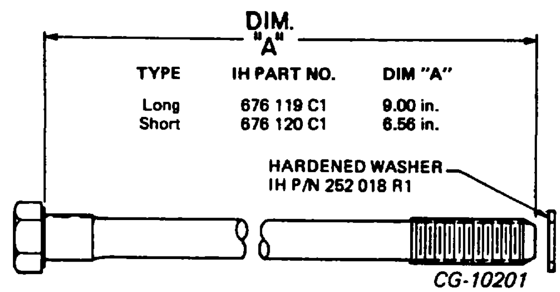


Figure 9b. - "Old Style" Cylinder Head Bolt and Hardened Washer

PARTS AFFECTED:

New IH Part No.	Description
691 475 C1	Long Cylinder Head Bolt
691 476 C1	Short Cylinder Head Bolt
	HARDENED Washer

Displaced IH Part No.
676 119 C1676 120 C1252 018 R1

EFFECTIVE ON:

The following engines utilize the "new style" long and short cylinder head bolts with flange head:

SPECIFICATIONS CHART

Dimension Title	300 Series Values Intake	300 Series Values Exhaust
Number of Valves per Cylinder	2	2
Valve Seat Runout in Cylinder Head	0.05 mm - (0.002 in)	0.05 mm - (0.002 in)
Valve Face Runout	0.038 mm - (0.0015 in)	0.038 mm - (0.0015 in)
Valve Stem Diameter	9.444 mm = (0.3718 in) 9.462 mm (0.3725 in)	9.444 mm = (0.3718 in) 9.462 mm (0.3725 In)
Valve Face Angle	30°00’-30°15'	45° 00' - 45° 15'
Valve Seat Insert Angle	30°00’-30° 15'	45° 00' - 45° 15'
Valve Seat Width	1.91 mm = (0.075 in) 2.26 mm (0.085 in)	1.91 mm = (0.075 in) 2.26 mm (0.085 in)
Minimum Valve Face Margin	1.73 mm = (0.068 in)	1.14 mm = (0.045 in)
Valve Head Recession From Face of Cylinder Head	0.00 mm = 0.000 in) 0.36 mm (0.014 in)	0.00 mm = (0.00 in) 0.36 mm (0.014 in)
Valve Seat Insert Counterbore Diameter	45.14 mm = (1.777 in)* 45.16 mm (1.778 in)	38.91 mm = (1.532 in) 38.94 mm (1.533 in)
Depth of Valve Seat Insert Counterbore	11.18 mm = (0.440 in) 11.23 mm (0.442 in)	11.15 mm = (0.439 in) 11.20 mm (0.441 in)
Valve Guide Type	Replaceable	Replaceable
Valve Guide Length	69.85 mm = (2.750 in)	69.85 mm = (2.750 in)
Valve Guide I.D. (Reamed After Assembly)	9.500 mm = (0.3740 in) 9.525 mm (0.3750 in)	9.500 mm = (0.3740 in) 9.525 mm (0.3750 in)
Valve Guide O.D	15.900 mm = (06260) 15.913 mm (0.6265 in)	15.900 mm = (0.6260 in) 15.913 mm (0.6265 in)
Maximum Allowable Stem Clearance in Guide Before Replacing	0.15 mm = (0.006 in)	0.15 mm = (0.006 in)
Valve Guide Bore Diameter (Ream Through After Assembly)	9.4107 mm = (0.3750 in) 9.4996 mm (0.3740 in)	9.4107 mm = (0.3750 in) 9.4996 mm (0.3740 in)
Valve Guide Interference Fit Dimension	0.0203 mm = (0.0008 in) 0.0660 mm (0.0026 in)	0.0203 mm = (0.0008 in) 0.0660 mm (0.0026 in)
Valve Guide Height From Cylinder Head Surface	25.20 mm = (0.992 in) 25.70 mm (1.012 in)	32.31 mm = (1.272 in) 32.82 mm (1.292 in)

Dimension Title	300 Series Values (cont'd.)	
	Intake	Exhaust
Number of Springs per Valve	1	1
Valve Spring Test Length (Valve closed)	59.4 mm - (2.34 in) 50.98 mm = (2.007 in)	59.4 mm - (2.34 in) 50.98 mm - (2.007 in)
Valve Spring Test Load (Valve closed)	294-311 N = (66-70 lbs.)	294-311 N = (66-70 lbs.)
Valve Spring Test Length (Valve open)	39.42 mm = (1.552 in)	39.42 mm = (1.552 in)
Valve Spring Test Load (Valve open)	694-730 N = (156-164 lbs.)	694-730 N = (156-164 lbs.)

* DT-360 Engine Only

SPECIFICATIONS CHART

Dimension Title	400 Series Values Intake	400 Series Values Exhaust
Number of Valves per Cylinder	1	1
Valve Seat Runout in Cylinder Head	0.05 mm = (0.002 in)	0.05 mm = (0.002 in)
Valve Face Runout	0.038 mm = (0.0015 in)	0.038 mm = (0.0015 in)
Valve Stem Diameter	9.444 mm = (0.3718 in) 9.462 mm (0.3725 in)	9.444 mm = (0.3718 in) 9.462 mm (0.3725 in)
Valve Face Angle	30°00'-30°15'	45°00'-45°15'
Valve Seat Insert Angle	30°00'-30°15'	45°00'-45°15'
Valve Seat Width	1.91 mm = (0.075 in) 2.26 mm (0.085 in)	1.91 mm = (0.075 in) 2.26 mm (0.085 in)
Minimum Valve Face Margin	2.24 mm = (0.088 in)	1.14 mm = (0.045 in)
Valve Head Recession From Face of Cylinder Head	0.00 mm = (0.000 in) 0.36 mm (0.014 in)	0.00 mm = (0.000 in) 0.36 mm (0.014 in)
Valve Seat Insert Counterbore Diameter	50.70 mm = (1.996 in) 50.72 mm (1.997 in)	41.25 mm = (1.624 in) 41.28 mm (1.625 in)
Depth of Valve Seat Insert Counterbore	12.93 mm = (0.509 in) 12.98 mm (0.511 in)	11.56 mm = (0.455 in) 11.66 mm (0.459 in)
Valve Guide Type	Replaceable	Replaceable
Valve Guide Length	69.85 mm = (2.750 in)	69.85 mm = (2.750 in)
Valve Guide I.D. (Reamed After Assembly)	9.500 mm = (0.3740 in) 9.525 mm (0.3750 in)	9.500 mm (0.3740 in) 9.525 mm (0.3750 in)
Valve Guide O.D.	15.900 mm = (0.6260 in) 15.913 mm (0.6265 in)	15.900 mm = (0.6260 in) 15.913 mm (0.6265 in)
Maximum Allowable Stem Clearance in Guide Before Replacing	0.15 mm = (0.006 in)	0.15 mm = (0.006 in)
Valve Guide Bore Diameter (Ream Through After Assembly)	9.4107 mm = (0.3750 in) 9.4996 mm (0.3740 in)	9.4107 mm = (0.3750 in) 9.4996 mm (0.3740 in)
Valve Guide Interference Fit Dimension	0.0203 mm = (0.0008 in) 0.0660 mm (0.0026 in)	0.0203 mm = (0.0008 in) 0.0660 mm(0.0026 in)
Valve Guide Height From Cylinder Head Surface	30.66 mm = (1.207 in) 31.17 mm (1.227 in)	32.69 mm = (1.287 in) 33.20 mm (1.307 in)

Dimension Title	400 Series Values (cont'd.)	
	Intake	Exhaust
Number of Springs per Valve	1	1
Valve Spring Free Length	59.4 mm = (2.34 In)	59.4 mm = (2.34 in)
Valve Spring Test Length	50.98 mm = (2.007 in)	50.98 mm = (2.007 In)
Valve Spring Test Load	294-311 N = (66-70 lbs.)	294-311 N = (66-70 lbs.)
Valve Spring Test Length	39.42 mm = (1.552 in)	39.42 mm = (1.552 in)
Valve Spring Test Load	694-730 N = (156-164 lbs.)	694-730 N = (156-164 lbs.)

SPECIFICATIONS CHART

Dimension Title	300/400 Series Cylinder Head Values
Deck to Deck Dimension (Head Thickness Overall)	106.4 mm = (4.198 In) 106.7 mm (4.202 In)
Maximum Allowable Runout	0.08 mm - (0.003 in)
Maximum Allowable Removal of Material	0.25 mm - (0.010 In)
Minimum Deck to Deck Dimension After Rework	106.38 mm - (4.188 in)

REMOVAL

Remove Cylinder Head as follows:

1. Drain cooling system.

   a. Disconnect and remove thermostat housing-to-water pump hose (1, Fig. 10).

   b. Remove thermostat housing (2) with thermostat

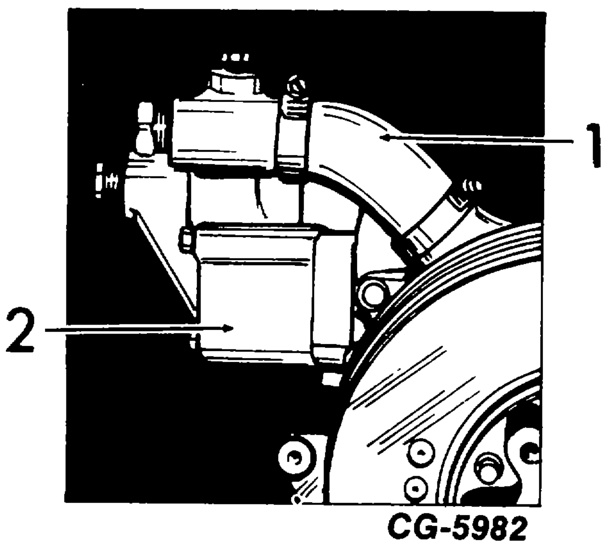


Figure 10. - Thermostat Housing and Water Pump Hose

1. Hose
2. Thermostat housing

2. Disconnect fuel return lines (1, Fig. 10) from nozzle holders (2). Cap fittings to prevent entry of dirt Into fuel system.

3. Remove cap screws (3), lift out nozzle assemblies (4). **Be extremely careful not to damage nozzle tips.** Place nozzle assemblies in rack to protect tips from damage.

4. Remove valve cover (5) and gaskets.

5. Remove bolts (6) securing valve lever assembly to cylinder head. Remove valve levers (rocker arms) as an assembly.

6. Remove push rods (7).

7. Remove remaining cylinder head bolts (8).

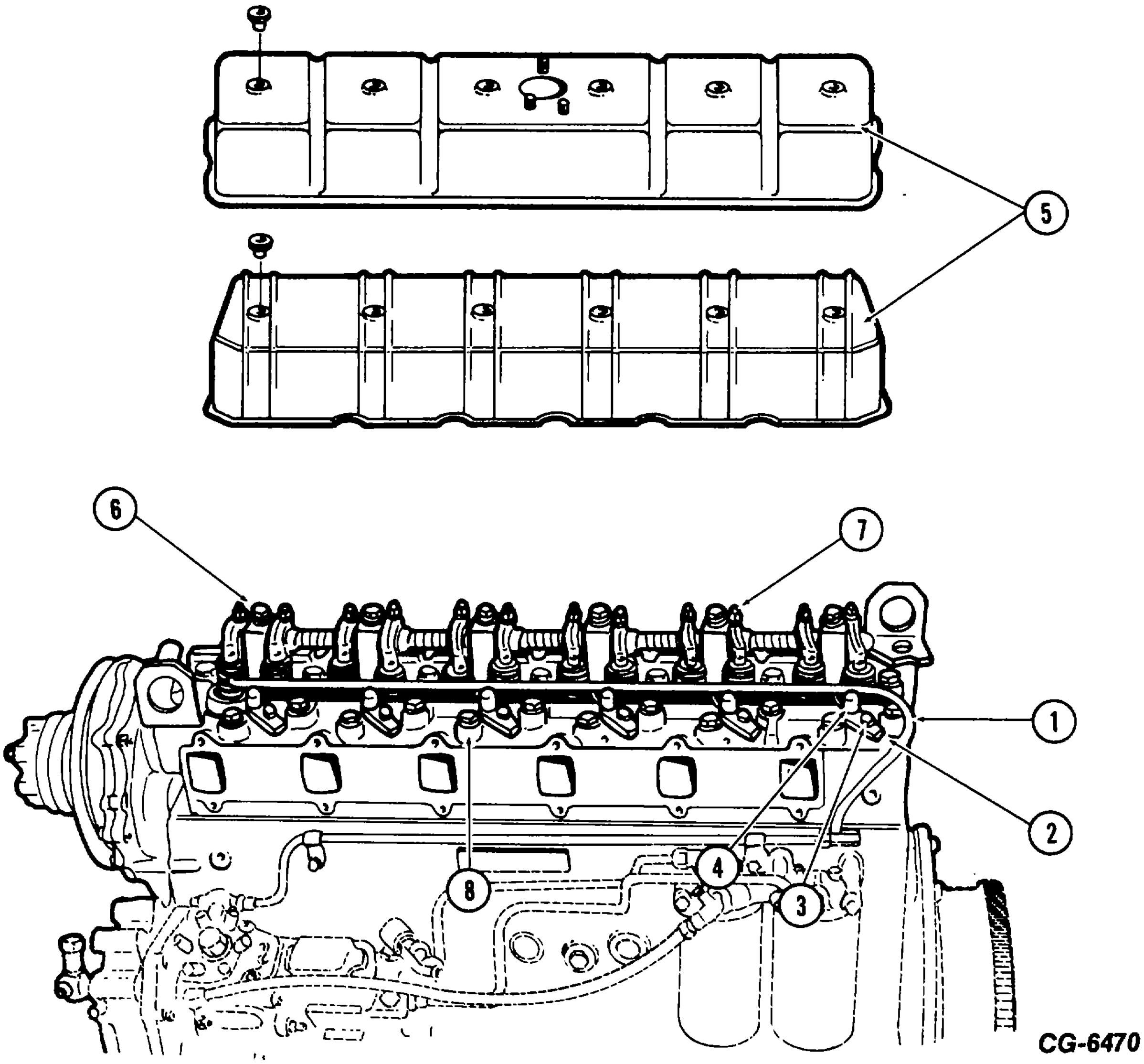


Figure 11. - Cylinder Head and Valve Lever Assembly

1. Fuel return line
2. Nozzle holders
3. Capscrews
4. Nozzle assemblies
5. Valve cover
6. Bolts (6)
7. Push rods
8. Bolts (20)

8. Insert 15 inch pry bar at left front side of cylinder head, between indentation of cylinder head and crankcase. Break seal formed by head gasket sealant prior to hoisting. Pry with a rolling motion as shown in Fig. 12. (See NOTE).

NOTE: New style head gaskets with premeasured sealant Figure 40, does not require this procedure.

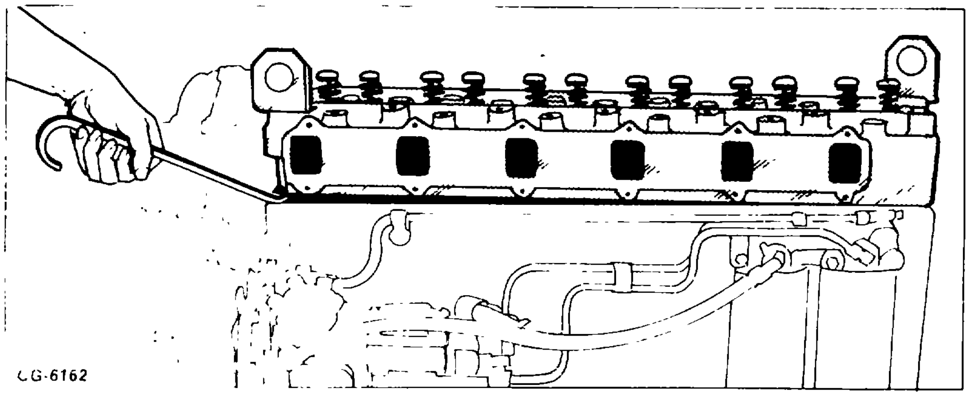


Figure 12. - Roll Pry Head Prior to Hoisting

9. Connect Lifting Beam to cylinder head lifting eyes and remove head from engine as shown in Fig. 13. PLACE HEAD ON WOOD BLOCKS TO PROTECT VALVES AND DECK.

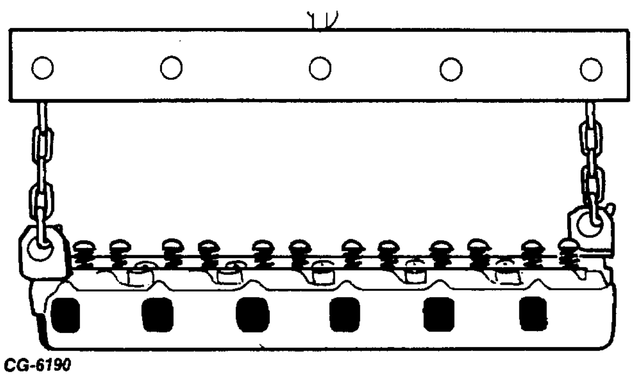


Figure 13. - Adjustable Lifting Beam

NOTE: ***All removals should be accomplished using an adjustable lifting beam. All supporting members (chains and cables) should be parallel to each other and as near perpendicular as possible to the top of the object being lifted.***

Remove Valves as follows:

1. Remove valves (1, Fig.14) with valve spring compressor tool.
   a. Compress valve springs (3).
   b. Remove spring retainer locks (6).
   c. Remove rotators (5) and oil shields (4).
   d. Allow valve to drop out of guide.
   e. If valve DOES NOT drop out, inspect valve stem for burrs. If burr exists, remove with a hone to prevent valve guide damage.
   f. Keep valves in order so reinstallation in original valve guide is assured.

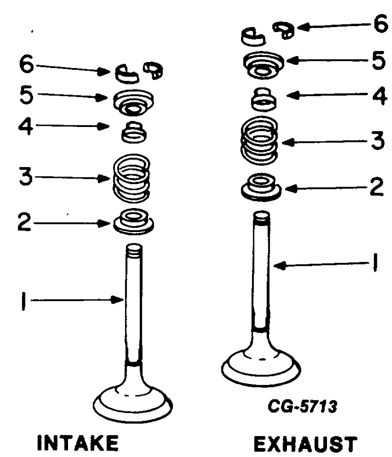


Figure 14. - Valve Components

1. Valve
2. Valve Spring Seat
3. Valve Spring
4. Oil Shield
5. Rotator
6. Valve Spring Lock

CLEANING, INSPECTION & REPAIR

Clean Cylinder Head as follows:

1. Remove deposites from UPPER and LOWER DECK of head. Pay special attention to EXHAUST VALVE PORTS, VALVE SEATS, INJECTION NOZZLE SLEEVES and WATER DIRECTORS.

    a. Use non-caustic solvent and BRASS wire brush to clean bores.

    b. Blow out carbon deposits with compressed air after cleaning. Clean Valves as follows:

1. Remove residue from VALVE SPRINGS, VALVE HEAD, STEM and BORES of VALVE GUIDE.

    a. Clean with suitable solvent and a BRASS wire brush.

    b. Lightly polish valve surface with extremely FINE emery paper.

NOTE: ***DO NOT USE STEEL BRUSHES these will scratch the surface and lead to valve failure.***

Clean Valve Guides as follows:

NOTE: ***Valve guides must be thorougly cleaned prior to valve installation. Preform valve guide bore cleaning on: 1. New service valve guides. * 2. Valve guides installed in new service cylinder heads. 3. Valve guides presently installed in cylinder head, which meet bore specifications.***

Failure to clean valve guide bore can cause premature valve guide wear and in severe conditions, valve breakage.

1. Coat a nylon brush (which has a slightly larger diameter than the I.D. of the valve guide) WITH SOAP AND WATER.

2. Insert brush Into I.D. of valve guide and with a turning motion, run the brush through to insure removal of gum, carbon, deposits and rust preventive from the guide and spiral groove (See Fig. 15).

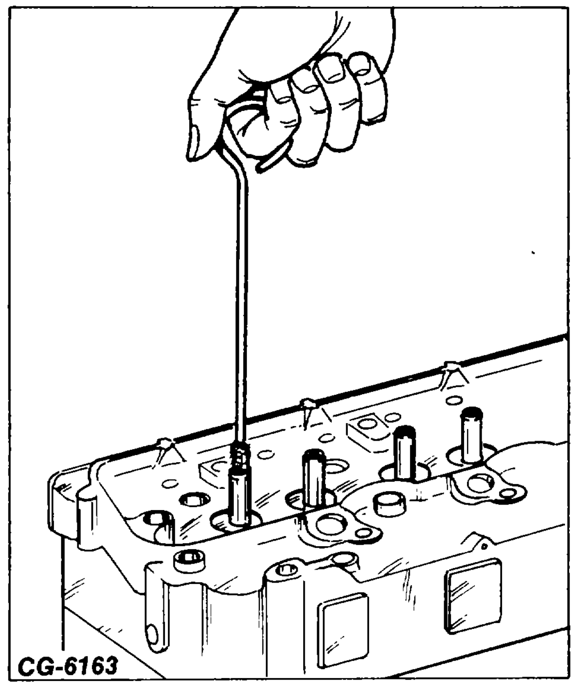


Figure 15. - Cleaning Valve Guide Bores

3. THOROUGHLY coat guide with clean engine oil after cleaning operation is complete.

NOTE: ***When installing valves and retainers do not use grease. Grease may stop the flow of lubricating oil into the valve guide and cause valve guide wear.***

*All valve guides furnished as service parts are reamed to size; however, it is necessary to ream guides to specified size after installation to remove any burrs or slight distortion caused by the pressing operation. BE EXTREMELY CAREFUL NOT TO REMOVE TOO MUCH MATERIAL. **Always** clean guides **after** this operation.

Inspect and Repair Cylinder Head as follows:

1. Visually inspect head for cracks using modern spraying methods.

   a. Spraying WILL expose hair line cracks or sand holes.

   b. Spraying WILL NOT show nozzle sleeve leaks as pressure testing will.

   c. If cracks are found, **replace cylinder head**.

   d. If NO cracks are found, continue with Step 2.

2. Pressure test cylinder head as follows:

   a. Fabricate gasket as shown in Fig. 16. Use 3 mm (1/8 in) rubber.

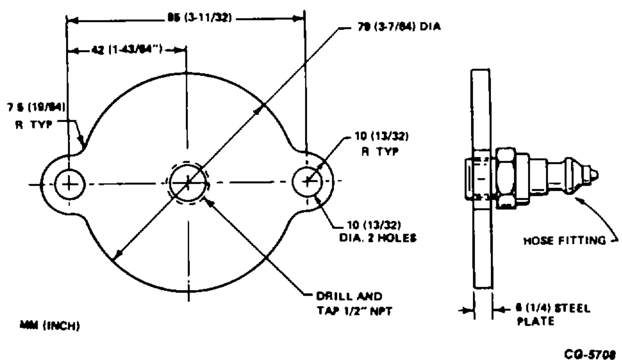


Figure 16. - Thermostat Housing Gasket

   b. Fabricate bottom pressure plate, to cover water directors, as shown in Fig.17 for 300 and 400 series engines. Use 13 mm (1/2 In} aluminum for a permanent plate or plywood of the same dimension for a temporary plate.

   c. Remove valves and install injection nozzles.

   d. Attach fitting to thermostat housing with pressure gauge. Run hot water at 69-83 kPa (10-12 psi) Into head.

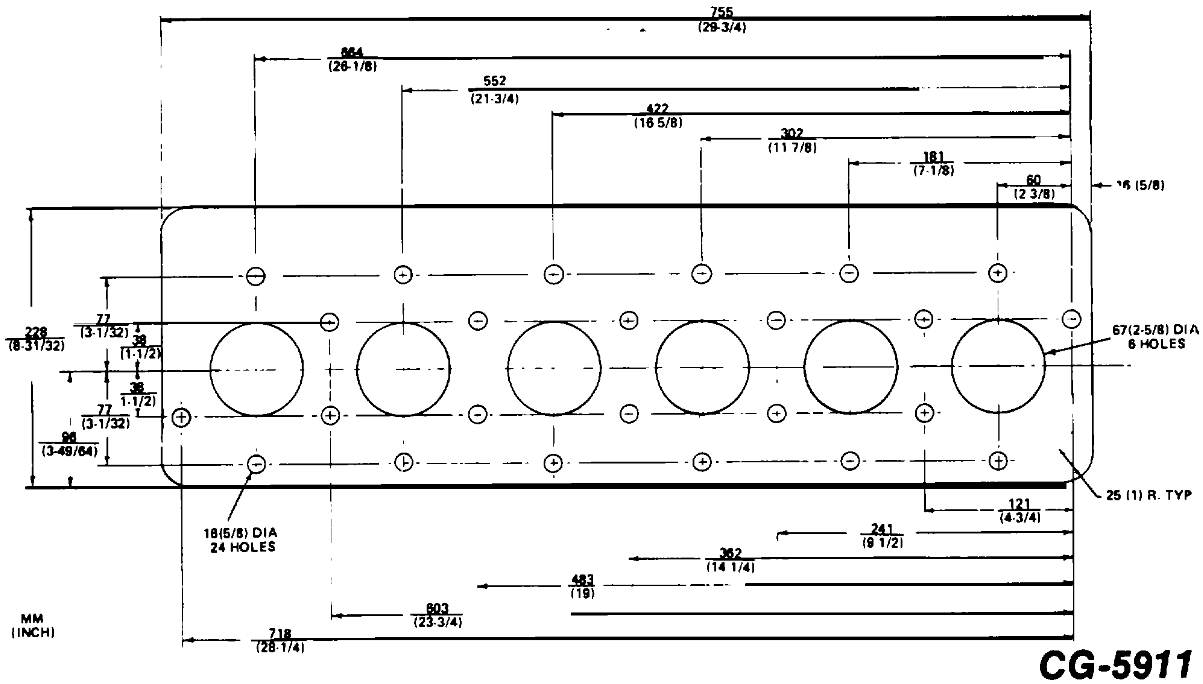
   e. Visually observe head for leakage at:

      1. Injection Nozzle Sleeve Flanges

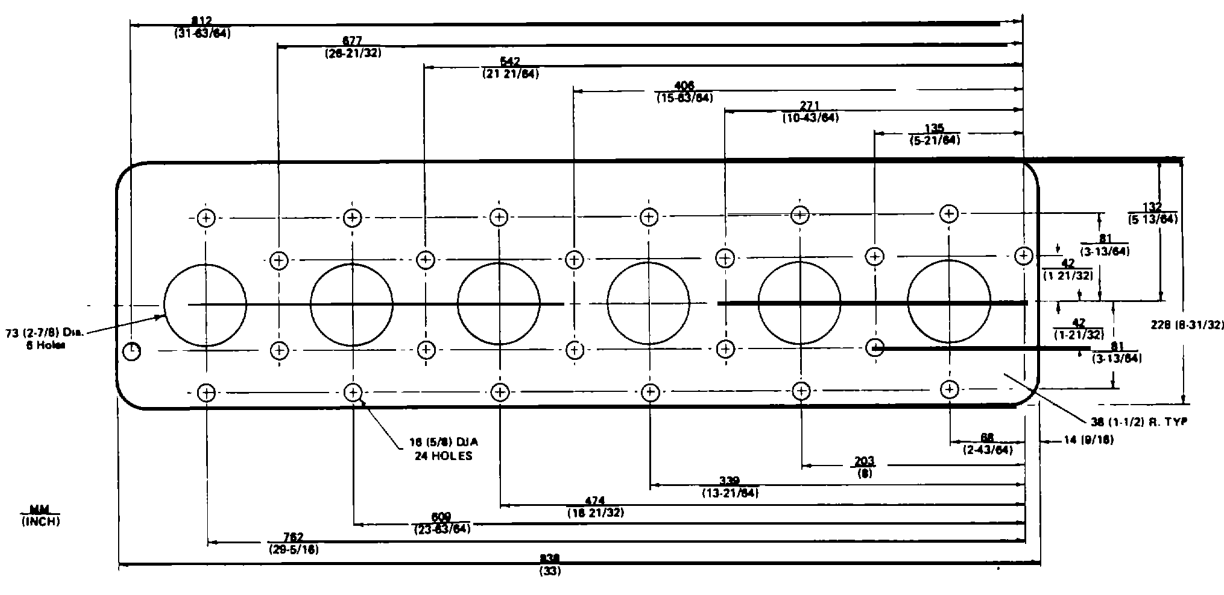
      2. Upper Deck

      3. Lower Deck

      4. Ports



Bottom Pressure Plate for 300 Series Cylinder Head



Bottom Pressure Plate for 400 Series Cylinder Head

Figure 17. - Cylinder Head Pressure Plate Fabrication

3. Inspect lower deck for flatness.

a. Use a straight edge long enough to span both length and width of HEAD. Follow checking pattern shown below.

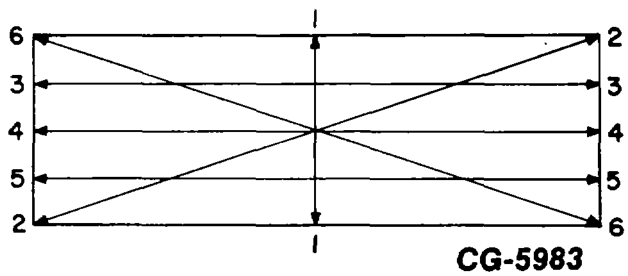


Figure 18. - Cylinder Head Checking Pattern-

b. Insert feeler gauge under straight edge at each check point.

c. Resurface HEAD if 0.15 mm (0.006 in.) feeler gauge can be inserted under straight edge when checking the length or 0.01 mm (0.004 in.) feeler gauge can be inserted under- straight edge when checking width.

NOTE: ***SUDDEN CHANGE IN CONTOUR SUCH AS SCRATCHES, GOUGES ETC. MUST NOT EXCEED 0.05 mm (0.002 in.) IN DEPTH.***

4. Cylinder head resurfacing procedure.

a. With a micrometer, measure distance from upper deck (valve cover seating surface) to lower deck (head gasket contact surface). As shown in Fig. 19.

Minimum Allowable
Deck to Deck Dimension
106.38 mm (4.188 in)

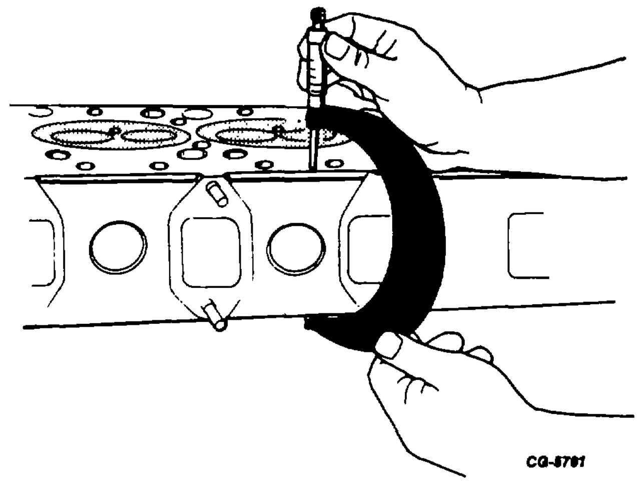


Figure 19. - Measuring Cylinder Head

b. **DO NOT** grind more than 0.25 mm (0.010 in) stock or go below the minimum allowable deck to deck dimension, or a cracked head at the lower deck may result.

c. After head resurfacing, grind valve seats so installed valves meet valve recession specifications of:

0.00 mm (0.000 in)
0.36 mm (0.014 in)

d. With valve assemblies installed, measure valve recession as shown in Fig. 20.

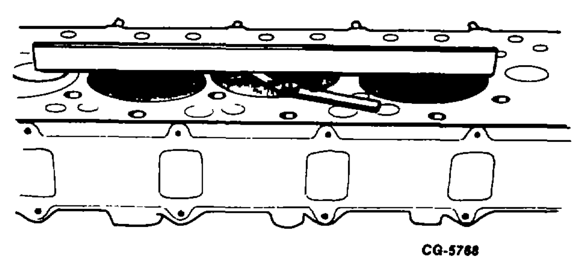


Figure 20. - Measuring Valve Recession

e. Replace valve seat inserts if valve recession exceeds maximum specifications.

5. Inspect NOZZLE SLEEVE BORE for: grease, oil, scale or rust after removing sleeve.

   a. Remove nozzle sleeve (2), Fig. 21) with slide hammer (3) and nozzle sleeve puller adapter (1). (See Tool List for tool number).

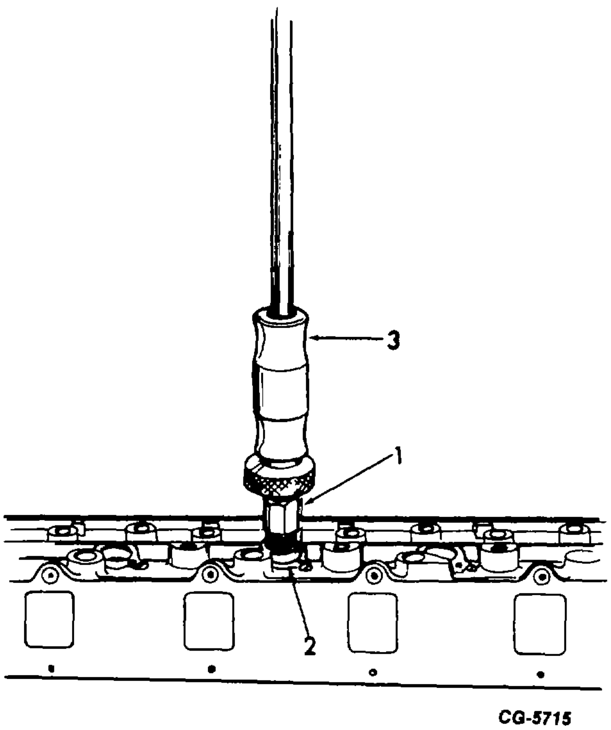


Figure 21. - Removing Nozzle Sleeve

1. Adapter
2. Sleeve
3. Slide hammer

   b. Inspect and clean bore as necessary.

   c. Reinstall injection nozzle sleeves as follows:

1. After cleaning bore, apply locite 262 to upper contact surface of sleeve (A) as shown in Fig. 22.

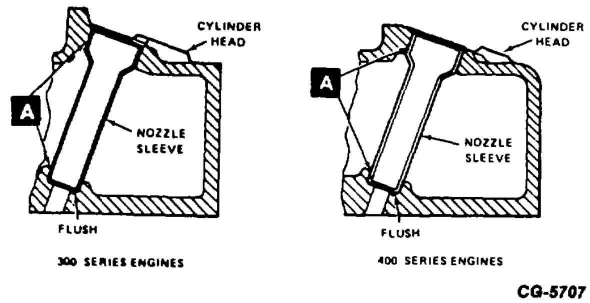


Figure 22. - Nozzle Sleeve Contact Points (Installed View)

2. Place nozzle sleeve (2, Fig. 23) in cylinder head bore. Position installing tool (1) in sleeve as shown in Fig. 22. Keep tool centered and tap squarely with brass hammer until sleeve is bottomed in bore. (See Tool List for tool number).

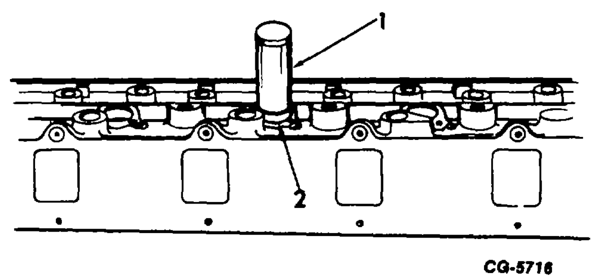


Figure 23. - Nozzle Installing Tool Placement

1. Installing tool
2. Nozzle sleeve

3. Tighten nozzle crab bolts to 27 N-m (20-lbf-ft) torque.

NOTE: ***Nozzle sleeves can be installed without removing the cylinder head.***

6. Inspect cylinder head COOLANT DIRECTORS for RESTRICTIONS or LOOSENESS.

   a. Visually check for RESTRICTIONS.

   b. Tap or pull directors by hand to check for LOOSENESS.

   c. Remove loose or restricted coolant directors. Use a slide hammer (1, Fig. 24) with a small enough jaw to hook under coolant director (2) "opening" as shown in Fig. 24.

   d. New coolant directors should be tapped into place with a small hammer and block. They must be recessed 1.5 mm (.06") below the bottom deck of the cylinder head.

   e. Aim coolant directors at angles shown in Fig. 25.

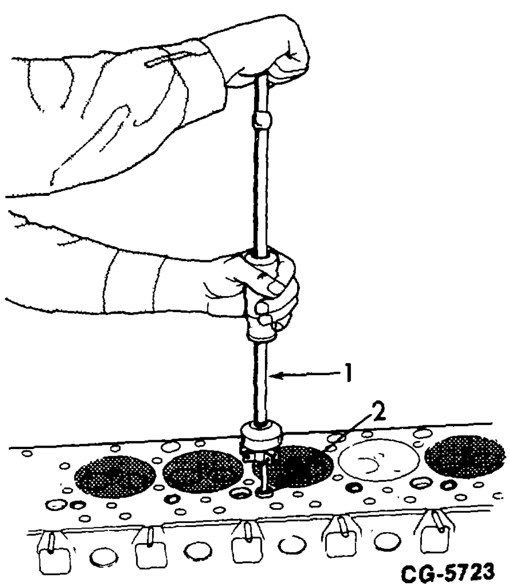


Figure 24. - Coolant Director Removal

1. Slide hammer
2. Water director

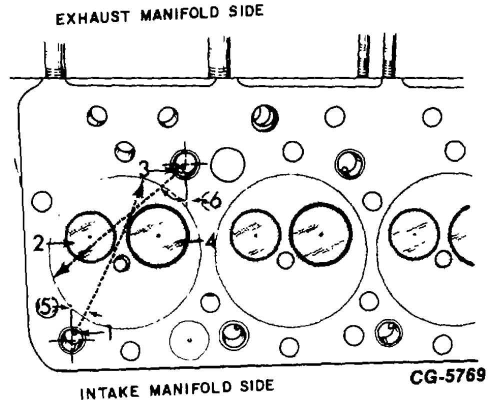


Figure 25. - Aiming Coolant Directors

1. Coolant Director
2. Exhaust Valve
3. Coolant Director
4. Intake Valve
5. 23°Angle
6. 55°Angle

7. Inspect Valve Guides as follows:

   a. After cleaning **ALL** valve guide bores, position a light at bottom of valve guide bore; examine walls for burning, cracking or excessive wear.

   b. Measure I.D. of valve guide at several points. VALVE GUIDE I.D. LIMITS ARE:

   9.500 mm (0.3740 in)
   9.525 mm (0.3750 in)

   c. Replace any guides which are:

      1. Burned
      2. Cracked
      3. Worn Beyond Limits
      4. Without Rifling

   d. Remove valve guides with valve guide remover (see Tool List for tool number).

e. Use valve guide installer (See Introduction for tool list) to install new guide. Keep valve guide recession from cylinder head surface at limits specified below:

NOTE: ***Install valve guides with (internal) threaded portion down. The 30 degree chamfer at the top of the guide is Intended to allow excess oil to drain away from the top of the guide and the threads are intended only to distribute the small amount of oil which enters the guide, not to introduce oil. Inverting the guides can lead to excessive oil consumption.***

300 SERIES

Intake	Exhaust
25.20 mm (0.992 in)	32.31 mm (1.272 in)
25.70 mm (1.012 in)	32.82 mm (1.292 in)

400 SERIES

Intake	Exhaust
30.66 mm (1.207 in)	32.69 mm (1.287 in)
31.17 mm (1.227 in)	33.20 mm (1.307 in)

Inspect and Repair Valves as follows:

1. Visually INSPECT each valve for excessive WEAR, BURN MARKS, WAR- PAGE, PITTING or SCUFFING at:
   a. Valve Stem Grooves.

   b. Valve Stems.

   c. Valve Heads

2. Replace valves which are seriously bent, worn, burnt, warped, pitted or scuffed.

3. Resurface valve face angle, if necessary.

   a. Maintain a minimum valve face margin of 1.73 mm (0.068 in) for intake valves and 1.14 mm (0.045 in) for exhaust valves on 300 Series engines.

   b. On 400 Series engines maintain a minimum valve face margin of 2.24 mm (0.088 in) for intake valve and 1.14 mm (0.045 in) for exhaust valves. See Fig. 26.

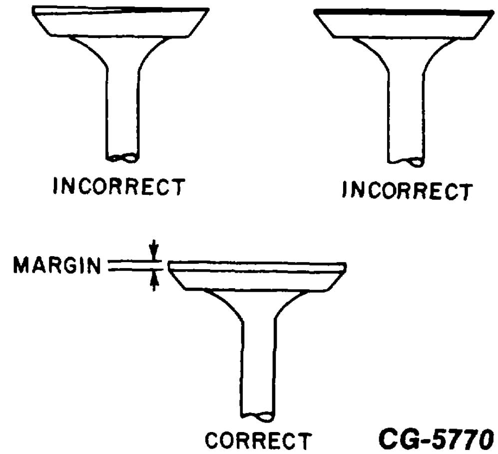


Figure 26. - Examples of Valve Face Margin

   c. Maintain valve face angles as shown in Fig. 27.

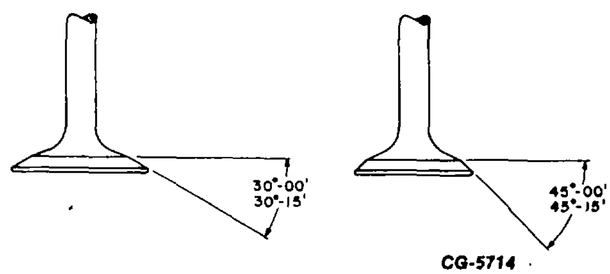


Figure 27. - Valve Face Angles (300/400 Series)

NOTE: ***An incorrect margin will not provide proper heat dissipation and lead to warpage or breakage.***

4. Resurface valve face angle as follows:
   a. Set valve in grinder to desired angle.

   b. Dress the wheel to proper angle.

   c. Take a light cut-off valve face angle surface, as shown in Fig. 28.

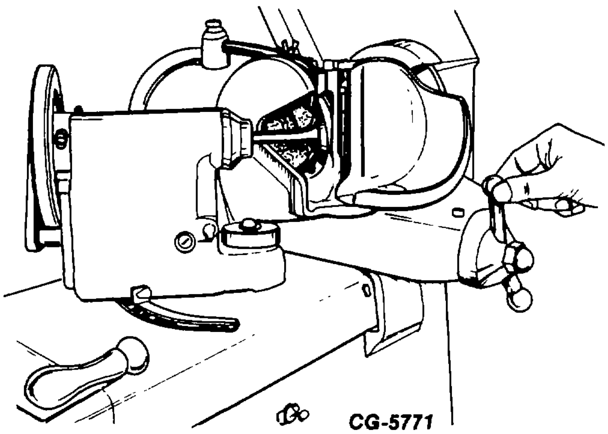


Figure 28. - Grinding Valve Face Angle

d. Replace valve if more than 0.20 mm (0.008 in) stock is removed from valve face angle or if margin falls below minimum specifications.

e. Check valve face runout, after resurfacing, with dial indicator.

f. Replace valve if runout (in reference to valve stem) is greater than 0.05 mm (0.002 in) total variation in dial indicator reading.

g. After resurfacing valves, clean valve guides and check valve face contact with valve seat using Prussion blue as follows:

1. Spread thin film of Prussion blue on valve face. Insert valve into its guide.

2. Apply pressure on exact center of valve head, while making a quarter turn in the seat.

3. Remove valve, inspect impression made on seat and on valve face.

4. Bluing should appear around entire contact surface of valve face and valve seat to be acceptable. CHECK SEVERAL TIMES TO PREVENT ERROR. If acceptable, proceed with valve installation.

5. If bluing **DOES NOT** show around the ENTIRE contact surface of the valve seat, the angles do not match and are UNACCEPTABLE. If this happens, correct by RESURFACING VALVE SEATS; NOT VALVE FACES.

5. Resurface valve seat as follows:

a. Dress the grinding wheel to correct angle. Lightly lubricate and install correct size pilot into valve guide bore.

b. Lower grinder head over pilot shank until wheel barely clears the valve seat. Turn on power. GENTLY apply grinding wheel to valve seat with little pressure other than weight of the wheel.

c. Raise wheel frequently to prevent overheating.

d. Grind seat to a smooth even surface.

e. Check seat concentricity, roundness and valve face contact using Prussion blue as previously outlined.

f. After grinding seats, it may be found that seats are wider than the specified width, as shown in Fig. 29.

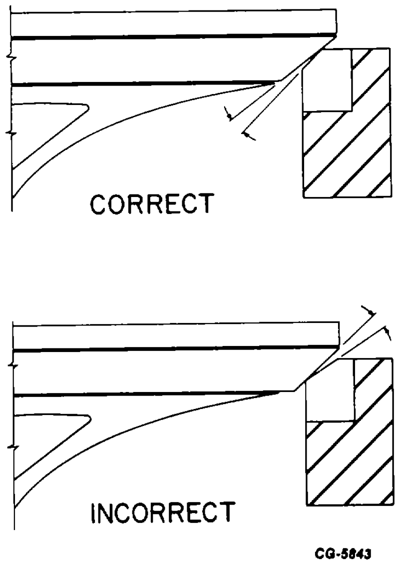


Figure 29. - Valve Seat Width

g. Correct wide valve seats by grinding top edge of seat with a stone mounted on grinder head. The stone must be a smaller angle (preferably 1 5 degrees) than the valve seat.

NOTE: ***If valve does not seat properly after resurfacing valve seats, replace valve seats.***

6. Replace valve seat as follows:

   a. Remove valve seats with a slide hammer and expanding screw with pre-cup puller. Two pre-cup pullers are available for service one for intake, one for exhaust valves. (See Tool List for tool numbers).

   b. Clean counterbore (in head), to assure proper valve seat mating and good heat transfer.

   c. If right fit is **NOT** assured between mating surfaces of valve seat and cylinder head counterbore, install oversize valve seat inserts as follows:

      1. Take a light cut from bottom of insert counterbore in cylinder head to dimensions shown in the valve seat insert chart for correct fit.

      2. Maintain radii shown in Fig. 30 when enlarging counterbore for oversize inserts.

VALVE SEAT INSERT CHART (OVERSIZE)

		DIAMETER OF CYLINDER HEAD COUNTERBORE*	
Engine	**Oversize Insert**	**Intake**	**Exhaust**
Naturally Aspirated	002 in	None	38.96-38.99 mm (1.534-1.535 in)
312 and 360	**.005 in	None	3904-39.07 mm (1 537-1.538 in)
	015 in	None	39.29-39 32 mm (1.547-1.548 in)
	.002 in	45.19-45.21 mm (1.779-1.780 in)	38.96-38.99 mm (1.534-1.535 in)
Turbocharged 360	**.005 In	45.26-45.29 mm (1.782-1.783 in)	39.04-39.07 mm (1 537-1.538 in)
	.015 in	45.52-45.54 mm (1.792-1.793 in)	39.29-39.32 mm (1.547-1 548 in)
All 414,	.002 in	50.75-50.77 mm (1.998-1.999 in)	41.30-41.33 mm (1.626-1.627 in)
436 and 466	**.005 in	50.83-50.85 mm (2.001-2.002 in)	41.38-41 40 mm (1.629-1.630 in)
	.015 in	51.08-51 10 mm (2.011-2.012 in)	41.63-41.66 mm (1.639-1.640 in)

*It is not necessary to enlarge the Insert counterbore before Installing the standard size Insert.
** .005 Inch oversize Insert is no longer available for service.

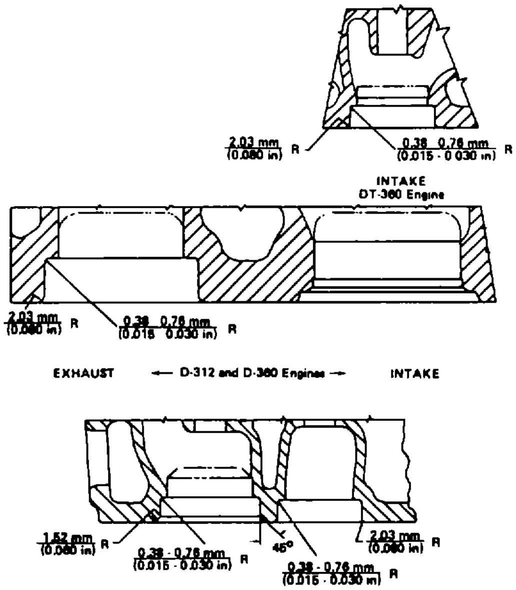


Figure 30. - Valve Seat and Insert Counterbore Radii

d. Install valve seat inserts as follows:

1. Chill valve seat inserts and driver tool in dry ice or Liquid Freon for one-half hour before installing.

NOTE: ***Chilling will prevent metal scraping at counterbore, ensuring maximum contact of mating surfaces.***

2. Align insert to avoid cocking.

3. Press insert into cylinder head using an arbor press and insert driver as shown in Fig. 31. Exert an even pressure of 2225 N•m (500 lbf-ft) for five (5) seconds to assure proper seating.

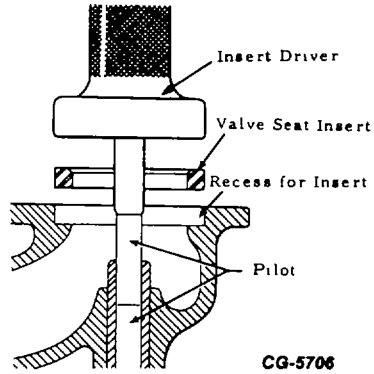


Figure 31. - Installing Insert

4. Properly seated, insert should be recessed into head as shown in Fig. 32.

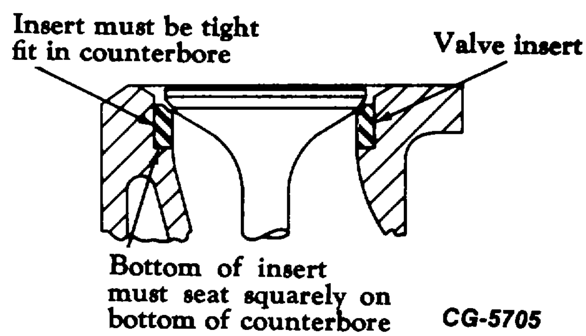


Figure 32. - Insert Properly Installed

Inspect Valve Springs as follows:

1. Clean all valve springs and valve spring seats in a suitable solvent.

2. Examine springs and seats for rust, pitting and cracks.

3. Test valve spring tension using a spring test loader (see Tool List for tool number) as follows:

MEASURE VALVE SPRING FREE LENGTH

a. Free Length: 59.4 mm (2.34 in.)
b. Insert valve spring into spring test loader, as shown in Fig. 33.

MEASURE MAXIMUM SPRING LENGTH IN USE (VALVE CLOSED)

c. Maximum length in use:

50.98 mm @ 294 to311 N
(2.007 in) (66 to 70 lbs.)

MEASURE MINIMUM SPRING LENGTH IN USE (VALVE OPEN)

d. Minimum length in use:

39.42 mm 694 to 730 N
(1.552 in.) @ (156-164 lbs.)

4. Replace any spring which is rusted, pitted, cracked or incapable of meeting tension requirements set forth.

NOTE: ***Valve spring tension can be tested in a spring tester or while assembled on the engine.***

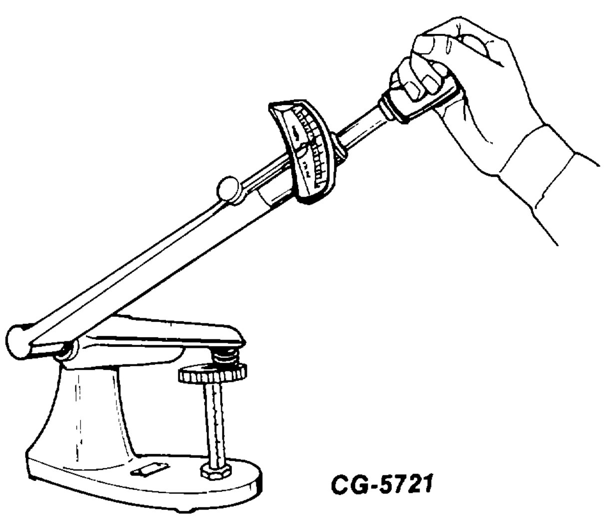


Figure 33. - Testing Valve Springs

Inspect Valve Spring Locks as follows:

1. Clean valve spring locks in a suitable solvent.

2. Check inside ribs of lock for wear which may cause looseness.

3. Check outside of locks for wear which might allow valve spring retainer to slide over lock.

NOTE: ***Wear on outside surface of locks can be caused by overspeeding engine.***

4. Replace any worn locks.

Inspect Valve Rotators (Roto Coil) as follows:

1. To properly test the rotator for function, a valve spring load must be applied to the rotator.

2. Place the valve spring, with the roto coil, in the spring tester. Place a bearing ball between the roto coil and ram of the spring tester, as shown in Fig. 30.

3. Compress valve spring and observe roto coil as it turns counterclockwise.

4. Replace any roto coil which does NOT turn.

5. Check oil seal (if equipped) for wear and replace if necessary.

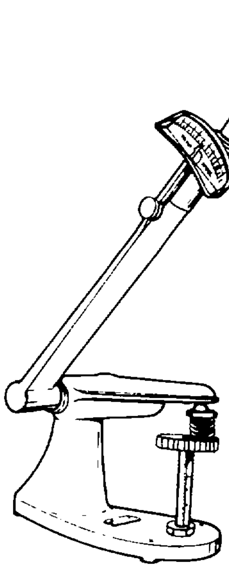


Figure 34. - Testing Valve Rotator

Reassemble Valves, Valve Lever and Shaft Assembly as follows:

1. Coat valve stems with clean engine oil (SAE 50) prior to inserting them from the bottom of the head.

2. Return each valve and its parts to the position from which it was removed.

3. Place spring seat, spring and roto coil (see NOTE) on valve stem.

NOTE: ***Roto coil is equipped with an oil seal, the lower valve keeper groove (on valve) must be cut at a 45 degree angle as shown in Figure 35***

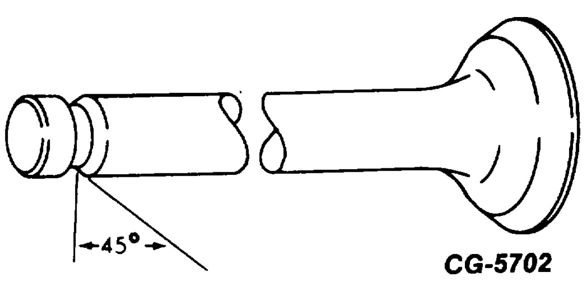


Figure 35. - Valve Keeper Groove

4. With a valve spring compressor, compress the spring far enough to install the valve locks in the keeper groove (Fig.35).

5. If necessary, press replacement cap plugs into each end of the shaft, (4, Fig.36).

6. With side of shaft (4) marked "TOP" up and bolt grooves toward assembler, slide one spring (3) to the center of the shaft.

7. Slide a rocker arm (1) into the shaft on each side of the spring, with the adjusting screw towards the assembler.

8. Slide a support bracket (2) onto the shaft from each end of the shaft to the rocker arm. The tapped hole in each bracket must be to the top and the through bolt holes must line up with the notched side of the shaft.

9. Slide all remaining parts on the shaft, observing the order shown in Fig. 36. Install the snap rings (5) into the grooves at each end of the shaft.

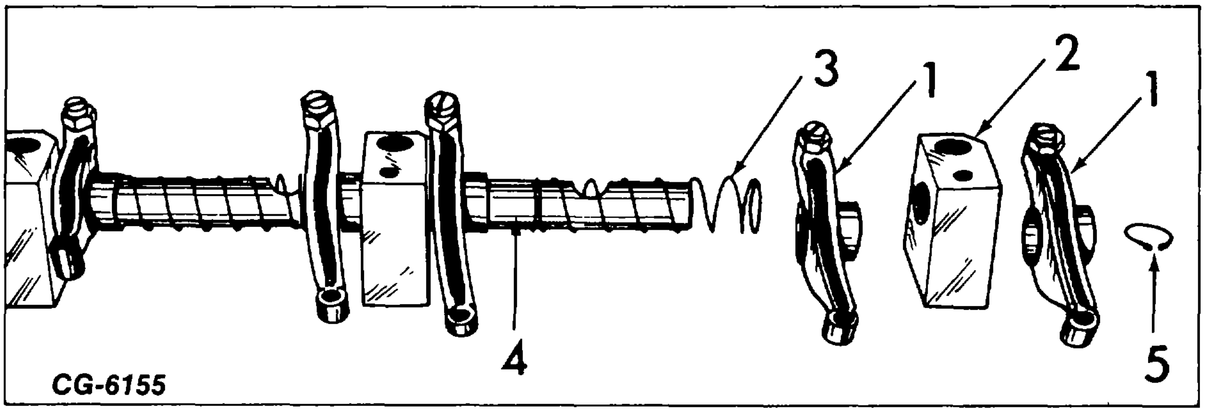


Figure 36. - Valve Lever and Shaft Assembly

1. Rocker arm
2. Support bracket
3. Spring
4. Shaft
5. Snap ring

Valve Lash Adjustment

NOTE: ***DO NOT adjust valves with the engine running. Severe damage can result from inserting feeler gauge between valve and valve lever due to close clearance of valve to piston.***

NOTE: ***Valve lash may be adjusted as a separate operation without cylinder head and valve lever removal, disassembly, cleaning, inspection or repair as previously described.***

All valves are adjusted by cranking the engine only twice.

Perform valve lash adjustment with the engine "warm" which means any temperature above freezing.

-IMPORTANT-

The Valve Lash Adjustment Chart reflects specification changes which result from the revised intake ramp height of the 400 Series Camshaft. The intake valve lash specification has been increased from .51 mm (0.020 in.) to .64 mm (0.025 in.). A common valve lash setting of 0.025 in. now exists for both intake and exhaust valves on 400 Series Engines (see Valve Lash Adjustment Chart).

Adjust Valve Lash as Follows:

1. Remove the valve cover. Turn the crankshaft until the number one piston is on the compression stroke and the timing pointer on the front cover is in line with the TDC mark (pin) on vibration damper or flywheel (as shown in Fig. 37).

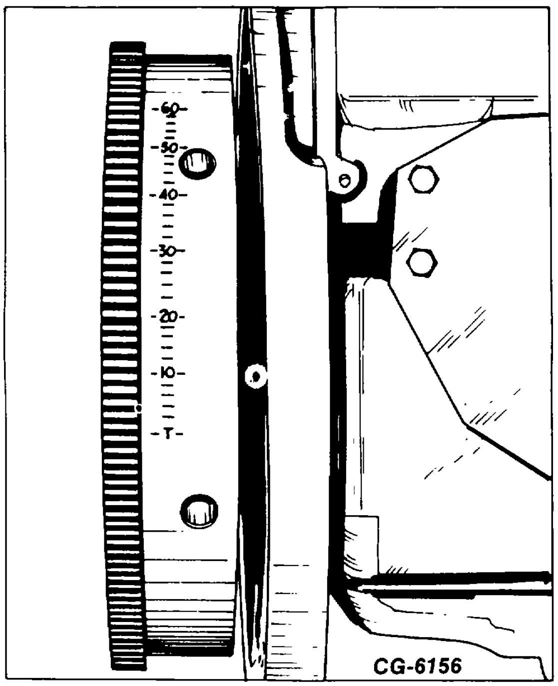


Figure 37. - Timing Marks on Flywheel

NOTE: ***Be sure that the number one piston is on the compression stroke by turning both push rods by hand to determine that both valves are closed. Valves are closed when push rods are loose and can be turned easily.***

2. Six valves are adjusted when the No. 1 piston is at TDC (compression) and the remaining six are adjusted when the No. 6 piston is at TDC (compression). As depicted in Fig. 38 odd numbered valves are intake valves; and even numbered valves are exhaust valves.

3. Valve tappet clearance (lash) is specified in Valve Lash Adjustment Chart (located in this section).

NOTE: ***When tightening head bolts, place a .005" feeler gauge between the outside brackets and the rocker levers to prevent binding.***

4. Replace the valve cover (see INSTALLATION in this Section).

WITH	ADJUST VALVES											
No. 1 Piston at T.D.C. (Compression)	INT 1	EXH 2	INT 3			EXH 6	INT 7			EXH 10		
No. 6 Piston at T.D.C (Compression)				EXH 4	INT 5			EXH 8	INT 9		INT 11	EXH 12

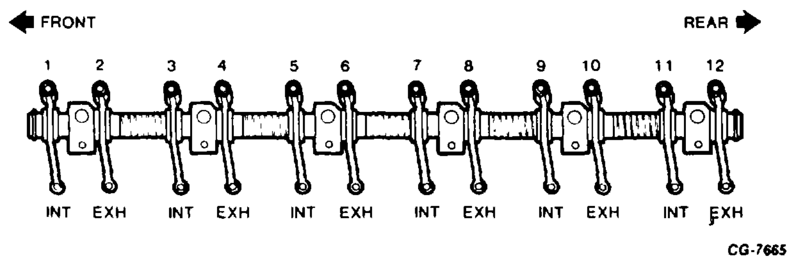


Figure 38. - Valve Arrangement (300/400 Series)

VALVE LASH ADJUSTMENT CHART

ENGINE	ENGINE Serial No.	INTAKE mm (in.)	EXHAUST mm (in.)
D-312	2504 and below	0.30 (0.012)	0.53 (0.021)
D-312	2505 and above	0.41 (0.016)	0.53 (0.021)
D-360 and DT-360	All Engines	0.30 (0.012)	0.53 (0.021)
D-414	126953 and below	0.51 (0.020)	0.64 (0.025)
D-414	126954 and above	0.64 (0.025)*	0.64 (0.025)
DT-414 and DT-414B	149604 and below	0.51 (0.020)	0.64 (0.025)
DT-414B	149605 and above	0.64 (0.025)*	0.64 (0.025)
D-436	83591 and below	0.51 (0.020)	0.64 (0.025)
D-436	83592 and above	0.64 (0.020)*	0.64 (0.025)
DT-436 and DT-436B	114240 and below	0.51 (0.020)	0.64 (0.025)
DT-436B	114241 and above	0.64 (0.025)*	0.64 (0.025)
D-466	54340 and below	0.51 (0.020)	0.64 (0.025)
D-466	54341 and above	0.64 (0.025)*	0.64 (0.025)
DT-466, DT-466B and DTI-466B	110913 and below	0.51 (0.020)	0.64 (0.025)
DT-466B and DTI-466B	110914 and above	0.64 (0.025)*	0.64 (0.025)
DT-466C and DTI -466C	400 001 and above	0.64 (0.025)*	0.64 (0.025)

*New intake valve lash specification for engines equipped with a revised camshaft.

ENGINE GEAR TRAIN TIMING

Valve train failures from broken or bent push rods, valves, rocker arms and worn valve keepers and/or rotators in many instances have been found to be caused by improper timing of the gear train. Depending on valve lash setting, if the camshaft gear is improperly timed by one (1) tooth early, the engine pistons will strike the intake valve heads or if the timing is set one (1) tooth late, the exhaust valve may contact pistons.

IN ALL CASES OF THE ABOVE, GEAR TRAIN TIMING CAN BE VERIFIED WITHOUT REMOVAL OF ENGINE FRONT COVER AND/OR TEAR DOWN.

IMPORTANT: The revised intake ramp height of the new 400 Series Camshaft requires the engine gear train timing specification be increased from .60 mm (0.024 in.) to .74 mm (0.029 in). Two methods are available when checking engine gear train timing without removal of front cover and/or engine tear down.

CHECKING ENGINE GEAR TRAIN TIMING WITHOUT REMOVING FRONT COVER AND/OR ENGINE TEAR DOWN.

METHOD ONE - USING A FEELER GAUGE

1. Adjust the No. 1 intake valve with the No. 1 piston set at TDC (Top Dead Center) compression stroke as follows:

ENGINE GEAR TRAIN TIMING SPECIFICATION CHART

Engine	Engine Serial No.	No. 1 Intake Valve Setting With No. 1 Piston @ TDC (Compression) [mm (in.)]
D-312	2504 and below	0.40 (0.016)
D-312	2505 and above	0.50 (0.020)
D-360 and DT-360	All Engines	
D-414	126953 and below	0.60 (0.024)
D-414	126954 and above	0.74 (0.029)’
DT-414 and DT-414B	149604 and below	0.60 (0.024)
DT-414B	149605 and above	0.74 (0.029)*
D-436	83591 and below	0.60 (0.024)
D-436	83592 and above	0.74 (0.029)*
DT-436 and DT-436B	114240 and below	0.60 (0.024)
DT-436B	114241 and above	0.74 (0.029)*
D-466	54340 and below	0.60 (0.024)
D-466	54341 and above	0.74 (0.029)*
DT-466, DT-466B and DTI-466B	110913 and below	0.60 (0.024)
DT-466B and DTI-466B	110914 and above	0.74 (0.029)*
DT-466C and DTI-466C	400 001 and above	0.74 (0.029)*

*New valve timing adjustment specification for engines equipped with revised camshaft.

2. Turn the engine forward to approximately BDC (Bottom Dead Center).
3. Place a 0.10 mm (.004 in.) feeler gauge between the valve lever and valve stem of the No. 1 intake valve and slowly rotate the engine forward until the feeler gauge becomes tight. This is now the point at which the No. 1 intake valve starts to open before top dead center. The following degree readings should be read on either vibration damper or flywheel depending on the application.

Engines	Readings
D-312 Below Eng. S/N 2505	30° ± 3°
D-312 Eng. S/N 2505 and Above	23° ± 3°
D-360 and DT-360	30° ± 3°
All 400 Series Engines	24° ± 3°

NOTE: One (1) tooth "out of time" on gear train equals approximately 11 degrees movement of vibration damper.

NOTE: If the timing on the No. 1 valve is within specifications, the other valves barring extreme camshaft lobe wear or poor adjustment will also be in time.

4. Readjust the No. 1 intake valve to its proper lash as described in this section.
5. If timing is found to be incorrect, removal of the engine's front cover is required to inspect punch mark and gear tooth position. Figure 39 depicts a properly timed assembly and number of teeth between marks.

. Crankshaft Gear
2. Idler Gear
3. Camshaft Gear
4. Injection Pump Drive Gear
5. Tachometer Drive Gear (if equipped)

(3–5: UTDS* Model 100 Fuel Injection)

6. Injection Pump Drive Gear

(5–6: Robert Bosch Fuel Injection Model MW)

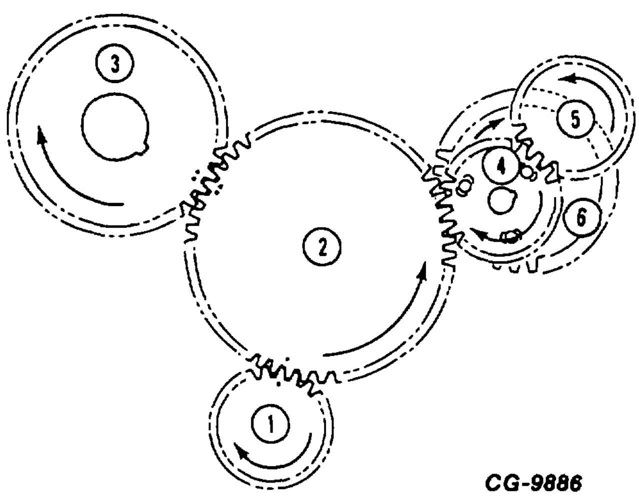


Figure 39. - Properly Timed Gear Train Assembly

22.5 TEETH BETWEEN PUNCH MARK 1 AND PUNCH MARK 2.

CG-9885

*United Technologies Diesel Systems (formerly AMBAC)

CHECKING ENGINE GEAR TRAIN TIMING

METHOD TWO USING A DIAL INDICATOR

1. Adjust the No. 1 intake valve with the No. 1 piston set at TDC (Top Dead Center) compression stroke as specified in Engine Gear Train Timing Specification Chart located under Method One.

2. Position the dial indicator fixture magnetic base on the valve cover fence rail with the indicator shaft on the No. 1 intake valve rotator.

3. Set dial indicator at zero.

4. Rotate the engine approximately one full revolution either direction to a position of 360’ from starting point.

5. Read the dial indicator. The following readings indicate proper gear train timing:

300 Series Engines	4.5 mm to 6.0 mm (.180 in. to .240 in.)
400 Series Engines	3.9 to 5.5 mm (.155 to .220 in.)

6. If dial indicator readings are outside the specified range, the engine’s front cover must be removed and punch mark and gear tooth position adjusted as specified in Figure 39.

IMPORTANT: Engine Gear Train Timing and Valve Lash Adjustment Procedure must be performed as described in this section. Following these procedures will assure proper valve and piston relationship and prevent pistons from striking valves.

INSTALLATION

Install Cylinder Head and Valves as follows:

1. Clean and dry cylinder head gasket surfaces.

2. Blow out cylinder head bolt holes with compressed air to prevent hydrostatic lock and possible block cracking when bolts are torqued.

3. Prior to cylinder head installation check cylinder sleeve protrusion (as described in Section 5).

   If protrusion above crankcase is not

   0.05 mm (0.002 in)
   0.13 mm (0.005 in),

   remove sleeve and follow counterboring procedure as described in Section 5.

4. Install NEW cylinder head gasket with premeasured sealant as shown in Fig. 40.

NOTE: *DO NOT use gasket cement. Heat transfer may be adversely affected.*

5. Install valve lever and shaft assembly on cylinder head following procedure outlined in this Section.

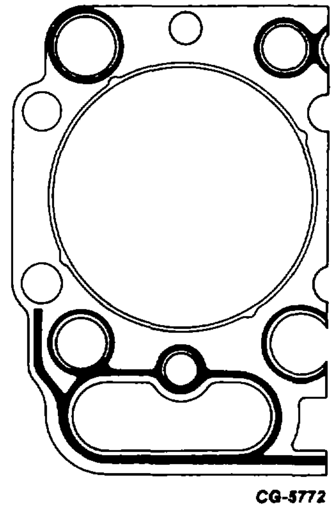


Figure 40. - Head Gasket with Pre-Measured Sealant

6. Use a hoist and sling to place and align head on crankcase dowels. MAINTAIN GASKET ALIGNMENT.

7. Using an accurate torque wrench, torque cylinder head bolts in three stages, following the procedure in Figure 41.

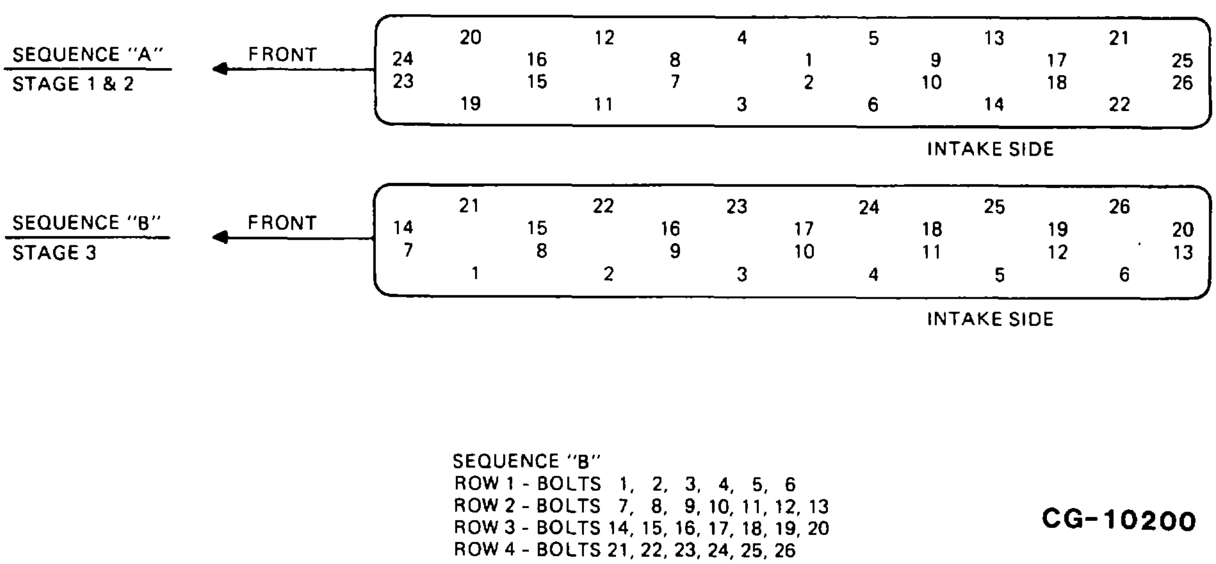


Figure 41. - Sequence for Tightening Cylinder Head Bolts

PROCEDURE

Tighten cylinder head bolts following the assembly steps listed:

1. Lubricate bolt threads, bolt head seating areas and washers (where applicable) with clean engine oil.

2. Tighten bolts in three (3) stages: Stage 1 Following sequence "A" tighten bolts to 150 N-m (110 Ibf-ft).

   Stage 2 Following sequence "A" tighten bolts to 210 N-m (155 Ibf-ft).

   Stage 3 Following sequence "B" tighten bolts, in rows, to 225 N•m (165 Ibf-ft).

NOTE: ***DO NOT back bolt off, "pull up" to torque level indicated.***

IMPORTANT: This procedure accommodates both old and new style cylinder head bolts.

NOTE: ***Check the two end rocker arms for freedom of motion after torquing first stage.***

8. Adjust valve lash following procedure described in this Section.

9. Adjust valve timing following procedure described in this Section.

10. Install valve cover as follows:

    a. Replace old packing rings with new under valve cover bolt washers to avoid oil leaks.
    b. Replace old valve cover gasket with a new gasket to assure an oil tight seal.
    c. Tighten the bolts to 3 N•m (26 Ibf-in.).

11. Install and connect leak lines to injection nozzle holders.

12. Using a new gasket, install and secure thermostat and thermostat housing to cylinder head. Secure hoses.

13. Using new gaskets install intake and exhaust manifolds as described in Section 2.

14. Reconnect fuel lines to injection nozzles and pump. Torque fittings to 47 N•m (35 Ibf-ft).

15. Fill cooling system to proper level (see Operator's Manual).

16. Operate engine under load for at least one hour, to bring it up to normal operating temperature (see ENGINE RUN IN SCHEDULE in Section 5).

17. After removal of cylinder head and replacement of a new cylinder head gasket, cylinder head bolts must be re-torqued and valve adjustments re-checked following the first hour of operation. (Refer to Fig. 41 for torquing sequence).

IMPORTANT: "New Style" cylinder head bolts with flange heads must NOT be intermixed with "Old Style" bolts and hardened washers. "New Style" bolts <u>DO</u> <u>NOT</u> use washers.

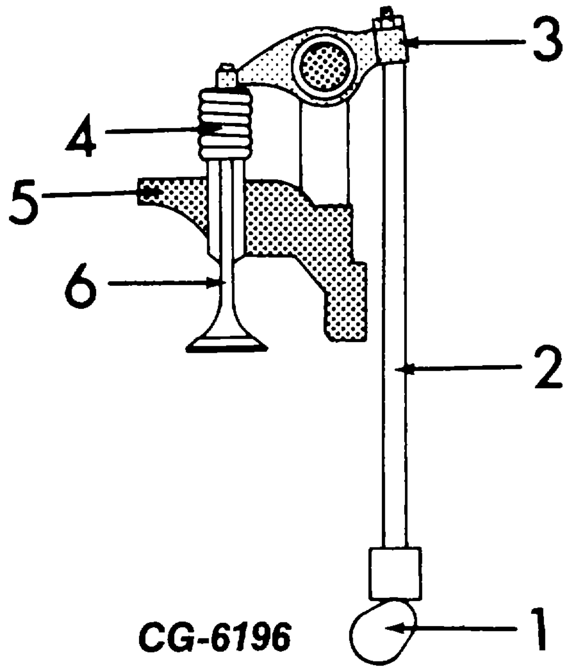


Figure 1. - Valve Train Assembly

1 - Cam
2 - Push rod
3 - Rocker arm
4 - Valve spring
5 - Cylinder head
6 - Valve

GENERAL

With the crankcase front cover removed the gear train becomes visible. The camshaft gear (1, Fig. 2) has twice as many teeth as the crankshaft gear (2), as shown.

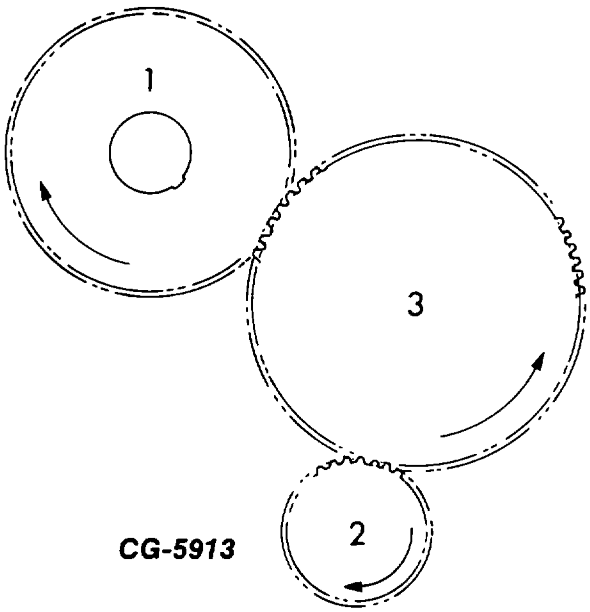


Figure 2. - Gear Train

1. Camshaft Gear
2. Crankshaft Gear
3. Idler Gear

Therefore, the camshaft rotates at one-half of the crankshaft speed due to the requirement to open and close the valves to each cylinder once for every two revolutions of the crankshaft.

The camshaft bearings are pressure-lubricated and have holes drilled in them. When the bushings (2, Fig. 3) are installed, the oil holes must align with the ones drilled in the crankcase (1). The oil hole in the rear bearing permits lubricating oil to travel to the valve lever mechanism.

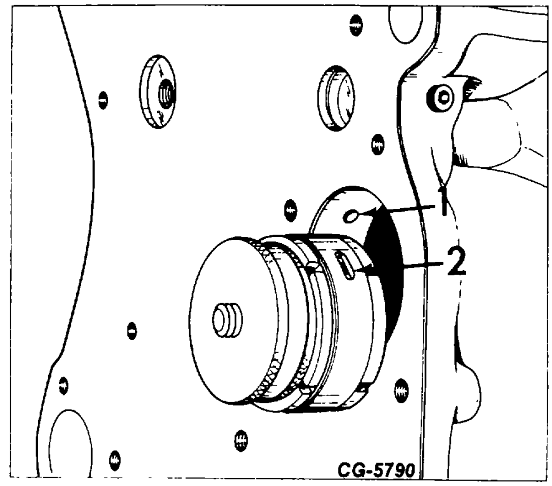


Figure 3. - Camshaft Lubrication

1. Drilled Oil Hole in the Crankcase
2. Bushings

400 SERIES TAPPET REVISIONS WHICH OCCURRED IN PRODUCTION

I. REVISED 400 SERIES TAPPET WITH INCREASED DIAMETER (Refer to Fig. 7).

The revised tappet measuring 28.4480/ 28.4353 mm (1.1200/1.1195 in.) has been released into production and service for all 400 Series Diesel Engines. The new tappet provides improved tappet life. The following changes occurred to accommodate the larger tappet:

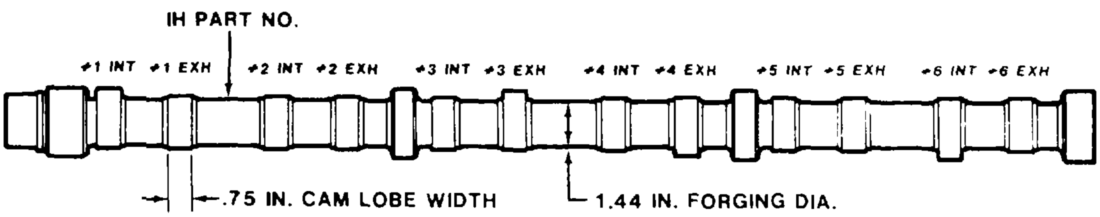
- Introduce a revised camshaft with a wide cam lobe and increased forging diameter (see Fig. 6).
- Introduce a revised crankcase by increasing the tappet bore diameter (see Section 6, Figure 4).

400 SERIES CAMSHAFT REVISIONS WHICH OCCURRED IN PRODUCTION

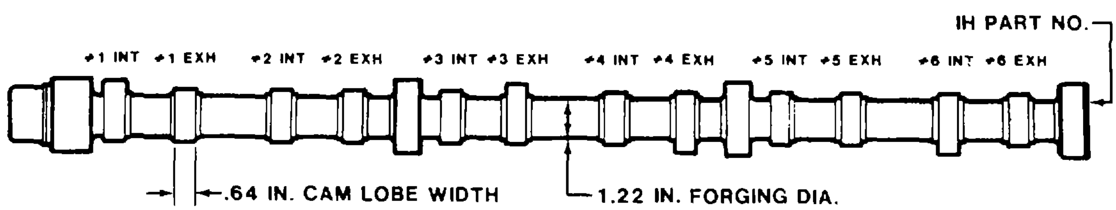
I. Revised Intake Ramp Height

The revised intake ramp height of the camshaft requires the engine gear train timing adjustment specification and intake valve lash specification be changed.

IMPORTANT: Refer to Section 3 for current engine gear train timing and valve lash adjustment specifications and procedures.



NEW STYLE CAMSHAFT (IH Part No. 1802337C1)*



DISPLACED STYLE CAMSHAFT (IH Part No. 691488C1)*

*NON-SERVICEABLE PART NO.CG-7912

Figure 6. - Camshaft Identification

II. Increased Cam Lobe Width and Forging Diameter

To accommodate the increased diameter tappet the camshaft with 19.05 mm (0.75 in.) wide cam lobe and 36.58 mm (1.44 in.) forging diameter has been released into production and service replacing the old camshaft with 76.26 mm (0.64 in.) wide cam lobe and 30.99 mm (1.22 in.) forging diameter. [Refer to Figure 6].

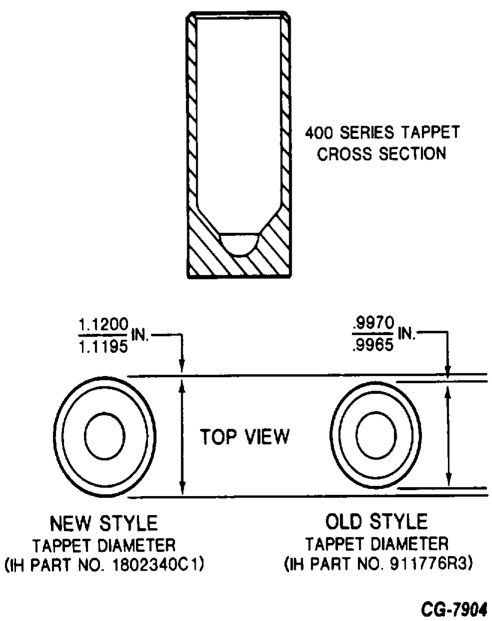


Figure 7. - Tappet Identification

IMPORTANT: Both New Camshaft (IH P/N 1 802 337 C1) and Displaced Camshaft (IH P/N 691 488 C1) have the revised intake ramp height providing a common intake and exhaust valve lash of 0.64 mm (0.025 in.)

Engines built with and after the following serial numbers incorporate the new style tappets and crankcase:

ENGINES	SERIAL NUMBER
D-414	Not Yet Available
D-436	Not Yet Available
D-466	Not Yet Available
DT-414B	155805
DT-436B	121623
DT-466B	140086
DT-466C	400001

Engines built with and after the following serial numbers incorporate the new style camshaft:

ENGINE	SERIAL NUMBER
D-414	Not Yet Available
D-436	Not Yet Available
D-466	Not Yet Available
DT-414B	156104
DT-436B	121816
DT-466B	140841
DT-466C	400001

The following is a list of acceptable combinations of camshafts, crankcases and tappets:

OLD STYLE CAMSHAFT	NEW STYLE CAMSHAFT	OLD STYLE CRANKCASE	NEW STYLE CRANKCASE	OLD STYLE TAPPET	NEW STYLE TAPPET
X		X		X	
X			X		X
	X		X		X
	X	X		X	

400 Series Valve Train Service Parts:

The 400 Series Engine Valve Train Service Package is available for service on 400 Series Engines built PRIOR to the Tappet and Crankcase Revisions incorporated in the following production engines:

CHART I

Engine	Engine Serial Number
D-414	Not Yet Available
D-436	Not Yet Available
D-466	Not Yet Available
DT-414 and DT-414B	155 805 and Above
DT-436 and DT-436B	131 623 and Above
DT-466, DT-466B and DTI-466B	140 086 and Above
DT-466C and DTI-466C	400001 and Above

Installation of the Valve Train Service Package on engine built prior to Engine Serial Numbers listed in Chart 1 will provide the same improved valve train lubrication and cam lobe and tappet durability as current production engines. For convenience in servicing the subject engines, a Valve Train Service Package (IH Part No. 1 802 464 C91) is available. In addition to this package, Camshaft Service Package (IH Part No. 1 802 339 C92), which is the normal Camshaft Service Package for all 400 Series Engines, must also be ordered. ALL PARTS IN BOTH PACKAGES MUST BE USED FOR ENGINES WITH ENGINE SERIAL NUMBERS BELOWTHOSE LISTED IN CHART 1.

IMPORTANT

THIS IS NOT A MANDATORY CHANGE! VALVE TRAIN SERVICE PARTS ARE AVAILABLE FOR THOSE CUSTOMERS WHO OPT FOR SUCH CHANGES.

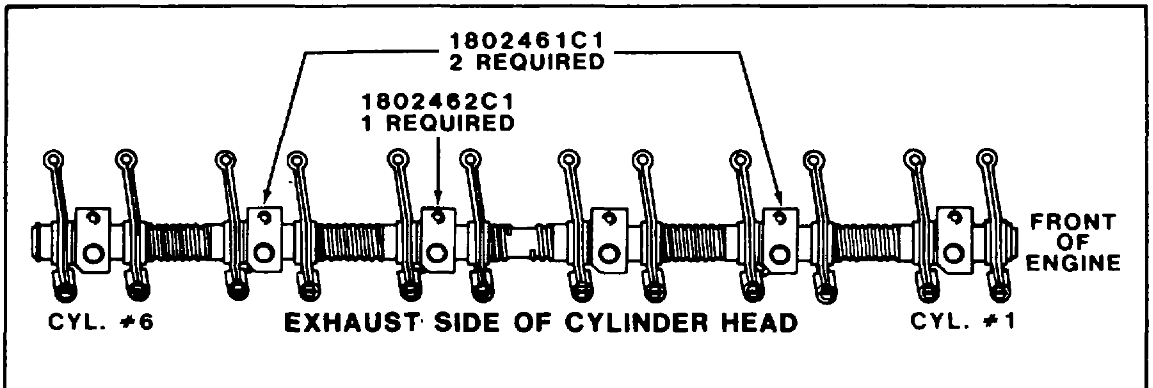
VALVE TRAIN SERVICE PACKAGE
IH PART NO. 1 802 464 C91
(Refer to Figure 8a)

Part Number	Description	Quantity
1 802 461 C1	Rocker Arm Bracket Assembly (For Cylinders No. 5 and No. 2)	2
1 802 462 C1	Rocker Arm Bracket Assembly (For Cylinder No. 4)	1
259 070 C92	Valve Tappet* (with Tungsten wafer)	12
1 802 507 C1	Push Rod* (See NOTE)	12
EMD-914	Rocker Arm Bracket Installation Drawing	1

*Old Tappet (IH Part No. 911 776 R3) and Old Push Rod (IH Part No. 675 621 C1) are still available for service for those customers opting not to install the valve train service package.

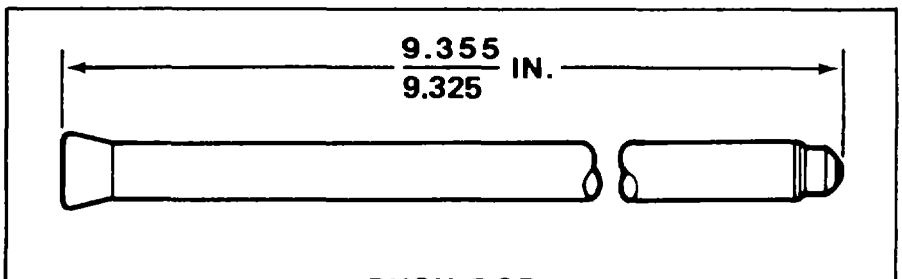
NOTE

A short push rod (IH Part No. 1 802 507 C1) is required to accommodate Valve Tappet (IH Part No. 259 070 C92).



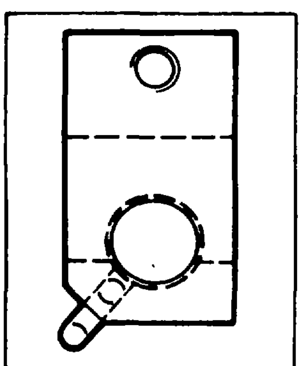
ROCKER ARM BRACKET INSTALLATION DRAWING

EMD-914



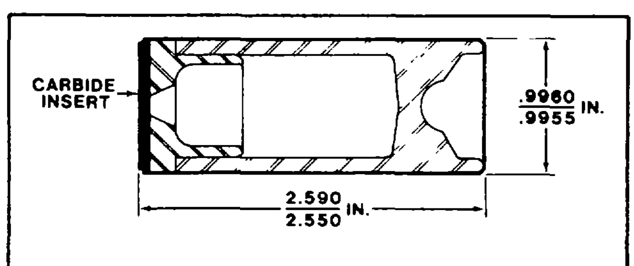
PUSH ROD

QTY.	IH PART NO.
12	1 802 507 C1



ROCKER ARM BRACKET ASSY.

QTY.	IH PART NO.
2	1 802 461 C1
1	1 802 462 C1



VALVE TAPPET

QTY.	IH PART NO.
12	259 070 C92

CG-8590

Figure 8a. - Valve Train Service Package

CAMSHAFT SERVICE PACKAGE
IH PART NO. 1 802 339 C92
(Refer to Figure 8b)

Part Number	Description	Quantity
1 802 506 C91	Camshaft Assembly	1
1 171 507 R1	Tag	1
691 490 C1	Product Graphic	1

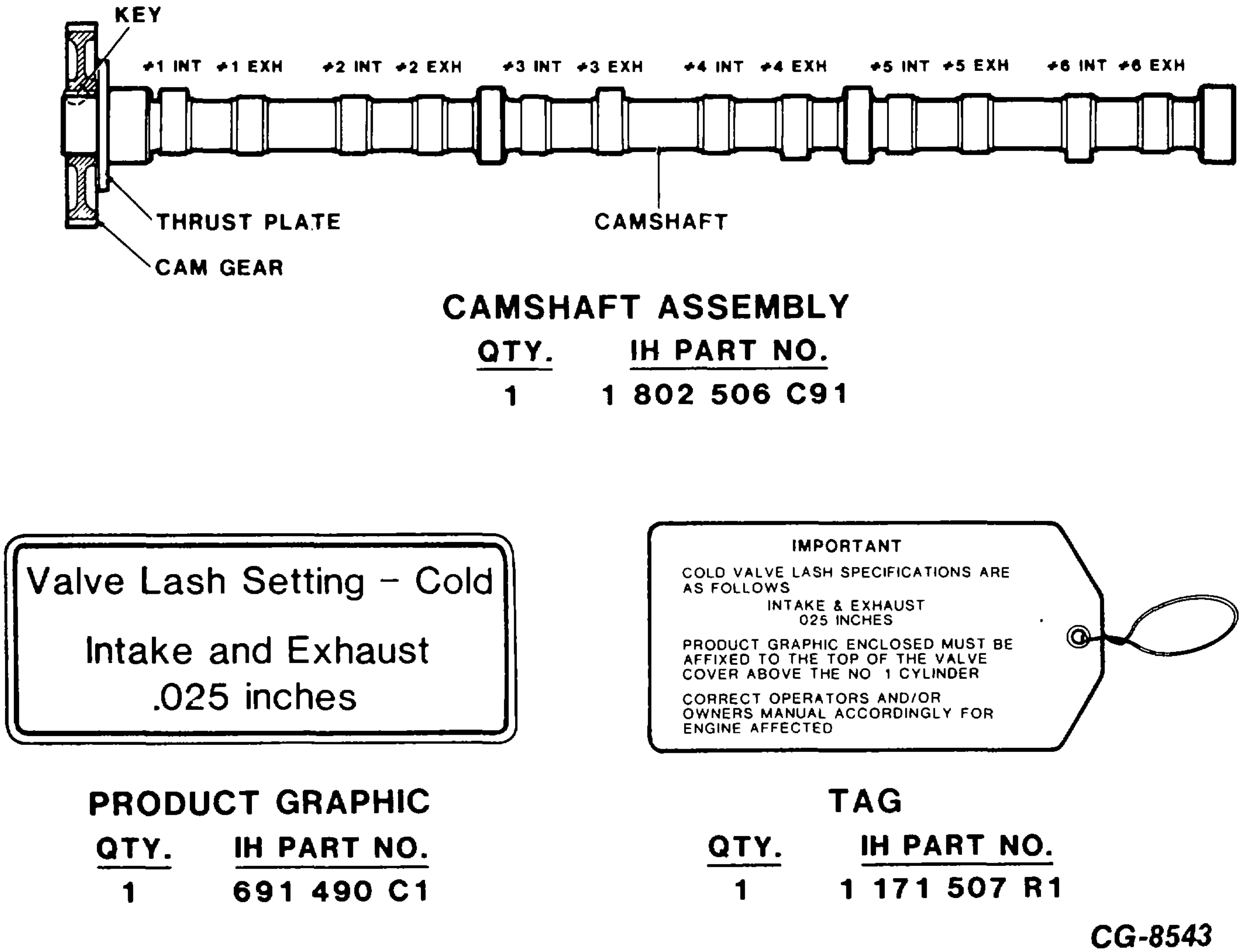


Figure 8b. - Camshaft Service Package

After installation, adjust valve lash to 0.64 mm (0.025 inch) for both intake and exhaust valves as instructed in Section 3. Place the product graphic included in Camshaft Service Package on the valve cover above the No. 1 cylinder.

Design changes to improve initial lubrication to valve train components have been made by revising the rocker shafts and rocker arms on 400 Series engines. Rocker shafts were revised by drilling 3.1750 mm (.125 in.) diameter holes through the shaft while the rocker arm assembly oil hole was relocated to a vertical position.

Figures 9 and 10 illustrate the displaced and new components.

Engines built with and after the following serial numbers incorporate the new rocker arm and rocker arm shaft:

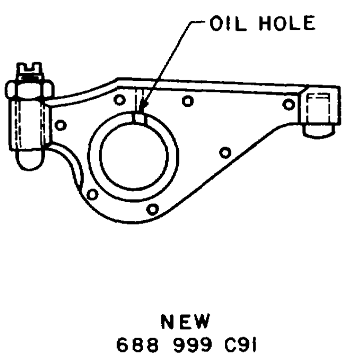
Engine	**Serial Number**
D-312	8499
D/DT-360	13716
DT-414	103448
DT-414B	140000
D/DT-436	46359
DT-436B	100000
D/DT-466	21868
DT/DTI-466B	75000
DT/DTI-466C	400001

IMPORTANT

1. Displaced shafts must **NOT** be used with new rocker arms.

2. New shaft may be used with **EITHER** new or displaced rocker arms.

3. Do **NOT** attempt to rework old shafts.



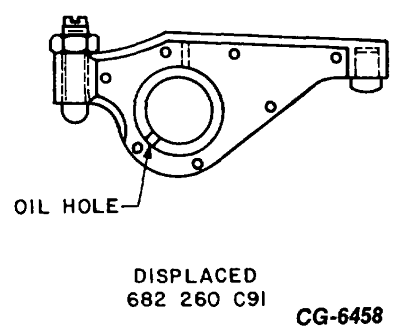


Figure 9. - Rocker Arm

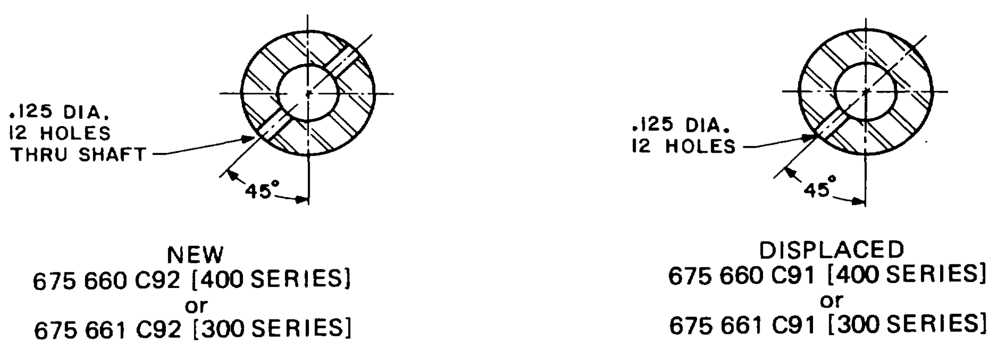


Figure 10. - Rocker Arm ShaftCG-6459

SPECIFICATIONS

DIMENSIONS	VALUES
Camshaft -	
Cam Lobe Lift (Total):	
Intake -	
D-312 (SN 2505 and Above)	6.759 mm (0.2661 in)
D-312 (Below SN 2505) and D and DT-360	6.97 mm (0.2744 in)
All 400 Series with Camshaft (IH P/N 691 488 C1 or 1 802 337 C1) [With Revised Intake Ramp]	7.455 mm (0.2935 in)
Exhaust -	
All 300 Series	7.125 mm (0.2805 in)
All 400 Series	7.384 mm (0.2907 in)
Maximum Permissible Cam Lobe Wear	0.51 mm (0.020 in)
End Clearance	0.13 mm (0.005 in) / 0.33 mm (0.013 in)
Camshaft Running Clearance	0.05 mm (0.002 in) / 0.17 mm (0.006 in)
Maximum Permissible Camshaft Running Clearance	0.20 mm (0.008in)
Bearing I.D. (Installed in Crankcase)	58.026 mm (2.2845 in) / 58.115 mm (2.2880 in)
Bearing Journal Diameter	57.948 mm (2.2814 in) / 57.976 mm (2.2825 in)
Service Bushings Furnished to Size	Yes
Thrust Plate Thickness (New)	6.96 mm (0.274 in) / 7.01 mm (0.276 in)
Thrust Location	0.13 mm (0.005 in) / 0.33 mm (0.013 in)

DIMENSIONS	VALUES
All 300/400 Series	
Valve lever and Shaft (Rocker Arm) Assemblies	
Valve Lever Shaft Diameter	21.567 mm (0.8491 in) 21.593 mm (0.8501 in)
Valve Lever Clearance On Shaft	0.048 mm (0.0019 in) 0.1 24 mm (0.0049 in)
Valve Lever Bushing (I.D.) .	21.64 mm (0.852 in) 21.69 mm (0.854 in)
Valve Tappets -	
Diameter	25.311 mm (0.9965 in) 25.324 mm (0.9970 in)
Length	61.90 mm (2.437 in)
Tappet Clearance In Crankcase	0.064 mm (0.0025 in) 0.102 mm (0.0040 in)
Valve Lever Springs -	
Number of Springs	5
Free Length	103.1 mm (4.06 in)
Test Length	52.6 mm (2.07 in)
Test Load	31 N•m (71 lbf-ft)
O.D	25.9 mm (1.02 in)

REMOVAL

NOTE: ***Prior to removal, or if complete tear down will not take place, cam lobe lift can be Inspected with camshaft In engine by using a dial Indicator as shown in Figure II. Record the lift readings of each lobe and compare these readings with those In the specifications. If wear is 0.51 mm (0.020 in) or greater replace the CAMSHAFT.***

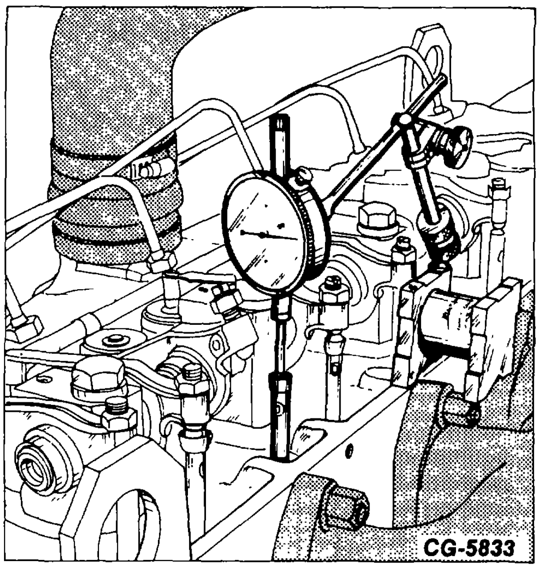


Figure 11. - Checking Cam Lobe Lift (Camshaft in Engine)

Remove Valve Train as Follows:

1. Remove Turbocharger (if equipped), manifolds, valve cover and cylinder head as described in previous sections.

2. Remove push rods.

3. Remove valve tappets.

NOTE: ***Mark the tappets as to location in the engine block, so they can be returned to their original position.***

4. Remove crankcase front cover. (Refer to section 7).

5. Crank engine until timing marks on crankshaft gear, camshaft gear and Idler gear are in line as shown in Fig. 12.'

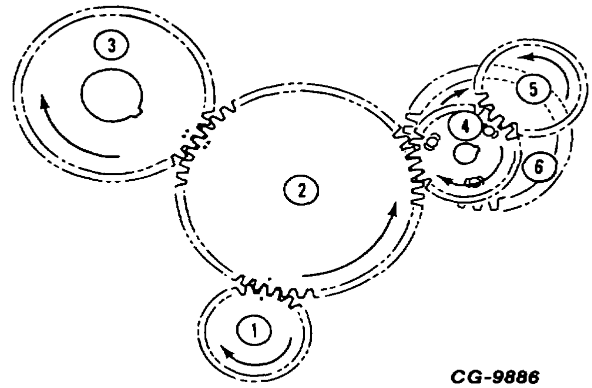


Figure 12. - Gear Train Timing Marks

1. Crankshaft Gear
2. Idler Gear
3. Camshaft Gear
4. Injection Pump Gear
5. Tachometer Gear (if equipped)

(items 3–5: UTDS* Model 100 Fuel Injection Pump)

6. Injection Pump Gear — Engines equipped with Robert Bosch Model MW Fuel Injection Pump

NOTE: ***Before removing the camshaft gear, check the camshaft end clearance. If***
<u>0.13 mm</u> <u>(0.005 inches)</u>
0.33 mm (0.013 inches)
specification is not met new parts are required.

6. Remove two cap screws securing camshaft thrust plate to crankcase. These screws are accessible by rotating camshaft gear and reaching through the holes in the gear.

7. Remove camshaft. (Support camshaft along its length, as it is being removed, to prevent cam lobes from damaging bushings).

*United Technologies Diesel Systems (formerly AM BAC)

CLEANING, INSPECTION & REPAIR

CLEANING

1. Clean all parts in solvent and dry with compressed air.

2. After cleaned parts are inspected, coat each with clean engine oil and store safely until reassembly.

NOTE: ***Do not damage the journals and lobes of the camshaft or the teeth of the gear.***

INSPECTION AND REPAIR

1. Visually inspect the camshaft. If ANY of the valve lobes are scuffed, scored or cracked.

2. Inspect the journals for wear. Using a micrometer measure the camshaft journal diameter to insure specifications of
   <u>57.948 mm</u> <u>(2.2814 inches)</u>
   57.976 mm (2.2825 inches)
   is met. If the journals are worn beyond these limits, replace the camshaft.

3. Check camshaft lobe wear as follows:

   a. Compare lifting areas of the cam lobes with a new camshaft. If excessive wear is visible replace the camshaft.
   b. If a new camshaft is not available for comparison, measure cam lobe wear with micrometer as follows:

      1. Take a reading across (A-C, Fig. 13) and across (B-D).
      2. Subtract (B-D) from (A-C). This will give the cam lobe lift.
      3. Replace camshaft when cam lobe wear limit of 0.51 mm (0.020 in) has been reached for any lobe. (Refer to SPECIFICATIONS in this section).

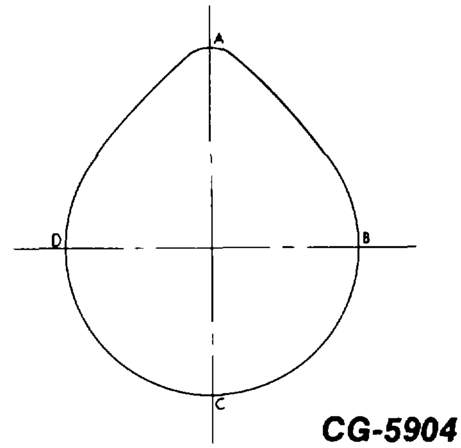


Figure 13. - Points of Measurement to Determine Cam Lobe Wear

4. Visually inspect thrust plate for wear, cracks and distortion. Then, check for specified shaft end clearance of
   <u>0.13 mm</u> <u>(0.005 in.)</u>
   0.33 mm (0.013 in.)
   Replace thrust plate if clearance is excessive or if plate is worn or damaged.

5. Inspect camshaft drive gear for worn or damaged teeth. If the bore of the gear is widened by repeated pressing so a tight fit is no longer possible, replace the gear with a new one. (See Section 7 for installation procedure).

6. Inspect bushings for wear. If worn, remove them as follows and replace with new bushings.

   a. Remove the flywheel and flywheel housing.
   b. Using a Camshaft Bearing Service Set (3, Fig. 14) with back-up nut (1) and expanding collet (2) pull the bushings out of the crankcase. (See tool list for tool number).

   1. Remove the front and rear bearings first.
   2. Pull the two intermediate bearings out the front of the crankcase.

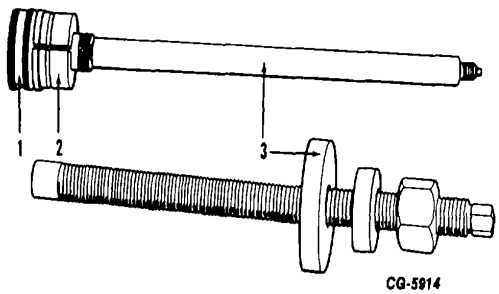


Figure 14. - Camshaft Bushing Puller and Installer Tool (Part of Camshaft Bearing Service Set)

1. Back-up Nut (817-18)
2. Expanding Collet (817-11)
3. Puller

NOTE: ***A screwdriver (2, Fig. 15) can be used as shown to hold the back-up nut so the collet can be expanded.***

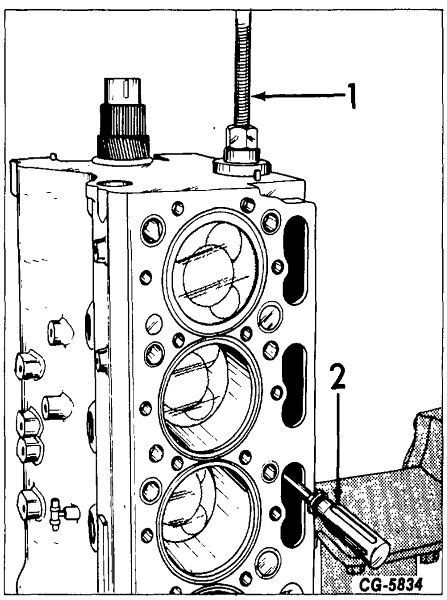


Figure 15. - Pulling Camshaft BushingsCGES1853

1. Bushing Puller and Installing Tool
2. Screwdriver

7. When bushings are removed inspect bushing bores in crankcase for burrs or other roughness liable to damage bushings when installed.

8. Inspect valve tappets. Replace any that are scuffed, scored, cracked or worn.

INSTALLATION

Install valve train components as follows:

1. If the camshaft bushings were removed install new bushings using the Camshaft Bushing Puller and Installer Tool. Be sure the oil holes in the bushing (2, Fig. 16) line up with the oil holes in the crankcase (1) as shown.

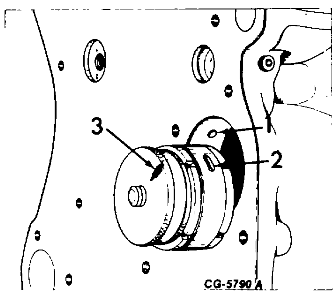


Figure 16. - Camshaft Bushing Installation

1. Crankcase Oil Hole
2. Bushing Oil Hole
3. Mark

2. To ease oil hole alignment, mark the back-up nut (3, Fig. 16) in line with the bushing oil hole (2) as shown when installing the bushings.

NOTE: ***The bushing and crankcase oil holes must line up.***

3. If it is necessary to replace the camshaft gear, proceed as follows:

   a. The drive gear on the camshaft must be pressed off since it is a shrink fit.

   b Place the thrust plate on the keyway end of the camshaft against the bearing journal.

   c. Insert the Woodruff Key into the keyway.

   d. Heat the camshaft gear to approximately 205°C (400°F).

NOTE: Use thermomelt stick to determine temperature. (See tool list for tool number).

   e. Press the gear against the shoulder on the shaft with the timing mark pointed outward as shown in Fig. 17.

CAUTION: Use asbestos gloves when installing gear.

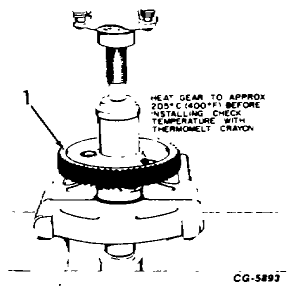


Figure 17. - Installing Camshaft Drive Gear

4. Coat the cam lobes, bearings and journals with clean engine oil and install the camshaft.

5. Install the camshaft so that the timing marks stamped on each gear as shown in (1, Fig. 17) are in line.

6. Alternately tighten the thrust plate cap screws to 27 N•m (20 Ibf-ft) torque.

7. Check the camshaft end play with a dial indicator.
   0.13 mm (0.005 in.)
   0.33 mm (0.013 in.)
   specifications must be met.

8. Install crankcase front cover as described in Section 6.

9. Lubricate the O.D. of the tappets with clean engine oil and tappet faces with Moly Kote "G-n" or Fel Pro C-670 paste. Then install tappets into tappet bores.

10. Install the cylinder head and adjust valve lash as outlined in Section 3.

NOTE: ***It is recommended that the engine be run at 1000 RPM from three to five minutes after engine is assembled. At 1000 RPM the tappets are under lighter load, thus lubrication of tappets and tappet bores is assured.***

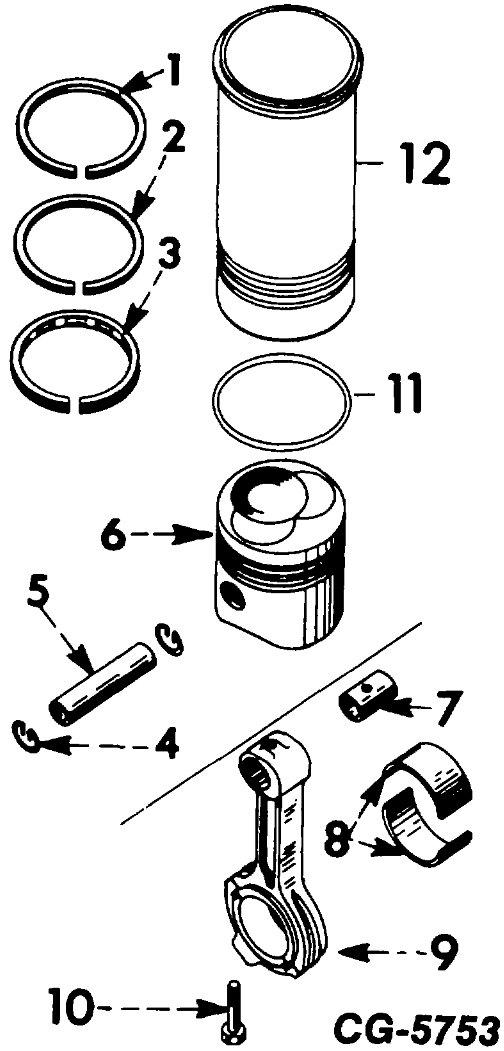


Figure 1. - Connecting Rods, Pistons, Rings and Sleeves

1. Piston Compression Ring (First groove, top)
2. Piston Compression Ring (Second groove, middle)
3. Piston 011 Ring (Third groove, bottom)
4. Piston Pin Retaining Ring
5. Piston Pin
6. Piston
7. Piston Pin Bushing
8. Connecting Rod Bolt
9. Connecting Rod
10. Connecting Rod Bolt
11. Cylinder Sleeve "O" Ring
12. Cylinder Sleeve

GENERAL

CONNECTING RODS are forged of high-grade steel. The rod has a bearing at each end. The upper bearing is a bushing-type used at the piston pin, which anchors it to the piston. The bearing at the crankshaft end of the rod (lower end) is a two-piece bearing that fits around the crankshaft journal and is secured by a bearing cap. The rod and bearing caps are mated parts with definite markings on both the cap and rod which prevent mismatching as shown in Fig. 2.

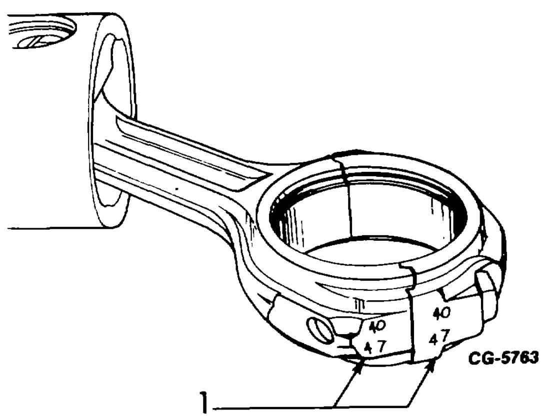


Figure 2. - Connecting Rod and Cap Identification Numbers

1. Mated Surface I.D. Numbers

Currently the 300 Series uses a 35° split line connecting rod and cap assembly (672116C91) with tang in rod and slots in cap.

The 400 Series uses two connecting rod assemblies:

1. The old 35° split line connecting rod and cap assembly (684294C91 and 685012C91) with slot and tang in rod and cap.

2. The new 45° split line connecting rod and cap assembly (688923C91) with tang in rods and slots in cap. The new rod and cap assembly have a revised piston pin, oil reservoir and bolts.

NOTE: ***Old and new connecting rods can be intermixed for engines In the field. New connecting rod bolts (6 766 79C2) can be used in the old connecting rod assemblies but old bolts (676679C1) must not be used In new connecting rod assemblies.***

The PISTONS are cast aluminum alloy, which are cam ground and weight controlled. Each piston is fitted with two COMPRESSION RINGS and one OIL CONTROL RING.

Atomized fuel is injected into a dish-shaped recess in the dome of the piston by the injection nozzle valve. The force of combustion pressure is transmitted by the piston and connecting rod to the crankshaft. The escape of combustion pressure past the piston is prevented by the piston rings. The fit of the piston and rings in the sleeve must be close enough to prevent the escape of combustion gases, yet free enough to keep friction to its working minimum.

The 300 Series and early 400 Series engines are equipped with a crankcase mounted ventilation system which utilizes conventional pistons and piston rings. Late model 400 Series engines have the new valve cover mounted crankcase ventilation system.

These used "BALANCE-PRESSURE" pistons with a revised second land configuration (Fig. 3) and top ring groove. A new "INTERMEDIATE PISTON RING" (Fig. 4) was also released with an increased ring gap specification.

Cutback Land Piston

All 400 Series Turbocharged engines use pistons incorporating the cutback land design [Refer to Fig. 3]. Cutback refers to the pistons smaller diameter above the top ring groove compared to the diameter below the top ring. The passageway created by the smaller diameter allows combustion gas pressure to reach the top piston ring.

The cutback land design uses combustion gas pressure to push the top compression ring down against the top piston ring grooves and out against the cylinder sleeve. Because the top ring is held tightly against the piston and cylinder sleeve, only a small amount of lubricating oil enters the combustion chamber and is consumed.

Balance Pressure Piston

DT-414, 436 and 466 w/ S/N 38089 and up, and DT-414B, 436B, 466B and 466C engines w S/N 76440 up, have Balance Pressure pistons. These pistons have the cutback land design and a wide groove below the top ring (Fig. 4). The intermediate piston ring used with the Balance Pressure Piston has an increased end gap of approximately .070 inches.

During engine operation, combustion gases that pass the top piston ring enter the wide groove. They move past the wide gap intermediate ring into the crankcase area and subsequently are discharged to the atmosphere through the new valve cover mounted breather. The top piston ring always has higher combustion pressure above and lower pressure below because gases passing the top ring are vented past the intermediate ring end gap and to the atmosphere. The Balance Pressure Piston design provides outstanding oil control.

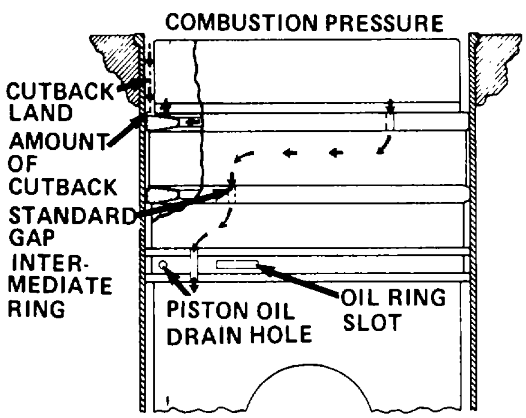


Figure 3. - Cutback Land Piston (Turbocharged only)

Following is a list of acceptable combinations of ventilation system, piston rings and pistons:

Crankcase Mtd. Ventilation (Old)	Valve Cover Mtd. Ventilation (New)	Old Rings	New Rings	Old Pistons	New Pistons
X		X		X	
X		X			X
	X	X		X	
	X	X			X
	X		X	X	
	X		X		X

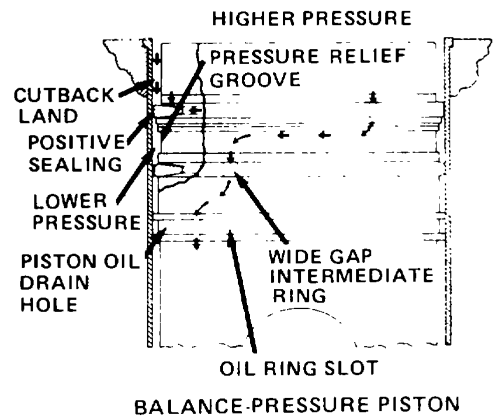


Figure 4. - Balance-Pressure Piston

NOTE: ***The technology utilized in designing the new piston and ring combination represents a significant advancement in engine oil control.***

The oil-regulating ring provides an even distribution of lubricating oil which aids in friction reduction and cooling action for the piston and cylinder sleeve. Excess oil is wiped by the rings back down to the crankcase.

The PISTON PIN is induction-hardened steel and anchors the piston to the connecting rod. The pin is retained in the piston by retainer rings in its bushing in the upper end of the rod. The aluminum alloy of the piston is excellent bearing material and no bushing is required between the pin and the piston.

The CYLINDER SLEEVES are the wet type. A flange at the top of each cylinder sleeve fits into a counterbore in the top of the crankcase and serves to position the sleeve correctly.

The cylinder sleeve is sealed against the circulating coolant at the upper flange by the cylinder head gasket and at the lower parts by the "0" ring. Both sealing forces must be handled with care to prevent damage.

SPECIFICATIONS

SPECIFICATIONS	DIMENSIONS
CONNECTING RODS:	
Side Clearance on Crankshaft All 300/400 Series	0.18 mm (0.007 in.) 0.38 mm (0.015 in.)
Maximum Permissible Bearing Side Clearance on Crankshaft All 300/400 Series	0.46 mm (0.018 in.)
Bearing Running Clearance All 300/400 Series	0.046 mm (0.0018 in.) 0.103 mm (0.0051 in.)
Maximum Permissible Bearing Running Clearance (before reconditioning) All 300/400 Series	0.18 mm (0.007 in.)
Pin Bore Diameter (without bearing) All 300/400 Series	43.777 mm (1.7235 in.) 43.828 mm (1.7255 in.)
Center to Center Distance Between Connecting Rod Bearing and Piston Pin Bearing. All 300/400 Series	214.33 mm (8.438 in.) 214.43 mm (8.442 in.)
Crankshaft Rod Journal Bore All 300/400 Series	81.28 mm (3.0008 in.) 81.31 mm (3.0028 in.)
Crankshaft Rod Journal Bearing I.D. (Std.) All 300/400 Series	76.220 mm (3.008 in.) 76.271 mm (3.0028 in.)
Bearing Inside Diameter at Piston Pin End (Bore or Hone After Assembly)	41.2902 mm (1.6256 in) 41.2953 mm (1.6258 in)

SPECIFICATIONS **DIMENSIONS**

CONNECTING RODS:

Skirt Clearance, Measured 90 degrees from pin hole at bottom of skirt.

300 Series .... 0.114 mm (0.0045 in.)
0.165 mm (0.0065 in.)

400 Series .... 0.114 mm (0.0045 in.)
0.190 mm (0.0075 in.)

Number of Rings Per Piston 3

Piston Ring Groove Widths:

300 Series

Top Compression Ring - Measure over 0.1150 in. gauge pins .... 3.8898 in. Upper Limit
(Full Keystone) .... 3.8574 in. Replacement Limit

400 Series

Top Compression Ring - Measure over 0.1150 in. gauge pins .... 4.3118 in. Upper Limit
(Full Keystone) .... 4.2794 in. Replacement Limit

300 Series and 400 Series N.A.

Intermediate Compression Ring - (Rectangular) .... Use Side Clearance and ring gap dimensions as criteria for determining piston groove wear.

Early Model 400 Series T.C.

Intermediate Compression Ring - Measured over 0.0900 in. gauge pins
(Half Keystone) DT-414, DT-436 and DT-466 .... 4.3244 in. Upper Limit
4.2793 in. Replacement Limit

Late Model 400 Series T.C.

Intermediate Compression Ring - Measure over 0.1150 in. gauge pins
(Full Keystone)

Effective on: DT-414 S/N 118710*, DT-436 S/N 63636*
DT-466 S/N 38089*, DT-414B, DT-436B, DT/DTI-466B and DT/DTI-466C
S/N 76440* .... 4.3168 in. Upper Limit
4.2844 in. Replacement Limit

Side Clearance:

Oil Control Ring -D-312, D and DT-360 .... 0.038 mm (0.0015 in.)
0.102 mm (0.0040 in.)

Oil Control Ring - D and DT-414, D and DT-436
DT-466, DT/DTI-466B and DT/DTI-466C .... 0.05 mm (0.002 in.)
0.10 mm (0.004in.)

*** Starting with these engine Serial Numbers and above.**

SPECIFICATIONS **DIMENSIONS**

CONNECTING RODS:

Number of rings per piston 2

Type (face and finish):

Top Ring .... Full Keystone (barrel face) -Chrome

Intermediate Ring
(300 Series) and (400 Series N.A.) .... Rectangular (tapered face) - Chrome
(Early Model 400 Series T.C.) .... Half Keystone (tapered face) - Chrome

(Late Model 400 Series T.C.) .... Full Keystone (tapered face) - Chrome

Ring Gap with New Sleeve:

Top Ring

(300 Series) .... 0.30 mm (0.012 in.)
0.64 mm (0.025 in.)

(400 Series) .... 0.41 mm (0.016 in.)
0.74 mm (0.029 in.)

Intermediate Ring
(300 Series) .... 0.51 mm (0.020 in.)
Rectangular Ring 0.84 mm (0.033 in.)

(400 Series N.A.)
Rectangular Ring with Narrow Gap**
D-414 w/Eng. S/N 126948 and below
D-436 w/Eng. S/N 82716 and below
D-466 w/Eng. S/N 54268 and below.. 0.51 mm (0.020 in.)
0.84 mm (0.033 in.)
Rectangular Ring with Wide Gap**
D-414 w/Eng. S/N 126949 and up
D-436 w/Eng. S/N 82717 and up
D-466 w/Eng. S/N 54268 and up .... 1.65 mm (0.065 in.)
1.98 mm (0.078 in.)
(400 Series T.C.)
Early Model with Half Keystone Ring .... 0.51 mm (0.020 in.)
0.84 mm (0.033 in.)

***Rings with wide gaps and narrow gaps can be intermixed in service.
***May be used with old or new piston. New full keystone ring with wide gap must not be used with crankcase mounted ventilation system.

SPECIFICATIONS

Late Model with Old Full Keystone
Ring with Narrow Gap** .... 0.51 mm (0.020 in.)
0.84 mm (0.033 in.)

Late Model with New Full Keystone
Ring with Wide Gap** .... 1.65 mm (0.065 in.)
1.98 mm (0.078 in.)

PISTON RINGS - OIL CONTROL:

Number of Rings Per Piston 1

Type .... One Piece Slotted - Chrome

Ring Gap

(300 Series) .... 0.25 mm (0.010in.)
0.58 mm (0.023 in.)

(400 Series) .... 0.25 mm (0.010 in.)
0.71 mm (0.028 in.)

PISTON PINS:

Diameter .... 41.270 mm (1.6248)
41.275 mm (1.6250)

Length:

(300 Series) .... 76.07 mm (2.995 in.)
76.33 mm (3.005 in.)

(400 Series) .... 89.03 mm (3.505 in.)
89.28 mm (3.515 in.)

Clearance in Rod .... 0.015 mm (0.0006 in.)
0.054 mm (0.0010in.)

Maximum Permissible Clearance in Rod,
before replacing .... 0.08 mm (0.003 in.)

Clearance in Piston .... 0.013 mm (0.0005 in.)
0.025 mm (0.0010in.)

Maximum Permissible Clearance in Piston,
before replacing .... 0.064 mm (0.0025 in.)

**Rings with wide gaps and narrow gaps can be intermixed in service.

***Maybe used with old on new piston. New full keystone ring with wide gap must not be used with crankcase mounted ventillation system.

SPECIFICATIONS	DIMENSIONS
CYLINDER SLEEVES:	
Inside Diameter:	
(300 Series)	98.43 mm (3.875 in.) 98.45 mm (3.876 in.)
(400 Series).	109.232 mm (4.3005 in.) 109.258 mm (4.3015 in.)
Length:	
(300 Series)	217.68 mm (8.570 in.) 218.19 mm (8.590 in.)
(400 Series)	239.01 mm (9.410 in.) 239.52 mm (9.430 in.)
Maximum Permissible Diameter Sleeve Wear, at Top of Ring Travel before Replacement	0.10 mm (0.004 in.)
Counterbore Dimension in Crankcase	8.84 mm (0.348 in.) 8.89 mm (0.350 in.)
Maximum Cylinder Sleeve Counterbore Allowable Salvage Depth	10.49 mm (0.413 in.)
Flange Thickness	8.94 mm (0.352 in.) 8.97 mm (0.353 in.)
Protrusion above Crankcase	0.05 mm (0.002 in.) 0.13mm (0.005 in.)

REMOVAL
Remove the Connecting Rods and Pistons as follows:

1. Remove the cylinder head as described in Section 3.

2. Remove the drain plug and drain the crankcase oil pan.

3. Remove the oil pan and gasket.

NOTE: ***It is recommended to check crankshaft bearing bolt torque on the main bearing and connecting rod bolts anytime the oil pan is removed.***

4. Check the main bearing and connecting rod bolt torques (prior to teardown) as follows:

   a. Using a direct reading torque wrench (Not a "CLICKER" type) place the socket over the bolt head and gently pull the wrench in the tightening direction to remove slack.

      1. Mark the bolt and rod with the marks in alignment.

      2. For mains, mark the cap and the socket.

   b. Loosen bolts 1/4 turn. Tighten with a slow steady motion and read the torque at the moment the marks are once again aligned.

   c. On the main bearing bolts if torque is found to be below 155 N•m (115 lbf-ft), and cap is not to be removed, back off 1/4 turn and retorque to 155 N•m (115 Ibf-ft). Those at 155 N•m (115 Ibf-ft) or higher should be left with marks aligned.

   d. For connecting rod bolts if the torque of both bolts is 175 N•m (1 30 Ibf-ft) or higher, and rod is not to be removed, they may be left with the marks aligned.

   e. If the torque of either bolt is found to be less than 150 N•m (110 Ibf-ft), the rod should be removed and inspected.

   f. If the torque of both connecting rod bolts is found to be at least 150 N•m (110 Ibf-ft), but either or both less than 175 N•m (130 Ibf-ft), the cap should be removed and the bearing inspected.

If bearing distress is noted or bearings are not a tight fit in rod and cap, new inserts should be used and the cap reinstalled. If no bearing distress is noted, reinstall the bearings and cap.

NOTE: ***Before proceeding with piston and connecting rod removal, inspect the sleeves at the upper end of the ring travel for the presence of a ridge. This ridge must be removed with a fine emery cloth and a carbon scraper before the piston is removed. This prevents damage to the piston ring lands during removal and also prevents damage to new piston rings when installing the piston. When removing a piston from the crankcase, do not allow the piston skirt to strike the crankcase or the connecting rod to strike the piston sleeve, as severe damage to the sleeve could result.***

5. Remove the connecting rod bolts from the rod caps and remove the caps and bearing inserts from the rod ends. Keep in order and observe markings to prevent mismatching.

6. Push the connecting rod and piston to the top of the cylinder and remove them from the top of the crankcase with EXTREME CARE.

7. Crank the engine by hand and remove all of the remaining pistons as outlined. Be sure to replace each bearing cap on its respective connecting rod after removal of the piston from the engine.

NOTE: ***It is advisable to wrap an oil-soaked cloth around the crankshaft connecting rod bearing journals to keep them as clean as possible. Wrap the piston and connecting rod assemblies in clean cloth also to protect them until installation.***

Remove the Cylinder Sleeves as TOIIOWS:

1. After piston and rod removal use the universal wet sleeve puller PLT-502-3; 17-22-2 (1, Fig. 5) and remove cylinder sleeves.

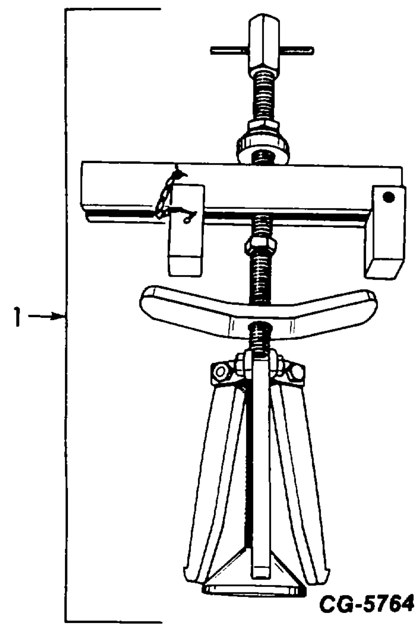


Figure 5. - Universal Wet Sleeve Puller (PLT-502-3) (17-22-2)

1. PLT-502-3 or 17-22-2

2. Position the puller in the sleeve. Hold the jaws of the puller and turn the screw, which spreads the jaws to grip the edge of the cylinder sleeve. Tighten the locking bar against the top of the sleeve.

3. Turn the bearing-mounted forcing nut to break the cylinder sleeve loose from the crankcase as shown in Fig. 6.

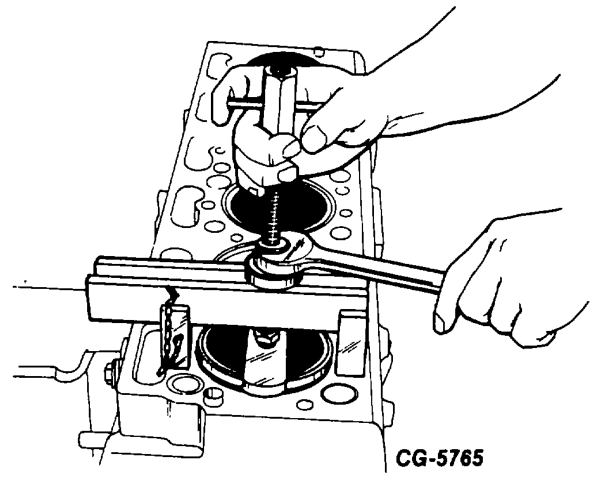


Figure 6. - Removing Cylinder Sleeve

4. Remove the sleeve; if necessary thread a slide hammer into the forcing screw to aid in removal.

NOTE: ***If more than one sleeve is to be removed and they are to be used again, it is important that the sleeves be marked with the cylinder number they were removed from.***

DISASSEMBLY

Disassemble Connecting Rods, Pistons and Rings as follows:

1. Remove the piston rings (3, 4 and 5, Fig. 7) with a piston ring expander. Remove the top compression ring first then the remaining rings in order.

2. Remove the piston pin retainers (2) from each piston.

3. Remove the piston pin (1) by hand.

NOTE: Do not apply excessive force to the piston pin. It is recommended that the piston be heated in water to 71°-82°C (160°-180° F) if the pin cannot be removed by hand when cold.

4. After the pin is removed, seperate the piston (6) from the connecting rod (7). Tag or mark the piston and parts with the number of the bore from which they were taken, so they may be reinstalled in their respective cylinders once inspected and/or repaired.

5. Remove connecting rod piston pin bushing (7, Fig. 1) using a suitable arbor press. Discard old bushing and replace with new. Refer to "REASSEMBLY" this section.

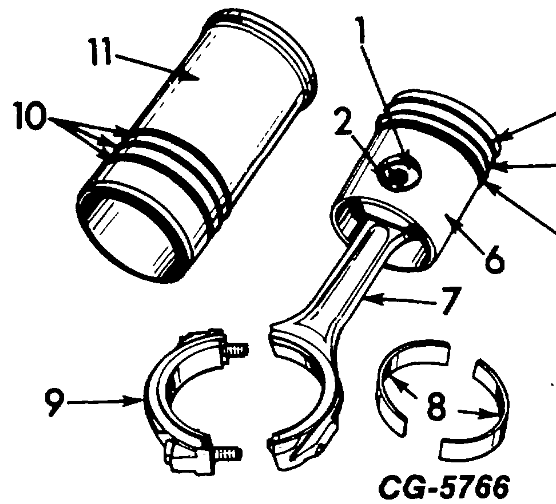


Figure 7. - Rod, Piston, Cylinder Sleeve and Related Parts

1. Piston pin
2. Piston pin retainer
3. Piston ring (first compresion)
4. Piston ring (second compression)
5. Oil control expander ring
6. Piston
7. Connecting rod
8. Bearing.
9. Connecting rod bearing cap
10. Cylinder sleeve packing ring locations
11. Cylinder sleeve

CLEANING, INSPECTION & REPAIR

Clean Connecting Rods as follows:

1. Using a non-caustic solution, clean the threads and mating surfaces between the rod and cap.

2. Clean the oil hole at the top of the rod and keep it uncloged.

3. Clean all bolts thouroughly.

Inspect Connecting Rods as follows:

1. Inspect all bolts for nicks or damage. When lubricated with SAE 30 oil, the bolts must screw into the rod face, by hand. If the bolt will not screw in by hand, reclean the rod threads and try a new bolt. If a new bolt does not screw in freely, the rod must be discarded.

NOTE: Do not retap rods as this is a special rolled thread.

2. When new bolts are used in a rod, they must be torqued o 175 N•m (130 Ibf-ft), loosened, and retorqued three times.

3. Check the integrity of connecting rod bearing bores for mis-match between cap and the rod and for "out-of-round". These checks are only valid when the insert is OMITTED and bolts are torqued to 175 N•m (130 Ibf-ft) using an SAE 30 weight oil as a lubricant under the head of the bolt and in the threads. An inside micrometer is recommended, but a dial bore gauge can be used for measurements.

NOTE: ***Lack of attention to the integrity of connecting rod bearing bores during an overhaul may result in a rod bearing failure. Careful attention must be given to all aspects of the rod and bolts.***

   a. Measure and record the three inside diameters of each rod at points "A", "B" and "C", as shown in Fig. 8.

   b. If the difference between points "A" and "C" is over 0.10 mm (0.004 in.), the mismatch is excessive and the rod should be discarded.

   c. If the difference between point "B" and the average of "A" and "C" (A + C divided by 2) exceeds 0.05 mm (0.002 in.), the rod should be discarded.

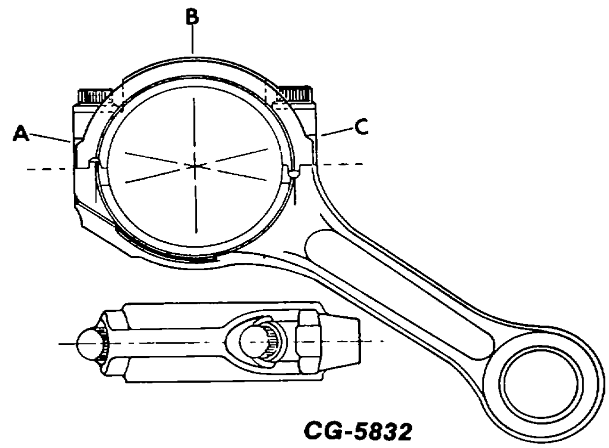


Figure 8. - Connecting Rod I.D. Measurement locations

Inspect Connecting Rod Bearing Fit as follows:

1. If bearing-to-crankshaft running clearances are to be reduced, because of wear, install undersize precision type bearing shells.

   a. Premature bearing failure will result from attempts to reduce journal-to bearing running clearances by modifying bearing caps, bearings or both.

   b. Such modifying will alter the engineered fit of the bearing shells in their bores and destroy the specifically desired "crush".

2. Bearing shells must fit tightly in the rod or case bore. Bearing manufacturers accomplish this by making the diameter at right angles to the parting line (A, Fig. 9) slightly larger than the actual diameter of the bore (B) into which they are assembled. The increased diameter (C) is refered to as "bearing crush".

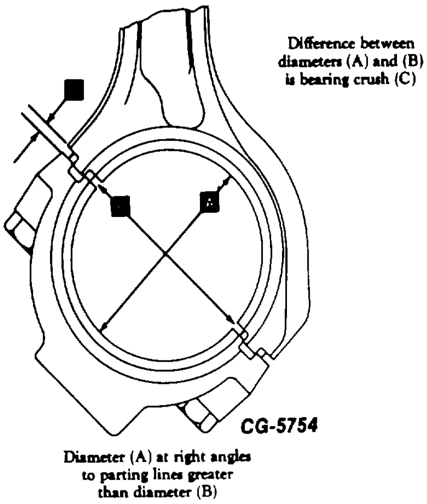


Figure 9. - Bearing Crush

When the assembly is drawn up tight, the bearing is compressed, assuring a positive contact between the bearing back and bore as shown in Fig. 10.

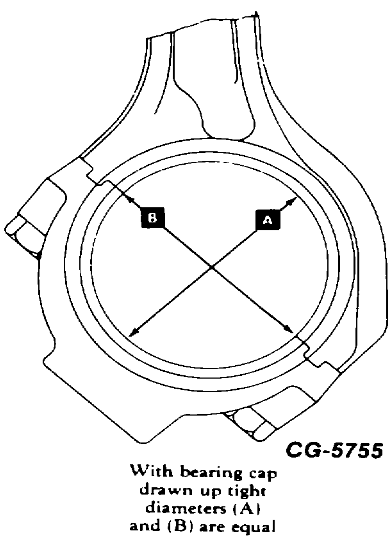


Figure 10. - Bearing Crush after Bolts are Torqued

3. To obtain correct "crush" torque bolts alternately and evenly to 1 55 N-m (11 5 lbf-ft).

4. Main and Connecting Rod bearings are designed with the "spread" (width across the open ends) slightly larger than the diameter of the crankcase bore or connecting rod bore into which they are assembled as shown in Fig. 11. The width across the rod bearing not in place is approximatly 0.64 mm (0.025 in.) more than when the bearing is installed. This condition is originally designed into the bearing causing it to spread outward at the parting line when "crush" load is applied by torquing the bolts. Some "snap" may be lost in normal use, but the bearing need not be replaced because of a nominal loss of this condition.

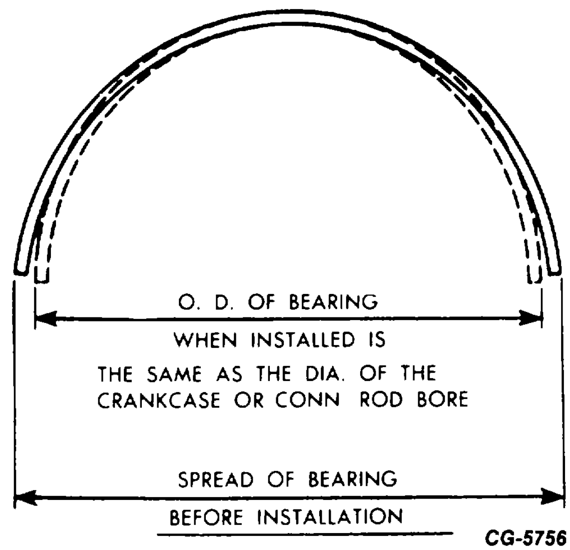


Figure 11. - Bearing Spread Illustration

5. Bearing spread causes the bearing to fit snugly which requires a force to seat it.

6. Fit connecting rod bearings and measure RUNNING CLEARANCE and END CLEARANCE as follows:

NOTE: ***Do not turn the crankshaft during the following procedures.***

a. Running clearance check using virgin lead wire.

1. Remove bearing cap, then clean and oil the crankshaft journal.

2. Place a suitable length of 0.010 in. virgin lead wire across the bearing then install the bearing cap, torquing nuts to 155 N•m (115 lbf-ft).

3. After torquing nuts, remove them along with the bearing cap.

4. Remove the virgin lead wire which will have been crushed down to the amount of clearance between the crankshaft journal and the connecting rod bearing.

5. Measure the crushed wire with a micrometer to determine RUNNING CLEARANCE.

b. Running clearance check using "PLASTIGAGE".

1. Remove bearing cap, then clean the bearing surface and exposed half of the crankshaft keeping them free of oil. ("Plastigage" is soluble in oil).

2. Place a piece of "Plastigage" across the bearing then install the bearing cap, torquing nuts to 155 N•m (115 Ibf-ft).

3. After torquing nuts, remove them along with the bearing cap.

4. The flattened plastic material will be found adhering to either the bearing shell or the crankshaft. DO NOT REMOVE THE "PLASTIGAGE".

5. To determine the running clearance, compare the width of the flattened plastic material at its widest point with the graduated marks on the envelope as shown in Fig. 12. The number within the graduation on the envelope indicates the clearance in thousandths of an inch.

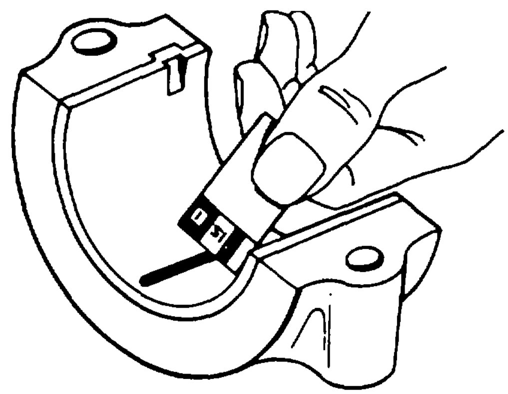


Figure 12. - Checking Connecting Rod Bearing Running Clearance

c. Running clearance check procedure using either virgin lead wire or "PLASTIGAGE".

1. The measurement should fall within
0.046 mm (0.0018 in.)
0.130 mm (0.0051 in.)
Remove the test material and reinstall the cap and bearing with correct torque if running clearance specification are met.

2. Repeat the chosen method of testing for all the remaining connecting rods.

3. If the measurements are not within the specified limits, and the torque wrench is known to be accurate, remove the bearing from the connecting rod and replace it with a new bearing.

NOTE: ***With the precision bearings used, no problem should be encountered, providing the crankshaft and connecting rod are in good order.***

d. Check connecting rod end clearance, using a feeler gauge as shown in (Fig. 13) maximum permissible bearing end clearance on crankshaft is 0.46 mm (0.018 in.).

1. The feeler gauge **MUST** cover both the connecting rod and cap (Fig. 13).

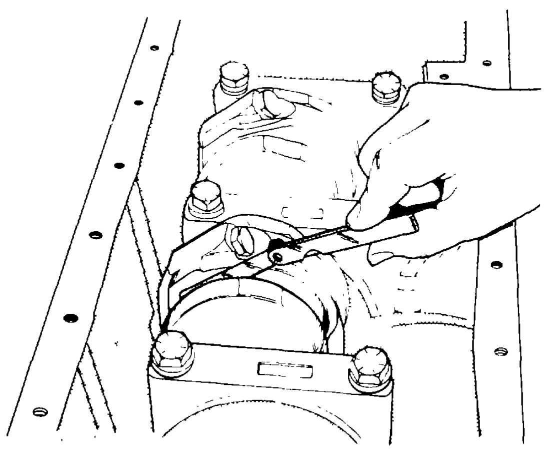

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Figure 13. - Checking Connecting Rod End Clearance

2. Excessive clearance may require replacement of the rods or shaft.

3. The check **MUST** be made to be certain that the specified clearance exits.

4. Lack of clearance could indicate a damaged rod or perhaps a rod bearing out of position.

Clean Pistons as follows:

1. Soak the piston and piston pin in ‘soap solution (until carbon is soft) and clean thoroughly. **NEVER USE A CAUSTIC SOLUTION.**

2. Clean all carbon from the piston ring grooves; using a nonmetallic brush. Be sure all oil holes in the piston are open.

Inspect Pistons as follows:

1. Visually inspect the pistons for scuffed or scored skirts and cracked or worn piston ring lands. Replace the piston if necessary.

2. Check running clearance between the piston and cylinder sleeve (with piston rings removed) for piston skirt wear. Measure at the largest piston diameter. If running clearance exceeds 0.165 mm (0.0065 in.) replace the piston.

3. Visually inspect the piston pins for wear. Replace any pins which show signs of corrosion or etching.

Inspect Piston Rings as follows:

1. Visually inspect NEW rings for any signs of damage prior to installation.

NOTE: ***Faulty rings cannot always be detected by the eye. Therefore, whenever a piston is removed from a cylinder, it is recommended that the piston rings be rep-laced.***

2. Prior to installing the rings on the pistons, check each ring for proper ring gap as follows:

a. Push the ring down into a new cylinder sleeve with a piston. (This will position the ring squarely in the sleeve).

b. Measure the gap between the ends of the ring with a feeler gauge as shown in (Fig. 14). If ring gap does not meet the specifications outlined in this section replace the ring.

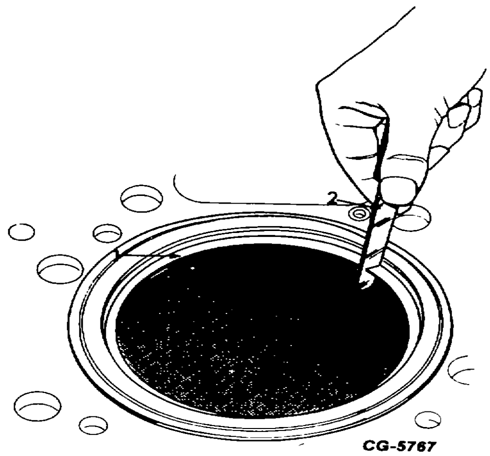


Figure 14. - Checking Piston Ring Gap

1. Piston ring
2. Feeler gauge

3. Install new rings in the piston grooves with a suitable ring installing tool as shown in Fig. 15.

    a. The No. 1 (compression ring) will have the word **"TOP"** stamped on the ring.

    b. The No. 2 (intermediate ring) will be marked **"TOP"**, **"UP"** or with a **"PIP"** on the top side of the ring.

Check TOP and INTERMEDIATE Piston compression ring groove widths for wear.

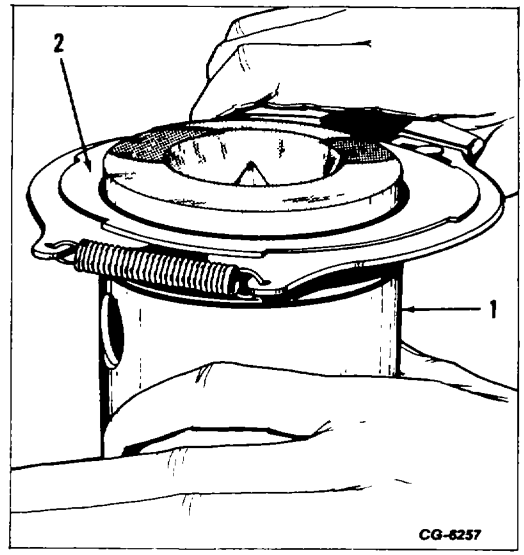


Figure 15. - Installing Piston Ring using Piston Ring Expander Tool

1. Piston
2. Piston Ring Expander Tool

NOTE: A new piston groove wear measuring Tool No. 3020 has been developed to accommodate the complex configurations of International Harvester's technologically advanced pistons.

Tool Description: The Tool, No. 3020, consists of two .0900 in. gauge pins and two 0.1150 in. gauge pins mounted on springs (Fig. 16). The .0900 in. gauge pins are used to measure piston groove wear on pistons with half keystone INTERMEDIATE compression ring grooves. The 0.1150 in. gauge pins are used to measure piston groove wear on pistons with full keystone TOP or IN-TERMEDIATE compression ring grooves.

The following checks are made to be sure that the compression rings (keystone) fit are correct and not carrying the piston load. If the measurement over gauge pins is not within specifications, replace old pistons and rings with new.

a. After piston has been thoroughly cleaned, locate the piston part number and engine model number stamped on top of piston (See Fig. 17.)

IMPORTANT: (Refer to Figure 18.)

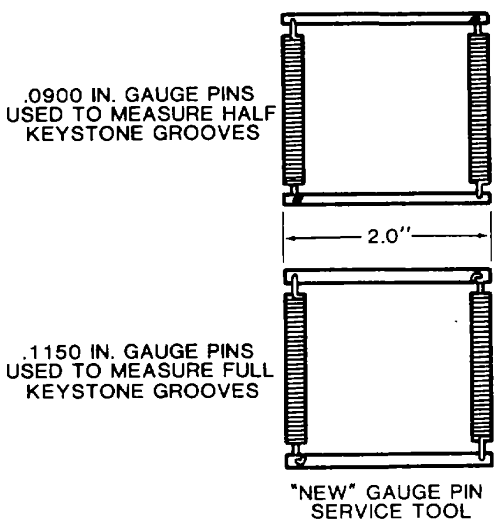
- Full keystone grooves use the 0.1150 in. gauge pin to determine piston ring groove wear.
- Half keystone grooves use the 0.0900 in. gauge pin to determine piston ring groove wear.
- Rectangular grooves DO NOT use gauge pins. Use side clearance and ring gap dimensions to determine piston ring groove wear.

b. Select appropriate size gauge pins for groove being measured (See Service Specification Chart for piston ring groove widths).

c. Place correct size gauge pin and spring assembly in piston groove to be measured. BE SURE THAT CENTER OF GAUGE PINS ALIGN WITH CENTER OF PISTON SO GAUGE PINS ARE PARALLEL. (See Fig. 19).

d. Select correct size outside micrometer to measure piston diameter over gauge pins as follows:

Engine	Micrometer Size
300 Series	3-4 in.
400 Series	4-5 in.



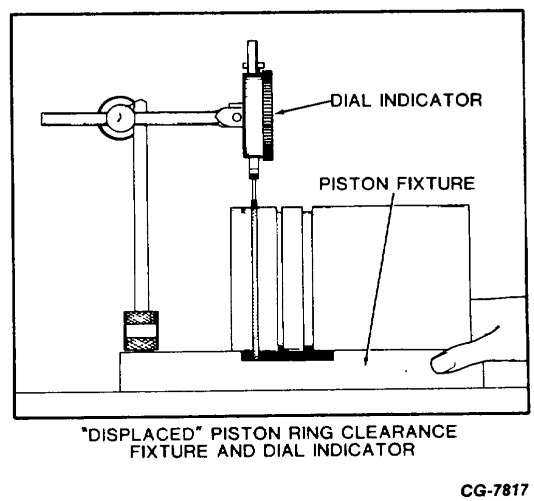


Figure 16. - Piston Groove Wear Measuring Tool (Tool No. 3020)

e. Place micrometer over gauge pins and take reading across the diameter of piston (widest point through piston center) [Refer to Figure 20]. Record measurement.

f. Refer to Service Specification Chart for piston ring groove widths to determine if piston may continue to be used in service.

g. If measurement over gauge pins is not with in specifications, indicating excessive piston groove wear, replace old pistons and rings with new.

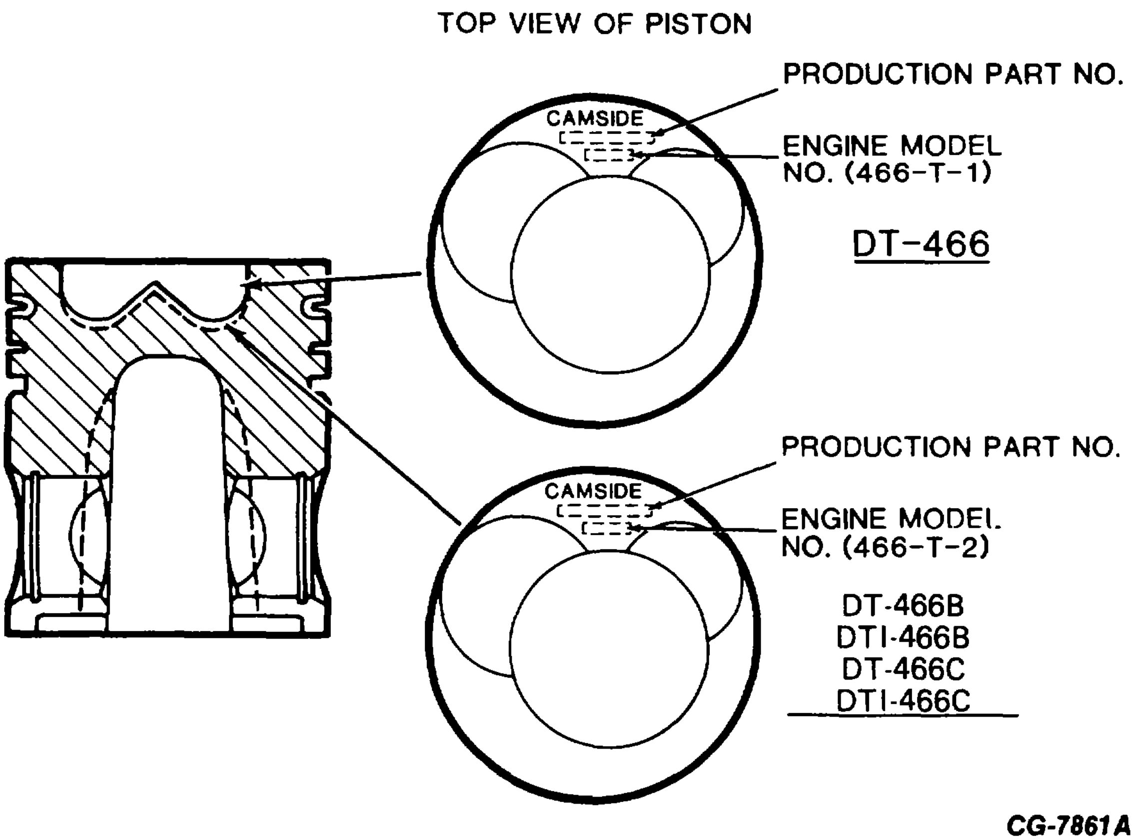
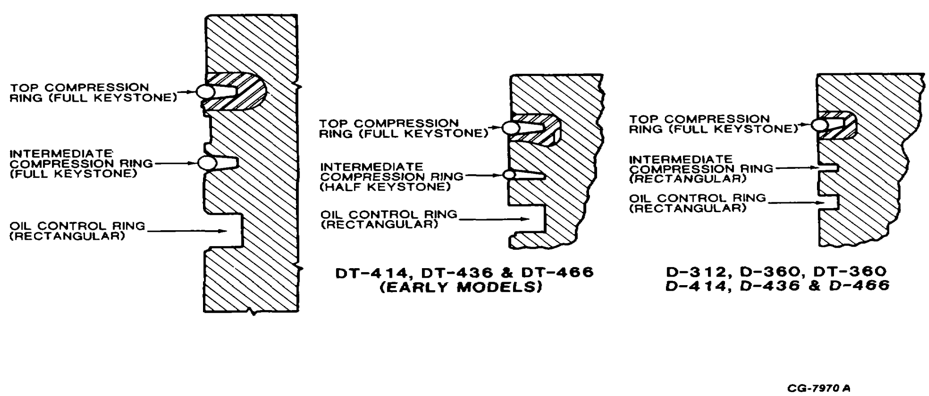


Figure 17. - Piston Identification

SERVICE SPECIFICATION CHART FOR PISTON RING GROOVE WIDTHS

		TOP COMPRESSION RING GROOVE				INTERMEDIATE COMPRESSION RING GROOVE			
				Dimension Over Pins				Dimension Over Pins	
Engine	Piston P/N	Groove Configuration	Ga. Pin Dia. (in.)	Upper Limit (in.)	Replacement Limit (in.)	Groove Configuration	Ga. Pins Dia. (in.)	Upper Limit (in.)	Replacement Limit (in.)
D-312	675 584 C1-C4	Full Keystone	0.1150	3.8898	3.8574	Rectangular	'	N/A	N/A
D-360	675 354 C1 & C2	Full Keystone	0.1150	3.8898	3.8574	Rectangular		N/A	N/A
DT-360	677 003 C1	Full Keystone	0.1150	3.8898	3.8574	Rectangular		N/A	N/A
D-414	671 543 C1	Full Keystone	0.1150	4.3118	4.2794	Rectangular		N/A	N/A
D-436	675 775 C1	Full Keystone	0.1150	4.3118	4.2794	Rectangular	*	N/A	N/A
D-466	671 544 C1	Full Keystone	0.1150	4.3118	4.2794	Rectangular	*	N/A	N/A
DT-414	677 007 C1	Full Keystone	0.1150	4.3118	4.2794	Half Keystone	0.0900	4.3244	4.2793
DT-436	677 018 C1	Full Keystone	0.1150	4.3118	4.2794	Half Keystone	0.0900	4.3244	4.2793
DT-466	677020C1	Full Keystone	0.1150	4.3118	4.2794	Half Keystone	0.0900	4.3244	4.2793
DT-414	684251 C1 or C2	Full Keystone	0.1150	4.3118	4.2794	Full Keystone	0.1150	4.3168	4.2844
DT-414B	684 251 C2	Full Keystone	0.1150	4.3118	4.2794	Full Keystone	0.1150	4.3168	4.2844
DT-436	684 253 C1-C3	Full Keystone	0.1150	4.3118	4.2794	Full Keystone	0.1150	4.3168	4.2844
DT-436B	684 253 C3	Full Keystone	0.1150	4.3118	4.2794	Full Keystone	0.1150	4.3168	4.2844
DT-466	684255 C1 orC2	Full Keystone	0.1150	4.3118	4.2794	Full Keystone	0.1150	4.3168	4.2844
DT/DTI-466B DT/DTI-466C	688 835 C1 or C2	Full Keystone	0.1150	4.3118	4.2794	Full Keystone	0.1150	4.3168	4.2844

* Rectangular groove configuration does not utilize measurement over gauge pins.
Use side clearance and ring gap dimensions as criteria for determining piston groove wear.
N/A dimension over pins not applicable for pistons with rectangular groove configuration.



DT-414, DT-436 & DT-466 (LATE MODELS)
DT-414B, DT-436B, DT/DTI-466B & DT/DTI-466C

Figure 18. - Piston Ring Groove Configuration

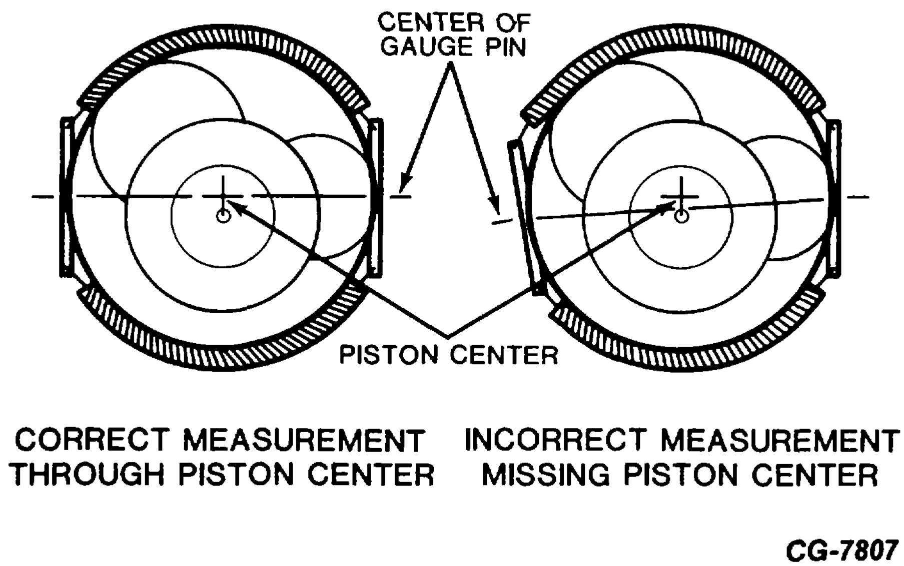


Figure 19. - Gauge Pin Installation

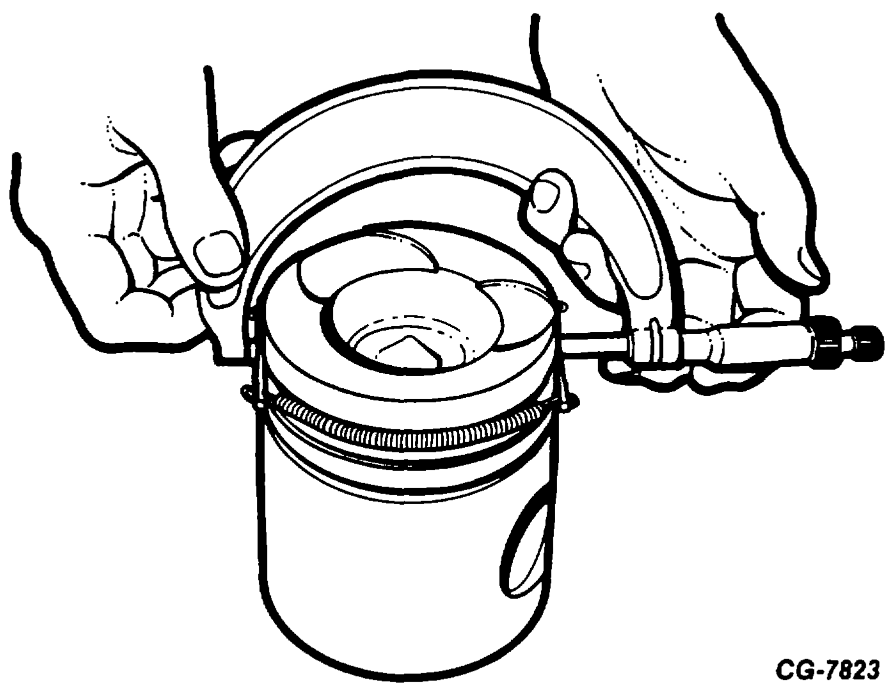


Figure 20. - Measurement Over Gauge Pins

8. Check the side clearance of each oil regulating ring in its respective groove.

a. Refer to “SPECIFICATIONS” for proper clearance.

b. On a used piston, it will probably be found that the side clearances tend to increase toward the top of the piston due to the greater operating temperature prevalent at this point.

9. Inspect the “windows” of the oil regulating rings for blocked oilways.

NOTE: ***Failure to keep the oilways clear will result in uneven lubrication of the piston and sleeve.***

10. All rings must fit loosely in the piston ring grooves without binding.

11. Ring bearing surfaces must be of a smooth/satin like finish with no burrs. Visually inspect new rings, prior to installation, for burrs.

NOTE: ***When new rings are being installed on a used piston for operation in a used sleeve, wear on the sleeve may have left a ridge where the piston reaches the top of its stroke. This ridge will cause noisy engine operation and breakage of the top ring. Remedy this by removing the ridge before installing the piston ring.***

Clean Cylinder Sleeves as follows:

1. Using a non-caustic soap solution clean the cylinder sleeves with minimally abrasive brush.
2. Thoroughly clean the “O” ring groove in the sleeves.
3. Dry the sleeves with compressed air.
4. Clean and flush out the water jacket in the crankcase.

Inspect Cylinder Sleeves as follows:

1. Measure the I.D. of the sleeve with an inside micrometer or bore gauge from the top and bottom of the sleeve where it is subjected to piston and ring travel, and the “O” ring area.

    a. Take measurements at right angles to determine if the sleeve is out of round or excessively tapered.

    b. Maximum permissible diameter sleeve wear, at top of ring travel, before replacement is 0.10 mm (0.004 in.).

    c. If sleeve does not meet specifications, it must be replaced with a new sleeve (and piston).

2. Inspect the sleeve for SCUFFING or SCORING. Replace sleeve (and piston) if this condition is found.

NOTE: ***Do not hone the cylinder sleeves.***

3. Inspect Counterbore for BURRS or FRACTURES.

If Sleeve Replacement is Required;

4. Identify between **Hardened** and **Unhardened** cylinder sleeves as follows:

    a. Make a solution known as NITAL by adding 10 parts of nitric acid to 90 parts of alcohol (rubbing alcohol is satisfactory).

    CAUTION! Add the nitric acid to the alcohol. Do not add alcohol to the nitric acid.

    b. Rub the I.D. of the sleeve near the top or near the bottom with the Nital. The etched area should extend into the sleeve approximately 1/2 inch and need be no more than 1/2 inch wide.

1. If the sleeve is hardened, a two tone gray pattern* will result with a sharp line of demarkation between the two colors.

2. If the sleeve is unhardened, the etched area will be one solid dark gray color.

c. Immediately after etching, neutralize the etched area with water and then coat it with oil.

* **The reason for the two-tone gray pattern in hardened sleeves is that the sleeves are not hardened at the extreme end. The soft area extends into the sleeve approximately 1/4 Inch. When etched with nital, the soft area will be light gray and the hard area will be dark gray.**

Inspect Crankcase as follows:

1. Check the crankcase counterbore depth with depth gauge (1, Fig. 22), 1 020 560 R91, at four points around the counter-bore (2) as shown in Fig. 22.

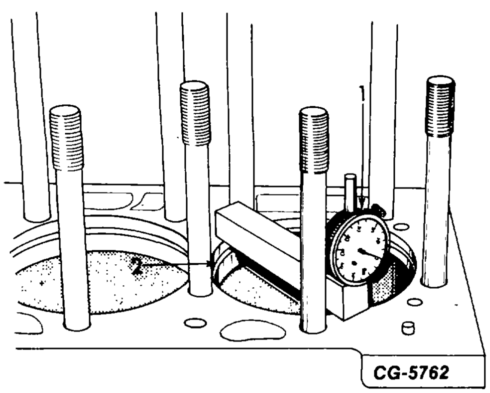


Figure 22. - Checking Crankcase Counterbore Depth

1. Depth gauge
2. Counterbore

a. Maximum variation between points of measurement before resurfacing is 0.03 mm (0.001 in.).

b. Resurface the counterbore using counterboring tool (No. 1 020 57491) as shown if Fig. 23. The following are basic components of the counterboring tool and are used in combination with the proper tool holder:

I.H. Part No.	Description
1 020 553 R91	Driver Unit, Handle & Tool Bits
1 020 554 R1	Adapter Plate
1 020 556 R1	Tool Holder (300 Series)
1 020 555 R1	Tool Holder (400 Series)

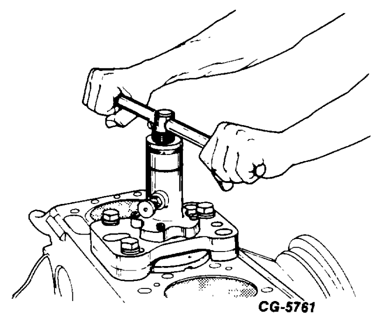


Figure 23. - Counterboring Tool Installed in Crankcase

2. Assemble the Counterboring Tool as follows:

a. Select the proper tool holder. Wipe all finished surfaces clean. Line up zero on the driver unit with zero on the adapter plate.

b. Install adapter plate (6, Fig. 24) onto driver unit (3) with four cap screws (4) provided with the unit..

c. Install tool holder (7) onto driver unit (3) allowing keyway in tool holder to engage over woodruff key.

d. Fasten tool holder (7) onto driver unit shaft with cap screw (8). Be sure washer is between cap screw and tool holder.

e. To disassemble tool holder from unit, remove cap screw and washer. Pull out on plunger (9) and permit shaft to move back and forth freely. By hand, bump tool holder against adapter plate until it is free from unit. DO NOT strike or damage the tool bit.

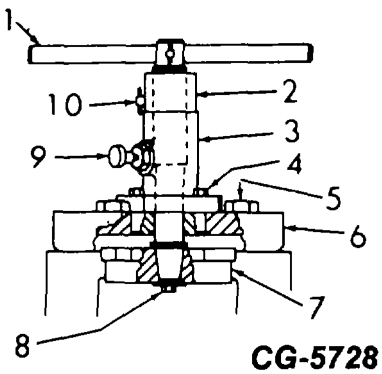


Figure 24. - Counterboring Tool and Component Parts

1. Handle
2. Adjusting nut
3. Driver unit
4. Cap screws
5. Cap screws
6. Adapter plate
7. Tool holder
8. Cap screw
9. Plunger
10. Locking screw

3. Preset the tool bit as follows:

   a. Install tool bit (1, Fig. 25) into tool holder (5).

   b. Place feeler gauge (3) on O.D. of tool holder as shown.

   c. Push tool bit out until it touches feeler gauge.

   d. Lock tool bit into position with clamp (4).

   e. Tool bit is now set for correct diameter cut.

NOTE: ***Tool bits must be handled with extreme care, to avoid possible damage from shock contact with hard surfaces.***

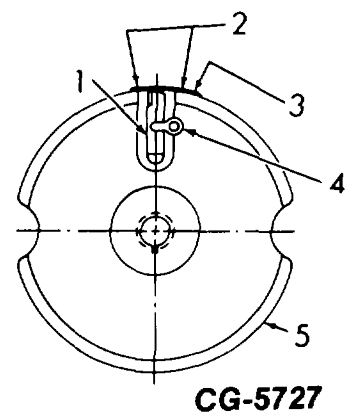


Figure 25. - Presetting Tool Bit

1. Tool bit
2. Press with fingers here
3. Feeler gauge 0.20-0.25 mm (0.008-0.010 In.) thick
4. Clamp
5. Tool holder

4. Prepare Crankcase for counterboring as follows:

   a. Remove all scale and carbon from deck and counterbore.

   b. Remove all burrs and nicks. Check edges of block for raised areas and remove with file. **DECK MUST BE FLAT**.

5. Install Counterboring Tool as follows: (Refer to Fig. 26).

   a. Pull out handle (1, Fig. 26) until plunger (9) will hold tool holder (7) in UP position.

   b. Place unit on crankcase with hold down holes matching holes in crankcase.

NOTE: ***If all counterbore ledges of one particular engine are to be counterbored to the same depth, take measurement of aft counterbores and set up counterboring tool on lowest counterbore ledge, to insure clean-up of all counterbores.***

c. Hold onto handle (1) and pull out on plunger (9).

d. Slowly and gently lower tool holder into counterbore, to avoid damage to the tool bit.

e. Engage larger diameter of tool holder into counterbore and allow tool bit to rest on counterbore ledge.

f. Loosen locking screw (10) and rotate adjusting nut (2) in a CLOCK-WISE DIRECTION until tool bit clears the counterbore ledge.

g. Tighten locking screw.

h. Assemble hold-down cap screws and washers (5) through adapter plate (6) into cylinder block finger-tight.

i. Tool holder must rotate freely.

j. Torque cap screws to 45 N•m (33 lbf-ft). Tighten each cap screw only a small amount before final torquing. Then cross-tighten in diagonal sequence.

6. Measure depth of counterbore as follows:

a. Using a depth micrometer (1, Fig. 26) measure from the top surface of adapter (2) to deck of crankcase (3) and record measurement.

b. Then, measure from top surface of adapter plate to counterbore ledge (4) and record measurement.

c. Subtract No. 1 reading from No. 2 reading, and this is the depth of the counterbore ledge as exemplified below.

EXAMPLE:

No. 1 Reading -
Top of Adapter Plate
to Counterbore Ledge 2.125"

No. 2 Reading -
Top of Adapter Plate
to Deck of Cylinder Block -1.750"
Depth of Counterbore = .375"

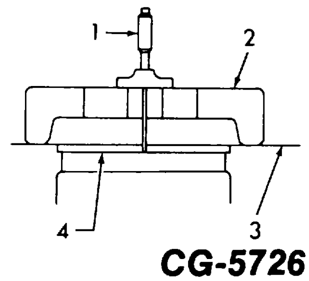


Figure 26. - Depth Measurement of Counterbore

1. Depth micrometer
2. Adapter plate
3. Deck of engine block
4. Counterbore ledge

7. Operate counterboring tool as follows:

a. Loosen locking screw (1, Fig. 27).

b. Rotate adjusting nut (2) in counter-clockwise direction until tool bit is resting on the lowest part of the counterbore ledge and there is clearance between the housing (5) and the adjusting nut.

c. The distance between the housing and adjusting nut equals the amount of material that will be removed from the counterbore ledge.

d. The adjusting nut has graduated markings to estimate the amount of the cut. Each mark is 0.03 mm (0.001 in.)

NOTE: ***Never attempt to remove more than 0.13 mm (0.005 in.) of material at one setting.***

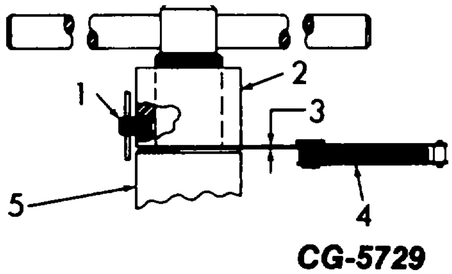


Figure 27. - Operation of Counterboring Tool

1. Locking screw
2. Adjusting nut
3. Depth of cut
4. Feeler gauge
5. Housing

NOTE: ***An alternate method for setting the depth of cut is to place a feeler gauge of required thickness between the adjusting nut and top housing. Make sure there is no grease or dirt between the adjusting nut and top of the housing.***

e. Rotate adjusting nut until feeler gauge is just held between adjusting nut and top of housing. All backlash must be removed.

f. Tighten locking screw (1, Fig. 27) securely and remove feeler gauge (4) if this ALTERNATE method is used.

g. Hold down on the handle applying more pressure on tool bit side and rotate clock-wise until the unit turns freely and is bottomed out between the adjusting nut (2) and top of the

NOTE: ***To avoid damage to the tool bit, never rotate counterclockwise when the tool bit is in contact with the counterbore ledge.***

h. Measure the counterbore depth as described earlier in steps (6, a-c) of this Section. Continue counterboring as required.

8. Maintain Counterboring Tool as follows:

a. Maximum tool bit life, of these accurately ground select carbide bits can be obtained by proper fitting into the tool bit holder and expert regrinding.

b. Regrind tool bits as shown in Fig. 27.

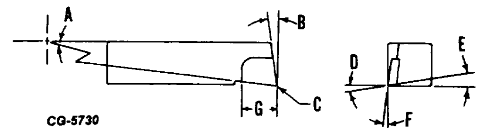


Figure 28. - Tool Bit Grinding Specifications

A. 0.24-0.51 mm (0.010-0.020 in.)
B. 8°
C. 0.20-0.25 mm (0.008-0.010 in.)R.
D. 7°
E. 10°
F. 6°
G. 4.7 mm (3/16 in.) minimum.

REASSEMBLY

Reassemble Connecting Rods, Pistons and Rings as follows:

1. Install new connecting rod piston pin bushing using a suitable arbor press. Bore or hone the new bushing to
   1.6256 - 1.6258 in.
   41.2902 - 41.2953 mm after assembly.

2. Generously coat the piston bore and piston pin with MOLYKOTE "G-n" paste or Fel-Pro C-670.

3. Insert the pin end of the connecting rod (6, Fig. 29) into the piston (7), aligning bored holes of the rod and piston (the short side of the split on the crank end of the rod is to be toward the side of the piston marked "CAMSIDE").

4. Align the bushing in the rod with the piston pin holes in the piston and push the piston pin (5) completely into position. (Pin is a loose fit at 21° C (70°F).

5. Squeeze the pronged ends of the piston pin retainer rings (4) and install a ring in the groove at each end of the piston to secure the piston pin.

6. Using a piston ring expander, install the rings into the grooves of the pistons.

   a. The compression rings (grooves Nos., 1 and 2) must be installed as directed by the word "TOP", "UP" or "PIP" mark stamped on the edge. The tapered face second compression rings must have the WITNESS MARK (shiny part) towards the bottom of the piston.

   b. The oil-regulating ring (groove No. 3.can be installed with either face up. The oil-regulating ring coil spring must be installed in the groove before the ring.

7. Position the split of the TOP ring 30° from the piston pin bore. Position the split of the second ring 180° from the top ring and position the split of the oil ring 90" from the second.

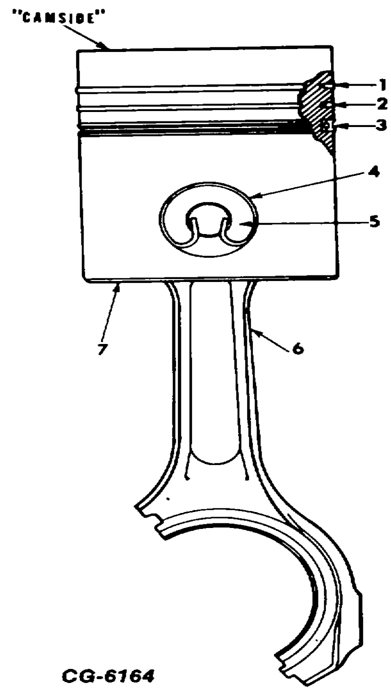


Figure 29. - Rod, Piston and Rings Reassembly

1. Top compression ring
2. Intermediate compression ring
3. Oil control ring
4. Retaining ring
5. Piston pin
6. Connecting rod
7. Piston

INSTALLATION

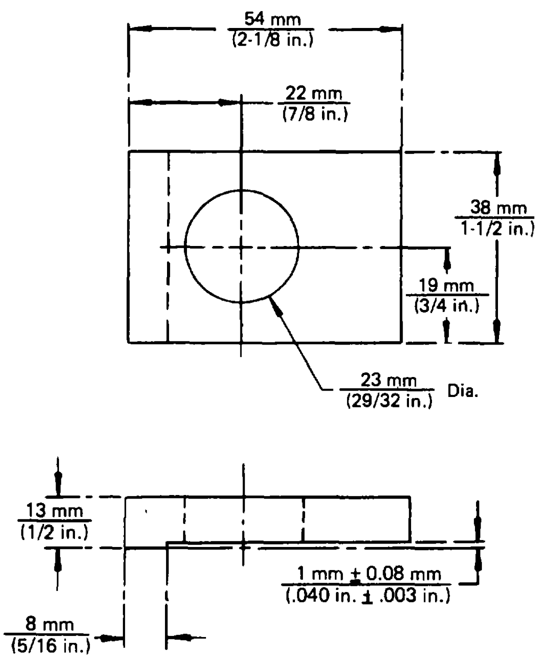
Install Cylinder Sleeves as follows:

1. Clean and dry the bore (in the crankcase) and flange counterbore. Also clean and dry the sleeve.

NOTE: ***When a new piston or a new piston and connecting rod assembly are being Installed, install a matched set of pistons and sleeves.***

2. Check Cylinder Sleeve Protrusion as follows:

   a. Place each sleeve in the crankcase without the "O" Rings. Clamp the sleeve down using three holding adapters as shown in Fig. 30. (Make sleeve holding adapters locally).



Material: Cold Rolled Steel
CG-5757

Figure 30. - Cylinder Sleeve Holding Adapter Specifications

   b. Use one of the hardened washers under each cap screw. Space the bolts to obtain uniform pressure on the sleeve flange as shown in Fig. 32. Torque the bolts in three stages: 55 N•m (40 Ibf-ft), 1 10 N•m (80 Ibf-ft) and 165 N•m (1 20 Ib. ft).

Holding Adapter

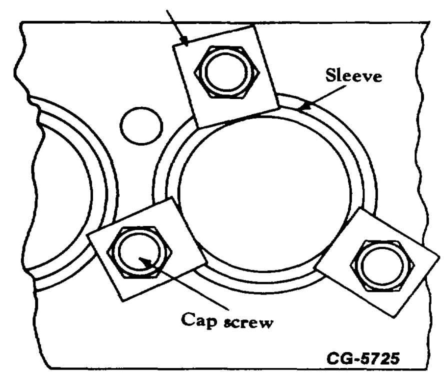


Figure 31. - Holding Adapter with Hardened Washers

   c. Place a dial indicator, with block, across the cylinder sleeve.

   d. With the dial indicator set on the flange of the cylinder sleeve, adjust the indicator to zero. Move the indicator block until the pointer drops to the crankcase deck and take a reading.

   e. If the sleeve flange is below the crankcase deck, rest the indicator pointer on the crankcase deck and set the indicator at zero. Move the indicator block until the pointer drops to the sleeve flange and take a reading.

f. Take readings at three or four points around the sleeve and use the average reading to determine which shim, if any, is needed to bring the protrusion within the

0.05 mm (0.002 in.)
0.13 mm (0.005 in.)
specification.

NOTE: ***Shims are available in 0.005 mm (0.002 in.), 0.10 mm (0.004 in.), 0.25 mm (0.010 in.), 0.51 mm (0.020 in.) and 0.81 mm (0.032 in.) thicknesses In a package.***

3. Install the necessary Shims and "O" Rings as follows:

a. Remove the clamping bolts and washers. Clean the TOP deck of the crankcase and the cylinder sleeve counterbore. Clean the sleeve.

b. Install the shim (if necessary) in the counterbore as shown in Fig. 32.

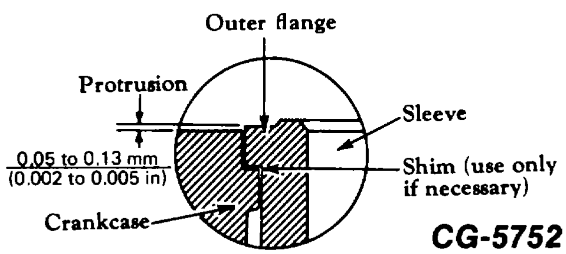


Figure 32. - Shim Placement

c. Coat the sealing "O" Rings with clean engine oil and install them into the grooves in the sleeves (without twist). The .rings MUST be installed in the following order: BOTTOM, CENTER and TOP.

NOTE: ***Be sure the "O" Ring is properly aligned in the groove.***

d. Brush the sealing ring contacting surface in the crankcase with clean engine oil.

e. Install the sleeve carefully into the same bore it was removed from. Press into place by hand.

f. Check sleeve protrusion as previously described in (2a-f) In this section.

Install Pistons and Connecting Rods as follows:

4. Coat the piston and piston ring compressor (PLT-500-2, 04-464-2 or SE-1680) for 400 series with clean lubricating oil.

5. Install the piston end rod assembly into the piston ring compressor.

NOTE: ***The piston and rod assemblies can be installed by turning the crankshaft only three times. Position the No. I and 6 crankpins at TDC. Install the No. 1 and 6 piston assemblies. Repeat this procedure for the Nos. 2 and 5 and Nos. 3 and 4 piston and rod assemblies.***

6. Coat the cylinder sleeve generously with clean lubricating oil. Install the compressor, with piston and rod, into the cylinder sleeve. The numbers on the rod must face away from the camshaft while the markings on top of the piston faces toward the camshaft side of the engine as shown in Fig. 33. Push down on the piston carefully until it is in the cylinder sleeve. Avoid striking the sleeve with the connecting rod.

7. Coat the connecting rod journal and connecting rod bearings with clean engine oil.

a. Install the upper half of the bearing in the connecting rod and pull the rod down onto the journal.

b. Install the connecting rod bearing cap with the numbered side of the cap matching the numbered side of the rod.

c. Install the bolts and tighten to 80 N•m (60 Ibf-ft) torque, then tighten to 175 N•m (1 30 Ibf-ft) torque.

NOTE: ***If bolts will not screw in by hand, re-clean the rod threads and try a new bolt. If a new bolt does not screw in freely, the rod must be discarded. Whenever new bolts are used in a rod, they must be torqued to 175 N•m (130 lb-ft), loosened, and retorqued three times.***

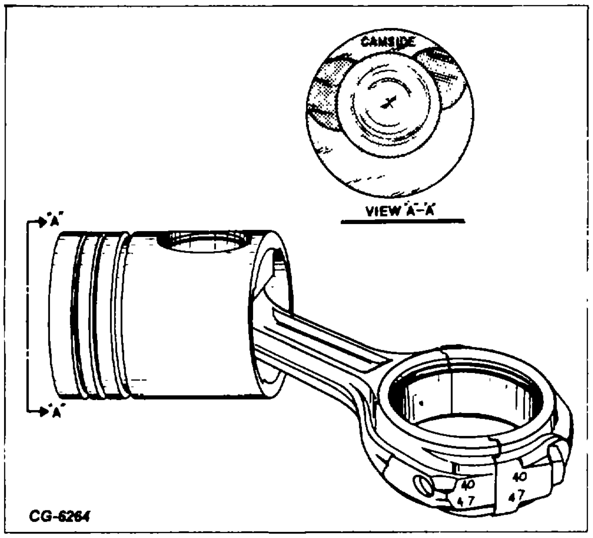


Figure 33. - Connecting Rod and Piston Marking in Relation to the Camshaft

1. Numbers face away from camshaft.
2. Markings on top of piston face toward camshaft.

8. Install the remaining rods and pistons in the same manner.

NOTE***: The connecting rod bearings must be fitted. Bearing clearance checked and connecting rod end play checked, as outlined previously in this section, prior to continuing with engine assembly.***

9. Install cylinder head & valves as described in Section 3.

NOTE: ***Whenever the cylinder head is removed valve lash must be adjusted as described in Section 3.***

10. Install Manifolds and Turbocharger (if equipped) as described in Sections 2 and 1 respectively.

11. Install the oil pan with a new gasket.

12. After installation of new pistons and/or new piston rings, the engine must be "RUN-IN" as follows:

NOTE: Do not run the engine at low or high-idle speeds for 'long periods after installing new rings or sleeves, as rings will not seat during idle operation.

a. Install the necessary diagnostic instruments similar to procedures outlined in diagnostic manual ISS-1526-3 for construction equipment, CGES-240 for OEM and On Highway Truck, GSS-1460 and GSS-1482 for Agricultural Equipment. Fill engine crank-case with lubricating oil as specified in specific operation and maintenance manual.

b. Perform a 60 minute (minimum) DYNAMOMETER or IN-VEHICLE Run-In Procedure as follows:

-ENGINE RUN-IN SCHEDULE-

1. Motor engine (w/dynamometer) or idle Engine (In-vehicle) at "No Load" @ 550-600 RPMI and check for leaks in water, lube oil, fuel and air-induction systems. Time required: 5 minutes.

2. Operate engine at 3/4 rated speed (RPM) and 1/2 rated load for that speed. Time required: 5 minutes.

3. Operate engine at ¾ rated load and rated speed (RPM). Time required: 5 minutes.

4. Operate engine at full load and rated speed for specific application. *Time required: 20-25 minutes.

5. Recheck for lube oil, air and water leaks. Inspect and replace oil filters if necessary.

6. Retorque cylinder head bolts, check valve lash (Section 3) and reset if necessary.

7. Set pump; then continue to operate engine at full load and rated speed to complete a minimum of 60 minutes total running time. The full load portion of this step must NOT be less than 10 minutes. Time required: 20-25 minutes.

NOTE: ***Engine temperature should be stabilized before cylinder head is retorqued or valve lash adjustment is done. It is not necessary to change oil after this run-in schedule. Change oil at the next scheduled change period.***

13. Prime the Lubricating System as follows:

a. Hand lubricate the various running parts, when assembling the over-hauled engine, with clean engine oil.

b. Pressure prime the lubrication system with oil, prior to starting, as follows:

1. Using Oil Leak Detector SE- 1632 attach the line from the oil leak detector to the oil cooler at the pipe plug.

*Refer to Performance Data Guidelines found in Diagnostic Manuals - ISS-1526-3, CG ES-240-2, GSS-140 and GSS-1482.

2. Inject sufficient oil into the engine to fill the oil filters and charge the entire system.

NOTE: ***If oil enters the engine at other than the cooler, oil will be blocked by the oil filter and will not flow to the lube oil pump.***

3. **DO NOT** rotate any diesel engine when priming with oil; otherwise, they are likely to start running.

4. After priming, check oil level before the engine is put back into service. Fill only in accordance with Operator's Manual Specifications.

5. Follow steps 12b, 1 through 4, for new or overhauled engines which have been in storage over an extended period of time. This will minimize the possibility of scuffing or heat buildup in the running components which could lead to immediate or low mileage failures.

NOTE: ***Order Oil Leak Detector SE-1632 from:***

Federal Mogul Service Co.
600 West Chicago Street
Coldwater, Michigan 49036
Attention: Special Order Dept.

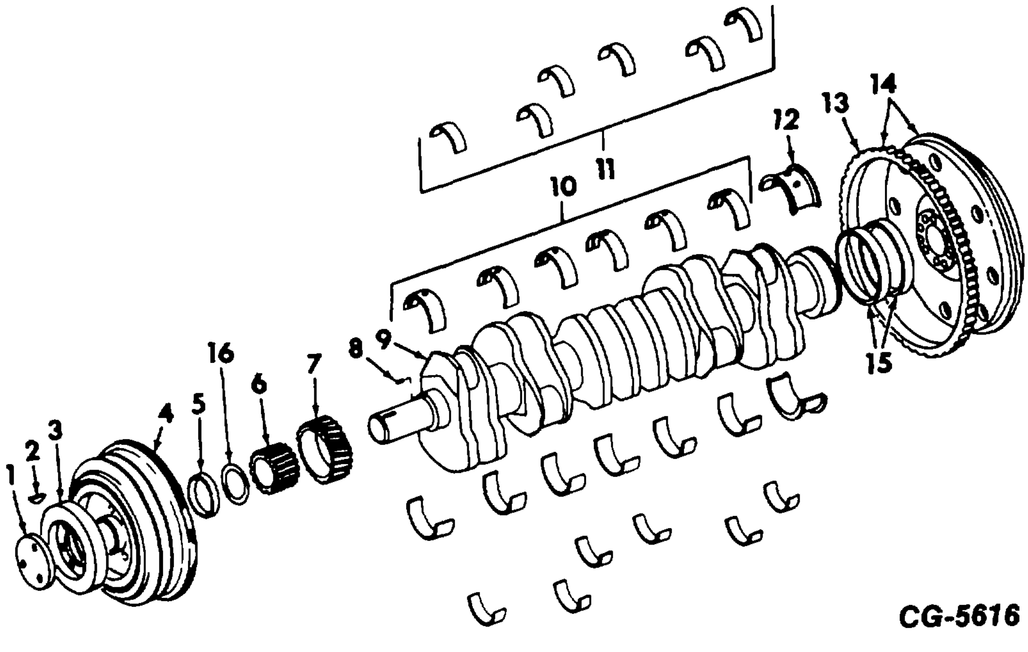


Figure 1. - Crankshaft, Bearings, Flywheel and Related Components

1. Plate, damper retaining
2. Key, woodruff
3. Damper, vibration
4. Pulley, crankshaft
5. Sleeve
6. Spline, oil pump
7. Gear, crankshaft
8. Pin, roll
9. Crankshaft
10. Bearings, crankshaft front
11. Bearings, connecting rod
12. Bearings, crankshaft rear
13. Gear, ring
14. Flywheel
15. Kit, crankshaft rear oil seal and wear sleeve
16. Washer, seal

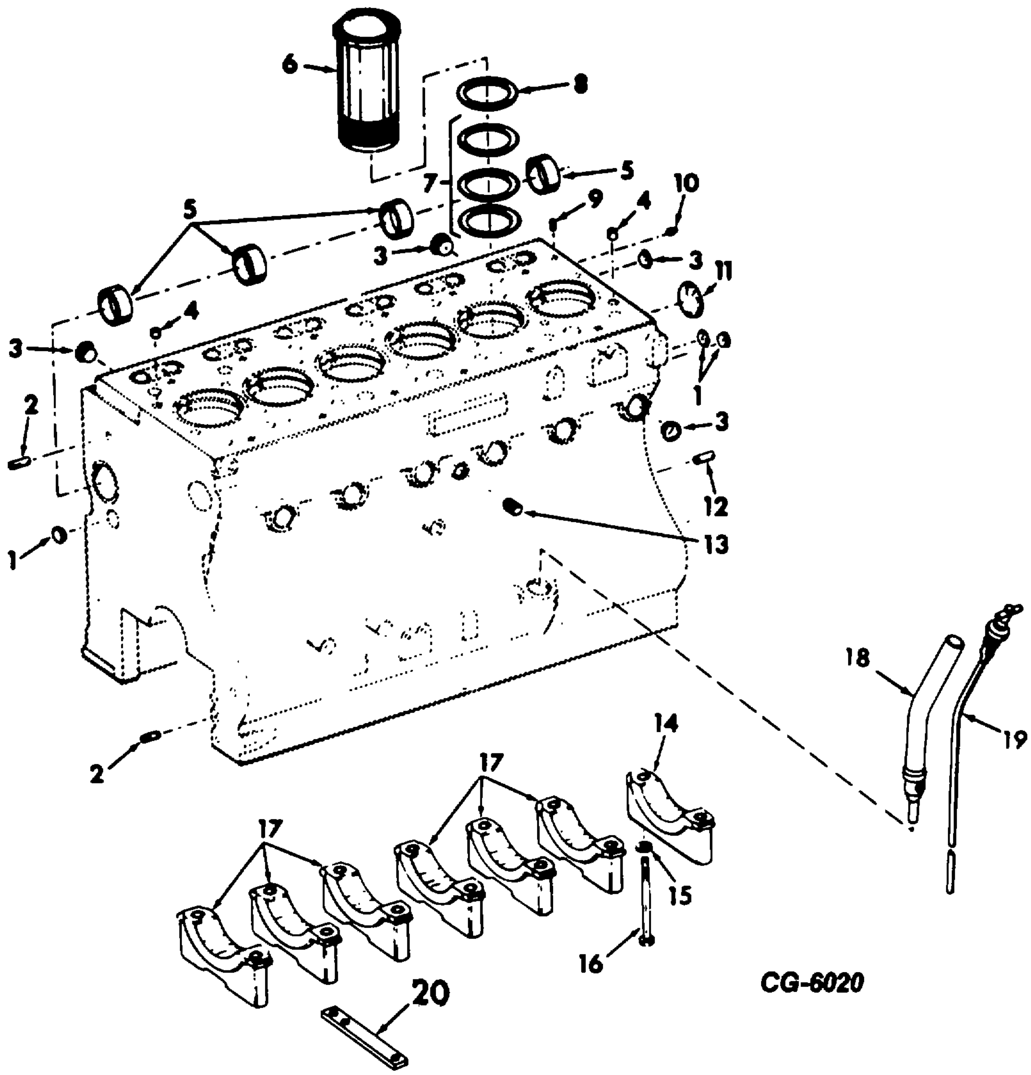


Figure 2. - Crankcase and Related Parts

1. Plug, cup
2. Dowel
3. Plug, cup
4. Dowel, bushing
5. Bearing Set, camshaft
6. Sleeve, cylinder
7. "0" Rings, cylinder sleeve
8. Shim, cylinder sleeve (as required)
9. Screw, set and steel ball
10. Plug, hex-socket
11. Ring, camshaft seal rear
12. Dowel
13. Plug, pipe
14. Cap, main bearing rear
15. Washer, main bearing cap bolt
16. Bolt, main bearing cap
17. Cap, main bearing front/intermediate
18. Pipe, oil filler (Typical)
19. Gauge, oil filler (Typical)
20. Bracket, suction pipe support

General

CRANKSHAFT

The crankshaft is fully counterbalanced and the journals are induction hardened. The D and DT-466 engines are also fillet hardened. There are seven main bearings, with the number - 7 (rear) bearing absorbing the end thrust. The crankshaft extension at the foreward end carries the main drive gear, a splined collar (which drives the lubricating oil pump) and the vibration damper. The gear and splined collar are a shrink fit and the damper, a press fit. The damper hole is keyed to the shaft and held in place by a retainer plate. The flywheel is mounted to the rear end of the crankshaft. Two seals, one at the front and one at the rear, prevent leakage of engine lubricating oil around the ends of the crankshaft.

MAIN BEARINGS

Bearing caps are furnished with the crankcase and these support the crankshaft in true alignment. Webs integral with the crankcase provide the upper half of the main bearing supports and removable caps provide the lower support. The caps are held in place with cap screws. The bearing caps are **NOT** interchangeable, and each has a number stamped upon it which signifies its correct location in the crankcase, as shown in Fig. 3. Number 1 is at the front of the engine.

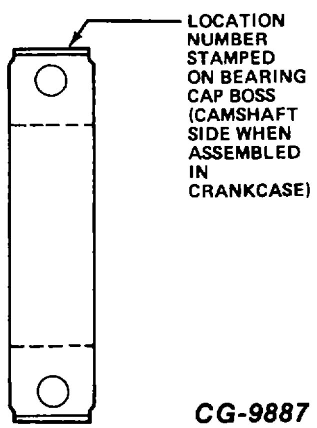


Figure 3. - Bearing Cap (Top View) Identification Number

FLYWHEEL

The flywheel Is attached to the rear of the crankshaft. Its purpose is to oppose and moderate by its inertia any fluctuations in the speed of the engine. It counteracts variable torque's during the stroke of the engine, and provides a rotating balance weight that carries the engine crankshaft over dead centers on the pistons.

It is secured to the end of the crankshaft with bolts. The cranking motor drive ring gear is a shrink fit and is replaceable.

CRANKCASE

There are two basic crankcases used: one for the 300 Series and one for the 400 Series Engines. The main differences are the physical dimensions; the 400 Series case is longer and higher.

All crankcases have seven main bearing areas with the thrust bearing saddle located at the rear. All cases are line bored with the caps in place and the bolts tightened to the specified torque. All caps are marked and are not interchangeable within the case itself or with other cases. On Turbocharged engines, each main bearing web has angled-drilled holes, which are fitted with coolant jet tubes that direct lubricating oil, under pressure, to the underside of each piston. A percentage of the lubricating oil fed to the main bearings passes through milled slots in the upper half of the bearing shells. The stream of oil from these jets is a constant flow during all periods of engine operation. N.A. engine crankcases have the twelve oil-jet holes plugged with balls.

There are two oil galleries cast into the case; one handles unfiltered oil from the pump to the cooler and then from the cooler to the filter base. Oil leaving the filter enters the second gallery and is distributed to various points of lubrication throughout the engine. Both galleries are sealed at the front and rear of the case with plugs. The camshaft is located directly above these galleries and is supported on finished bushings pressed into the case.

The cast-in water-distribution passageway is plugged at the rear of the case. A breather pipe aerates the crankcase. The breather pipe is located below the exhaust manifold with the element inside the crankcase, on the "OLD" CRANKCASE MOUNTED ventilation system.

However, the "NEW" VALVE COVER MOUNTED ventilation system aerates the crankcase and reduces oil carry-over through the crankcase breather. The breather element, which requires service is located on the valve cover.

400 Series Crankcase Revision

With the introduction of the NEW 400 SERIES TAPPET (See Section 4), a new crank-case (IH P/N 1 802 330 C1) with a 28.524 mm (1.1230 in.) tappet bore diameter has been released into production and service re-placing the old style crankcase (IH P/N 675 500 C4) with 25.400 mm (1.0000 in.) tappet bore diameter. The new crankcase can be identified by (IH Part No. 1 802 330 C1) appearing on the right hand side of the crank-case as shown in Figure 4.

IMPORTANT: Some new crankcases (IH Part No. 1 802 330 C1) with 1.1230 in. Tappet bores will have old (IH Part No. 675 500 C4) Rev. w/cost on the side (Fig. 4). Identify 400 Series crankcase Revision by Engine Serial Number.

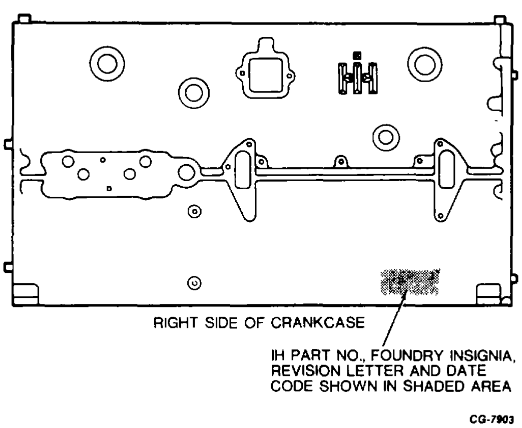


Figure 4. - 400 Series Crankcase Identification

Engine	**Serial No.**
DT414B	155806 and above
DT436B	121623 and above
DT466B	140086 and above
DT466C	400001 and above

IMPORTANT: The crankcase (IH Part No. 1 802 330 C1) is a NON-SERVICE Part Number, to be used for Identification only. Refer to appropriate parts catalog when ordering parts.

400 Series Front and Intermediate Crankshaft Upper Main Bearing Insert Revision.

A revised front and intermediate crankshaft upper main bearing insert has been released with piston oil jet tube holes (1, Figure 5) relocated to the center of the oil groove (2, Figure 5). This change provides increased load carrying capability of the bearing.

The "Old Style" bearing insert with "Offset" piston oil jet tube holes (Refer to Figure 21) drilled to align with piston oil jet tubes may be intermixed with the "New Style" bearing insert. [Refer to Figure 20 to view "Old Style" Insert]. The "New Style" bearing insert is designed to be used WITHOUT changing the location of the piston oil jet tubes in the main bearing. This is accomplished by providing a large chamfer on the back side of the "New Style" bearing (3, Figure 5) which assures proper oil flow to piston oil jet tubes.

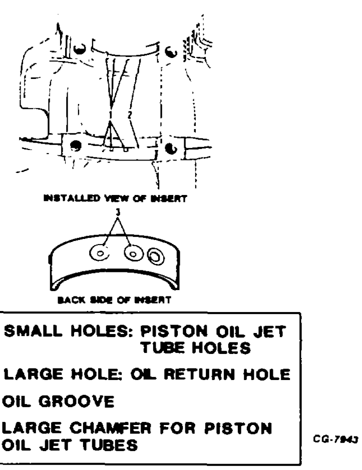


Figure 5. - "New Style" Bearing Insert

SPECIFICATIONS

DIMENSIONS VALUES

CRANKSHAFT:

Crankpin Diameter	76.142 mm 76.175 mm	(2.9977 in.) (2.9990 in.)
Main Journal Diameter	85.705 mm 85.738 mm	(3.3742 in.) (3.3755 in.)
Maximum Permissible Journal out-of-roundess, before Reconditioning	0.0130 mm	(0.0013 in.)
Number of Main Bearings		7
Main Bearing Running Clearance	0.046 mm 0.0130 mm	(0.0018 in.) (0.0051 in.)
Maximum Permissible Main Bearing Clearance, before Reconditioning	0.15 mm	(0.006 in.)
End Clearance	0.15 mm 0.30 mm	(0.006 in.) (0.012 in.)
Maximum End Play before Reconditioning	0.51 mm	(0.020 in.)
main Bearing Bore in Crankcase,		
Line Reamed	93.688 mm 93.713 mm	(3.6885 in.) (3.6895 in.)
Thrust Bearing Location		Rear

FLYWHEEL

Large Bore Flange Run-out (Total indicator reading)	0.20 mm	(0.008 in.)
Large Bore Concentricity with Crankshaft (Total indicator reading)	0.20 mm	(0.008 in.)

REMOVAL

REMOVAL

Remove Flywheel as follows:

1. Remove the engine clutch (if equipped). (Refer to respective chassis manual for engine clutch-removal procedure).

2. Remove flywheel bolts. Pull off flywheel with ring gear. Support the flywheel so as not to damage the crankshaft dowel pin.

Remove the Rear Oil Seal as follows:

1. ENGINES EQUIPPED w/OIL SEAL RETAINER:

    a. Remove the retainer (3, Fig. 6) and gasket (2).

    b. Press the seal (1) out of the retainer as shown.

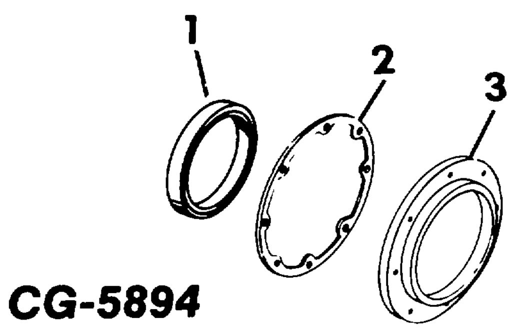


Figure 6. - Rear Oil Seal and Related Parts

1. Seal and sleeve
2. Gasket
3. Retainer

2. ENGINES NOT EQUIPPED w/OIL SEAL RETAINER:

    a. Using a chisel, split the oil seal (1, Fig. 7), as shown.

    b. Remove the seal from the flywheel housing.

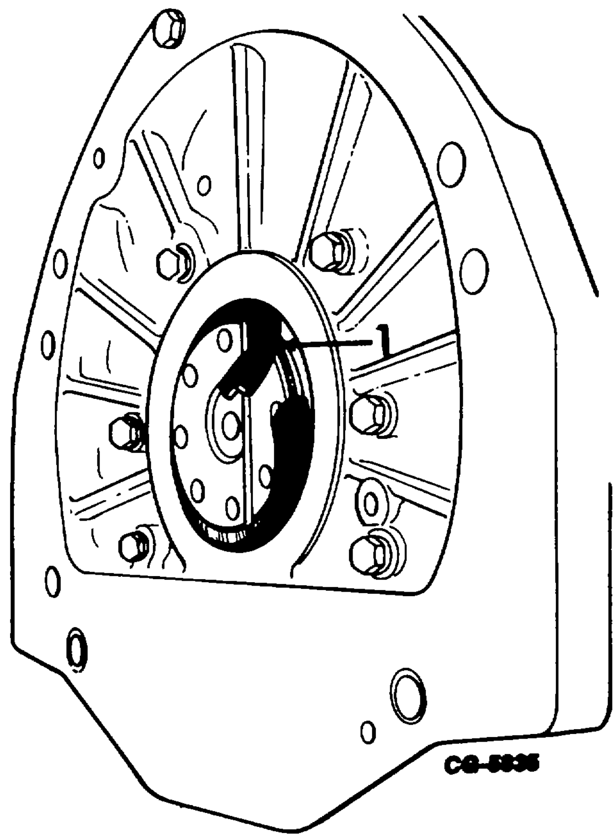


Figure 7. - Removing Oil Seal from Flywheel Housing

1. Oil Seal

NOTE: ***Be careful not to damage the seal bore in the housing.***

    c. Cut the wear sleeve with a muffler chisel. Be careful not to damage the crankshaft flange.

    d. Remove the wear sleeve.

NOTE: ***IH recommends the Mac Tool No. MC-22 or an equivalent tool as shown in Fig. 8.***

CG-5836

Figure 8. - Mac Tool No MC-22 (Muffler Chisel)

Remove the Crankshaft Bearings as follows:

1. Drain the oil from the crankcase oil pan, then remove the oil pan.

2. Remove the cap screws securing the crankshaft bearing caps.

   Tap the caps lightly with a soft metal hammer or mallet to loosen them, then remove lower bearings.

   a. If the bearings are to be reused, identify each bearing as to its original position.

   b. Remove the Lower Bearing from the caps.

   c. Wrap the pieces in a clean cloth and store them until reassembly.

NOTE: ***If the crankshaft is to be removed, disregard step 3.***

3. Remove the upper bearing halves as de-scribed in methods a or b.

   a. Insert a thin piece of flexible soft metal between the crankshaft and crankcase. This will push against the end of the bearing furthest from the nib holding the bearing in the crankcase support. Simultaneously, turn the crankshaft in the direction of rotation. This will cause the bearing to slide easily from position.

   b. An alternate method of removing upper bearing halves is to hammer the closed end of a small cotter pin to form a "T".

   Insert the prongs of the cotter pin into the oil hole of the crankshaft journal with the flattened head just protruding. Rotate the crankshaft and the cotter pin head will push the bearing from position.

Remove the Crankshaft as follows:

1. After flywheel is removed, remove the flywheel housing (with crankshaft rear oil seal retainer attached) from the crankcase.

NOTE: ***It is not necessary to remove the flywheel housing if all that is required is to replace the crankshaft rear oil seal.***

2. Remove the oil lubricating pump as described in Section 8.

3. Remove the crankcase front cover assembly as described in Section 7.

4. Remove the connecting rod bearing caps and push the assemblies to the top of their travel.

5. Lift the crankshaft out of the crankcase with a nylon sling (see tool list for tool number) and hoist as shown in Fig. 9.

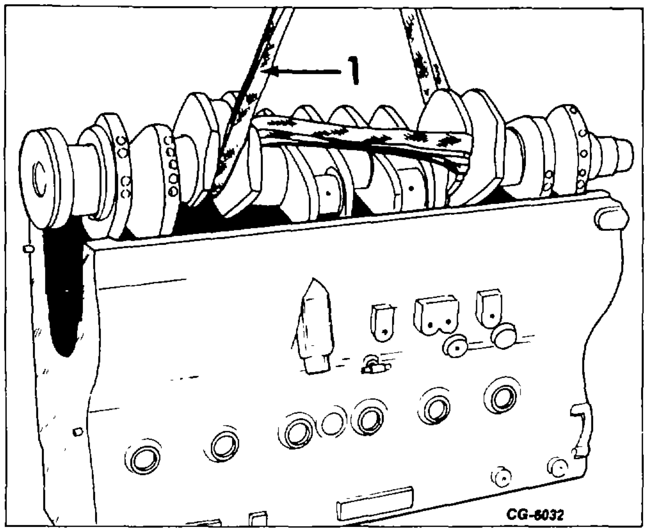


Figure 9. - Removing Crankshaft from Crankcase

1. Nylon sling

6. Remove the upper main bearing halves.

7. Remove the rear oil seal wear sleeve using a muffler chisel such as Mac Tool No. MC-22 or equivalent (obtain locally). Hold chisel flat against the crankshaft to prevent damage by the chisel's point as shown in Fig. 10.

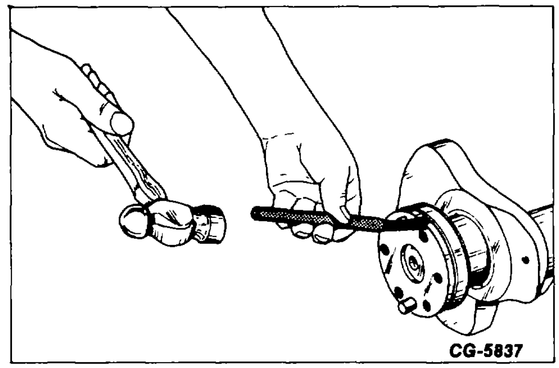


Figure 10. - Removing Wear Sleeve with Muffler Chisel

CLEANING, INSPECTION & REPAIR

CLEANING

Clean the Crankshaft and Main Bearings as follows:

1. Clean all parts with non-caustic cleaning solvent.

2. Dry with compressed air.

3. Clean all the crankshaft internal oil passages of any dirt or sludge that may have accumulated. Run a stiff wire brush through the oil passages to loosen the deposits, then wash the passages and external surfaces of the crankshaft thoroughly with fuel oil. Blow the passages and external surfaces dry with compressed air.

Clean the Flywheel and Ring Gear as follows:

1. Wash the flywheel and ring gear in non-caustic solvent.

2. Dry with Compressed air.

Clean the Crankcase as follows:

1. During overhaul it is best to clean the crankcase in a chemical "hot tank." This removes all carbonous material and mineral deposits that collect in the cooling passages.

2. Clean all lube oil passages, thoroughly.

3. Remove gallery plugs and swab with a brush and solvent. (Reseal all plugs upon installation).

4. Clean all threaded holes with a tap of appropriate size and blow clean with compressed air.

INSPECTION AND REPAIR

Inspect the Crankshaft and Main Bearings as follows:

1. Visually inspect the bearings for wear and evidence of uneven bearing support. If such evidence is found, examine the bearing caps and supporting surfaces of the crankcase for high spots and burrs.

2. Visually inspect the crankshaft journals for scoring.

3. Measure the diameter of each journal using a micrometer as shown in Fig. 11. Measure each journal at two points, at right angles to each other. Move the micrometer over the entire width of the journal. Limits of:

85.705 mm	(3.3742 in.)
85.738 mm	(3.3755 in.)

   must be observed.

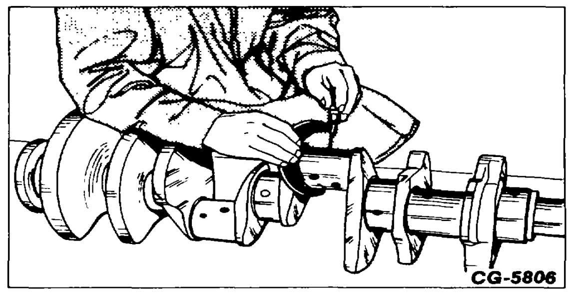


Figure 11. - Measuring the Crankshaft Journals

4. Check HARDNESS, on every journal which incurred a bearing failure or shows evidence of overheating, as follows:

   a. Using a Rockwell Hardness Tester, check at least three locations.

NOTE: ***Fillet hardened shafts should be checked as close to the fillet as possible. Non-fillet hardened shafts should be checked at least 13 mm (1/2 inch) from the fillet.***

   b. Check rod journals at top, bottom and one other location. (Top and bottom determined with journal at TDC).

   c. Minimum hardness:

D-312, D and DT-360, D and DT-414, D and DT-436 non-fillet hardened shafts.	30 RC
D, DT and DTI-466 fillet hardened shafts.	45 RC

   If any reading is below the minimum hardness, REPLACE the crankshaft.

NOTE: ***All crankshafts must be hardness checked before regrinding. Bearing failures can cause overheating of crankshaft journals, resulting in reduction of hardness.***

5. Inspect the crankshaft gear teeth and splined collar for wear and chipping. Replace damaged parts as required.

6. Visually inspect the drilled holes in the main and connecting rod journals to assure that all passages are open after cleaning.

Repair the Crankshaft as follows:

Special precautions must be taken during grinding when regrinding the crankshaft. The following MUST be adhered to when regrinding or the crankshaft can be severely weakened:

IMPORTANT: All 466 Series engines have fillet-hardened crankshafts. Take caution during grinding.

NOTE: ***Due to the exacting standards and controls for shaft regrinding, it is recommended that this work be done by I.H. ReNEWed Stations. However, regrind locally where equipment experience can produce quality standards. Proceed as follows:***

a. Check for hardness as described earlier in this section.

b. Crankshafts may be straightened ac'-cording to following instructions:

 1. Crankshaft straightening is required when main bearing journal runout is in excess of .007" T.I.R. checked at #4 main bearing.

 2. Check runout with #1 and #7 main bearing journal in "V" blocks When straightening, support crankshaft on #1 and #7 main journals, straightened with the deflection of #4 main journal limited by a positive stop to "A" (see chart).

 3. Apply straightening force to #4 main journal.

ENGINE	"A"
300 Series	.200"
400 Series	.500"

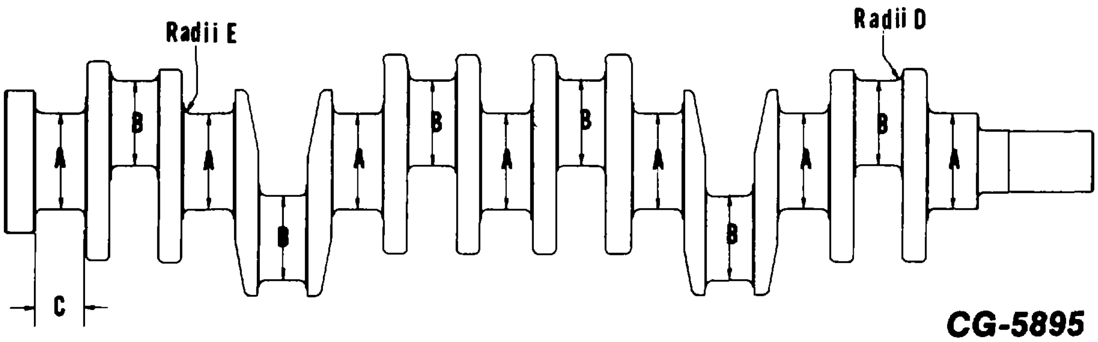
⚠ CAUTION! Crankshaft must be Magnaglo or Magnaflux inspected for cracks after straightening is completed. Crankshaft must not be deflected more than the indicated limit at #4 main journal. Crank-shaft must be demagnetized after inspection.

c. Grind crankshaft observing the following precautions:

 1. Use only a mechanical or an automatic wheel dresser to prevent chatter, burring and poor surface finish.

 2. Select the appropriate grinding wheel. An aluminum-oxide wheel with a 50 grit surface and maximum hardness of M, is recommended to reduce the possibility of burns during grinding.

 3. Straight-cutting oils are recommended as the best coolant for grinding crankshafts.



.010 Inch Undersize Crankshaft*	A	B	C	D	E
300 Series	85.451-85.484 (3.3642-3.3655)	75.888-75.921 (2.9877-2.9890)	36.614-36.690 (1.4415-1.4445)	5.59-5.97 (0.220-0.235)	3.89-4.06 (0.153-0.160)
400 Series	85.451-85.484 (3.3642-3.3655)	75.888-75.921 (2.9877-2.9890)	45.29-45.36 (1.783-1.786)	5.59-5.97 (0.220-0.235)	5.59-5.97 (0.220-0.235)
020 Inch Undersize Crankshaft*	A	B	C	D	E
300 Series	85.197-85.230 (3.3542-3.3555)	75.634-75.667 (2.9777-2.9790)	36.614-36.690 (1.4415-1.4445)	5.59-5.97 (0.220-0.235)	3.89-4.06 (0.153-0.160)
400 Series	85.197-85.230 (3.3542-3.3555)	75.634-75.667 (2.9777-2.9790)	45.29-45.36 (1.783-1.786)	5.59-5.97 (0.220-0.235)	5.59-5.97 (0.220-0.235)
.030 Inch Undersize Crankshaft*	A	B	C	D	E
300 Series	84.943-84.976 (3.3442-3.455)	75.380-75.413 (2.9677-2.9690)	36.919-36.995 (1.4535-1.4565)	5.59-5.97 (0.220-0.235)	3.89-4.06 (0.153-0.160)
400 Series	84.943-84.976 (3.3442-3.3455)	75.380-75.413 (2.9677-2.9690)	45.59-45.67 (1.795-1.798)	5.59-5.97 (0.220-0.235)	5.59-5.97 (0.220-0 235)

Figure 12. - Limits for Undersize Crankshaft Grinding

***Grinding Limits:**

Maximum allowable taper on crankpins and journals 0.0038 mm per 25.4 mm of length (0.00015 per Inch of length).

Crankpins and journals must be polished to 20 Micro-inch maximum - to 5 Micro-Inch minimum, and must not be over 0.003 mm (0.0005 inch) out of round.

4. Maintain a grinding wheel speed of 6500 surface feet per minute with a work spindle speed of approximately 40 to 45 RPM, for satisfactory results.

CAUTION! As a normal precaution, it is recommended that a CO2 fire extinguisher be near the grinding machine, just In case any excessive heat should ignite the oil. If a fire should start, it can be rapidly extinguished without causing any damage to the machine or surrounding area by following the normal fire-extinguishing procedure.

5. Feed rates should be slower than normal to prevent any burning.

6. Maintain grinding limits as shown in Fig. 12.

d. Allow the shaft to thoroughly cool, prior to inspecting for dimensional tolerances.

e. Prior to lapping inspect for burning during the regrinding procedure with TAROSOV ETCH as follows:

CAUTION! Due to the sharp odor and flammability of the Tarosov Etch, the etching should be done In a well-ventilated area, away from any open flame.

1. Clean the surface with a scouring powder and water or a good solvent.

2. Wash thoroughly and rinse with alcohol.

3. Apply etchant No. 1 (4 parts Nitric acid in 96 parts water) for approximately 16 seconds with a cotton swab.

4. Rinse with water and dry.

5. Apply etchant No. 2 (2 parts Hydrochloric acid in 98 parts acetone) for approximately 15 seconds with a cotton swab.

CAUTION! Acetone Is highly flammable.

6. Rinse with alcohol and dry thoroughly with compressed air.

7. TAROSOV ETCH will show up as a change of color after each etch, if the crankshaft has been burned. Areas rehardened by excessive heat appear nearly white, while softened areas turn a dark grey or black. Areas unaffected by the heat of grinding etch a light gray.

SCRAP THE CRANKSHAFT IF ANY BURNS SHOW UP AFTER ETCHING.

f. After grinding and lapping visually inspect the surface for grinding cracks, using magnaflux on Elotherm crankshafts.

SCRAP THE SHAFT IF ANY SUR-FACE CRACKING IS FOUND.

Inspect the Flywheel and Ring Gear as follows:

1. When used with clutches having bi-metallic-driven members examine the contact face of the flywheel for heat cracks and scoring. Service or replace if scoring is excessive.

2. When used with clutches having ceremetallic-driven members, scoring of the flywheel is normal. However, if scoring is excessive reface or replace the flywheel as required.

3. Inspect the ring gear for broken teeth and replace it if necessary.

4. Remove the pilot bearing from the flywheel (if equipped). After cleaning inspect it for wear and damage.

   a. If the bearing is still serviceable lubricate it with clean engine oil and reinstall it.

   b. If the bearing has considerable service, replace it.

Repair the Flywheel and Ring Gear as follows:

1. Grind the flywheel as required. The maximum allowance for removal is 1.6 mm (1/16 in.).

   a. It is not necessary to remove all grooves or scoring.

   b. **DO NOT** remove more surface material than specified. Otherwise interference of the driven member hub with the clutch pilot bearing in the flywheel will result.

2. Remove the broken ring gear from the flywheel by heating the gear with a torch to expand it. Then drive gear from the flywheel.

3.Install a new ring gear as follows:

   a. Heat the gear to 260° 290°C (500° 550°F) for expansion.

   b. Place the hot gear onto the flywheel.

   c. The chamfered edge of the ring gear I.D. must be next to the shoulder of the flywheel.

4. Check Flywheel Housing Face Run-Out as follows:

   a. Attach a dial indicator to the crankshaft flange and place the indicator pointer against the flywheel housing flange.

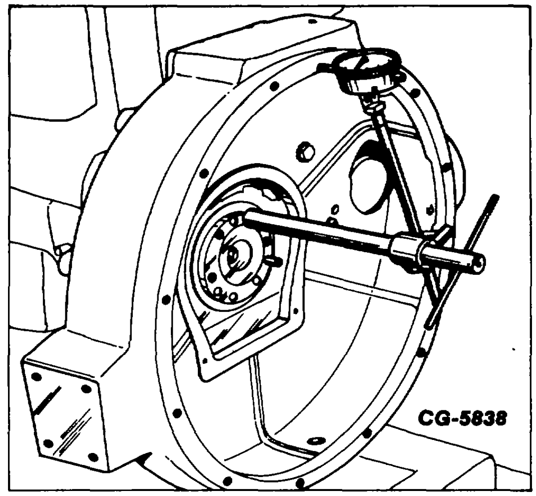


Figure 13. - Checking Run-Out of Flywheel Housing Face in Relation to the Axis of the Crankshaft

   b. Check at four points 900 apart, for total face variation.

   c. Keep crankshaft "end play" at zero in the same direction for all readings as shown in Fig. 13.

   d. Allowable housing face run-out tolerance is 0.20 mm (0.008 in.)

5. Check Flywheel Housing Bore Concentricity as follows:

   a. Attach a dial indicator to the crankshaft and place the indicator pointer against the flywheel housing bore as shown in Fig. 14.

   b. Rotate the crankshaft slowly and note total indicator reading variation.

   c. Allowable housing bore concentricity tolerance is 0.20 mm (0.008 in.).

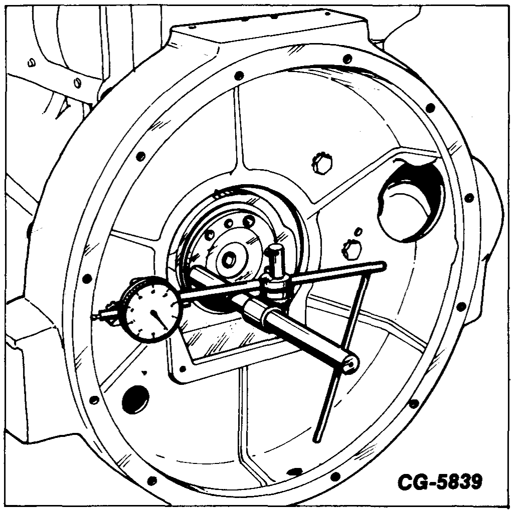


Figure 14. - Checking the Concentricity of the Flywheel Housing Bore in Relation to the Axis of the Crankshaft.

Inspect the Crankcase as follows:

1. Check the crankcase deck for "PULLED" thread holes which may interfere with the head and gasket fit. **Lightly** file these areas to restore flatness.

NOTE: ***DO NOT resurface the block. Any defects in the surface not correctable by light filing necessitates crankcase replacement.***

2. Threaded holes with damaged threads may be salvaged with "Heli-Coil Repair." 3.400 Series Only: Inspect the lower cylinder sleeve pilot bore for erosion. If a possibility exists that water leakage may occur from erosion, machine the lower bore as follows:

   a. Rework the crankcase as shown in Fig. 15. Adhere to specified dimensions.

IMPORTANT: Do Not Rework 300 Series Crankcases.

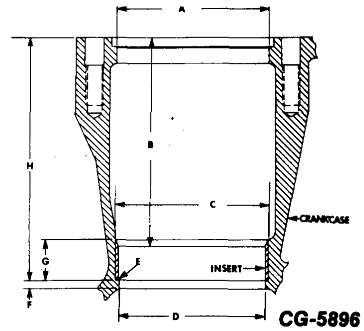


Figure 15. - Crankcase Rework Illustration for Lower Cylinder Sleeve Insert. (400 Series Only)

Symbol	Dimension
A	(*)(.**) 125.83-125.88 mm (4.954-4.956 in)
B	172.97-173.99 mm (6.810-6.850 in)
C	(-) 126.098-126.124 mm (4.9645-4.9655 in)
D	(*) (') 122.38-1 22.43 mm (4.818-4.820 in)
E	0.25 mm (0.010 in) R. Max.
F	4.45 mm (0.175 in)
G	33.66 mm (1.325 in)
H	202.31 mm (7.965)

* - Diameter to be concentric within 0.03 mm (0.001 inch) total indicator reading.

** - Diameter to be concentric within 0.05 mm (0.002 inch) total indicator reading.

*** - Center line to be square with crankshaft bearing bores within 0.08 mm (0.003 inch) in 305 mm (12 inches).

4. Install a Lower Pilot Bore insert as follows:

   a. Obtain correct bore part number from the parts catalog.

   b. Apply "Locoquic Primer Grade T" (aerosol) completely around the rebored area of the block, and around the O.D. of the repair insert.

   c. When the primer is dry (approximately 30 seconds) apply "Loctite Bushing Mount" to the O.D. of the repair insert.

NOTE: ***DO NOT wipe off any primer since it is a catalyst that insures the proper curing of the bushing mount.***

NOTE: Curing time will vary from 30 minutes to four hours depending upon the temperature. At 21 °C (70° F) a one hour curing time should be expected.

d. Set the insert (2, Fig. 16) in the cylinder block (1) as shown.

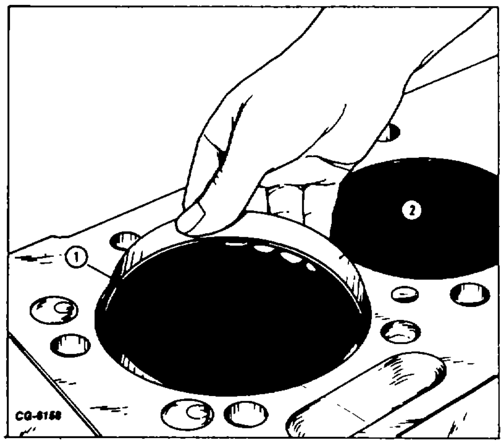


Figure 16. - Inserting Insert into Block

1. Cylinder bore
2. Lower pilot bore insert

e. Push the insert through the upper bore with the I.D. chamfer of the insert toward the cylinder head deck.

f. Install the pilot (2, Fig. 17) and insert driver into the cylinder bore (1) as shown.

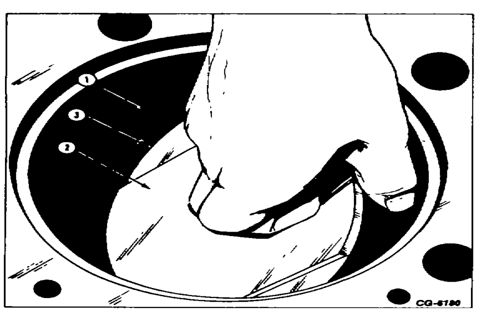


Figure 17. - Pilot and Insert Driver

1. Cylinder bore
2. Pilot
3. Insert driver

NOTE: ***The machine shop should furnish the appropriate size drive, pilot and handle for this procedure.***

g. Rest the insert, (3, Fig. 18) pilot (4) and insert driver (5) as a unit in position for insertion into the lower bore.

h. Install the insert driver handle (2, Fig. 18) into the insert driver (5) and pilot (4).

i. Install the centering plate(1, Fig. 18) over the insert driver assembly and into the counterbore as shown.

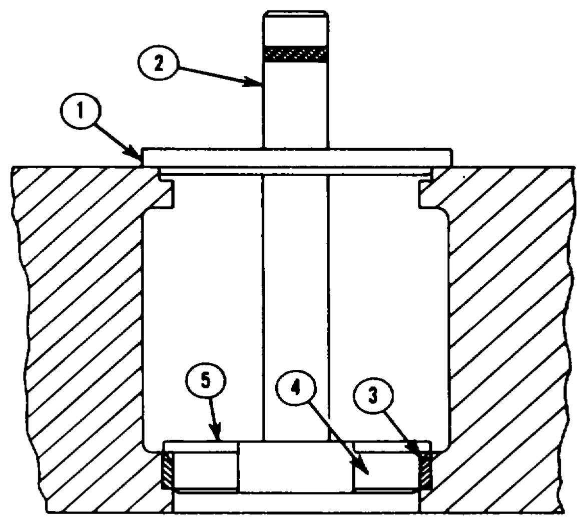


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Figure 18. - Installing Insert

1. Centering plate
2. Handle
3. Insert
4. Pilot
5. Driver

j. Tap gently on the insert driver handle until the insert is located on the start of the cylinder bore.

k. Drive the insert into place with a heavy hammer.

5. Inspect the 12 piston oil jet tubes used in Turbocharged Engines. Be sure they are open and clean as shown in Fig. 19.

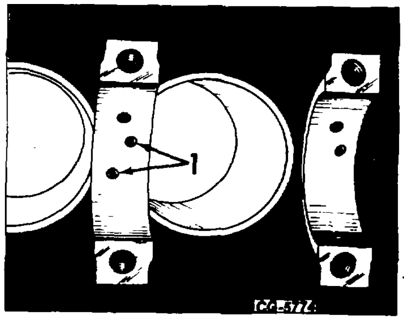


Figure 19. - Piston Oil Jet Tubes

1. Oil jets

NOTE: ***DO NOT remove oil jets unless damaged.***

6. If tubes are damaged replace as follows:

   a. Remove damaged tubes with a pilot driver (1, Fig. 20) as shown.
   b. Install new oil jet tubes with the same pilot driver shown in Fig. 20.
   c. The jet tube (when installed) must not project above the surface; but must be recessed 3 mm (1/8 inch) below the surface as shown in (2, Fig. 20).

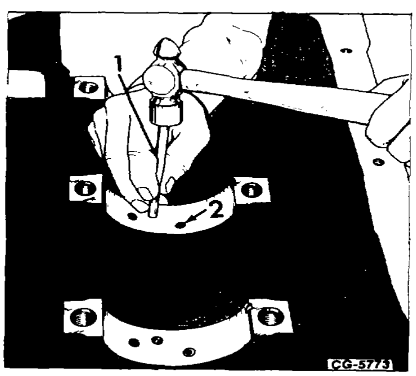


Figure 20. - Removing/Installing Piston Oil Jet Tubes

1. Pilot driver
2. Oil jet tube

   d. The top half of the main bearing insert (1, Fig. 21) is slotted to provide a flow of oil to the Jet tubes and camshaft bushings as shown.

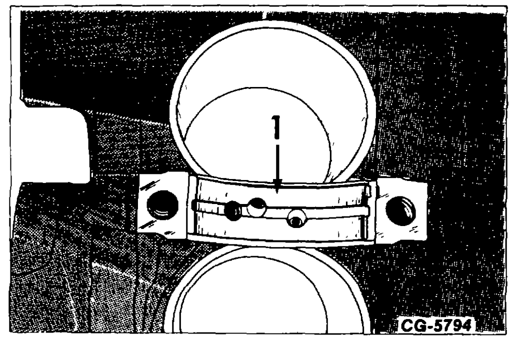


Figure 21. - Main Bearing Insert - Old Style Shown w/OFFSET Piston Oil Jet Tube Holes

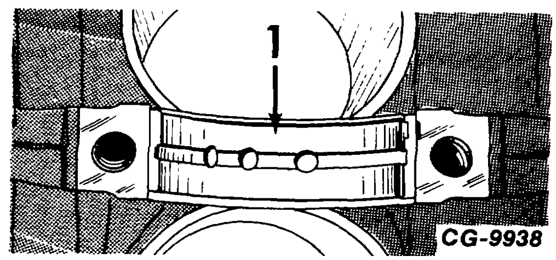


Figure 21A. - Main Bearing Insert - New Style w/Piston Oil Jet Tube Holes in Line

7. Repairs for coolant or oil leaks in crankcase casting can be performed in areas shown in Figure 21B only. Instructions are as follows:

Restrictions:

   a. No repairs may be made within one inch of an internal rib, wall or boss casting.

   b. Casting cracks can not be repaired.

   c. Leak to be repaired must be within tap drill diameter.

   d. Maximum plug size allowed for repair is 1/4-18 NPTF.

   e. Leaks to be plugged (repaired) must be at least 3 inches apart.

Procedure:

f. Locate leak. Drill through using a 1/8-27 NPTF or 1/4-18 NPTF tap drill, depending on size. Hole must be square with surface being repaired.

g. Tap 1/8-27 or 1/4-18 NPTF.

CAUTION: Do not over tap. Plug head must be above casting surface when installed.

h. Clean chips and dirt from internal passages.

i. Apply coat of Loctite #601 to O.D. of pipe plug; install plug.

j. Allow 4 hours cure time.

k. Grind protruding portion of plug flush with casting surface, if desired.

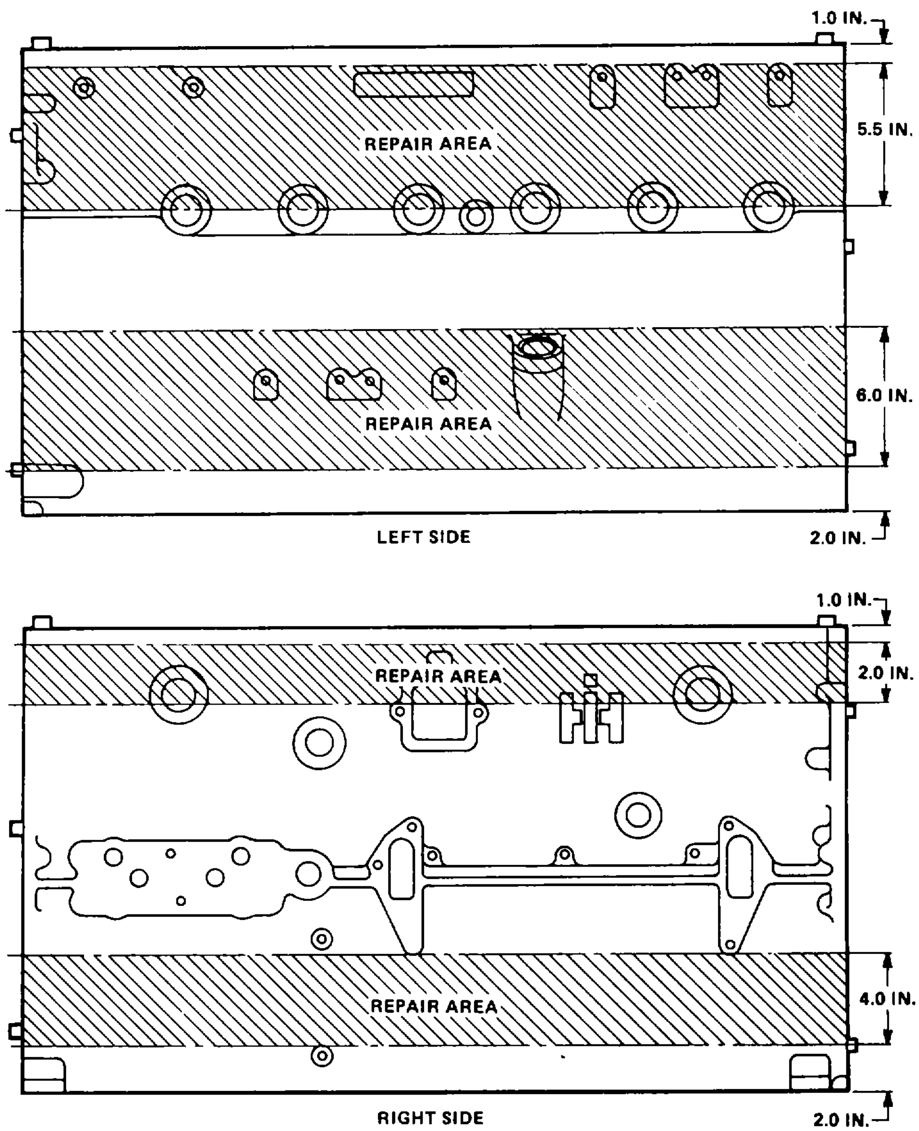


Figure 21B. - Crankcase Casting Leak-Repair Areas

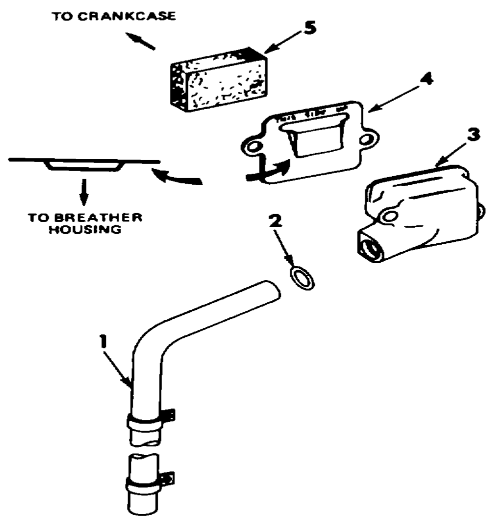


Figure 22. - Conventional Crankcase Mounted Breather Assembly

1. Breather tube
2. "O" ring
3. Breather body
4. Baffle housing
5. Breather element

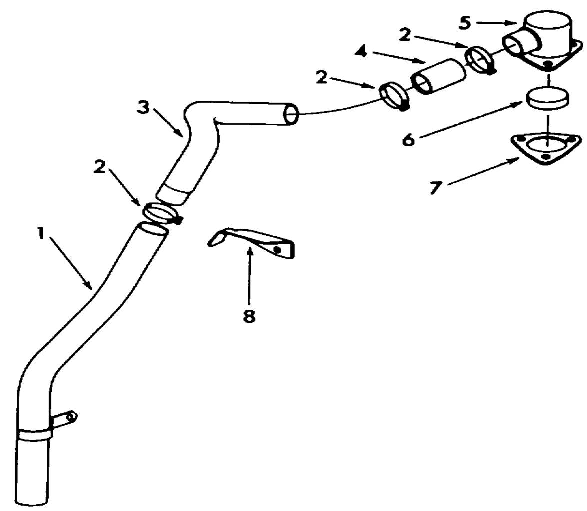


Figure 23. - Valve Cover Mounted Breather Assembly

1. Lower breather tube
2. Clamps
3. Upper breather tube
4. Hose
5. Breather housing assembly
6. Breather element
7. Breather gasket
8. Breather tube support

8. The "OLD" Crankcase Mounted ventilation system requires breather replacement as follows:

   a. Remove the screws securing the breather tube (1, Fig. 22) and the screws securing the housing (3).

   b. Remove the housing (3, Fig. 22), baffle housing (4) and element (5).

   c. Install a new breather element (5, Fig. 22) and a new baffle housing (4). Install body (3) with tube (1) and secure hardware.

NOTE: ***Element must be installed in the crankcase, not in the breather body, to avoid excessive oil carryover into the tube.***

9. The "NEW" Valve Cover Mounted ventilation system requires breather replacement as follows:

   a. Remove screws securing the breather housing assembly (5, Fig. 23) and clamps ’(2) securing hose (4) to breather tube (3) and housing.

   b. Remove breather housing and element (6, Fig. 23).

   c. Install a new breather element (6, Fig. 23) and inspect the breather gasket (7). Replace the gasket if damaged.

   d. Reassemble components as shown in Fig. 23.

Crankshaft Forging Number Identification to Engine

With the similarity of crankshaft assemblies and only the stroke being different, it is necessary to verify for proper replacement part by checking forging number to application.

Model	Crankshaft Forging Number	Forging Number Location
312	675 707 C1	2nd Check
360	675 351 C2	2nd Check
414	675 050 C1	2nd Check
436	675 051 C1	1st Check
466	675 591 C2	1st Check

INSTALLATION

Prior to Crankshaft installation, check the Crankcase for trueness as follows:

1. Using a lint-free cloth, wipe the bearing supports of the crankcase **free of oil.**

2. Support the crankcase bottom side up as shown in Fig. 24 using wooden blocks to level it.

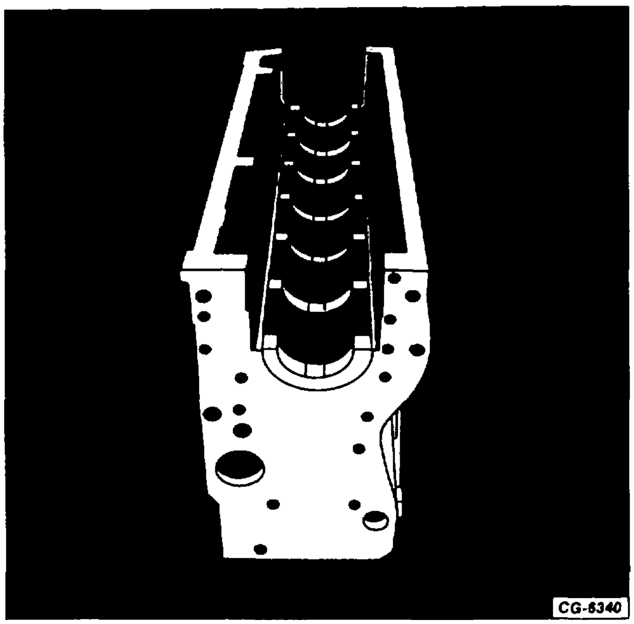


Figure 24. - Crankcase Bottom-Side-Up View

3. Install the upper halves of the bearings (bearings with oil hole in center) on the crankcase.

   a. If the original bearings are to be reinstalled, be sure they go to the positions from which they were removed.
   b. The nibs of the bearings must fit into the notches in the crankcase bearing supports.

4. Apply Prussian Blue on the crankshaft main journals and lower them carefully and evenly onto the bearings. DO NOT install the bearing caps and lower bearings.

5. Rotate the crankshaft approximately one-half revolution.

6. Remove the crankshaft evenly and inspect the upper bearings for an even transfer of bluing from journals to bearings.

7. Replace any bearings that do not show an over-all even bluing.

NOTE: ***It is advisable to replace all bearings with new, if one of the originally used bearings has to be replaced.***

8. When satisfied that the crankcase is in good order and free from any distortion and burrs around the upper bearing seats proceed as follows:

   a. Clean all bluing from the bearings and crankshaft journals.

   b. If using the original bearings coat the bearing surfaces with a small amount of clean engine oil.

   c. Install the bearing halves (bearing with oil hole in center).

   d. Carefully install the crankshaft.

Fitting New Main Bearing Caps...

Replacement main bearing caps, available for service, require the face and sides of the caps be modified to the dimensions of the old cap to assure a perfect fit in the crankcase.

Modify the caps as follows:

1. Place a drill rod or a new drill of any size from 6 to 13 mm (1/4 to 1/2 in.) in the bore of the OLD caps. Measure the distance from the face of the cap (1, Fig. 25) to the drill rod shank with a depth gauge as shown and record the reading.

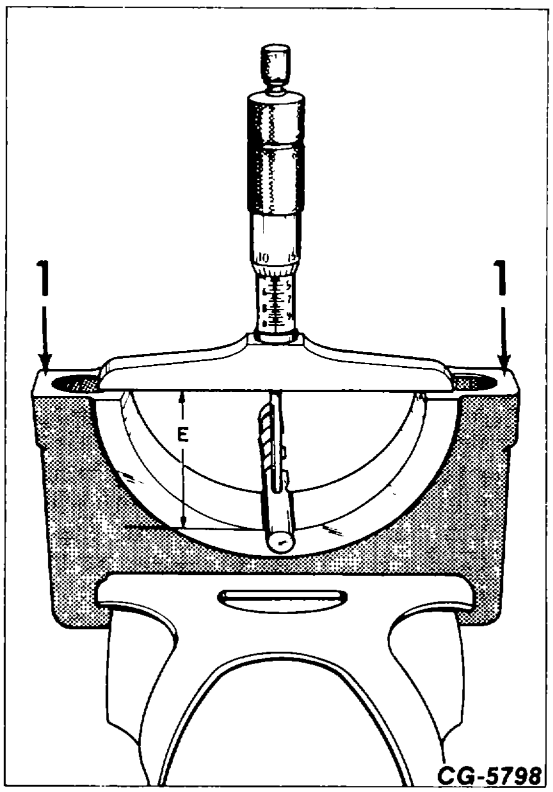


Figure 25. - Measuring Dimension "E"

1. Surface "D" main bearing cap face

Measure the diameter of the drill rod shank with a micrometer and add this reading to the one taken with the depth gauge, to derive dimension "E" in Fig. 25.

NOTE: ***If the cap being replaced is broken and dimension "E" cannot be determined, use one of the other caps to measure "E". Install and torque the cap before continuing.***

2. Mill or grind surface "D" (1, Fig. 25) of the NEW cap to dimension "E" plus 0.05 mm (0.002 in.).

NOTE: ***0.05 mm (0.002 in.) is added to dimension "E" to allow enough stock for a finish cut on surface "D" after the cap and bearing have been fitted to the crankcase.***

NOTE: The Bearing Cap must be located on its machined side when grinding surface "D" to hold squareness.

3. Clamp the OLD bearing cap to a surface plate (2, Fig. 26).

4. Place a drill rod (1, Fig. 26) of any size from 6 to 13 mm (1/4 to 1/2 inch) on the inside of the cap (against notched side).Measure this distance with a micrometer as shown in Fig. 26 and record the reading.

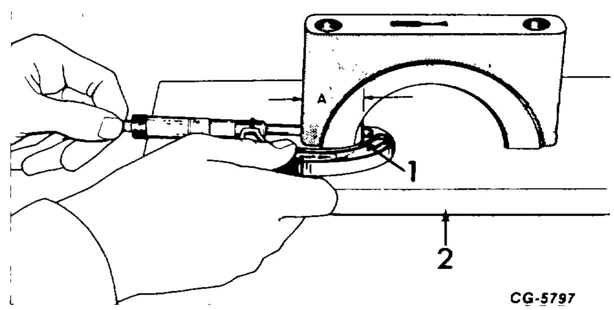


Figure 26. - Measuring Dimension "A"

1. Drill rod
2. Plate

5. Measure the diameter of -the drill rod shank and add this reading to the reading taken in step 4 above. This will be dimension "A".

6. Measure dimension "A" of the NEW bearing cap in the same manner as described in steps 2, 4 and 5 above.

7. Subtract dimension "A" of the OLD cap from dimension "A" of the NEW cap and record the difference. Mill or grind this amount from surface "C" (Fig. 27) of the new cap. Dimension "A" of both caps will now be equal.

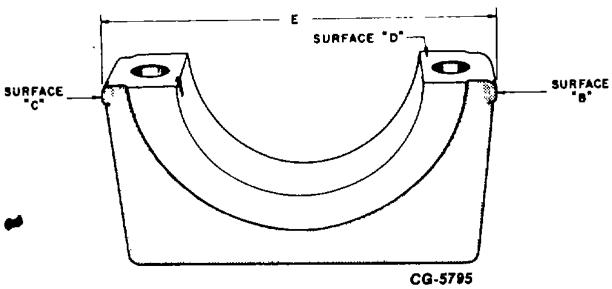


Figure 27. - Bearing Cap Finished Length

Surface "C"
Surface "B"
Surface "D"

NOTE: ***Surface "C" (Fig. 27) must be held square with surface "D" and parallel to the bearing bore.***

8. Mill or grind surface "B" (Fig. 27) of the new cap until the dimension "E" 153.67153.72 mm (6.050-6.052 in.) shown from surface "C" to "B" is obtained.

NOTE: ***Surface "B" (Fig. 27) must be held square with surface "D" and parallel to the bearing bore.***

Fit Main Bearings in Main Bearing Caps as follows:

1. Install a new bearing in a new bearing cap or the original bearing in the original bearing cap, as called for.
2. Check the bearing clearance as follows:

NOTE: ***DO NOT turn the crankshaft during this procedure.***

a. Clean the bearing surface and the exposed half of the crankshaft journal. Be sure these surfaces are free of oil.
b. Place a suitable length of 0.010 inch virgin lead wire or a piece of Plastigage across the bearing surface as shown in Fig. 28.

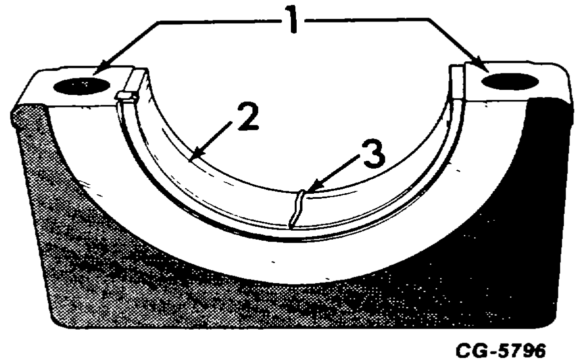


Figure 28. - Position of Virgin Lead or Plastigage

1. Surface "D"
2. Bearing
3. Plastigage

c. Install the bearing cap and torque the cap screws to 155 N•m (115 lbf-ft).

d. Remove the bearing cap. When virgin lead is used, measure the crushed thickness with a micrometer and record the results. When Plastigage is used, the flattened plastic material will be found adhearing to either the bearing or the crankshaft. DO NOT remove the plastigage. Determine bearing clearance by comparing the width of the flattened plastic with the graduations on the envelope as shown in Fig. 29.

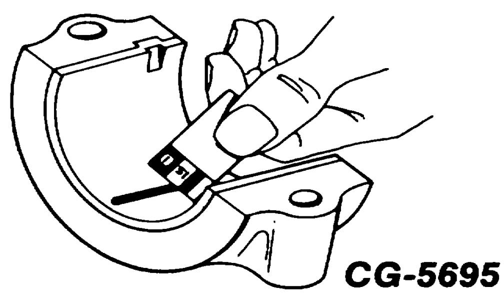


Figure 29. - Reading Bearing Clearance with Plastigage

3. For OLD bearings and caps, if the crankshaft, bearings and crankcase are in good condition, the bearing running clearance should fall within

0.046 mm (0.0018 in.)
0.130 mm (0.0051 in.)

a. If the clearance obtained is more or less than the specified amount, replace with a new bearing.
b. Should the clearance remain excessive, it may be necessary to replace the crankshaft.

4. For NEW bearings and caps proceed as follows:

a. Measure the diameter of the crankshaft journal and record this reading. If it is less than

85.705 mm (3.3742 in.)
85.738 mm (3.3755 in.,)

subtract the difference from the virgin lead or Platigage reading.

b. Subtract the bearing running clearance of

0.046 mm (0.0018 in.)
0.130 mm (0.0051 in.,)

from the measurement obtained in Step 4a. Mill or grind this amount from surface "D" (3, Fig. 28) of the new bearing cap.

NOTE: ***Surface "D" (Fig. 27) must be held square with the bearing cap bore.***

c. Recheck the bearing running clearance, with virgin lead or plastigage, to assure

0.046 mm (0.0018 in.)
0.130 mm (0.0051 in.)

specifications are met.

5. When acceptable results are achieved for either old or new parts proceed as follows:

a. Remove the Plastigage or Virgin lead.

b. Add clean engine oil to the bearing and install the center main bearing cap.

c. Torque the cap screws to 155 N-m (115 lbf-ft).

6. Check each main bearing in the manner described.

Continue Crankshaft and Main Bearing installation as follows:

1. Check the crankshaft end clearance as outlined:

a. Loosen the rear main bearing cap screws.

b. Hold the crankshaft towards the front of the engine, using a suitable bar or large screwdriver, so the crankshaft thrust surface is tight against the rear of the thrust flange of the bearing in the crankcase.

c. Check the clearance across the bearing split as shown in Fig. 30.

0.15 mm (0.006 in.)
0.30 mm (0.012 in.)

clearance must be maintained.

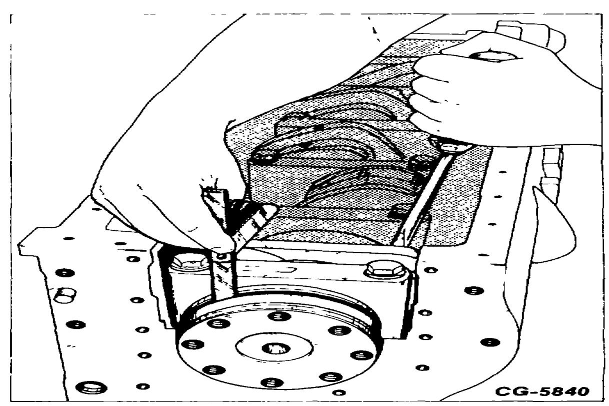


Figure 30. - Checking Crankshaft End

d. Hold the crankshaft towards the rear of the engine and check the clearance across the bearing split. If the clearance is more than specified, replace the rear main bearing with a new one.

e. With the feeler gauge in place, tighten the rear main bearing cap to 155 N•m (115 lbf-ft) torque.

f. Remove the feeler gauge and wedging tool.

2. Pull the connecting rods down onto the crankshaft. Be sure that the bearings are in place.

a. Install the connecting rod bearings and bearing caps. Make sure that the correct cap is located on its rod and that the identifying numbers are on the intake manifold side of the engine.

b. Oil the bearings with clean engine oil.

c. Torque the connecting rod bolts to 175 N•m (130 lbf-ft).

3. Recheck the connecting rod end clearance as described in Section 5.

4. Install a new rear oil seal as outlined.

a. Inspect the oil seal bore for a chamfer. If no chamfer is found, use a file to break the edge of the bore. This will prevent possible damage to the oil seal casing during installation.

CAUTION: Care should be taken not to damage the bore while filing the chamfer edge.

b. Prior to wear sleeve and oil seal installation, clean the bore and crankshaft of all foreign material.

c. Use the wear sleeve and oil seal installing tool (see tool list for tool number) as shown in Fig. 31.

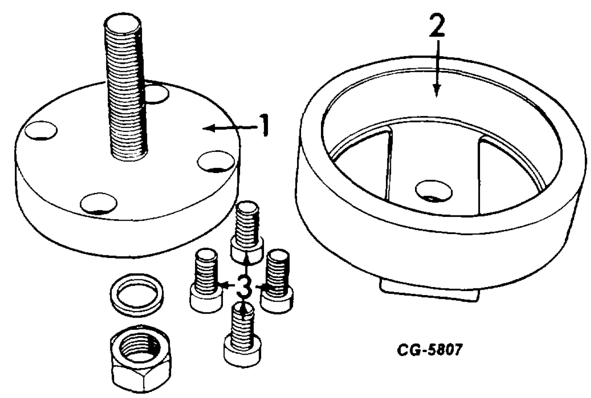


Figure 31. - Wear Sleeve and Oil Seal Installer

1. Centering plate
2. Installing tool
3. Allen head screws

d. If the oil seal and wear sleeve are NOT unitized (preassembled), assemble seal to sleeve prior to installing onto crankshaft as follows:

1. Clean and lubricate single lip seal with grade 251 H-EP grease or clean engine oil.

2. Fill double lip seal with grade 251H-EP grease at cavity between lips.

3. Assemble seal onto sleeve as shown in Fig. 32 by pushing the seal in the direction of the arrow.

NOTE: ***Seal must be installed onto side of sleeve with chamfer on O.D. (2, Fig. 32) to avoid damage to seal lip.***

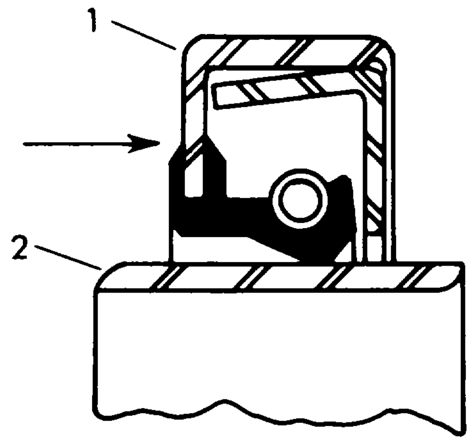


Figure 32. - Assembling Seal to Sleeve

1. Seal (single lip)
2. Chamfer on O.D. of sleeve

e. Install the retainer (1, Fig. 36) retainer gasket (2) (if equipped) on the flywheel housing prior to installing unitized seal and sleeve assembly.

f. Install the flywheel housing if it was removed.

NOTE: ***Seal bore in housing or retainer must be concentric with crankshaft within 0.25 mm (0.010 in.) full indicator measure as shaft is rotated 360°.***

g. Attach the centering plate (2, Fig.33) to the crankshaft flange (1) using the four alien head screws. DO NOT tighten the screws at this time.

NOTE: ***Only four bolt holes in the crankshaft will line up with the holes in the centering plate.***

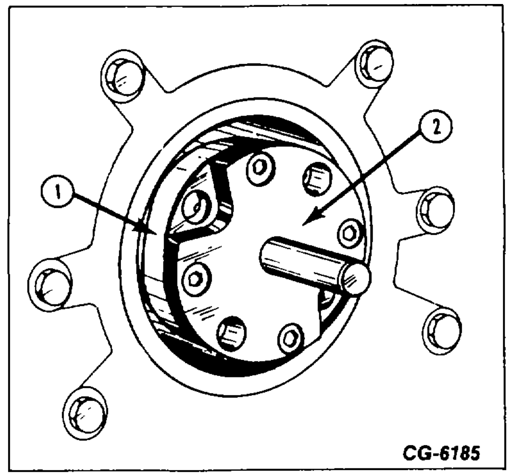


Figure 33. - Installing Oil Seal and Wear Sleeve

1. Crankshaft flange
2. Centering plate

h. Position the wear sleeve (3, Fig. 34) with oil seal (1) on the centering plate (2) and crankshaft as shown. Tighten the four allen head screws.

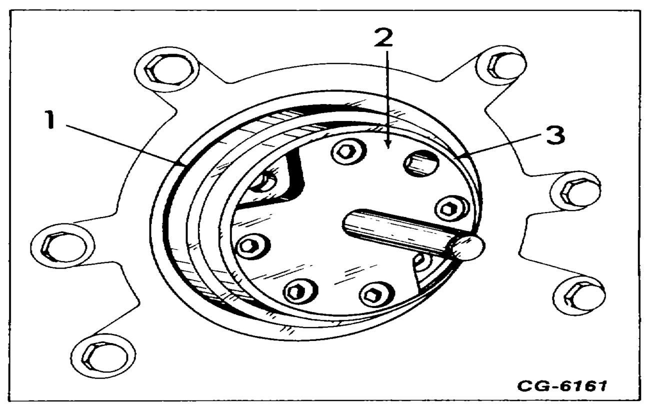


Figure 34. - Oil Seal and Wear Sleeve Installation

1. Oil seal
2. Centering plate
3. Wear sleeve

NOTE: ***Never remove the oil seal from the sleeve during assembly.***

i. Coat the I.D. of wear sleeve and O.D. of oil seal with a thin film of R.T.V. liquid gasket (Dow 732, General Electric 1473 or equivalent). DO NOT get any of this liquid on the seal lip or O.D. of the wear sleeve.

j. Position the wear sleeve and oil seal installing Tool (2, Fig. 35) on the centering plate (3) then tighten thrust washer (4) as shown.

This will center the wear sleeve and oil seal (1) on the crankshaft.

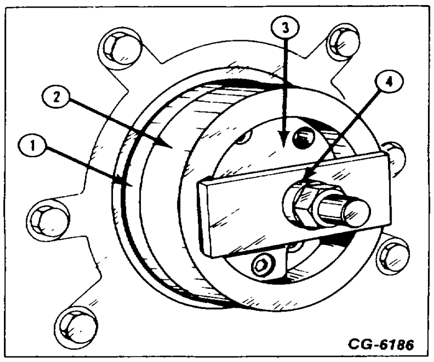


Figure 35. - Oil Seal and Wear Sleeve Installing Tool

1. Oil seal
2. Installing tool
3. Centering plate
4. Thrust washer

k. The following dimensions are automatically obtained when the service tool (specified in the tool list) is used as directed. See Fig. 36.

Oil Seal Location	"A" Installed Sleeve See (Fig. 34)	B" Installed Seal See (Fig. 34)
Single Lip in Housing on Crankshaft	7/8 In. sleeve- 4 70 mm (0.185 in) 3/4 In. sleeve- 7.11 mm (0 280 In)	7.62 mm (O 300 In)
Double Lip in Housing or Retainer on Crankshaft or PTO gear	4 70 mm (0.185 in)	7.62 mm (0.300 in)

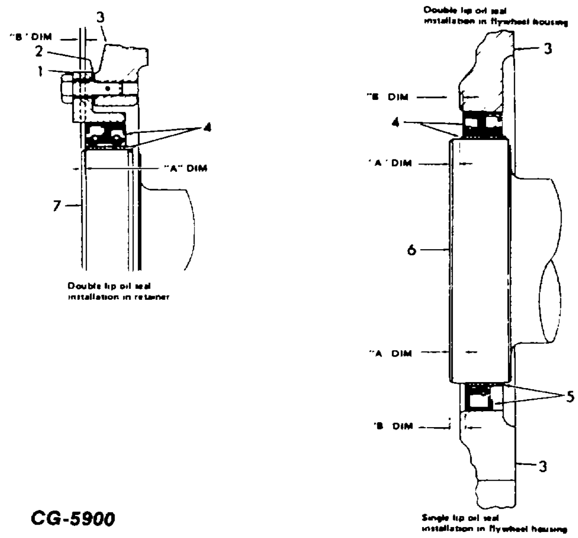


Figure 36. - Single and Double Lip Oil Seal and Wear Sleeve Installation and Dimension Diagram

1. Retainer
2. Gasket
3. Flywheel housing
4. Unitized seal/sleeve (double lip)
5. Unitized seal/sleeve (single lip)
6. Rear face of crankshaft
7. Rear face of crankshaft, spacer or PTO gear

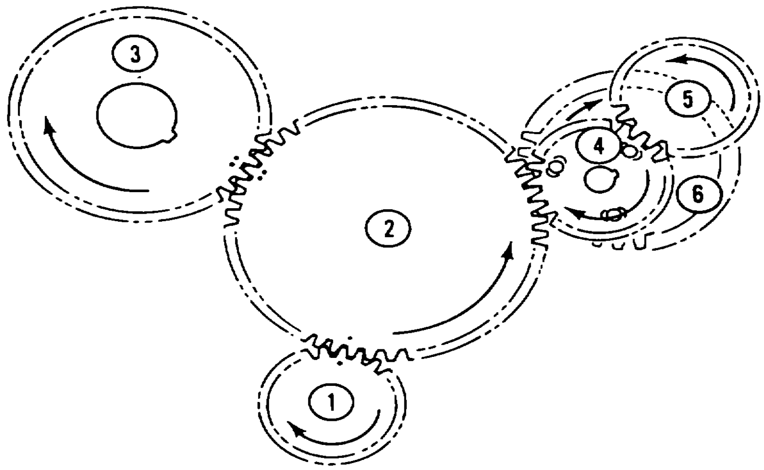
NOTE: ***Seal face must be parallel with rear of crankshaft within 0.25 mm (0.010 in.)***

5. Install the crankcase front cover. (Refer to Section 7, **"Timing Gear Train").**

6. Install the oil pump and vibration damper. (Refer to Section 8, **"Lubricating Oil Pump").**

7. Install the crankcase oil pan using a new gasket. Torque the pan drain plug to 45 N•m (33 Ibf-ft).

8. Fill the engine crankcase with lubricant specified in the **Operator's Manual.**



CG-9886

Figure 1. - Timing Gear Train

1. Crankshaft Gear
2. Idler Gear
3. Camshaft Gear
4. Injection Pump Gear ⎤ Engine equipped with
5. Tachometer Gear ⎦ UTDS* Model 100
   (if equipped) Injection Pump
6. Injection Pump Gear ⎤ Engines equipped with Robert Bosch Model MW Fuel Injection Pump

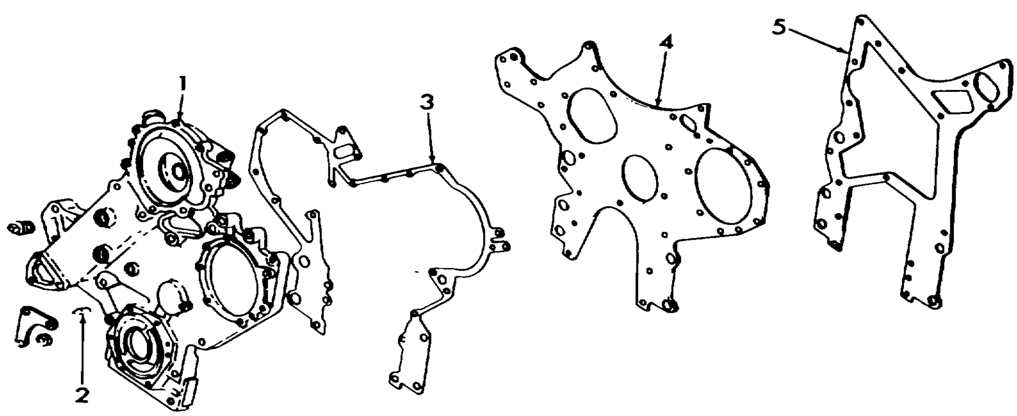


Figure 2. - Crankcase Front Cover and Related Parts

1. Crankshaft gear
2. Idler gear
3. Camshaft gear
4. Injection pump gear
5. Tachometer gear (if equipped)

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GENERAL

The gear train lies under the crankcase front cover. The gear train is simple in design. The idler gear (2, Fig. 3), driven by the crankshaft gear (1), drives the engine camshaft gear (3) and the injection pump gear (4 or6, depending on pump). If equipped, a tachometer adapter (5, Fig. 4a) mounts to the injection pump drive gear access cover (6, Fig. 4a). The tachometer driven by a slot in the end of the injection pump camshaft for engines equipped with Robert Bosch Model MW Fuel Injection Pump. For engines equipped with UTDS* Model 100 Fuel Injection Pump a plastic tachometer gear (5, Fig. 3) meshes with the injection pump gear (4, Fig. 3) to drive the tachometer.

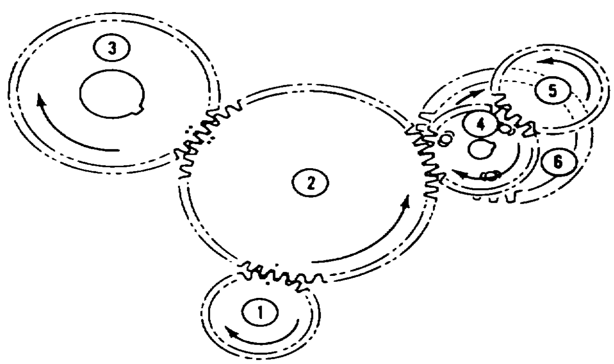

Figure 3. - Timing Gear Rotation

1. Crankshaft
2. Idler
3. Camshaft
4. Injection pump]– Engine equipped with UTDS* Model 100 Injection Pump
5. Tachometer (if equipped)
6. Injection pump – Engines equipped with Robert Bosch Model MW Fuel Injection Pump

The idler gear is supported on a set of tapered roller bearings. The camshaft gear is keyed to the shaft and held in place by a press fit. The injection pump gear (5 or 7, Fig. 4 or 4a) is fastened to the pump shaft by means of a hub.

For engines equipped with UTDS* Model 100 Fuel Injection pump, the tachometer (6) is fastened by two nuts and a thrust plate, as shown in Fig. 4.

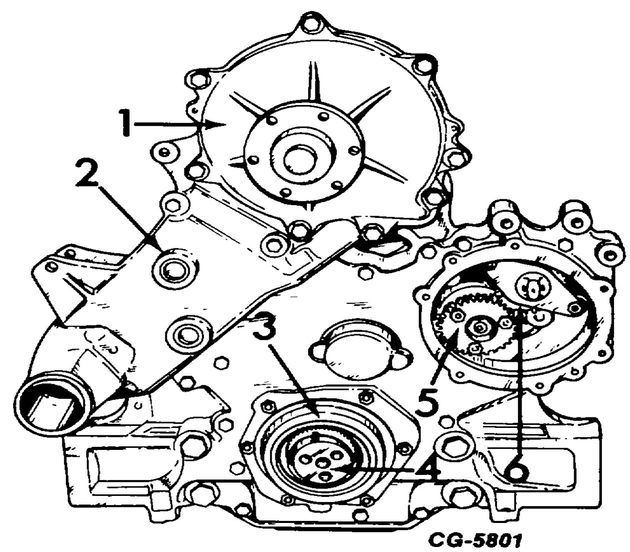

Figure 4. - Crankcase Front Cover - Engines equipped with UTDS Model 100 Fuel Injection Pump*

1. Water pump
2. Front cover
3. Lube oil pump
4. Crankshaft
5. Injection pump gear
6. Tachometer gear

The Crankcase Front Cover (2, Fig. 4 or 4a) serves many purposes. In addition to housing the gear train, the front cover carries the water pump (1), lube oil pump (3) and fuel injection pump (not shown).

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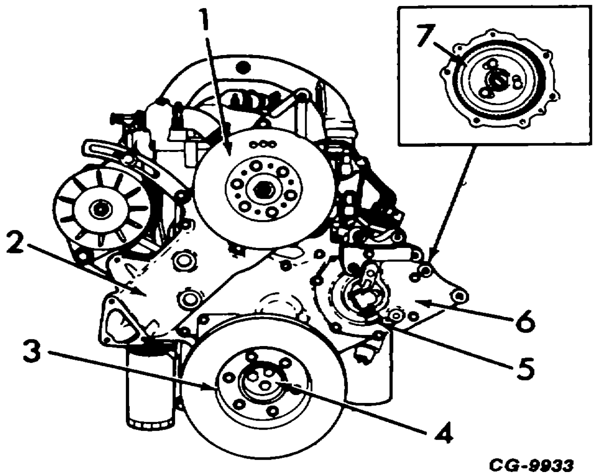


Figure 4A. - Crankcase Front Cover - Engines Equipped with Robert Bosch Model MW Fuel Injection Pump

1. Water pump
2. Front cover
3. Lube oil pump
4. Crankshaft
5. Tachometer drive
6. Injection pump drive gear cover
7. Injection pump gear (with gear cover removed)

Passages for coolant, water and lube oil, are cast into the front cover. The water inlet to the crankcase and the unfiltered oil passageway to the oil cooler align with holes in the front cover. Machined surfaces are provided for mounting the pumps.

The water pump cone is machined and acts as the "back" plate for the water pump. The water pump, oil pump and injection pump can be removed without disturbing the front cover. This applies whether the engine is equipped with a "full" front cover as shown in Fig. 5, or with an "earless" front cover as shown in Fig. 6. The front cover used is dependent on the application.

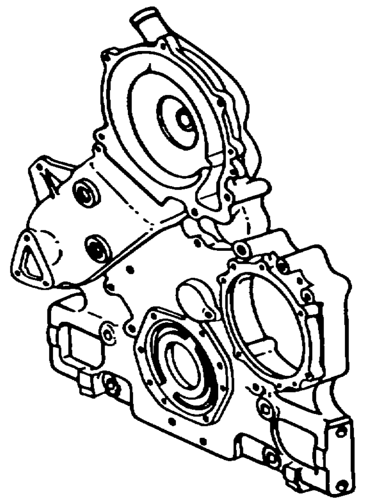


Figure 5. - "Full" Front Cover

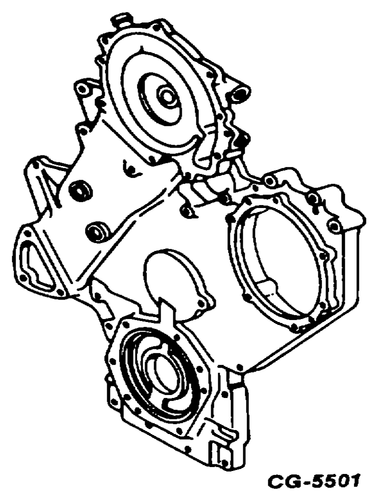


Figure 6. - "Earless" Front Cover

A common gasket is used for both the "Full" & "Earless" front covers, however, installation instructions must be followed to prevent improper gasket installation and subsequent engine damage, (as described under Installation of this section).

SPECIFICATIONS

DIMENSIONS	VALUES	
Timing Gears:		
Crankshaft to Idler Backlash (New)	0.08 mm / 0.18 mm	(0.003 in / 0.007 in)
Crankshaft to Idler Backlash (Wear Limit)	0.41 mm	(0.016 in.)
Idler to Crankshaft Backlash (New)	0.08 mm / 0.18 mm	(0.003 in / 0.007 in)
Idler to Crankshaft Backlash (Wear Limit)	0.41 mm	(0.016 in.)
Idler to Injection Pump Backlash (New)	0.08 mm / 0.18 mm	(0.003 in. / 0.007 in.)
Idler to Injection Pump Backlash (Wear Limit)	0.41 mm	(0.016 in.)

Prior to removing the crankcase front cover it will be necessary to remove "other equipment" (i.e. alternator, air and freon compressor, steering and vacuum pump etc.), depending upon the application. Refer to the Operator's Manual and Service Manual to determine local needs.

When the Front Cover is free of applicable accessories remove it as follows:

NOTE: ***Observe the variations which exist between the Agricultural Equipment, Payline and Truck groups.***

1. Engines with "RUBBER"* vibration dampers should be checked for wobble before removing.

   a. Attach a dial indicator to the vibration damper flange as shown in Fig. 7.

   b. Check at least four points 90° apart.

   c. If wobble exceeds 1.5 mm (0.06 in.) total indicator reading, replace the damper.

* Damper is not made of rubber, rather it has a rubber insert.

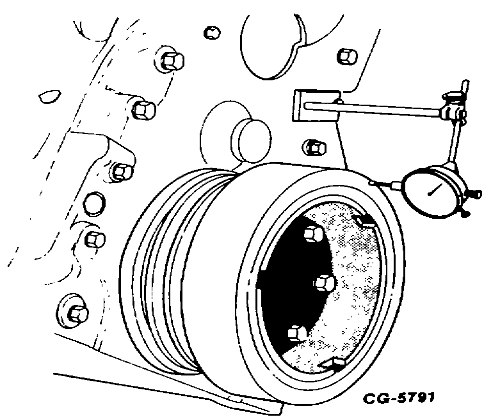


Figure 7. - Checking "Rubber" Damper for Wobble

2. Remove "RUBBER" vibration damper as follows:

   a. Remove the cap screws, damper plate (if equipped) and retainer plate securing the vibration damper to the crankshaft.

   b. Engines equipped with the Three-Hole Damper (1, Fig. 8) must use the puller 89-10-17 (2) for early Agricultural and Payline Equipment as shown in Fig. 8.

NOTE*: It Is necessary to modify the puller bolt holes with a file to match the bolt pattern of the damper hub.*

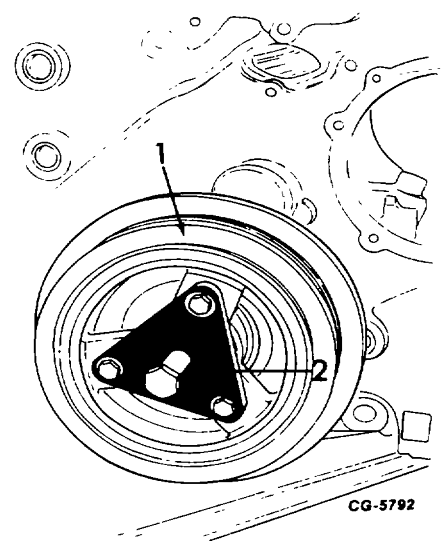


Figure 8. - Puller Installed on Three Hole Vibration Damper

1. Vibration damper
2. Puller (89-10-17)

   c. Late model Agricultural equipment requires the puller 04-33-3 (2, Fig. 9) to remove the vibration damper (1) as shown.

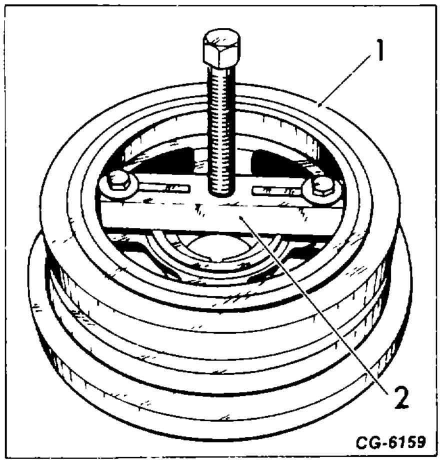


Figure 9. - Late Model Vibration Damper and Puller for Agricultural Applications

1. Vibration damper
2. Puller (04-33-3)

d. Engines equipped with the Four-Hole Damper (1, Fig. 10) must use the puller PLT-514 (2) for Payline applications as shown.

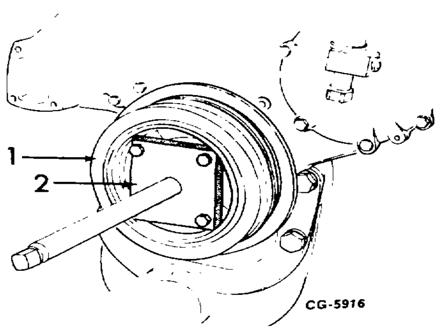


Figure 10. - Puller Installed on Four Hole Vibration Damper

1. Vibration damper
2. Puller (PLT-514)

3. Remove Viscous Vibration Damper (if applicable) as follows:

   a. Remove the cap screws (1, Fig. 11) which secure the viscous damper to the crankshaft pulley and remove the damper.

   b. Remove the cap screws (2, Fig. 11) with then retainer plate securing the crankshaft pulley to the crankshaft, as shown.

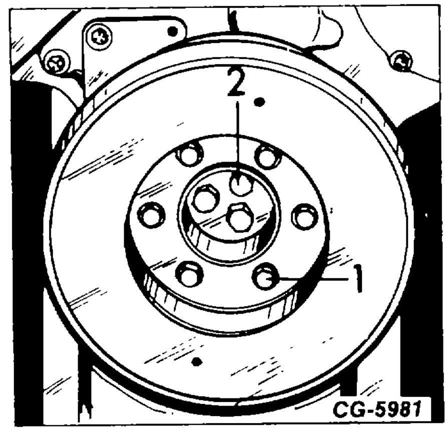


Figure 11. - Viscous Vibration Damper

1. Vibration damper cap screws
2. Retainer plate cap screws

   c. Remove the crankshaft pulley from the crankshaft using puller PLT-514 modified to the bolt pattern of the pulley.

4. Remove the oil pump assembly as outlined in Section 8.

5. Remove the Tachometer drive and injection pump access cover and gasket from the front cover.

6. Remove the bolts securing the front cover from the crankcase front plate.

7. Remove the front four cap screws securing the oil pan to the front cover.

8. Remove the front cover.

Prior to removing any individual gear Check the Backlash between each set of gears as follows:

1. Attach a dial indicator to the crankcase at a suitable location.

2. Insert the end of the indicator between any two teeth of the gear to be measured.

3. Move the gear by hand, slightly, then read dial indicator to determine backlash.

NOTE: ***Backlash between any set of timing gears should not exceed 0.41 mm (0.016 in.). Any gear exceeding this value requires service.***

Remove the Idler Gear as follows:

1. Remove the retainer bolt (1, Fig. 12), stub shaft (2) and bearing (3). A split ring prevents the bearing from coming off the stub shaft.

2. Remove the idler gear (4, Fig. 1 2), bearing (5) and spacer (6) as shown.

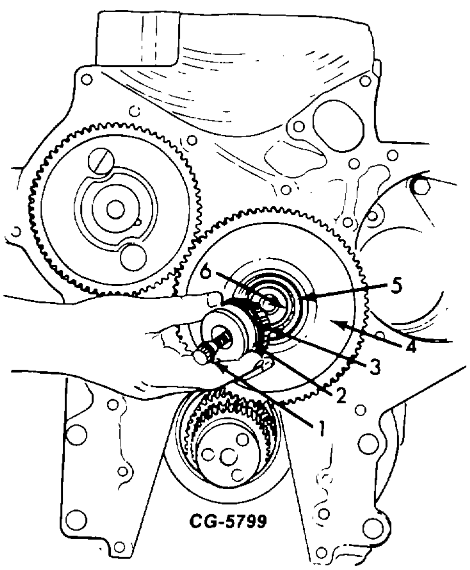


Figure 12. - Removing Idler Gear

1.	Retainer bolt	4.	Idler gear
2.	Stub shaft	5.	Bearing
3.	Bearing	6.	Spacer

If necessary, remove the Injection Pump Drive Gear as follows:

With Crankcase front cover off (Refer to Figures 13 and 13a)

1. Remove the three drive gear bolts (1).

2. Remove the pump drive gear (2) from the dowel as shown

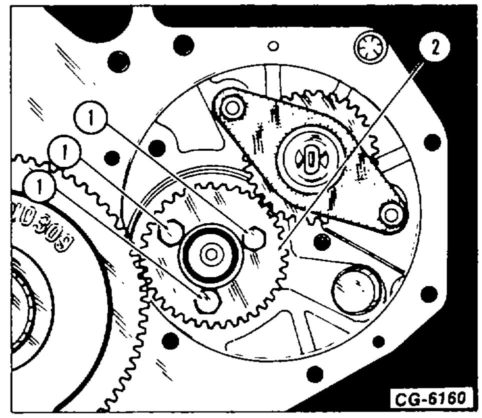


Figure 13. - Removing Injection Pump Gear Engines equipped w/UTDS (formerly AMBAC) Model 100 Fuel Injection Pump (with front cover off)

1. Drive gear bolts (3)
2. Injection pump drive gear

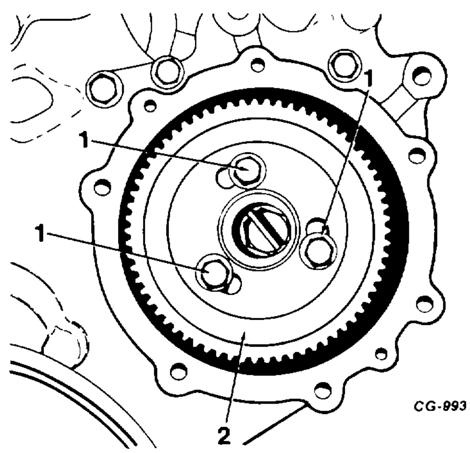


Figure 13a. - Removing Injection Pump Gear (Engines equipped w/Robert Bosch Model MW Fuel Injection Pump) [with front cover off])

1. Drive gear bolts (3)
2. Injection pump drive gear

With Crankcase front cover on (Refer to Figures 14 and 14a

1. Remove the pump access cover (1).

2. Remove the three drive gear bolts (2) securing the gear to the pump adapter and timing plate.

3. Remove the gear (3) as shown.

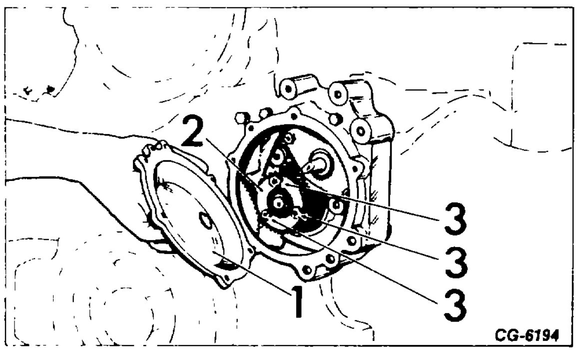
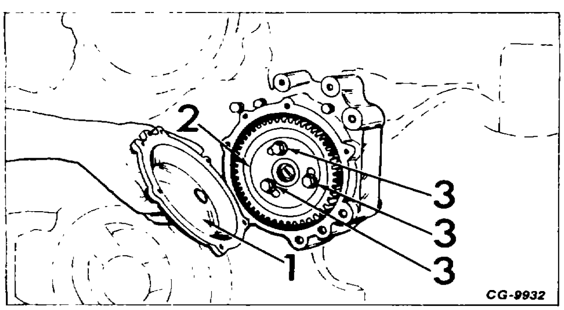


Figure 14. - Removing Injection Pump Drive Gear (UTDS Model 100 Fuel Injection Pump) [with front cover on])*

1. Access cover
2. Injection pump drive gear
3. Drive gear bolts (3)



Figures 14a. - Removing Injection Pump Drive Gear (Robert Bosch Model MW Fuel Injection Pump) [with front cover on])

1. Access cover
2. Injection pump drive gear
3. Pump drive gear bolts and washers (3)

If necessary remove the Tachometer Drive Gear as follows: (For engines equipped with UTDS* Model 100 fuel injection pump)

1. Remove the two nuts (1, Fig. 15) and thrust plate (3), as shown.

2. Remove the spacers (from the mounting studs) and remove the gear (2, Fig. 15) from the dowel in the injection pump mounting adapter.

If necessary remove the Crankshaft Drive Gear and Oil Pump Drive Spline as follows:

1. Remove crankcase front plate and crankshaft. (Refer to Section 6).

2. With the crankshaft removed from the crankcase, support the front of the crankshaft.

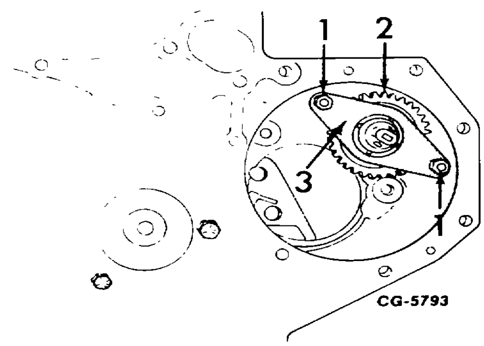


Figure 15. - Removing Tachometer Drive Gear (UTDS Model 100 Fuel Injection Pumps)*

1. Nut
2. Tachometer drive gear
3. Thrust plate

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3. Using a hammer and chisel split the drive spline and gear (individually) as shown in Fig. 1 6.

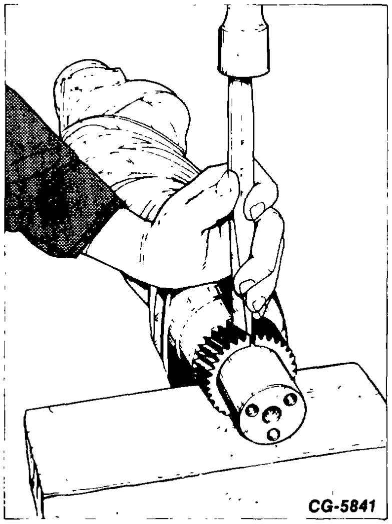

Figure 16. - Removing Crankshaft Gear

NOTE: The drive gear should be split in the root adjacent to the roll pin slot.

If it is necessary to remove the Camshaft Timing Gear refer to Section 4.

CLEANING, INSPECTION & REPAIR

CLEANING

Clean all Gears and related components as follows:

1. Clean all parts in solvent
2. Blow dry with compressed air.

Clean Vibration Damper as follows:

Vibration Damper with Rubber Insert

1. Clean with detergent (soap) only. **DO NOT USE SOLVENT.**

2. Blow dry with compressed air.

Viscous Vibration Damper

1. Clean with oil solvent.

2. Blow dry with compressed air.

Clean the Front Cover as follows:

1. Clean all traces of gasket material from gasket surface of crankcase front cover and front plate.

2. Blow dry with compressed air.

INSPECTION:

Inspect the Gear Train as follows:

1. Visually inspect all gears for wear or damaged teeth.

   a. Remove any worn or damaged gear as outlined previously.

   b. Replace damaged gears with new. Follow the installation procedure outlined in this Section.

2. Visually inspect the following components for wear or damage if the gear is removed.

   a. Bearings
   b. Spacer
   c. Stub shaft; as shown in Fig. 17

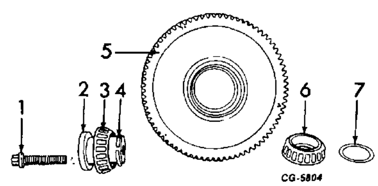

Figure 17. - Gear and Component Parts (Idler Gear Shown)

1. Retaining bolt	3. Bearing	5. Gear
2. Stub shaft	4. Spacer	6. Bearing
		7. Spacer

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Inspect the Vibration Damper as follows:

Vibration Damper with Rubber Insert -

1. Visually inspect for abrasion, cracking or tearing of rubber at the inner or outer diameter of the rubber member.

   a. Replace the damper if the cavity depth is 3 mm (0.12 in.) or more through 360°.

   b. Replace the damper if voids 6.35 mm (0.25 in.) deep through 900 are found.

2. Inspect alignment of Inertia Member (outer Iron Ring) with Hub:

   a. Locate alignment marks (made with a punch or chisel) on MOST "RUBBER" dampers.

   b. Measure the movement between the hub and the inertia member.

   c. The marks normally fall on a radial line from the center of the damper hub. If more than 1.5 mm (0.06 in.) misalignment is found, replace the damper.

3. Measure wobble on the front face of the inertia member as described earlier in this section.

Inspect Vibration Damper

The viscous type vibration damper consists of an inertia mass (flywheel) enclosed in a fluid-tight housing but separated therefrom by a thin wall of viscous fluid (silicone oil). Any movement of the inertia mass, therefore, is resisted by the friction of the fluid; which tends to dampen excessive torsional vibrations in the crankshaft.

Damper failure can lead to a broken crankshaft and extensive engine damage. Certain guidelines can be followed which will diminish the chance of damper failure:

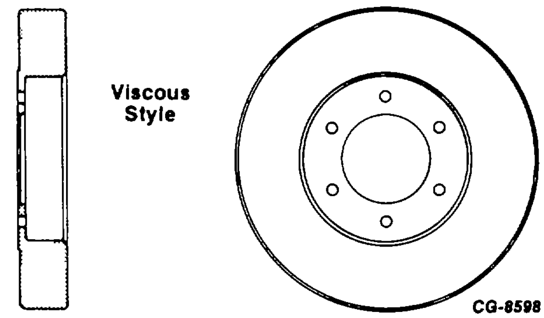

Figure 18.

1. Check the viscous damper visually for:

   a. DENTS-Even small dents can cause the inertia mass (flywheel) which floats in silicone fluid to contact the outer housing. Such contact can cause damper malfunction. Replace dented dampers.

   b. LEAKS-Clean damper thoroughly and inspect for silicone fluid leaks. Such leaks can possibly occur at cracks or seam openings in housing. Replace damper if any leaks are found.

NOTE: The damper cannot be repaired.

2. Check for housing distortion with a micrometer as follows:

   a. Remove paint off damper at the four points shown in Figure 19.

   b. Measure depth of damper housing at each point.

   c. If any of the points (A, B, C, D) vary more than .002 in., it is necessary to replace the damper.

NOTE: Housing distortion can result in damper leakage or improper damper functioning if outer housing contacts inertia mass (flywheel).

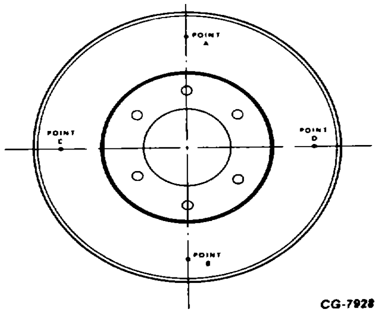

Figure 19. - Damper Housing Measurement Locations

Viscous and "RUBBER" Dampers

1. **Applications with "Rubber" Dampers:** The wear sleeve is pressed on the vibration damper hub.

2. **Applications with Viscous Dampers:** The wear sleeve is pressed onto the pulley hub.

3. Inspect the oil seal wear sleeve (1, Fig. 20) visually. Examine for wear, nicks and scratches.

   a. Remove the sleeve if any of the above conditions exist.

   b. Use a chisel to split the wear sleeve. BE CAREFUL NOT to damage the damper hub.

   c. Install a new sleeve as shown in Fig. 21, using tool No. 3004, depicted in Fig. 22.

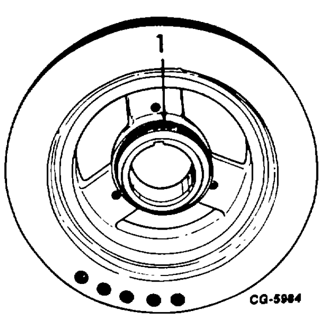

Figure 20. - Wear Sleeve on Vibration Damper (Three-Hole Damper Shown)

1. Wear sleeve

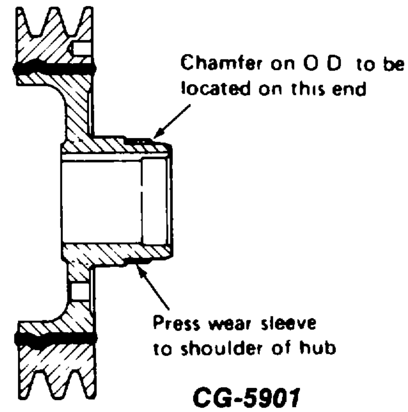

Figure 21. - Wear Sleeve Installation (All Applications Similar)

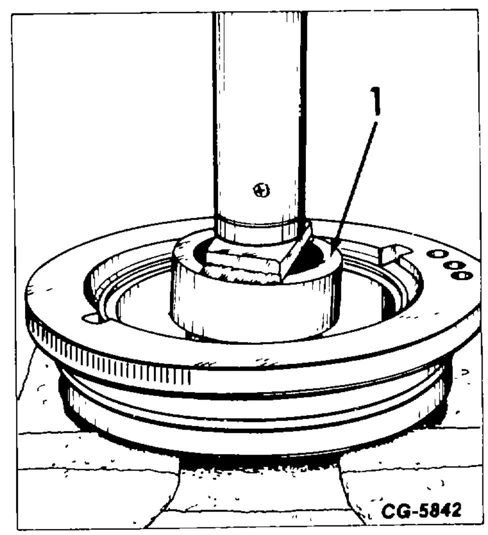

Figure 22. - Crankshaft Pulley Hub Wear Sleeve Installing Tool

1. Service Tool No. 3004

Inspect the Crankcase Front -Cover as follows:

1. Visually inspect the front cover for cracks and distortion.

2. Visually inspect the front plate for damage.

3. Replace any cover or plate which is damaged.

INSTALLATION

Install the Timing Gear Train, Front Cover and Vibration Damper as follows:

1. Reinstall crankshaft with new drive gear and drive spline installed as follows: (Refer to Section 6 for crankshaft installation).

   a. Remove the roll pin from the crankshaft and press a new pin (1, Fig. 23) in its place, as shown. Adhear to 1.78 mm (0.070 in.) pin protrusion.

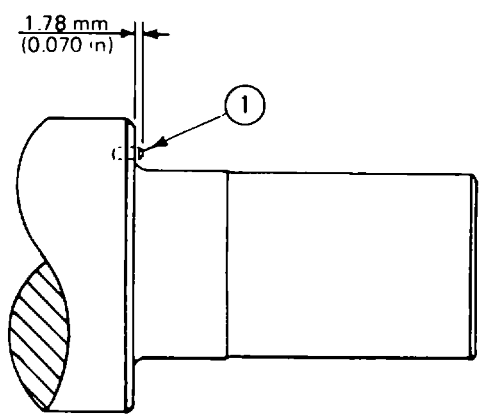

Figure 23. - Roll Pin Installation Diagram

   1. Roll pin

   b. Heat the new gear and spline evenly to approximately 400".

   c. Identify appropriate heat using a thermomelt stick (see tool list for number).

   When the initial dull and chalky mark turns a glossy liquid the desired temperature is reached.

NOTE: ***Pay no attention to color change when using thermomelt***.

   d. Using asbestos gloves, align the notch on the rear of the gear with the roll pin in the crankshaft. Slide the gear until it seats against the crankshaft shoulder.

   e. Slide the spline on the crankshaft until it seats against the gear. Hold the gear and spline until they cool sufficiently to hold in place.

2. Using a new gasket, install the crankshaft front plate. Tighten bolts to 27 N•m (20 Ibf-ft) torque.

3. Install the camshaft, camshaft gear and valve tappets as described in Section 4.

NOTE: Check camshaft end play and be sure the tappets move freely in their bores.

4. Install the idler gear as follows:

   a. Assemble component parts as shown in Fig. 24.

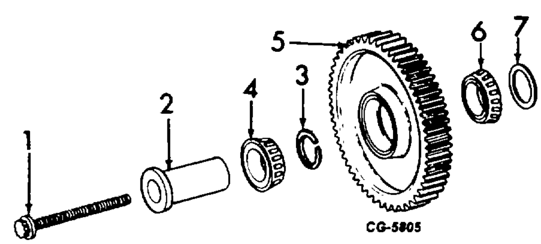

Figure 24. - Idler Gear and Component Parts Assembly

1.	**Retaining bolt**	**5.**	**Gear**
2.	**Stub shaft**	**6.**	**Bearing**
3.	**Spacer**	**7.**	**Spacer**
4.	**Bearing**		

   b. Install the assembly with the timing marks facing out. Be sure the rear spacer (7, Fig. 24) is in position. A small amount of grease will aid in holding the spacer.

   c. Install and tighten the retaining bolt (1, Fig. 24)to 115 N•m (85 Ibf-ft) torque.

5. If the injection pump gear was removed install it as follows: (For engines equipped w/UTDS* Model 100 Fuel Injection Pump)

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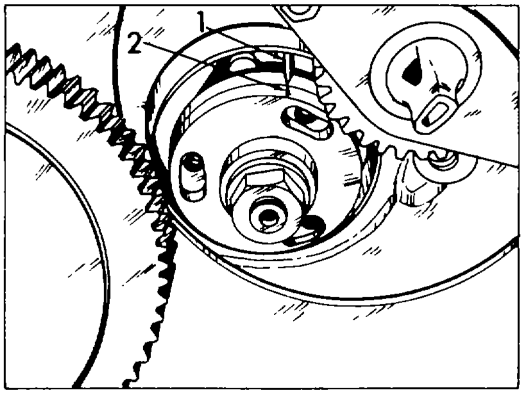
a. Be sure the engine crankshaft timing is set at the specified static timing prior to going any further.

b. Align the timing pointer (1, Fig. 25 or 26) with the line mark (2, Fig. 25 or 26) on the pump as shown.



Figures 25. - Injection Pump Timing Marks (Early Model Pump) [UTDS Model 100 Fuel Injection Pump]*

1. Timing pointer 2. Timing mark

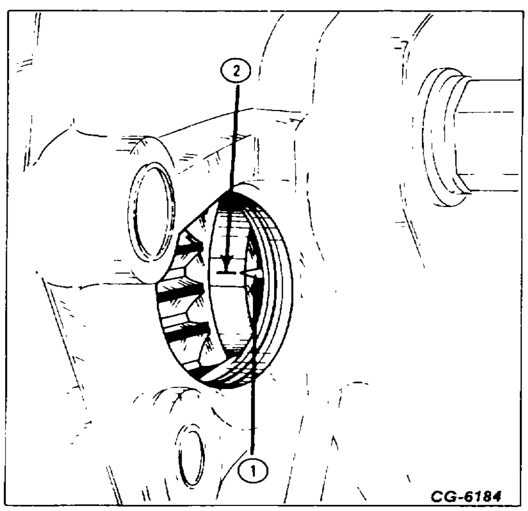


Figure 26. - Injection Pump Timing Marks (Late Model) [UTDS Model 100 Fuel Injection Pump]*

1. Timing pointer 2. Timing mark

NOTE: ***Disregard any timing marks on the idler gear. They are not used.***

c. Install the drive gear (2, Fig. 27), meshing it with the idler gear (1), as shown.

d. Holding the pump shaft with a socket wrench (3, Fig. 27) torque drive gear bolts to 35 N•m (26 lbf-ft).

e. Rotate engine crankshaft counter-clockwise 90° then rotate clockwise until pump timing pointer and timing mark align.

NOTE: ***The injection pump may be timed by removing the access cover only.(UTDS* Model 100 Fuel Injection Pump)***

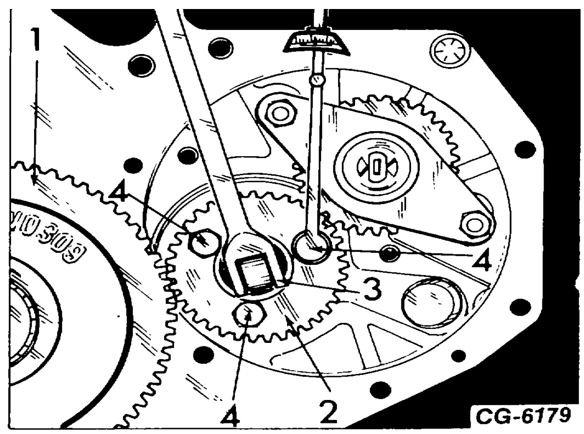


Figure 27. - Tightening Drive Gear Bolts

1. Idler gear
2. Drive gear
3. Socket wrench
4. Drive gear bolts

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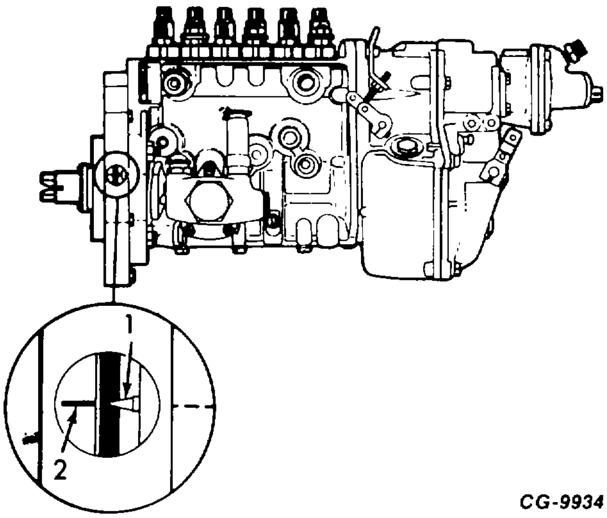

Figure 27a. - Injection Pump Timing Marks

1. Timing pointer
2. Timing mark

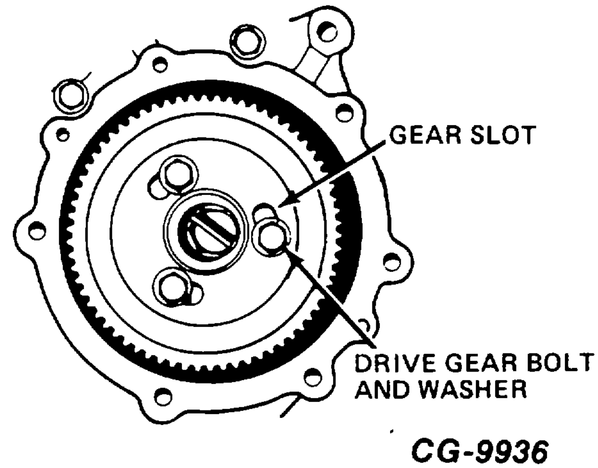

Figure 27c. - Drive Gear Bolt Slots

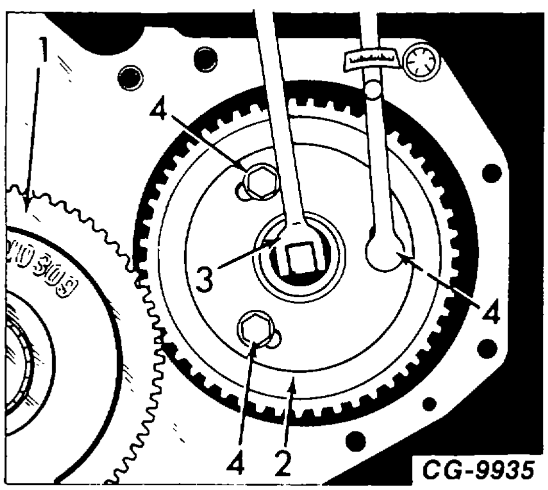

Figure 27b. - Tightening Drive Gear Bolts (Robert Bosch Model MW Fuel Injection Pump)

1. Idler gear
2. Drive gear
3. Socket wrench
4. Drive gear bolts (3)

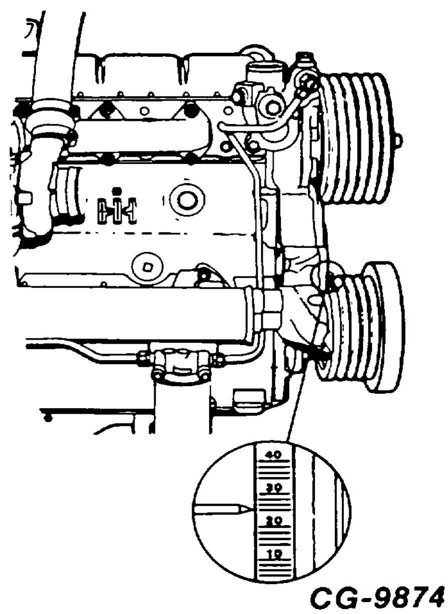

Figure 27d. - Engine to Injection Pump Timing on Pulley

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(formerly AMBAC)

6. If the injection pump gear was removed install it as follows: (For engines equipped with Robert Bosch Model MW Fuel Injection pump)

   a. Be sure that engine crankshaft timing is set at specified static timing prior to going any further.

   b. Using drive gear bolts and washers, loosely install' injection pump drive gear to injection pump meshing it with the idler gear (1, Fig. 27b). Make sure drive gear is positioned in gear slots (Fig. 27c) so it allows for adjustment.

   c. Align timing pointer (1, Fig. 27a) with timing mark (2, Fig. 27a) by rotating injection pump clockwise (as viewed from drive gear end).

NOTE: ***For engines equipped with Robert Bosch Model MW Fuel Injection Pump the timing pointer is located on the injection pump mounting adapter and the timing mark is located on the drive hub.***

   d. Holding the pump shaft with a socket wrench (3, Fig. 27b) torque drive gear bolts to 47 N•m (35 Ibf-ft).

   e. Rotate engine crankshaft counterclockwise 900 then rotate clockwise until pump timing pointer and timing mark align.

   f. Observe engine to injection pump timing on crankshaft pulley (Fig. 27d). Refer to specifications (introduction) for correct alignment (or see Chart 1, Section 11, Page 16).

7. If the tachometer drive gear was removed, proceed as follows: (UTDS* Model 100 Fuel Injection Pump)

   a. Insert the gear onto the dowel.

   b. Slip the spacers over the mounting studs or bolts.

   c. Place the thrust plate over the studs and gear.

   d. Install and tighten nuts to 27 N•m (20 Ibf-ft) torque.

8. Using a new gasket, install the crankcase front cover.

-Full Front Cover-
(See Fig. 5)

   a. For front covers with "ears" install the gasket as shown in Fig. 28. **DO NOT remove ears (shaded areas).**

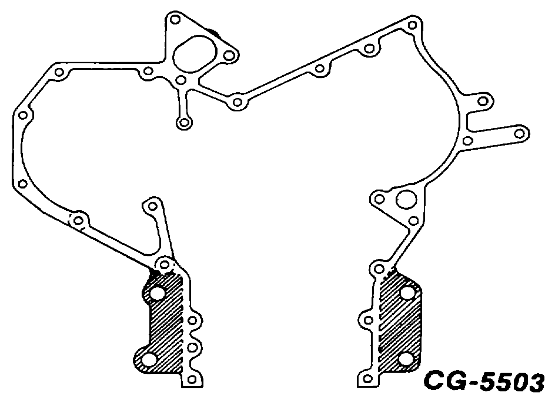

Figure 28. - Front Cover Gasket (Rear View)

- Earless Front Cover -
(See Fig. 6)

   b. When the gasket (Fig. 28) is used on "earless" front cover applications, install the gasket and front cover then remove the ears (shaded areas on Fig. 28).

NOTE: ***If the "EARS" are removed prior to installation, gasket misalignment may result:***

NOTE: ***Improper front cover installation will result in cover distortion or loose engine mounting bolts.***

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9. Install the cylinder head and adjust the value lash. (Refer to Section 3).

10. Using a new gasket, install the water pump. (Refer to Section 9).

11. Reconnect all hose connections. Install the alternator or idler pulley (depending upon application).

12. Using a new gasket, install the injection pump access cover with the Tachometer drive. The Tachometer drive MUST project 15.2 + 0.8 mm (0.60 + 0.03 in.) from the rear face of the access cover. (Engines equipped with UTDS* Model 100 Fuel Injection Pump.)

NOTE: ***Be sure to engage the tang of the Tachometer drive with the slot in the Tachometer drive gear for engines equipped with UTDS* Model 100 Fuel Injection pump. For engines equipped with Robert Bosch Model MW Fuel Injection Pump, engage the tang of the Tachometer drive with the slot in the end of the injection pump camshaft.***

13. Install a new crankshaft front oil seal into the lubricating oil pump housing as follows:

    a. Press a new oil seal (1, Fig. 29) into the oil pump body (2). Observe the 50.8 mm (2.0 in.) dimension, as shown.

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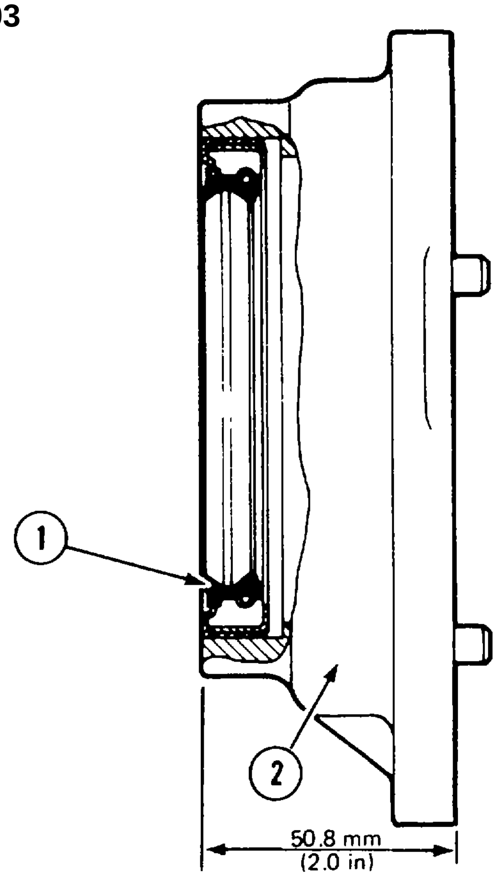

Figure 29. - Oil Seal Installation Diagram

1. Oil Seal 2. Pump body

    b. Install the oil pump housing. (Refer to Section 8).

14. Install the oil pump. (Refer to Section 8).

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15. Install the vibration damper as follows:

a. "RUBBER" Vibration Dampers:

1. Heat the damper in boiling water for a period **NOT** to exceed one hour.

2. Lightly coat the key and keyway areas with No. 2 (BLACK) Permatex.

3. Install the vibration damper by aligning the key and keyway then push.

4. Remove all excess Permatex from the retainer-mounting surface of the damper to insure proper retention of the damper assembly to the crankshaft.

5. Secure damper with the retaining plate and torque cap screws to 142 N•m (105 Ibf-ft).

6. Install damper plate if equipped.

NOTE: ***DO NOT heat vibration damper for more than one hour. The elastic member can be damaged. DO NOT attempt to install the damper cold.***

b. Viscous Vibration Dampers:

1. Heat the crankshaft pulley to approximately 400°. Use a 388°F thermomelt crayon (see tool list for tool No.) to determine temperature.

NOTE: ***The marked surface will melt and become a glossy liquid.***

2. Lightly coat key and keyway areas with No. 2 (BLACK) Permatex and install key.

3. Using asbestos gloves, align the keyway with the key in the crankshaft and push the pulley onto the shaft until it contacts the oil pump drive spline.

4. Install retainer plate and cap screws. Torque cap screws to 170 N•m (1 25 Ibf-ft).

5. Assemble viscous damper to crankshaft pulley with hardened washers and cap screws. Torque cap screws to 47 N•m (35 Ibf-ft).

16. On-Highway Trucks only:

Install the steering pump (if equipped). Refer to CTS-2001.

17. Install the freon compressor and idler (if equipped). Refer to the following:

a. Construction Equipment - ISS-1541, "Air Conditioning Service Manual".

b. On-Highway Trucks - CTS-2001

c. Agricultural Equipment

18. Install the air compressor and idler (if equipped). Refer to the following:

a. Construction Equipment "Air Compressor".

b. On-Highway Trucks CTS-2001

c. Agricultural Equipment -

19. Install the alternator or idler pulley (depending upon application) from its mounting bracket.

NOTE: ***It is recommended that the engine be run at 1000 RPM from 3 to 5 minutes after engine assembly. At this RPM tappets are under lighter load, thus assuring initial lubrication at the tappets and tappet bores.***

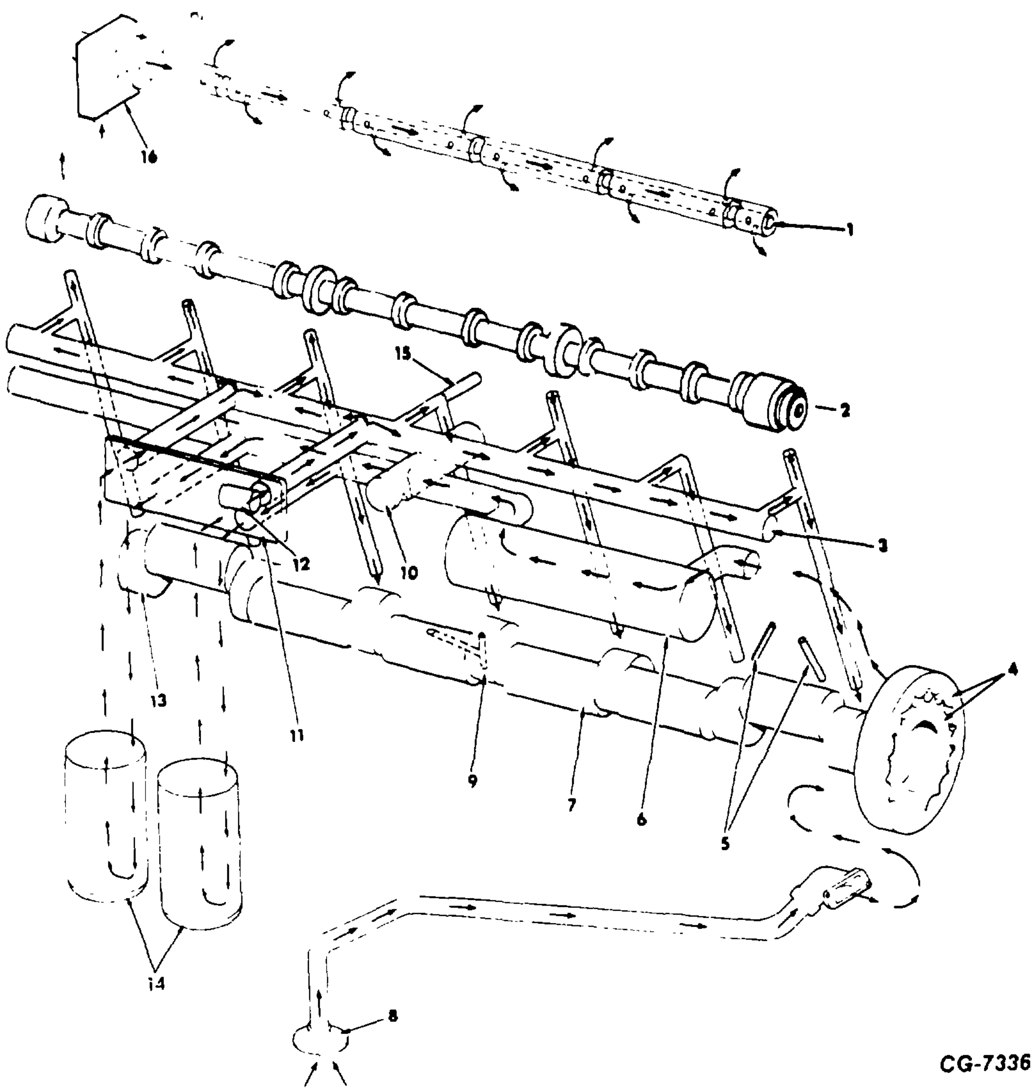

*Figure 1. - Engine Lubrication System**

1. Shaft
2. Camshaft
3. Main oil gallery
4. Oil pump
5. Piston cooling jet
6. Oil cooler
7. Crankshaft
8. Suction tube
9. Main bearing
10. Main regulator valve assembly
11. Filter base
12. Bypass valve
13. Main rear bearing
14. Filters
15. Injection pump oil supply
16. Bracket, valve lever assembly

***Filter location will vary depending upon application.**

GENERAL

The lube oil system is unique in that with the exception of the injection pump and Turbocharger oil supply (1 5, Fig. 1), there Is NO EXTERNAL PIPING to direct oil from one component to the next. The system is a full- flow type with a by-pass valve.

The lubrication system supplies filtered lubricating oil at optimum temperatures throughout the engine to reduce friction, minimize wear and operate engine controls. Oil pressure is used to end starting fuel delivery when the engine starts, and is an actuating force in the injection pump advance unit. Lubricating oil transfers heat from the turbocharger, piston sleeves, valves and other components to the cooling system and surrounding air.

Because the lubricating oil contacts most moving parts in the engine, keeping the lubricating oil free of abrasive materials is necessary to obtain long engine life.

Lubricating Oil Pump:

The pump (4, Fig. 1) is a "GEROTOR" type mounted on and driven directly by the crankshaft (7) at engine speed. Oil from the sump in the oil pan flows through a tube (8) and to the front cover opening (3, Fig. 2) where it enters the pump.

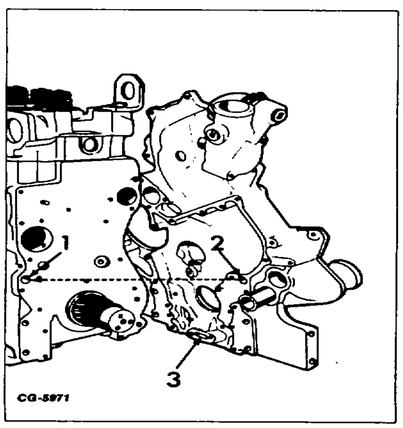

Figure 2. - Lube 011 Passage Locations in Front Cover & Crankcase

1. Lower oil gallery
2. Pressure outlet
3. Front cover opening

After passing through the pump, the oil re- enters the cover and is channeled through the pressure outlet (2, Fig. 2) of the cover Into the forward end of the lower oil gallery (1, Fig. 2) of the crankcase.

Leaving the gallery, the oil passes through the externally mounted oil cooler (6, Fig. 1). Upon leaving the cooler, the oil re-enters the crankcase passage and flows past the main regulator valve assembly (10, Fig. 1). The oil, under regulated pressure, again leaves the crankcase, and through two passageways, enters the externally mounted filter base (11).

Depending upon the immediate conditions, the oil can continue on in one of two directions, or in some instances, divide and travel in both. During normal operation, the flow of oil continues on through both filter elements (14, Fig. 1) on its way back into the crankcase main oil gallery. However, if the filters are not changed as per Operator's Manual recommendations, excessive filter contamination and pressure drop will result. When such conditions occur, the pressure differential type of by-pass valve will open allowing the oil to by- pass the filters and flow directly into the crankcase main oil gallery where it Is distributed to all parts of the engine. Oil fed to the main bearings also reaches the connecting rod bearings and the piston cooling jets (5, Fig. 1). The same drilled holes that feed oil down to the mains direct oil up to the camshaft bushings. The annulus cut in the rear camshaft bearing allows some of the oil fed to continue up to the rear valve lever shaft bracket (16, Fig. 1) where it is transferred to the hollow shaft (1, Fig. 16) and distributed to all valve levers. Push rod ball sockets, tap- pets, valve stems, cam on the camshaft and the gears are all SPLASH-LUBRICATED.

The "GEROTOR" pump draws oil from the pan through a stationary pickup tube .(1, Fig. 3) bolted to the crankcase front cover (2, Fig. 3).

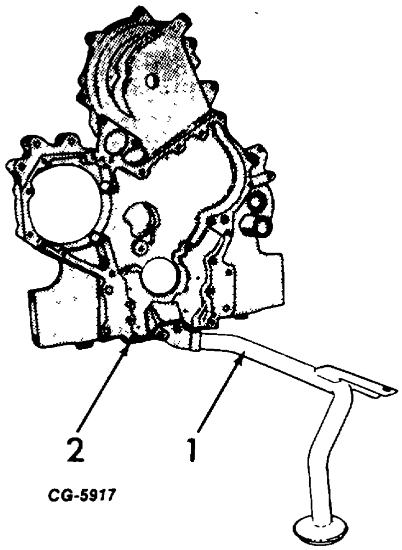

Figure 3. - Crankcase Front Cover and Lube 011 Suction Tube

1. Oil suction tube
2. Crankcase front cover

The pump assembly with an "O" Ring sealed porting plate (1, Fig. 4) is fastened to the crankcase front cover so the forward end of the crankshaft passes through the pump. A splined sleeve (3, Fig. 4) on the crankshaft engages the inner rotor (2, Fig. 4). This drives the pump at engine speed.

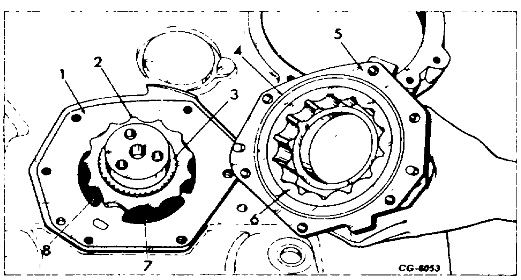

Figure 4. - "GEROTOR" Lubricating Oil Pump

1. Porting plate
2. Inner rotor
3. Spline
4. "0" Ring/Seal Ring
5. Pump housing
6. Outer rotor
7. Oil intake
8. Pressure port

The inner rotor (2, Fig. 4) is concentric to the crankshaft, whereas the outer rotor (6, Fig. 4) is not. There are 14 spaces in the outer rotor and only 13 teeth on the inner rotor. As the pump rotates, oil from the pan enters the pump on one side (7, Fig. 4) as the teeth leave the outer rotor. The oil is carried to the other side of the pump in the spaces and as the teeth re-enter the spaces, the oil is forced out the pressure port (8, Fig. 4) on its way to the oil cooler.

A lip-type front engine oil seal is pressed into the pump housing and the housing is dowel pinned to the front cover which automatically aligns the pump and seal.

Two different oil pumps are used; one for the Turbocharged engines and one for the naturally aspirated models. The basic difference is the width of the pump which affects the capacity. The Turbocharged engines, with two cooling jets per piston, use the larger-capacity pump.

Lubricating Oil Filters:

The oil filters (1, Fig. 5) are the full-flow type and are interconnected by common internal passages in the crankcase. One passage is for the inlet (3) and one for the outlet (5). The filters do not have internal by-pass valves. Instead, one by-pass valve (4) located in the filter base (2) controls the oil flow through the filters.

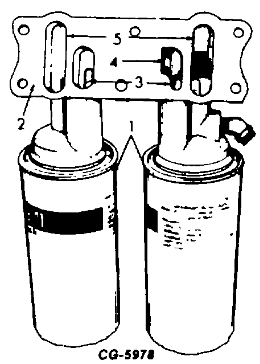

Figure 5. - Oil Filters and Filter Base

1. Oil filters
2. Filter base
3. Inlet passage
4. By-pass valve
5. Outlet passage

Depending upon the immediate conditions, the oil can continue on in one of two directions or, in some instances, divide and travel in both. During normal operation, the flow of oil continues on through both filter elements (14, Fig. 1) on its way back into the crankcase main oil gallery. However, if the filters are not changed per Operator's Manual recommendations, excessive filter contamination and pressure drop will result. When such contamination occurs, the pressure differential type of by-pass valve will open allowing the oil to by-pass the filters and flow directly into the crankcase main oil gallery where it is distributed to all parts of the engine.

OIL PRESSURE REGULATOR VALVE:

The unique design of the lubricating oil regulating valve extends the life of the oil filters in that it controls the volume and pressure of the filtered oil supplied to the engine. The volume of oil supplied by the pump is in excess of what is needed to lubricate the engine. This valve divides that flow. The volume needed to lubricate the engine is directed to the filters and excess is dumped to return. When all points of lubrication within the engine are satisfied, restriction to flow causes pressure to build in the filtered oil gallery and on the face of the valve. As this force moves the valve toward the regulator spring the port in the unfiltered oil gallery is uncovered and excess oil is dumped to return. Due to volume changes caused by changes in engine RPM the valve will dump more or less oil to the return keeping filtered oil pressure and volume within the specified range. Thus, the only oil filtered is that which is needed to lubricate the engine.

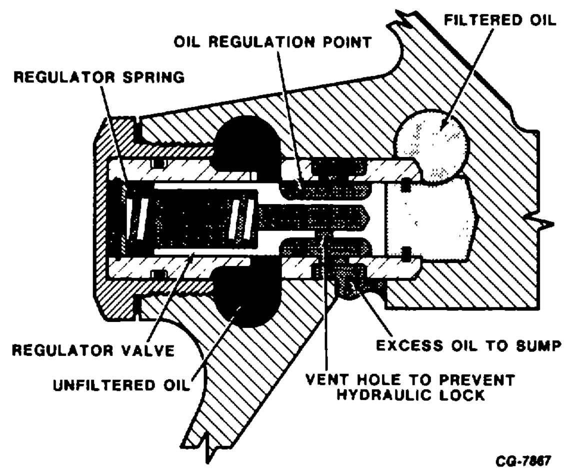

Figure 6. - Oil Pressure Regulator Valve Operation

Oil Cooler:

The oil cooler is mounted on the right side of the engine. All of the engine oil is circulated from the oil pump through the cooler and into the oil filters. Water flows from the radiator through numerous tubes in the oil cooler.

SPECIFICATIONS

DIMENSION	VALUE
Oil Pump:	
Type	"GEROTOR"
Drive	Crankshaft
End Clearance, Inner and Outer Rotor to Housing	0.0508 mm (0.002 in.) / 0.121 mm (0.0048 in.)
Radial Clearance, between Outer Rotor Housing	0.140 mm (0.0055 in.) / 0.241 mm (0.0095 in.)
Engine Oil Pressure* (Run engine until normal operating Temperatures are reached)	
At Low Idle Speed	69 kPa (10 psi) @ 650 rpm Minimum
At Rated Speed	290 to 448 kPa (42 to 65 psi)
Minimum Pressure at Rated Speed	241 kPa (35 psi)
Engine Oil Filter:	
Type	"SPIN-ON"
Number	2
Filter By-Pass Location	In Oil Filter Base
By-Pass Valve Spring:	
Free Length	52.71 mm (2.075 in.)
Test Length	23.55 mm (0.927 in.)
Test Load	27.2 N (6.12 lbs.)

*Oil pressure measurement should be made utilizing an oil gallery tap rather than a remote location.

SPECIFICATIONS

Pressure Regulating Valve Spring

Free Length .... .55.17 mm (2.172 In.)

Test Length .... 31.24 mm (1.230 in.)

Test Load .... 68.1 N (15.3 lbs.) ± 5%

Outside Diameter .... 12.70 mm (0.500 in.)

Pressure Regulating Valve Assembly

Location .... In crankcase, to rear of oil filter.

Setting 331 kPa (48 psi) / 359 kPa (52 psi)

Valve Assembly Diameter .... 25.36 mm (.9985 in.) / 25.33 mm (.9975 in.)

Valve Clearance in Bore .... 0.10 mm (0.004 in.) / 0.05 mm (0.002 in.)

Crankcase Bore ID .... 25.45 mm (1.002 in.) / 25.37 mm (0.999 in.)

REMOVAL

Remove the Lubricating 011 Pump as follows:

1. Remove the vibration damper as described in Section 1.

2. Remove the bolts and washers securing the pump housing to the front cover.

NOTE: ***Whenever the oil pump housing is removed from the crankcase front cover, be careful not to mix the six oil pump housing cap screws with any other hardware. These cap screws have a nylon pellet mounted in the threads to seal through tapped holes which go into the oil cavity. behind the crankcase front cover. Installation of cap screws not so equipped will result in oil leaks at these points. The leaks will not be obvious until after the engine has been put back into service. To prevent the possible loss of the cap-screw sealing characteristic, the cap screws should not be used more than two or three times.***

3. Remove the pump housing (5, Fig. 4) with the outer rotor (6) and "O" ring (4) from the front cover.

4. Remove the inner rotor (1, Fig. 7), housing plate (2) and "O" ring (3), as shown.

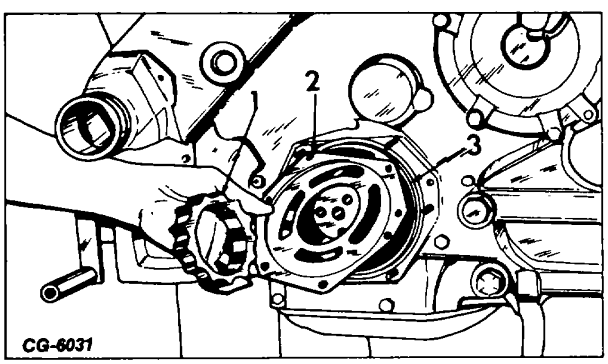

Figure 7. - Removing Inner Rotor and Housing Plate

1. Inner rotor
2. Housing plate
3. "O" ring/seal ring

5. Remove the seal washer (2, Fig. 7) from the crankshaft (if equipped).

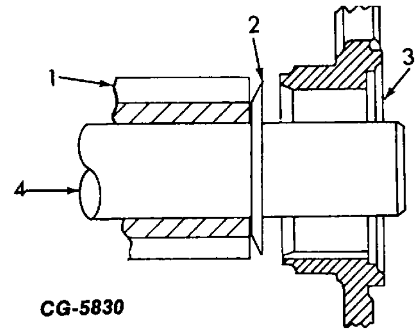

Figure 8. - Crankshaft Seal Washer

1. Crankshaft spline
2. Seal washer
3. Vibration damper
4. Crankshaft

Remove the Oil Filters as Follows:

1. Clean the filter elements and base with diesel fuel before removing.
2. Disconnect the Turbocharger oil-supply line (if equipped) at the filter base.
3. Remove the six bolts securing the filter base to the crankcase

NOTE: ***Whenever the oil filter base is removed from the crankcase, be careful not to mix the capscrews with any other hard- ware. These special screws are necessary to prevent oil leaks as one of the bolt holes connects with an oil pressure gallery.***

4. Remove the filter base with the elements attached.

5. Remove base gasket.

Remove the Oil Cooler as follows:

1. Drain the cooling system
2. Drain the lubrication system.
3. Remove the four screws securing the cooler to the crankcase.
4. Remove the cooler by pulling towards the rear of the engine.

CLEANING, INSPECTION AND REPAIR

CLEANING

Clean all Parts as Follows:

1. Wash all parts thoroughly in an oil solvent.
2. Dry with compressed air.

INSPECTION

Inspect the 011 Lubricating Pump as follows:

1. Visually inspect the rotors, housing and housing plate for nicks, burrs, scoring or unusual wear. Replace parts which are worn or damaged.

NOTE: *The inner and outer rotors are a matched set and cannot be replaced separately.*

2. Check the radial clearance between the outer rotor (1, Fig. 9), and the pump housing (2) with a feeler gauge, as shown.
 0.140 mm (0.0055 In.)
 0.241 mm (0.0095 in.)
limits must be maintained.

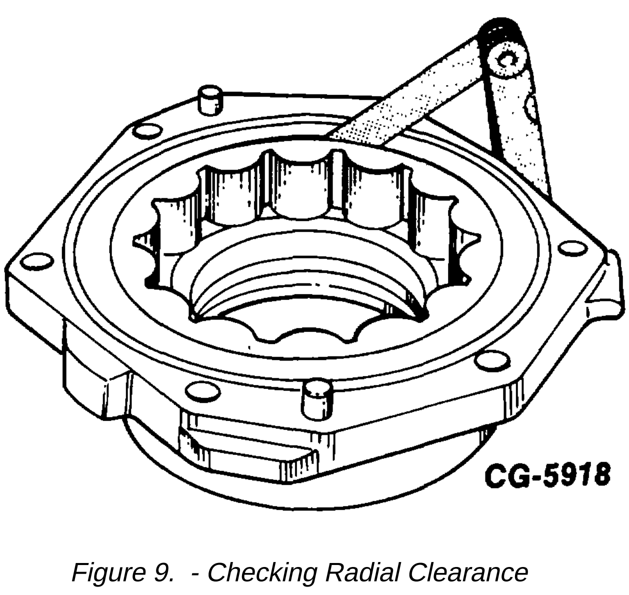

Figure 9. - Checking Radial Clearance

1. Outer rotor
2. Pump housing

3. Check the end clearance, using Plastigage as follows:
   a. Place a strip of Plastigage (3, Fig. 10) onto rotors and cover with housing, using a new "O" ring in groove.
   b. Secure housing to front cover.
   c. Remove housing and measure the Plastigage.
   d. 0.0508 mm (0.002 in.) 0.1219 mm (0.0048 in.) limits must be maintained.
   e. Remove the Plastigage and outer rotor (1).

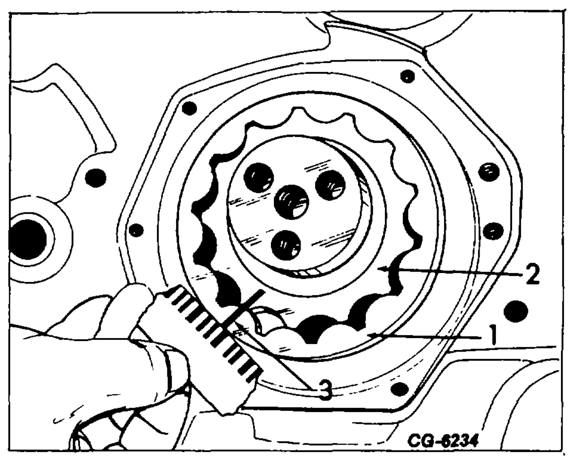

Figure 10. - Checking End Clearance

1. Outer rotor
2. Inner rotor
3. Plastigage

2. Drain and blow out any solvent and foreign matter inside of the coolers. Be certain that all passages are clean and clear before Installation.

NOTE: ***DO NOT use wire brushes or steel scrapers for removing deposits.***

Inspect the Oil Cooler for leaks as follows:

1. Perform an "Air Pressure" test as follows:

   a. Construct two plates as specified in Fig. 11 and 12.

   CAUTION! Use adequate safety precautions when performing the following tasks.

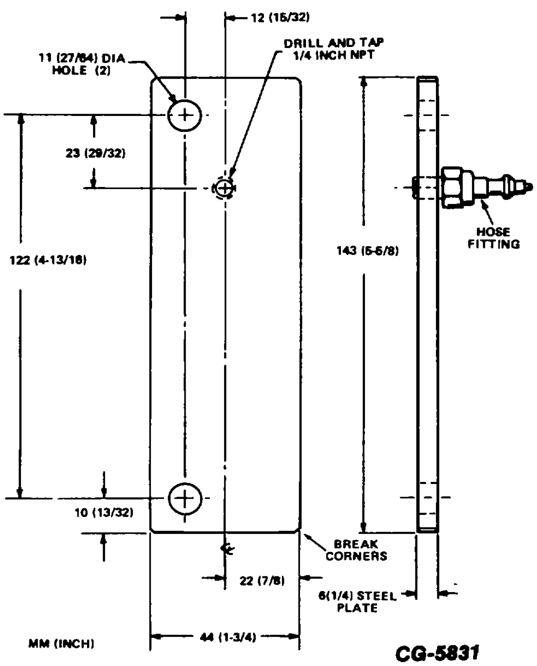

Figure 11. - Pressure Plate with Air Coupling

   b. Fasten the plates, using new oil cooler gaskets, to the cooler.

   c. Install an air pressure hose to the cooler as shown in Fig. 13.

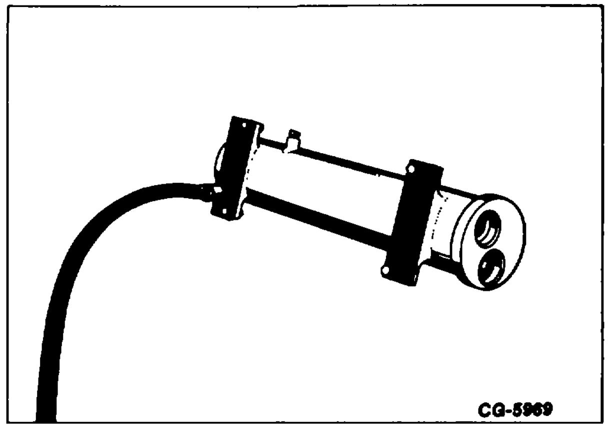

Figure 13. - Air Hose to Cooler

   d. Immerse the assembly in a container of water, heated to 49°C (120°F). This stabilizes the metal parts of the cooler.

   e. Apply 935 kPa (150 psi) air pressure while immersed.

   f. Replace if there are moving or growing bubbles after one minute.

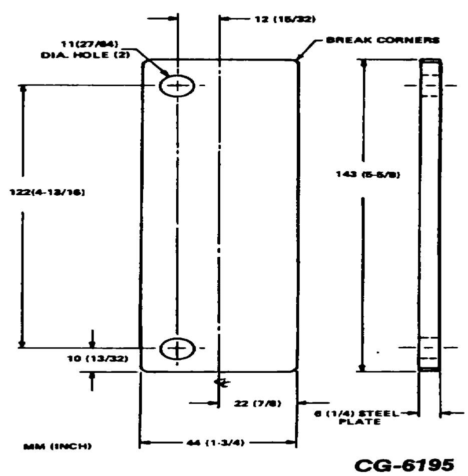

Figure 12. - Pressure Plate

Inspect Oil Pressure Regulator Valve as follows:

1. Remove valve retaining plug from crank- case.
2. Remove oil pressure regulating valve from crankcase bore.
3. Move the regulator inner valve assembly (1, Fig. 13) to ensure it operates freely.
4. Inspect per Figures 13a and 13b.
5. Make sure that the snap rings (4 and 5, Fig. 13) are in position and the inner valve spool has an unobstructed 3.175 mm (0.125 in.) diameter bleed hole (3, Fig. 13).

NOTE: ***This inspection can be performed without oil pressure regulator valve disassembly.***

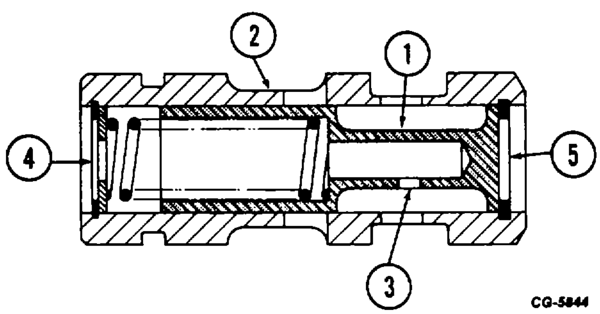

Figure 13. - Oil Pressure Regulator Valve

1. Inner Valve Assembly
2. Outer Valve Assembly
3. 3.175 mm (.125 in.) Bleed Hole
4. Snap Ring
5. Large Snap Ring

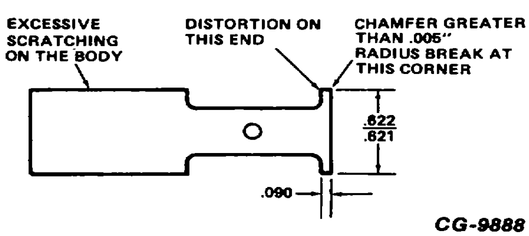

Figure 13a. - Lube Oil Pressure Regulating Valve Check Points

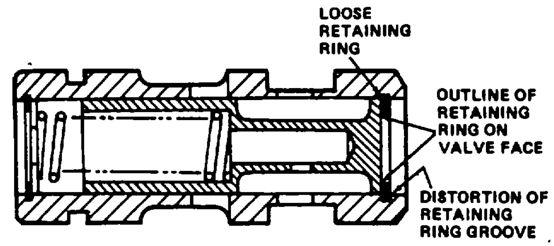

Figure 13b. - Cross-Sectional View of Pressure Regulating Valve Complete Assembly Check Points

NOTE: ***If conditions exist as shown in Figures 13a and 13b and dimensions are not as specified replace complete valve assembly.***

Inspect and Repair Oil Drain Hole as follows:

1. Locate oil drain hole in the crankcase pressure regulator valve bore (Fig. 14).

NOTE: ***The oil drain hole is an elliptical shaped port, positioned in the lower radius of the bore. Three o'clock to six o'clock on 400 Series engines and six o'clock to nine o'clock on 300 Series engines. Obstruction of the drain hole will result in excessive oil pressure and possible oil filter rupture.***

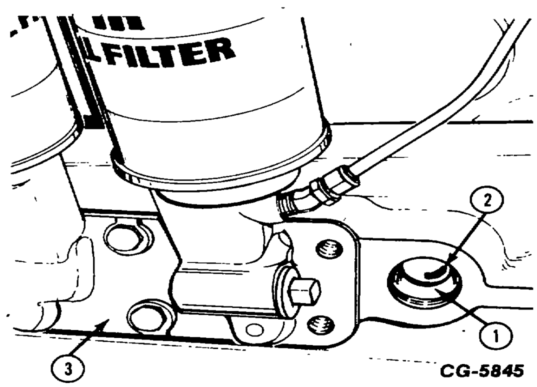

Figure 14. - Pressure Regulator Valve Bore (AE Application Shown)

1. Oil Pressure Regulator Valve Bore
2. Elliptical Drain Hole - approximately 12.7 mm (0.5 in.) X 6.3 mm (0.25 in.)
3. Oil Filter Base

2. With oil pressure regulator valve removed, inspect for proper dimensions of oil drain hole (2, Fig. 14).

3. If drain hole is obstructed, the following procedure should be performed:

   a. Drain oil and remove oil pan.

   b. With oil pressure regulator valve removed, block off all horizontal oil passages indexing with oil pressure regulator valve - using grease impregnated rags.

   c. Using a drill and die grinder, enlarge the drain hole by removing thick iron or iron and burnt in sand from the casting. Drain hole is accessible from bottom of crankcase at inner wall.

   d. THOROUGHLY FLUSH entire area with engine oil ensuring all foreign matter is removed.

   e. Install oil pan. Tighten oil pan mounting capscrews to 20 N•m (15 Ibf-ft.)

   f. Replace oil pressure regulator valve. Tighten to 230 N•m (170 Ibf-ft).

   g. Fill engine to specified level.

   h. Check engine oil pressure with engine at normal operating temperature.

Inspect the 011 Pick Up Tube as follows:

1. Pressure test the tube using the following to perform the test:

   a. Air pressure gauge, 0 to 350 kPa (0 to 50 psi range).

   b. Miscellaneous pipe fittings.

   c. Regulating air control valve.

   d. Foam rubber pad, 100 mm (4 in.) sq. X 25 mm (1 in.) thick.

   e. Air supply.

   f. Soap solution.

   g. Accurate torque wrench.

2. Remove the oil pan.

3. Check the torque 25 N•m (18 Ibf-ft) of the oil tube flange mounting bolts.

4. Remove the engine oil cooler bottom drain plug.

NOTE: ***The side drain plug Is for engine coolant.***

5. Install the necessary fittings, air gauge and regulator at the drain plug top boss.

6. Apply foam rubber to seal oil pick-up tube suction screen.

7. Connect the air supply hose to the regulator valve.

NOTE: ***Keep the air regulator valve closed when connecting air supply hose to regulator valve.***

8. Gradually open the air control valve and apply 140 to 205 kPa (20 to 30 psi) at air gauge (mounted at outlet of air regulating valve) to maintain 20 to 35 kPa (3 to 5 psi) air pressure in pipe.

9. Check oil pick-up pipe, using prepared soap solution as follows:

   a. Tube - Check tube for cracks.

   b. Oil Pick-Up Housing - Check metal housing for seam cracks and braze connection of housing to tube.

   c. Support Bracket - Check for leaks where bracket is brazed to pipe.

   d. Manifold - Check where pickup tube is brazed to the manifold.

   e. Mounting - Check the manifold to gasket and to mounting of the front cover.

10. If leakage Is found in areas "a" thru "c" of Step 9, the pick-up pipe should be replaced with a pre-tested assembly.

11. If leakage is found in areas "d" or "e", remove the assembly and investigate the cause. (i.e. bad or missing gasket, manifold machine marks, flaws in the seal surface or flat face nut).

NOTE: ***If the manifold sealing surface Is found defective, replace the complete oil pick-up tube assembly.***

Clean the Oil Filter Components as follows:

1. Discard filter elements.

2. Disassemble by-pass valve, plug and spring in filter base.

3. Wash all parts in diesel fuel.

4. Dry all parts with compressed air.

Inspect the 011 Filter Components as follows:

1. Visually inspect the inlet and outlet passages in the filter base for restrictions.

2. Visually inspect the by-pass valve for wear or damage. Replace if necessary.

3. Check by-pass valve spring using a valve spring load testor. Free length of 52.71 mm (2.075 in.) and a test length of 23.55 mm (0.927 in.) under 27.2 N•m (6.12 Ibf-ft) should be maintained. Replace if necessary.

Clean the Oil Cooler as follows:

1. Immerse the cooler into a cleaning solvent such as Stoddard or equivalent to loosen any sludge on foreign matter.

NOTE: ***DO NOT use caustic solution of any kind.***

INSTALLATION

Assemble and Install the Lubricating Oil Pump as follows:

1. Press a new oil seal into the pump housing. Refer to Section 7 for procedure.

2. Install a new seal washer (2, Fig. 7) with the larger diameter facing out (toward pulley), onto the crankshaft.

NOTE***: New seal washer should also be Installed to engines not equipped.***

3. Install the pump as follows:

   a. Install a new "O" ring (3, Fig. 6) into the groove in the crankcase front cover; then install the plate.

   b. Install the inner and outer rotors onto the crankshaft.

   c. Using the new "O" ring (4, Fig. 4) in the groove in the housing (5), position the outer rotor (6) in the housing and install the housing onto the crankcase front cover.

   d. Secure the housing to the cover.

4. Install the vibration damper as described in Section 7.

NOTE: ***Inspect the wear sleeves on the damper hub for wear or damage. Replace if necessary. Refer to Section 7 for detailed information.***

Assemble and Install the Lubricating Oil Filters as follows:

1. Install the valve and spring into the bore of the filter base. Install the plug and tighten to 50 lbs. torque.

2. Using a new gasket, install the filter base onto the crankcase. Secure in place with the hardware previously removed.

3. Connect the Turbocharger oil-supply line to the base (if equipped).

4. Lubricate filter gasket with oil or grease. HAND TIGHTEN filter 1/2 to 3/4 turn after gasket contacts filter head. DO NOT OVERTIGHTEN.

Install the Oil Cooler as follows:

1. Install new "O" rings on tubes from cooler to front cover.
2. Using new gaskets, install the oil cooler to the crankcase.
3. Fill the cooling system and the lubricating oil system as specified in the Operator's Manual, and check all connections for leaks.

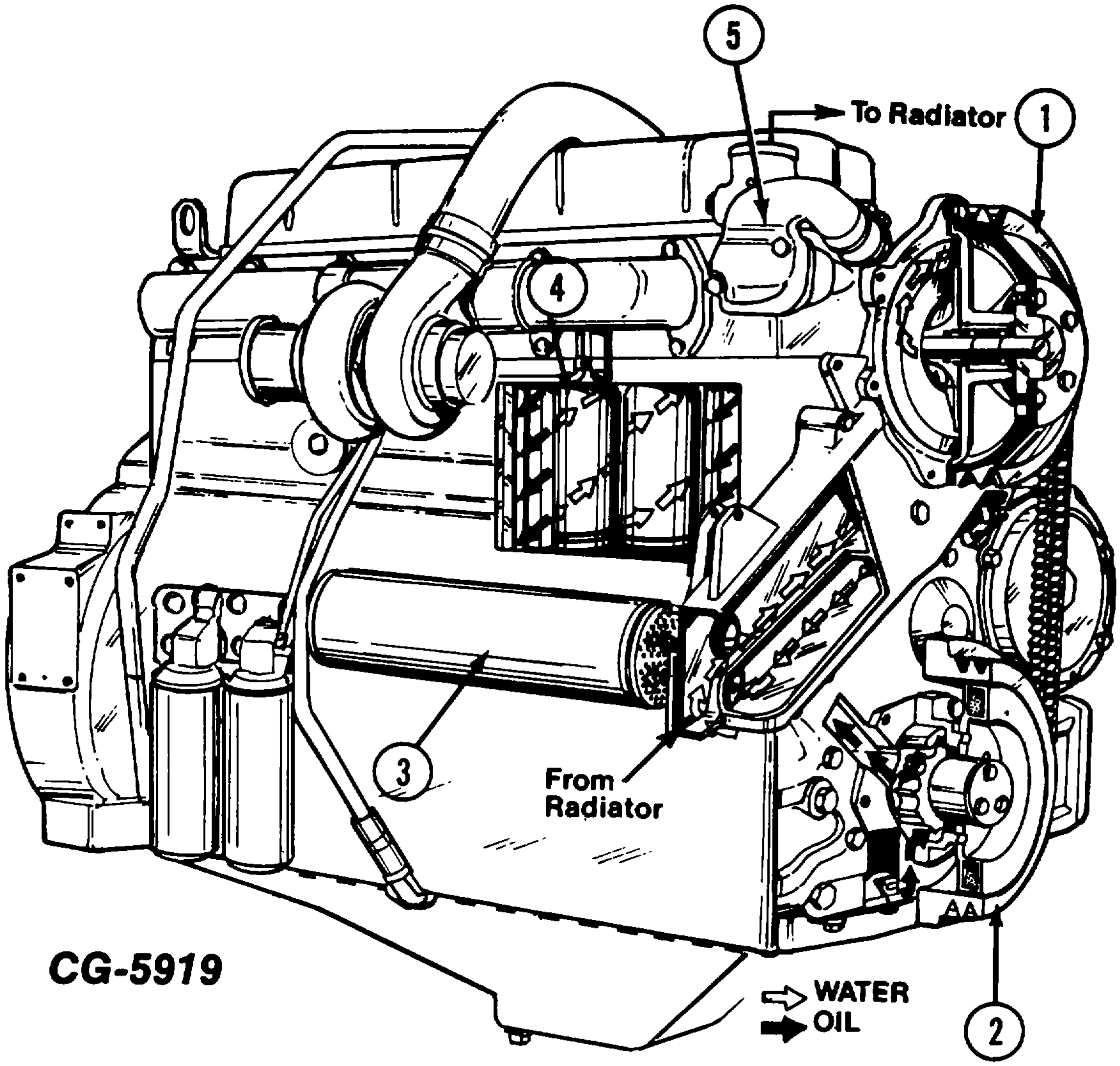

Figure 1. - Engine Cutaway Showing Coolant Passages

1. Water pump
2. Oil pump
3. Oil cooler
4. Cylinder sleeve
5. Thermostat housing

WATER PUMP

The belt-driven centrifugal pump is built into the front cover but can be removed when service is necessary. Water Inlet and outlet passageways are cast into the cover.

Coolant from the lower tank of the radiator enters the front cover near the bottom and flows to the center of the pump Impeller through the upper channel. Upon leaving the Impeller, the coolant enters the lower channel which divides the flow. Part of the flow travels Pack down to the lower end and enters the oil cooler as shown in figure one. After flowing through the cooler, It re-enters the upper channel to mix with the incoming coolant from the radiator.

The other part of the pump flow enters the distribution passageway cast In the crankcase. The passageway directs coolant from the front to the rear of the crankcase, evenly distributing the coolant, to the lower sections of each cylinder sleeve. The coolant enters each sleeve chamber on a tangent causing It to swirl around the sleeve as it travels upward and into the head. This swirling of the coolant aids In preventing sludge and rust accumulations, which greatly reduce cooling efficiency.

Coolant directors (2, Fig. 2) in the cylinder head water passages direct the coolant for scrubbing the valve seat areas and nozzle tubes, as shown. Two air bleed holes (1) vent the crankcase into the cylinder head coolant passages.

The coolant flowing out of the cylinder head enters the thermostat housing. Here the coolant Is either directed to the radiator If at operating temperature or directed back to the pump if not at operating temperature.

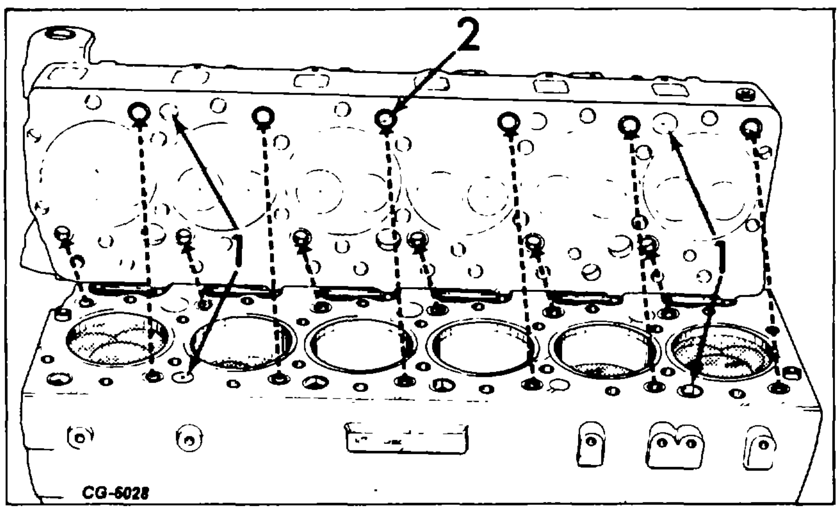

Figure 2. - Coolant Passages In Cylinder Head and Crankcase

1. Air Bleed Holes
2. Coolant Director

SPECIFICATIONS:

DIMENSION	VALUE
Water Pump	
Impeller Vane Height to Mounting	0.25 mm 0.010 in.
Face of Housing (7 Vane)	0.25 mm 0.02210 in.
Clearance Between Housing and Back Face of Impeller (4 Vane & 8 Vane)	
Light Duty	0.25 mm 0.010 in
(with Pressed-On Hub)	1.17 mm 0.046 in.*
Heavy Duty	0.25mm 0.010 in.
with Nut Retained Hub) (4 & 8 Vane)	1.17mm 0.046 in.*
Heavy Duty	
(with Nut Retained Hub) (7 Vane)	0.31 mm 0.012 in.
	1.63 mm 0.064 in.*
Bearing End Play	0.038 mm 0.0015 in.
(Roller Bearing Only)	0.241 mm 0.0095 in.

*All dimension with end play of shaft to rear.

WATER PUMP INSPECTION

It is recommended that water pump assemblies be inspected at every oil change interval for coolant leakage and bearing end play. The water pump should be removed, disassembled and inspected every 120,000 mi. (193, 121 Km.), 4000 hours or 27 months, whichever occurs first.

Water Pump Inspection at Oil Change Interval 6000 Mile (9600 KM.), 200 Hours or 3 Months

Coolant Leakage

Each water pump housing features an inspection port (9, Fig. 8) which allows operators and maintenance personnel to determine if the water pump seal is leaking coolant. Ex- amine the inspection port for the presence of coolant or blockage by grease or dust. If coolant or excessive grease is present at the inspection port, remove the pump (refer to "Removal" this section) and install a new, ReNEWed or locally rebuilt assembly.

Remove any inspection port blockage with a wire or rod.

IMPORTANT: I F BLOCKAGE IS NOT REMOVED, and the water pump seal leaks, coolant will enter the bearings and damage the bearings and shaft.

Bearing End Play

Verify end play by grasping the water pump pulley hub (7, Fig. 8) and moving the pulley fore and aft. Specified end play is 0.038 to 0.241 mm (0.0015 to 0.0095 in.). If the end play appears to be excessive completely loosen all belts and measure end play using a dial indicator. Replace the assembly if 0.241 mm (0.0095 in.) is exceeded.

120,000 Mile (193, 121 Km), 4000 Hour or 27 Month Inspection

Parts Replacement

The bearing oil seals, bearings, and water pump seal assembly must be replaced at disassembly. If the pump was allowed to operate with a leaking water-pump seal, the shaft and housing will be damaged and must be replaced.

REMOVAL

Remove the Water Pump as follows:

1. Remove the six bolts securing the fan to the water pump pulley.
   a. Remove the fan.
   b. Remove the pulley from the water pump hub.
2. Remove all stud nuts and bolts.
3. Remove the water pump and gasket from the front cover.

NOTE: ***This procedure applies for both press fit and nut retained hub water pump assemblies.***

PROCEDURE FOR WATER PUMPS WITH A PRESS FIT HUB:

DISASSEMBLY

Disassemble the Water Pump, with a Press Fit Hub, as follows:

1. Using a puller, remove the fan hub (1, Fig. 3) from the water pump shaft. Use a bar (2) to prevent the hub from turning.

NOTE: A hydraulic puller may be required to remove the hub from the shaft.

2. Remove the snap ring (1, Fig. 4) in the bearing housing (2) as shown.

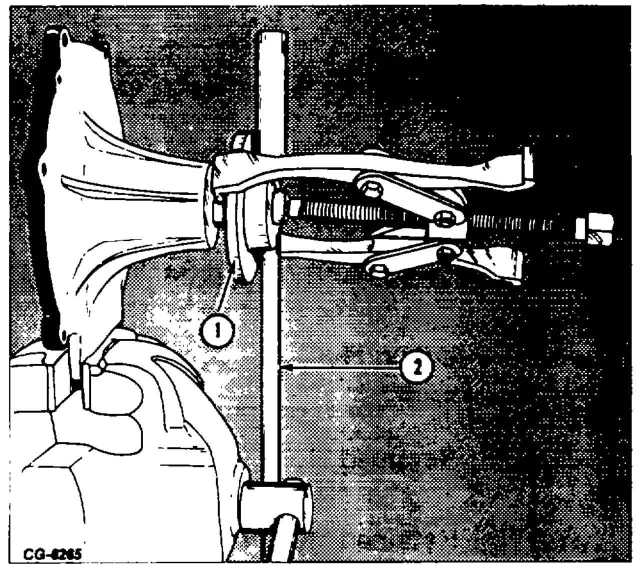

Figure 3. - Removing the Fan Hub

1. Fan hub
2. Bar

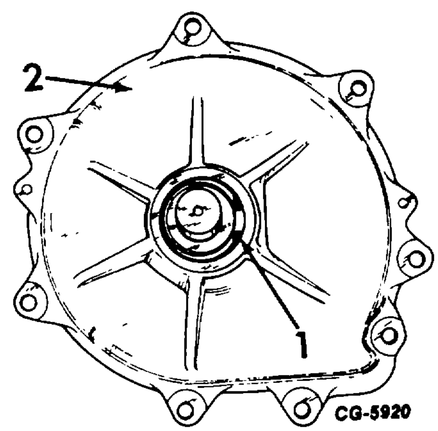

Figure 4. - Bearing Snap Ring Removal

1. Snap ring
2. Bearing housing

3. Pull off the impeller (1, Fig. 5) using the two 1/2 inch holes provided as shown.

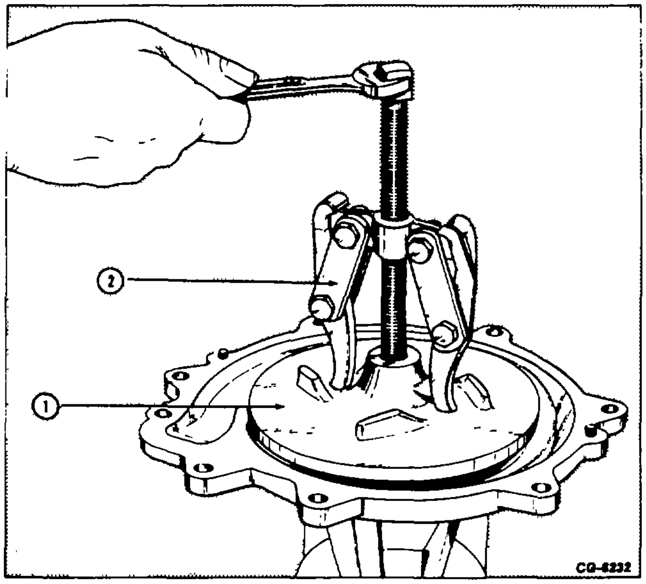

Figure 5 - Removing Impeller

1. Impeller
2. Puller

NOTE: ***If the impeller is equipped with 1/4 inch holes, enlarge them to 1/2 inch to accept a small puller (2, Fig. 5).***

4. Support the bearing housing (1, Fig. 6) as shown and press the shaft and bearing assembly out of the bearing housing.

5. Pry out the ceramic seat and boot (1, Fig. 7) from the impeller and discard it, along with the water pump seal (2) as shown.

6. Drive out the metal part of the water pump seal (5, Fig. 8) from the front of the housing. Discard.

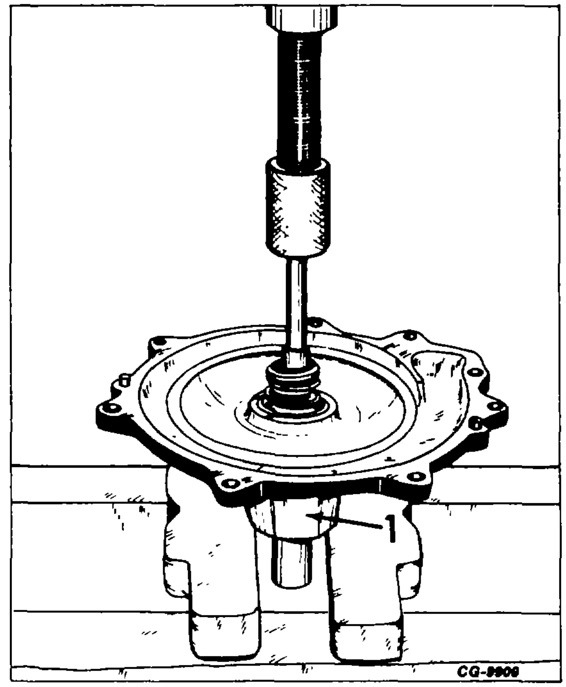

Figure 6. - Removing Shaft and Bearing Assembly

1. Bearing housing

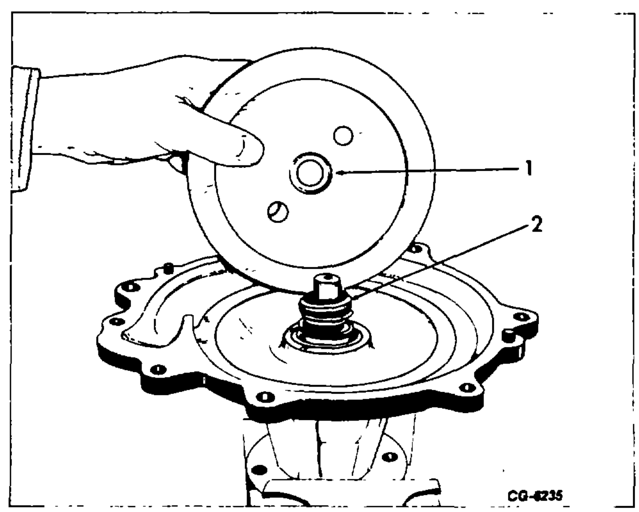

Figure 7. - Water Pump Seal

1. Seat and boot
2. Seal

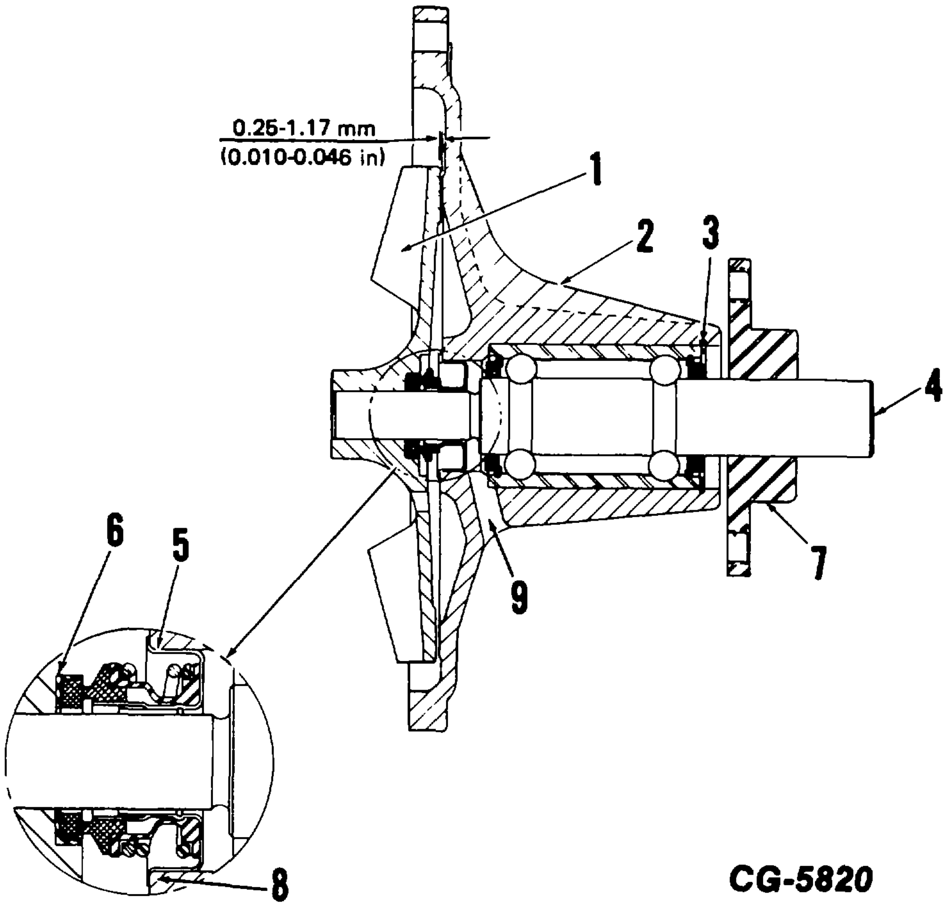

Figure 8. - Water Pump Cross Section (Press Fit Hub)

1. Impeller
2. Bearing housing
3. Snap ring
4. Shaft and bearing assembly
5. Water pump seal
6. Seal seat and bushing assembly
7. Hub
8. "O" Ring (when used)
9. Inspection port

CLEANING, INSPECTION & REPAIR

CLEANING

Clean the Water Pump as follows:

1. Wash all parts thoroughly in a good solvent.
2. Dry with compressed air.

INSPECTION AND REPAIR

Inspect and Repair the Water Pump as follows: (Refer to Fig. 8)

1. After cleaning visually inspect the shaft and bearing assembly (4) for wear and leakage. Replace if necessary.
2. Visually inspect the bearing housing (2) for wear or damage. Replace if necessary.
3. Inspect the impeller vanes (1) for erosion, remove any nicks, burrs or roughness especially from around the edges. Replace if necessary.
4. It is recommended that a new hub (7) be used. A re-used hub may work loose due to material being removed when pressing it on and off.
5. When servicing the water pump, ALWAYS replace the water pump seal (5) and seal seat and bushing assembly (6).
6. Bearing and shaft assembly should be replaced.

REASSEMBLY AND INSTALLATION

Reassemble and install the Water Pump with a Press Fit Hub as follows: (4 and 8 Vane Pumps only)

1. Support center of bearing housing (4, Fig. 9) with a sleeve(s) as shown.
2. Press bearing assembly (3, Fig. 9) until it bottoms in housing. DO NOT PRESS ON SHAFT TIP.

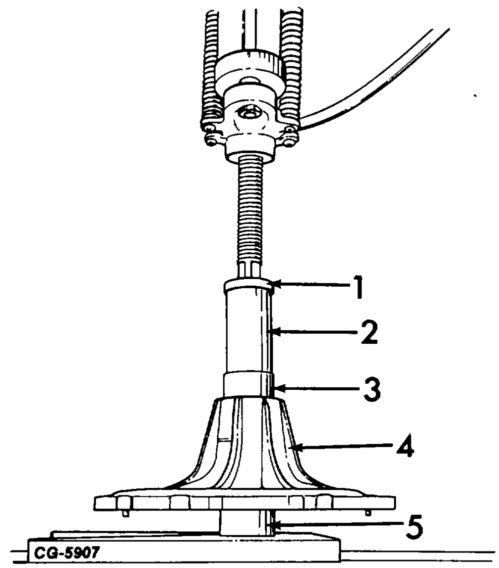

Figure 9. - Installing Shaft & Bearing

1. Step Plate
2. Sleeve
3. Bearing Assembly
4. Bearing Housing
5. Sleeve

3. Install snap ring (3, Fig. 8).

4. Support pump on front end of shaft (Fig. 10).

5. Install hub:

   a. Support hub (1, Fig. 10) and press shaft (2) through hub.

   b. Dimension "A" should be 112.01 mm (4.410 in.).

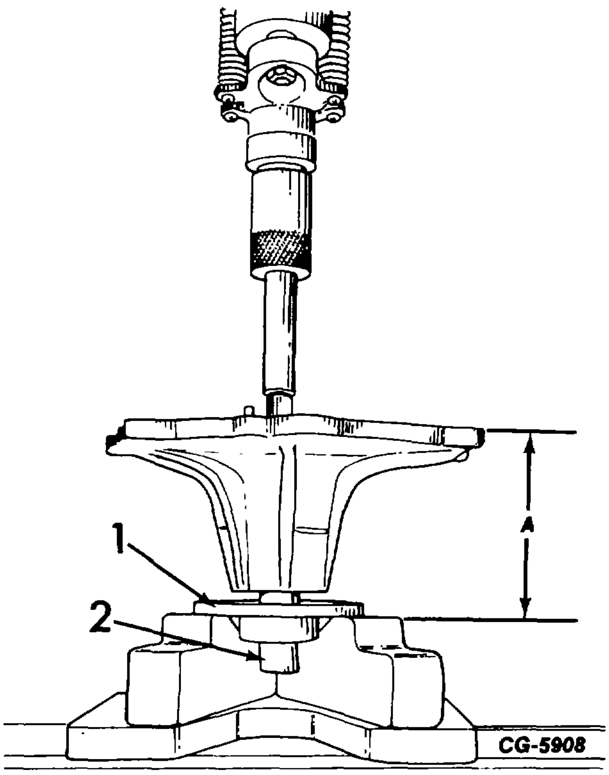

Figure 10. - Installing Fan Hub

A = 112.01 (4.410 in.)

1. Fan Hub
2. Shaft (Front end)

6. Install coolant seal in bearing housing (Fig. 11).

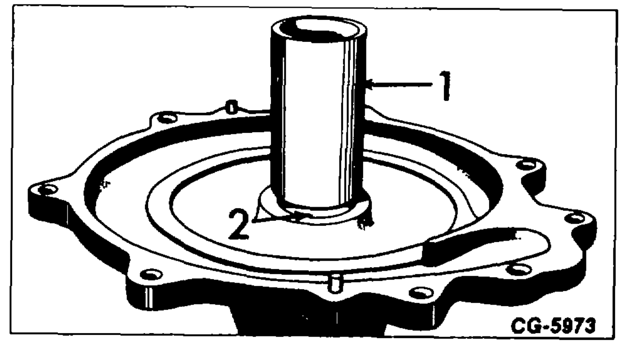

Figure 11. - Installing Seal into Bearing Housing

1. Sleeve
2. Seal

IMPORTANT: An "O" ring is necessary on coolant seal used with new style bearing housing which has a groove provided (Fig. 12). With old style bearing housing, which has no groove, an "O" ring MUST NOT be used on the coolant seal. Instead apply Permatex #3 to seal O.D. before installing (Fig. 13).

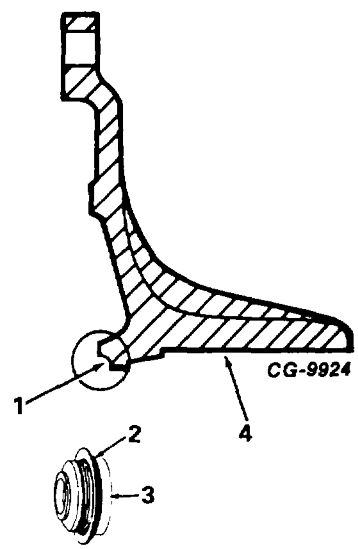

Figure 12. - New Style Bearing Housing with Groove and Coolant Seal with "O" Ring

1. Groove
2. "O" Ring
3. Coolant Seal
4. Bearing Housing

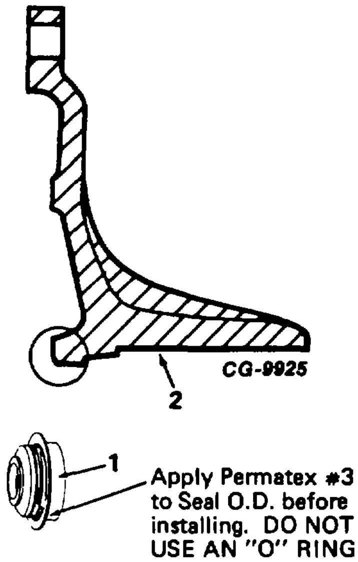

Figure 13. - Old Style Bearing Housing and Coolant Seal

1. Coolant Seal
2. Bearing Housing

7. To install coolant seal seat into impeller:

a. Moisten seal seat (6, Fig. 8) and cup O.D. with water before assembly.

b. By hand, press seal seat to bottom of impeller counter bore.

c. Support shaft at front end. Take up shaft end play toward rear by pushing down on the housing.

d. Press impeller (1, Fig. 8) onto shaft with shaft supported on front end as shown in Fig. 14. Prior to fully installing, place two 0.71 mm (0.028 in.) feeler gauges under the impeller as shown in Fig. 15.

e. IMPORTANT: Impeller to housing clearance 4 and 8 vane pumps:

0.25 - 1.17 mm
(0.010 - 0.046 in.)

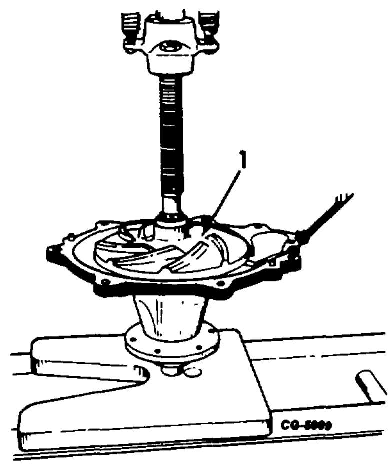

Figure 14. - Installing Impeller

1. Impeller

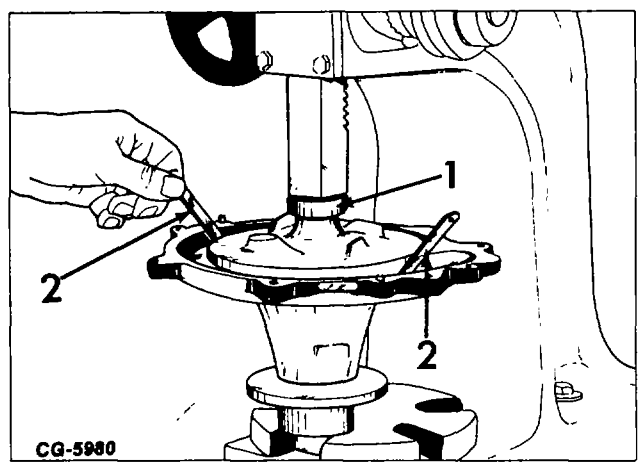

Figure 15. - Measuring Impeller to Housing Clearance

1. Sleeve
2. Feeler Gauge

Determine impeller to housing clearance as follows:

1. With feeler gauges in place press impeller until feeler gauges (2, Fig. 15) are snug.

2. Use a sleeve (1, Fig. 15) under press ram as shaft will protrude slightly from impeller.

8. Using a new gasket, secure water pump to crankcase front cover.

9. Install water pump pulley, fan and fan spacer, if one was used.

PROCEDURE FOR WATER PUMPS WITH A NUT RETAINED HUB:

DISASSEMBLY

Disassemble the Water Pump, with a Nut Retained Hub, as follows:

1. Pull off the impeller (1, Fig. 16) using the two 1/2 inch holes provided as shown.

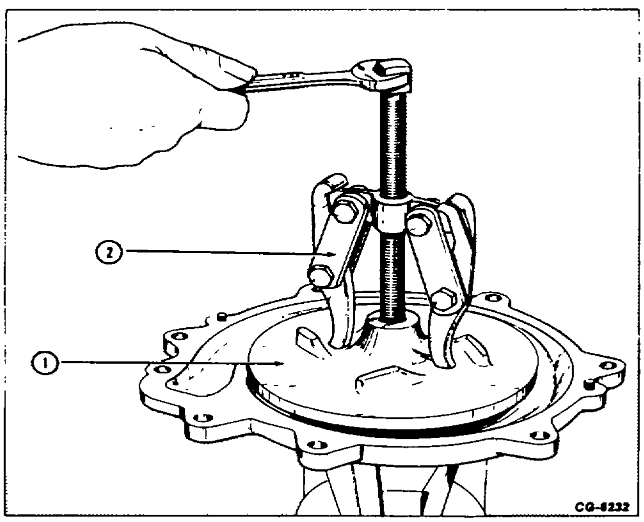

Figure 16. - Removing Impeller

1. Impeller
2. Puller

NOTE: If the impeller is equipped with 1/4 inch holes, enlarge them to 1/2 inch to accept a small puller (2, Fig. 16).

2. Pry out the ceramic seat and boot (1, Fig. 17) from the impeller and discard it, along with the water pump seal (2) as shown.

NOTE: The metal part of the seal will remain in the housing until later.

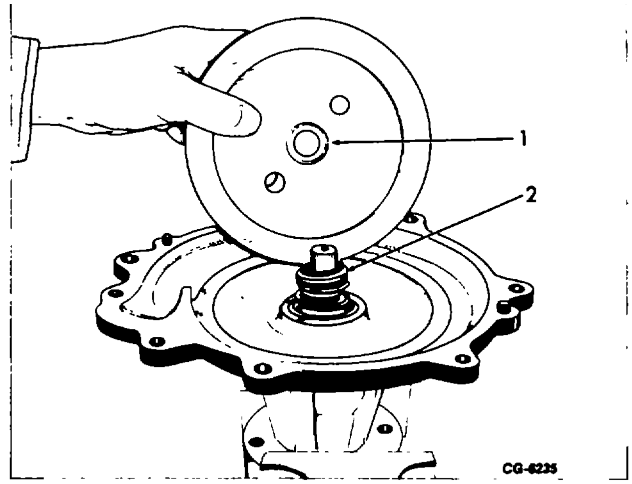

Figure 17. - Water Pump Seal

1. Seat and boot
2. **Seal**

3. Remove the hub nut (1, Fig. 18) hub (2), and key (3) (if equipped), as shown in the sectional view of the water pump.

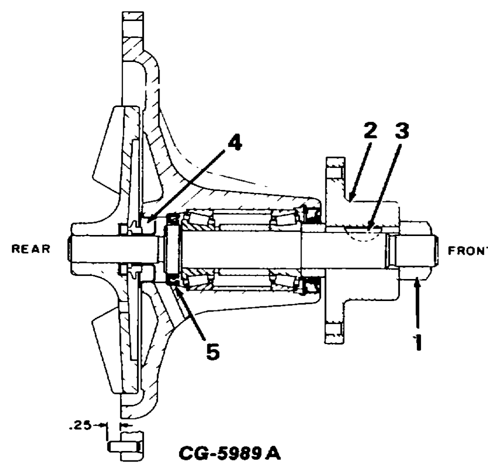

Figure 18. - Water Pump Cross Section (Nut Retained Hub)

1. Hub nut
2. Pulley hub
3. Woodruff key
   early model only
4. Water pump seal
5. Rear bearing seal

4. Remove the spacer/wear sleeve (2, Fig. 19), then discard the front bearing grease seal (1) as shown.

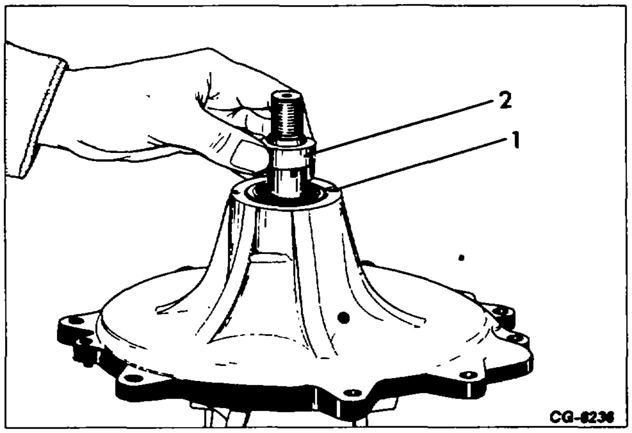

Figure 19. - Front Grease Seal and Wear Sleeve Removal

1. Front bearing grease seal
2. Spacer/wear sleeve

5. Remove the retainer ring (1, Fig. 20) using a ring expander (2) as shown.

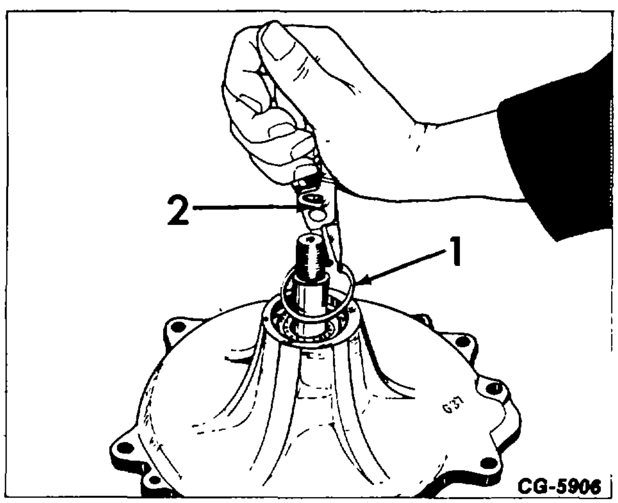

Figure 20. - Retaining Ring Removal

1. Retaining ring
2. Ring expander tool

6. Press out the shaft from the rear of the housing, as shown in Fig. 21. The bearings and spacers will come out with the shaft (1, Fig. 21). Press bearings from shaft.

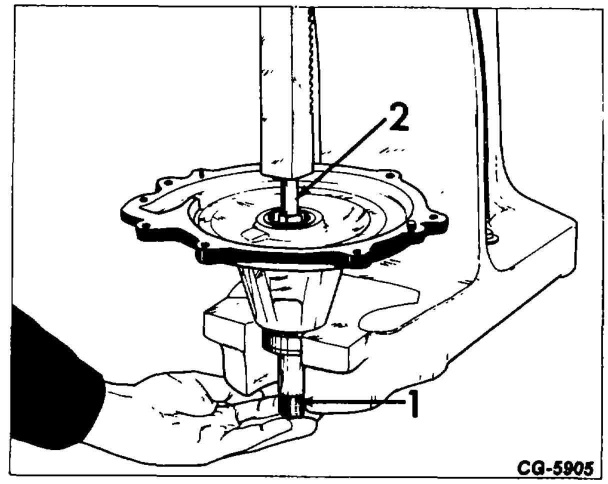

Figure 21. - Press Out Shaft and Bearings

1. Bearings, spacers and shaft
2. Steel rod

7. Drive out the metal part of the water pump seal (4, Fig. 18) from the front of the housing, and rear bearing grease seal (5) from the rear. Discard both parts.

CLEANING, INSPECTION AND REPAIR

CLEANING

Clean the Water Pump as follows:

1. Wash all parts thoroughly in a good solvent.
2. Dry with compressed air.

INSPECTION AND REPAIR

Inspect and Repair the Water Pump as follows: (Refer to Fig. 22)

1. After cleaning visually inspect the shaft wear sleeve and bearing spacer for wear and corrosion. Replace if necessary.
2. Visually inspect the bearing housing (2) for wear or damage. Replace if necessary.

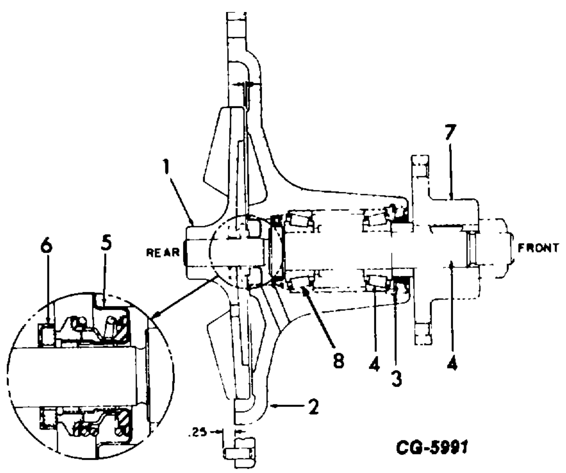

Figure 22. - Water Pump Cross Section (Nut Retained Hub)

1. Impeller
2. Bearing housing
3. Retaining ring
4. Shaft
5. Water pump seal
6. Seal seat and bushing assembly
7. Hub
8. Bearing assembly

3. Inspect the impeller vanes (1) for erosion, remove any nicks, burrs, or roughness especially from around the edges. Replace if necessary.
4. When servicing the water pump, ALWAYS replace the water pump seal (5) and seal seat and bushing assembly (6).

REASSEMBLY AND INSTALLATION

IMPORTANT: A new high temperature grease is now used in production, service and ReNEWed water pump assemblies with a nut retained hub. The new grease (specification EMS B27-5004, Type 1) must be used when reassembling these water pumps. The grease specification EMS B27-5004 is met by Amoco's Reckon Premium Grease No. 2 Color Red and may be obtained locally. If a local distributor cannot be found, contact:

Amoco Oil Company
200 E. Randolph Drive
Chicago, IL 60601
Phone: (312) 856-5111

IMPORTANT: Seals and bearings must be replaced. Reassemble and Install the Water Pump with Nut Retained Hub as follows: (Refer to Fig. 23)

1. Apply a coat of Aviation Permatex #3 to rear bearing seal bore. See DETAIL "A" Fig. 23.
2. Pack new rear seal (5, Fig. 23) cavity full of grease*, lubricate seal lip with grease*. Press new rear seal into housing so open end of seal faces towards bearing.
3. Prepack rear roller bearing inner race assembly (6) with grease*. Support shaft (11) at impeller end and press inner race assembly to bottom on shoulder of shaft.

*Lubricating Grease per EMS B27-5004, Type I - Use Amoco Rykon Premium Grease No. 2 Color Red.

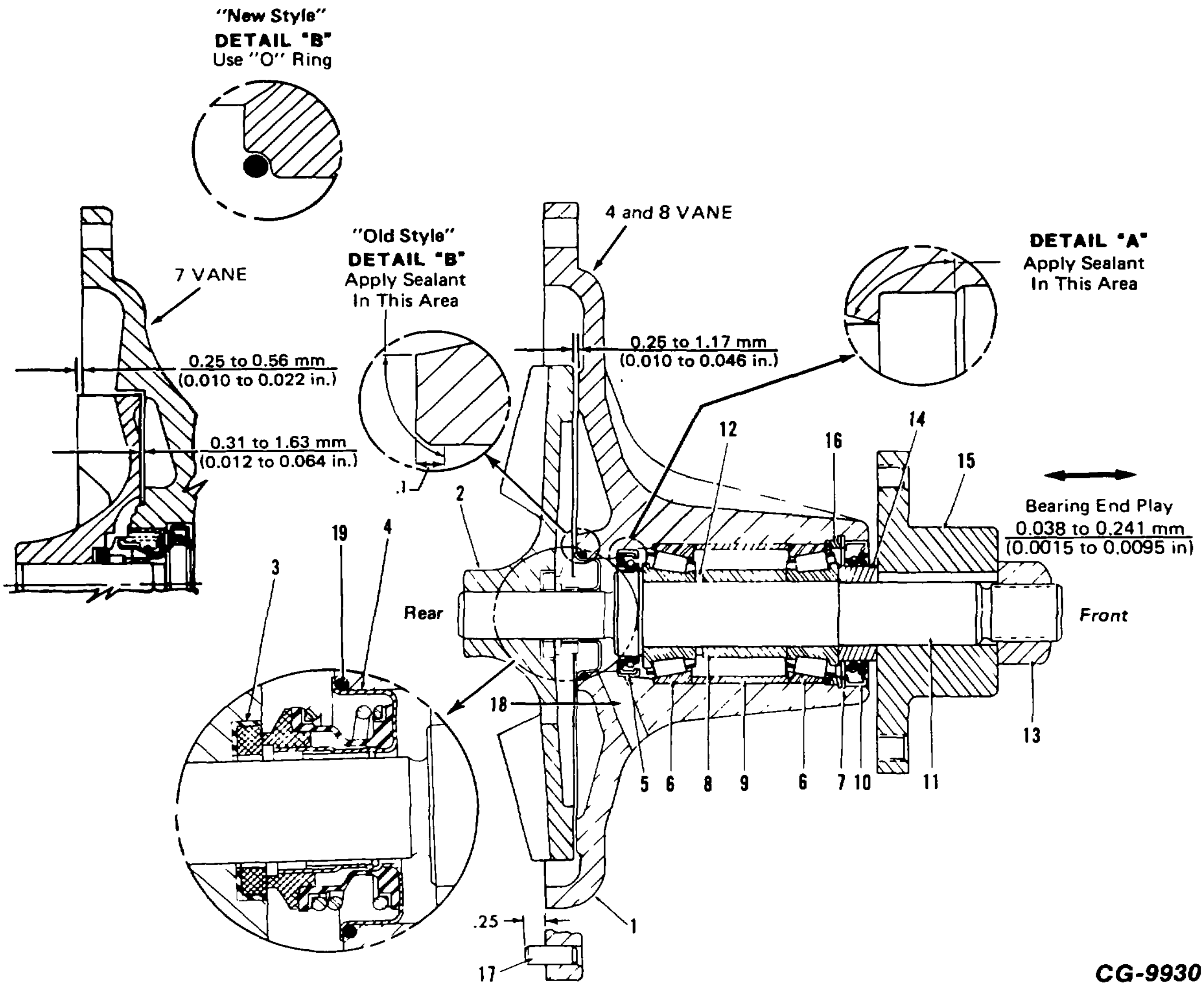

Figure 23. - Cross Section of Water Pump

1. Bearing housing
2. Impeller
3. Water pump seal seat
4. Water pump seal
5. Rear bearing seal
6. Bearing assembly
7. Retaining ring
8. Inner bearing spacer
9. Outer bearing spacer
10. Front bearing seal
11. Water pump shaft
12. Spacer (part of item 6)
13. Nut flange type lock 3/4-16
14. Wear sleeve
15. Water pump pulley hub
16. Retaining ring spacer
17. Dowel pin
18. Inspection port
19. "O" Ring, if groove is provided

4. Lightly lubricate seal surface of shaft and O.D. of shaft installation sleeve with grease* and install shaft into front of pump with installation sleeve (Fig. A).

IMPORTANT: The shaft installation sleeve (Fig. A) can be used with both old and new style water pump shafts but MUST DEFINATELY be used with the new style shaft (Fig. A). Installing the new style water pump shaft ,without the shaft installation sleeve could cause rear seal damage and/or displacement. The shaft installation sleeve can be fabricated locally.

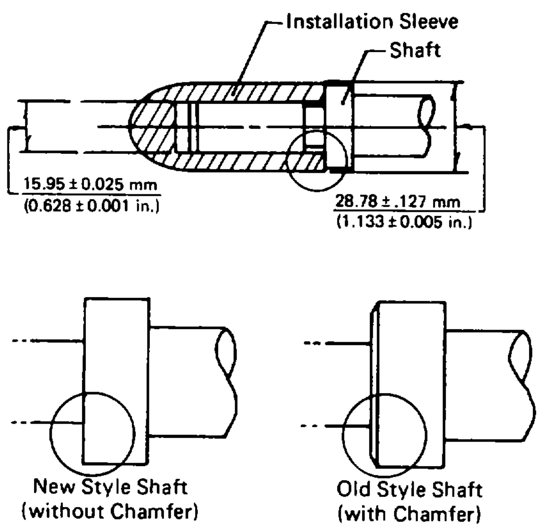

Figure A. Shaft Installation Sleeve and Old vs. New Style Water Pump Shaft

5. Remove shaft installation sleeve.

6. Grease* rear roller bearing outer race and press into housing against shoulder.

7. Install spacer (9).

8. Press in outer race of front bearing and make sure the outer bearing races and spacers are bottomed.

*Lubricating Grease per EMS B27-5004, Type I - Use Amoco Rykon Premium Grease No. 2 Color Red.

9. Install spacers (8 and 12).

10. Fill cavity between spacers with 17cc (.6 oz.) of grease*.

11. Prepack front roller bearing inner race assembly with grease*. Support shaft at impeller end and press inner race assembly until it bottoms on shaft.

12. Install spacer (16) and snap ring (7).

13. Pack spring area of front seal (10) full of grease* and lubricate seal lip with grease*. Install front seal into housing against snap ring.

14. Lightly lubricate seal surface of wear sleeve (14). Install wear sleeve.

15. Install hub (15) on shaft.

16. Install nut (13) according to the following:

    a. If a flange nut is used apply engine oil to threads. Torque to 237 N•m (175 lbf-ft).

    b. If a regular nut is used add Loctite #242 to threads. Torque to 203 N•m (150 lbf-ft).

    Torque shaft by internal hex while holding nut.

17. Install coolant seal (4) in bearing housing.

IMPORTANT: An "O" ring is necessary on coolant seal used with new style bearing housing which has a groove provided (Fig. 23a). With old style bearing housing which has no groove an "O" ring MUST NOT be used on the coolant seal. Instead apply Permatex #3 to seal O.D. before installing (Fig. 23b).

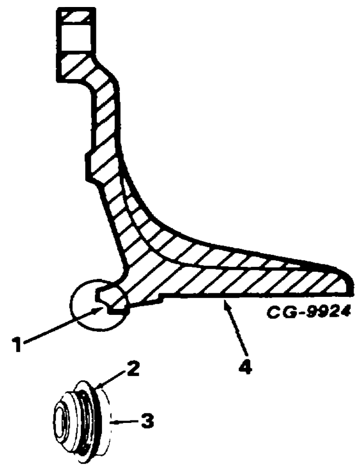

Figure 23a. - New Style Bearing Housing with Groove and Coolant Seal with "O" Ring

1. Groove
2. "O" Ring
3. Coolant Seal
4. Bearing Housing

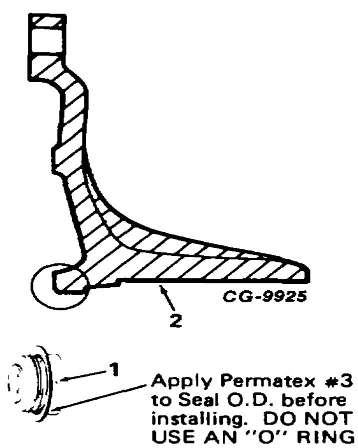

Figure 23b. - Old Style Bearing Housing and Coolant Seal

1. Coolant 2. Bearing Housing

18. To install coolant seal seat into impeller:

    a. Moisten seal seat (3) and cup O.D. with water before assembly.

    b. By hand, press seal seat to bottom of impeller counter bore.

    c. Support shaft at front end. Take up shaft end play toward rear by pushing down on the housing.

    d. Press impeller (2) onto shaft with shaft supported on front end as shown in Fig. 24. Prior to full installing, place two 0.71 mm (0.028 in.) feeler gauges under the impeller as shown in Fig. 25 (for 4 and 8 vane pumps).

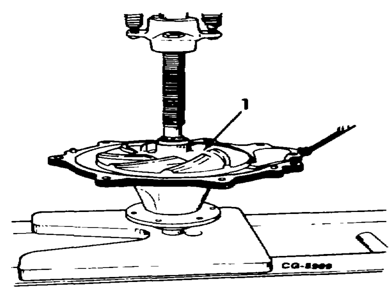

Figure 24. - Installing Impeller

1. Impeller

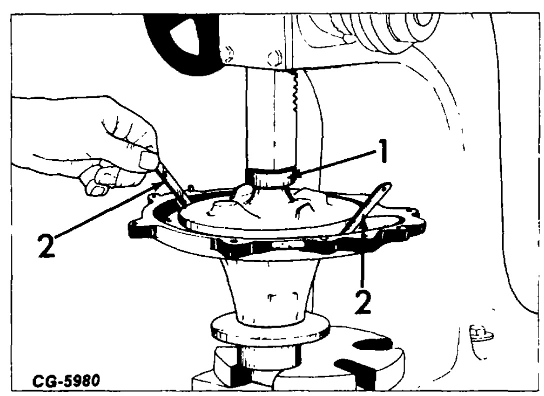

Figure 25. - Measuring Impeller to Housing Clearance

1. Sleeve
2. Feeler Gauge

e. IMPORTANT: Impeller to housing clearance 4 and 8 vane pumps:

0.25 - 1.17 mm
(0.010 - 0.046 in.)

7. Vane Pumps: 0.31 - 1.63 mm
(0.012 - 0.064 in)

Determine impeller to housing clearance as follows:

1. With feeler gauges in place press impeller until feeler gauges (2, Fig. 25) are snug.

2. Use a sleeve (1, Fig. 25) under press ram as shaft will protrude slightly from impeller.

NOTE: Use an appropriate size feeler gauge (0.97 mm [0.038 in.]) for the 7 vane pump.

19. Using a new gasket, secure water pump to crankcase front cover.

20. Install water pump pulley, fan and spacer, if one was used.

THERMOSTAT

The thermostat is used to control the temperature of the engine coolant. It is located in a housing attached to the cylinder head. The housing is arranged to return the coolant to the radiator or to by-pass it depending on the coolant temperature.

When the coolant is more than 82°C (180°F), the thermostat is actuated, becoming fully open at 94° (202°F). During this time, the coolant is directed by the thermostat, in the thermostat housing, to flow to the top water tank of the radiator for air cooling. Coolant in the engine is replaced with coolant from the radiator bottom tank to the water pump.

REMOVAL

Remove the Thermostat as follows:

1. Disconnect the hose.

2. Remove the bolts and lock washers, then remove the thermostat housing.

3. Remove the thermostat housing gasket and discard.

CLEANING, INSPECTION AND REPAIR

CLEANING

Clean the Thermostat Housing as follows:

1. Wash the housing in solvent.

2. Dry with compressed air.

INSPECTION AND REPAIR

Inspect and Repair the Thermostat as follows:

1. Inspect for accuracy as follows:

   a. Suspend the thermostat in a container of water. DO NOT allow the thermostat to touch the sides or bottom of the container.

   b. Heat the container.

   c. Measure the water temperature with a thermometer suspended in container.

   d. If the thermostat opening temperature is 6°C (10°F) above or below the 82°C to 94°C (180°F to 202°F) rating, replace the thermometer.

2. Visually inspect the housing for cracks and burrs. Replace if necessary.

3. Inspect the housing seal for brittleness, cracks or wear. Replace if necessary.

REASSEMBLY AND INSTALLATION

Reassemble and Install the Thermostat as follows:

1. Install thermostat in housing.
2. Place a new thermostat housing gasket onto housing.
3. Attach thermostat housing to cylinder head with two bolts and lock washers. Connect the hose.

IDLER PULLEYS

NOTE: For Fleetstar (2050) and Cargostar Motor Truck Applications equipped with DTI-466 or DT/DTI-466B & C engines a new air compressor Idler Pulley Assembly (Figure 26) has replaced the old style assembly (Figure 27) in production and service.

The new style features an idler pulley bearing shaft that is mounted by a press fit into the idler pulley support bracket.

New Style Idler Pulley is Effective on:

DT-466B & C - S/N 82896 & up
DTI-466B & C - S/N 83066 & up

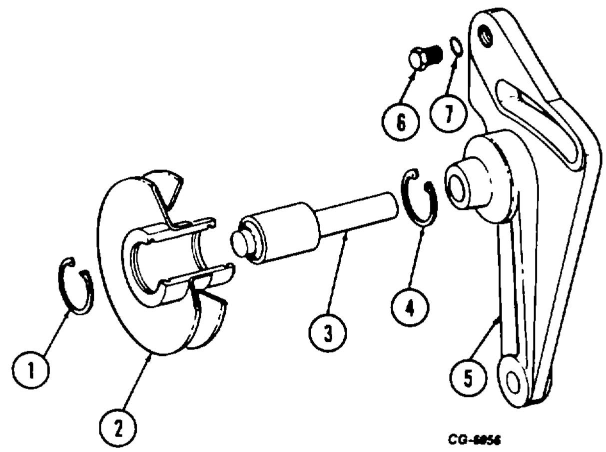

Figure 26. - New Style

1. Ring, front retaining
2. Pulley, air compressor idler
3. Bearing (with shaft), idler
4. Ring, rear retaining
5. Bracket, idler support
6. Bolt, 1/2 - 13 x 3/4
7. Washer, 1/2 hardened

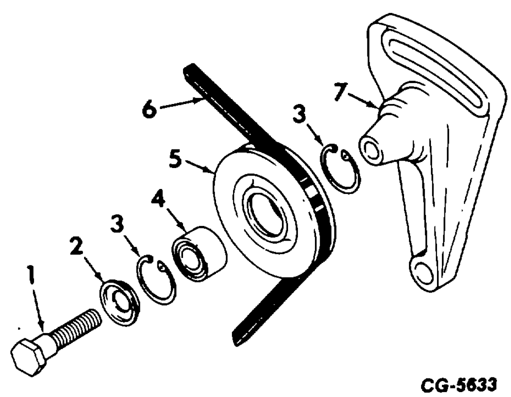

Figure 27. - Displaced Style

1. Shaft, idler pulley
2. Shield, bearing
3. Ring, retaining
4. Bearing, idler
5. Pulley, air compressor idler
6. Bracket, idler support
7. Jam nut

REMOVAL

Remove the Fan Idler Pulley as follows:

1. Loosen belt tension and remove belts.

2. Remove idler pulley assembly from the engine.

NOTE: This procedure applies to all fan idler pulleys regardless of the bearing type.

Remove the Air Compressor Idler Pulley as follows:

1. Loosen the belt tension and remove the belt.

2. Remove the idler pulley assembly from the engine.

PROCEDURE FOR FAN IDLER PULLEY WITH FRONT AND REAR ROLLER BEARING:

DISASSEMBLY

Disassemble the Fan Idler Pulley with Front and Rear Roller Bearing as follows:

1. Remove screws (1, Fig. 28), cover (2) and gasket (3).

2. Hold the shaft (4) securely and remove nut (5) and washer (6).

3. Lift the pulley with bearing cups (7 and 8), spacer (9) and oil seal (10) off the shaft. The outer bearing cone (11) will come off with the pulley.

4. Remove the inner bearing cone (11) and spacer (12) from the shaft as shown.

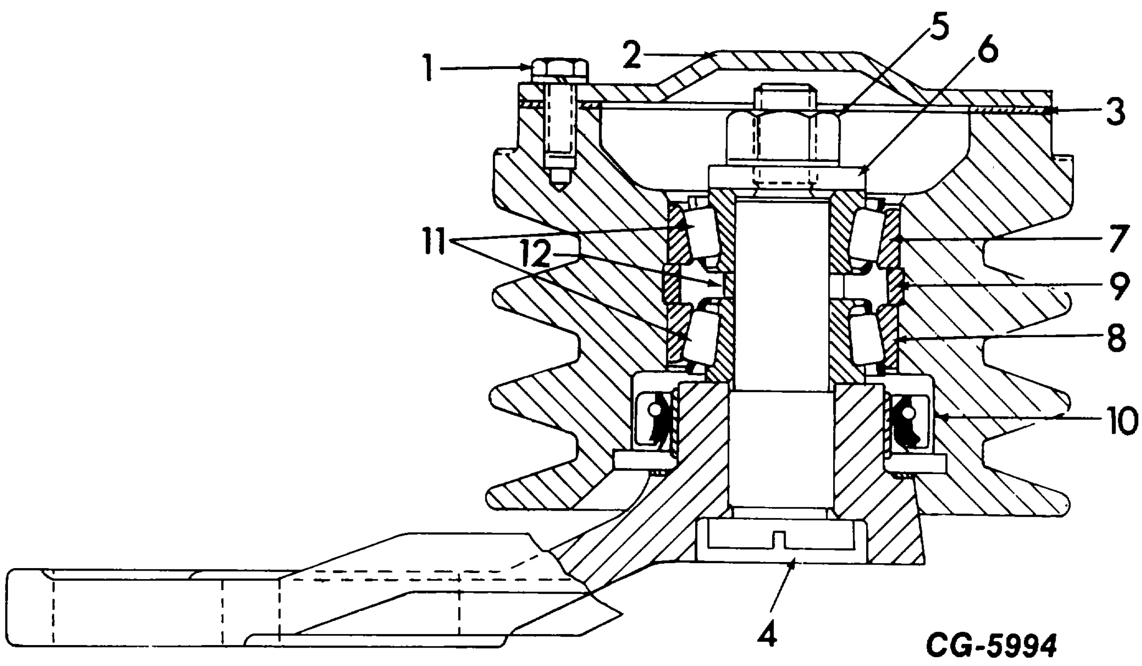

Figure 28. - Fan Idler Pulley Assembly (If Applicable)

1. Screw	4. Shaft	7. Bearing cup	10. Oil seal
2. Cover	5. Nut	8. Bearing cup	11. Bearing cone
3. Gasket	6. Washer	9. Spacer	12. Spacer

CLEANING, INSPECTION AND REPAIR

CLEANING

Clean the Fan Idler Pulleys as follows:

1. Wash all parts in cleaning solvent to remove all grease.
2. Dry with compressed air.
3. DO NOT spin bearing cones with compressed air.

INSPECTION AND REPAIR

Inspect and Repair the Fan Idler Pulley with Front and Rear Roller Bearing as follows: (Fig. 29)

1. Visually inspect the bearing cones (1, Fig. 29) for binding, roughness, overheating or other damage. If the cones require replacement it is necessary to also replace the bearing cups (2 and 3) and spacers (4 and 5).
2. Visually inspect the bearing cups (2 and 3) inside of the pulley hub for roughness, overheating or other physical damage. If the cups require replacement, replace the cones (1) and spacers (4 and 5) also.
3. Using a slide hammer with proper expander, remove bearing cups from pulley hub. Remove spacer (4) from groove in pulley hub. Check bearing bore of hub for wear or damage. Replace hub if necessary.
4. Check pulley shaft (6) for cracks or thread damage. If necessary to replace, cut it out of the bracket (8). DO NOT damage the bracket.

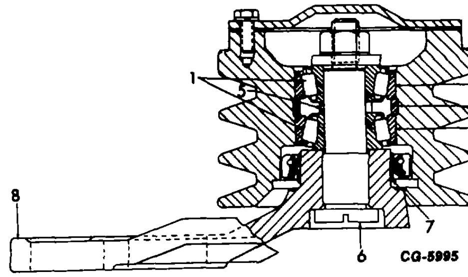

Figure 29. - Fan Idler Pulley Assembly

1. Bearing cone
2. Bearing cup
3. Bearing cup
4. Spacer
5. Spacer
6. Pulley shaft
7. Wear sleeve
8. Bracket

REASSEMBLY AND INSTALLATION

Reassemble and Install the Fan Idler Pulley (with Front and Rear Roller Bearing) as follows:

1. Press shaft (11, Fig. 30) into bracket (12) until head bottoms in bracket counterbore.
2. Install spacer (7) in the groove of pulley hub.
3. Press front bearing cup (6) into pulley bore until it bottoms on spacer (7).
4. While supporting the pulley by the front bearing cup, press rear bearing cup (8) into pulley bore until it bottoms on spacer (7).
5. Install oil seal (9) (with lip facing out) flush with pulley bore.
6. Prepack area between seal (9) and bearing cup (8) with I.H. 251H-EP grease.

7. Wipe wear sleeve (10) with grease.

8. Prepack rear bearing cone (14) with I.H. 251H-EP grease and install onto shaft (11).

9. Install spacer (15) onto shaft.

10. Install pulley (13) onto the shaft. Be careful not to damage oil seal (9).

11. Prepack front bearing cone (14) and install onto shaft.

12. Install washer (4) and nut (3). Torque nut to 102 N•m (75 lbf-ft) while holding the shaft securely.

13. Fill the cavity of the pulley with I.H. 251H-EP grease.

14. Using a new gasket (5), install and secure cover (2).

15. Install assembly on the engine. Refer to the Operator's Manual for belt adjusting procedures.

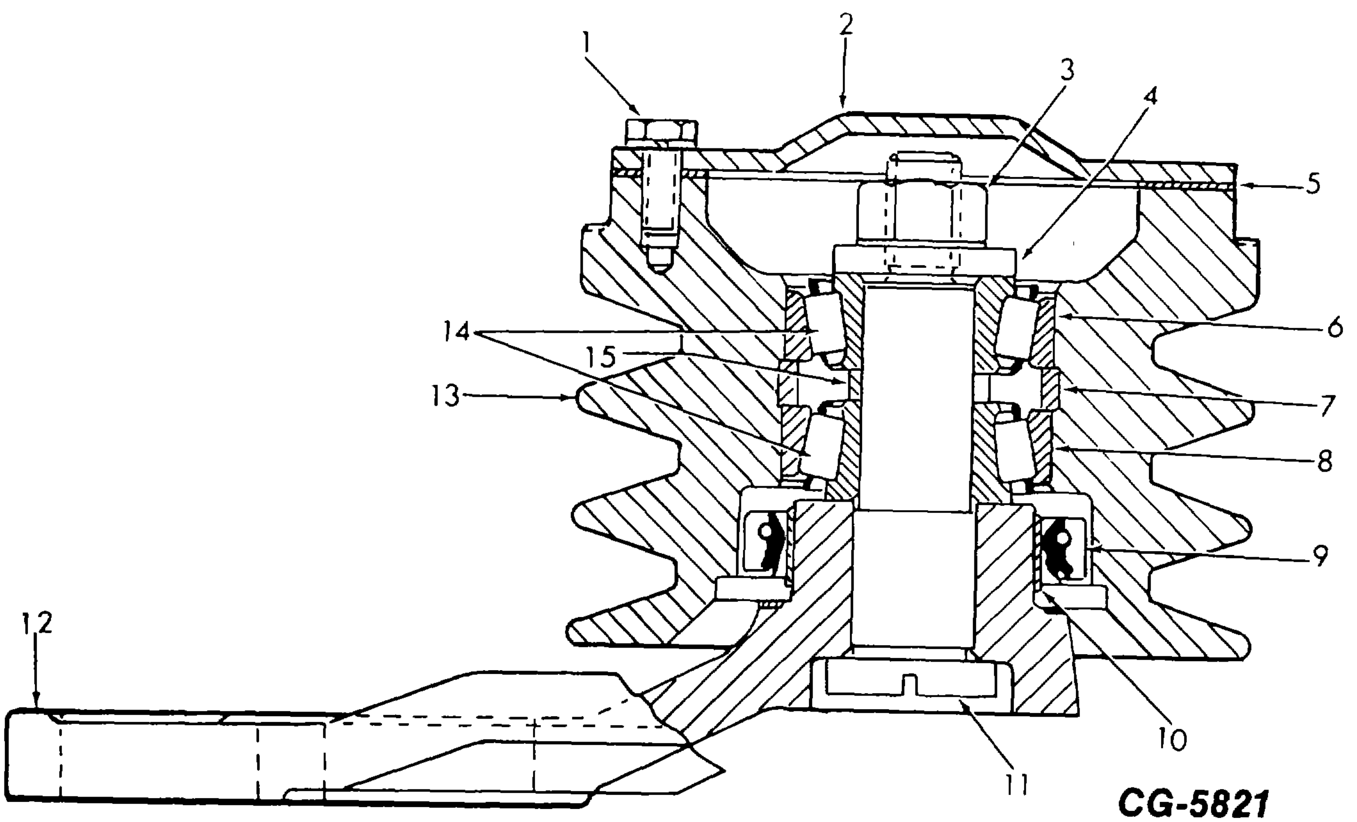

Figure 30. - Idler Pulley Assembly

1. Screw
2. Cover
3. Nut
4. Washer
5. Gasket
6. Bearing cup
7. Spacer
8. Bearing cup
9. Oil seal
10. Wear sleeve
11. Pulley shaft
12. Bracket
13. Pulley
14. Bearing cones
15. Spacer

PROCEDURE FOR FAN IDLER PULLEY WITH FRONT BALL BEARING AND REAR ROLLER BEARING:

DISASSEMBLY

Disassemble the Fan Idler Pulley with Front Ball Bearing and Rear Roller Bearing as follows:

1. Remove the plug (1, Fig. 31).
2. Remove the nut (2) and washer (3).
3. Using a suitable puller, remove the pulley (4).
4. With a snap ring pliers, remove the outer snap ring (5).

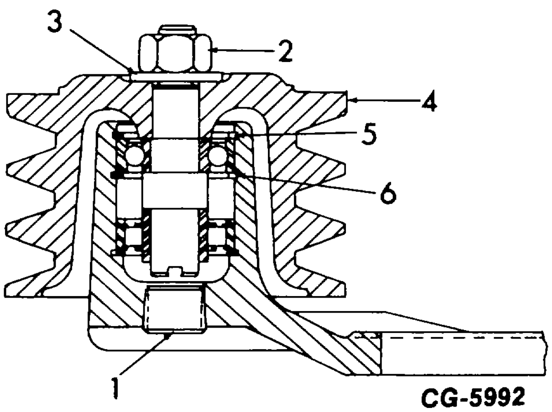

Figure 31. - Fan Idler Assembly with Front Ball Bearing and Rear Roller Bearing

1. Plug
2. Nut
3. Washer
4. Pulley
5. Snap ring (outer)
6. Snap ring (inner)

5. Tap out the shaft and ball bearing assembly from the rear of the bracket. Use a brass drift, as shown in Figure 32.
6. Remove ball bearing (1, Fig. 33) from the shaft (2) with a suitable puller (3) as shown.

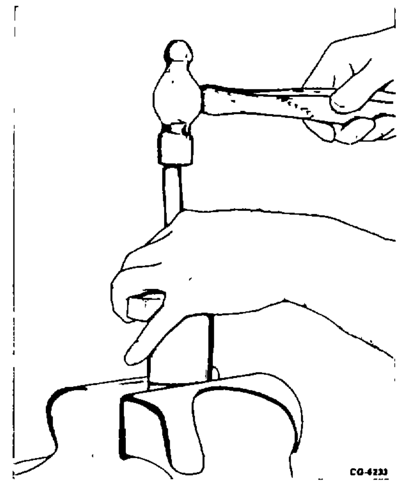

Figure 32. - Removing Shaft with Brass Drift

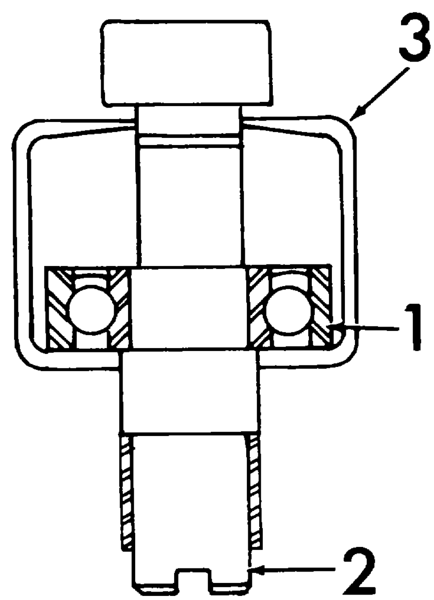

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Figure 33. - Removing Ball Bearings

1. Ball bearing
2. Shaft
3. Puller

NOTE: The inner race of the roller bearing cannot be removed from the shaft without damaging both parts. When replacement of either part is required, use a new roller bearing assembly and a new shaft.

7. Using a snap ring pliers, remove the inner snap ring (6, Fig. 31).

8. Remove the roller bearing (1, Fig. 34) from the bracket (2) with a suitable puller (3), as shown.

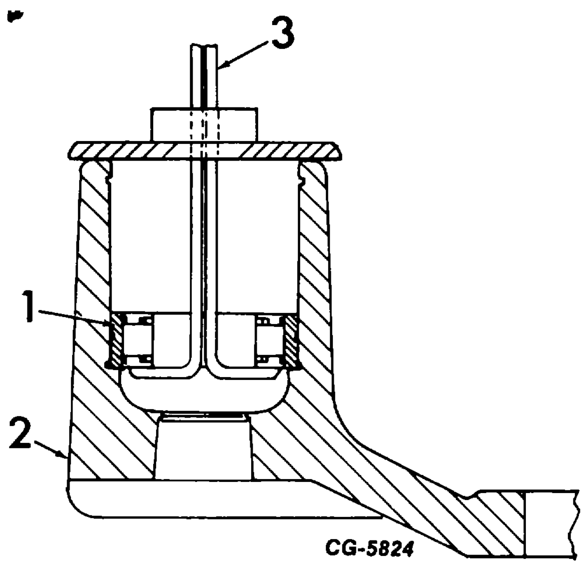

Figure 34. - Removing Roller Bearings

1. Roller bearing
2. Bracket
3. Puller

CLEANING, INSPECTION AND REPAIR

CLEANING

Clean the Fan Idler Pulleys as follows:

1. Wash all parts in cleaning solvent to remove all grease.

2. Dry with compressed air.

3. DO NOT spin bearing cones with compressed air.

INSPECTION AND REPAIR

Inspect and Repair the Fan Idler Pulley with Front Ball Bearing and Rear Roller Bearing as follows: (Fig. 35)

1. Visually inspect the ball bearing (1, Fig. 35) for roughness, overheating or damage to the seal (2).

2. Inspect the roller bearing (3) and replace as necessary.

3. Inspect the pulley shaft (4) for cracks or thread damage.

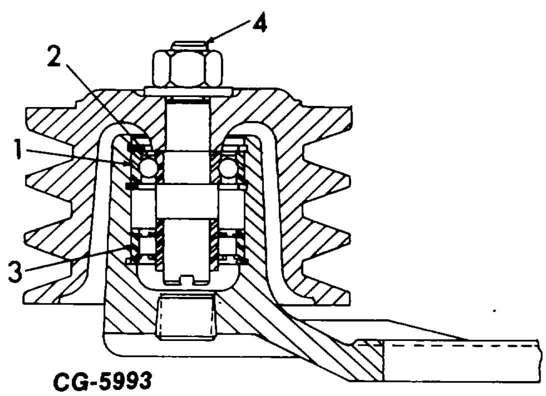

Figure 35. - Fan Idler Assembly

1. Ball bearing
2. Seal
3. Roller bearing
4. Shaft

REASSEMBLY AND INSTALLATION

Reassemble and Install the Fan Idler Pulley (with Front Ball Bearing and Rear Roller Bearing) as follows:

IMPORTANT: When rebuilding the fan idler bracket, it is necessary to use the Pilot Tool (PLT-561 or SE-4038) on the end of the idler pulley shaft when installing it in the idler bracket. Use of the tool will ensure accurate entry of the inner race into the roller bearing assembly, without damage on DT-466 engines.

Pilot tool is in effect starting on DT-466 with engine Serial Number 98453 and up.

1. To facilitate removal of the tool, the pipe plug hole (1, Fig. 36) in the idler bracket must be enlarged. Drill and tap hole with 57/64 drill to 3/4 inch NPT. Thoroughly clean reworked idler bracket to insure all machining chips are removed.

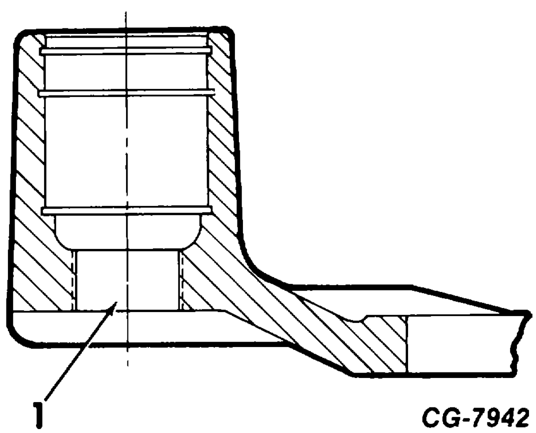

Figure 36. - Rework of Idler Bracket

1. Idler Bracket Hole

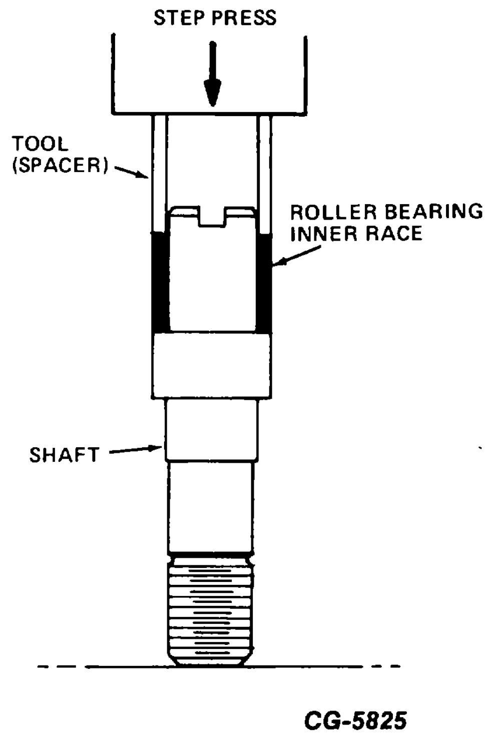

Figure 37. - Installing Inner Race

2. Press inner race of roller bearing onto the shaft until it is against the shoulder as shown in Figure 37.

3. Pack roller bearing rollers with 251 H-EP grease.

4. Supporting the base of the idler bracket, press roller bearing outer race and roller assembly into idler bracket until it bottoms against bracket as shown in Figure 38. APPLY FORCE TO OUTER RACE ONLY.

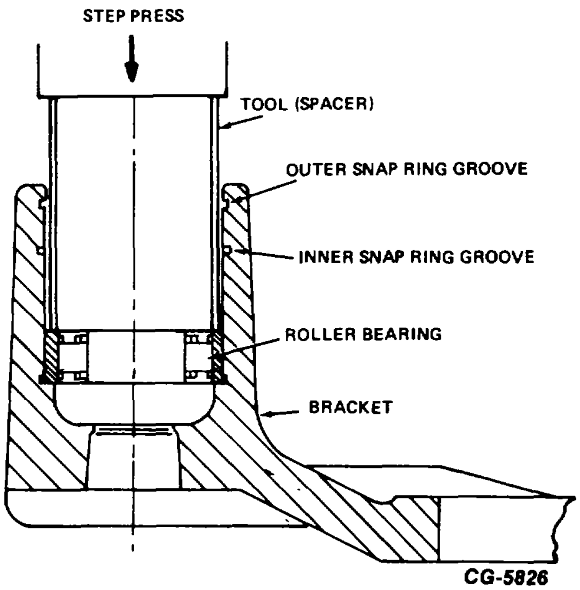

Figure 38. - Installing Roller Bearing

5. Install inner snap ring (10, Fig. 39).

6. Press bearing (8, Fig. 39) on shaft until it is against the shoulder as shown in Figure 40. Apply force to inner race only. When installing the bearing, be sure its seal faces the threaded end of the shaft.

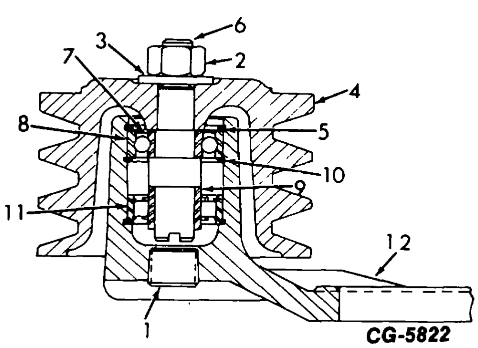

Figure 39. - Fan Idler Assembly with Front Ball Bearing and Rear Roller Bearing

1.	Plug	7.	Seal
2.	Nut	8.	Ball bearing
3.	Washer	9.	Inner race
4.	Pulley	10.	Retainer ring
5.	Retainer ring	11.	Roller bearing
6.	Shaft	12.	Bracket

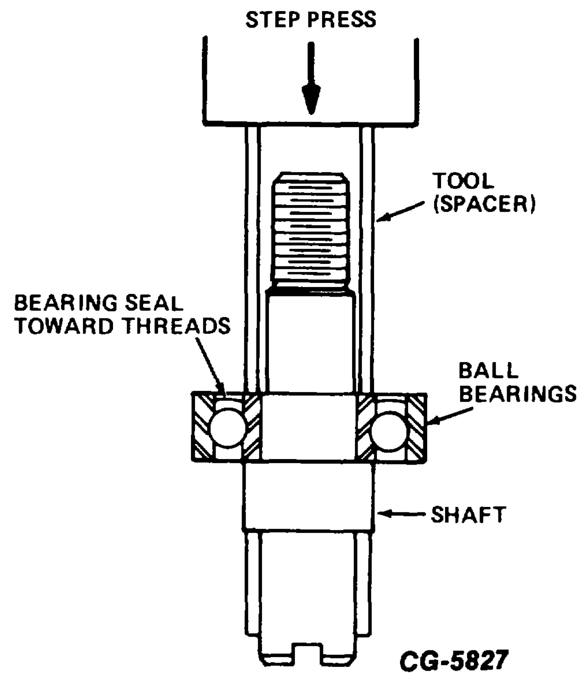

Figure 40. - Installing Ball Bearing

7. Apply 5 ± 1 grams (0.18 oz.) 251 H-EP grease on the shaft between ball bearing and roller bearing race as shown in Fig. 41. Place Tool (2, Fig. 41) on end of idler shaft (1) and press ball bearing with shaft into bracket until bearing is against inner snap ring.

NOTE: Insure damage free entry of inner race into roller bearing as follows:

1. Keep shaft assembly vertical when pressing in the bracket.
2. Make sure no grease is smeared off the shaft during assembly.
3. Apply force to outer race of ball bearing only.

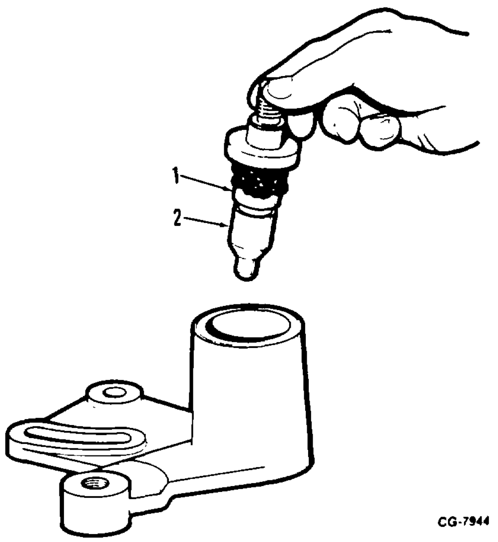

Figure 41. - Installing Shaft

1. Idler shaft
2. Pilot Tool (PLT-561 or SE-4038)

8. Install outer snap ring (5, Fig. 39).

9. Remove the nylon guide tool from end of shaft.

10. Support shaft through hole in bracket with a suitable rod or spacer as shown in

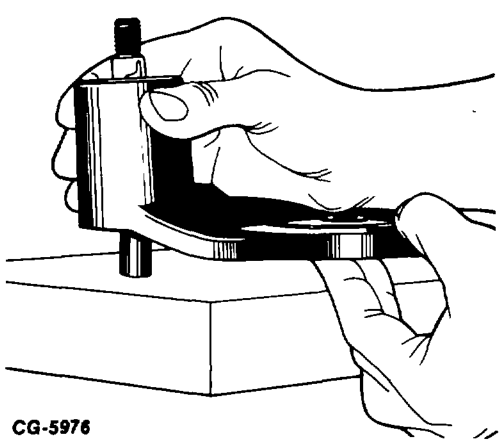

Figure 42. - Supporting Shaft

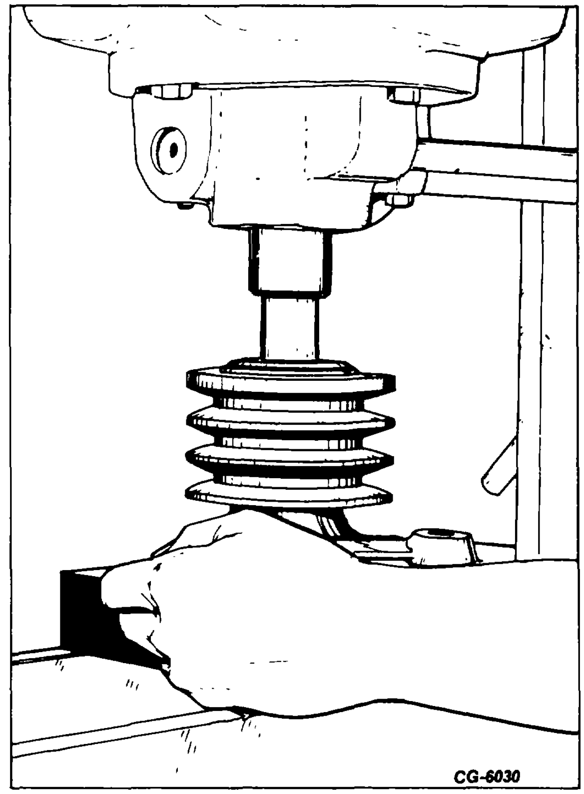

Figure 43. - Pressing on Pulley

11. Press pulley on shaft until it is bottomed against ball bearing as shown in Figure 43. DO NOT support idler bracket.

12. Install washer (3, Fig. 39) and nut (2).

13. Fabricate a tool from bar stock as specified in Figure 44.

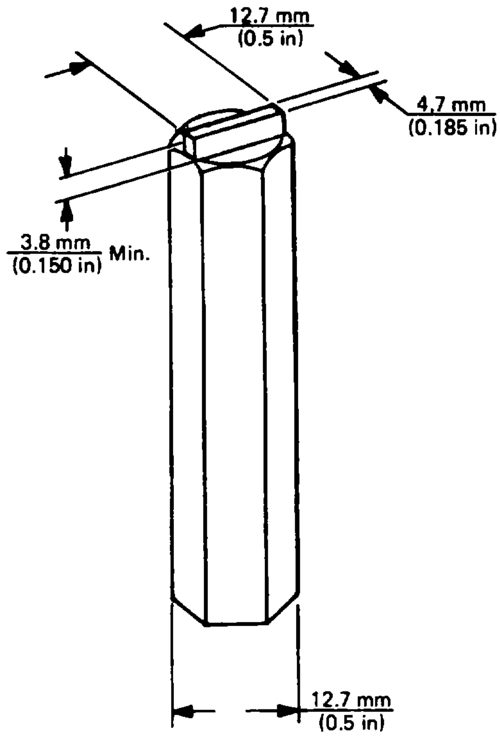

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Figure 44. - Tool Fabrication Dimensions for Holding Shaft

14. Apply 102 N•m (75 lbf-ft) torque to nut and shaft as shown in Figure 45.

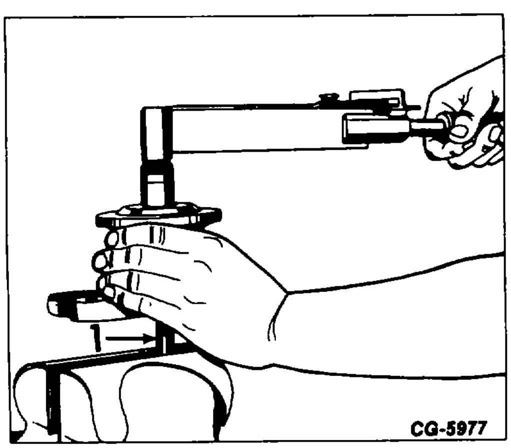


Figure 45. - Torquing Nut

1. Tool

15. Install plug (1, Fig. 39), into bracket.

16. Install idler onto engine.

17. Install belts. Refer to the Operator's Manual for belt adjusting procedures.

PROCEDURE FOR AIR COMPRESSOR IDLER PULLEY.

DISASSEMBLY

Disassemble the Air Compressor Idler Pulley (New Style) as follows: (See Fig. 46)

1. With suitable tool, press bearing (3, Fig. 46) out from idler bracket (5).

2. Remove front retaining ring (1) from pulley (2).

3. Remove rear retaining ring (4).

4. Press bearing (3) from pulley (2).

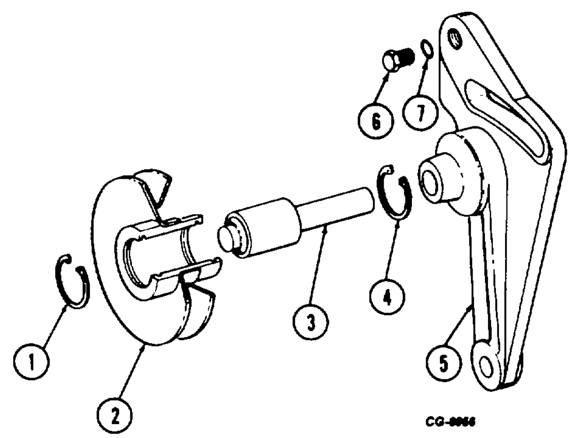


Figure 46. - New Style

1. Ring, front retaining
2. Pulley, air compressor idler
3. Bearing (with shaft), idler
4. Ring, rear retaining
5. Bracket, idler support
6. Bolt, 1/2 - 13 x 3/4
7. Washer, 1/2 hardened

Disassemble the Air Compressor Idler Pulley (displaced style) as follows: (See Fig. 47)

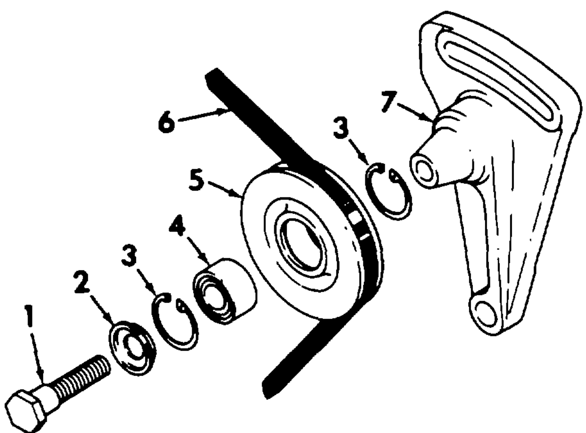
1. Hold shaft (1, Fig. 47) and remove jam nut (7).

2. Hold bracket (6) and remove the shaft (1).

NOTE: Shaft is threaded into bracket.

3. Remove the pulley (5) from the shaft (1). If the shaft is equipped with a dust seal, remove the seal and discard it.

4. Remove the two retaining rings (3) from the pulley (5) and the bearing (4).



CG-5633

Figure 47. - Displaced Style

1. Shaft, idler pulley
2. Shield, bearing
3. Ring, retaining
4. Bearing, idler
5. Pulley, air compressor idler
6. Bracket, idler support
7. Jam nut

CLEANING, INSPECTION AND REPAIR

CLEANING

Clean the Air Compressor Idler Pulley as follows:

1. Clean all parts in solvent.

2. Dry with compressed air.

INSPECTION AND REPAIR

Inspect and Repair the Air Compressor Idler Pulley as follows:

1. Visually inspect the bearing for binding, roughness, overheating or other damage. Replace as necessary.

2. Visually inspect the threads and bearing surface on the shaft for damage or wear. Replace if necessary.

3. Inspect the threads in the bracket for damage. (Displaced style).

REASSEMBLY AND INSTALLATION

Reassemble and Install the Air Compressor Idler Pulley (New Style) as follows:

1. Install front ring (2, Fig. 48) into ring groove at large end of pulley hub (3).
2. Apply engine oil to the O. D. of the bearing race. Support the pulley (3) at the large diameter of the hub and, pressing only on the outer race of the bearing (1), press the stub end of the bearing into the hub until the bearing bottoms against the retaining ring.
3. Install the rear retaining ring (4) into the ring groove at the chamferred end of the pulley hub (3).
4. Apply engine lubricating oil to the bearing shaft (5) and, pressing only on the front (stub end) of the shaft, press the shaft into the bracket (6) until the shaft (5) is flush with the rear finish of the bracket (6).
5. Apply Loctite No. 271 thread lock to bolt and torque to 81 N•m (60 ft-lbs.)

NOTE: Bolt (6, Fig. 46) is used to apply leverage to idler pulley assembly when tightening belts.

6. Install assembly on engine.
7. Refer to Operator's Manual for belt adjusting procedure.

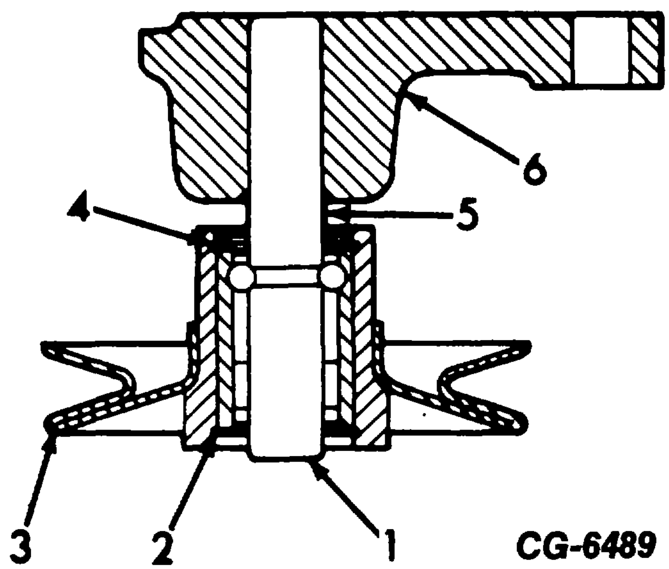


Figure 48. - Air Compressor Idler Pulley (New Style)

1. Bearing, idler
2. Ring, front retaining
3. Pulley, air compressor idler
4. Ring, rear retaining ring
5. Shaft, bearing
6. Bracket, idler support

Reassemble and Install the Air Compressor Idler Pulley (Displaced style) as follows:

1. Install bearing (5, Fig. 49) into pulley (6) and secure it with retaining rings (4).

2. Install shaft (1) through bearing (5) into bracket (3). Tighten shaft to 54 N•m (4 lbf-ft) torque.

NOTE: The dust seal is no longer required and should not be re-used.

3. Install nut (2) on shaft (1) and torque to 108 N•m (80 lbf-ft) while holding shaft.

4. Retorque shaft (1) to 54 N•m (40 lbf-ft) while holding nut.

5. Install assembly on engine. Refer to the Operation, Maintenance and Diagnostic Manual, 1 085 843 R1, for belt tension requirements.

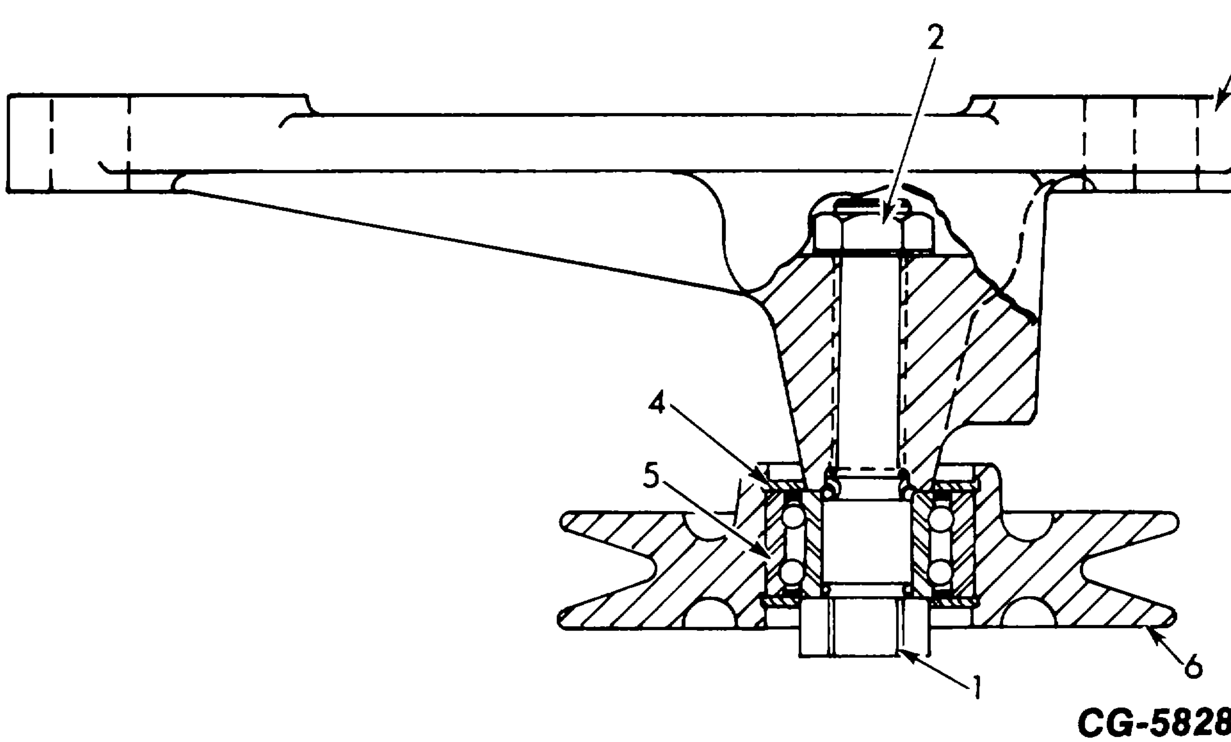


Figure 49. - Air Compressor Idler Pulley (Displaced Style)

1. Shaft
2. Nut
3. Bracket
4. Retainer ring
5. Bearing
6. Pulley

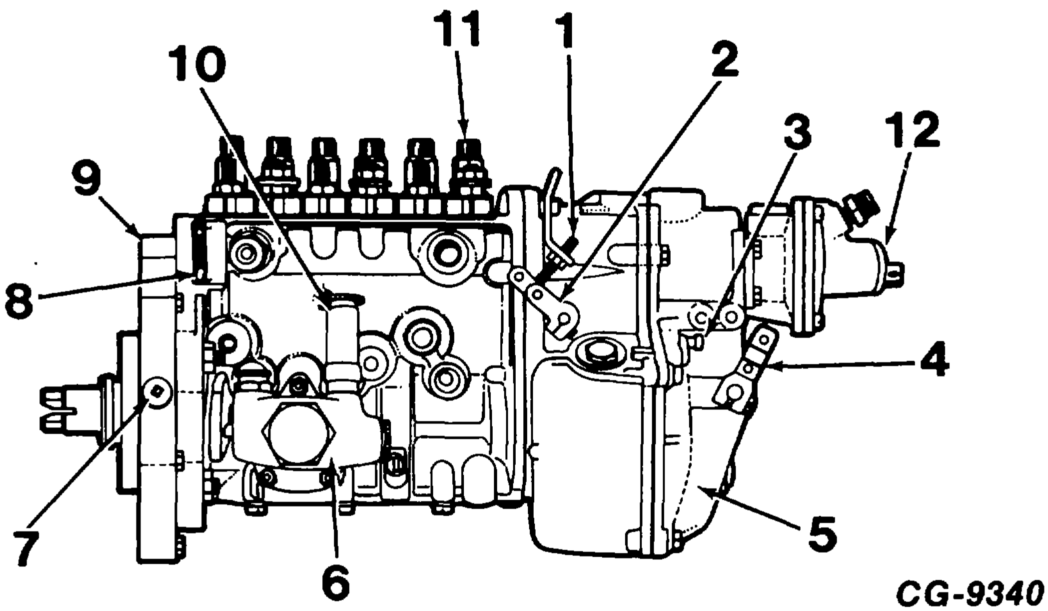


Figure 1 - Robert Bosch Model MW Fuel Injection Pump

1. Shut-off Stop Screw
2. Shut-off Lever
3. High Idle Stop
4. Throttle Lever
5. RQV Governor Housing
6. Fuel Supply Pump
7. Timing Pointer Plug
8. Serial Number Plate
9. Mounting Adapter
10. Hand Priming Pump
11. Plunger
12. Aneroid

GENERAL PUMP INFO

Engines with serial numbers below 400 000 use the UTDS* Model 100 pump, with the exception of DT-466B, TD 15C Paydozers and DT-466B, 175C Payloader which use the Robert Bosch MW Pump.

Engines with serial numbers above 400 000 (all DT-466 "C" series) use the Robert Bosch Model MW Pump.

OPERATION ROBERT BOSCH MODEL MW PUMP

PUMP FEATURES

The Robert Bosch Model MW injection pump is a multiple plunger design with one plunger, barrel and delivery valve for each engine cylinder. A variable speed governor allows engine speeds to be controlled within specified limits for power takeoff applications.

Depending upon engine application or customer preference, the pump is equipped with an electrical or mechanical fuel shutoff. Each pump has a hand priming pump to fill filters after replacement of fuel. Exhaust smoke levels during engine acceleration are controlled by an aneroid assembly.

The pump consists of the following major components which will be reviewed, first briefly then in more detail to assist the reader in understanding construction features and pump operation: (Figure 2)

Mounting Adapter
MW Injection Pump
Supply Pump with Hand Priming Pump
RQV Governor
Aneroid Assembly
Fuel Return Valve

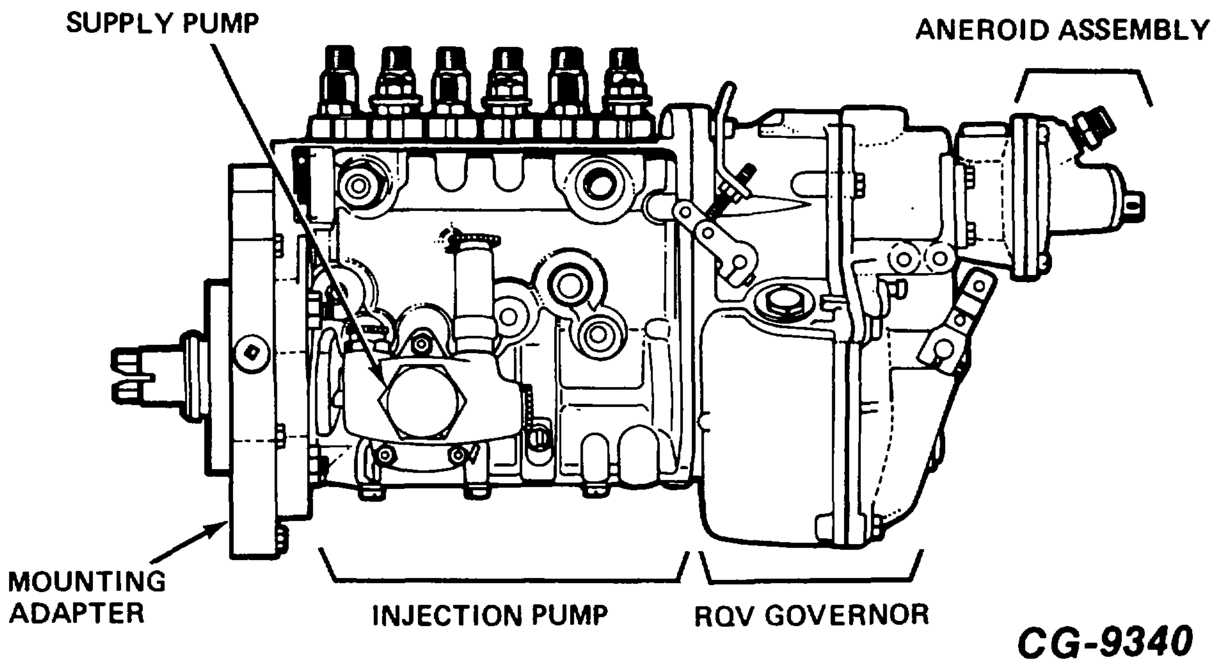


Figure 2. - Pump Features

*United Technologies Diesel Systems (formerly AMBAC)

Mounting Adapter

A mounting adapter incorporating four studs attaches to the injection pump housing. Capscrews through the injection pump drive gear cover secure the mounting adapter to the engine front plate. Removal of the timing pointer plug in the adapter is necessary when verifying or adjusting pump to engine timing.

The mounting adapter is an integral part of the injection pump because it contains the timing pointer. During injection pump calibration, a port closure mark is stamped on the injection pump hub directly in line with the pointer. Because the timing pointer is located on the mounting adapter and the mounting adapter is fastened to the injection pump housing by the four studs and nuts, these four nuts should not be loosened.

Loosening the nuts and rotating the pump housing in relationship to the mounting adapter will change the relationship of the timing pointer/hub mark which was established during injection pump calibration.

MW Injection Pump

Within the MW injection pump housing are the individual barrels and plungers, roller tappets and activating camshaft. Each barrel and plunger assembly is connected with the control rack to allow simultaneous changes of fuel delivery. A notch in the end of the pump camshaft drives the tachometer adapter. Fuel is drawn from the vehicle fuel tank through the primary and final fuel filters by the supply pump.

Supply Pump with Hand Priming Pump

The piston-type supply pump is activated by the eccentric on the injection pump camshaft and serves as a mount for the hand priming pump. Since all fuel entering the injection pump must be filtered to ensure long pump life, the hand priming pump should be used when changing fuel filters. Always install the fuel filters "dry" and use the hand pump to fill the filters and bleed air from the fuel system.

RQV and RSV Governors

A variable speed governor known as the "RQV" is used on truck engines. RSV variable speed governors are used on agricultural and construction equipment engines. RQV governors are used on truck engines because control lever forces are much lower and do not stress the driver’s foot.

Aneroid Assembly

Exhaust smoke levels during engine acceleration are controlled by using an aneroid. The aneroid limits fuel delivery during acceleration until the turbocharger speed is sufficient to provide adequate air for complete combustion. An external line connects the intake manifold to the aneroid to allow manifold pressure to activate the aneroid. A leak in the aneroid diaphragm or intake manifold to aneroid line will cause the injection pump to stay in the "cutback" position and reduce engine power.

Fuel Return Valve

A fuel return check valve is mounted to the injection pump housing and all fuel that is not injected passes through the check valve and then through a special orificed rubber hose. The function of the fuel return check valve is to provide a positive seal to prevent fuel from draining out of the pump housing when the engine is stopped. The fuel return check valve opens at approximately 18 psi. Therefore, total fuel flow through the injection pump housing is controlled by the orifice in the rubber hose as long as the supply pump pressure is above 18 psi. After the fuel flows through the orifice, the fuel pressure drops from the intermediate pressure ahead of the orifice to low pressure.

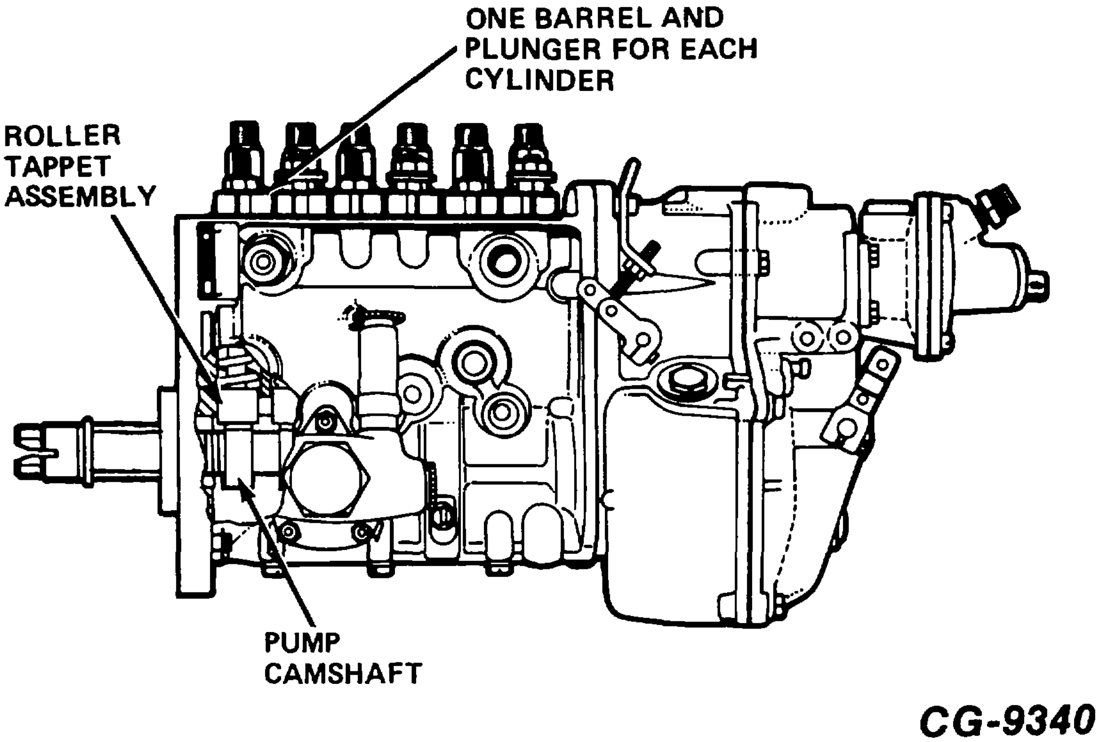


Figure 3.

MULTIPLE PLUNGER DESIGN

The injection pump is of the multiple plunger design with one plunger, barrel and delivery valve assembly for each engine cylinder (Figure 3). Each plunger is activated by the pump camshaft through roller tappet followers. Pump rotation, as viewed from the drive end of the pump, is clockwise and at one-half engine speed. Three gears are used to drive the injection pump; the crankshaft gear, engine idler gear and the injection pump gear which is bolted to the injection pump hub.

INJECTION PUMP LUBRICATION

Engine lubricating oil flows through an external line from the crankcase to a pump housing oil inlet fitting located slightly to the rear of the hand priming pump (Figure 4). Oil then flows through a housing passage which indexes with the number four tapped body. All oil lubricated parts within the injection pump and governor are lubricated by splash with the exception of the number four tappet body. Oil flow into the injection pump is very low. Therefore, a minimum of one pint of oil must be added through the upper governor housing plug when an injection pump is installed. Return oil flows out of the injection pump housing at an opening just above the front camshaft bearing and into the engine front cover. Engine oil and filters should be changed at the intervals recommended by International Harvester to prevent buildup of wear materials in the oil, replace essential anti-wear additives and maintain lubricating oil disparancy. If inadequate oil filters, extended oil drain intervals, or non-recommended oil classifications are used, engine and injection pump life will be reduced.

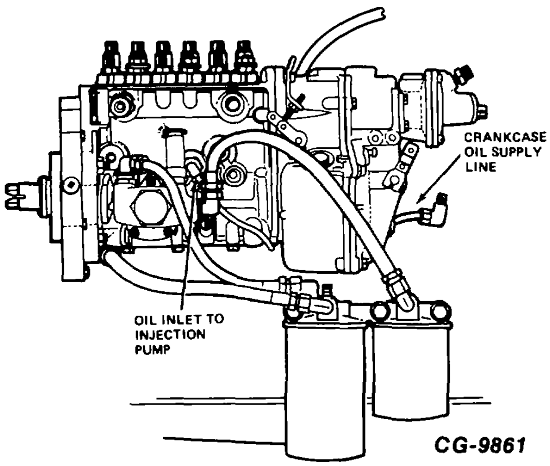


Figure 4. - Injection Pump Lubrication

INJECTION PUMP IDENTIFICATION

Identification of injection pump and governor can be made by referring to two nameplates, one on the front top left of the injection pump housing and one on the rear of the injection pump housing (Figure 5). The pump housing nameplate provides the Robert Bosch combination number which defines the injection pump components supplied by the manufacturer. The production IH part number for the complete injection pump assembly including governor, transfer pump, mounting adapter, etc., is located on the governor housing. Robert Bosch's governor number, size and rating is also located on the governor housing.

FUEL SYSTEM FLOW

As fuel travels through the fuel system, it will be under suction (negative pressure), intermediate pressure, high pressure (injection pressure) and low pressure (Figure 6).

Negative Pressure

The piston-type supply pump creates a suction at its inlet and pulls fuel from the fuel tank, through the fuel supply lines and through the primary fuel filter. No filter is used on the fuel suction line extending into the fuel tank

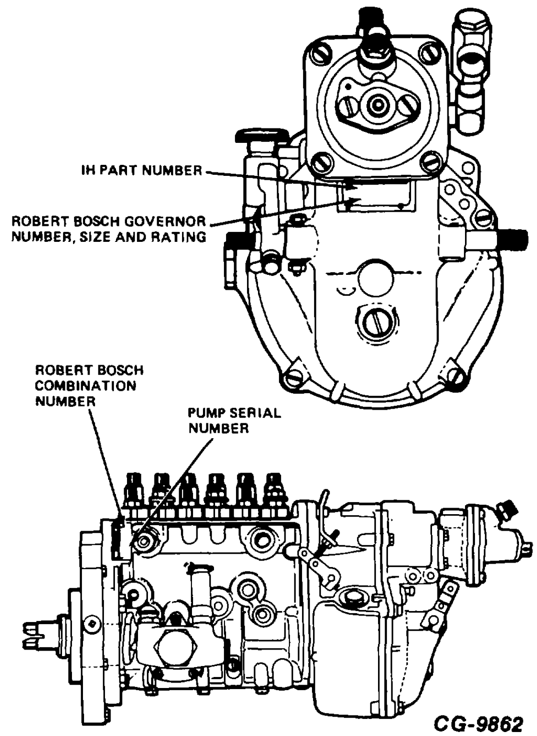


Figure 5. - Injection Pump Identification

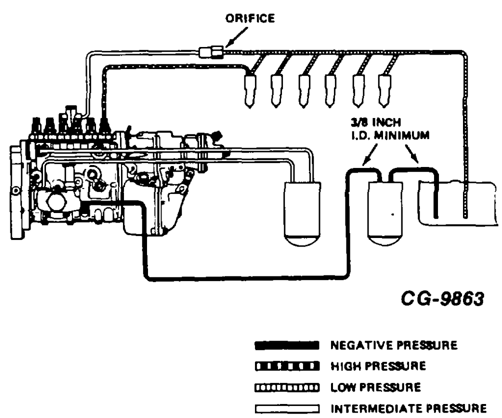


Figure 6. - Fuel System Flow

because wax particles could plug the filter in cold weather. Fuel lines and fittings between the supply pump inlet and the fuel tank must be a minimum of three-eighths inches inside diameter. Small diameter fuel supply lines or fittings will reduce fuel flow and can reduce engine power output.

A special hose is used between the primary fuel filter outlet and the supply pump inlet to dampen supply pump fuel pulses. Use of a substitute hose in this position can cause lower engine power even though supply pump pressure can be within specifications.

Intermediate Pressure

The supply pump produces an intermediate pressure, called supply pump pressure at its outlet and forces fuel through the final fuel filter and into the injection pump housing. Fuel under intermediate pressure surrounds each barrel assembly. Fuel pressure in the housing is controlled by the orificed fitting in the fuel return hose located "downstream" of the fuel return check valve and the supply pump piston spring calibration. A special rubber hose between the final filter outlet and the injection pump housing dampens pressure waves from the supply pump. Substitute hoses can cause lower engine power even though supply pump pressure can be within specifications.

High Pressure

The injection pump meters and delivers fuel at high pressure, up to an instantaneous 9000 psi pressure after nozzle valve opening, through the injection pipes or lines to the injection nozzle assemblies. This high pressure fuel causes the nozzle valve to open and fuel flows through the nozzle orifices into the combustion chamber. The amount of fuel delivered is controlled by the injection pump governor. A small amount of low pressure fuel returns from the nozzle assemblies to the fuel tank through the leakoff lines.

Low Pressure

An orifice fitting in the end of fuel hose from the fuel return check valve limits the amount of fuel returned to the fuel tanks. After fuel passes through the orifice, it is at low pressure.

SUPPLY PUMP AND HAND PRIMING PUMP COMPONENTS

The supply pump consists of a pump housing, roller tappet assembly, pressure spindle and "O" ring, plunger, plunger spring, suction valve, pressure valve and associated fittings, gaskets and covers (Figure 7). Three studs and nuts secure the supply pump and gasket to the injection pump housing. The eccentric on the injection pump camshaft actuates the supply pump plunger through the roller tappet and pressure spindle. An "O" ring around the pressure spindle retains the fuel within the supply pump. Each injection pump assembly is equipped with a hand priming pump which is threaded into the supply pump housing.

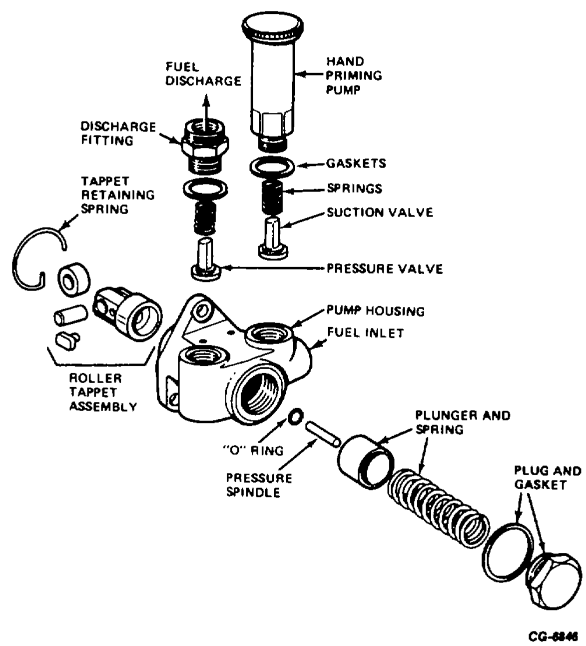


Figure 7. - Supply Pump and Hand Priming Pump Components

Supply Pump Operation

The supply pump plunger establishes and separates two chambers within the supply pump, the suction chamber and the pressure chamber (Figure 8). Two operating strokes occur within the pump operating cycle. During the intermediate stroke, the revolving camshaft eccentric drives the roller tappet, pressure spindle and pump plunger towards the plunger spring. A portion of the fuel present in the suction chamber equal to the swept volume or quantity of fuel or air delivered per stroke flows through the pressure valve to the pressure chamber. Towards the end of the intermediate stroke, the spring loaded pressure valve closes.

As soon as the rotating eccentric has reached its maximum travel or stroke toward the plunger spring, the delivery and suction stroke starts. During this stroke, the plunger spring drives the plunger and pressure spindle toward the roller tappet. A portion of the fuel present in the pressure chamber flows through the pressure valve to the final filter and then to the injection pump housing. Simultaneously during this stroke, fuel flows through the pump suction into the suction chamber.

During the spring-actuated delivery and suction stroke, all fuel swept out of the pressure chamber flows out the discharge fitting. The fuel volume swept out of the pressure chamber is slightly less than the fuel volume entering the suction chamber. Actual fuel volume swept out of the pressure chamber is the fuel volume swept out of the suction chamber minus the volume of the pressure spindle reaching into the pressure chamber.

Therefore during the intermediate stroke, a quantity of fuel corresponding to the volume of the spindle is fed to the injection pump. For example, if the fuel volume in the pressure chamber were nine millimeters and the fuel volume in the suction chamber were ten millimeters at a given plunger travel, one millimeter would flow through the pressure valve during the intermediate stroke.

Because the plunger spring provides the force to pump the fuel and the camshaft eccentric and roller tappet merely positions the plunger, supply pump pressure is self-limiting. When supply pump pressure exceeds a specified value, the plunger spring lifts the plunger only

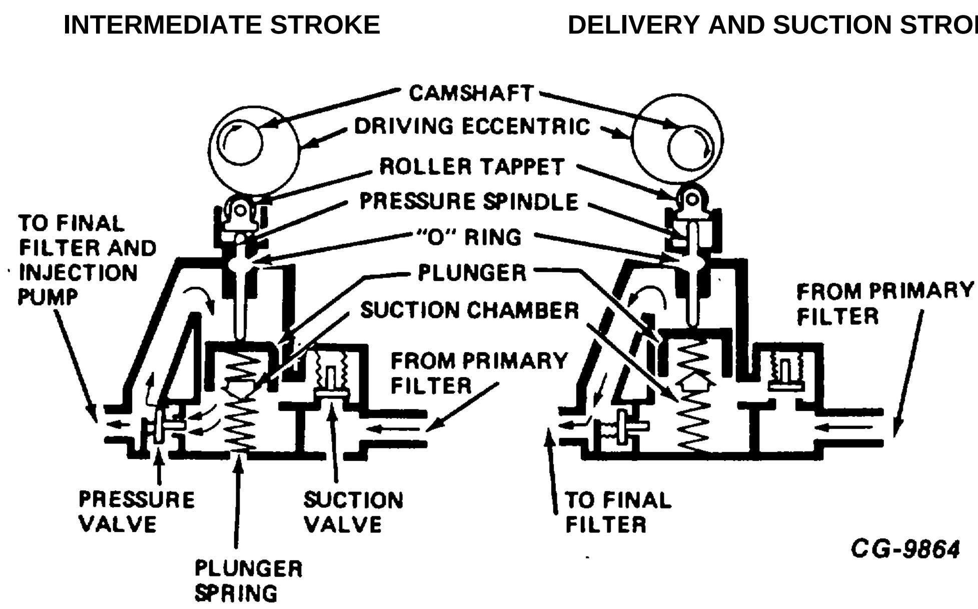


Figure 8. - Supply Pump Operation

a portion of the full stroke. Therefore the fuel quantity delivered per stroke is smaller and the fuel pressure remains constant. If the return fuel line were blocked at the fuel check valve assembly or orificed fuel return hose, the pump pressure would rise to a maximum value and the supply pump would deliver only the amount of fuel necessary to maintain the maximum value. This self-limiting feature protects the injection pump from excessively high fuel pressures.

Hand Priming Pump Operation

Each injection pump assembly is equipped with a hand priming pump which is screwed into the supply pump housing just above the suction valve (Figure 9). With the aid of the hand priming pump, fuel can be pumped from the fuel tank through the primary and final fuel filters into the injection pump. Approximately six milliliters are delivered per stroke.

To operate the pump, loosen the knurled knob until the plunger can be pulled upwards. Moving the plunger upward causes the fuel suction valve to open and fuel to flow into the suction chamber. When the plunger is pressed downward, the suction valve closes the pressure valve opens. Fuel then flows through the pressure valve and towards the final filter and injection pump housing. Operate the pump until solid fuel flows from the final filter bleeder fitting. Always tighten the knurled knob after operating the pump because engine operation with the knob loose will damage the hand priming pump.

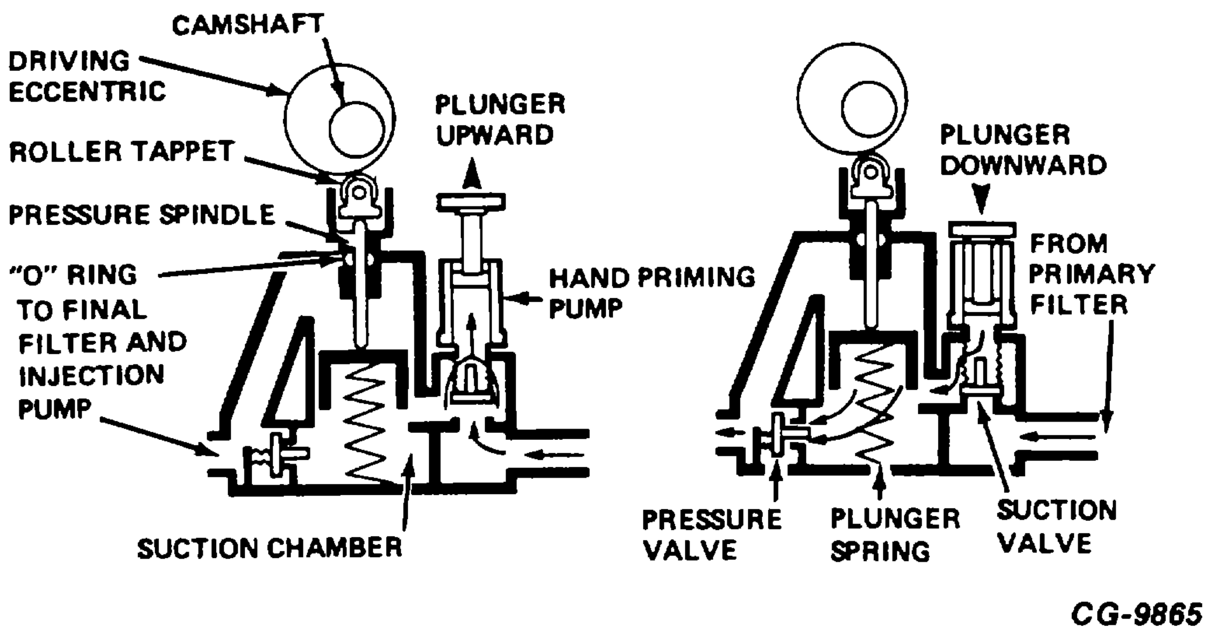


Figure 9. - Hand Priming Pump Operation

BARREL AND PLUNGER

Components

One barrel and plunger assembly for each engine cylinder mounts to the injection pump housing. Each barrel flange which contains two slotted holes is positioned over two pump housing studs and is secured with two flat washers, lock washers and nuts. Threaded into the top of the barrel is the delivery valve holder (Figure 10).

The delivery valve gasket, delivery valve, delivery valve spring and washer are installed into the upper barrel bore prior to the installation of the delivery valve holder. An "O" ring on the delivery valve holder acts as a dust seal to prevent foreign material or liquids from entering the delivery valve holder threads.

When the injection pump is assembled, shims are inserted around the number one housing studs and between the pump housing and number one cylinder barrel flange to establish the specified plunger lift to port closure. These shims are available in various thicknesses.

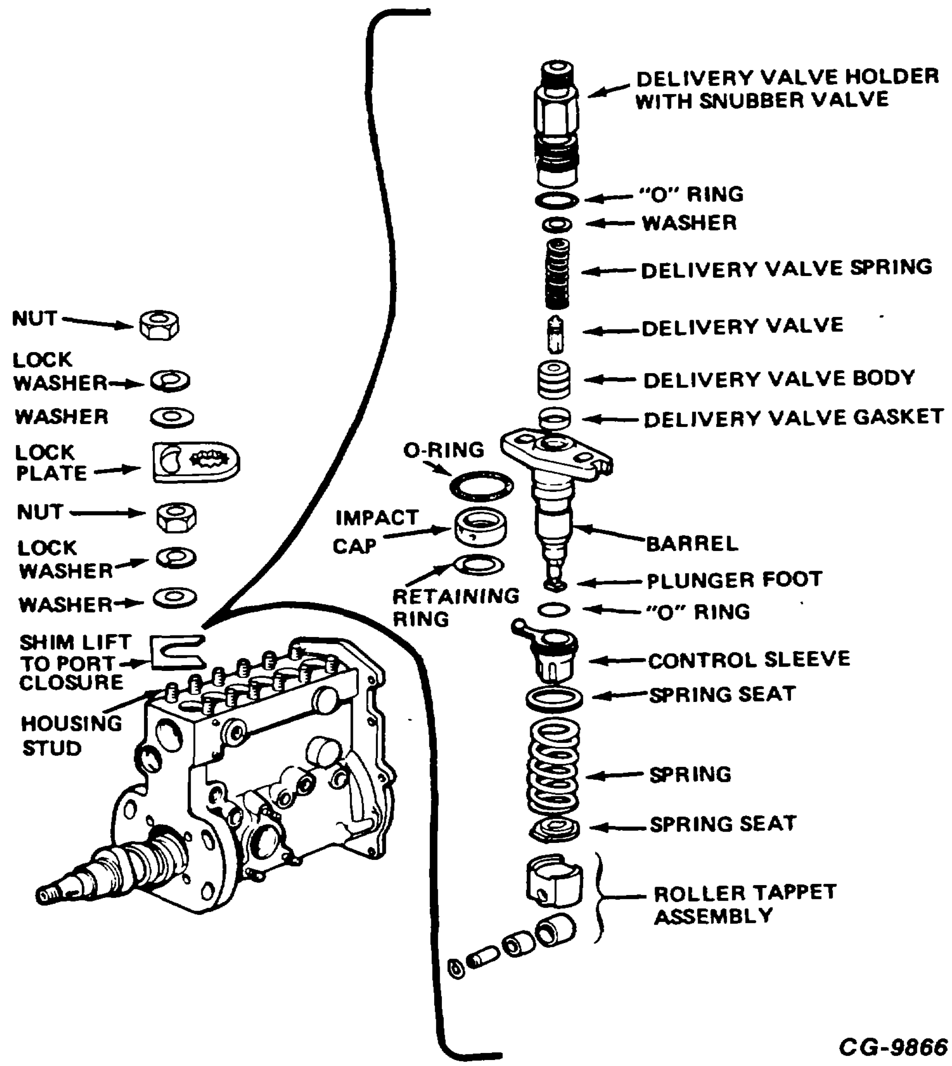


Figure 10. - Barrel and Plunger Components

After the specified plunger lift to port closure is established for number one barrel and plunger, the remaining barrels and plungers are "phased" in discharge order "port close" every sixty degrees.

Fuel is retained around the barrel and within the pump housing by an "O" ring and oval "O" ring. Located on the barrel body and approximately three-eighths inches below the barrel flange is an "O" ring groove. This groove contains an oval "O" ring which seals against the upper housing bore and retains fuel within the upper housing barrel cavity. An "O" ring located at the bottom of the injection pump housing cavity and retained by a spacer seals against the lower end of the barrel. The spacer is pressed into the housing and can be replaced if it is damaged.

Barrel Construction

When the barrel is installed into the pump housing, the barrel flange with the adjustment notch is positioned opposite the control rack. Pump balance, which is the term used to describe equal delivery per cylinder, is adjusted during production pump calibration by rotating the barrel using the adjustment notch (Figure 11).

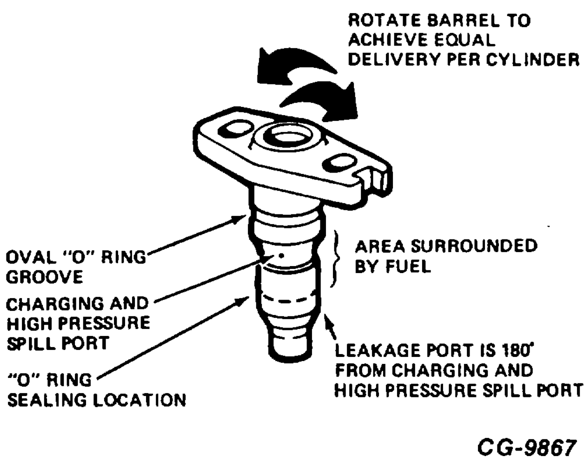


Figure 11. - Barrel Construction

Two fuel passages in the barrel allow fuel to flow from the pump housing cavity and into/ out of the plunger barrel. The upper barrel passage is the charging and high pressure spill port and the lower passage is the leakoff port. The leakoff port indexes with a groove on the plunger and allows high pressure fuel which has leaked past the upper plunger/barrel to return to the pump housing cavity.

To protect the pump housing from erosion when high pressure fuel spills back into the pump cavity at the end of the pumping cycle, a metal impact cap and retaining ring covers the upper barrel duct. This cap has six holes and is installed so the holes do not align with the charging port in the barrel.

Plunger Construction

Each barrel and plunger is a matched metal to metal fit to each other and produces peak injection pressure of approximately 9000 pounds per square inch. Camshaft rotation causes the roller tappet to lift the plunger a constant amount or stroke on each pumping cycle. Fuel delivery per stroke is varied by rotating the plunger through a control sleeve, common control rack, governor and control lever to change the effective plunger stroke.

At the top of the plunger, a retard start notch in conjunction with the charging/high pressure spill port in the barrel aid engine starting by retarding injection timing (Figure 12). After the engine starts, effective plunger stroke is determined by the relationships between the plunger helix and the charging/high pressure spill port. The accelerator pedal must be fully depressed to allow the control rack to move into the start fuel position.

High pressure fuel that leaks past the upper plunger and barrel area is returned to the pump housing cavity through the plunger leakoff groove and leakoff port in the barrel. Additional smaller grooves located above the leakoff groove and 180 degrees from the helix allow fuel to flow to the leakoff groove.

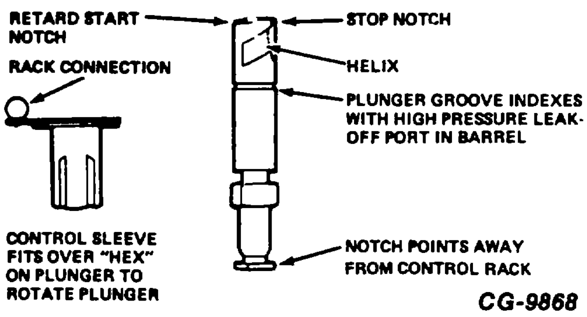


Figure 12. - Plunger Construction

Plunger Positions During Injection Cycle The injection cycle can be described by observing the plunger in its four principle positions in the barrel (Figure 13). At bottom dead center the plunger is held down on the lowest point of the cam lobe by the plunger spring and the top of the plunger is below the barrel charging/high pressure spill port. Fuel at supply pump pressure flows through from the injection pump housing fuel gallery through the barrel charging/high pressure spill port to fill the area above the plunger.

Port closure begins when the rising plunger covers the charging/high pressure spill port and fuel is trapped above the plunger.

Start of injection occurs as the plunger continues upward and causes high pressure fuel to unseat the delivery valve. Fuel then flows past the delivery valve, through the injection pipe, and unseats the nozzle valve and fuel is injected into the cylinder.

End of injection occurs when the plunger moves up to the point where the charging/ high pressure spill port is uncovered by the helix. High fuel pressure above the plunger is relieved through the helix, through the barrel charging/high pressure spill port into the injection pump fuel gallery. This pressure drop allows the delivery valve and injection nozzle to seat, thus ending injection.

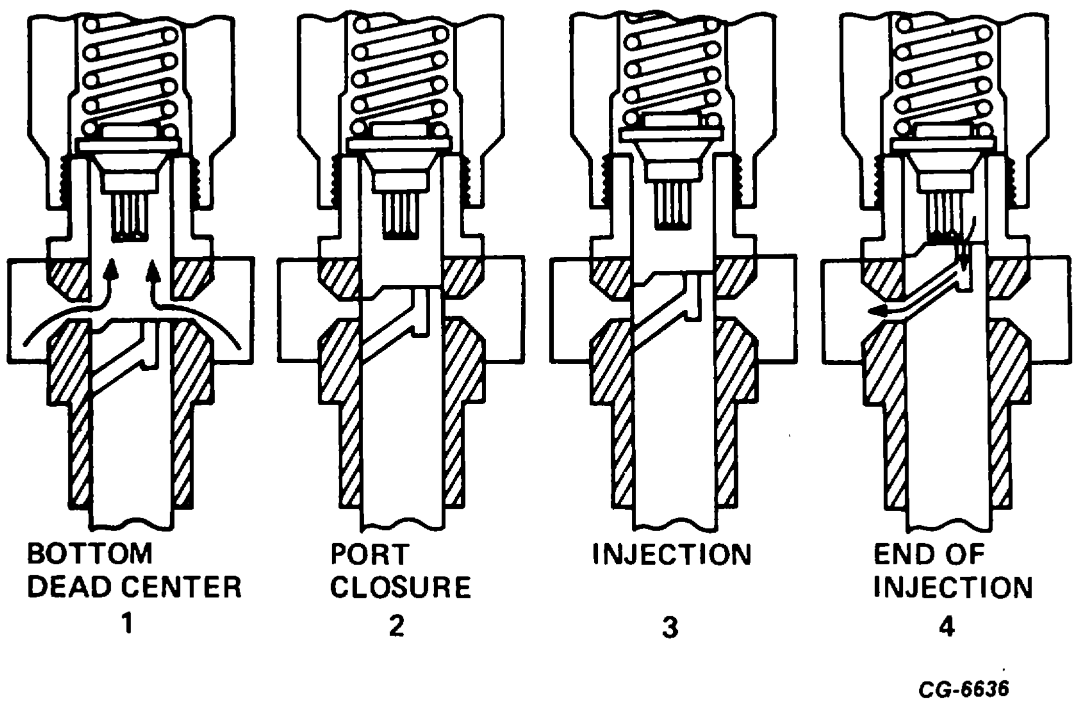


Figure 13. - Plunger Positions During Injection Cycle

Delivery Valve and Snubber Valve

The delivery valve, which is held on its seat by spring pressure, prevents all the fuel from draining out of the high pressure line between pumping cycles. Just prior to the time the delivery valve seats, the delivery valve allows a specified amount of fuel, called the retraction volume, to flow out of the injection line. The retraction volume is sufficient to establish a residual line pressure which is low enough to prevent pressure waves within the line from causing secondary injection.

Within the delivery valve holder is another component called the snubber valve which affects fuel injection. The snubber valve is an integral part of the holder and essentially consists of a disc with a hole in the center of the disc (Figure 14). The disc is free to move

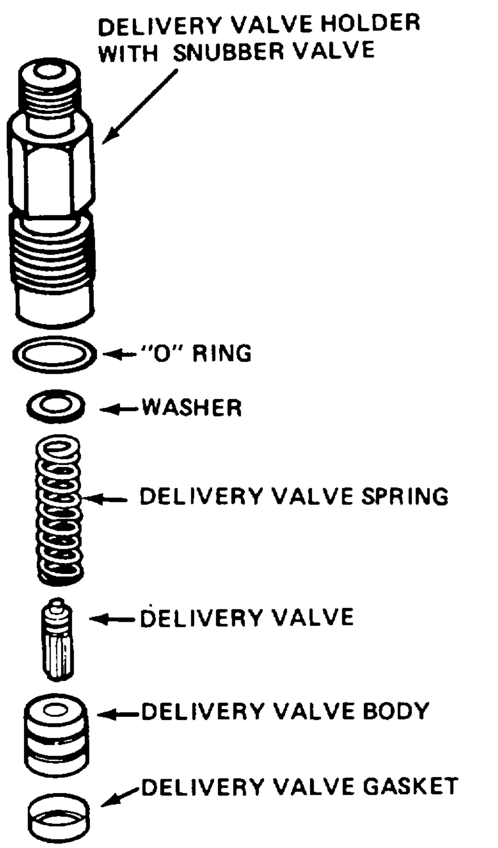


Figure 14. - Delivery Valve and Snubber ValveCGES-185-3

within the holder. During injection, fuel flows around the disc and to the nozzle. When the helix aligns with the charging/high pressure spill port, injection ends and a small amount of fuel flows back towards the plunger. Fuel then flows through the center of the disc which results in a delay in fuel pressure decay within the line which minimizes secondary injection and prevents line pressure from going below zero which would cause line cavitation.

Metering Positions

Metering (providing the proper amount of fuel to meet engine requirements at various loads and speeds) is accomplished by rotating the plunger in its barrel to change the effective pumping stroke. The effective stroke is the distance traveled upward by the plunger from the time the charging/high pressure spill port is covered until it is again uncovered by the helix. A short effective stroke means a small amount of fuel is injected. As effective stroke increases, the amount of fuel injected increases.

The metering function can be described by observing the relationships of plunger helix to barrel charging port under various metering positions (Figure 15).

Starting

For starting, plunger is rotated by control rack to a point where the plunger retard notch aligns with the charging/high pressure spill port. The effective plunger stroke is nearly the maximum during starting. The maximum effective plunger stroke occurs just after the plunger rotates "past" the retard notch.

Engine Operating (Metered Delivery)

At engine operating speeds from idle through maximum governed speed, the quantity of fuel delivered is determined by the effective stroke (port closing to port opening) as controlled by the position of the throttle lever and governor.

Engine Stop (No Delivery)

To stop the engine, plungers are rotated so that vertical slots (stop slots) are in line with barrel ports. As plunger moves up and down, fuel is transferred back and forth from top of plunger through vertical sl6ts into charging gallery. The ports do not close, thus, no delivery.

Plungers are rotated to the various metering positions by the control rack. Rack movement is controlled by the shutoff lever to stop the engine.

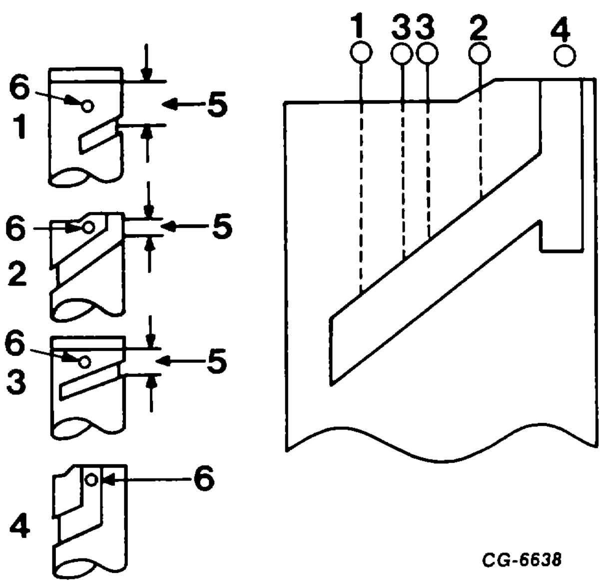


Figure 15. - Metering Positions

1. Start Position (Charging Port Closed)
2. Idle Position (Charging Port Closed)
3. Full Load Position (Charging Port Closed)
4. Stop Position (Charging Port Open)
5. Effective Stroke
6. Charging Port Position

EXTERNAL INJECTION PUMP CONTROLS (Figure 16)

Prior to starting the engine, the injection pump shutoff lever must be moved to the "run" position. this lever is moved to the "run" position from the "shutoff" position by an engine mounted electric shutoff or by a pull cable. An electric shutoff is standard on some engines such as in the Cargostar. DT- 466C truck engines which were originally equipped with a cable shutoff, can be converted to an electric shutoff in the field.

During injection pump calibration, the "shut- off" lever position is established by positioning the shutoff lever adjusting screw. The shutoff screw should not be moved after calibration because fuel delivery might not be completely stopped or the internal rack might be bent.

Electric shutoff and cable linkage adjustments must also allow full control rack travel when the shutoff lever should be in the "run" position. Follow the linkage adjustment procedures in the on-engine repairs section to ensure full rack travel during engine operation.

Driver accelerator pedal movements are transmitted through a cable to the engine. Depending upon engine application, the cable is connected directly to the injection pump control lever or to engine mounted linkage which is connected to the control lever at full pedal depression, the control lever must contact the high idle stop to allow full rack travel and maximum engine power output.

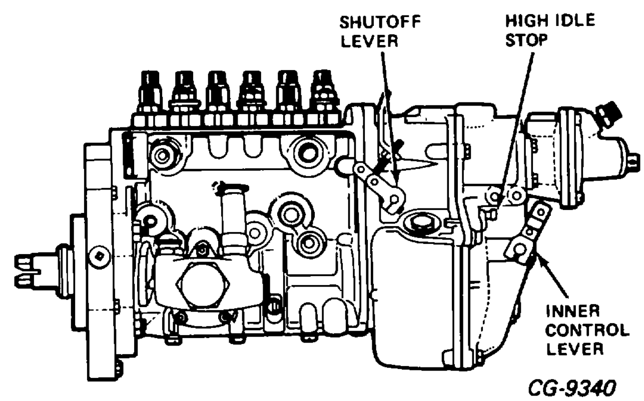


Figure 16. - External Injection Pump Controls

The high idle stop is sealed at the engine production plant. Adjustments to high idle speed should be made in accordance with existing warranty policies. High idle speed can only be raised a small amount by adjusting the high idle screw even if the screw is completely removed.

When the control lever contacts the low idle stop, the injection pump is in the low idle speed position. Low idle speed is changed by moving the low idle adjustment screw and should be adjusted with the engine at operating temperature. To compensate for parasitic loads which affect low idle speed, the low idle speed should be set slightly higher so engine speed will be within specifications when load is applied. Examples of major parasitic loads are mixer drums and automatic transmissions.

RQV GOVERNOR AND ANEROID (Figure 17)

Low idle speed can be adjusted on the engine as described in the on-engine repairs section. If diagnostic testing confirms that any other adjustment is indicated, follow the current warranty procedures to resolve the problem.

To replace a leaking aneroid diaphragm, the injection pump must be removed, the new diaphragm installed and the injection pump recalibrated. DO NOT ATTEMPT TO REPLACE THE ANEROID WITHOUT RE-CALIBRATING THE INJECTION PUMP. SEEMINGLY SMALL CHANGES TO THE INJECTION PUMP CONTROL RACK SETTINGS CAN DESTROY THE ENGINE.

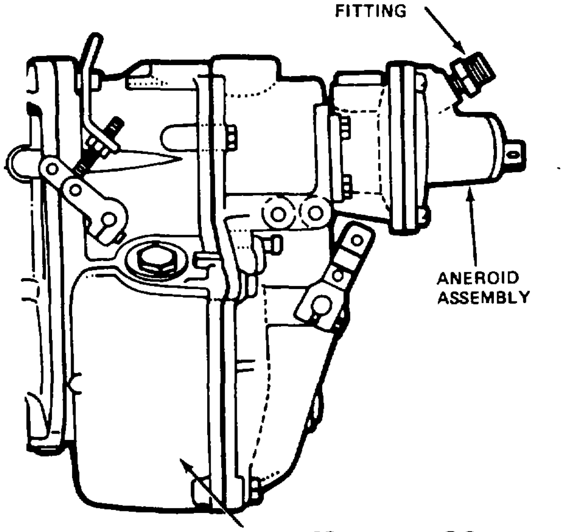


Figure 17. - RQV Governor and Aneroid

ON-ENGINE INJECTION PUMP REPAIRS

REMOVAL

CLEANLINESS IS OF UTMOST IMPORTANCE WHEN SERVICING FUEL INJECTION SYSTEMS. ALWAYS CLEAN ENGINE BEFORE INJECTION PUMP IS REMOVED OR DISCONNECTING FUEL LINES. ALWAYS PLUG OR CAP ANY OPENING TO PREVENT DIRT, PAINT CHIPS OR OTHER FOREIGN MATERIAL FROM ENTERING THE FUEL SYSTEM.

Barrel to plunger clearances are approximately one hundred millionths of an inch (0.0001000 inches). Normally the difference between a serviceable and a worn out barrel and plunger assembly is that dirt entered the fuel system and caused minute wear between the barrel and plunger.

Thorough cleaning prior to disassembly and an understanding that any dirt entering the injection pump causes damage is essential to obtaining long fuel system life.

NOTE: Prior to injection pump removal, conduct the diagnostic checks and adjustments found in the appropriate diagnostic manual.

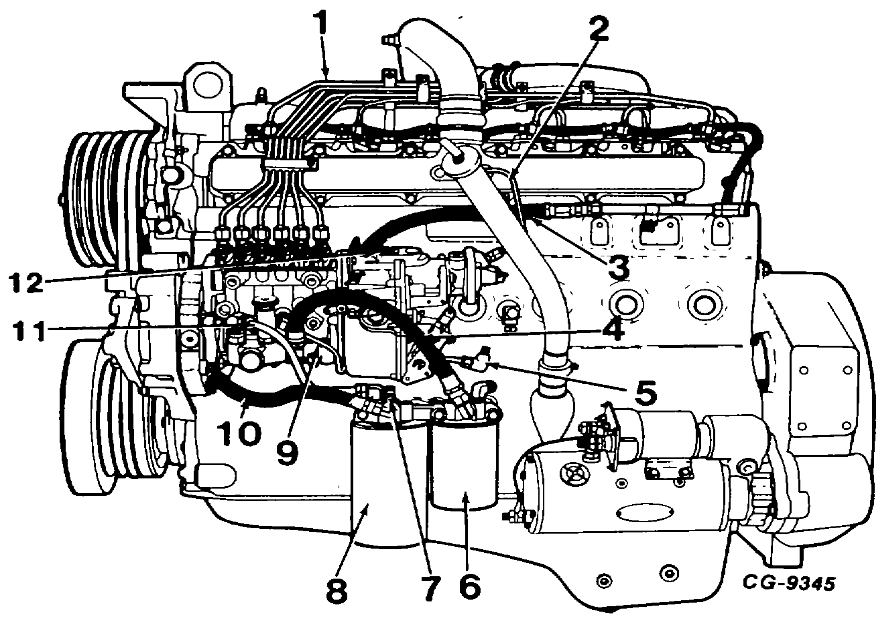


Figure 18. - DT-466C (Side View)

1. High Pressure Lines
2. Aneroid Tube
3. Fuel Return Line (with orifice)
4. Transfer Pump to Primary Filter Hose
5. Oil Supply Elbow
6. Primary Fuel Filter
7. Final Fuel Filter Bleed Tap
8. Final Fuel Filter
9. Oil Supply Line
10. Final Filter to Pump Supply Hose
11. Transfer Pump to Filter Tube
12. Governor Plug

REMOVAL PROCEDURE: (For a detailed disassembly procedure refer to appropriate Service Manual.

1. Disconnect battery cables.

2. Disconnect accelerator cable or linkage from outer injection pump control lever.

3. Remove injection pump timing pointer plug and gasket from left side of pump mounting adapter.

4. Rotate engine in normal operating direction until engine front cover timing pointer is approximately 90 degrees from top dead center dot on crankshaft pulley. (The injection pump is driven at one-half engine speed. Therefore, each time the injection pump hub mark is aligned with injection pump timing pointer, engine should be on number one cylinder compression stroke).

NOTE: If engine gear train was disassembled, verify that engine is positioned at number one cylinder compression stroke by:

a. Removing valve cover.
b. Observing that number one cylinder intake and exhaust valve levers are loose.
c. If number one cylinder valve levers are not loose, rotate engine one complete revolution to approximately 90 degrees before top dead center.

5. Turn engine slowly in normal direction of rotation until timing mark on hub is aligned with injection pump timing pointer (observe through mounting adapter, Figure 19). If engine is turned past timing mark, rotate engine counterclockwise at least 90 degrees to remove gear train backlash. Rotate engine until timing mark and pump timing pointer are aligned.

ROTATE ENGINE TO ALIGN TIMING POINTER AND INJECTION PUMP HUB MARK

OBSERVE ENGINE TO INJECTION PUMP TIMING ON PULLEY

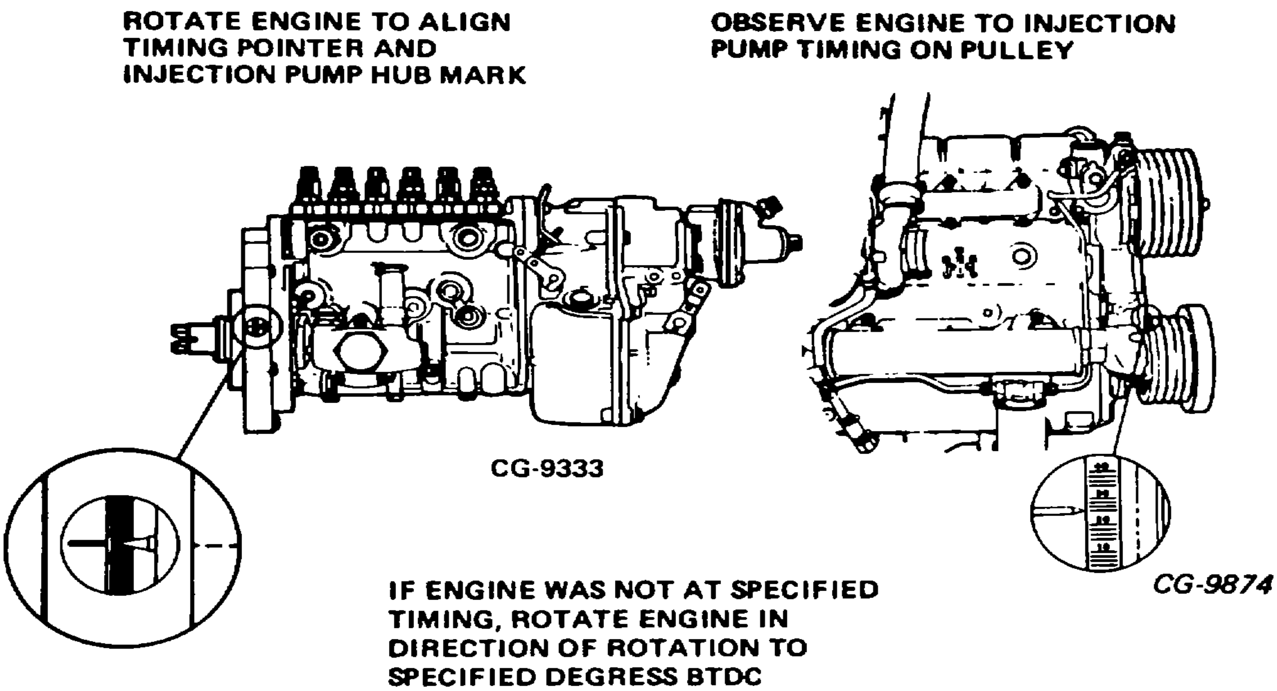


Figure 19. - Prepare to Remove Injection Pump

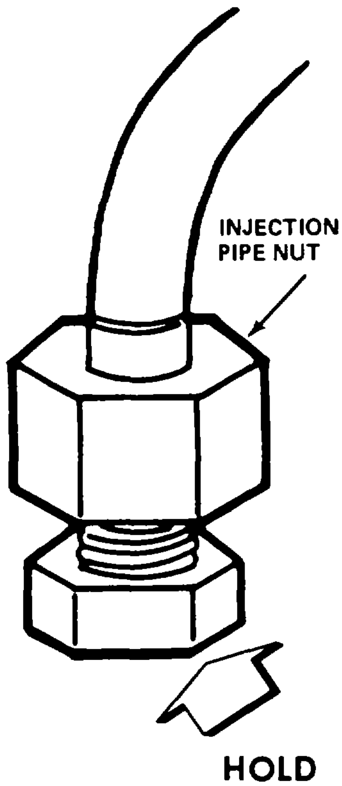
6. Observe engine front cover timing pointer and crankshaft pulley degree alignment. To ensure an accurate reading, view pointer straight on the engine should now be positioned at specified static pump to engine timing.

CHART 1

Engine Model	Emission Standard	Horse power Rating	Static Timing-Degrees
DT466C	Federal	210	23±1
DTI-466C	California	210	18±1
DT-466C	Federal	195	23±1
DTI-466C	California	195	18±1
DT466C	Federal	180	21±1
DT-466C	California	180	17±1
DT-466C	Federal	165	21±1
DT-466C	California	165	17±1

If timing is not within specifications, rotate engine to correct crankshaft position (specified degrees before top dead center) before removing injection pump. If necessary to rotate engine in opposite direction of normal rotation to achieve specified timing, rotate engine to 90 degrees before top dead center and then rotate engine to specified timing. This procedure takes up gear backlash.

7. Remove high pressure injection pipes as an assembly of six lines (Figure 18) from injection nozzles and pump (Figure 20). Cap all openings to keep dirt out of fuel system.



INJECTION PUMP DELIVERY VALVE HOLDER MUST BE HELD WITH A WRENCH TO PREVENT MOVEMENT WHEN HIGH PRESSURE PIPING IS REMOVED FROM INJECTION PUMP. IF THE DELIVERY VALVE HOLDER IS ROTATED DURING INJECTION PIPE REMOVALIINSTALLATION, FUEL LEAKAGE MAY RESULT.

CG-9871

Figure 20. - Removing Injection Pipes

8. Disconnect lubricating oil line from injection pump and intake manifold line to aneroid line.

9. Remove ground and power supply from electric shutoff solenoid.

10. Disconnect electric shutoff assembly from injection pump by removing capscrew from shutoff lever and mounting bracket from engine.

11. Disconnect fuel return hose at flex connector located just below center of intake manifold. Fuel return check valve is part of replacement injection pump assembly. Low pressure fuel lines must remain with the engine as they are not part of replacement injection pump assembly. Fuel return hose between fuel return check valve and engine fuel return contains an orifice restriction fitting to limit fuel return flow. Cap openings to keep dirt out of fuel system.

12. Disconnect fuel lines and hoses to supply pump. Disconnect final filter hose to injection pump at final filter header. Cap openings to keep dirt out of fuel system.

13. Remove injection pump drive gear access cover capscrews, washers and bolts (Figure 21).

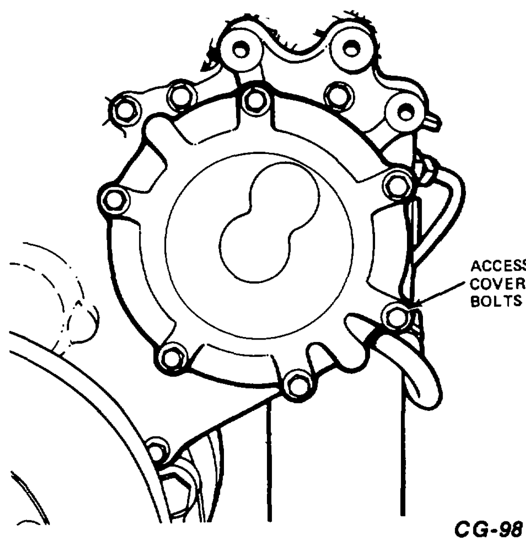


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Figure 21. - Drive Gear Access Cover

14. Remove injection pump drive gear bolts and washers from injection pump hub and remove pump from engine (Figure 22).

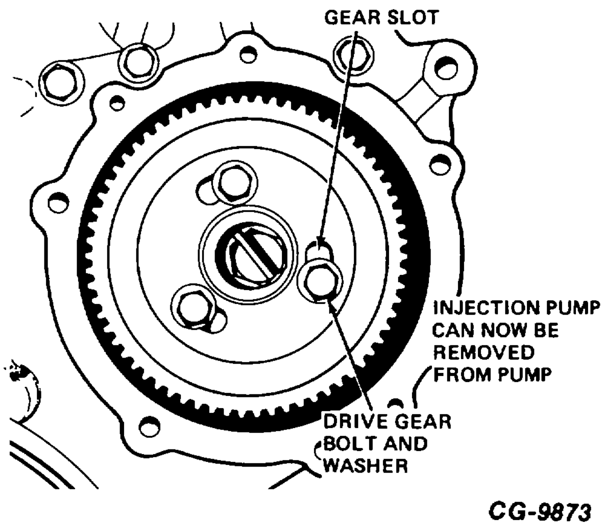


Figure 22. - Injection Pump Drive Gear

15. Tilt pump forward to drain lubricating oil from pump and cap all openings.

16. Remove final filter to injection pump housing hose at housing inlet connector. Remove fuel return hose from fuel return check valve and cap all openings.

INSTALLATION

1. Remove timing pointer access plug from left side of replacement injection pump mounting adapter. If original injection pump is being reinstalled, some of the following steps can be omitted.

2. Inspect engine emission decal and obtain engine model and horsepower rating.

3. Select correct performance data guidelines and verify that specified part number injection pump is installed.

4. Install injection pump drive gear loosely to injection pump using drive gear bolts and washers.

5. Rotate pump clockwise (as viewed from drive gear end) until timing mark on pump drive hub is aligned with timing pointer in adapter hole (Figure 23).

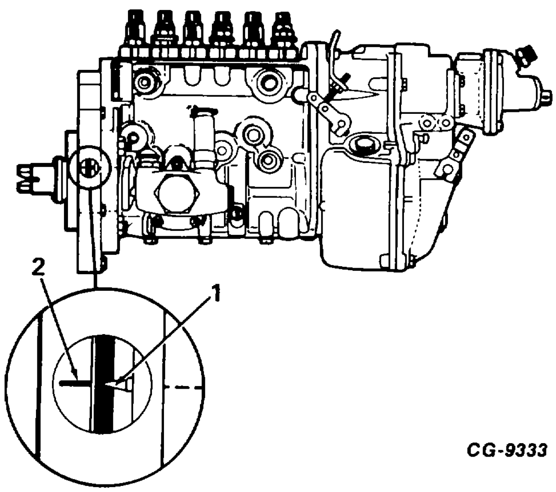


Figure 23. - Timing Pointer and Timing Mark

1. Timing pointer
2. Timing mark

6. Rotate loosened pump drive gear counterclockwise (as viewed from drive gear end) to 3/4 of full extent of drive gear bolt slots.

7. Install final filter to injection pump hose and rubber coated clamp. If the clamp is omitted, the hose may rub on adjacent parts and leak.

8. Install final filter to pump housing hose to inlet connector on pump housing.

9. Clean front cover plate and install new gasket and injection pump assembly.

10. With injection- pump in position on engine, secure pump adapter to front plate with bolts, nuts and washers. Torque bolts and nuts to 24 ft-lbs. (33 N•m).

11. Verify alignment of pump timing pointer to hub mark through mounting adapter opening (Figure 23). Rotate pump drive hub as required for proper alignment. Torque pump drive gear bolts to 35 ft-lbs. (47 N•m). Observe engine to injection pump timing on pulley (Figure 24). Refer to Chart 1 on Page 19, this section, for correct timing.

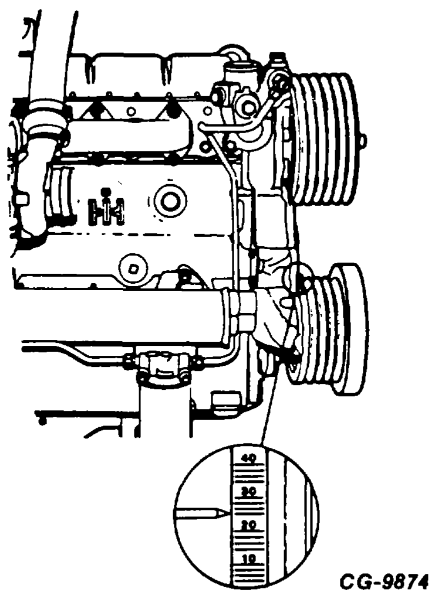


Figure 24. - Engine to Injection Pump Timing on Pulley

12. Install drive gear access cover.

13. Install lubricating oil line to injection pump.

14. Install fuel supply, fuel return and high pressure injection pipes with all clamps and brackets. Clean inside of each injection pipe with filtered air before assembling to injection pump and nozzles.

    INJECTION PUMP DELIVERY VALVE HOLDER MUST BE HELD WITH A WRENCH TO PREVENT MOVEMENT WHEN HIGH PRESSURE PIPING IS BEING INSTALLED (refer to Figure'20).

15. As applicable, install electric shutoff assembly, ground and power supply wire.

16. Add minimum of one pint of engine oil to governor through the upper governor housing plug (Figure 25). Because injection plug is splash lubricated, engine oil must be added to a replacement pump.

17. Install throttle cable or linkage to outer control lever. Adjust throttle cable or linkage so tang in outer control lever is in "override position." At "override" lever tang will be approximately half way from center of control lever to end of slot.

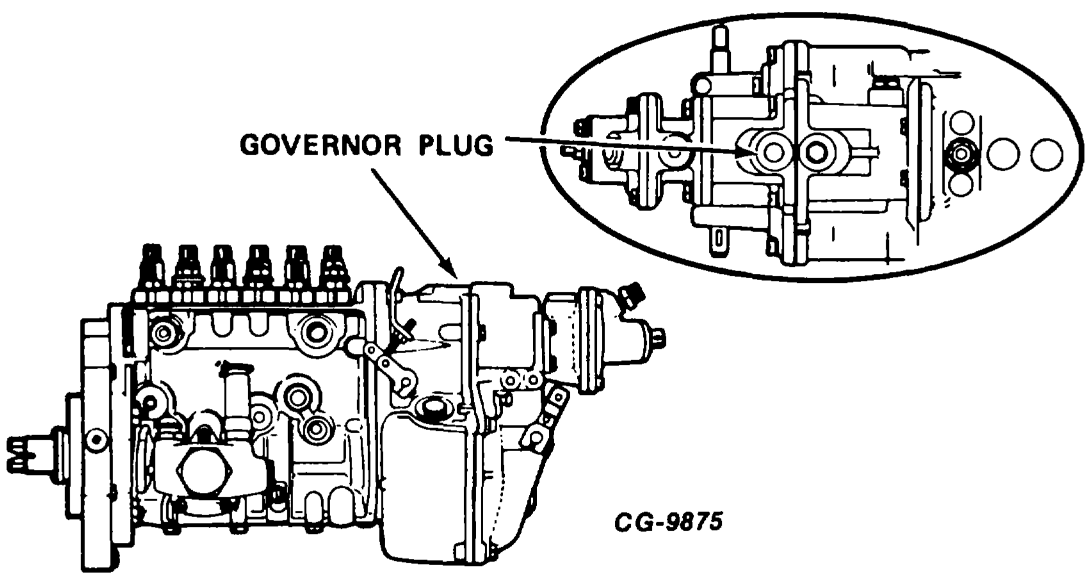


Figure 25 - Governor Housing Plug

18. After replacing fuel injection pump or replacing fuel supply lines, prime fuel system using these procedures:

    a. Loosen all six high pressure fuel lines at nozzle end.
    b. Loosen hand priming pump handle.
    c. Operate priming pump until pump action becomes solid (harder to pump).
    d. Position injection pump shutoff lever in run position with electric shutoff or mechanical cable.
    e. Crank engine for fifteen seconds.
    f. Operate priming pump until pump action becomes solid. Tighten priming pump handle securely.
    g. Crank engine for fifteen seconds and observe fuel/air leakage at each nozzle/ fuel pipe connector. When fuel flows from each nozzle connector, tighten connector.
    h. Start engine and operate until engine runs smoothly.

REPLACING INJECTION PUMP MOUNTING ADAPTER GASKET

The same procedures required to replace injection pump should be followed to replace mounting adapter gasket (Figure 26).

If a severe oil leak exists between mounting adapter and injection pump housing, injection pump must be removed and repaired. Timing pointer and injection pump hub relationship will be changed if mounting adapter to injection pump housing nuts are loosened.

IMPORTANT

DO NOT LOOSEN INJECTION PUMP TO MOUNTING ADAPTER NUTS BECAUSE INJECTION PUMP TIMING POINTER AND HUB RELATIONSHIP WILL BE CHANGED.

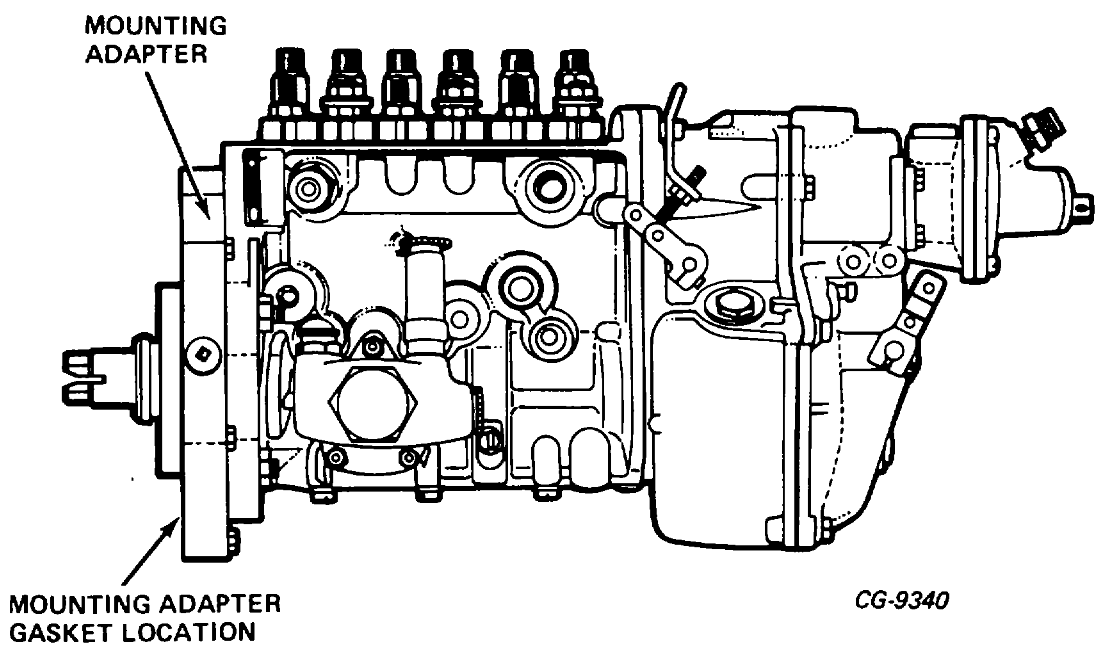


Figure 26. - Mounting Adapter and Gasket Location

TIGHTENING UNSEALED NUTS OR SCREWS TO CORRECT LEAKAGE

Unsealed nuts or screws may be tightened to stop fuel or lubricating oil leakage. When careful tightening does not stop leakage, fittings which use copper gaskets can be removed. For example, injection pump housing fuel inlet and outlet fittings and oil inlet fitting use copper gaskets between fitting and housing which can be replaced.

IF DELIVERY VALVE HOLDER (FIGURE 27) LEAKS, DO NOT TIGHTEN HOLDER. FOLLOW PROCEDURES IN CURRENT WARRANTY MANUAL TO RESOLVE HOLDER LEAKAGE.

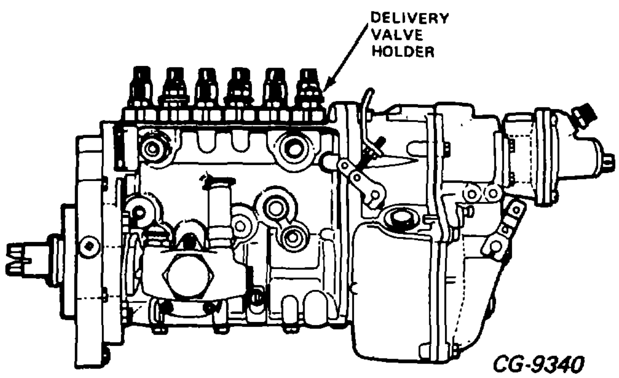


Figure 27.

REPAIRING OR REPLACING FUEL INLET OR RETURN FITTINGS

Replacing Fuel Return Check Valve The fuel return check valve (Figure 28) has a nominal opening pressure of 18 psi and retains fuel within injection pump when engine is stopped. Return fuel flow from pump is controlled by an orifice in the fuel return hose.

The valve can be cleaned or replaced as required. To remove valve, disconnect fuel return hose at fuel return line fitting located just below intake manifold center. Noting position of valve will aid in its reinstallation.

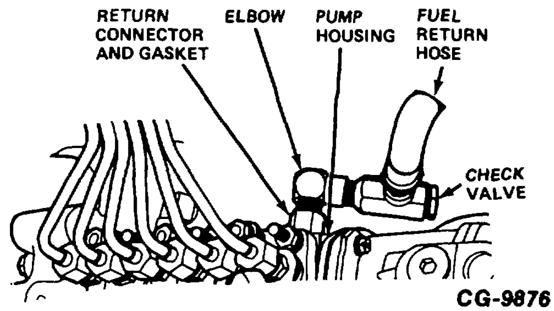


Figure 28.

Injection Pump Housing Pump Return Connector and Elbow

Fuel leakage can occur at injection pump housing return elbow or connector (Figure 28). If tightening does not stop leakage, install new elbow fitting or use Loctite Hydraulic sealant on elbow. Install a new copper gasket if fuel leaks at pump housing connector.

Injection Pump Housing Inlet Connector and Elbow

The final filter to pump housing hose (Figure 29) uses a flex connector at the filter header. Remove hose at header, then hose bracket at bottom of pump housing prior to removing hose. The hose connects to a brass elbow which is threaded into the pump housing connector (Figure 29). Fuel leaks may be corrected by installing a new copper gasket between pump housing and inlet connector or by installing a new elbow.

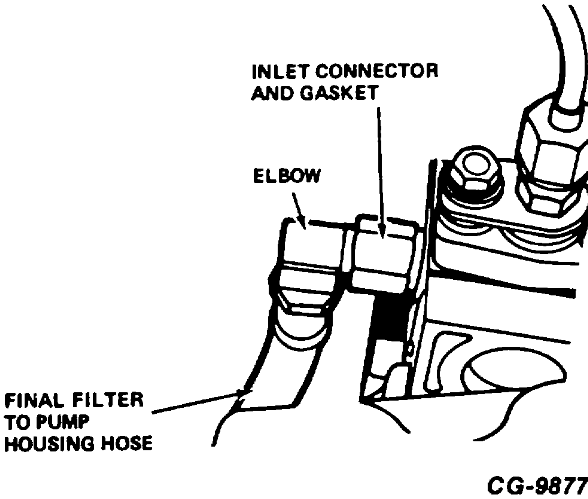


Figure 29.

REPLACING HAND PRIMING PUMP

The hand priming pump is threaded into the supply pump housing (Figure 30). After removing old priming pump, place Loctite hydraulic sealant on pump threads and install new pump with new copper washer.

ALWAYS TIGHTED HAND PRIMING PUMP HANDLE AFTER USE. THE PUMP WILL LEAK AND BE DAMAGED IF HANDLE IS LOOSE DURING ENGINE OPERATION.

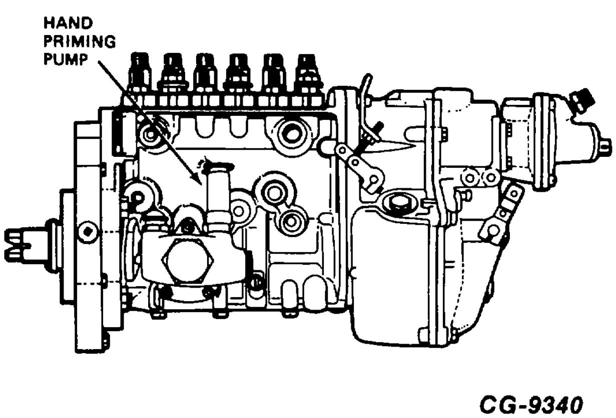


Figure 30. - Hand Priming Pump

REPLACING FUEL SUPPLY PUMP

Three washers, lock washers and nuts retain the supply pump to pump housing (Figure 31). Remove these parts, fuel inlet and oil outlet fittings and hand priming pump to remove old pump. Install new supply pump housing mounting gasket when installing new pump. The supply pump will be easier to install if engine is rotated so injection pump camshaft eccentric is in lowest position.

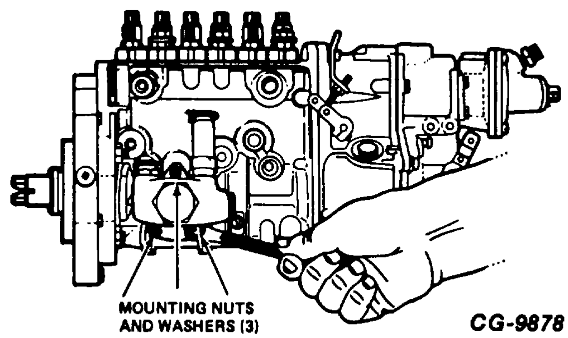


Figure 31. - Replacing Fuel Supply Pump

REPLACING LUBRICATING OIL FITTINGS

Lubricating oil enters the pump from an external oil line which originates at a crankcase fitting just above the fuel filters. The oil line connects to a brass elbow and the elbow to the injection pump inlet connector (Figure 32). If tightening these fittings does not stop oil leakage, replace oil line grommet, brass elbow or inlet connector and copper washers as necessary.

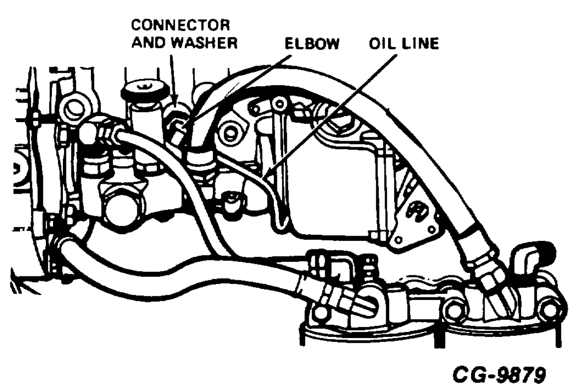


Figure 32. - Lubricating Oil Fittings

REPLACING TIMING POINTER PLUG OR GASKET

The plug should be installed using Loctite hydraulic sealant. The gasket can be re-used. (Figure 33)

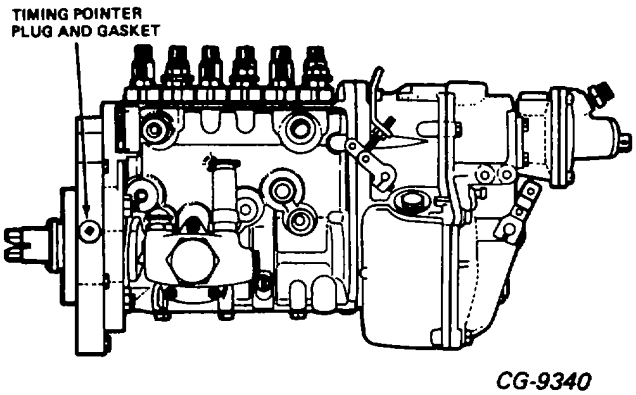


Figure 33.

ADJUSTING LOW IDLE SPEED

When the upper end of the control lever is moved fully towards the governor housing, the control lever will contact the low idle stop. The low idle speed specification, with the engine at operating temperature, is 625-675 rpm.

To adjust low idle speed, loosen locknut with a 10 mm wrench and raise or lower low idle stop (bolt) with an 8 mm wrench (Figure 34).

Raise stop to increase speed, lower to decrease speed. Tighten locknut when specified speed is reached. To compensate for parasitic loads which affect low idle speed, low idle speed should be set slightly higher so engine speed will be within specifications when load is applied. Examples of major parasitic loads are mixer drums and automatic transmissions.

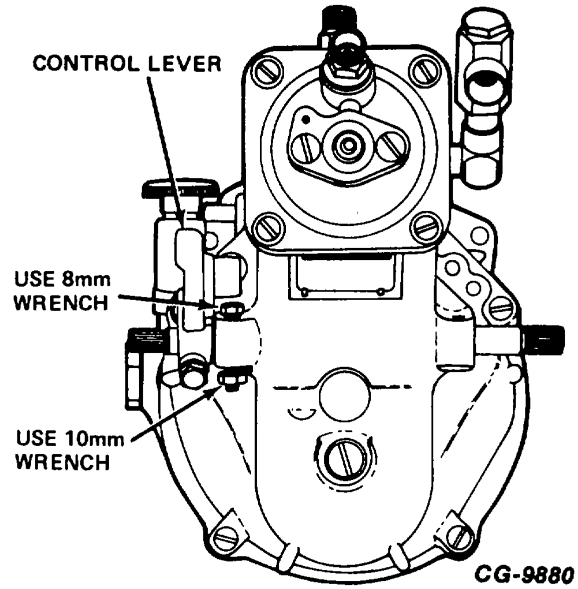


Figure 34.

REPLACING OUTER THROTTLE CONTROL LEVER

The outer throttle control lever attaches to the injection pump control shaft and is retained by a capscrew, spacer washer, washer, lock washer and nut (Figure 35). The spacer washer must be installed inside control lever slot to prevent lever breakage. Torque capscrew to 55 lb-in.

Injection pump calibration is required if the inner control lever must be replaced because individual lever dimensions vary sufficiently to affect pump calibration.

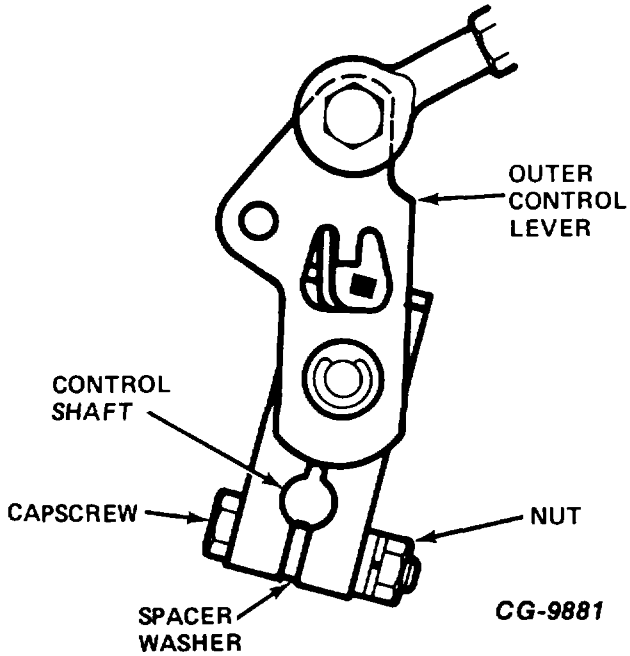


Figure 35. - Outer Throttle Control Lever

REPLACING OR REPAIRING ELECTRIC SHUTOFF SOLENOID, MOUNTING BRACKET, ADJUSTING ROD AND ROD END AND ADJUSTING LINKAGE (FIGURE 36)

All Cargostar vehicles are equipped with electric shutoffs. If a vehicle was originally equipped with cable shutoff, electric shutoff can be field installed.

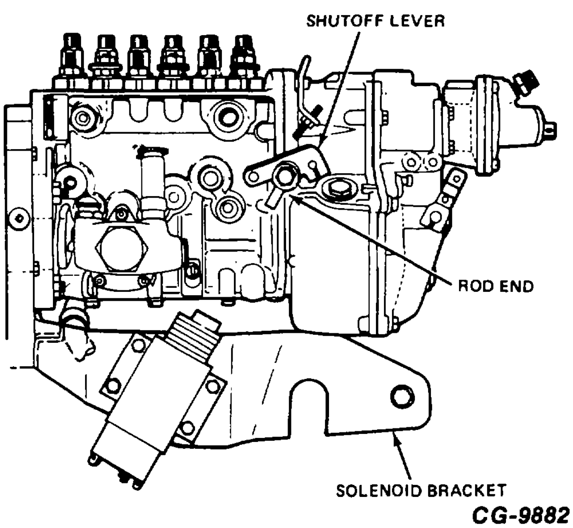


Figure 36.

Follow these procedures step by step to prevent solenoid burnout or internal damage to injection pump.

1. Remove solenoid plunger from solenoid and cap opening.

2. Assemble solenoid to bracket and tighten bolts.

3. Assemble bracket to engine at front cover and crankcase mounting locations.

4. Assemble rod end to shutoff lever and tighten bolt. DO NOT connect rod end to adjusting rod at this time.

5. Thread adjusting rod to solenoid plunger until bottomed, then tighten locknut.

6. Reinstall plunger into solenoid, depress plunger to bottom, energize solenoid using a 12 volt D.C. power source with 8 ampere "slow blow" fuse protection (Figure 37). Be sure that positive lead is connected to positive terminal, negative to negative. When solenoid is mounted to engine, the positive terminal will be closest to engine water pump and the negative terminal will be between the positive terminal and the unused auxiliary terminal. The auxiliary is closest to flywheel housing. Solenoid is to be energized through step 7.

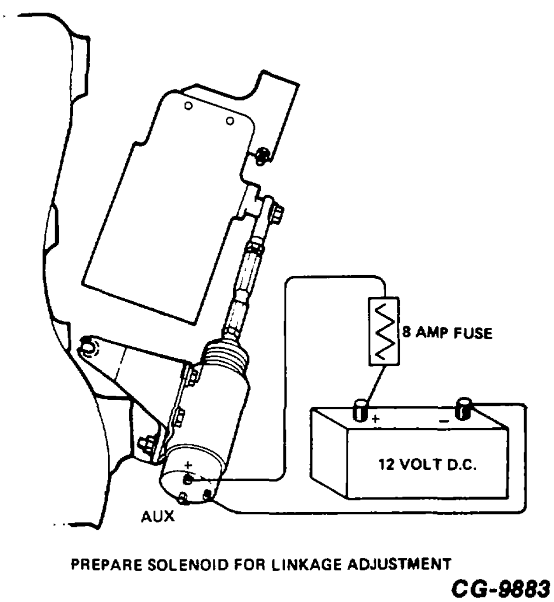


Figure 37.

Do not allow negative wire lead to contact "aux" terminal on solenoid. This will cause fuse or solenoid to burn out.

A suitable slow blow fuse is marketed by Little Fuse and is identified as 313 3AG 8A Slo-Blo.

7. Lift shutoff lever and screw adjusting rod thread into rod end until shutoff lever just stops its downward movement.

8. Turn adjusting rod upper end Two Full Turns in opposite direction (raising shutoff lever) and tighten locknut against upper rod end.

9. De-energize solenoid.

Assembly and adjusting steps 1 through 8 will ensure that solenoid plunger will be fully seated at bottom of stroke and Internal injection pump shutoff lever will not contact internal housing stop tab nor interfere with injection pump fuel rack during "excess fuel" starting conditions. Shutoff stop screw has been Factory Preset limiting solenoid plunger total travel to approximately 1.000 inch from bottom of stroke (run position) to end of stroke (shutoff position).

Do not adjust shutoff lever stop screw. If stop screw position is changed, injection pump must be removed and stop screw position set on the test bench. When stop screw is improperly adjusted, control rack may not move sufficiently to stop fuel delivery or may damage internal injection' pump rack stop.

10. Cycle solenoid 34 times to assure proper operation. After cycling solenoid, make sure solenoid rubber boot is properly seated. With solenoid energized, there should be no chatter.

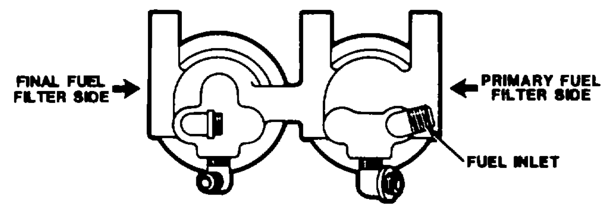
CAUTION

Do not cycle more than 6 times within one minute. additional cycling may cause pull-in coil overheating resulting in burnout.

FUEL FILTER HEADER (Figure 38)

Bleeding Air From Fuel System:

1. Loosen supply hose by loosening connector at elbow located at top of header (Figure 39).
2. Operate hand priming pump until a steady fuel flow emerges.
3. Reconnect tube to elbow and operate engine at idle for 10 minutes.



FUEL FILTER HEADER (TOP VIEW)
(IH PART NO. 676143C2

Figure 38. - Fuel Filter Header

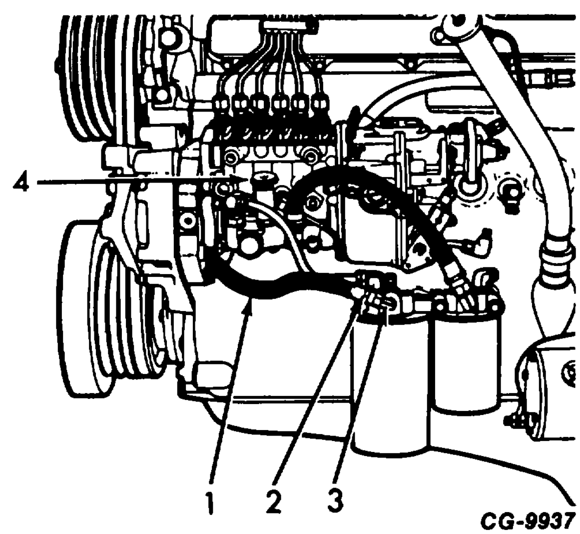


Figure 39. - Fuel Filter Header

1. Supply hose
2. Connector
3. Elbow, 90°-1/4 NPTF
4. Hand priming pump

Field Test for Transfer Pump Pressure and Inlet Restriction:

1. Disconnect supply hose by loosening connector at elbow (Figure 39).

2. Install tee fitting (IH P/N 444 121) with reducer coupling (IH P/N 444 024) and hose assembly (IH P/N 688 187 C1) with 5/8-18 45° flare swivel connectors at each end between elbow and supply hose as shown in Figure 40.

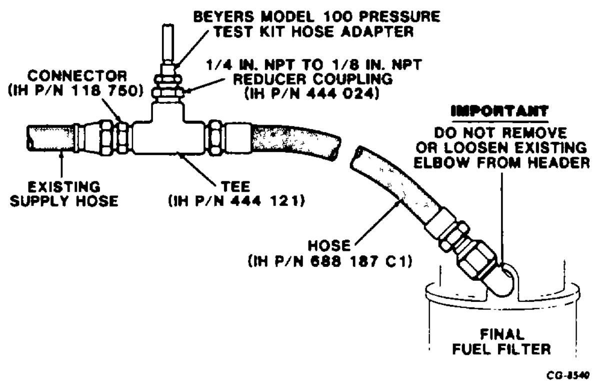


Figure 40. - Measuring Transfer Pump Pressure

3. Connect pressure gauge at reducer as shown in Figure 40.

4. Inspect throttle linkage for any binding that can restrict full travel of linkage or cause linkage to be difficult to operate.

5. Linkage should have a slight spring override at wide open throttle.

6. Inspect all lines and connectors between fuel tank and injection pump. Be sure lines are not pinched, connections are tight and valve at fuel tank is fully opened.

7. Run engine at high idle (RPM).

8. Record pressure and compare readings to specifications shown in appropriate Engine Diagnostic Manuals:

Publication	Application
CGES-240-1	**On-Highway Truck & OEM**
ISS-1526-3	**Construction Equipment**
GSS-1414-1	**Agricultural Equipment**

9. If specifications are not met, change fuel filters.

10. If changing fuel filters does not bring fuel pressure into specs, a vacuum check taken at supply inlet will measure total restriction on suction side of fuel system (between tank and supply pump).

NOTE: If installation of new fuel filters corrects reading DO NOT check inlet restriction.

Check inlet restriction as follows:

1. Install tee fitting and hose assembly (Figure 41) between pump inlet and inlet line (Figure 42).

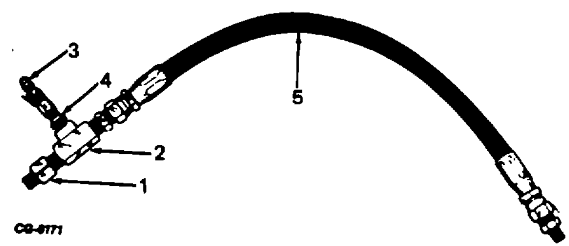


Figure 41. - Hose Assembly for Measuring Fuel Inlet Restriction

1. Connector (Part No. 118 752)
2. Tee (Part No. 120 280)
3. Standard 1/8 inch Male Connector as used in Pressure Kit (SE-2239) or (PLT-300) for Connection to Manometer or Gauge
4. Reducing Bushing (Part No. 119 933)
5. Hose (Part NO. 610 403 C91)

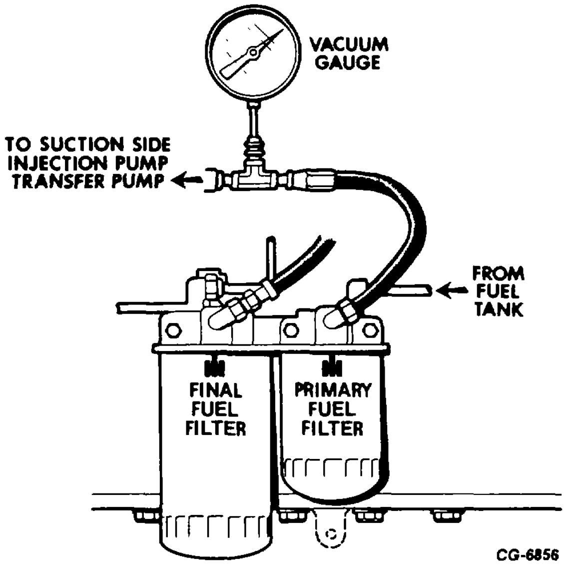


Figure 42. - Fuel Inlet Restriction Test at Supply Inlet

2. Install a vacuum gauge having a range of 0-50 kPa (0-15 in. Hg).

3. The restriction measured at full load and rated speed should be no more than 20 kPa (6 in. Hg.).

4. If low fuel pressure is evident and not caused by either a transfer pump pressure or fuel inlet restriction problem, the injection nozzles should be removed and checked for proper opening pressure or plugged orifices.

NOTE: Plugged orifices indicate foreign material in the nozzles.

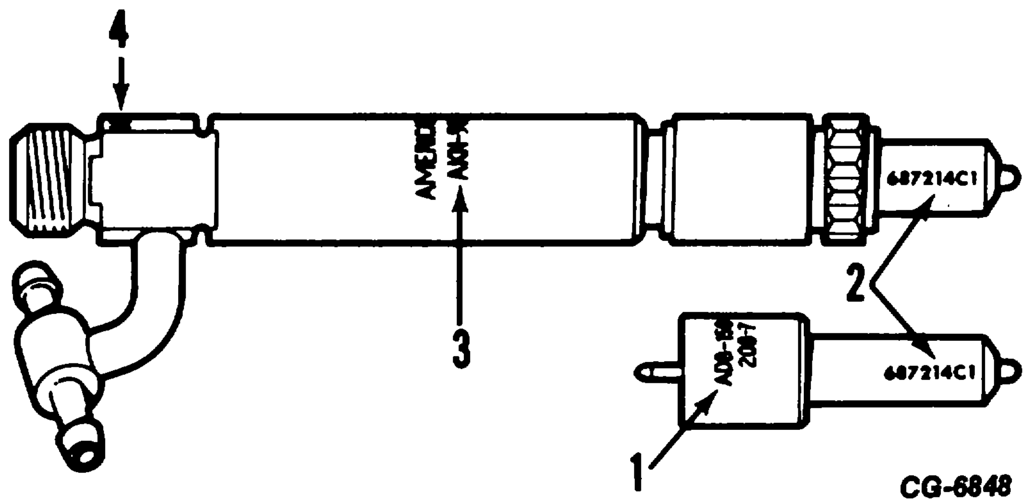


Figure 1. - Nozzle and Nozzle Holder

1. Nozzle identifying number
2. IH part number
3. Nozzle holder
4. Injection nozzle code

FUNCTIONAL DESCRIPTION OF NOZZLE AND NOZZLE HOLDER

NOZZLE

The UTDS* ADB-M type nozzles are of the closed, differential, hydraulically-operated type.

Fuel, under high pressure, flows Into the fuel duct In the body and enters the pressure chamber. When the fuel pressure in the pressure chamber exerts sufficient force on the differential area of the nozzle valve to overcome the opposing spring pre-load, the nozzle valve is lifted, allowing fuel to enter the nozzle body sac and flow through the spray holes. The fuel flowing through the spray holes is atomized as it enters the combustion chamber.

When the end of the pumping stroke occurs, there is a sudden drop in line pressure. As a result, the pressure in the nozzle pressure chamber drops rapidly. Since the pressure adjusting spring is exerting a downward force on the nozzle valve and Is no longer being opposed by fuel pressure, the nozzle valve moves downward rapidly until it seats in the nozzle body - the nozzle is now closed.

Since there is a slight amount of clearance (controlled) between the nozzle valve and body, a small amount of leakage between the valve and body will occur. This leakage is necessary for valve O D. and body I D. lubrication.

NOZZLE HOLDER

The UTDS* AKN-M type nozzle holder is a unit which retains the nozzle in the cylinder head and transfers the fuel from the high pr6ssure tubing to the nozzle duct. The holder assembly consists of a holder body, doweled nozzle spacer, lower spring seat, pressure adjusting spring, shims and a nozzle retaining nut.

The holder body contains a high pressure tubing connection at the upper end, a high, pressure fuel duct, a leak-off duct and drain connection. The lower end is counterbored to accept the pressure adjusting spring and shims. The lower face is lapped to a fine surface finish and contains two locating dowel pin holes. The lower spring seat provides a seat for the spring and a contact surface for the nozzle valve stem. The nozzle spacer contains two locating dowel pins which locate the nozzle radially to the holder body to insure proper spray pattern orientation. Both faces of the spacer are lapped to a fine surface finish to provide gasketless, high pressure seals between the holder body face, spacer faces and nozzle body face. The spacer also acts as the nozzle valve stop. The cap nut clamps the nozzle, and spacer, to the holder body.

Fuel flowing through the high pressure tubing enters the nozzle holder and flows down the high pressure duct, through the spacer duct and to the nozzle. The slight fuel leakage between the nozzle valve and body enters the spring chamber in the holder body and flows through a return duct to a drain connection.

*United Technologies Diesel Systems
(formerly AMBAC)

- INJECTION NOZZLE SPECIFICATIONS -

DIMENSION TITLE	VALUE IN METRIC MEASURE	VALUE IN ENGLISH MEASURE
Nozzle cap nut torque (with nozzle installed)	45 N•m	33 Ib-ft
Nozzle retainer bolt torque	27 N•m	20 Ib-ft
Injection high pressure line connector torque*	41 N•m	30 Ib-ft
Leakage test pressures **	3448 kPa	500 psi
Opening Pressure New or reconditioned	24820 kPa 25855 kPa	(3600 psi) (3750 psi)
Minimum opening pressure before replacement........	20,000 kPa	2900 psi

* Injection line fittings at the pump and nozzle are frequently overtightened due to the fitting size (3/4"). This wedges the injection line, often partly closing the ends. This alters fuel delivery characteristics, raises injection line pressures and causes injection pump failures. Inspect the ends of the injection lines and discard any with wedged or damaged fittings or holes.

** When subjected to 3448 kPa (500 psi) hydraulic pressure below opening pressure for 5 seconds, wetting of the nozzle tip is permissible without the formation of a droplet.

INSTALLATION

Install the Injection Pump Nozzles as follows:

1. When cylinder head is not removed, plug the nozzle opening to prevent contaminants from falling into the combustion chamber when preparing the nozzle sleeve bore for the nozzle sleeve.

2. Refer to Section 3, for a detailed procedure on nozzle sleeve installation.

NOZZLE CHART

Nozzle Holder Ass'y Original Equipment	Nozzle and Holder Ass'y Number IH ReNEWed	Nozzle Number	Code (See NOTE 1)	Nozzle Identification Number Inscribed on Valve Body (See NOTE 2)	Number and Dia. of Spray Holes mm (in)	Opening Pressure (New) (See NOTE 3)
675 960 C91*	631 570 C91	673 570 C91	A	ADB-152M-164-7	4-0.274 mm 0.0107 in	24825-28855 kPa (3600-3750 psi)
675 967 C91*	631 571 C91	673 599 C1	B	ADB-152M-165-7	4-0.314 mm 0.0122 in	24825-28855 kPa (3600-3750 psi)
682 654 C91*	749 039 C91	682 960 C1	C	ADB-150M-168-7	4-0.330 mm 0.0129 in	24825-28855 kPa (3600-3750 psi)
687 145 C91*	749 680 C91	687 146 C1	J	ADB-152M-206-7	4-0.300 mm 0.0118 in	24825-28855 kPa (3600-3750 psi)
687 372 C91*	749 945 C91	687 400 C1	P	ADB-152M-213-7	4-0.340 mm 0.0133 in	24825-28855 kPa (3600-3750 psi)
688 840 C91*	749 763 C91	687 214 C1	N	ADB-150M-208-7	4-0.350 mm 0.0137 in	24825-28855 kPa (3600-3750 psi)
691 348 C91**	735 094 C91	691 399 C1	R+	ADB-150M-228-7	4-0.350 mm 0.0137 in	24820-28855 kPa (3600-3750 psi)
1 806 169 C91		1 806 170 C1	P	N/A		24825-28855 kPa (3600-2750 psi)
1 802 769 C91		1 802 770 C1	S	ADB-150N-236-7		24825-28855 kPa (3600-3750 psi)

NOTE 1: Code located near or on top of holder.

NOTE 2: Nozzle identification number cannot be seen with nozzle assembled in holder.

NOTE 3: Readjust nozzle when opening pressure is below 20000 kPa (2900 psi).

* Used on 300 and 400 Series Engines.

** Used on 400 Series Engines with Injection Pump Part Nos. 691 344 C91 and 691 345 C91

\+ Indicates close controlled sac volume to reduce emissions.

ROBERT BOSCH

MODEL PE(S)-6 MW

FUEL INJECTION PUMP

SERVICE MANUAL

FORM CGES-375

SEPTEMBER, 1984

Printed in United States of America

SERVICE MANUAL

FORWARD

This manual is part of a series of manuals intended to assist service technicians in maintaining International® Engines in accordance with the latest technical advancements.

Due to a commitment of continuous research and development some procedures, specifications and parts may be altered to improve International® products and introduce technological advances.

Periodic revisions may be made to this publication and mailed automatically to "Revision Service" subscribers. The following literature supporting the 400 Series Diesel Engine is available from:

Forward Requests to:	International Harvester Company Printing, Procurement and Distribution 807 Blackhawk Drive Westmont, Illinois 60559

FORM NO.	DESCRIPTION
CGES-185-3	300/400 Series Engine Service Manual
1 171 575 R1	DT/DTI-466C Diesel Engine Operation Manual
CGES-240-3	Diesel Engine Diagnostic Manual
CGED-365	Diagnostic Form (DT/DTI-466C)

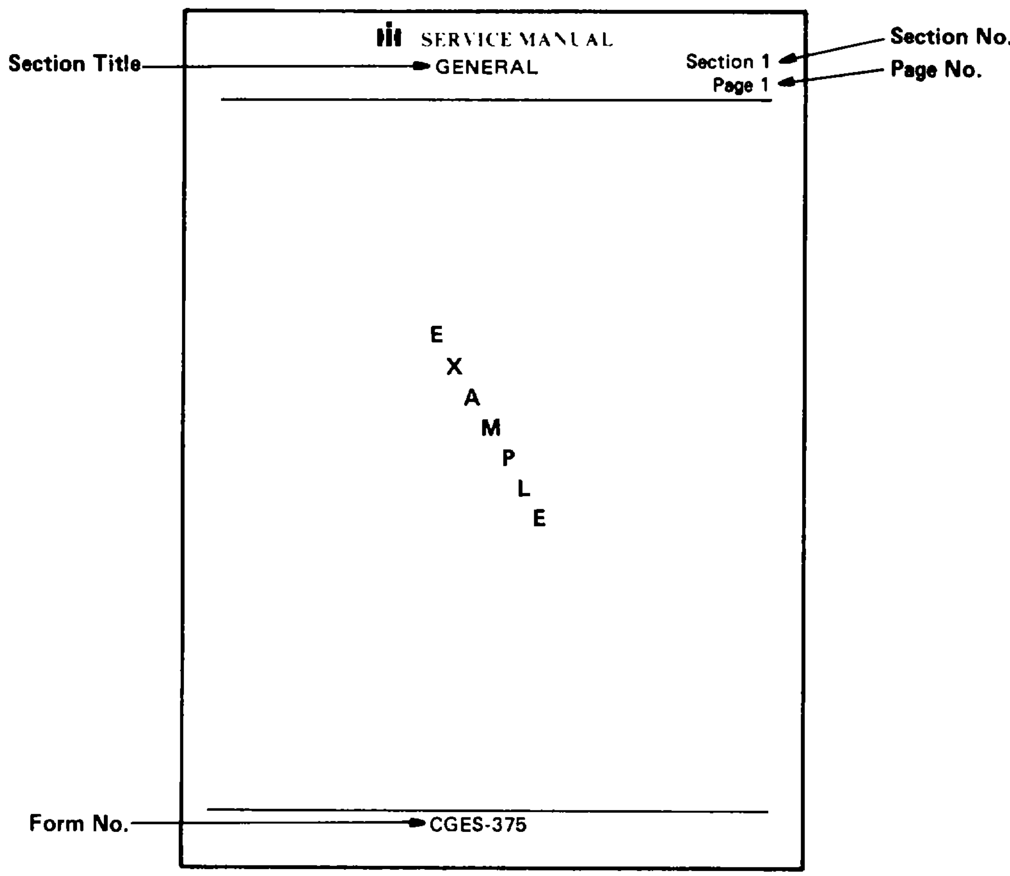
CGES-375
Printed in United States of America

SERVICE MANUAL

INTRODUCTION

This manual is arranged in sections with the pages numbered consecutively in each section. Any drawings are also numbered consecutively in each section. Included at the top of each page is the section title, section number and page number. The bottom center of each page will show the manual form (i.e. CGES-375).

NOTE: Future revisions will be indicated by a dash one, dash two, etc. after the form number (i.e. CGES-375-1 will be revision number one).



An index arranged according to sections will be found at the beginning of this manual. This manual is divided into six sections which are:

SECTION ONE - - General Pump Information

SECTION TWO - Disassembly

SECTION THREE - Cleaning and Inspection

SECTION FOUR - Reassembly

SECTION FIVE - - Calibration

SERVICE MANUAL

TABLE OF CONTENTS

Printed in United States of America

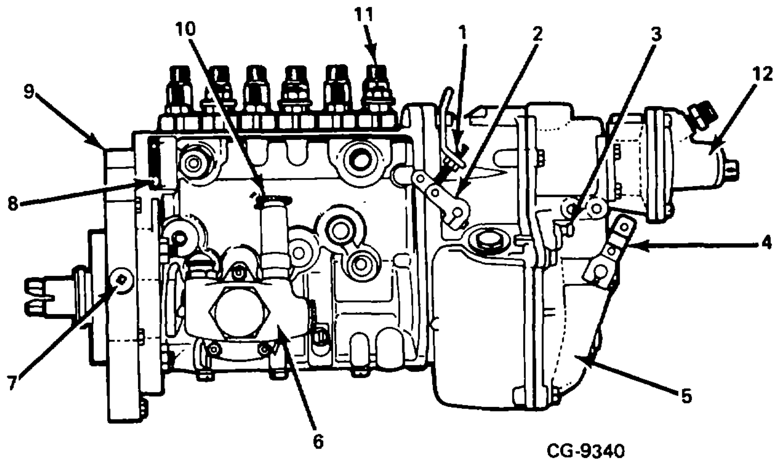


Figure 1. Robert Bosch Model MW Fuel Injection Pump

1.	Shut-off Stop Screw	5.	RQV Governor Housing	9.	Mounting Adapter
2.	Shut-off Lever	6.	Fuel Supply Pump	10.	Hand Priming Pump
3.	High Idle Stop	7.	Timing Pointer Plug	11.	Plunger
4.	Throttle Lever	8.	Serial Number Plate	12.	Aneroid

DESCRIPTION

The Robert Bosch Model PE(S)-6MW Injection Pump is used on the International DT-466C diesel engine.

The injection pump is an in-line, plunger type, with an individual plunger and barrel pumping element for each engine cylinder. The injection sequence is 1,5, 3, 6, 2, 4.

The injection pump assembly incorporates mechanical, flyweight type RQV variable speed governor.

The pump throttle lever and the high-speed stop screw are located on the left side of the governor assembly. The fuel shut off lever is also located on the left side of the governor.

The injection pump is located on the left side of the engine. High pressure lines connect the pump to the nozzles. Operating and service instructions for the nozzles are given in CGES-200-2 Service Manual.

IDENTIFICATION

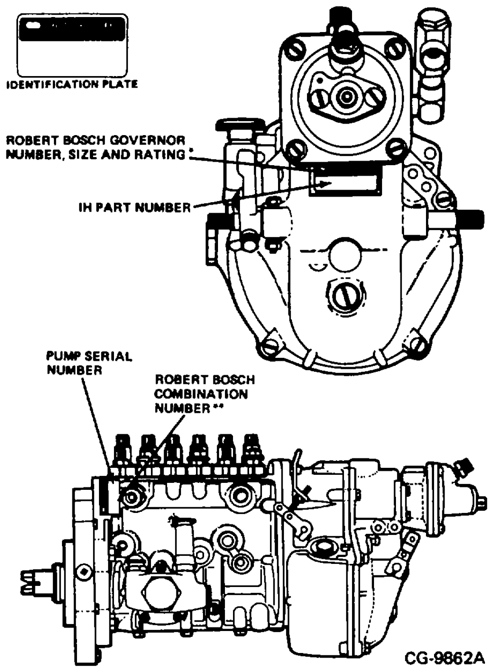
Identification of injection pump and governor can be made by referring to two nameplates, one on the rear of the governor housing, and one on the front top left of the injection pump (Figure 2). The nameplate on the rear of the governor gives the IH part number of the complete pump and governor assembly and the Robert Bosch governor number, size and rating. The nameplate on the left side, gives the Robert Bosch pump description number.

OPERATING PRINCIPLES

The injection pump is the in-line type with an individual plunger and barrel pumping element for each engine cylinder. Each plunger stroke is constant, but its effective pumping (metering) stroke is variable and is controlled by the positioning of a common control rack connected through linkage to the governor and the vehicle's throttle lever.

The individual plunger and barrel pumping elements receive fuel at supply pump pressure from the injection pump housing fuel gallery, and forces it under very high pressure through the injection nozzles into the engine combustion chamber.

The injection pump plungers are moved by tappet assemblies which ride on the lobes of the injection pump camshaft. The injection pump camshaft is timed to the engine to inject fuel into each cylinder at the proper time.



* Code for Robert Bosch governor number RQV 350 1200 MW 43-5:

R	= Flyweight governor
Q	= Fulcrum lever model
V	= Variable speed governing (all-speed)
350	= Low idle pump speed
1200	= Full load rated speed
MW	= Fits on "MW" size pump
43-5	= Application number

** Code for Robert Bosch combination number PES 6MW 100/320 RS 1108:

PE	= Inline injection pump
S	= Flange mounted
6	= Number of cylinders
MW	= "MW" size pump
100	= Plunger diameter in 1/10 mm
/	= Pump model
320	= Number code for location of feed pump and governor
R	= Rotation of pump as seen from drive end (right hand clockwise)
S1108	= Application number

Figure 2. Injection Pump Identification

Each plunger has a delivery valve above the plunger. The delivery valve, which is held on its seat by spring pressure, prevents fuel from draining out of the high pressure line between pumping cycles.

The injection cycle can be described by observing the plunger in its four principle positions in the barrel. The four positions are shown in Figure 3.

At bottom dead center the plunger is held down on the lowest point of the cam lobe by the plunger spring. Top of plunger is below the charging port of barrel. Fuel at supply pump pressure flows through the charging port to fill the area above the plunger.

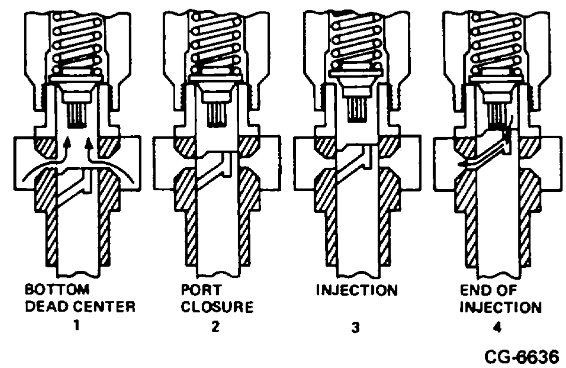


Figure 3. Four Principle Plunger Positions of Injection Cycle

1. Bottom Dead Center
2. Port Closure
3. Injection
4. End of Injection

Port closure begins when the rising plunger covers the charging port and fuel is trapped above the plunger.

Start of injection occurs as the plunger continues with charging ports covered, fuel is forced upward under high pressure, unseats the delivery valve and is injected into the cylinder.

End of injection occurs when the plunger moves up to the point where the charging port is again uncovered by the lower helix. Fuel pressure above the plunger is relieved to the charging gallery. This pressure drop allows delivery valve and injection nozzle to seat thus ending injection.

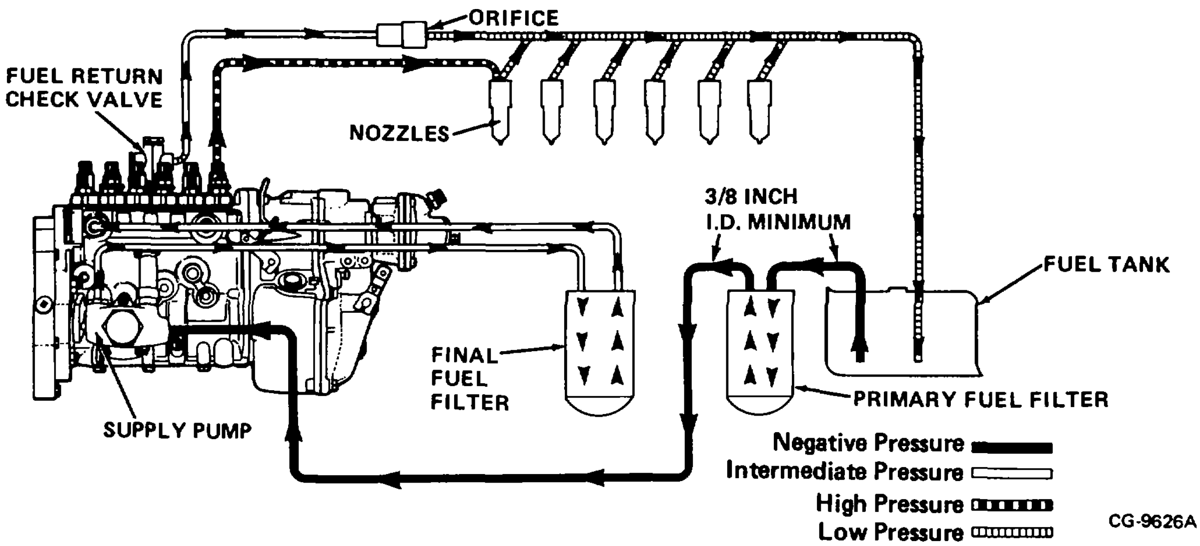


Figure 4. Fuel System Flow

FUEL SYSTEM FLOW

As fuel travels through the fuel system, it will be under suction (negative pressure), intermediate pressure, high pressure (injection pressure) and low pressure (Figure 4).

Negative Pressure

The piston type supply pump creates a suction at its inlet and pulls fuel from the fuel tank, through the fuel supply lines and through the primary fuel filter. No filter is used on the fuel suction line extending into the fuel tank because wax particles could plug the filter in cold weather. Fuel lines and fittings between the supply pump inlet and the fuel tank must be a minimum of three-eighths inches inside diameter. Small diameter fuel supply lines or fittings will reduce fuel flow and can reduce engine power output.

Intermediate Pressure

The supply pump produces an intermediate pressure, called supply pump pressure, at its outlet and forces fuel through the final fuel filter and into the injection pump housing. Fuel under intermediate pressure surrounds each barrel assembly. Fuel pressure in the housing is controlled by the orificed fitting in the fuel return hose located "downstream" of the fuel return check valve and the supply pump piston spring calibration. A special rubber hose between the final filter outlet and the injection pump housing dampens pressure waves from the supply pump. Substitute hoses can cause lower engine power even though supply pump pressure can be within specifications.

High Pressure

The injection pump meters and delivers fuel at high pressure, up to an instantaneous 9000 psi pressure after nozzle valve opening, through the injection pipes or lines to the injection nozzle assemblies. This high pressure fuel causes the nozzle valve to open and fuel flows through the nozzle orifices into the combustion chamber. The amount of fuel delivered is controlled by the injection pump governor. A small amount of low pressure fuel returns from the nozzle assemblies to the fuel tank through the leakoff lines.

Low Pressure

An orifice fitting in the end of fuel hose from the fuel return check valve limits the amount of fuel returned to the fuel tanks. After fuel passes through the orifice, it is at low pressure.

METERING

Metering (providing proper amount of fuel to meet engine requirements at various loads and speeds) is accomplished by rotating the plunger in its barrel to change the effective pumping stroke. The effective stroke is the distance traveled upward by the plunger from the time the charging port is covered until it is again uncovered by the lower helix. A short effective stroke means a small amount of fuel is injected. As effective stroke increases, the amount of fuel injected increases.

The metering function can be described by observing the relationship of plunger helix to barrel charging port under various metering positions as shown in Figure 5.

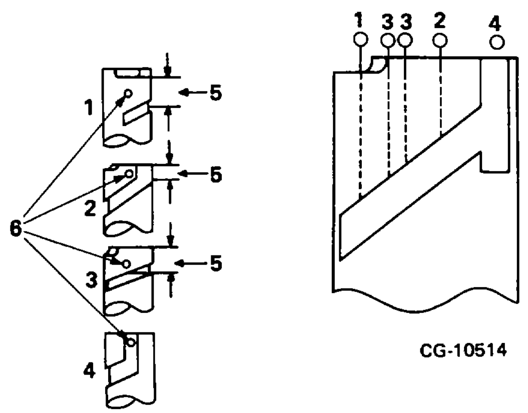


Figure 5. Helix and Charging Port Metering Positions

1. Start Position (Charging Port Closed)
2. Idle Position (Charging Port Closed)
3. Full Load Position (Charging Port Closed)
4. Stop Position (Charging Port Open)
5. Effective Stroke
6. Charging Port Position

Starting (Excess Fuel)

For starting, plunger is rotated by control rack to a point where the maximum effective stroke (port closing to port opening) is obtained. When engine starts, release accelerator pedal. This rotates plunger out of start fuel position to decrease fuel delivery.

Engine Operating (Metered Delivery)

At engine operating speeds from idle through maximum governed speed, the quantity of fuel delivered is determined by effective stroke (port closing to port opening) as controlled by the position of the throttle lever and governor.

Engine Stop (No Delivery)

To stop the engine, plungers are rotated so that vertical slots (stop slots) are in line with barrel ports. As plunger moves up and down fuel is transferred back and forth from top of plunger through vertical slots and into charging gallery. The ports do not close - thus, no delivery.

Plungers are rotated to the various metering positions by the control rack. Rack movement is controlled by the throttle lever and governor speed.

PUMP FEATURES

Mounting Adapter

A mounting adapter (9, Figure 1) incorporating four studs attaches to the injection pump housing. Capscrews through the injection pump drive gear cover secure the mounting adapter to the engine front plate. Removal of the timing pointer plug (7, Figure 1) in the adapter is necessary when verifying or adjusting pump to engine timing.

The mounting adapter is an integral part of the injection pump because it contains the timing pointer. During injection pump calibration, a port closure mark is stamped on the injection pump hub directly in line with the pointer. Because the timing pointer is located on the mounting adapter and the mounting adapter is fastened to the injection pump housing by the four studs and nuts, these four nuts should not be loosened.

Loosening the nuts and rotating the pump housing in relationship to the mounting adapter will change the relationship of the timing pointer/hub mark which was established during injection pump calibration.

Supply Pump With Hand Priming Pump

The piston-type supply pump (6, Figure 1) is activated by the eccentric on the injection pump camshaft and serves as a mount for the hand priming pump (10, Figure 1). Since all fuel entering the injection pump must be filtered to ensure long pump life, the hand priming pump should be used when changing fuel filters. Always install the fuel filters "dry" and use the hand pump to fill the filters and bleed air from the fuel system.

Aneroid Assembly

Exhaust smoke levels during engine acceleration are controlled by using an aneroid (12, Figure 1). The aneroid limits fuel delivery during acceleration until the turbocharger speed is sufficient to provide adequate air for complete combustion. An external line connects the intake manifold to the aneroid to allow manifold pressure to activate the aneroid. A leak in the aneroid diaphragm or intake manifold to aneroid line will cause the injection pump to stay in the "cutback" position, and reduce engine power.

Fuel Return Valve

A fuel return check valve is mounted to the injection pump housing (1, Figure 6) and all fuel that is not injected passes through the check valve and then through a special orificed rubber hose. The function of the fuel return check valve is to provide

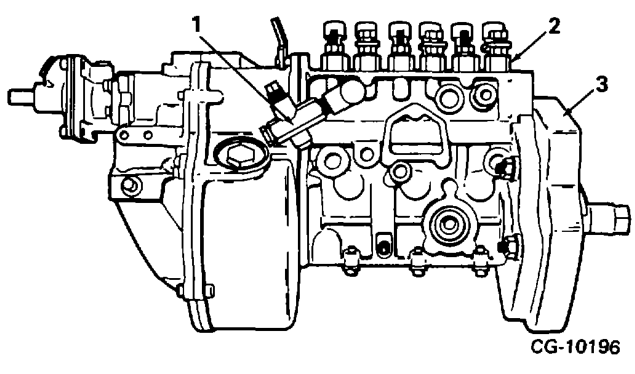


Figure 6. Right Side View of Injection Pump

1. Fuel Return Valve
2. Delivery Valve Holder
3. Drive Gear

a positive seal to prevent fuel from draining out of the pump housing when the engine is stopped. The fuel return check valve opens at approximately 18 psi. Therefore, total fuel flow through the injection pump housing is controlled by the orifice in the rubber hose as long as the supply pump pressure is above 18 psi. After the fuel flows through the orifice, the fuel pressure drops from the intermediate pressure ahead of the orifice to low pressure (Figure 4).

GOVERNOR

The mechanical flyweight governor (5, Figure 1) which is mounted on the injection pump, is the variable speed type, identified by the manufacturer as ROV 350-1200 (or -1300). The 350-1200 (or -1300) designation refers to the injection pump speed range in which the governor functions. This corresponds to 700 to 2400 (or 2600) engine RPM, since the pump camshaft rotates at 1/2 engine speed. Figure 7 illustrates a typical cut-away view of the RQV governor

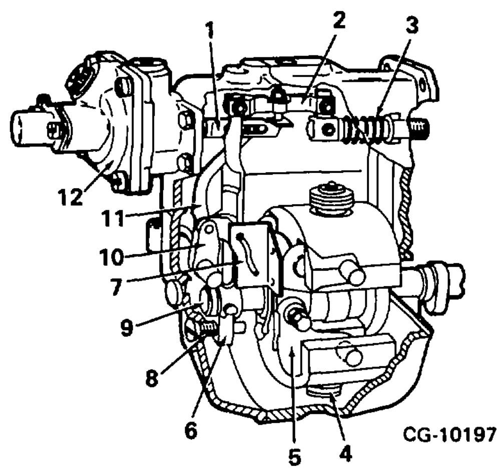


Figure 7. Cut-Away View of Governor Assembly

1. Stop Shackle
2. Rack Link
3. Control Rack
4. Governor Springs
5. Bell Crank
6. Sliding Block
7. S-Plate
8. Guide Pin
9. Adjusting Pin
10. Guide Lever
11. Rocker Arm
12. Aneroid

The functions of the governor are:

(1) limit minimum (lo-idle) engine speed, (2) limit maximum engine speed and (3) maintain smooth speed control (without stalling, surging or hunting) within the limits of its regulation throughout the operating speed range of the engine.

The all-speed governor provides speed control at any fixed position of the control lever (accelerator pedal). This provides the vehicle operator with the most satisfactory driving characteristics. The governor tends to keep engine speed constant at the level determined by position of the accelerator pedal and automatically increases or reduces fuel delivery in response to minute changes in engine speeds without a significant change in road speed and without the operator changing position of the accelerator pedal.

The transfer pump, a single action none positive displacement plunger type pump, is driven by the injection pump camshaft.

The transfer pump can supply more fuel than is required for injection. Excess fuel, utilized for cooling injection pump, is routed from the injection pump fuel gallery back to the fuel pump.

NOZZLE

The American Bosch ADB-M type nozzles (Figure 8) are of the closed differential hydraulically-operated type.

Fuel, under high pressure, flows into the fuel duct in the body and enters the pressure chamber. When fuel pressure in the pressure chamber exerts sufficient force on the differential area of the nozzle valve to overcome the opposing spring preload, the nozzle valve is lifted, allowing fuel to enter the nozzle body sac and flow through the spray holes. The fuel flowing through the spray holes is atomized as it enters the combustion chamber.

When the end of the pumping stroke occurs, there is a sudden drop in line pressure. As a result, the pressure in the nozzle pressure chamber drops rapidly. Since the pressure adjusting spring is exerting a downward force on the nozzle valve and is no longer being opposed by fuel pressure, the nozzle valve moves downward rapidly until it seats in the nozzle body - the nozzle is now closed.

Since there is a slight amount of clearance (controlled) between the nozzle valve and body, a small amount of leakage between the valve and body will occur. This leakage is necessary for valve O.D. and body I.D. lubrication.

NOZZLE HOLDER

The American Bosch AKN-M type nozzle holder (Figure 8) is a unit which retains the nozzle in the cylinder head and transfers the fuel from the high pressure tubing to the nozzle duct. The holder

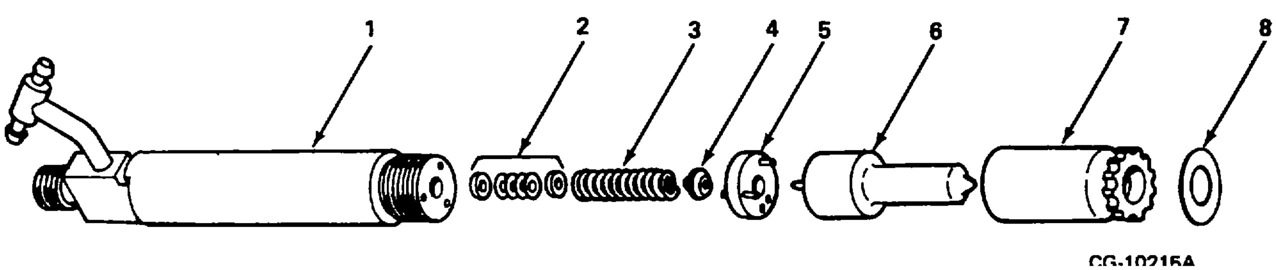


Figure 8. Exploded View of Fuel Injection Nozzle and Holder Assembly

1. Holder Body
2. Shim(s)
3. Pressure Adjusting Spring
4. Spring Seat Guide
5. Valve Stop Spacer
6. Nozzle Body and Nozzle Valve
7. Cap Nut
8. Copper Gasket

assembly consists of a holder body, doweled nozzle spacer, lower spring seat, pressure adjusting spring, shims and a nozzle retaining nut.

The holder body contains a high pressure tubing connection at the upper end, a high pressure fuel duct, a leak-off duct and drain connection. The lower end is counterbored to accept the pressure adjusting spring and shims. The lower face is lapped to a fine surface finish and contains two locating dowel pin holes. The lower spring seat provides a seat for the spring and a contact surface for the nozzle valve stem. The nozzle spacer contains two locating dowel pins which locate the nozzle radially to the holder body to insure proper spray pattern orientation. Both faces of the spacer are lapped to a fine surface finish to provide gasketless, high pressure seals between the holder body face, spacer faces and nozzle body face. The spacer also acts as the nozzle valve stop. The cap nut clamps the nozzle and spacer to the holder body.

Fuel flowing through the high pressure tubing enters the nozzle holder and flows down the high pressure duct, through the spacer duct and to the nozzle. The slight fuel leakage between the nozzle valve and body enters the spring chamber in the holder body and flows through a return duct to a drain connection.

PUMP SPECIFICATIONS

Injection Pump Type	In-Line Plunger
Pump Speed	One-Half Engine Speed
Pump Rotation (Viewed From Drive End)	Clockwise
Firing Order	1, 5, 3, 6,2, 4
"Slider-to-Housing" Distance	39.15 t 0.2 mm (1.54± .008 in.)
Basic Setting of S-Plate	21.5 ± 0.2 mm (.847 ± .008 in.)
Camshaft Protrusion	20.7 - 22.2 mm (.817 - .877 in.)'
Axial End Play of Governor Weight Assembly	.05 - .10 mm (.002 - .004)

TOOLS		
Quantity Required	**Robert Bosch Part Number**	**Description**
1	KDEP 2919/A	Holding Fixture
1	KDEP 2988	Camshaft Slotted Cylindrical Nut Remover (also used for reassembly).
1	KDEP 2886	Governor Flyweight Remover
1	KDEP 1056	Side Plug Puller
3	KDEP 1068	Tappet Holder
1	KDEP 1505	Tappet Depressor
1	KDEP 1066	Assembly Jig
1	9 681 238 902	Spacer Ring Installer
3	KDEP 1052	Plunger Retainer
2	KDEP 1057	Spacer Plate
1	KDEP 1059	Bearing Installer
1	KDEP 1069	Ball Bearing installer
1	KDEP 1058	Side Plug Installer
1	1 682 329 038	Guide Bolt Gauge
1	9 681 238 904	S-Plate Gauge
1	KDEP 2949	Screwdriver Bit
1	1 413 462 040	Plug
1	2 916 710 611	Copper Gasket
1	1 688 130 030	Bracket (Rack Travel)
1	1 687 233 015	Dial Indicator
2	9 683 233 302	Fuel Gallery Plug 1/4 NPT (for high pressure phasing)
1	1 413 462 040	Fuel Gallery Plug M16 Thread (LPC)
1	1 683 350 065	Adapter Bushing
1	1 682 012 008	Pin for LPC (lift-to-port closure) Gauge
1	1 688 130 135	Plunger Lift Device
1	1687 233 012	Dial Indicator (LPC)
1	1 683 350 066	Adapter Bushing (LPC)
1	KDEP 2989	Governor Spring Adjusting Wrench
1	KDEP 1047	Aneroid Tool (Full Load)
1	KDEP 1048	Aneroid Tool (Cutback)
6	1 688 901 016	Test Nozzle Holder Assy (.5 mm orifice)

Additional Tools Required When Using Robert Bosch Test Stand		
Quantity Required	**Robert Bosch Part Number**	**Description**
1	KDEP 2885	Coupling Wrench
1	KDEP 2916	Coupling Puller
1	KDEP 2963	Pump Holding Bracket
1	0 681 440 006	Governor Setting Protractor
2	1 683 457 020	Fuel Gallery Adapter
1	1 685 720 060	Mounting Flange
1	1 687 233 015	Dial Indicator
2	1 688 030 122	Support Bracket
1	1 688 130 095	Dial Indicator Stand
6	1 688 901 016	Test Nozzle Holder Assy (.5 mm orifice)
1	9 681 236 402	Drive Coupling
1	9 681 237 201	Aneroid Tester

Bacharach Calibration Stand Accessories*		
Quantity Required	**Bacharach Part Number**	**Description**
1	67-6635	Adapter
6	77-0194	Fuel Lines (6 mm OD x 2 mm ID x 600 mm Length)
1	67-6973	Spacer Assembly
1	67-5387	Flange Mounting Bracket, use #67-4125 for Rail Type Stands.
1	67-2863	Drive Hub 25 mm
1	67-5649	Throttle Arm Positioner, use #67-3905 for Rail Type Stands.
2	67-0916	Rubber Hose Assembly (1/2 ID x 36")
2	67-0915	PVC Hose (1/2 ID x 36")
1	67-5538	Base Bracket, use #67-2861 for Rail Type Stands.

*Calibration Stand of 10 HP or more is recommended. Existing 5 HP bench is acceptable.

TOOL SOURCE ADDRESS LIST

Robert Bosch Corporation
2800 South 25th Avenue
Broadview, IL 60153

Viscosity Oil Company
3200 South Western Avenue
Chicago, IL 60608

Bacharach Instruments
Division of United Technologies
625 Alpha Drive
R.I.D.C. Industrial Park
Pittsburgh, PA 15238

TORQUE CHART

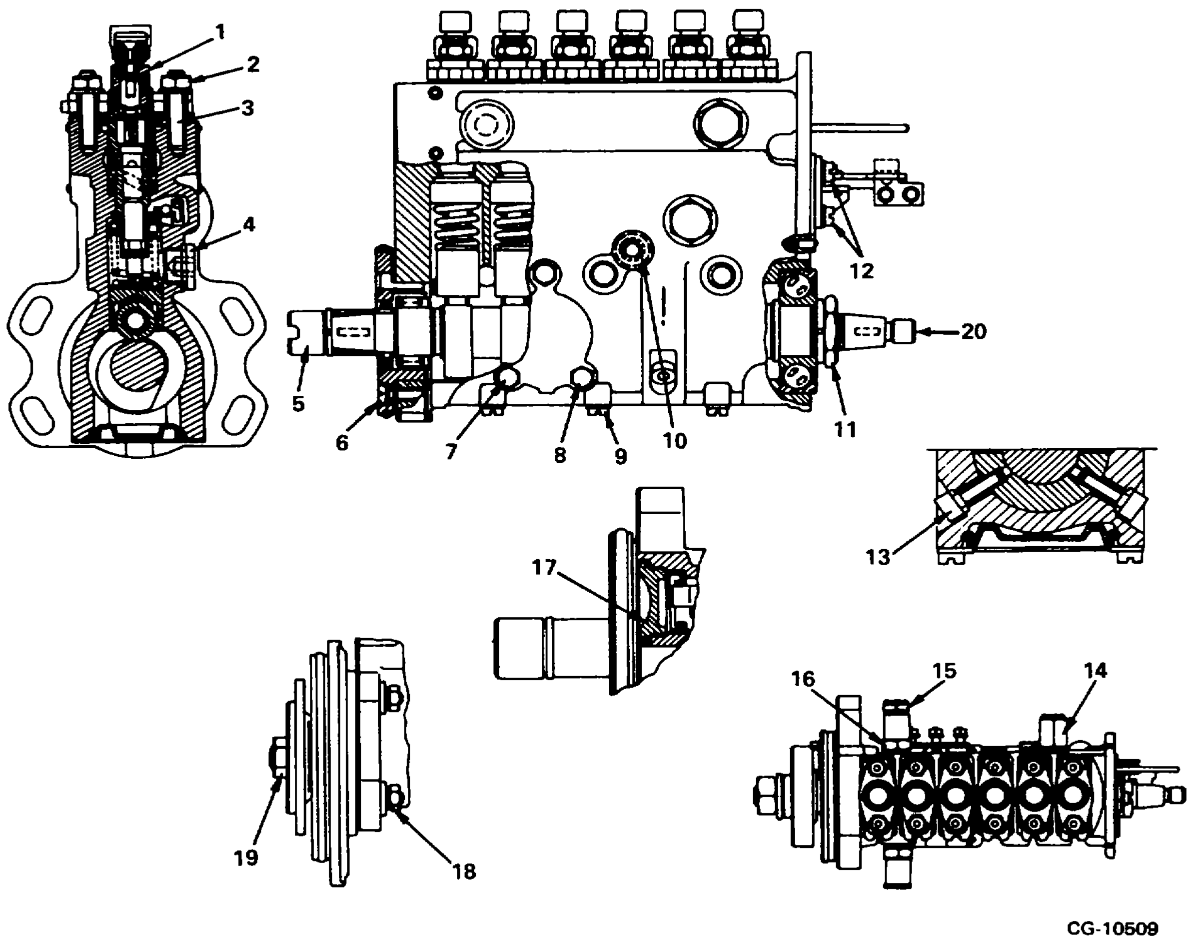


Figure 9. Torque

1. Delivery Valve Holder 60 minus 10 N•m (43 minus 7 ft-lbs)
2. Barrel Flange Nut 20-25 N•m (14-18 ft-lbs)
3. Barrel Stud 8-13 N•m (6-10 ft-lbs)
4. Lift to Port Closure Plug 3040 N•m (22-30 ft-lbs)
5. Injection Pump Hub Nut 85-100 N•m (83-74 ft-lbs)
6. Bearing End Plate 10-12 N•m (7-8 ft-lbs)
7. Transfer Pump Mounting Studs 3-4 N•m (2-3 ft-lbs)
8. Transfer Pump Mounting Nuts 4-7 N•m (3-5 ft-lbs)
9. Bottom Cover Screws 4-7 N•m (3-5 ft-lbs)
10. Oil Inlet Fitting 3040 N•m (22-30 ft-lbs)
11. Camshaft 100-120 N-m (74-88 ft-lbs)
12. Lock Plate Screws 4-7 N•m (3-5 ft-lbs)
13. Camshaft Support Bearing Screw 8-10 N•m (6-7 ft-lbs)
14. Fuel Return Valve 30-40 N•m (22-30 ft-lbs)
15. Fuel Fitting 30-40 N•m (22-30 ft-lbs)
16. Fuel Inlet Fitting 30-40 N•m (22-30 ft-lbs)
17. Rack Housing Plug 45-55 N•m (33-40 ft-lbs)
18. Adapter Nuts 45-50 N•m (33-36 ft-lbs)
19. Adapter Nut 100-110 N•m (74-81 ft-lbs)
20. Governor Weight Nut 54 N•m (40 ft-lbs)

Not pictured - governor mounting screws 6-8 N•m (4-6 ft-lbs)

DISASSEMBLY

Special Tools

To overhaul the pump assembly, metric wrenches and sockets will be required. Special rebuild tools called out throughout the text will speed repair and protect parts from damage. See Service Tool Chart (Section 1, Page 8).

PREPARATION

Pump and governor repair should be performed in a clean area free from airborne dirt. A separate injection room is preferred. Work bench, vise and tools should be clean. The use of trays is recommended for keeping injection pump parts in order. The pump assembly should be thoroughly cleaned before disassembly. Use only clean solvent and clean filtered test oil to clean injection pump parts.

Prepare the pump for disassembly as follows:

1. Drain fuel and lubricating oil from pump and governor housings.
2. Cap or plug fuel and lube oil openings after draining.
3. Use clean diesel fuel or kerosene to clean exterior of pump and governor assembly.
4. Clamp holding fixture KDEP 2919/A (Figure 1) in vise. Remove two pump housing to adapter bolts. Secure injection pump assembly to holding fixture.

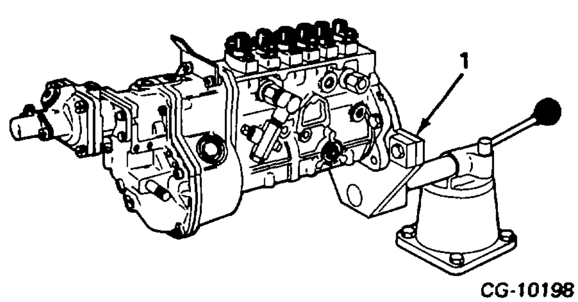


Figure 1. Injection Pump Mounted in Holding Fixture

1. Holding Fixture KDEP 2919/A

5. Remove fuel supply pump mounting bolts (Figure 2). Remove supply pump and drain lubricating oil into a container.
6. Remove fuel return valve. Hold adapter in place with a 3/4 inch wrench while removing elbow and valve body (Figure 3).

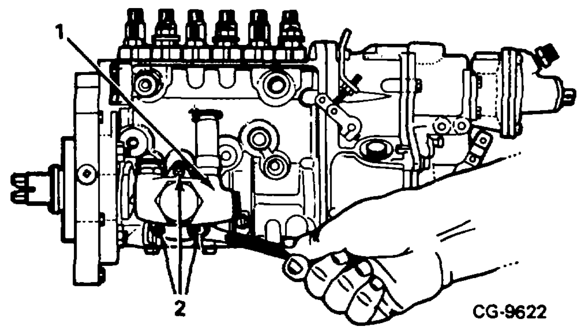


Figure 2. Removing Fuel Supply Pump

1. Fuel Supply Pump
2. Mounting Bolts

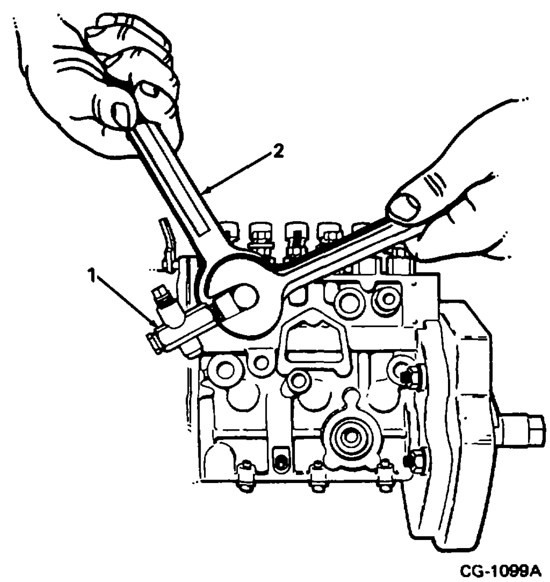


Figure 3. Fuel Return Valve Removal

1 Fuel Return Valve
2. 3/4 Inch Wrench

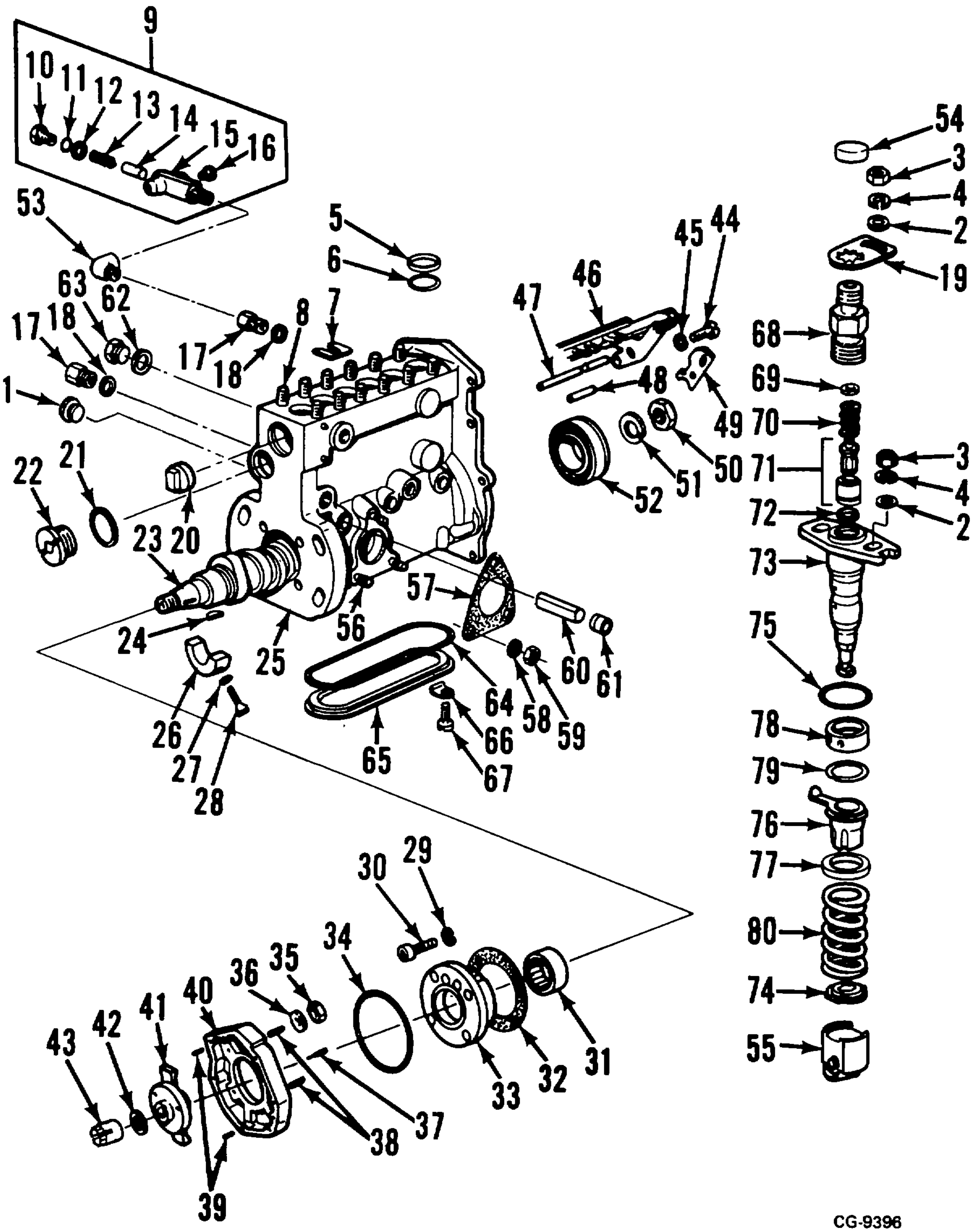


Figure 4. Exploded View of Pump Housing

Legend for Figure 57.

1. Housing Screw Plug
2. Housing Stud and Plunger Plate Lock Spacer
3. Housing Stud and Plunger Plate Lock Nut
4. Housing Stud and Plunger Plate Lock Washer
5. Housing Plunger Spacer
6. Housing Plunger O-Ring
7. Plunger and Barrel Shim
8. Pump Housing Stud
9. Check Valve Assembly
10. Plug
11. Piston Plug Gasket
12. Washer (.0.3 mm)
13. Piston Spring
14. Valve Stem
15. Valve Body
16. Piston Plug
17. Fuel In & Out Fitting
18. Fuel In & Out Fitting Gasket
19. Plunger Lock Plate
20. Housing Rack Plug
21. Housing Plug Gasket
22. Housing Screw Plug
23. Injection Pump Camshaft
24. Camshaft Woodruff Key
25. Pump Housing Assembly
26. Camshaft Support
27. Support Lock Washer
28. Camshaft Support Screw
29. Front Bearing Housing Washer
30. Front Bearing Housing Screw
31. Camshaft Front Bearing
32. Front Bearing Housing Gasket
33. Front Bearing Housing
34. Front Bearing Housing Ring
35. Adapter Stud Nut
36. Adapter Stud Washer
37. Timing Pointer
38. Adapter Stud
39. Dowel Pin
40. Pump Mounting Adapter Assembly
41. Injection Pump Hub
42. Pump Drive Hub Lock Washer
43. Pump Drive Hub Nut
44. Control Rack Screw
45. Control Rack Washer
46. Plunger Control Rack
47. Pump Rack Pin
48. Stop Plate Pin
49. Stop Plate
50. Camshaft Rear Nut
51. Camshaft Rear Lock Washer
52. Camshaft Rear Bearing
53. Overflow Elbow
54. Delivery Valve Sealing Cap
55. Roller Tappet Assembly
56. Pump Housing Fuel Supply Stud
57. Fuel Supply Pump Gasket
58. Lock Washer
59. Supply Pump Stud Nut
60. Camshaft Spacer
61. Camshaft Plug
62. Port Closure Plug Gasket
63. Port Closure Plug
64. Bottom Cover Gasket
65. Housing Bottom Cover
66. Cover Screw Lock Washer
67. Bottom Cover Screw
68. Delivery Valve Holder
69. Valve Spring Washer
70. Delivery Valve Spring
71. Delivery Valve With Cap
72. Delivery Valve Gasket
73. Plunger and Barrel
74. Lower Spring Seat
75. Impact Cap O-Ring
76. Control Sleeve
77. Upper Spring Seat
78. Impact Cap
79. Cap Retainer Snap Ring
80. Tappet Roller Spring

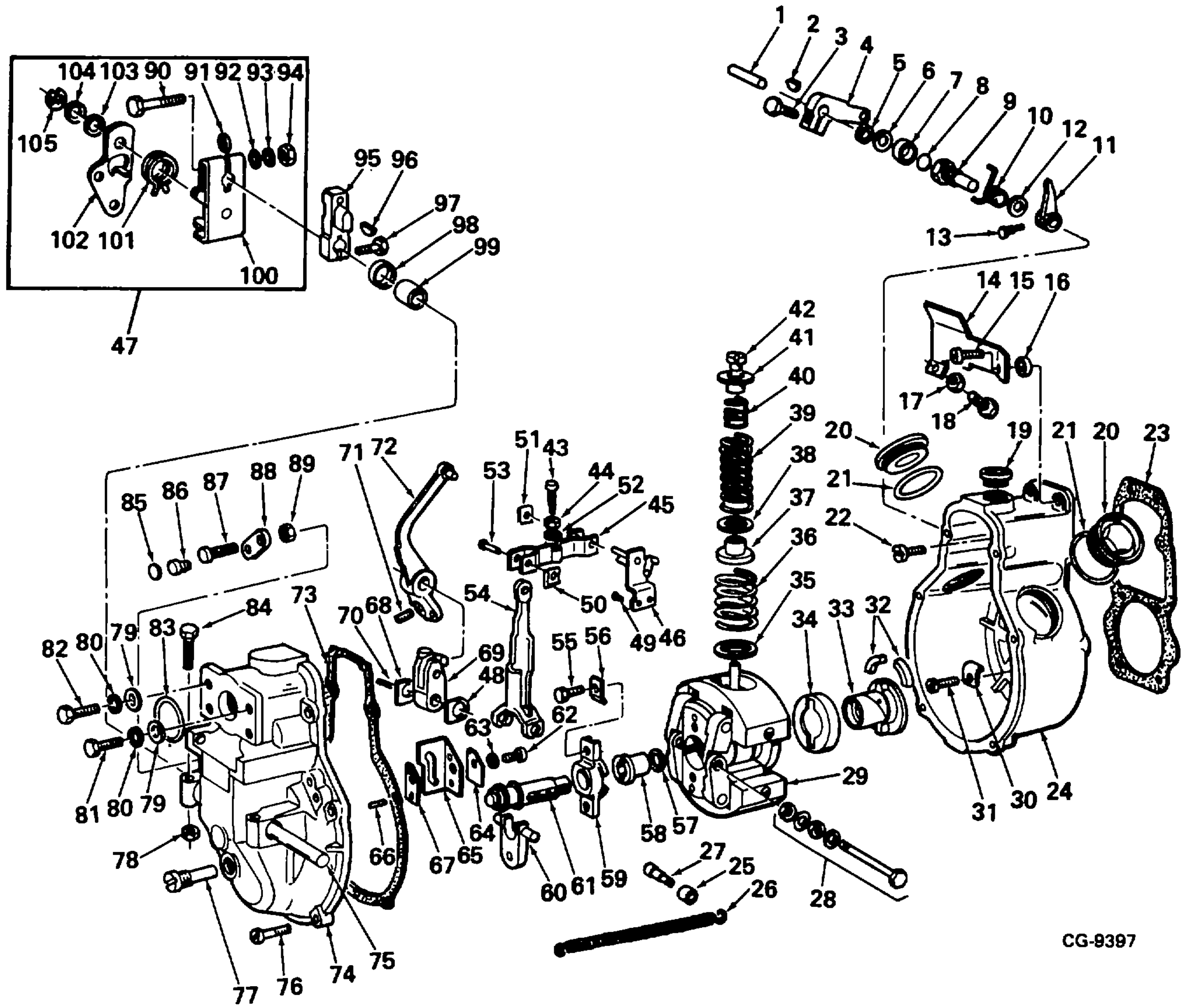


Figure 5. Exploded View of Governor

Legend for Figure 58.

1. Stop Lever Shaft
2. Woodruff Key
3. Screw
4. Stop Lever Control
5. Not Used
6. Stop Lever Shim
7. Cap
8. Stop Lever O-Ring
9. Governor Housing Bushing
10. Not Used
11. Stop Lever
12. Stop Lever Spacer
13. Screw
14. Shut-Off Bracket
15. Governor Housing and Bracket Screw
16. Spacer Ring
17. Shut-Off Bracket Nut
18. Shut-Off Bracket Screw
19. Governor Housing Top Plug
20. Governor Housing Side Plug
21. Side Plug Gasket
22. Governor Housing Screw
23. Governor Housing to Pump Gasket
24. Governor Housing Assembly
25. Retaining Pin Bushing
26. Extension Spring
27. Retaining Pin
28. Governor Flyweight Bolt Assembly
29. Governor Flyweight Assembly
30. Governor Housing Lock Washer
31. Governor Housing Screw
32. Flyweight Rubber Damper
33. Flyweight Drive Hub
34. Flyweight Retainer
35. Outer Spring Shim
36. Outer Idling Spring
37. Lower Spring Seat
38. Middle Spring Shim
39. Middle Spring
40. Inner Spring
41. Upper Spring Seat
42. Nut
43. Link Screw
44. Link Screw Nut
45. Fulcrum Lever and Connector Plate Link
46. Connector Plate
47. Control Lever Assembly
48. Governor Rocker Arm Plate
49. Connector Plate Rivet
50. Link Clip
51. Link Clip
52. Link Lock Washer
53. Link Pin
54. Fulcrum Lever
55. Guide Bushing Screw
56. Guide Bushing Lock Plate
57. Flyweight Securing Nut Shim
58. Flyweight Securing Nut
59. Guide Bushing
60. Guide Block
61. Guide Sleeve
62. Screw
63. Lock Washer
64. Lock Plate
65. S-Plate
66. S-Plate Pin
67. S-Plate Shim
68. Governor Rocker Arm Plate
69. Guide Block
70. Control Pin
71. Govenor Rocker Arm Spring
72. Governor Rocker Arm
73. Governor Cover Gasket
74. Governor Cover Assembly
75. Governor Control Lever Shaft
76. Governor Cover Screw
77. Guide Bolt
78. Lever Stop Nut
79. Flat Washer
80. Lock Washer
81. Aneroid Screw
82. Aneroid Screw
83. Aneroid O-Ring
84. Lever Stop Screw
85. Seal Plug
86. Seal Holder Screw
87. Stop Screw
88. Seal Holder
89. Seal Nut
90. Control Lever Screw
91. Control Lever Spacer
92. Control Lever
93. Lock Washer
94. Control Lever Screw Nut
95. Throttle Lever
96. Woodruff Key
97. Throttle Lever Screw
98. Control Lever Shaft Seal
99. Governor Cover Bushing
100. Control Lever with Shaft
101. Control Lever Spring
102. Control Lever
103. Control Lever Washer
104. Control Lever Shim
105. Control Lever "C" Clip

GOVERNOR DISASSEMBLY

1. Using 10 mm Allen wrench, remove plug from rack link adjustment access hole in top of governor housing.

2. Remove seal wire and remove 4 aneroid assembly to governor housing screws (Figure 6).

3. Move control lever fully back against low idle stop screw.

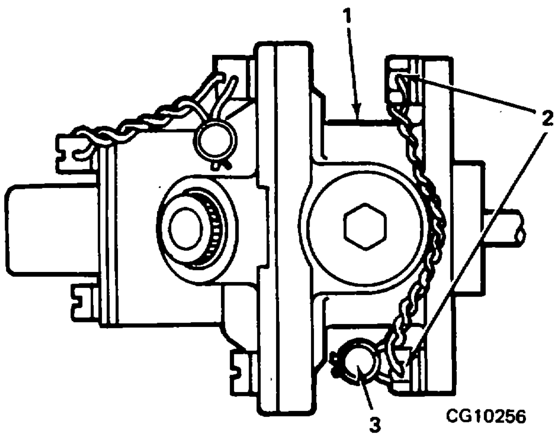


Figure 6. Aneroid Mounting

1. Intermediate Housing
2. Mounting Screws
3. Seal Wire

Caution should be exercised when removing aneroid assembly from governor housing not to damage link.

4. Turn aneroid assembly slightly counterclockwise and unlock link from rocker arm guide pin before trying to remove (Figures 7 and 8).

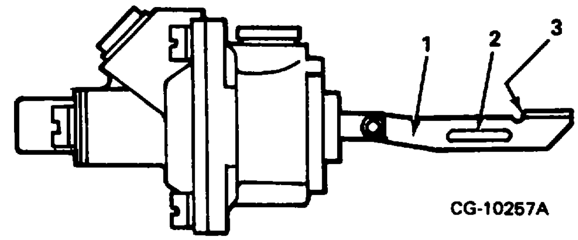


Figure 7. Aneroid Assembly

1. Link
2. Rocker Arm Guide Pin Slot
3. Maximum Fuel Stop Surface

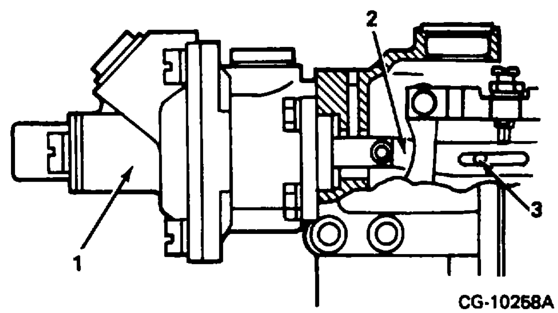


Figure 8. Removing Aneroid

1. Aneroid Assembly
2. Link
3. Rocker Arm Guide Pin

5. Remove slotted screw guide pin (Figure 9) from governor cover. Use large screwdriver to fit slot of this screw which has been sealed in place with Loc-Tite Red.

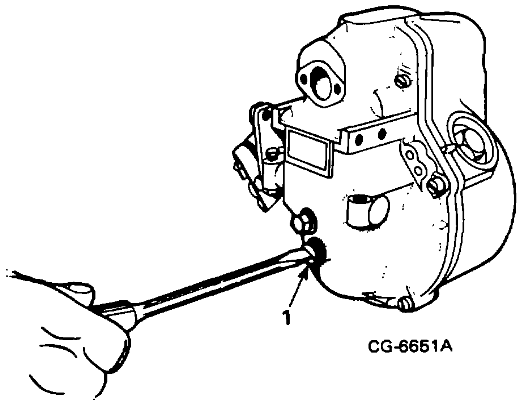


Figure 9. Removing Guide Pin

1. Slotted Screw Guide Pin

6. Remove six governor cover screws and take off governor cover (Figure 10). Lift cover up and operate control lever to release internal linkage.

7. Remove pin retaining clip and link pin and disconnect floating lever from rack link.

8. Pull top of floating lever back and down to remove floating lever and slider (Figure 11) from guide bushing.

NOTE: U sing a rubber band or wire around delivery valve secure rack link-up to prevent link damage (Figure 11).

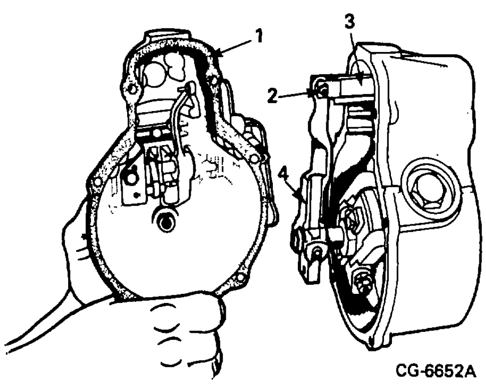


Figure 10. Removing Governor Cover

1. Cover
2. Link Pin
3. Rack Link
4. Floating Lever

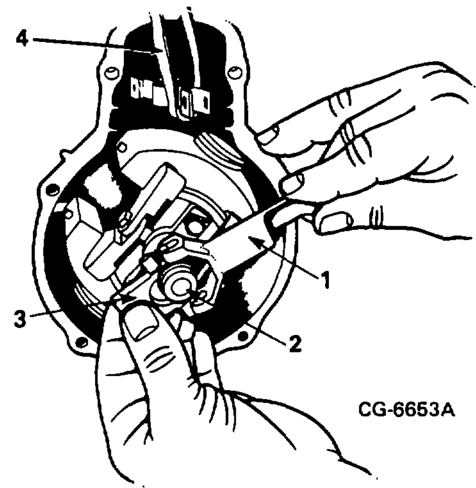


Figure 11. Removing Floating Lever and Slider

1. Floating Lever
2. Guide Bushing
3. Slider
4. Rubber Band or Wire

9. Raise tabs on lock washer and remove double nutted thru-bolt and guide bushing from governor flyweight assembly (Figure 12).

10. Raise tabs on lock plates, remove two cap screws and take out guide bushing (Figure 13).

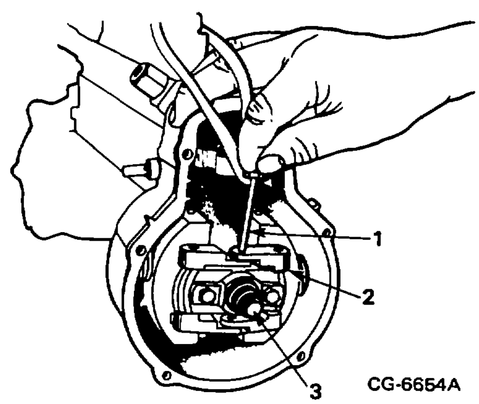


Figure 12. Removing Thru-Bolt from Flyweight Assembly

1. Thru-Bolt
2. Flyweight Assembly
3. Guide Bushing

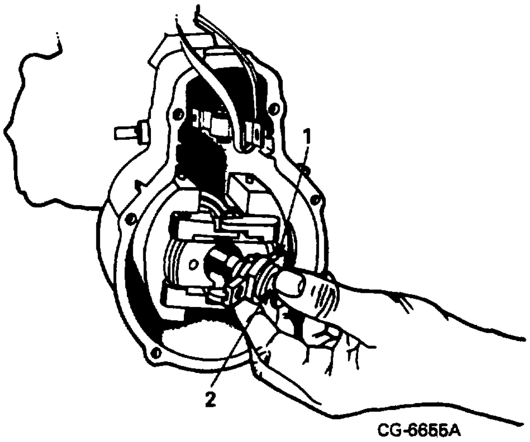


Figure 13. Removing Guide Bushing

1. Guide Bushing Support
2. Guide Bushing

11. Using KDEP 2988 remover tool on slotted cylindrical nut and holding the camshaft with a wrench at the front of the pump to keep it from rotating, remove the cylindrical nut (Figure 14) and spacer shim under the nut.

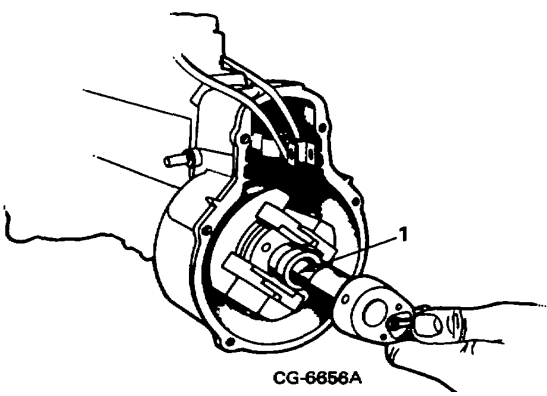


Figure 14. Removing Cylindrical Nut

1. Cylindrical Nut Remover KDEP 2988

12. Install KDEP 2886 governor flyweight remover tool (Figure 15) and remove flyweight assembly. Since governor weight assembly is serviced as a complete unit, no further disassembly is required until rebuild.

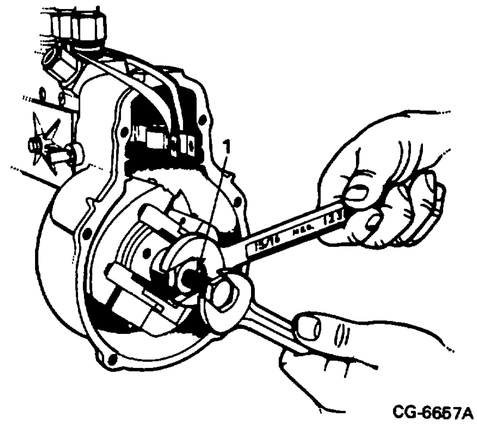


Figure 15. Removing Governor Flyweight Assembly

1. Governor Flyweight Remover Tool KDEP-2886

13. To remove governor housing remove rack link and unscrew eight governor housing to pump housing mounting screws. Remove governor housing and bracket (Figures 16 and 17).

    NOTE: Governor housing screws are locktited. Governor housing will not have to be removed from pump housing unless governor housing is damaged or cracked, fuel dilation is suspected, there are other leaks, or camshaft bearing damage is evident.

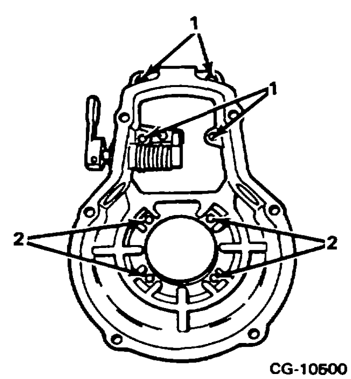


Figure 16.

1 & 2. Capscrews

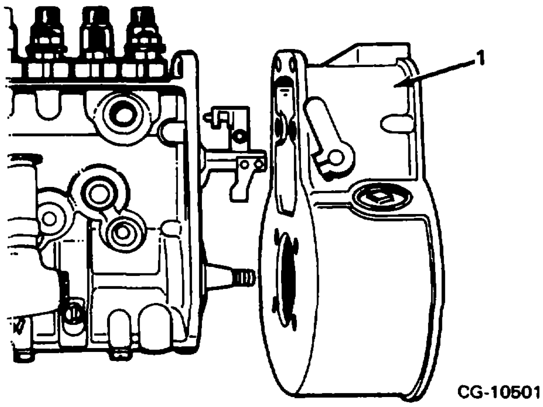


Figure 17.

1. Governor Housing

> **IMPORTANT**
> BE CAREFUL NOT TO DAMAGE EXPOSED CONTROL RACK GUIDE PIN WHEN GOVERNOR IS REMOVED FROM THE PUMP.

Pump Disassembly

14. Remove camshaft rear bearing nut and lockwasher (Figure 18) if rear bearing is to be replaced.

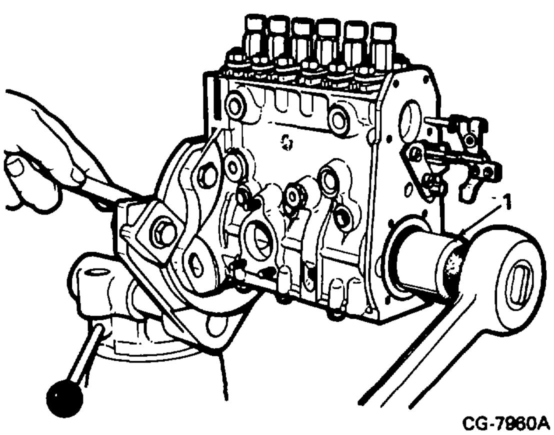


Figure 18. Removing Rear Bearing Nut and Lockwasher

1. 32 mm Socket

15. Assemble side puller KDEP 1056 to plug (Figure 19). Remove side plug by inserting collet jaws into side of plug. Tighten wing nut until jaws grip plug. Hold handle and turn shaft with a 27 mm wrench until plug is free. Repeat for other two plugs.

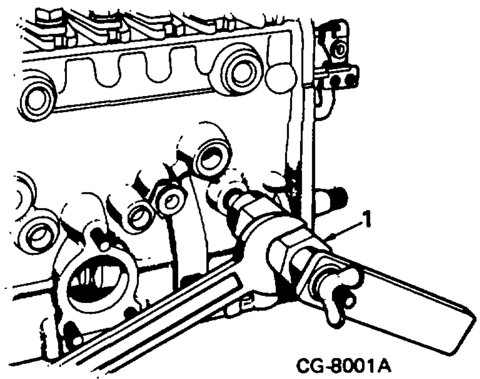


Figure 19. Removing Side Plugs

1. KDEP 1056

16. Remove tappet spacer block from side plug hole with long nose pliers (Figure 20).

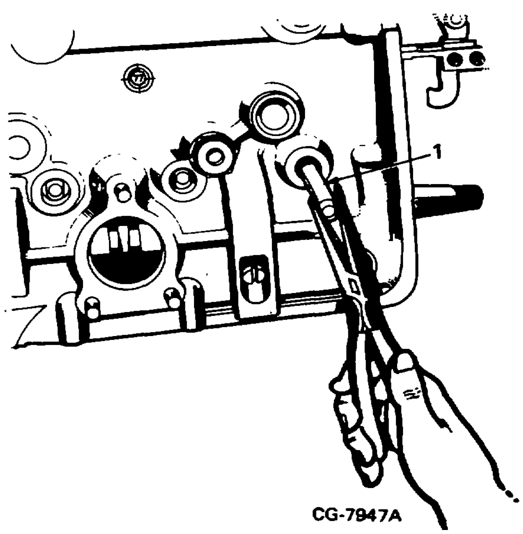


Figure 20. Removing Tappet Spacer Block

1. Tappet Spacer

Camshaft Removal

17. To make insertion of tappet holders KDEP 1068 easier loosen barrel flange nuts 3 turns, remove split shims and tap flanges so there is a slight clearance between barrel flanges and pump housing.

18. Remove bottom cover (Figure 21).

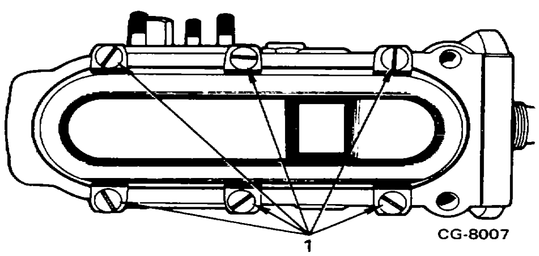


Figure 21. Removing Bottom Cover

1. Screws

19. Turn rotating handle of tappet holder (KDEP 1068) counterclockwise as far as it will go. Grease ramps and guide piece (Figure 22).

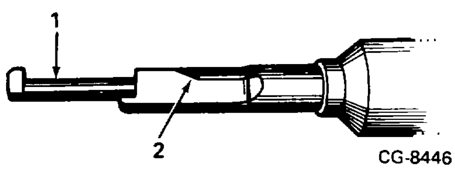


Figure 22. Tappet Holder 1068

1. Guide Piece 2. Ramps

20. With pump upside down, rotate camshaft until No. 1 plunger is at TDC.

NOTE: Camshaft front end should have drive end cam nut installed to protect end from damage when rotating (Figure 23).

21. Hold tappet holder with ramps up and insert holder as far as possible into the side hole. The tappet holder will only go part way in, lifting tappet No. 1 off the camshaft (Figure 23). Rotate camshaft until plunger No. 2 is at TDC. Push tappet holder the rest of the way in (push hard with the palm of hand).

IMPORTANT

DO NOT DRIVE IN WITH HAMMER.

The tappet holder will depress both tappets when correctly installed. Tappet No. 2 is now lifted off the camshaft.

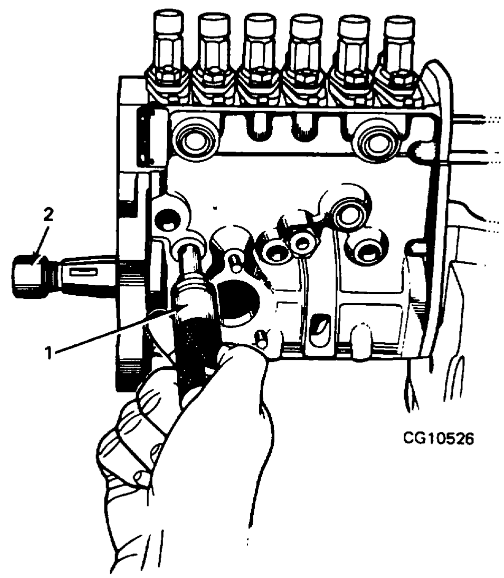


Figure 23. Installing Tappet Holder

1. Tappet Holder KDEP 1068
2. Drive End Cam Nut

22. Rotate camshaft and repeat step 16 until all tappets are lifted off camshaft. Check all holders to be sure they are properly installed before removing camshaft. When holders are properly installed camshaft should oscillate freely.

23. Remove intermediate bearing screws.

24. Use an arbor press to push camshaft, with attached rear bearing, out of the pump housing (Figure 24).Be careful with intermediate bearing. Do not let camshaft fall to floor.

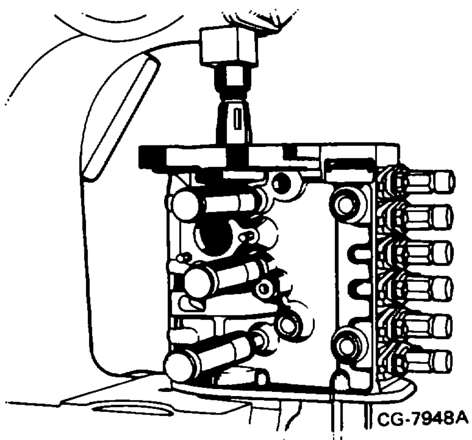


Figure 24. Camshaft Removal

IMPORTANT

CARE SHOULD BE TAKEN TO PROTECT EXPOSED CONTROL RACK GUIDE PIN WHEN USING THE ARBOR PRESS.

PUMP TAPPET AND BARREL REMOVAL

25. Attach bracket of tappet depressor tool KDEP 1505 (Figure 25) to pump bottom edge using two screws (supplied with tool) and tighten. Using the double adapter (holds two tappets) insert adapter into tube end of small round bar.

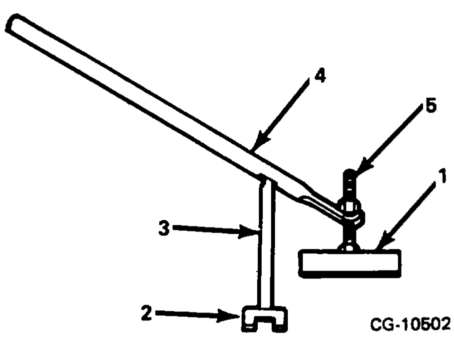


Figure 25. Tappet Depressor Tool KDEP 1505

1. Bracket
2. Double Adapter
3. Small Round Bar
4. Depressor Bar
5. Threaded Screw on Bracket

26. Place adapter over tappets No. 1 and No. 2. Hook depressor bar under upper nut of threaded rod on bracket and adjust nut for leverage.

27. While pushing on tappets screw knurled handle of tappet holder in until it pops out (Figure 26). Hold on to holder when depressing tappets because foot of holder is spring loaded and toll will spring out.

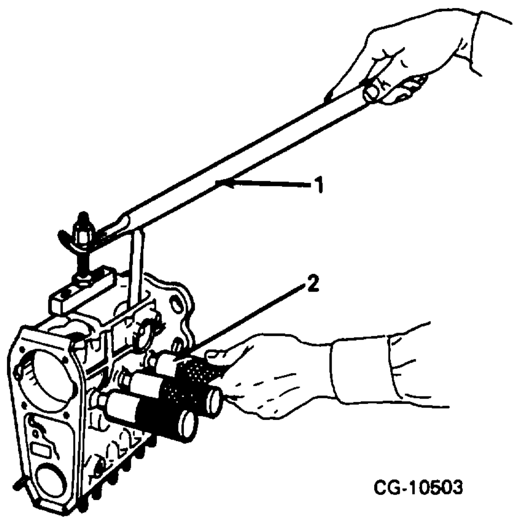


Figure 26. Tappet Removal

1. Tappet Depressor Tool KDEP 1505
2. Tappet Holder

NOTE: If tappet depressor tool KDEP 1505 is not available use spring compressor KDEP 1067 as follows:

a. Mount pump in spring compressor KDEP 1067 (5, Figure 27). Place pump upside down with governor end toward vise. With spacer plate in between, slide clamping device (2, Figure 27) against right side of pump and secure pump in place.

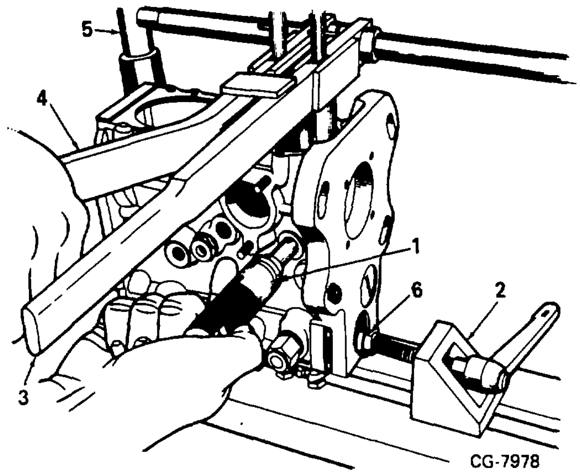


Figure 27. Tappet Removal (If Tappet Depressor Tool KDEP 1505 is not available)

1. Tappet Holder
2. Clamping Device
3. Right Lever
4. Left Lever
5. KDEP 1067
6. Spacer Plate Location

b. Position right lever (3, Figure 27) and then left lever (4) over first two tappets. Adjust crossbar (5) up or down to make levers point up slightly when resting on tappets.

c. Holding one hand on tappet holder (1, Figure 27), depress left lever compressing both springs to unload and remove tappet holder. Hold onto holder when depressing tappets because foot of holder is spring loaded and tool will spring out.

28. Repeat procedure for the next four tappets.

29. Remove each roller tappet, lower spring seat, plunger and spring.

IMPORTANT

KEEP PARTS FOR EACH CYLINDER TOGETHER.

30. Position rack so control sleeve ball is in notch of pump housing (Figure 28).

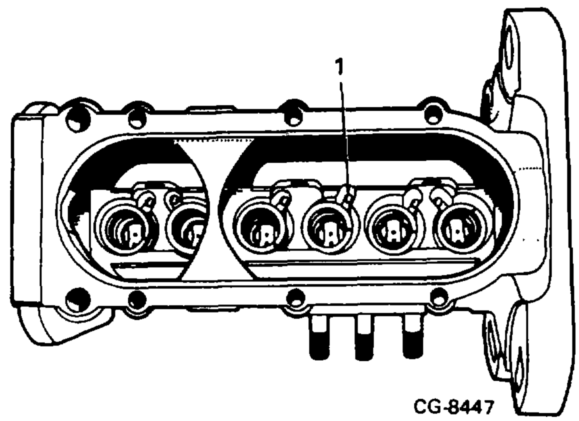


Figure 28. Rack Positioning

1. Control Sleeve Ball

31. Remove control sleeves and upper spring seats.

32. Remove tappet depressor tool (or, if used, remove pump from spring compressor KDEP 1067).

BARREL REMOVAL

33. Remove barrel flange nuts and lockwashers (Figure 29) (assembly jig KDEP 1066 may be used). Remove each barrel from housing. Store each barrel with its plunger and shims.

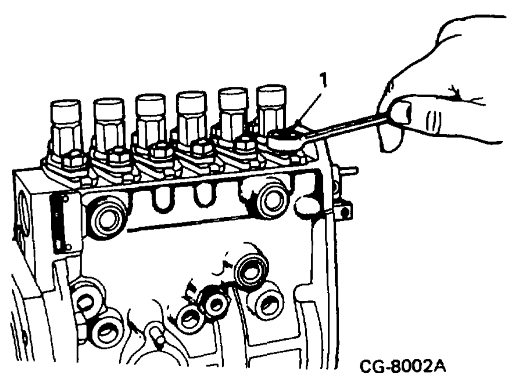


Figure 29. Barrel Removal

1. Flange Nuts

34. Remove four capscrews and lockwashers from camshaft bearing retainer on drive end of pump (Figure 30).

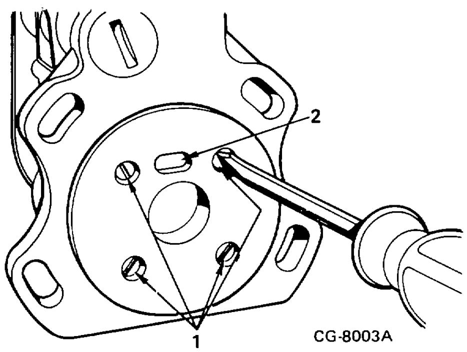


Figure 30.

1. Retainer Mounting Screws
2. Oil Drain Hole

35. Remove rack screws, lockwashers and retaining plate (Figure 31). Pull rack out of pump housing.

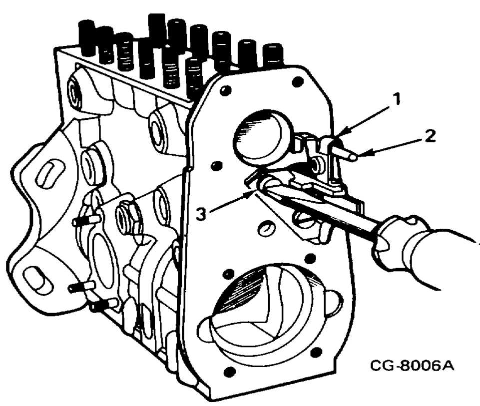


Figure 31.

1. Control Rack
2. Guide Pin
3. Screws

Injection pump housing is now ready for inspection.

ANEROID

The aneroid (Figure 32) should be disassembled, cleaned and inspected when the injection pump is disassembled or if the aneroid is suspected of malfunction. The diaphragm assembly must be replaced if signs of leakage, cracking or hardening exist. Replace o-ring on diaphragm stop.

IMPORTANT

TO REPLACE A LEAKING ANEROID DIAPHRAGM, THE INJECTION PUMP MUST BE REMOVED, THE NEW DIAPHRAGM INSTALLED AND THE INJECTION PUMP RECALIBRATED. DO NOT ATTEMPT TO REPLACE THE ANEROID WITHOUT RECALIBRA-TING THE INJECTION PUMP. SEEMI-NGLY SMALL CHANGES TO THE INJECTION PUMP CONTROL RACK SETTINGS CAN DESTROY THE ENGINE.

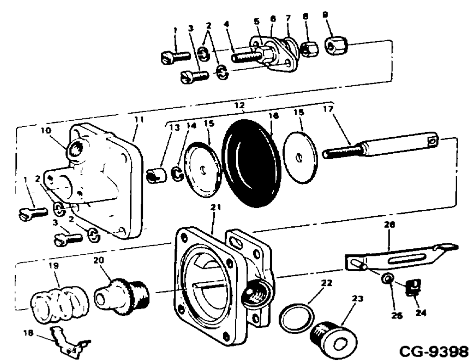


Figure 32. Exploded View of Aneroid

1. Screw
2. Washer
3. Screw (w/Seal Hole)
4. Pin
5. Nut
6. Stop Assy.
7. O-Ring
8. Nut
9. Nut
10. Bushing
11. Cover Assy.
12. Shaft Assy.
13. Nut
14. Washer
15. Seat
16. Diaphragm
17. Shaft
18. Clip
19. Spring
20. Bushing
21. Housing
22. Gasket
23. Plug
24. Clip
25. Washer
26. Max. Fuel Aneroid Shackle

FUEL SUPPLY PUMP

The fuel supply pump(Figure 33) should be disassembled, cleaned and inspected for damage or wear. Damaged or worn parts must be replaced, along with gaskets and o-ring before reassembly.

CHECK VALVE

The check valve assembly should be cleaned and inspected. If signs of malfunction exist the valve must be replaced.

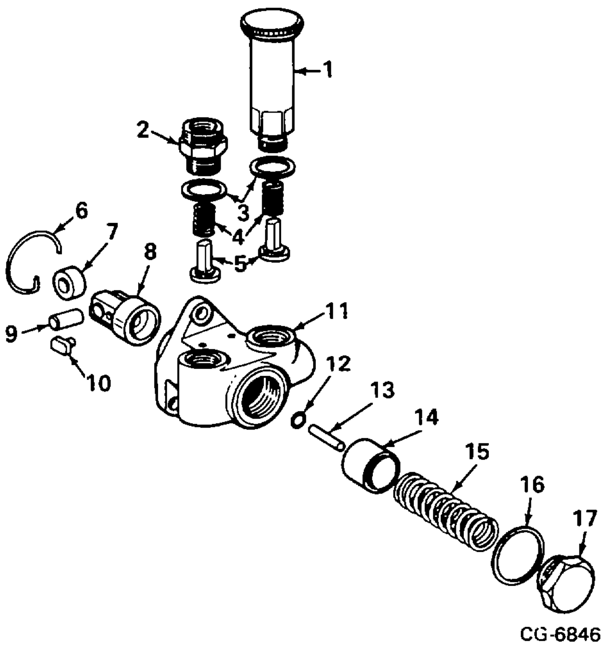


Figure 33. Exploded View of Fuel Supply Pump

1. Hand Priming Pump
2. Fitting
3. Gasket
4. Spring
5. Valve
6. Snap Ring
7. Roller
8. Tappet
9. Pin
10. Slider
11. Housing
12. O-Ring
13. Spindle
14. Piston
15. Spring
16. Gasket
17. Plug

CLEANING AND INSPECTION

A thorough cleaning and inspection of all parts is important for the injection pump and governor assembly.

Each machined surface should be cleaned of all old gasket material and wash all parts in clean fuel oil or calibrating oil.

When inspecting for damage or wear, it is a good practice to replace any part that is questionable.

Part	Inspect For Following Condition(s)	Corrective Action When Required
Injection Pump Housing	Cracks, chips, evidence of overtorque or stripping of screw threads, damage in roller tappet bores.	If damaged, replace
	Damaged camshaft bearing located in front bearing retainer and bearings on camshaft.	If damaged, replace bearing as follows: 1. Remove governor housing from pump housing (Governor Disassembly, step 13, section 2, page 8). 2. Remove gasket material from governor and pump housings. 3. Obtain new gasket and install governor housing onto pump housing. Apply Loctite to mounting screws to secure. 4. Remove and replace bearing in front bearing retainer. 5. Remove and replace bearing on camshaft.
	Leak at fuel gallery closing plug.	If known to be leaking, replace pump housing.
Camshaft	Deep wear or grooving on cams or bearing surfaces.	Replace camshaft (with camshaft replacement, bearing must also be replaced). IMPORTANT: See Page 4, this section.
Roller Tappets	Pressure marks or grooving.	Slight marks or grooving - smooth out with polishing cloth. More serious wear - replace parts.
Spring Seats	Worn or bent.	Replace seats
Springs	Broken or rust coated.	Replace springs.
Barrels and Plungers	Damage (scratches, scoring, etc.) on lapped surfaces of plunger. See NOTE*	Replace barrel and plunger
Control Sleeves	Damage	If damaged, replace

*NOTE: Test the set by washing out with test oil and pulling plunger part way out of barrel. It must fall back slowly by its own weight.

Part	Inspect For Following Condition(s)	Corrective Action When Required
Control Rack	Burrs on gear teeth or scratches along sides.	Polish with crocus cloth. Replace if any binding with housing exists.
Delivery Valve Assembly	Damage at delivery valve seat or needle.	Replace complete assembly.
Gaskets, Seats and O-Rings	ALWAYS REPLACE WHEN REBUILDING PUMP When replacing barrel lower spacer rings, spacer ring installer 9 681 238 902 must be used (see Reassembly'- Section 4, Page 1).	
Transfer Pump	Fuel leakage past pump drive stem. See NOTE*	Replace as a complete unit only.
Governor Housing and Cover	Cracks, stripped screw threads, burrs on mating surfaces.	Replace.
Governor Weight Assembly	Worn bell cranks, damaged weights, stripped adjusting nut threads, worn or damaged springs.	Replace weight assembly as complete unit. Weight springs and shims may be replaced individually.
Governor	ADJUST AS OUTLINED BELOW.	

*NOTE: Plug outlet side of transfer pump and pressurize inlet side with air to 103-137 kPa (15-20 psi). When submerged in fuel oil, no air leaks are permitted past pump drive assembly.

GOVERNOR ADJUSTMENT

1. Perform a static check on balanced movement of governor weights by making a temporary build-up *less springs* but using spring seats, trial spacer bushings (obtained locally) and adjusting nuts (Figure 1) on each weight as follows:

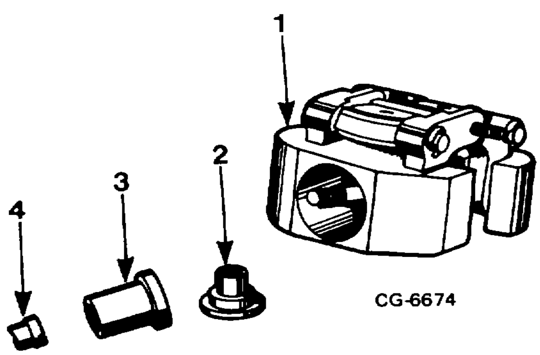


Figure 1. Details of Flyweight Assembly

1. Governor Flyweight Assembly
2. Spring Seat
3. Trial Spacer Bushing
4. Adjusting Nut

Install double-nutted thru-bolt in weight assembly. Apply slight pressure to center of bolt and check for excessive rocking movement in one or the other weights (Figure 2). If excessive rocking does occur try using a different size lower spring seat (available in three sizes). When installing the three different size weight springs, remove the trial spacer bushings.

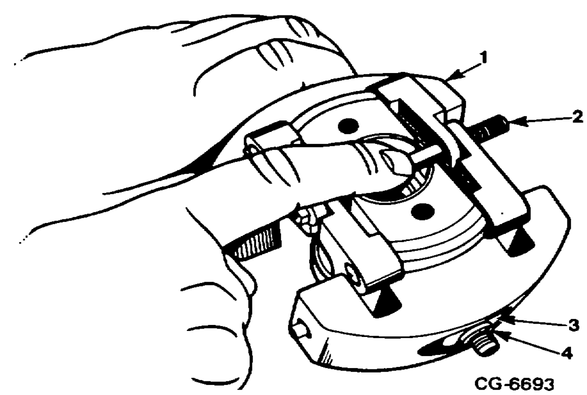


Figure 2. Checking Flyweight Trail Build-Up

1. Rocking Movement
2. Through Bolt
3. Trail Spacer Bushing
4. Adjusting Nut

2. Reinstall flyweight springs. Always start preliminary shim pack under governor shims as follows:

   Outer spring: 0.5 (.020") Intermediate Spring: 1.5 mm (.060") Inner Spring: None

   Install outer spring seat and adjusting nut.

   When installing adjusting nut, preload of governor springs should range from 4 to 10 90 degree "clicks" from flush nut position with threaded bolt. Preliminary adjustment should be equal on both spring sets.

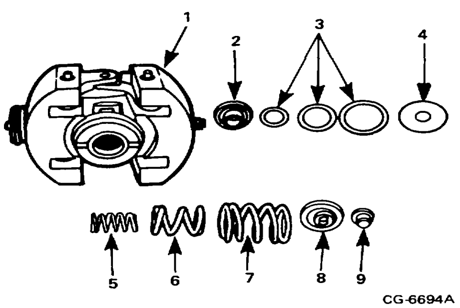


Figure 3. Exploded View of Flyweight Springs

1.	Flyweight Assembly	6.	Intermediate Spring
2.	Lower Spring Seat	7.	Outer Spring (Lo-Idle)
3.	Adjusting Shims	8.	Upper Spring Seat
4.	Wear Shim	9.	Adjusting Nut
5.	Inner Spring		

3. Inspect damper buffers for damage. If any loose rotational movement exists in governor weight assembly relative to the camshaft, replace buffers. Replace buffers as a set if needed (Figure 5).

4. Assemble prelubricated buffers in damper retainer and place damper hub on weight assembly.

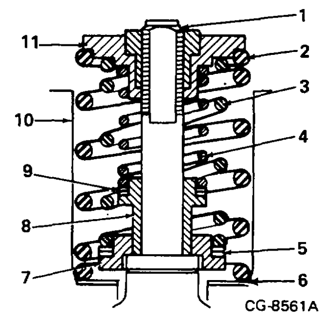


Figure 4. Sectional View of Flyweight Spring Installation

1.	Cylindrical Adjusting Nut	7.	Lower Spring Seat (Lower Half)
2.	Lo-Idle Spring	8.	Lower Seat (Upper Half)
3.	intermediate Spring	9.	Inner Spring Shim
4.	Hi-Idle Spring	10.	Flyweight Assembly
5.	Intermediate Adjusting Shim	11.	Upper Spring Seat
6.	Wear Shim		

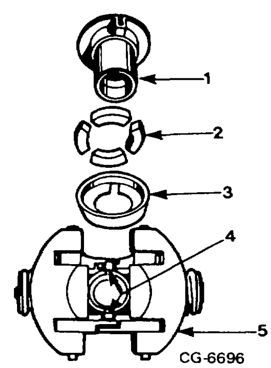


Figure 5. Exploded View of Damper Hub

1.	Damper Hub	4.	Mounting Tang
2.	Buffer	5.	Flyweight Assembly
3.	Retainer		

S-Plate: Sliding parts should operate free of bind; any grooves or pressure marks on curve should be smoothed with fine emery.

Guide Bushing: If any parts of the guide bushing are worn or damaged, replace the complete unit.

CAMSHAFT

Injection pump part numbers 1 802 604 C91, 1 802 605 C91, 1 802 606 C91, 1 802 607 C91, 1 802 608 C91, 1 802 643 C91 and 1 802 995 C91 were built with old style camshaft (Figure 6) and old style fuel return hose with a .062 in. diameter orifice (Figure 7). If camshaft replacement is required order new style camshaft (IH P/N 1 806 505 C1) and new style fuel return hose with a .046 in. diameter orifice (IH P/N 1 806 503 C1). The new camshaft provides improved fuel supply pump performance and the reduced orifice diameter is required to maintain appropriate fuel return flow to the tank and internal fuel injection pump housing pressures.

IMPORTANT

THE NEW CAMSHAFT (1 806 505 C1) MUST USE THE FUEL RETURN HOSE WITH .046 IN. DIAMETER ORIFICE (1 806 503 C1). CONVERSELY THE OLD CAMSHAFT (691 248 C1) MUST USE THE FUEL RETURN HOSE WITH .062 IN. DIAMETER ORIFICE (1 802 897 C1).

NOTE: With the new camshaft and fuel return hose added to any of the injection pumps listed above it becomes a C92 suffix pump. This is important when determining correct supply pump pressure on individual pump data sheets (Section 5 - Calibration).

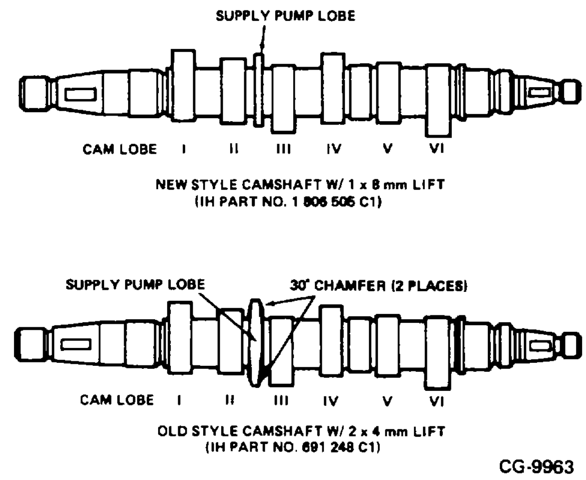


Figure 6. Camshaft Identification

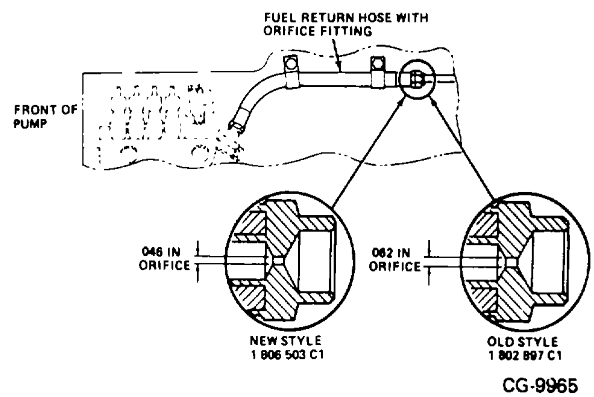


Figure 7. Old vs. New Fuel Return Hose with Orifice Fitting

PUMP ASSEMBLY

1. It is suggested that all delivery valves and plunger and barrel assemblies be inspected and ready prior to pump reassembly.
   While still in assembly jig KDEP 1066 install copper gasket, delivery valve, spring and washer into barrel. Tighten delivery valve holder nut with O-ring to specifications (see torque chart Section 1, Page 10).

IMPORTANT
DELIVERY VALVE HOLDER MUST BE TIGHTENED (SEE TORQUE CHART, SECTION 1, PAGE 10) OUTSIDE OF PUMP PRIOR TO PUMP REASSEMBLY.

All parts must be returned to their original position. Clean fuel oil or calibration oil must be available for lubricating the individual parts prior to assembly.

BARREL

2. Install barrel lower O-ring in housing. Install barrel lower spacer ring in pump housing, if it was removed, using 9 681 238 902.

3. Assemble impact cap with snap ring and O-ring onto barrel. Be sure hole in impact cap does not line up with spill/fill port in barrel.

4. Lubricate O-ring and lower surface of barrel, and install barrel with adjustment slot on the barrel flange opposite the control rack (Figure 1).

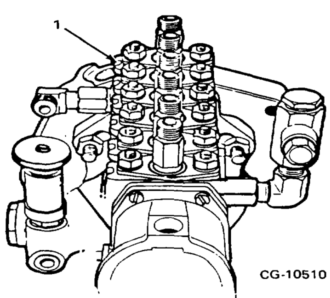


Figure 1. Adjustment Slot Location

1. Adjustment Slot

Push down with hand pressure: the barrel should stay down when pressure is released. If not, remove barrel and check for pinched O-ring.

5. Install spacer plates KDEP 1057 under barrel flanges and install flat washer, lockwasher and nuts. Tighten to specifications. Install fitting locks, flat washer, lockwasher and nuts.

6. Turn pump upside down. Install each plunger in correct barrel. Position the notch on the plunger foot so it points away from the rack, thus sealing the port (Figure 2)

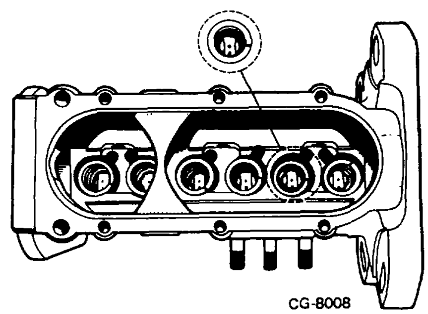


Figure 2.

1. Plunger

7. Install plunger retainersKDEP1052 (Figure3).

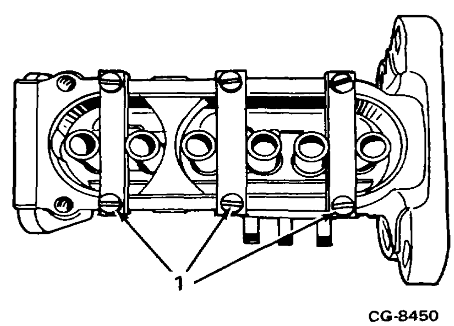


Figure 3. Install Plunger Retainers

1. Plunger Retainers

8. Connect air coupling to intake of gallery and plug return port. Submerge pump housing in an oil bath and pressurize pump to 5 bar (75 PSI).

   Look for leakage (bubbles) from top and bottom of pump. Any bubbles other than small bubbles coming from inside plunger retainer tubes indicates a leak. Correct any leaks found. If no leaks are found remove air hose, gallery outlet plug, plunger retainers and plungers.

9. Loosen barrel retaining nuts and back off so washers are loose.

PLUNGER AND RACK

10. Install control rack and fasten retaining plate with two screws and lockwashers. Check rack for freedom of movement.

11. Insert each control sleeve after positioning rack so that the control sleeve ball will fall into the slot of the control rack (Figure 4).

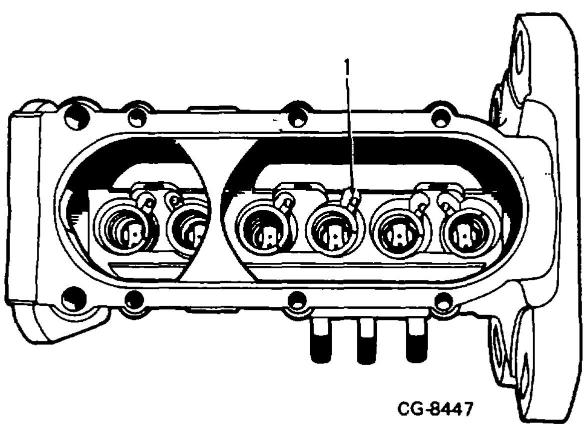


Figure 4. Control Sleeve Ball Positioning

1. Control Sleeve Ball

12. When all control sleeves are installed, move rack back and forth to make sure control sleeves all move freely and together.

13. Coat each upper spring seat with grease and stick upper spring seat to spring.

14. Insert each spring and upper seat into pump housing.

15. Insert each plunger into correct barrel. Make sure each plunger foot is positioned so that notch on plunger foot points away from control rack (Figure 5).

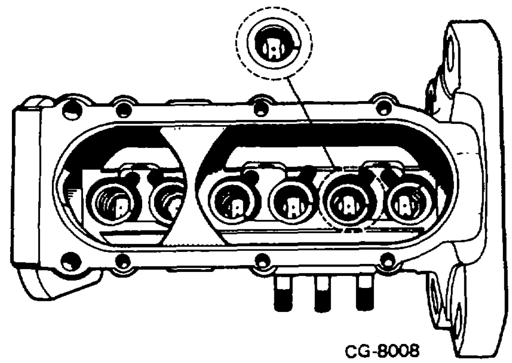


Figure 5.

1. Notch on Plunger Foot

17. Move rack back and forth and watch plungers. The control rack should move freely without binding and the plungers should rotate together.

18. Coat each lower spring seat with grease. Stick lower spring seat on each roller tappet (Figure

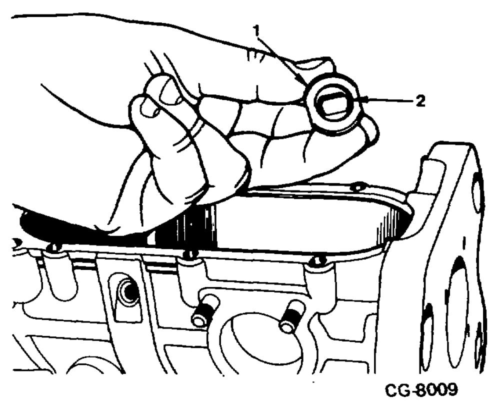


Figure 6. Tappet and Spring Seat

1. Tappet 2. Spring Seat

19. Insert tappets in normal position (when using spring compressor KDEP 1067 follow procedure in note below).

20. Reassemble tappet depressor tool KDEP 1505 (see note below). Turn tappet holder handles fully counterclockwise, grease ramps and guide piece.

21. Starting with tappets No. 1 and 2 push tappets down. Insert tappet holder (ramps up) into side plug hole between two tappets. A fourthinch should show between holder handle and pump housing.

NOTE: If tappet depressor tool KDEP 1505 is not available mount pump in spring compressor KDEP 1067 and proceed as follows (eliminate steps 1 9-21):

a. Insert each tappet in housing so that roller tappet axis is at a right angle to the pump (Figure 7)

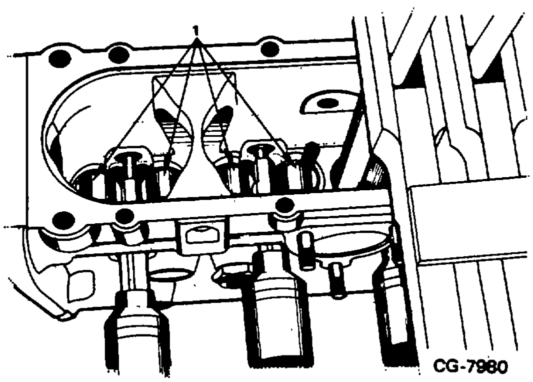


Figure 7. Tappet Positioning

1. Tappets at Right Angles

b. Turn tappet holder handles fully counterclockwise, grease ramps and guide piece. With spring compressors handles pointing in opposite directions, place spring compressor levers over first two tappets. Depress right lever of spring compressor as far as possible. Hold lever down and slowly turn right handle clockwise 45° (Figure 8).

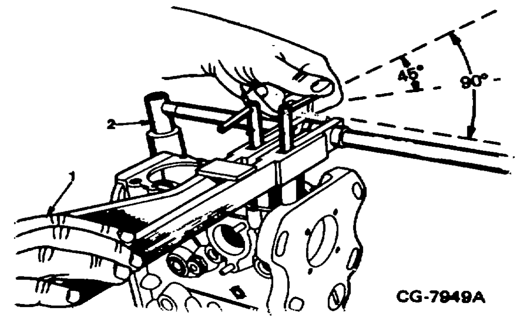


Figure 8.

1. Downward Force 2. Spring Compressor

c. When handle is turned 45° the foot of the plunger will go into the lower spring seat hole allowing the lever to go down farther.

d. Depress right lever further and turn handle clockwise until the handle is at 90° from lever (Figure 8).

e. Push other tappet down with left lever. The left lever will hold both tappets down. Slowly turn left handle clockwise. When left handle is turned approximately 45° foot of the plunger will go into lower spring seat hole. Push lever all the way down and turn clockwise until handle is at 90° from lever.

f. While holding left lever down (both tappets depressed), fully insert a tappet holder (ramps up) into the side plug hole between two tappets.

22. The first two tappets have now been held in place by the tappet holder. Repeat this procedure until-all tappets are held in place with tappet holders.

> **CAUTION**
> Make sure tappet holders are properly seated.

23. Remove tappet depressor tool (or spring compressor) and mount the pump right side up in vise.

24. Look at tops of plungers to be sure all are oriented in the same direction.

25. Install roller bearing in drive end bearing plate with KDEP 1059.

26. Install drive end bearing retaining plate, oil return hole must be toward top of pump (Figure 9). Mounting screws must be coated with Loc-Tite 601.

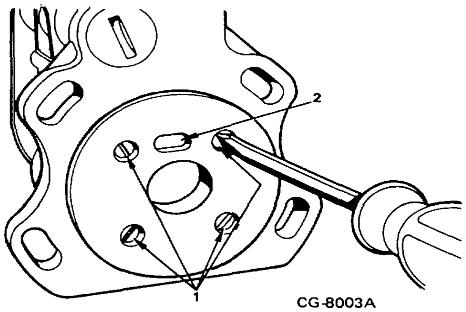


Figure 9. Install Drive End Bearing Plate

1. Mounting Screws 2. Oil Return Hole

27. Lubricate intermediate bearing. Install camshaft with intermediate bearing. Carefully press in camshaft from governor end. Using ball bearing installer KDEP-1069, press only on outer race of ball bearing while guiding intermediate bearing into place. Be careful camshaft does not catch on roller tappets.

NOTE: If camshaft replacement is required see Section 3, Page 4.

28. Install camshaft intermediate bearing screws with copper washers. See torque specifications.

29. Remove tappet holders as follows: Starting from governor end of pump, rotate camshaft until No. 6 cam lobe is at TDC. Turn handle of tappet holder clockwise until #6 tappet contacts cam lobe. Rotate camshaft until No. 5 cam lobe is at TDC. Turn handle of tappet holder clockwise until No. 5 tappet contacts cam lobe. The tool can now be removed from housing.

30. Repeat step 32 until all holders are removed.

IMPORTANT

DO NOT ALLOW TAPPETS TO SLAM AGAINST CAMSHAFT. DOING SO COULD CAUSE PREMATURE FAILURE OF CAMSHAFT AND/OR ROLLER TAPPETS.

31. Install tappet spacer block in side plug holes.

32. Coat new side plug with Loctite 601 and install with side plug installer KDEP 1058.

33. Place a new O-ring on bottom cover and mount bottom cover to pump.

34. Remove spacer plates and install correct shims under each barrel flange.

35. Install supply pump.

36. Tighten supply pump mounting nuts. See torque chart.

37. Install fuel return valve.

GOVERNOR REASSEMBLY

1. Install governor housing to pump, (See torque chart). Apply Loctite 601 to internal screws.
2. Install flyweight assembly to camshaft (Figure 10). Install spacer shim and secure to camshaft with slotted cylindrical nut. Spacer shims are available in .05 mm increments to adjust for axial end play of governor weight assembly, specified at .05 .10 mmm (.002 .004 in). Use cylindrical nut tool KDEP 2988. Torque nut to specifications.
3. Check action of damper by holding camshaft, grasping weight assembly and twisting to note for slight movement.
4. Install guide bushing; secure bushing with two cap screws lock screws in place with lock plate tabs.
5. Install guide bushing assembly; temporarily secure with thru-bolt at this time, since another measurement will be made later in procedure.

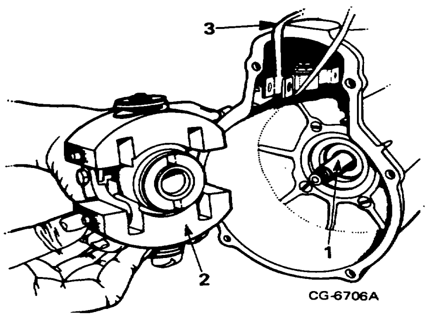


Figure 10. Installing Flyweight Assembly

1. Camshaft
2. Flyweight Assembly
3. Rubber Band or Wire

6. Install slider and floating lever open slot of floating lever to right. Pin floating lever to rack link to hold in place.

7. Check "slider-to-housing" distance with guide bolt gauge 1 682 329 038 (Figure 11). Notch in gauge must fit in groove on guide bushing when gauge is placed against mating surface of housing (no gasket)

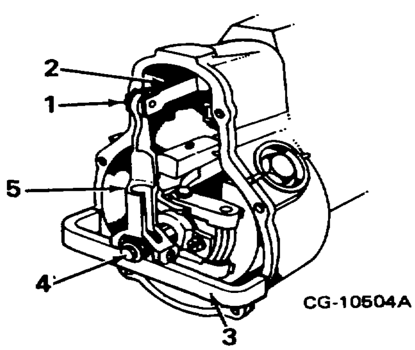


Figure 11. Slider-to-Housing Distance

1. Pin
2. Rack Link
3. Guide Bolt Gauge 1 682 329 038
4. Adjusting Pin
5. Floating Lever

NOTE: If guide bolt gauge 1 682 329 038 is not available use a depth micrometer to measure from back of slider to governor mating surface (no gasket) (Figure 12). Distance (item 4) should be 39.15 i .2 mm (1.54 ± .008").

Adjust by turning screw inside of guide bushing. Back screw out to increase distance or turn screw in to decrease distance (one half turn of screw moves sliding block approximately .5 mm (.020").

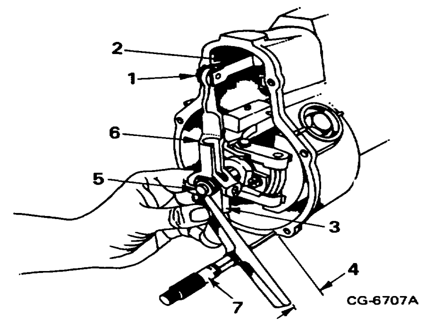


Figure 12. Measuring Slider-to-Housing Distance (If Guide Bolt Gauge 1 682 329 038 is not available)

1. Pin
2. Rack Link
3. Slider
4. Slider-to-Housing Distance
5. Guide Bushing
6. Floating Lever
7. Depth Micrometer

8. Secure double-nutted thru-bolt in governor weight assembly by installing lockwasher and nut. Bend over tabs of lockwasher to secure. Operate rack back and forth to recheck all linkage for free movement.

   Remove seal cover from hi-idle adjusting screw locknut on governor cover and back out hi-idle adjusting screw. Hi-idle screw is removed so that control lever can be moved full forward for making next check.

   Check "basic setting of S-plate", the distance from governor cover surface (gasket in place) to guide pin shaft when guide pin is in maxim fuel position and bottomed in S-plate. Using S-plate gauge 9 681 238 904 (Figure 13), notch in tang of gauge should fit over guide pin shaft when bar is placed on governor cover surface (gasket in place).

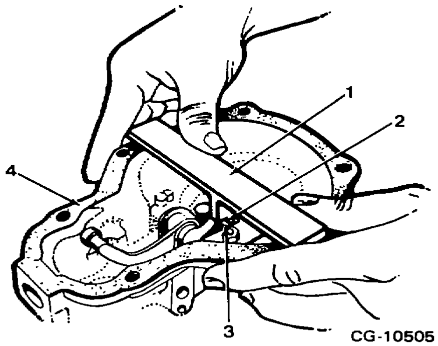


Figure 13. Basic Setting of S-Plate

1. S-Plate Gauge 9 681 238 904
2. Notch in Gauge
3. Guide Pin
4. Gasket

NOTE: If S-plate gauge 9 681 238 904 is not available use a depth micrometer to measure S-plate setting (distance to measure described above) (Figure 14). Basic setting is 21.5 ± 0.2 mm (.847

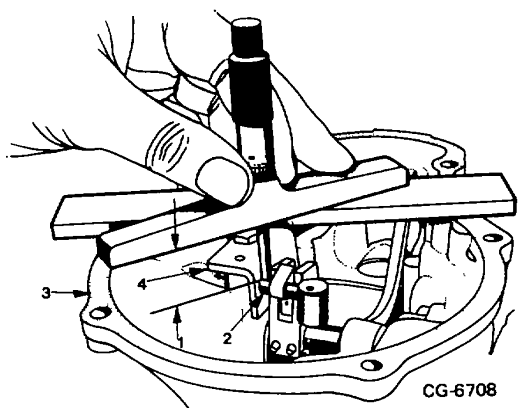


Figure 14. Measuring S-Plate Basic Setting (If S-Plate Gauge 9 681 238 904 is not available)

1. Basic Setting
2. Guide Pin
3. Gasket
4. Curve Plate
5. Depth Micrometer

9. Add shims under S-plate mounting to decrease basic setting or remove shims to increase basic setting (Figure 15). Check for free travel of guide pin shaft in S-plate after resetting. Check to be sure cotter pin has been used to secure pin between rack link and floating lever.

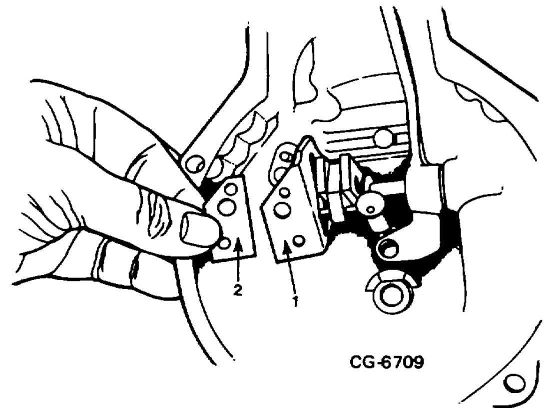


Figure 15. Locating for S-Plate Shim Adjustment

1. S-Plate 2. Shim

10. Install governor cover to housing. When installing, apply small dab of grease to floating block to hold hollow end up and note that floating block enters floating lever. Operate control lever to facilitate installation. Secure cover with six cover screws.

11. Install guide bolt in rear of governor cover. Apply Loctite hydraulic sealant compound to threads before installing.

12. If governor control lever and/or accelerator lever assembly were removed, reinstall at this time as follows:

    a. Install woodruff key and governor control lever on shaft and tighten securely.

    b. Install accelerator lever assembly on shaft (Figure 16) and tighten securely.

IMPORTANT

ACCELERATOR LEVER CAN BE INSTALLED IN ANY POSITION AND CAN BE REMOVED AND REINSTALLED AT ANY TIME. GOVERNOR CONTROL LEVER, ONCE HIGH SPEED SCREW HAS BEEN SET, SHOULD *NEVER* BE REMOVED AND REINSTALLED WITHOUT RECHECKING HIGH IDLE SPEED.

13. Position control lever fully back against loidle stop screw.

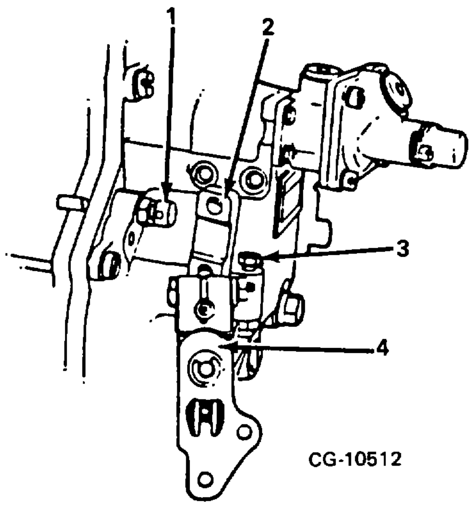


Figure 16. Accelerator Lever Assembly

1. Full Load Position 3. Low Idle Position
2. Governor Control Lever 4. Accelerator Lever

14. Insert aneroid assembly into governor housing. Rotate aneroid assembly approximately 45 degrees in the counterclockwise direction (from installed position). Slide aneroid assembly into governor housing, then rotate aneroid assembly 45 degrees clockwise to the horizontal position (Figure 17).

15. Move control lever to the vertical position.

NOTE: To ease this operation, interior of governor housing can be lighted by removing seal wire and plug from governor adjustment access cover on side of governor housing and inserting penlight through access hole.

16. After aneroid strap is engaged with rocker arm pin, push aneroid assembly into position against governor housing and secure with 4 mounting screws.

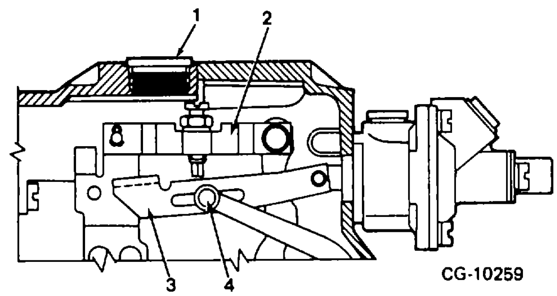


Figure 17. Engaging Aneroid Strap to Rocker Arm Pin (Governor Housing Cut Away for Illustration.)

1. Starting Fuel Cut-Out Speed Adjustment Shackle Access Hole
2. Rack Link
3. Max. Fuel
4. Rocker Arm Pin

Check aneroid assembly as follows:

a. Hold accelerator lever full forward. This should place rack in excess fuel (starting) position with adjustment screw of rack link resting on top of mating flange on aneroid shackle (Figure 18).

b. Slowly move fuel shut-off lever to rear. If installation is correct, a distinct "click" will be heard as rack moves back from excess fuel position and adjustment screw on rack link engages with rear edge of mating flange on aneroid shackle (Figure 19).

c. If correct positions of parts (steps a and b) cannot be obtained ("click" is not heard), check for proper engagement of slot in aneroid strap to rocker arm pin. If necessary, loosen aneroid assembly mounting screws and connect aneroid strap to rocker arm pin per step 14.

Further reassembly including hi-idle adjusting screw, miscellaneous locks, seals, etc. cannot be completed until after pump is calibrated. Pump is now ready for mountinq to calibrating stand.

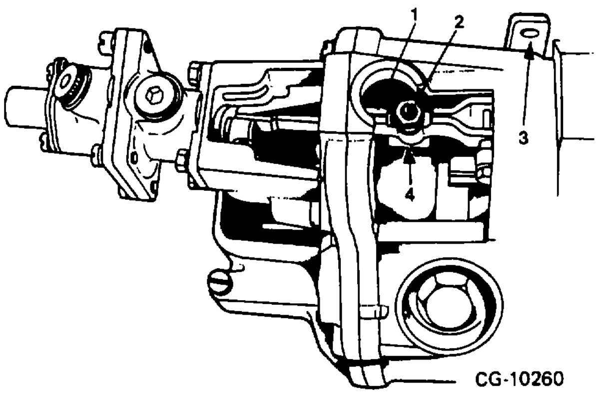


Figure 18. Rack Link and Stop Shackle in Excess Fuel (Starting) Position (Governor Housing Cut Away for Illustration)

1. Rack Link
2. Adjustment Screw Resting on Top of Mating Flange
3. Shut-Off Lever
4. Aneroid Shackle Mating Flange

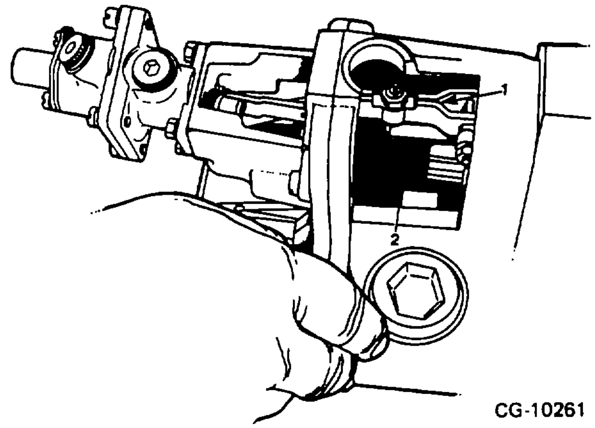


Figure 19. Rack Link and Max. Fuel Aneroid Shackle in Full Load Fuel Position (Govenor Housing Cut Away for Illustration)

1. Rack Link
2. Aneroid Shackle Mating Flange

INJECTION PUMP CALIBRATION

Following injection pump or governor service and overhaul, the pump must be recalibrated to establish correct internal timing, fuel delivery and governor operation. It is also recommended that pump calibration be checked on a calibrating stand anytime the injection pump is removed to perform engine service operations.

IMPORTANT

FOR PROPER INJECTION PUMP OPERATION IT IS NECESSARY THAT CALIBRATION AND ADJUSTMENT CHECKS ARE PERFORMED IN SEQUENCE, AS OUTLINED IN THIS SECTION.

NOTE: Refer to individual pump calibration charts and data sheets (at end of this section) for specifications mentioned throughout this section.

CALIBRATING STAND

A calibration stand with 10 HP or more is recommended. Existing stands of 5 HP are acceptable.

When installing the pump on the test stand follow instructions furnished with the stand.

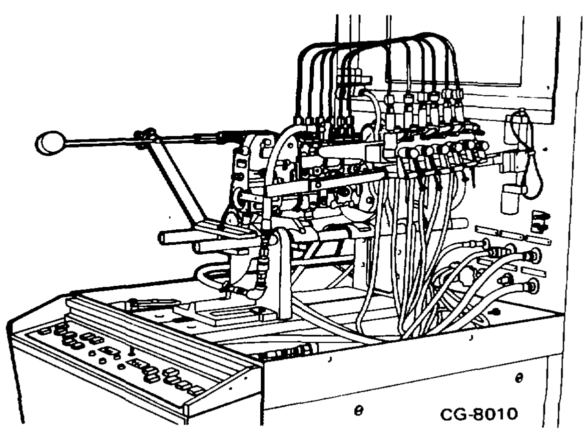


Figure 1. Pump on Calibration Stand

Calibrating Stand Maintenance

The calibrating stand must be kept in good operating condition. Maintenance checks and lubrication of test stand components must be performed periodically to assure satisfactory results. Calibrating oil must be of the specified type. Calibrating oil and filter must be changed regularly. Transfer (supply) pump must maintain minimum specified pressure since injection pump calibration depends upon correct supply pump oil pressure.

To assure uniform delivery, calibrating stand test nozzles should be tested for balance (equal delivery) every six months or whenever 200 pumps have been tested. The method for balancing the test nozzles is as follows:

a. Adjust all test nozzles to specified test nozzle opening pressure. (See Pump Stand Manual.)

b. Install an injection pump on calibrating stand.

c. Perform the "Maximum Fuel Delivery Check" and record amount of fuel obtained from No. 1 pumping element.

d. Install each of the remaining test nozzles in the No. 1 nozzle position and note delivery from each nozzle. If necessary, adjust nozzle opening pressure to obtain same flow as recorded for nozzle No. 1 (Step c.). Nozzles must be balanced to within 0.5cm3 per 1000 strokes.

e. After nozzle balance (uniform delivery) has been obtained, recheck opening pressure of all nozzles. If nozzle opening pressure is not within specified limits (3000 ± 25 psi), nozzle should be repaired or replaced.

MOUNTING ON STAND

Before mounting the pump on stand, make sure pump camshaft can be rotated more then 360°. This is especially important when the pump has been overhauled.

When installing pump on stand follow instructions with stand.

Before mounting pump on stand remove access plug with screwdriver bit KDEP 2949. Remove fuel inlet adapter and plug opening with bushing 1 413 462 040 and copper gasket 2 916 710 611 so it is flush with pump housing.

ESTABLISH PORT CLOSURE ON NO. 1 CYLINDER

1. Mount pump on stand and install rack dial indicator 1 687 233 015, bracket 1 688 130 030, adapter bushing 1 683 350 065 and rack pin 1 683 201 013 (Figure 2).

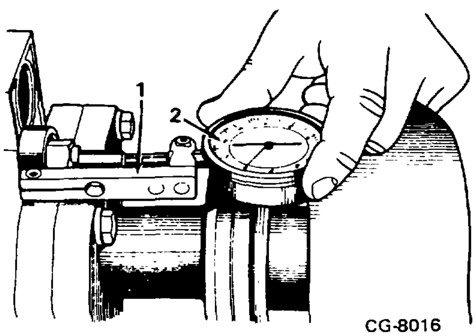


Figure 2. Installing Dial Indicator (Rack Gauge)

1. Bracket 1 688 130 030 with Adapter Bushing 1 683 350 065 and Rack Pin 1 683 201 013.

2. Dial Indicator 1 687 233 015

2. Zero dial indicator when rack is pushed to shut-off. Be sure rack does not bottom out on indicator. Move throttle lever to max. position Total rack travel should be as specified on individual pump calibration chart for starting fuel delivery (Step 17).

3. Move rack out of starting fuel position with shut-off lever. Dial indicator should read about 10 mm ± 2 mm.

4. Mount lift-to-port closure measuring device 1 688 130 135 with dial indicator 1 687 233 012, adapter bushing 1 683 350 066 and tappet pin 1 682 012 008 to pump (Figure 3). Make sure tappet number one is at bottom dead center (B.D.C.). The plunger lift-to-port closure is the distance in mm from the B.D.C. position of the cam to port closing by the plunger. Lift-to-port closure is only measured at element number one. Subsequent elements are phased at 60 degree intervals (see Step 10).

5. Zero the dial indicator at bottom dead center position of the roller tappet.

IMPORTANT

HIGH PRESSURE PHASING IS RECOMMENDED. (FOR LOW PRESSURE PHASING REMOVE DELIVERY VALVE, SPRING AND WASHER. UPON REPLACEMENT, NEW DISCHARGE FITTING AND GASKET AT BOTTOM OF DELIVERY VALVE ARE REQUIRED EACH TIME AS THEY ARE A ONE-TIME TORQUE DESIGN).

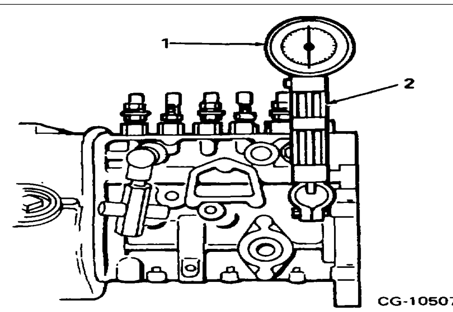


Figure 3. Establishing Initial Plunger Lift (No. 1 Pumping Element)

1. Dial Indicator 1 687 233 012

2. Plunger Lift Device 1 688 130 135 with Pin 1 682 012 008 and Adapter Bushing 1 683 350 066.

6. With the bleeder screw open at number one calibrating nozzle holder assembly, increase feed pressure until calibration fluid comes out of overflow tube with no bubbles.

7. Turn camshaft slowly in direction of rotation (clockwise) until port closure is reached. Port closure is reached when the flow of calibrating fluid from nozzle holder overflow tube changes from a steady stream to drops.

8. Read dial indicator for proper lift (see Calibration Chart for specification). Zero the pump stand degree wheel at this point for phasing. Return tappet to B.D.C. and repeat Steps 6 and 7 to ensure repeatability.

9. Compensate for deviation from the specified measurement by inserting the proper size adjusting spacer (available in thickness steps of 0.05 mm) between the barrel flange and pump housing (Figure 4).

IMPORTANT

ADJUSTING SPACERS OF THE SAME THICKNESS MUST BE USED ON BOTH SIDES OF BARREL AND VALVE ASSEMBLY AND ONLY ONE SPACER SHOULD BE USED ON EACH SIDE.

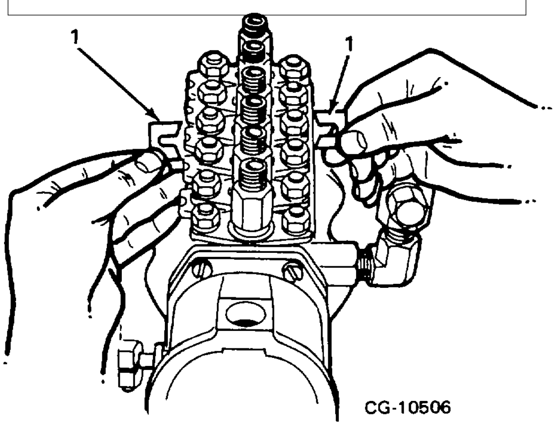


Figure 4. Inserting Adjusting Spacers

1. Adjusting Spacers

PHASING

10. Check port closure for the remaining plungers in pump discharge order by rotating the camshaft in 60 degree intervals.

No. 1	No. 5	No. 3	No. 6	No. 2	No. 4
0°	60° ± 1/20	120° ± 1/2°	180° ± 1/2°	240° ± 1/2°	300° ± 1/2°

At each of these intervals check port closure as outlined in Steps 7 and 8 (nozzle bleeder screw opening to correspond with element number).

11. If port closure is not exactly as specified ± 1/2 degree, adjust by selecting proper spacer for under the barrel flange. If port closure occurs too early, increase spacer thickness. If too late, reduce spacer thickness.0.05 mm spacer equals 0.2°.

GOVERNOR ADJUSTMENT

12. Insure zero dial indicator setting as outlined in Step 2. Adjust shut-off lever stop screw (Figure 5) to 1.5 - 2.0 mm (.060 - .079") rack position.

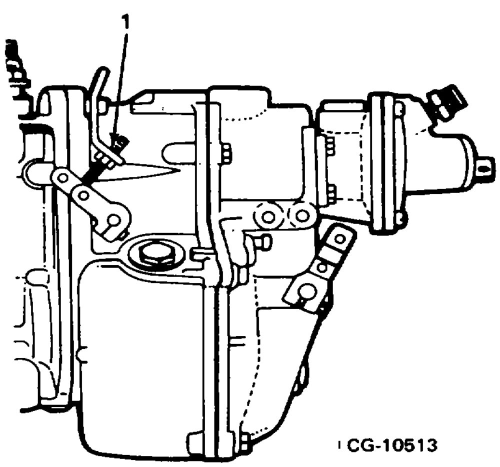


Figure 5.

1. Shut-off Lever Stop Screw

IMPORTANT

INSTALL DELIVERY VALVE SPRING AND WASHER, IF REMOVED.

13. Add clean engine oil to injection pump sump (one pint). Set feed pump pressure to 2 PSI.

Check Governor Preliminary Cut-Off (Governor Internal Adjustment)

14. With control lever assembly in full forward position and hi-idle stop screw removed, rack position should be 20.0 21.0 mm (.787" .827") as shown on dial indicator prior to start. Operate calibrating stand at specified RPM and observe rack position. Rack position should be 8.0 mm (.315") as shown on dial indicator.

If preliminary governor cut-off does not come into effect within specifications, corrective adjustments inside governor housing are made as follows:

a. Remove seal wire and governor access plug from side of governor housing.

b. Check control rack and governor assembly for binding and correct if needed.

c. Adjust cut-off by increasing or decreasing pre-tension of governor weight springs. Use KDEP 2989 governor spring adjusting wrench on cylindrical nut to make this adjustment (Figure 6).

To raise governor cut-off, pre-tension is increased; to lower governor cut-off, pretension is decreased. "Cam" nut is selflocking but must be turned 1/4 turns to assure its being in locked position. Preload of governor springs should range from 4 to 10 quarter (1/4) turns (clicks) from flush on each side. Alter preload range as required.

d. Spring set may be one-half turn out of balance with opposite set if necessary to obtain desired governor cut-off.

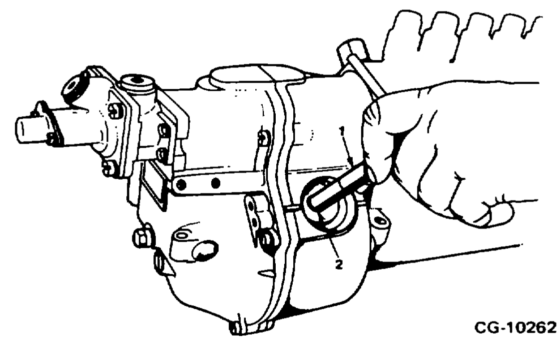


Figure 6. Making Preliminary Governor Cut-Off Adjustment

1. Adjusting Wrench KDEP 2989
2. Governor Cut-Off Adjusting Nut

e. If specified governor cut-off can not be obtained by adjusting preload, remove adjusting nut, spring seat and intermediate spring. Add or remove intermediate spring shims on both sides to achieve specified control rack position and recheck (must end up with same amount of shims on each side).

f. If specified governor cutoff cannot be obtained by steps c, d or e, recheck "slider to housing" and "S-plate" basic dimensions.

Check Governor Cut-Off (Governor External Adjustment)

15. Install hi-idle stop screw and operate test stand, with control lever assembly in full load position (fully forward), at specified RPM. Check rack setting on dial indicator and compare with specifications given on CALIBRATION CHART.

If rack is not positioned within specified limits, make hi-idle adjustments (Figure 7) as follows:

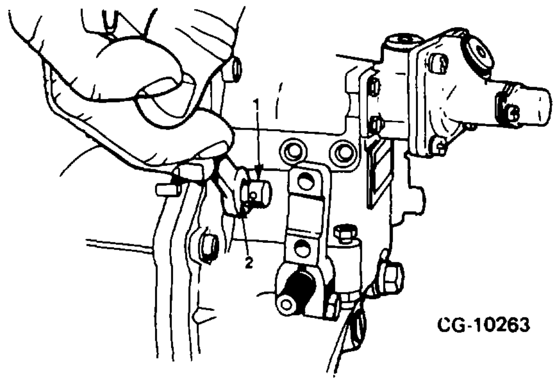


Figure 7. Adjusting Hi-Idle Rack Position

1. Hi-Idle Stop Screw 2. Lock Nut

a. Loosen locknut and turn hi-idle stop screw with wrench counterclockwise to decrease rack dimension, or clockwise to increase rack dimension.

b. Tighten locknut and recheck rack dimension.

Governor Performance at No-Load (Hi-Idle) Check

16. Operate test stand, with control lever assembly positioned as specified, at specified RPM listed on CALIBRATION CHART and observe rack position. Rack position as shown on dial indicator should be as specified on Calibration Chart.

If specified rack position is unattainable, recheck governor cut-off (internal adjustment) and governor cut-off (external adjustment) calibrations.

Governor End Regulation Check

17. Operate test stand at specified RPM with control lever assembly in full load position (fully forward) and observe rack position. Rack position should be 0.1-1.0 mm (.0039-.039"). If specified rack position is unattainable, recheck governor cut-off internal adjustment and governor external adjustment calibrations.

Governor Lo-Idle Regulation Check

NOTE: Steps 18 and 19 are not independent checks. One must not be achieved without the other.

18. Operate test stand at specified RPM with control lever assembly positioned as specified.

If rack is not within specified limits, make governor adjustments as follows:

a. Remove adjusting nut (count clicks to flush), spring seat and outer spring. Add or remove outer spring shims to achieve specified control rack position.

b. To increase rack position shims must be added and to decrease rack position shims must be removed. Add or remove same shim pack on both sides.

c. Install outer spring, spring seat, adjusting nut, preload governor springs to initial setting from flush position and recheck.

d. If specified rack position still cannot be obtained by steps a, b and c, recheck "slider to housing" and "S-plate" basic dimensions (Section 4, Page 5).

Lo-Idle Back-Up Check

19. Operate test stand at specified RPM with control lever positioned as specified.

Decrease test stand speed to 100 RPM. Rack position should be 9.0 mm (.354") or greater as shown on dial indicator.

If rack is not positioned as specified, repeat Steps 3 on. Bring low idle stop screw up to touch control lever (Figure 8).

Step/No Step Check

20. Check for continuous rack movement while increasing speed within the range specified on calibration chart (Step/No Step Check). Rack should not stay in any one position for more than 25 RPM. If rack is "sticky, " correct.

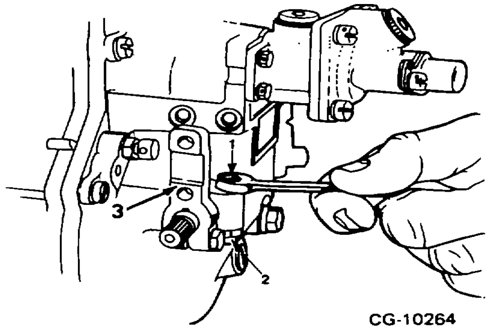


Figure 8. Adjusting Lo-Idle Position

1. Lo-Idle Stop Screw
2. Lock Nut
3. Control Lever

Adjust Full Load Fuel Setting and Balance Delivery

21. This is an operating test to assure that the injection pump provides the proper quantity of fuel at full load setting and at the same time provides a balanced fuel delivery between pumping elements. Test and adjustment is made as follows:

    a. Operate test stand at specified RPM with control lever in full load position (fully forward) and specified boost pressure, note rack position as shown on dial indicator.

    b. If not within specifications remove cover from rear of aneroid. Remove aneroid fuel adjustment plate. Using KDEP 1047 loosen inner jam nut then adjust outer nut clockwise to reduce power and fuel or counterclockwise to increase power and fuel (Figure 9).

    c. Operate test stand for fuel delivery at specified RPM and boost pressure for 1000 strokes. Read and record flow to each of the six graduates.

    d. If average fuel delivery for all pumping elements and imbalance between individual pumping elements do not meet specifications (see CALIBRATION CHART), adjust affected elements (see balanced delivery adjustment procedure).

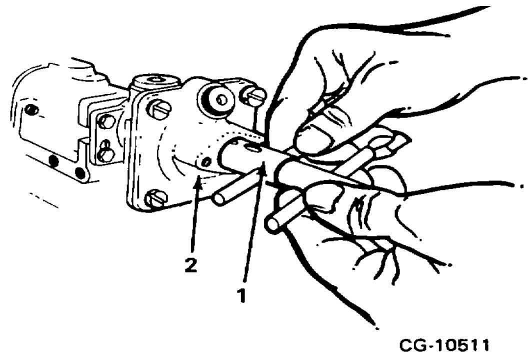


Figure 9. Adjusting Full Load Fuel Setting

1. KDEP 1047
2. Aneroid

Balanced Delivery Adjustment Procedure

22. If fuel flow of one or more pumping elements are not within specified balance limits given on CALIBRATION CHART, adjust affected elements as follows:

NOTE: Loosen injection line nut prior to adjusting barrel assemblies.

   a. Loosen barrel flange clamping nuts.

   b. Adjust barrels by turning clockwise (as viewed from top) to increase delivery, counterclockwise to decrease delivery.

IMPORTANT

ALWAYS USE BACK-UP WRENCH ON DELIVERY VALVE HOLDER WHEN TIGHTENING OR LOOSENING FUEL INJECTION LINE NUT.

   c. Check balance at low idle RPM. Adjust throttle lever to obtain low idle delivery.

   d. Maximum difference between cylinders is ±1 cc from average at rated and ± 2 cc from average at low idle.

NOTE: Balance should be maintained to as close a tolerance as is reasonably possible to prevent readjustment in later tests.

Fuel Delivery at Lo-Idle Check

23. This is an operating test to assure that the injection pump provides the proper quantity of fuel at lo-idle. Test and adjustment are made as follows:

    a. Operate test stand at specified RPM with control lever in lo-idle position (fully back) for 1000 strokes.
    b. Record fuel delivery from elements and compare results with specifications given on CALIBRATION CHART.
    c. Check balanced delivery between pumping elements and compare imbalance with specifications given on CALIBRATION CHART.
    d. Adjust fuel delivery and imbalance (see Test 21).

Check Fuel Delivery at Torque Check Speed

24. This is an operating test to assure proper pump and governor operation. Perform the test as follows:

    a. Operate stand at specified RPM with control lever locked in full load (fully forward) position for 1000 strokes.

    b. Record fuel delivery from elements and check for balanced delivery between pumping elements and compare with specifications given on CALIBRATION CHART. If not within specifications repeat Steps 20, 21 and 22.

Check Aneroid Controlled Power and Fuel (Cutback)

25. Check with boost line disconnected. If not within specifications proceed as follows:

    a. Remove cap from rear of aneroid.

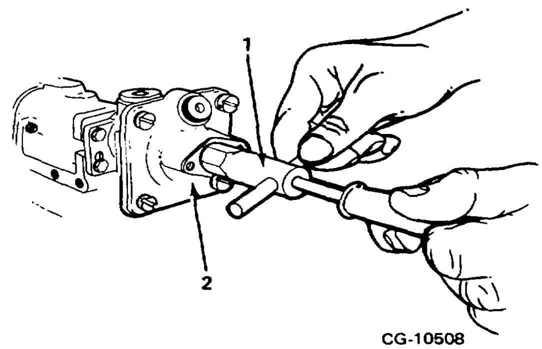


Figure 10. Adjusting Aneroid Cutback

1. KDEP 1048 2. Aneroid

    b. Using KDEP 1048 (Figure 10) turn socket head screw clockwise to increase power and fuel or counterclockwise to decrease power and fuel.

Check Low Speed Power and Fuel (Aneroid Controlled)

26. This adjustment is for correct spring preload. If not within specifications on calibration chart (Step 14) adjust as follows:

    a. Remove recessed hex head plug from top of aneroid. Use a screwdriver as a lever for turning the star wheel.

    b. If power or fuel are below specifications engage screwdriver blade with star wheel pushing screwdriver towards engine. This reduces spring preload, increasing power and fuel.

    c. If power or fuel are above specifications pull engaged screwdriver away from engine, increasing spring preload and reducing power and fuel.

    After adjustments are made make sure Steps 21 and 25 are still correct.

Check Fuel Shut-Off

27. This adjustment is made to protect pump internal stop and rack from damage. Adjustment is made by loosening stop bracket against which shutoff lever will strike (Figure 11). Operate shutoff lever to rear and hold in this position (rack against internal stop). Reposition external stop lever bracket so that shutoff lever will contact bracket stop screw just before rack would be stopped by the internal stop. Rack setting (dial indicator reading) with rack against external stop should be between 1.5 2.0 mm (.059 .079").

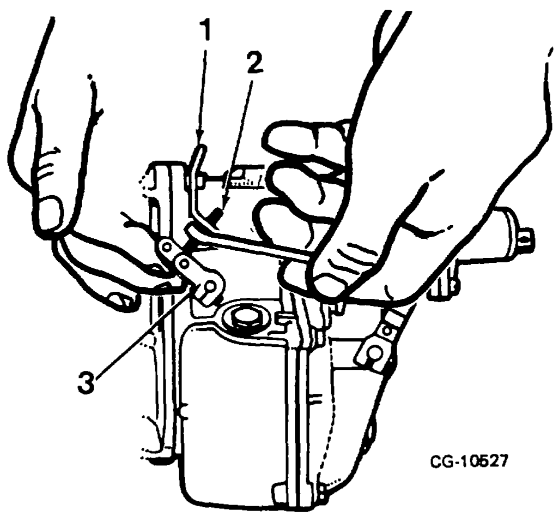


Figure 11. Adjusting External Stop Bracket

1. Stop Bracket
2. Stop Screw
3. Shutoff Lever

Check Start Fuel Cutout

28. This is an operating test made to assure that control rack will move from start fuel to full load fuel position at specified pump speed. Adjustment is made by varying the height of the rack link adjustment screw.

    Increase test stand speed slowly from 50 RPM and simultaneously operate control lever between lo-idle and hi-idle stops until cutout occurs and observe test stand speed. Test stand speed should be between specified RPM. If specified test speed is not obtained, reposition rack link adjusting screw height as follows: (See Figure 12)

    a. Using 10 mm Allen wrench, remove plug from adjustment access hole in top of governor housing.

    b. Loosen adjusting screw locknut (10 mm).

    c. If cutout occurred below specified speed, turn adjusting screw counterclockwise and if cutout occurred above specified speed turn adjusting screw clockwise.

    d. Tighten adjusting screw locknut and repeat test.

    e. Reinstall plug in adjustment access hole.

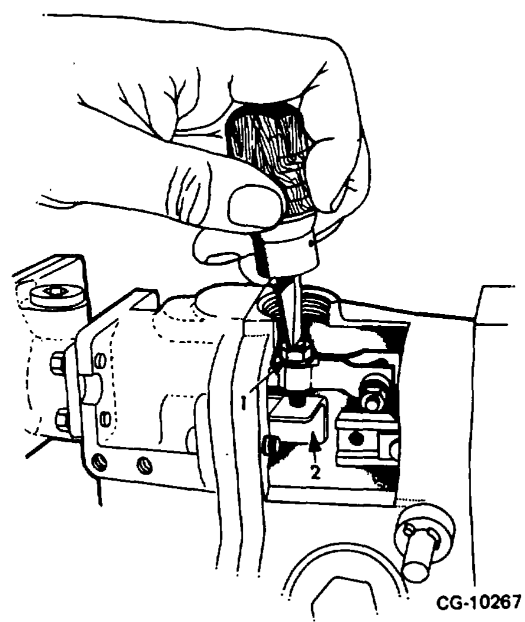


Figure 12. Adjusting Excess Fuel Rack Position (Governor Housing Cut-Away for Illustration)

1. Adjustment Screw
2. Stop Shackle

Check Start Fuel Quantity

29. This is an operating test made to assure that the injection pump provides the proper quantity of fuel to start the engine. Test is made as follows:

    a. Remove dial indicator from injection pump and install rack end cap.

    b. Operate test stand at specified RPM with control lever locked in start position (fully forward) for 1000 strokes.

    c. Record fuel delivery from elements and compare with specifications given on CALIBRATION CHART.

    d. If fuel delivery does not meet minimum specifications, remove shim(s) from under screw head located at the end of control rack. If fuel delivery exceeds maximum specification, add shim(s) under screw head.

    e. Install rack end cap and recheck fuel delivery.

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INJECTION PUMP AND ENGINE TEST DATA
(CALIBRATION DATA ON REVERSE SIDE)

Pump No: 1 802 608 C92
Application: .... S-Series, Cargostar, Paystar, 1853 FC Bus

Engine DTI-466C
Model B210C
Rating .... 210 BHP @ 2600 RPM
Timing:
Static .... 1 8°± 1° BTDC
Turbocharger No 684 698 C91
1 806 078 C91
Lift-to-Port Closing .... 3.05 ± 0.05 mm
Governor Spring No:
Outer 684 872 C1
Middle 397 764 C1
Inner 1 806 308 C1

Supply Pump Pressure (Rated)
1 802 608 C91 .... 31 psi
1 802 608 C92 .... 50 psi
Test Nozzles: SAE 0.5 Orifice Plate Nozzles
Tool Number .... Bosch No. 1 688 901 016
Service Tool No. SE-2756
Test Nozzle Opening Pressure .... 3, 000 psi
High Pressure Test Fuel Lines:
Length .... 600 mm (24")
O.D .... 6 mm (.24")
I.D .... 2 mm (.079")
Tool Number: .... Bacharach No. 77-0194
Calibrating Fluid .... VISCOR 1487 or 1487AW (SAE J967 D Standard +)
Fluid Operating Temperature .... 100-110°F
Calibration Feed Pump Pressure ... 1.5 BAR (21.5 psi)

ENGINE TEST DATA**

		Rated Speed	Torque Check Speed	Droop Check Speed
Engine (RPM) +10		2600	1800	1400
Horsepower	Max.	210	186	-
Fuel (lbs/hr)	Max.	93	68	39
Manifold Pressure	Int.	36-42	24-30	-
(in. Hg.)	Exh.	36-42	14-20	-
Exhaust Temperature at Sea Level ('F Max.)***		-	-	-

*See CAMSHAFT, Section 3, Page 4.
**Engine test ambient conditions are: Air temperature 85°F, Barometer 29.38 In. Hg.
***Exhaust temperature increase 15°-20°F per 1000 ft. increase in altitude.
+ Latest Revision.

CALIBRATION DATA FOR PUMP: 1 802 608 C92
(INJECTION PUMP AND ENGINE TEST DATA ON REVERSE SIDE)

NOTE: Operate pump in low range for 10 min. to assure fluid is at normal operating temperature.

TEST SEQUENCE	INJECTION PUMP RPM	CONTROL LEVEL ASSY. POSITION (Ref.)	CONTROL RACK POSITION MM (INCH) (Ref.)	FUEL DELIVERY CC/1000 STROKES	ANEROID	REMARKS AND SPECIFICATIONS
1. Pre-stroke Setting	____	Forward	12.5 (.492)	____	20 psi	3.05 +0.05 mm (.120" ±.002") Lift to port closure.
2. Pump Camshaft Phasing	____	Forward	12.5 (.492)	____	20 psi	60 ±0.5° Firing Order 1-5-3-6-2-4
3. Preliminary governor Cut-off	1440-1505	Forward (no hi-idle stop)	8.0 (.315)		20 psi	Gap between lever and hi-idle screw.
4. Governor Cut-off	1375	Forward (hi-idle screw adjusted)	10.65 (.417)	75-81	20 PSI	____
5. Governor Performance at No Load (Hi-Idle)	1500-1520	Forward	4.0 (.157)	20-25	20 psi	____
6. Governor End Regulation	1580	forward	0.1-1.0 (.0039-.039)		20 psi	____
7. Lo-Idle Regulation	350	Back	6.4 (.252)	15-20	20 psi	Set, if necessary.
8. Lo-Idle Back-up Check	100	Back	9.0 (.35) Minimum		20 psi	____
9. Step/No Step Check	370-650	____	____	____	____	Look for continuous rack movement, if "sticky" correct.
10. Fuel Delivery at Full Load (Rated Speed)	1300	forward	12.5 (492)	111.0 ±1	20 psi	Maximum imbalance 2.0-cc/1000 strokes between pumping elements.
11. Full Delivery at Lo-Idle	350	Back	6.4 (.252)	15-20	20 psi	Maximum imbalance 2.0 cc/10000 strokes between pumping elements.
12. Fuel Delivery at torque Check Speed	900	Forward	12.5 (.492)	105.5 ±1	20 psi	Maximum imbalance 2.0 cc/10000 strokes between pumping elements.
13. Aneroid Cutback	800	forward	9.3 (.355)	60.5 ±1	0 psi	____
14. Aneroid Spring Adjustment Check A	800	Forward	Cutback rack position plus 0.5 (.02)	____	5.5-7.5 in Hg	Start Travel
Check B	800	Forward	Full load rack position minus 0.5 (.02)	____	18.2-20.2 in Hg (8.92-9.90 psi)	End of Travel
15. Fuel shut-off	____	____	1.5-2.0 (.059-.079)	____	0 psi	Shut-off level back against stop.
16. Start Fuel Cut-out	240-280	____	____	____	0 psi	Operate level from hi-idle to lo-idle
17. Fuel Delivery at Start	100	Forward	21.0 (.827)	140-180	0 psi	

ENGINE

TURBOCHARGER DT-466

CONTENTS

DESCRIPTION

The turbocharger is essentially an exhaust driven blower (Fig. 1). Its purpose is to increase engine power by supplying compressed air to the combustion chambers permitting greater fuel consumption at an efficient air-fuel ratio.

The turbocharger consists basically of the turbine wheel and shaft assembly, turbine wheel housing, compressor wheel and housing and the center housing.

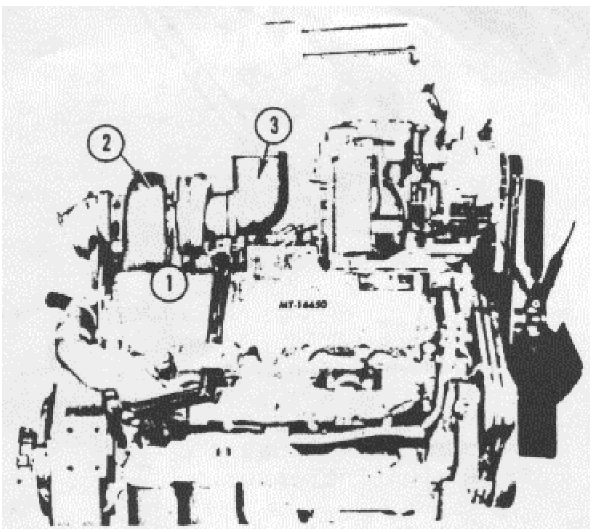


Fig. 1. Turbocharger

1. Center Housing
2. Turbine Housing
3. Compressor Housing

The turbine wheel housing, bolted to the center housing, receives exhaust gases from the engine. The exhaust gases spin the turbine wheel and shaft in the range of 70, 000 rpm at rated engine speed and load. This motion is transferred to the compressor wheel secured to the other end of the shaft.

Outside air, after passing through the air cleaner, is piped to the compressor wheel housing which is clamped to the center housing. Here the air is compressed and directed into the intake manifold.

The center housing supports the shaft on two bearings. These bearings "float" on a film of oil and touch neither the housing or Shaft. Oil to cool and lubricate the bearings is supplied under pressure through passages in the center housing. A sealing ring at each end of the shaft prevents oil from leaking into the turbine wheel or compressor wheel housings and also prevents exhaust gases or compressed air from leaking into the center housing. A thrust collar and thrust washer absorb any slight axial movement of the shaft.

OPERATION

In a naturally aspirated or normal breathing engine, air enters the engine at atmospheric pressure, mixes with a specified amount of fuel and is burned in the combustion chamber, producing a certain amount of power.

It was found that if more air could be put into the combustion chamber (Fig. 2), more fuel could be burned and greater power produced from the same size engine. This increased amount of air or air-fuel mixture forced into the combustion chamber became known as a "supercharge."

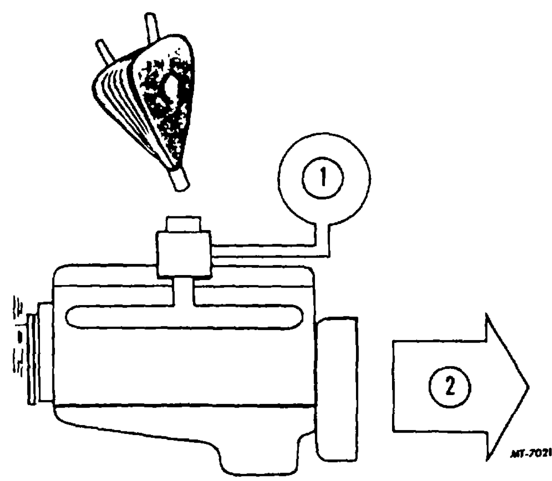


Fig. 2. Air Being Forced Into Engine

1. Fuel 2. Increased Power

On a turbocharged diesel engine (Fig. 3), the turbocharger supplies air under pressure to the intake manifold which provides a greater amount of air to the combustion chamber. The fuel injection system is calibrated to inject the correct amount of fuel for the increased volume of air.

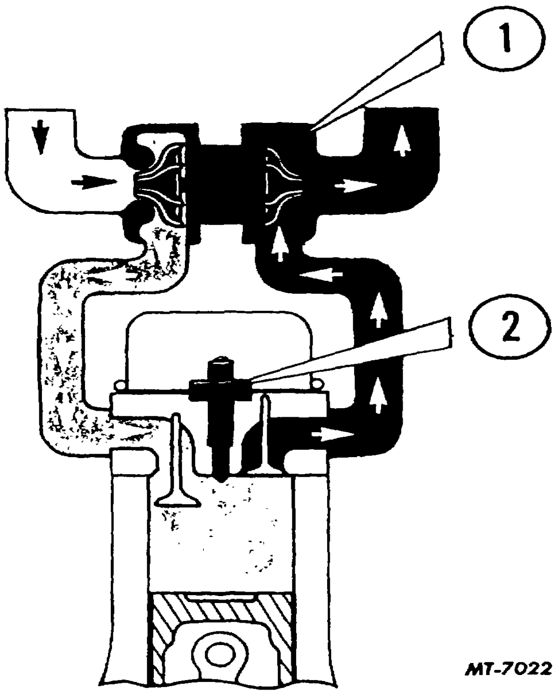


Fig. 3

1. **Turbocharger**
2. **Fuel Injector**

The turbocharger, in addition to exhaust volume and velocity, depends upon exhaust heat. Under loaded conditions at maximum fuel delivery, the turbocharger becomes very efficient and supplies the increased air volume needed to support proper combustion (Fig. 4).

Since the turbine speed is governed by the exhaust energy of the engine at any speed, the turbocharger delivers the correct volume of air at any throttle position. Also, less air resistance at higher elevations allows the turbocharger to spin faster and maintain correct air delivery, thereby avoiding the power loss and excessive smoking that occurs on naturally aspirated and supercharged engines at high altitude.

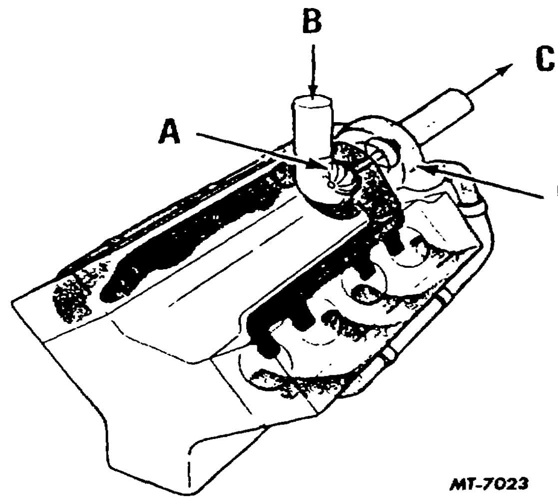


Fig. 4. Turbocharger Cycle

A. Compressor Wheel Speed Increases as Exhaust Expansion Increases.

B. Increased Fuel Consumption Requires Greater Air Intake.

C. Exhaust Temperature Increased with Greater Fuel Consumption.

D. Increased Exhaust Temperature Results in Greater Expansion within Turbine Housing.

The basic operating principles of the turbocharger are as follows:

The engine exhaust is directed into the turbine housing (Fig. 5). As the exhaust passes through the nozzle ring vanes, it gains velocity and strikes the turbine wheel vanes. This action spins the turbine wheel shaft to which the compressor wheel is attached.

As the compressor wheel turns, it draws air from the air cleaner into the compressor housing, compresses it and forces it into the intake manifold. This provides a greater volume of air in the combustion chamber. Because a greater volume of air is delivered to the combustion chamber, a greater amount of fuel is required to obtain the correct air-fuel mixture. This increased consumption of fuel at the correct air-fuel ratio results in increased power output.

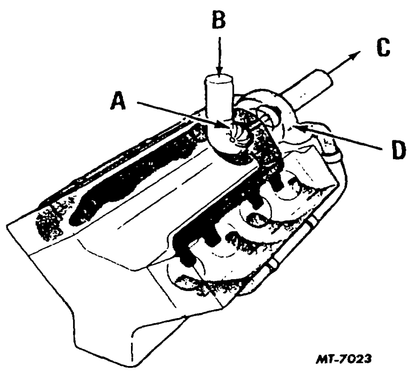


Fig. 5. Air and Exhaust Flow In Turbocharged Engine

1. Air Intake
2. Turbocharger
3. Exhaust

SERVICE PRECAUTIONS

Regardless of their rugged appearance, turbochargers are to be handled with extreme care. The internal parts are manufactured to close tolerances and are very sensitive to accumulations of dirt, nicks and scratches.

Care must be taken to prevent damage to the components while they are on the workbench.

The turbine wheel, compressor impeller, shaft and related parts form a balanced assembly which rotates at very high speeds.

Bending of the turbine or compressor vanes or removal of any vane material during servicing could cause a serious out-of-balance condition which could quickly destroy the turbocharger.

The greater air flow requirements of a turbocharged engine makes it extremely important that the air intake system be kept clean. The air cleaner must be serviced at recommended intervals to avoid power loss due to air cleaner restriction and to prevent possible entry of dirt into the turbocharger and engine.

Turbocharging an engine is more than merely bolting on the turbocharger and driving away. The installation must be carefully engineered to provide the best performance and avoid "overcharging" which could be destructive. Also, the engine must be designed to handle the greater air and fuel flow, higher pressures and temperatures, and increased torque and power output.

After assembly, all openings in the turbocharger should be capped or taped closed, or the entire turbocharger should be encased in a clean polyethylene bag to prevent entry of foreign material. Keep openings covered until the unit is installed on the engine.

To prevent damage to the bearings, the turbocharger must be prelubricated at installation or if the engine has not been operated for a long period of time. To prelubricate the bearings, place 4 to 5 ounces of clean oil into the turbocharger oil inlet opening.

GENERAL MAINTENANCE AND CLEANING PROCEDURES

1. Prevent the entrance of foreign material by covering or plugging all openings into the turbocharger when handling or assembling the unit. Covers must remain in place until the turbocharger is installed and all connections are secured.

2. All connections to the turbocharger (manifolds and piping) must be clean and free of foreign material, since serious damage to the turbocharger or engine could result. All connections must be airtight.

3. Exhaust stacks of extra long length and other fixtures must not be rigidly attached to the turbocharger.

4. For initial running when installing a new or rebuilt turbocharger or after the engine has been in storage for 30 days or more or when engine oil filters have been changed, it is recommended that 4 to 5 ounces of oil (same type and grade as used in the crankcase) be put into the oil inlet opening in the turbocharger with a squirt can. This will provide sufficient lubrication for the turbocharger bearings until normal engine

lubrication is established. Connect the oil inlet line.

5. If engine oil becomes contaminated by water, the turbocharger must be drained to prevent sludge formation. It is recommended that after an engine overhaul, an oil inlet filter (see "Engine Service Manual") be installed and used during the first 5 to 25 hours of operation and then removed, as this filter can clog with carbon that is normally suspended in the oil of a diesel engine.

6. It is imperative that the air cleaner service outlined in the Operator's Manual be rigidly followed because of the oil carry-over and power losses that can be incurred with a restricted air cleaner.

Air flow requirements for diesel turbocharged engines are considerably greater than for a non-turbocharged engine of the same size running at the same speed. Air inlet accessories must minimize the restriction at this higher air flow and maintain performance of the turbocharger unit.

The engine crankcase breather should be cleaned periodically to be sure that there is no restriction.

During normal operation, the turbocharger should be free from vibration or unusual noises.

9. The exhaust stack should be covered to prevent water from entering and damaging the turbine during shutdown periods or when unit is being transported.

10. Periodic inspection of the compressor wheel should be made to check for soft carbon deposits, damaged blades, interference or excessive end play.

COMPRESSOR CLEANING PROCEDURE

1. The frequency of cleaning the compressor end of the turbocharger depends on the condition under which the engine is operated. Before cleaning, inspect the components for signs of rubbing or other defects which might not be evident after cleaning.

2. Refer to respective engine section for removal of turbocharger from engine.

3. Remove the compressor housing (and Key 9, Fig. 7).

4. To prevent damaging the compressor wheel, rest the unit on wooden blocks in a pan or container for cleaning fluid. The compressor wheel must be down and the shaft vertical.

NEVER REST THE WEIGHT OF THE UNIT ON THE WHEEL.

5. Fill the container only up to the edge of the compressor housing, using a good grade metal cleaner or equivalent. Never use a caustic solution.

Do not allow the cleaning fluid to get to the rotating housing.

6. After deposits have softened, remove with a soft brush or plastic blade scraper.

7. Wash the compressor cover in cleaning fluid and dry thoroughly.

8. Assemble the compressor cover and install turbocharger. Refer to "Engine Service Manual" for installation procedures.

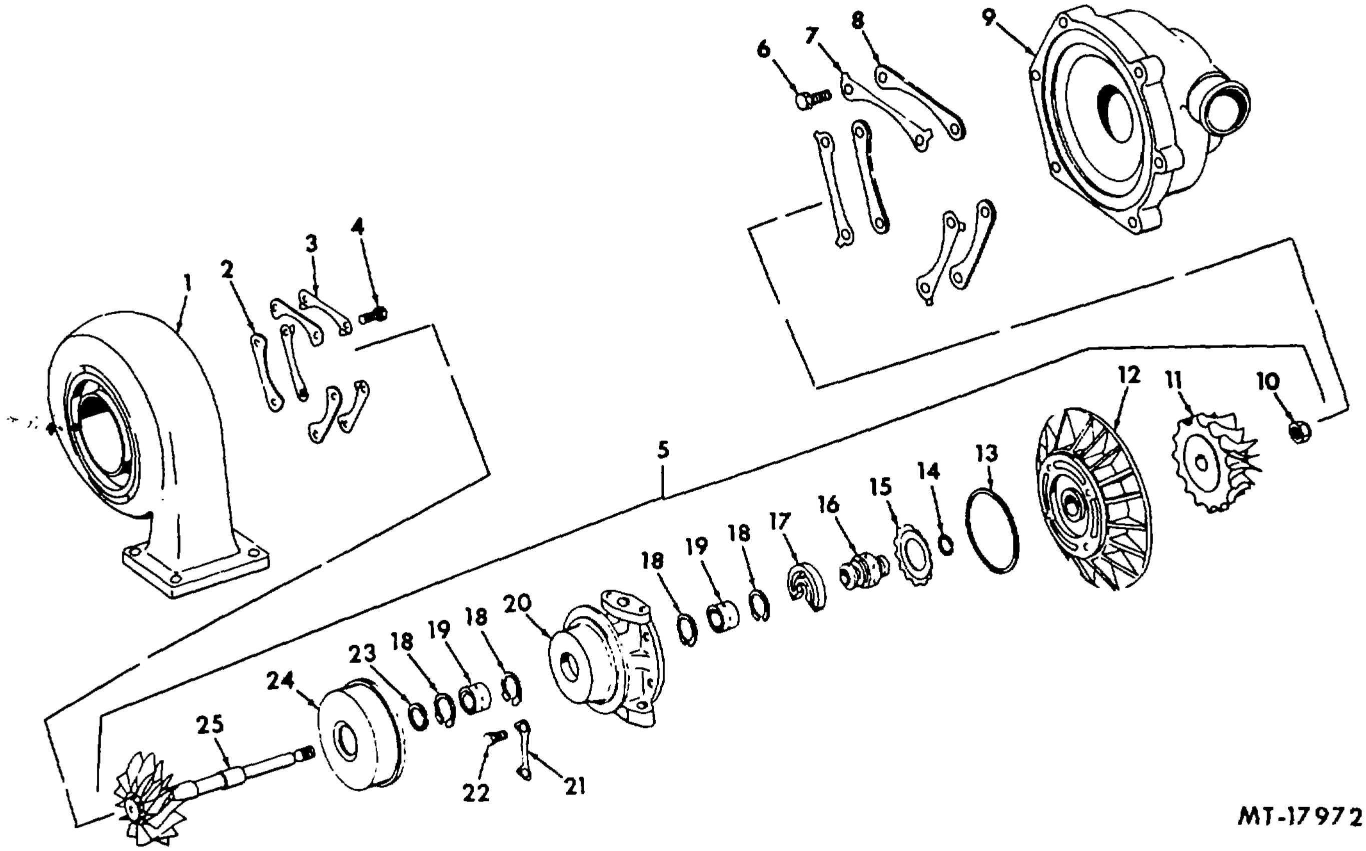


Fig. 7. DT-466 Turbocharger (Exploded View)

Key	Description	Key	Description
1	HOUSING, Turbine	13	RING, Plate Seal
2.	CLAMP, Housing (3)	14	RING, Piston
3	PATE, Lock (3)	15	SPRING, Plate
4	SCREW, Hex Hd Cap (6)	16	WASHER, Thrust
5	CORE ASSEMBLY	17	COLLAR, Thrust
6	SCREW, Hex Hd Cap (6)	18	RING, Retaining (4)
7	PLATE, Lock (3)	19	BEARING, Housing (2)
8	CLAMP, Housing (3)	20	HOUSING, Center
9	HOUSING, Compressor	21	PLATE, Lock
10	NUT, Impeller Lock	22	SCREW, Hex Hd Cap (4)
11	WHEEL, Impeller	23	RING, Seal
12	PLATE, Back	24	SHROUD, Turbine
		25	WHEEL, Turbine

PRE-DISASSEMBLY CHECKS

Make the following checks and if the turbocharger meets these requirements, it can be considered satisfactory and reinstalled on the engine. If it does not meet the requirements, it must be rebuilt (refer to "Disassembly").

CHECK FOR FREE ROTATION

1. Stand the turbocharger on bench with shaft in a horizontal position.

2. Wheels must spin freely when turned by hand.

CHECK AXIAL END PLAY

1. Clamp turbocharger in a vise and position a dial indicator with a magnetic base on the frame of the vise (Fig. 8). (Any type base may be used as long as a similar position can be obtained.) Place the foot of the indicator on the turbine end of the shaft.

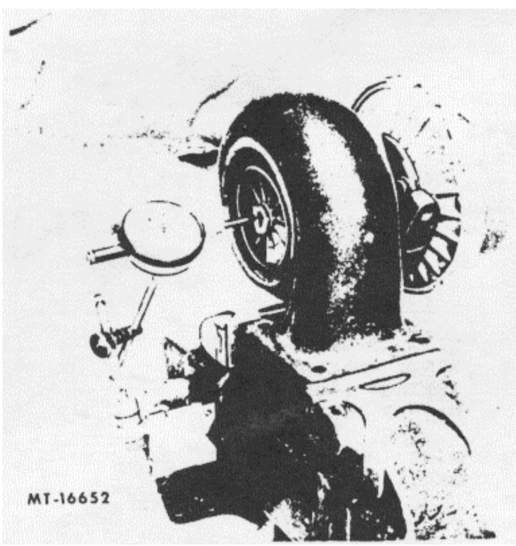


Fig. 8. Checking Axial End Play

2. Move the shaft back and forth by hand and record the reading.

3. If the reading exceeds the specifications, the turbocharger must be disassembled and repaired (see "Specifications").

CHECK RADIAL SHAFT MOVEMENT

1. Remove the protective cover from the oil drain port in the center housing.

2. Install a two inch contact point extension on the dial indicator and position the indicator as shown in Fig. 9. The indicator contact point must contact the turbine shaft through the oil drain port in the center housing.

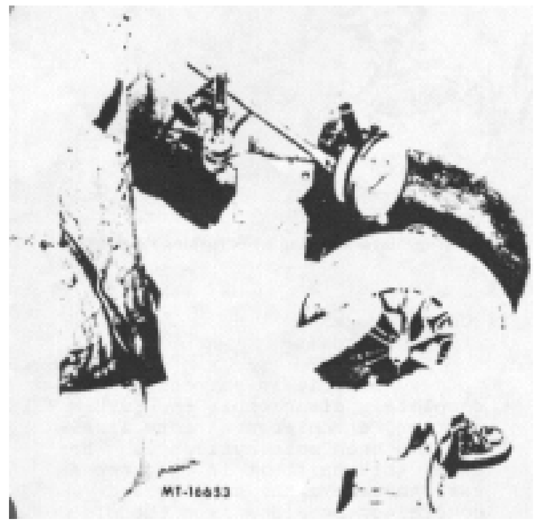


Fig. 9. Checking Radiator Shaft Movement With Housing Installed

3. Hold both ends of the rotating assembly and move the shaft up and down, parallel to the extension of the dial indicator (Fig. 9), Be sure to exert equal pressure on both ends of the rotating assembly.

4. If the readings are not within specifications, the turbocharger must be disassembled and repaired (see "Specifications").

5. If the indicator readings taken in Step 3 were satisfactory, but interference between the compressor housing and compressor wheel is suspected, punch mark the compressor housing, center housing and back plate to facilitate reassembly and remove the compressor housing and diffuser.

6. Install the dial indicator as outlined in CTS-4104 Page 9

Step 2 and recheck the radial shaft movement as outlined in Step 3 (Fig. 10). If the readings exceed those obtained in Step 3, indications are that the compressor wheel is contacting the compressor housing and servicing is required.

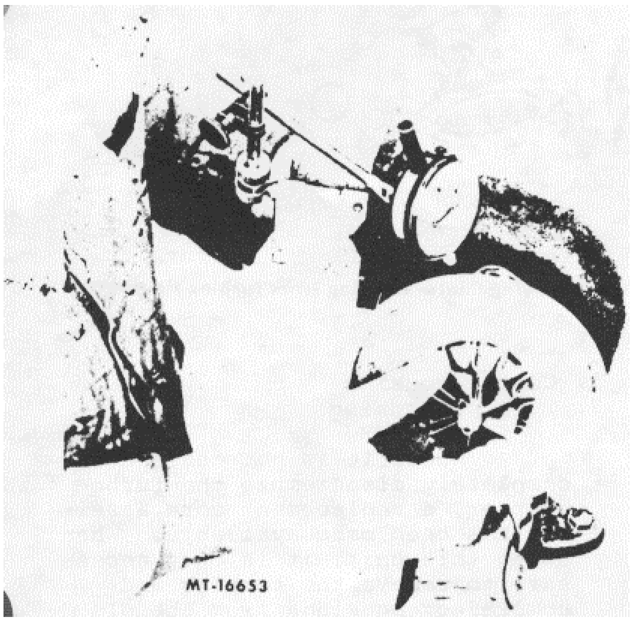


Fig. 10. Checking Radial Shaft Movement with Compressor Housing Removed

COMPRESSOR END

Check for dirt accumulation inside the compressor housing.

COMPRESSOR WHEEL

Examine carefully for bent blades, evidence of rubbing on O.D., face and back of wheel, and for pieces of blade broken off. If any of these conditions exist, wheel must be replaced.

TURBINE WHEEL

Remove core assembly from turbine housing. Examine wheel carefully for evidence of rubbing on housing. Check for bent or broken blades. Do not attempt to straighten blades.

DISASSEMBLY

1. Cover intake and exhaust ports. Wash the exterior of the turbocharger.

   Use a commercially approved cleaner only. A caustic solution will damage certain parts and should not be used.

2. Place turbocharger on bench.

3. Mark the assembled position of parts (Fig. 11) as follows:

   a. Compressor housing-to-back plate.

   b. Back plate-to-center housing.

   c. Center housing-to-turbine housing.

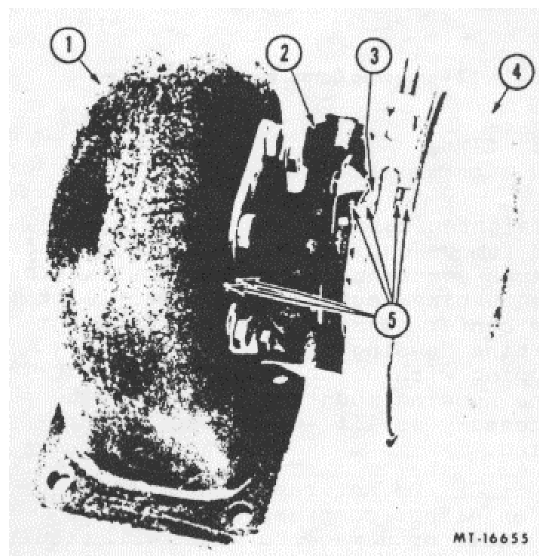


Fig. 11. Related Positions of Parts

1. Turbine Housing
2. Center Housing
3. Back Plate
4. Compressor Housing
5. Punch Marks

4. Remove the clamp or capscrews and lock plates and stand the turbocharger on the bench as shown in Fig. 12. Carefully lift the turbine housing with center housing attached from the compressor housing. A light tapping with a rubber mallet on the compressor mounting flange may be necessary as lifting pressure is applied.

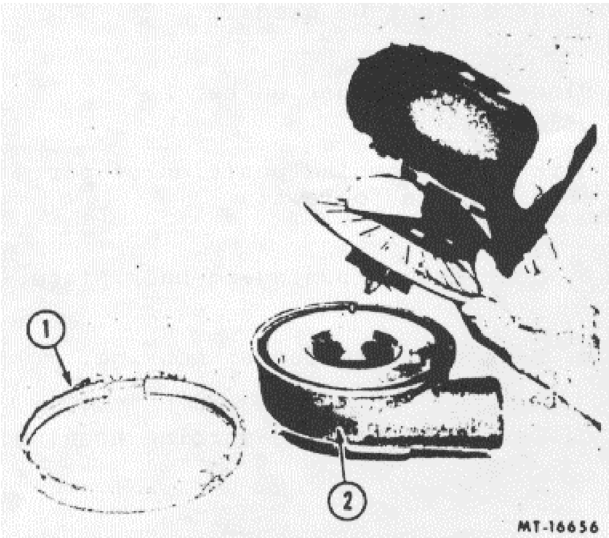


Fig. 12. Removing Compressor Housing

1. Clamp
2. Compressor Housing

5. Straighten tabs on the lock plates and remove capscrews, lock plates and clamps securing the center housing to the turbine housing. Carefully lift the center housing assembly from the turbine housing (Fig. 13). A light tapping with a rubber mallet on turbine housing mounting flange may be necessary as lifting pressure is applied.

Do not test center housing on either compressor or turbine wheel or damage to wheel will result.

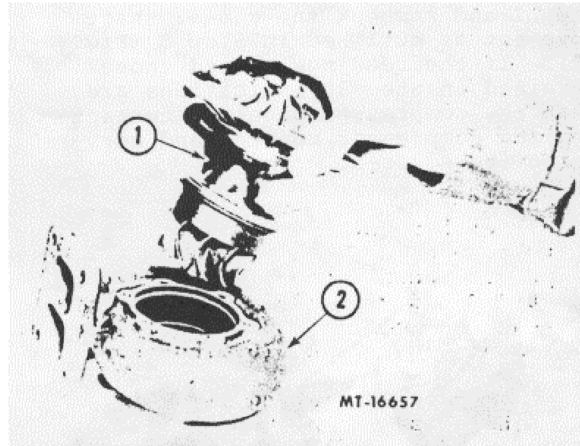


Fig. 13. Removing Center Housing From Turbine Housing

1. Center Housing
2. Turbine Housing

Where it is not desired to completely disassemble the turbocharger, a replacement core assembly has been made available. When using this unit, it is only necessary to remove the turbine and compressor housings from the old unit and install them on the new core assembly.

6. Remove the locknut from the turbine shaft (Fig. 14):

Do not apply side thrust when loosening the lock nut as it is possible to bend the shaft.

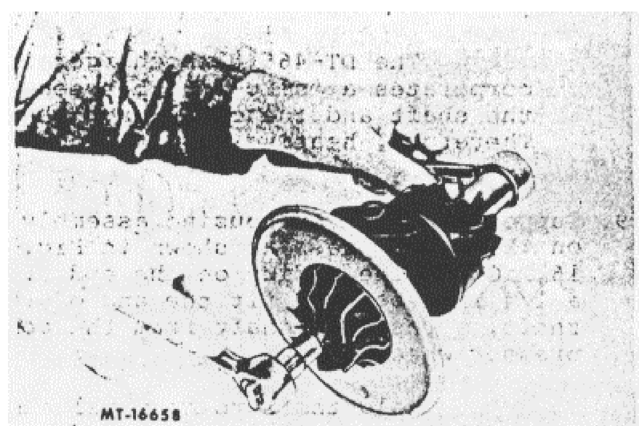


Fig. 14. Lock Nut Removal

7. On DT-466 applications, slide the compressor wheel from the turbine shaft. If carbon buildup prevents easy removal, press the shaft from the compressor wheel according to Step 9.

9. Support the center housing assembly on the arbor press as shown in Fig. 16. Grind the radius on the end of a 1/4 inch bolt to fit the end of the shaft. Press the shaft from the compressor wheel.

   Hold the turbine wheel and shaft to prevent it and the shroud from being damaged by dropping.

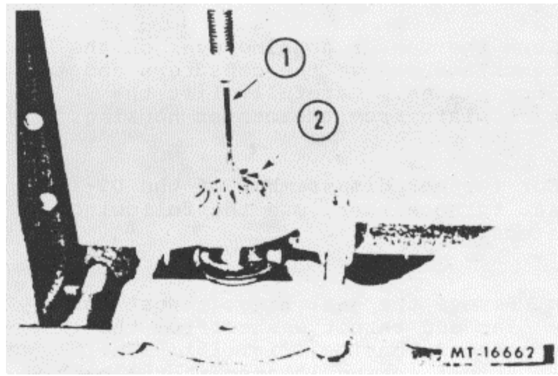


Fig. 16. Separating Compressor Wheel From Turbine Shaft

1. Bolt 2. Compressor Wheel

10. Straighten the tabs on the lock plates and loosen the capscrews securing the center housing to the back plate (Fig. 17). Do not remove the capscrews in this position.

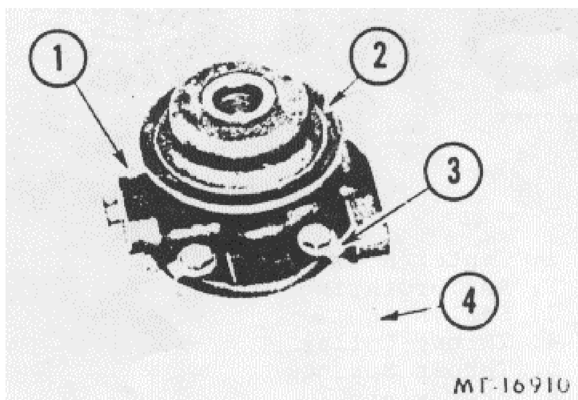


Fig. 17. Center Housing Assembly

1. Center Housing
2. Shroud
3. Lock Plate
4. Back Plate

11. Turn the center housing over on the bench and remove the capscrews and lock plates. Carefully lift the back plate from the center housing.

12. For further disassembly of the DT466 turbocharger, use the following steps: a. Remove the seal ring, thrust collar and thrust washer from the center housing (Fig. 18). The thrust spring located in the back plate is replaceable, but should not be removed unless replacement is necessary.

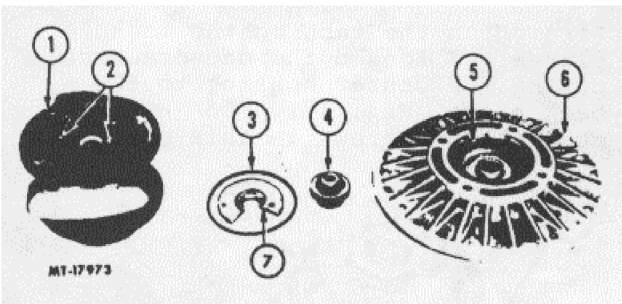


Fig. 18

1. Center Housing
2. Anti-rotating Pins
3. Seal Ring
4. Thrust Collar
5. Thrust Spring
6. Back Plate
7. Thrust Washer

b. With a sharp pick, remove the spiral bearing retainers from the bearing bore on the compressor side of the housing (Fig. 19). Remove the bearing. Turn the center housing over on the bench and remove the retainers and bearing from the turbine end (Fig. 19).

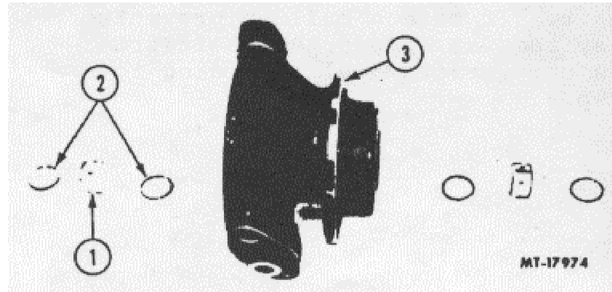


Fig. 19

1. Bearing
2. Retainers
3. Center Housing

Replace the two inboard retainers only if they appear to be damaged or worn. The inboard retainers are subject to distortion during removal so they must be replaced with new retainers if removed.

c. Remove the seal ring from the thrust collar (Fig. 20). Discard the seal ring.

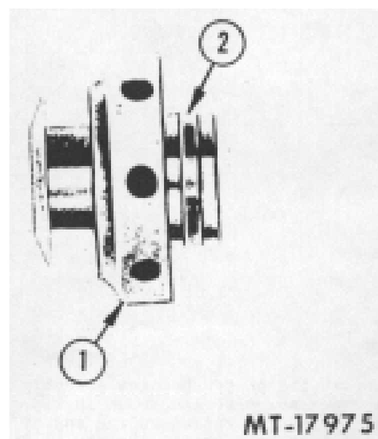


Fig. 20

1. Thrust Collar
2. Seal Ring

d. Carefully expand and remove the piston ring (Fig. 7) from the turbine wheel and shaft.

INSPECTION

Before cleaning, inspect all the components for signs of rubbing or other defects which might not be evident after cleaning.

Submerge and soak all parts in a good metal cleaner. The cleaning solution should be agitated to do a satisfactory job, but special care should be taken to insure the parts do not strike each other.

Never use a caustic solution for cleaning, as this will permanently damage certain parts.

Use only a soft brush, plastic blade scraper or compressed air jet to remove deposits. Never use a wire brush or steel blade scraper for this purpose.

Be sure all wheel blades are thoroughly cleaned, as any deposits left on the blades will affect balance.

Clean all internal cavities of the center housing thoroughly with compressed air.

Check both wheels of the rotor assembly for damaged or distorted vanes and for possible contact with their respective housings and air inlet. The spacing between the vanes and the contour must be uniform. Check for cracked, bent or damaged blades. Replace if necessary.

<u>Do not attempt to straighten blades.</u>

Inspect the turbine housing for cracks or excessive scoring in the outlet contour. Inspect the compressor housing for damage.

On the DT-466 turbocharger, inspect the thrust washer and collar for wear or damage. Inspect the thrust spring in the back plate for wear or damage. This spring need not be removed unless damage is evident.

TURBINE WHEEL AND SHAFT

Inspect the bearing surfaces for excessive scratches and wear. If the shaft is only slightly scratched, it may be reused. Never grind or polish the shaft, as this will affect balance.

Inspect piston ring groove walls for scoring. Minor scratches are acceptable.

Check carefully for cracked, bent or damaged turbine blades.

Do not attempt to straighten blades.

BEARINGS

Inspect for scratches or worn surfaces. Replace bearing if tin plate is worn off.

CENTER HOUSING

Inspect for worn or scored surfaces in bearing bores.

Inspect the flanges that mate to the compressor housing for nicks or gouging.

The flanges must be smooth to provide proper clearance for compressor wheel and turbine wheel.

Replace the housing if the bores are scored or show signs of excessive wear.

REASSEMBLY

When lubricating of parts is specified, use the same type oil as used in the engine.

DT-466 TURBOCHARGER

(Reference numbers in parenthesis refer to Figure 7, unless otherwise specified.)

1. If the inboard bearing retainers (18) were removed, use a sharp pick to install new retainers into their grooves in the bore of the center housing. Insure the retainers are properly seated in the grooves.

2. Lubricate the housing bearings (19) with clean engine oil and push them into the bores until they seat against the retainers (18). Install new outer retainers (18) after installing bearings.

3. Install the piston ring (14) into the groove on the shaft (25).

4. Place the shroud (24) over the turbine end of the center housing. Carefully insert the shaft (25) through the shroud and center housing.

5. Install a new seal ring onto the thrust collar (Fig. 20). Install the thrust washer onto the collar with the flat surface of the washer next to the large diameter of the collar (Fig. 21).

6. Install the thrust collar and washer over the shaft (25), thrust washer first and engage the holes in the washer with the anti-rotating pins (Fig. 18) in the center housing.

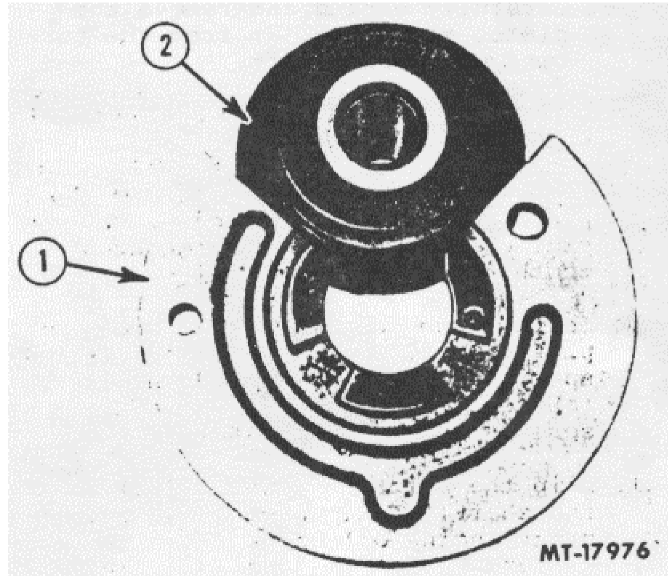


Fig. 21

1. Thrust Washer
2. Thrust Collar

7. Install a new seal ring (13) into the groove in the compressor side of the center housing.

8. Insure the thrust spring is correctly seated in the back plate (Fig. 22).

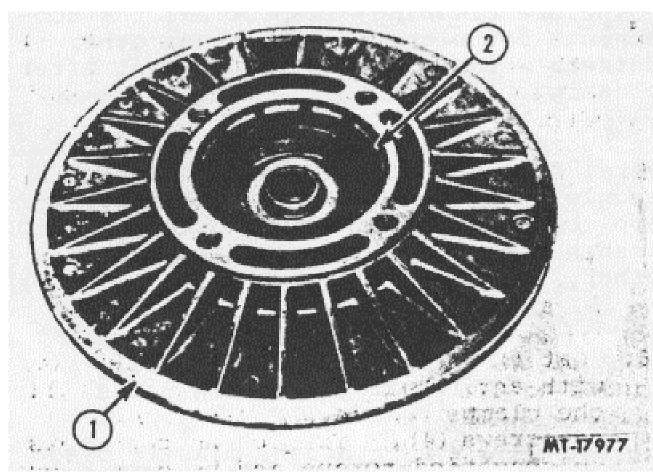


Fig. 22. Thrust Spring In Back Plate

1. Back Plate
2. Thrust Spring

9. Align the marks made during disassembly (Fig. 11) on the back plate (12) with those on the center housing (20) and carefully install the back plate over the shaft and thrust collar. Be careful not to damage the seal ring when engaging the thrust collar into the bore in the back plate. The back plate is easily installed if the open side of the seal ring is engaged into the back plate bore first.

10. Install the capscrews (22) and lock plates (21). Torque the capscrews to specified torque and bend the lock tabs on the lock plate to secure the screws (see TORQUE CHART).

11. Slip the compressor wheel (11) onto the shaft. Apply a small amount of clean engine oil on the threads and washer face of the lock nut (10). Install the lock nut finger tight.

12. Carefully place the assembled center housing in a vise equipped with brass jaws; clamping on the hex on the end of the turbine wheel.

13. Tighten the lock nut (10) using a double universal joint to avoid side load which could cause the shaft to bend. Upon reaching specified torque tighten an additional 1/4 turn (see TORQUE CHART).

14. Remove the assembly from the vise and spin the wheels by hand. The wheels must rotate freely; insure the turbine wheel does not rub the shroud (24).

15. Align the marks made during disassembly (Fig. 11) on the center housing with those on the turbine housing. Carefully install the turbine end of the center housing into the turbine housing.

16. Coat the threads of the capscrews (4) with anti-seizing compound. Install the clamps (2), lock plates (3) and capscrews (4). Torque the capscrews to specified torque and bend the lock tabs on the lock plates to secure the capscrews (see TORQUE CHART).

17. Align the marks (Fig. 11) on the compressor housing with those on the center housing and back plate. Carefully install the compressor housing and secure with capscrews (6), clamps (8) and lock plates (7). Torque the capscrews to specified torque and bend the lock tabs on the lock plates to secure the capscrews (see TORQUE CHART).

18. Push the shaft as far as possible from the turbine end and check for binding during rotation. Repeat check, pushing from compressor end. The shaft must rotate freely with no interference at either end of the turbocharger.

19. If the turbocharger is not to be installed immediately, lubricate internally and install protective covers on all openings.

20. Install the turbocharger on the engine according to the specified "Engine Service Manual."

SPECIFICATIONS		
DESCRIPTION	**DT-466**	
Turbine Shaft Axial End Play	02- .10 mm (.001- .004")	
Turbine Shaft Radial Shaft Movement.	08 -.15 mm (.003 -.006")	

TORQUE CHART

DESCRIPTION	DT-466
Back Plate-to-Center Housing Capscrews	4.5 - 6.8 N•m (40 - 60 lbf-in)
Shaft Lock Nut (Hot)	N.A.
Shaft Lock Nut (Final Time) (18 - 20 lbf-in) *	2.0 - 2.3 N•m
Center Housing-to-Turbine Housing Capscrews	11.3 - 14.7 N•m (100-130 lbf-in)
Compressor Housing Clamp Nut	N.A.
Center Housing-to-Compressor Housing Capscrews	12.4 - 14.7 N•m (110-130 lbf-in)

* Turn lock nut additional 1/4 turn after reaching torque value.

TROUBLE SHOOTING

CONDITION	POSSIBLE CAUSE	REMEDY
<u>Shaft and Turbine Wheel</u>		
a. Bearing surfaces scratched and worn.	a. Dirty or insufficient oil.. Wheel overspeeding.	a. Replace
b. Discoloration	b. Overheating or insufficient oil	b. Reuse if slightly discolored and not deeply scratched.
c. Worn on one side only	c. Operating with unbalanced wheel.	c. Replace.
d. Cracked, bent or damaged blades	d. Foreign objects, heat or fatigue.	d. Replace.
<u>Bearings</u>		
a. Both ID and OD scratched and worn.	a. Dirty or insufficient oil. Wheel overspeeding.	a. Replace.
b. Seized on shaft or excessive OD wear	b. Overheating or lubrication failure.	b. Replace.
c. Worn on one side only	c. Operating with unbalanced wheel.	c. Replace.
<u>Bearing Housing</u>		
a. Bore scratched or worn.	a. Dirty or insufficient oil.	a. Replace.
b. Carbon deposits.	b. Oil leaking; overfueling.	b. Clean housing. Re-move any restriction from air intake system or oil drain -

CONDITION	POSSIBLE CAUSE	REMEDY
Compressor End Dirty.	a. Excessive intake restriction or a restricted oil drain line.	a. Check for clogged air cleaner element, collapsed hose or leaks in air inlet pipe. Clean compressor end and oil drain line.
	b. Insufficient air filtration.	b. Secure the connections between the air cleaner and turbocharger.
	c. Long period of operation without cleaning.	c. Disassemble and clean the unit.
Compressor Wheel a. Rubbing on OD of blades,	a. Worn bearing or unbalanced turbine wheel.	a. Replace parts as necessary.
b. Rubbing on cover or back face.	b. Insufficient clearance, cover damaged or thrust washer worn.	b. Improper end play. Replace damaged or worn parts.
c. Inlet leading edge of blades either worn or pieces broken off.	c. Loose pieces in air intake system.	c. Check air intake system for loose nuts, bolts or other foreign material. Replace wheel assembly.
Shaft Rotation		
Wheel drags	a. Carbon buildup behind turbine wheel or dirt accumulation behind compressor wheel.	a. Disassemble and clean the unit.
	b. Bearing worn excessively or seized to shaft due to dirty oil or low oil pressure.	b. Replace bearing and change oil.
Shaft End Play		
a. End play exceeds specifications,	a. Thrust bearing or thrust rings worn or distorted.	a. Replace parts as necessary.
b. End play less than specifications.	b. Carbon buildup behind turbine wheel or dirt buildup behind compressor wheel.	b. Disassemble and clean the unit.
Turbine Wheel Radial Movement		
a. Radial movement exceeds specifications.	a. Worn bearings or shaft, or bore in bearing housing worn,	a. Replace worn parts.

Insert this new Section in your CTS-4001 Service Manual.

COOLING SYSTEM

GENERAL

CONTENTS

PRINTED IN THE UNITED STATES OF AMERICA

CONTENTS (Continued)

Subject **Page**

COOLING SYSTEM MAINTENANCE (Continued)

DESCRIPTION

The purpose of the cooling system is to maintain the most efficient operating temperature of an engine without causing damage to the components. Approximately 1/3 of the energy produced when fuel burns is converted into power by the engine. The other 2/3 of the energy must be disposed of by the exhaust system and the cooling system or engine damage will result.

Basically, the circulation of coolant through the cooling system relies upon the water pump. The water pump draws coolant from the radiator and forces it through the water jackets and cylinder heads, where it accumulates heat. The coolant then flows to the upper radiator tank and down through the radiator where it is cooled by air 'drawn through the radiator fins.

The damages or effects caused by cooling system neglect are usually gradual and are therefore often overlooked. This manual provides the reader with basic component knowledge, maintenance procedures, service intervals, trouble-shooting and coolant and inhibitor recommendations.

COOLANT

The selection and maintenance of the engine coolant is as important to long engine life as the selection and changing of the engine lubricating oil and oil filters. The following section provides IH's recommendations for selecting the engine coolant and maintenance of the coolant inhibitors.

COOLANT SELECTION

IH engines will operate successfully with a water/antifreeze mixture or inhibited water as the coolant. Never use water alone as it allows rust, scale deposits and corrosion to occur within the engine.

Water

Water used in the cooling system must meet the following standards:

1. Total Hardness not to exceed 170 parts per million (10 grains/gallon maximum) to prevent scale deposits. Water containing dissolved magnesium and calcium (the usual reason for water hardness) above the specified amount will cause scale deposits to develop in the engine.

2. Chlorides not to exceed 40 parts per million (2.5 grains/gallon maximum) to prevent corrosion.

3. Sulfates not to exceed 100 parts per million (5.8 grains/gallon maximum) to prevent corrosion.

4. Dissolved Solids not to exceed 340 parts per million (20 grains/gallon maximum) to minimize sludge deposits, scale deposits, corrosion or a combination of these.

If any of the above requirements cannot be met, use distilled, de-ionized or de-mineralized water. Water samples can be tested by water treatment laboratories to determine if local water supplies meet these standards. "Softened" water that is prepared using common salt (sodium chloride) contains excessive amounts of chlorides which will interfere with the water softening capabilities of coolant filters using ion-exchange resins.

Anti-Freeze

IH Anti-Freeze and Coolant contains all necessary inhibitors and has been tested for use in IH products. It is an ethylene glycol type anti-freeze and compatible with chromate and non-chromate type coolant filters.

Several factors should be considered for successful operation when using ethylene glycol type anti-freezes.

1. The boiling point of ethylene glycol anti-freeze solutions is higher than plain water but their ability to transfer heat is less. Therefore in hot weather, coolant temperatures will run higher than systems containing plain water. This also holds true for engine lubricating oil and transmission oil temperatures where oil to water coolers are used.
2. An anti-freeze concentration greater than 68% will adversely affect freeze protection and heat transfer rates. Anti-freeze concentrations between 68 and 100% actually have a higher freezing point than a 68% anti-freeze concentration. Due to the higher freezing point and reduced heat transfer rates, concentrations greater than 68% should not be used. It is also important to remember that anti-freeze may retain its freeze protection for more than one season but coolant conditioners must be added to maintain corrosion protection. Figure 1 illustrates the freezing point of anti-freeze according to its percentage of concentration.
3. Anti-freeze containing sealer or anti-leak additives should not be used in IH engines. These additives may cause plugging problems in the cooling system and restrict coolant flow.
4. Anti-freeze formulated with methoxy propanol or propolene glycol is not recommended for use in IH engines, due to a reaction with engine internal seals, coolant hoses and potential fire hazard due to lower flash points than ethylene glycol type antifreeze.
5. The use of methanol alcohol or methoxy propanol (Dowtherm 209) based anti-freeze may result in separation of the anti-freeze and water.

Coolant Conditioners All cooling system inhibitors, including those in antifreeze solutions, become depleted through normal operation. If the inhibitors in anti-freeze are allowed to become depleted, the anti-freeze becomes corrosive and attacks and coats the metallic surfaces of the cooling system. This coating reduces the heat transfer. Cooling system conditioners which contain these inhibitors must be added to maintain corrosion protection. These conditioners are available as a liquid or in a coolant filter.

Freezing Point C (F)	Percentage Anti-Freeze Concentration by Volume	Specific Gravity @ 16°C (60°F)
0° (+ 32)	0	1.000
- 7° (+20)	15	1.025
-12° (+10)	25	1.040
-18° (0)	33	1.053
- 23° (-10)	40	1.062
29% (- 20)	45	1.070
-34° (-30)	48	1.074
-40° (-40)	53	1.080
-46° (-50)	56	1.088
-51° (-60)	59	1.092
-57° (-70)	62	1.095
-63° (-80)	65	1.097
-68° (-90)	67	1.098
- 69° (- 92)	68	
NOTE: As shown below, a further increase in antifreeze volume increases the freezing point.		
-63° (-80)	71	1.100
-57' (-70)	75	1.106
-51° (-60)	79	1.110
-46° (-50)	83	1.113
-40° (-40)	87	1.117
-34° (-30)	91	1.119
- 34° (- 30)	95	1.123
-22° (- 8)	100	1.127

MT-28258

Figure 1. - Coolant Mixture Freezing Points

The two types of recommended conditioners are as follows:

1. IH coolant conditioner is a complete inhibitor system, of a non-chromate type, which provides corrosion protection, pH control for maintaining an acid free coolant and water softening to prevent the formation of mineral deposits. It is compatible with both water and IH anti-freeze and coolant.
2. The coolant filters available on IH vehicles, contain a blend of metaborate, tetraborate, nitrite, nitrate, silicate, M.B.T., phenolphthalein, and an organic polymer designed to provide superior cooling system protection to that obtained with either chromate or borate coolant filters.

   These coolant filters should only be used with ethylene glycol type anti-freezes that do not contain anti-leak additives. The anti-leak or stop leak additives are removed by the water filter. This could restrict coolant flow through the filter.
3. Soluble oil is not recommended for use on IH truck engines as its use will reduce heat transfer. There are no miracle additives that will increase heat transfer or prevent overheating. Conditioned water is still the best coolant.

COOLANT SYSTEM COMPONENTS

The following is a list of the major components making up the cooling system. Points of inspection of each component are covered in general terms.

RADIATOR

This component is one of the most important, as this is where most of the heat of the system is dissipated. The radiator is made up of the following parts:

Top and Bottom Tank

Look for leaks, particularly where tank is soldered to core. Vibration and pulsation from pressure can fatigue soldered seams.

Filler Neck

The sealing seat must be smooth and clean. Cams on the filler neck must not be bent or worn, as this will not allow the cap to seal properly. Ensure that the overflow tube is not plugged.

Tubes

Because these are very small, they can become clogged, or partially blocked, by rust and scale. The general condition of the cooling system and operating temperature are indications as to the cleanliness of the tubes. Another good test is to feel the core for cold spots.

Fins

These thin metal sheets radiate, or pass off, the heat picked up by the tubes. They should be kept free of bugs, leaves, straw and other interference to allow free passage of air. Bent fins should be straightened for maximum heat dissipation.

Radiator Cap (Pressure-Sealing Type)

Its purpose is to hold the cooling system under a slight pressure, increasing the boiling point of the cooling solution and preventing loss of the solution due to evaporation and overflow.

The cap (Figure 2) has a spring-loaded valve, the seat of which is below the overflow pipe in the filler neck. This prevents the escape of air or liquid while the cap is in position. When the cooling system pressure reaches a predetermined point, the cap valve opens and will again close when the pressure drops below the predetermined point.

When removing the pressure type cap from the radiator, perform the operation in two steps. Loosen the cap to its first notch to raise the valve from the gasket and release the pressure through the overflow pipe. In the first stage position of the cap, it should be possible to depress the cap approximately 3mm (1/8"). The depression can be adjusted by bending the prongs on the cap. Care should be taken when bending the prongs to ensure the cap is not too loose, as this would prevent proper sealing. Then slowly continue to turn cap counterclockwise until you can remove it.

NOTE - When removing the cap, loosen it slowly and then pause to allow the pressure to bleed. This will avoid possible burning by hot water or steam.

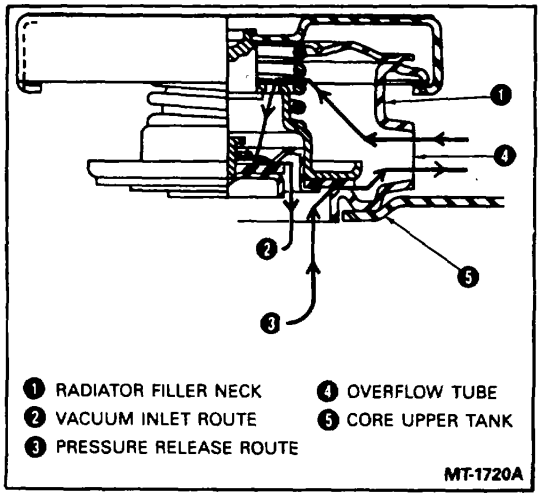


Figure 2. - Radiator Cap (Pressure Type)

Continuous Deaeration Cooling System

The continuous deaeration cooling system used on some IH chassis, (Figure 3) is designed to keep the cooling system free of trapped air, vent the cooling system during the filling operation and completely vent the system in about five to ten minutes. The deaeration system also aids in rapid warm-up of cold engines.

Why are we concerned about the air in the cooling system? It has been found that air trapped in the cooling system will hasten corrosion in the system. Air expands more than water when heated and increases the expansion loss through the overflow pipe. More important is the possible loss of the water pump prime due to excessive amount of air, resulting in complete stoppage of coolant flow.

It has been found that when coolant flow stops even for a short period, the engine is put in immediate danger.

When engine is operating at full throttle, the piston rings can scuff, score or seize in as quickly as 30 seconds after the coolant flow stops. Even if coolant is present, boiling, at the points of maximum heat transfer, will occur. The transfer of heat will be reduced, and the temperature will rise high enough to destroy the lubricant oil film in the cylinder. The piston will also expand as its temperature is raised, and scoring can occur.

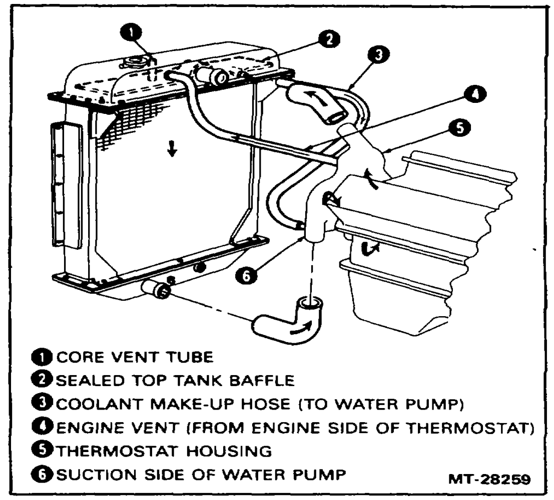


Figure 3. - Continuous Deaeration System

This damage may not be immediately noticed, and the engine will continue to operate. But this overheating can shorten the service life of the engine, resulting in high oil consumption, excessive blowby, or piston scoring especially on engines which have accumulated high mileage (200, 000 to 400, 000 miles).

A properly designed deaerated cooling system must have the ability to deaerate when the engine is cold, when the thermostat is closed, as well as when the engine reaches operating temperature. To accomplish this, the radiator top tank is designed with two sections divided by a baffle (Figure 4). The core of the radiator is vented through a tube which extends above the coolant level in the upper portion of the tank. This tube provides the vent needed for the core (Figure 2).

A make-up line is provided from the upper portion of the tank to the suction side of the water pump, to supply coolant to the cooling system. Another vent line is connected from the engine side of the thermostat housing to the top tank above the coolant level. This line provides a vent for the engine.

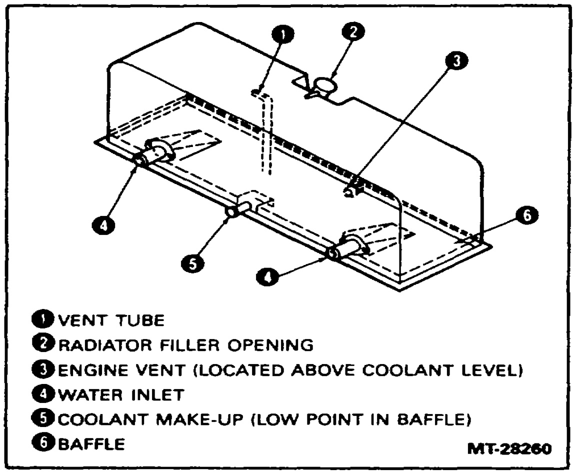


Figure 4. - Radiator Top Tank Used With Continuous Deaeration Cooling System

When the cooling system is filled through the upper portion of the tank, coolant enters the main cooling system at the water pump and fills the radiator core and the engine from the bottom, forcing air out the vents.

The basic design of the radiator top tank, used with the continuous deaeration cooling system, can be seen in Figure 3. The tank piping can be seen in Figure 2. These illustrations are not for a particular installation, but only a typical installation.

On some IH chassis, the radiator does not have a two section top tank. But, the chassis still has a continuous deaeration cooling system. On such chassis, the upper section of the radiator top tank is replaced with a remote mounted surge tank, with external housing, that duplicates the function of the vent tube and the coolant make-up line.

ENGINE WATER JACKET

The water jacket permits coolant to be circulated around the cylinder walls, combustion chambers and valve assemblies. Some of the coolant passages are small and can become clogged If the cooling system does not receive the proper maintenance.

Close inspection should be given to the following areas:

Core Plugs

These are sometimes mistakenly termed "freeze plugs".

The plugs are present due to engine block casting methods and not to protect against expansion from freezing.

Core plugs that show signs of leaking or rusting through should be replaced. Refer to respective Engine Manual for core plug replacement.

Drain Plugs

The drain plugs located in the water. jacket should receive seasonal care and be kept free of rust and scale.

Gaskets

Must be in good condition to prevent both internal and external leaks. If there are external leaks around gaskets, there may also be internal leaks into the engine.

Proper tightening of the head bolts with a torque wrench is essential for preventing leaks around the head gasket.

WATER PUMP

The water pump circulates the coolant through the cooling system. It should be checked carefully for leaks and proper lubrication. If leaking or in bad condition, it should be rebuilt or replaced promptly. For water pump rebuild, refer to respective Engine Manual.

FAN

The fan should be checked for loose or bent blades. A loose blade could work free during operation and cause damage. A bent blade will reduce the fan's efficiency.

THERMOSTAT

Thermostats provide a means of retarding or restricting the circulation of coolant during engine warm-up. An inoperative thermostat can cause engine overheating and a subsequent loss of coolant. Thermostats can be tested by submerging in hot water and noting the opening and closing temperature. Use an accurate high temperature thermometer for making this test. Refer to Engine Manual for proper opening and closing temperatures.

HOSES AND CLAMPS

The only coolants which are recommended for use in IH cooling systems are those which contain an ethylene glycol base. Other base coolants may damage rubber hoses, especially those made of silicone rubber. Type of rubber used can usually be determined by color. Silicone hoses are made in "COLOR" while other rubber hoses are "BLACK". If coolants used are not of ethylene glycol base, this may affect your engine warranty.

CAUTION - ANTI-FREEZE MADE WITH METHOXY PROPANOL OR PROPYLENE GLYCOL IS NOT RECOMMENDED FOR USE WITH IH ENGINES. THESE TYPES OF ANTI-FREEZE CAN DAMAGE ENGINE INTERNAL SEALS AND COOLANT HOSES AND CREATE A POTENTIAL FIRE HAZARD DUE TO LOWER FLASH POINTS THAN ETHYLENE GLYCOL TYPE ANTI-FREEZE.

Hoses and clamps should be checked regularly as they are often the source of hidden trouble. Hoses may appear in good condition on the outside but the inside may be partially deteriorated. If there are any doubts about a hose doing its job, replacement should be made. Clamps should be inspected to ensure they are strong enough to hold a tight connection.

TRANSMISSION OIL COOLER

On some trucks equipped with automatic or semi-automatic transmissions, the transmission oil is circulated through an oil cooler or heat exchanger. The function of this unit is to control transmission temperature and thereby keep oil in the proper temperature range for its most efficient lubrication. This is accomplished by using engine heat to bring transmission temperature up or by using the cooling system to dissipate any excessive heat generated within the transmission. Leakage due to corrosion or an improper sealing will cause contamination between the cooling system and transmission.

FAN AND ACCESSORY BELT ADJUSTMENT

Fan and Accessory Drive Belts

New belts have a break-in period and lose tension during groove seating.

NOTE - New belt Initial Installation tension Is higher than the re-tension value applied to a used belt (run five minutes or longer). This Is done to minimize number of belt adjustments and prevent belt operation under low tension during break-in period.

Belt tension checks must be performed using a Belt Tension Gauge, such as a Howard KRIKIT Gauge, tool number 7401-0071. This tool is available from:

Howard Manufacturing Company
59996 South Crocker
Little Town, Colorado 80120
Phone (303) 794-2510

NOTE - Use of the KRIKIT Gauge Is restricted to SAE 3/8, 1/2 and 11/16 Inch belts. Check tension on the midpoint range of the longest span of belt.

New belts should be checked at 483 km (300 miles) or 10 hours, then checked again after 2 414 km (1, 500 miles) or 50 hours. The second service adjustment of belts establishes tension stabilization.
Before adjusting belt tension, check the tension several times. Use an average of the readings.
Belt tension checks must be made at midpoint between pulleys at the longest belt span. Refer to Belt Tension Chart.
The 9.0 liter fan and water pump drive belts have an idler pulley with spring tension. No adjustment is needed.
In multi-belt drives, the belt tension readings taken on the same span may vary considerably between belts. When this occurs, average readings to establish applied tension, except in the application of the DT/DTI 466 engines' power steering pump (Vickers), where the values stated are for each belt.

Belt Tension Chart

Tension Condition	Belt Tension
New Belt Installation	423-444 N•m (95-100 lb-ft)*
Re-tension New Truck upon delivery After 10 hours (or 300 miles) After 50 hours (or 1, 500 miles) - At intervals of 200 hours (or 6, 000 miles)	356-378 N•m (80-85 Ib-ft)-
Minimum Permissible Tension	267 N•m (60 Ib-ft)

*DT/DTI 466 Engine Power Steering (Vickers) Pump
New Belt - 356 N•m (80 lb-ft) per belt
Re-tension - 222 N•m (50 Ib-ft) per belt
Minimum Permissible Tension - 222 N•m (50 Ib-ft) per belt

EFFECTS OF COOLING SYSTEM NEGLECT

A neglected cooling system can lead to inefficient engine operation, either directly or indirectly. Most of the problems may be traced to overheating; however, an engine that is running too cold can be just as troublesome.
Overheating may lead to troubles such as the following:

1. Burned valves.
2. Pinging or knocking.
3. Vapor lock.
4. Poor lubrication-increased engine wear.
5. Sticking valves and valve lifters.
6. Short spark plug life.
7. Engine hot spots.
8. Need for higher octane fuel.

Overcooling often results in the following:

1. Excessive fuel consumption.
2. Sludge formation in crankcase.
3. Corrosive acids found in crankcase.

COOLING SYSTEM MAINTENANCE
COOLING SYSTEM INHIBITORS

Systems With Coolant Filters

When the vehicle is manufactured, the coolant filter is equipped with precharge filter element which is larger in size than the normal service element. The precharge element contains a sufficient amount of chemical to precharge the cooling system to the recommended concentration. The precharge (larger) coolant filter should only be used to precharge the cooling system on a new engine or when the coolant is replaced. The continued use of the precharge element could result in plugging and overheating problems.

The normal service element is used to replace the precharge element after the first 19 000 km or 12, 000 miles. Subsequent replacements of the normal service element after 16 000-19 000 km or 10, 000-12, 000 mile intervals will maintain the required concentration. Servicing too often may result in the formation of a white deposit in the system.

Unlike the old borate and chromate water filters, the new water filters must be used only after the cooling system has, been thoroughly drained and chemically flushed with inhibited hydrochloric acid or inhibited oxalic acid. Failure to chemically flush, prior to using the new water filters, may result in plugged radiator and heater cores or even solder deterioration. The chemical in the new water filters will loosen any cooling system scale.

Systems Without Coolant Filters

Vehicles without a coolant filter must have the coolant inhibitors replenished by adding IH cooling conditioner. The conditioner should be added as recommended in the respective Operator's Manuals.

NOTE-- A complete drain, flush and refill with water and conditioner, or IH anti-freeze and coolant is recommended once a year. This Includes all vehicles regardless of yearly mileage.

If the cooling system has been permitted to become rusty or dirty, use IH cooling system cleaner and neutralizer carefully, following cleaning recommendations on the container.

Coolant Testing for Inhibitor Strength

Coolant should be checked for reserve alkalinity, using test strips available from various sources, at each oil change. Indication of a low alkalinity condition requires adding IH cooling conditioner, changing cooling filter or changing contaminated coolant.

DRAINING THE COOLING SYSTEM

When the cooling system of a vehicle is drained, some coolant is likely to be retained in the pockets of the cooling system. This is especially true in engines equipped with oil coolers or heat exchangers having a tube bundle. If only water with cooling conditioner is used and these engines are drained and then exposed to freezing temperatures, the water conditioner will freeze and possibly rupture one or more of the tubes. The resulting leak will be difficult to locate and could eventually damage the engine by mixing the coolant with the engine oil.

To avoid damage, take one of the following precautions when draining for shipment or storage in freezing temperature:

1. Fill the cooling system with anti-freeze solution, operate engine until the thermostat opens or until circulation is observed in the radiator circuit, then drain.
2. If conditioned water is used, drain the engine. Then blow out the residual solution in the cooler tubes with compressed air through one of the drain cocks or plugs on the cooler.

CLEANING THE COOLING SYSTEM

Once a year the cooling system should be drained and thoroughly flushed.

Unless the cooling system is treated with a corrosion preventative, rust and scale will eventually clog up passages in the radiator and water jackets. This condition is aggravated in some localities by formation of insoluble salts from the water used.

IH cleaning solutions are available, which have proven very successful in removing accumulation of rust, scale, sludge and grease. This solution should be used according to the recommendation on the container.

CAUTION - DO NOT USE CHEMICAL MIXTURES TO STOP RADIATOR LEAKS EXCEPT IN ANY EMERGENCY. NEVER USE SUCH SOLUTIONS INSTEAD OF NEEDED RADIATOR REPAIR.

When draining the cooling solution, disconnect the radiator outlet hose, as large particles of sediment will not pass through the drain.

WARNING - USE ONLY THE FOLLOWING PROCEDURE TO REMOVE THE PRESSURE-TYPE CAP FROM THE RADIATOR. ALWAYS ALLOW THE ENGINE TO COOL FIRST. WRAP A THICK, HEAVY CLOTH AROUND THE CAP. PUSH DOWN, LOOSEN CAP SLOWLY TO ITS FIRST NOTCH POSITION; THEN PAUSE A MOMENT. THIS WILL AVOID POSSIBLE SCALDING BY HOT WATER OR STEAM. CONTINUE TO TURN CAP TO THE LEFT AND REMOVE.

CAUTION - IF THE COOLANT SHOULD GET EXTREMELY LOW AND THE ENGINE VERY HOT, LET THE ENGINE COOL FOR APPROXIMATELY 15 MINUTES BEFORE ADDING COOLANT. THEN, WITH THE ENGINE RUNNING, ADD COOLANT SLOWLY. ADDING COLD WATER TO A HOT ENGINE MAY CRACK THE CYLINDER HEAD OR CRANKCASE.

1. Coolant shut-off cocks to heaters and other accessories should be open to allow complete circulation during cleaning, flushing and draining. Run the engine with the radiator covered if necessary, until temperature is up to operating range of 72-84°C

(160-180°F). Stop engine, remove radiator cap carefully (if so equipped) and drain system by opening drain cocks on radiator and crankcase.

2. Allow engine to cool, close drain cocks and pour cleaning compound into radiator, according to directions. Fill system with water.
3. Place a clean drain pan to catch overflow and use to maintain level in radiator. Avoid spilling solution on vehicle paint.
4. Install radiator cap (if so equipped) and run engine at moderate speed, covering radiator if necessary, so the radiator reaches a temperature of 84°C (180°F) or above but does not reach the boiling point. Allow the engine to run at least two hours at 84°C (180°F) so the cleaning solution will take effect. Do not drive vehicle or allow liquid level in radiator to drop low enough to interfere with circulation.

   NOTE - Stop engine as often as necessary to prevent boiling.

5. With the engine stopped, feel the radiator with bare hands to check for cold spots, and then observe the temperature reading. Where there is no change in temperature for some time, drain the cleaning solution.
6. If clogging of the core is relieved but not fully corrected, allow the engine to cool, pressure-flush the system (see Pressure Flushing), and repeat cleaning operation.
7. If clogging of core, indicated by cool spots on the core is not relieved, radiator core must be removed for mechanical cleaning. Mechanical cleaning requires removal of upper and lower tanks and rodding out the accumulated rust and scale from the water passage of the core.

PRESSURE FLUSHING

1. Disconnect the upper radiator hose which connects the radiator core to the engine water outlet and remove thermostat from engine water outlet.
2. Clamp a convenient length of hose to the radiator core outlet opening and attach another suitable length of hose to the radiator inlet opening to carry away the flushing stream.
3. Connect the flushing gun to compressed air and water pressure and clamp the gun nozzle to the hose attached to the radiator outlet opening.
4. With radiator cap (if so equipped) on tight, fill core with water. Apply air pressure in short blasts to prevent core damage.
5. Continue filling radiator with water and applying air pressure in short blasts until the water comes out clear.
6. Clamp the flushing gun nozzle firmly to a hose attached securely to the engine water outlet opening. Fill engine block with water, partly covering water inlet opening to permit complete filling.
7. Apply compressed air to blow out water and loose sediment. Continue filling with water and blowing out with air until flushing stream comes out clear.
8. For badly clogged engine water jackets that do not respond to regular pressure flushing, remove engine cylinder head and core hole plugs and with a suitable length of small copper tubing attached to the flushing gun nozzle, flush the water jackets through the openings.
9. If the vehicle is equipped with a heater connected to the cooling system, flush the heater, following the same procedure as for the radiator core.
10. After completing the flushing operation, clean out the-radiator overflow pipe, inspect the water pump, clean the thermostat and the radiator cap control valve (if so equipped). Check thermostat for proper operation before installation. See "Thermostat."
11. Blow insects and dirt from radiator core air passages, using water if necessary.

FILLING THE COOLING SYSTEM

To eliminate air being trapped within the engine or heater, the following procedure should be followed when filling the engine coolant system.

1. Set parking brake.
2. Fill cooling system until coolant reaches bottom of radiator filler opening. Let stand approximately 5 minutes; recheck level.
3. Start engine.
4. Allow engine to operate, without radiator cap, at a fast idle until the engine reaches its normal operating temperature.
5. After engine reaches its normal operating temperature, trapped air will be expelled from system.
6. With engine still running, add sufficient coolant to fill system. If the radiator has a filler neck extension with a vent hole near the top, the system is full when the coolant level is at the bottom of the extension. If the radiator does not have an extended filler neck, fill the system to approximately 25.4mm (1 inch) below the bottom of the filler neck.

TEST EQUIPMENT

To aid the serviceman in maintaining the cooling system at top efficiency, various items of test equipment are available. Among these are the Cooling System Pressure Tester and the Hydrometer.

Hydrometers

Hydrometers (Figure 5) are used to test the freezing protection of an anti-freeze solution and work on the principle of specific gravity or weight of the anti-freeze solution. They are simple to use, If used in the proper manner. When using the hydrometer, the solution must be at least 44°C (110°F). The temperature and level must be noted correctly and the float must be able to move freely. Read only the hydrometer scale corresponding to the type anti-freeze solution in the radiator. Keep hydrometer clean inside and out and treat it with the same care as given any other precision instrument.

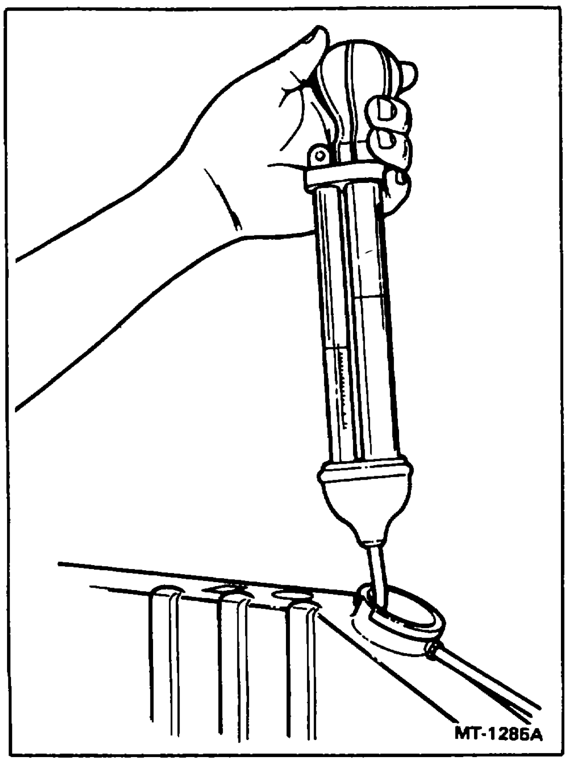


Figure 5. - Using Hydrometer to Test Anti-freeze Solution

SE-2384 Pressure Tester

This tester (Figure 6) consists of a heavy duty pump complete with adapters for remotely applying pressure to the cooling system at the radiator fill neck. The pump is equipped with a pressure gauge, manual pressure relief valve and hose assembly, with twist-on clamp bracket to receive the adapters. The adapters can be quickly attached together for a small or large filler neck either with a shallow or deep neck.

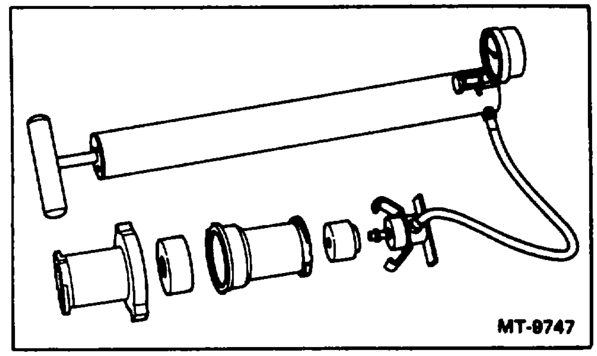


Figure 6. - SE-2384 Cooling System Pressure Tester

SE-2395 Anti-Freeze and Battery Tester

This tester (Figure 7) is designed for quick and accurate checking of anti-freeze protection and battery specific gravity readings. Coolant may be checked hot or cold with a minimum amount of coolant or battery acid required. Operating instructions are included with the

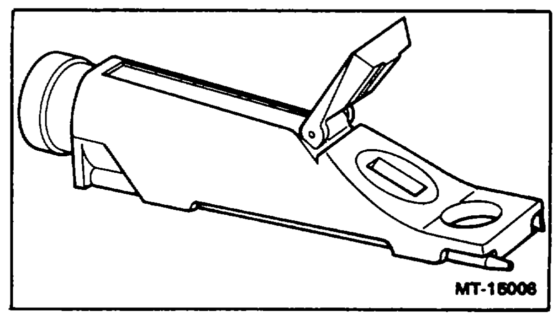


Figure 7. - SE-2395 Anti-Freeze and Battery Tester

TROUBLESHOOTING
CAUSES OF COOLANT LOSS

Leaks and Seepage

May be either external or internal.
External leaks easy to locate, may occur at radiator, heater, water pump, core plug hole, hose connections, radiator cap, drain cocks and gaskets.
Internal leaks are more difficult to locate since these leaks occur at cracks and faulty head gaskets. Internal leaks are indicated by a decrease in coolant level and the presence of coolant in crankcase.

CAUTION - CORRECT THIS CONDITION IMMEDIATELY OR SERIOUS DAMAGE TO ENGINE WILL RESULT.

Boiling

May be caused by any of the following:
1. Radiator or other parts of cooling system clogged with rust or scale.
2. Grille or bug screen clogged.
3. Radiator core fins damaged.
4. Thermostat defective - stuck closed.
5. Water pump leaking air into system.
6. Radiator hose collapsed or rotting inwardly.
7. Radiator pressure cap defective.
8. Cylinder head loose, causing exhaust gas leakage into cooling system.
9. Water pump impeller corroded or loose on shaft.
10. Anti-freeze protection inadequate, causing partial freeze-up.

After-Boil

Boiling which may occur in a cooling system after the engine is shut off even though it did not occur during operation is known as after-boil. This condition, which usually happens to cooling systems that need attention, occurs because the coolant is still picking up heat from the engine and the heat is not being dispersed by circulation through the radiator. Other causes of after-boil are over-protection or use of high-temperature thermostat with alcohol-type anti-freeze, improper installation of the thermostat, or a thermostat that is operating improperly.

Foaming

Foaming of coolant may also cause coolant loss. This occurs only with a very dirty cooling system and under severe operating conditions. Usually an air or exhaust leak in the system contributes to foaming and this is caused by a faulty gasket, leaky radiator hose or water pump seal. Foam is an excellent insulator and can seriously interfere with proper circulation.

Evaporation

Evaporation reduces the amount of coolant in the system. This is a common occurance where alcohol-base types of anti-freeze are used. A faulty pressure cap may also be the cause of evaporation.

CAUSES OF OVERHEATING

Cooling System

1. Low coolant supply.
2. Leaks at any of the following: gaskets, hose connections, water pump, radiator, heater, core plugs, drain cock or plugs, cracked head or block.
3. Broken or loose fan belt.
4. Radiator clogged.
5. Collapsed or clogged hose.
6. Defective pressure cap.
7. Worn or corroded impeller on water pump.
8. Foaming.
9. Radiator air flow obstructed.
10. Bent fan blade.
11. Improper or defective thermostat.

Miscellaneous

1. Clogged muffler or tail pipe.
2. Stiff re-built engine.
3. Dragging brakes.
4. Low engine oil level.
5. Engine overloaded.

CAUSES OF OVERCOOLING

1. Missing thermostat.
2. Defective thermostat stuck open.
3. Short runs and intermittent driving.

TROUBLESHOOTING THE CONTINUOUS DEAERATION COOLING SYSTEM

If the engine fails to reach normal operating temperature, the following checks should be made to find the possible cause:
1. Visually inspect the thermostat to be sure it is the correct thermostat and has the proper range.
2. Check the thermostat to make sure the valve is not held open by foreign matter and that the thermostat valve closes with a good seal.
3. Check the operation of the thermostat in a pan of water. Heat the water. The thermostat should begin to open at about 95°C (170°F). The thermostat should be fully open at 102°C (185°F). At any temperature below 95°C (170°F), the thermostat valve should be tightly closed.
4. The engine will not warm up properly if accessories such as heaters, air compressors or cooling system water filters are not connected in the proper manner. These accessories should not be connected so that the outlet coolant goes to the radiator core. These units should not be connected to the make-up line, because the make-up line will not be large enough to carry the excess coolant.

5. Where shutters are used, the shutterstat should be adjusted to open the shutters when the coolant from the engine outlet is 10 degrees above the engine thermostat opening temperature. In general, with a 95°C (170°F) thermostat the shutters should start to open when the engine outlet temperature is 100°C (1 80°F). The shutters should be fully open when the outlet water temperature reaches 105°C (190°F).
6. If the engine cooling system reaches operating temperature but there is insufficient cab heat, the heater should be inspected to be sure it is connected properly and operating correctly.

NOTE - Because of the advantages of the continuous deaeration system, it is important that the proper related parts be reinstalled on the occasion of service or repair. The use of radiator cores, upper tanks and hoses other than specified is not recommended.

TRANSMISSION

CTS-4219 TRANSMISSION

TABLE OF CONTENTS

SPECIFICATIONS

General Application Guidelines

GVW Range:	Up to 65, 000 lbs.
HP Range:	175-235 HP
RPM Range:	2200-3600
Engine Types:	Mid-range diesel and big gas

PTO Specifications

Model	Speed*	Spicer® Bulletin
CM 5952 D	490	SPR 130

* Per 1000 RPM of engine speed

Specifications for CM-59 Series
Model 5952-D

Speeds .... 5 forward/1 reverse
Torque Capacity .... To 600 ft. lbs.
Length* .... 24.7" (627 mm)
Weight .... 362 lbs. (1 64.3 kg)
Clutch Housing .... SAE No. 2 & 3
Clutch .... 13" or 14" push or pull, single or 2-plate
Yokes and Flanges .... 1480, 1550, & 1610 series
Drive Gear .... 11/2", 13/4"
Oil Capacity .... 17 pints (8 liters)
Brake .... Optional mounting
Speedometer Drive .... Provision will be made in the rear bearing cap for installation.
Power Take-Off .... Standard 6-bolt left side
Standard 8-bolt right side
Countershaft rear PTO mount optional

*From bell housing facing to end of spines on output shaft.

Gear Ratios
Model 5952-D

Gear	Ratio	% Step
1	7.17	
		--85
2	3.88	
		--84
3	2.11	
		--64
4	1.29	
		--29
5	1.00	
R	7.17	

OPERATION

Replacement Parts

The exploded views of subassemblies incorporated here are for the mechanic's convenience. The parts are arranged in their correct order and may be used as a reference for the assembly or disassembly of this unit.

Synchronizer Information

The purpose of a synchronized transmission is to simplify shifting and to help the driver get a clash free shift. To receive these results, however, It is important to under- stand how the synchronizer works.

When a shift is required, the operator declutches and moves the shift lever toward the desired gear. When the synchronizer ring makes contact with the gear, the blockers automatically prevent the shift collar from completing the shift until the gear and mainshaft speeds are matched. At that time, the blocker automatically neutralizes. The lever moves smoothly and easily into gear.

It takes one or two seconds to match speeds. Steady pressure on the shift lever helps the synchronizer do its job quickly If the lever is "forced" into gear, it is possible to override a blocker. This defeats the purpose of the synchronizer, however, and can cause gear clash.

Finally, remember that this transmission is not synchronized in first and reverse gears because these gears are normally selected when the vehicle is stationary. No synchronizing of engine speed and road speed is required to get in gear from a stop.

Caution: Always start in first gear. Starting in any other gear may cause hard shifting and internal transmission damage. This is because a synchronizer needs gear rotation to do its job.

Driver Instructions

To begin shifting, first depress the clutch and wait for complete release. Move the shift lever into 1 st gear. Next, accelerate to an RPM that will allow enough momentum to select the next higher gear while still allowing vehicle acceleration after the shift has been completed. (There is usually no reason to go all the way to the governor before you shift to second.)The progressive shift technique helps save fuel. This method can vary depending on the GVW of the vehicle, road condition and type of service.

When 2nd gear is desired. declutch and move the lever toward 2nd, keeping steady pressure on the lever The synchronizer will pick up the gear and synchronize its speed to the mainshaft speed. The lever will move into gear easily.

Continue in the same manner to top road speed. Notice that to have good performance as you approach top road speed, you must accelerate closer to the governed speed before you allow the engine to drop to the next gear shift point. This is because air resistance at higher speeds requires more horsepower. You receive maximum horsepower and performance at governed speed.

When you downshift, use the same procedure. However, the engine must be raised to the governor as the clutch is engaged after completing the shift. To downshift from top gear, declutch as you approach the shift point (the shift usually starts about 100 RPM over the shift point), and move the shift lever with a steady even pressure toward 4th gear. The synchronizer will pick up 4th gear and speed it up to vehicle speed, allowing a clash free shift. After the shift, re-engage the clutch while accelerating to keep the vehicle moving at the desired speed. If further downshifts are required, continue in the same manner.

When downshifting, remember that 1 st gear is not synchronized. Double clutching is required to complete a clash free shift. You can double clutch on all other shifts as well. This only aids the synchronizer in doing Its lob by manually helping to match the engine speed and road speed.

Caution: Do not tow vehicles equipped with Spicer transmissions without first pulling the axle shafts or disconnecting the driveshaft. Lubrication of the internal gear train is inadequate when the vehicle is towed. Also, do not pull or roll start vehicles in first or reverse gears.

Spicer® Transmission Lubrication

To insure proper lubrication and operating temperatures in these units, it is important that proper lubricants be used and correct oil levels be maintained.

Recommended Lubricants

The lubricants listed below are recommended, in order of preference, for use in all Spicer mechanical transmissions, auxiliaries and transfer cases.
DO NOT USE EXTREME PRESSURE ADDITIVES, such as found in multi-purpose or rear axle type lubricants. These additives are not required in Spicer transmissions, and in some cases may create transmission problems. Multi-purpose oils, as a group, have relatively poor oxidation stability, a high rate of sludge formation and a greater tendency to react on or corrode the steel and bronze parts.

Oil Changes

We recommend an initial oil change and flush after the transmission is placed in actual service. This change should be made any time following 3000 miles (4827 km), but never exceed 5000 miles (8045 km) of over-the-road service. In off-highway use, the change should be made after 24 hours-but before 100 hours-of service have been completed.

Many factors influence the following oil change periods. Therefore, a definite mileage interval is not specified here. In general, however, it is suggested that a drain and flush be scheduled every 50,000 miles (80,450 km) for normal over-the-highway operations. Off-highway uses usually require an oil change every 1000 hours. The oil level in the transmission should be checked every 5000 miles (8045 km) on-highway, or every 40 hours in off-highway operation. When it is necessary to add oil, we recommend that types or brands of oil not be mixed. The correct oil level in all Spicer transmissions is established by the filler plug opening.

Refill

First, remove all dirt around the filler plug. Then refill the transmission with new oil. Use the grade recommended for the existing season and prevailing service. The lubricant should be level with the oil fill plug located on the right side of the transmission case.

Overfilling

Do not overfill the transmission. This usually results in oil breakdown due to excessive heat and aeration from the churning action of the gears. Early breakdown of the oil will result in heavy varnish and sludge deposits that plug up oil ports and build up on splines and bearings. Oil overflow escapes onto the clutch or parking brakes, causing additional trouble.

TEMPERATURE	GRADE	TYPE
Above 0° F (-18°C) Below 0° F (-18°C)	SAE 30, 40, or 50 SAE 30	Heavy duty engine oil meeting MIL-L-2104D or MIL-L- 46152B, API-SF or API-CD NOTE: Oils meeting MIL-L-2104B and 2104C, or 46152 are also acceptable.
Above 0° F (-18°C) Below 0° F (-18°C)	SAE 90 SAE 80	Straight mineral gear oil - R & O Type, API-GL-1

General Precautions for Disassembly

IMPORTANT
Read this section before starting the detailed disassembly procedure.
Follow each procedure closely in each section, making use of both the text and the pictures.

Rebuild Facilities

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 A light chain hoist should be used to handle the mainshaft and countershafts during removal and reassembly procedures.

Cleanliness

Transmissions should be steam cleaned prior to disassembly. Seal all openings before steam cleaning. This will prevent dirt and water entry, which can damage serviceable parts.
Dirt is abrasive and will cause premature wear of bearings and other parts. Therefore, we suggest having a small wash tank nearby so parts can be cleaned prior to reassembly.

Bearings

When a transmission is removed at relatively low mileage, the 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 mileage or transmission condition warrants a complete overhaul, it is recommended that all bearings be replaced.

End Yokes and Flanges

End yokes and flanges should be installed and removed with the correct drivers and pullers-not with a hammer. Hammering is not only destructive to the yoke or the flange, but also can cause serious internal transmission damage. For example, hammering destroys or mutilates the pilot diameters, as well as warps or bends the flange. Hammering on end yokes will close in the bearing bores or misalign yoke lugs, resulting in early journal needle bearing failures.
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, however, two conditions can exist.

(a) If the bearing fit is *tight* on the shaft, usually the bearings will brinell since they absorb the pounding force of the hammer.

(b) If the bearing fit is loose, the shaft will keep moving inward until it is stopped by the internal parts such as the pilot bearing thrust washers and snap rings.

Remote Control

Disassembly

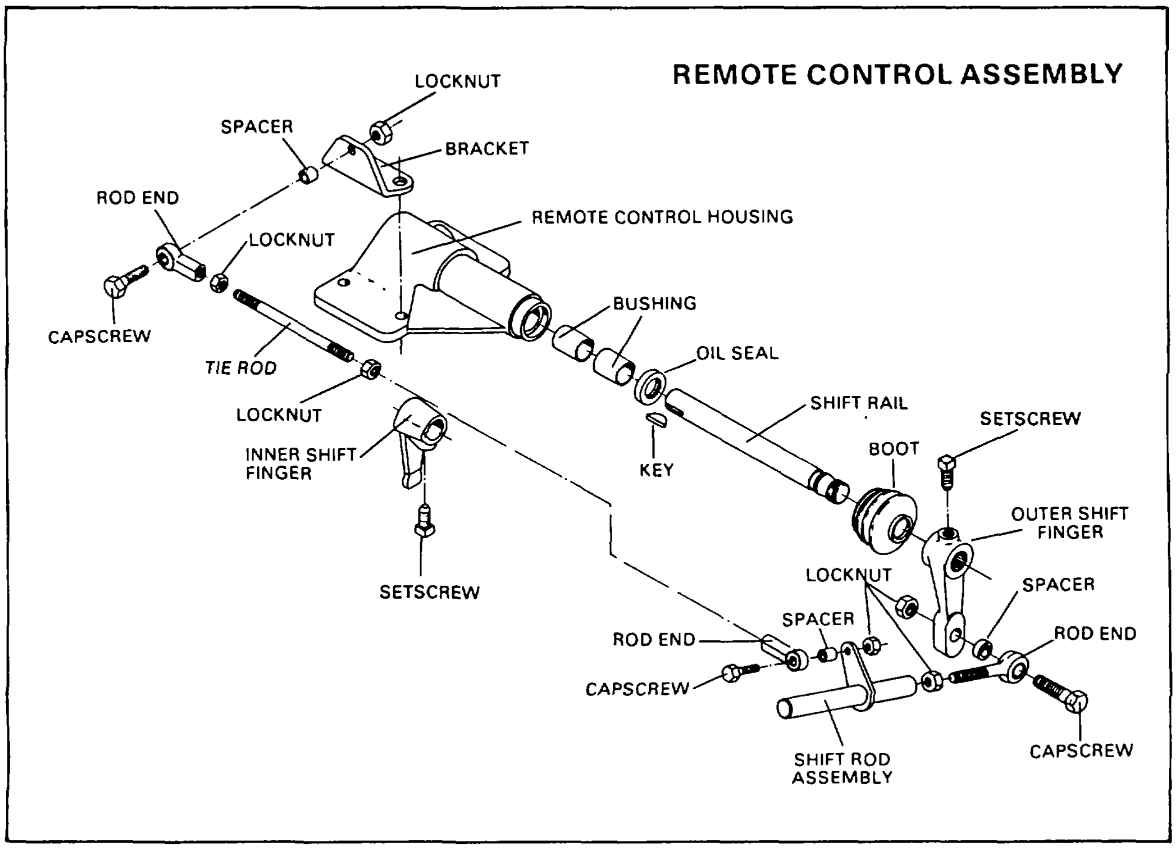
1. Remove the six capscrews and lockwashers. Separate the remote control from the shifter housing.
2. Remove the setscrew from the universal joint assembly, and pull the universal joint from the rod.
3. Remove the four capscrews and lockwashers that hold the end cover and gasket in place.
4. Remove the setscrew from the joint shift rod finger. Tap the rod through the cross holes in the housing.
5. Remove the finger from the housing.
6. Remove the setscrew from the inner shift finger.
7. Slide the rod and bracket assembly from the inner shift finger. Be careful not to lose the key.
8. Remove the seals from the cross holes in the housing.

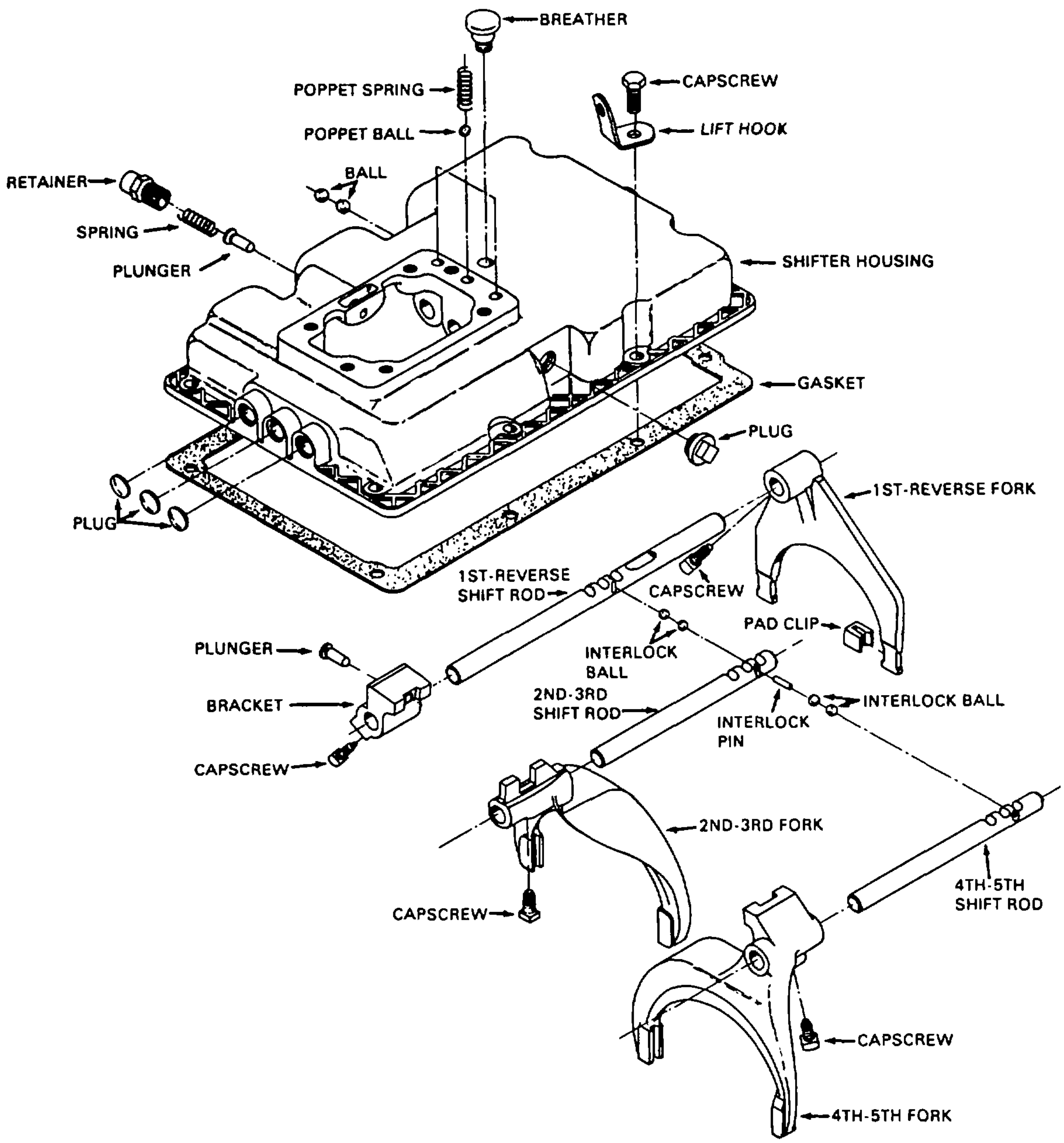
Inspection

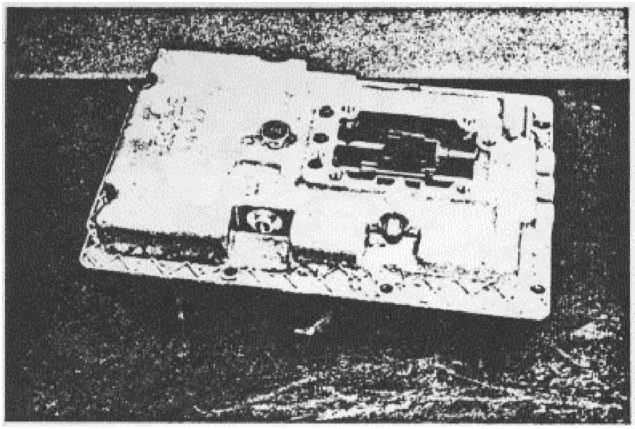
Check the shift fingers for excessive wear. Also check all bores and rods for excessive wear or scuffing. Clean all parts thoroughly, and apply a light coat of grease to the pivot points when reassembling.

Reassembly

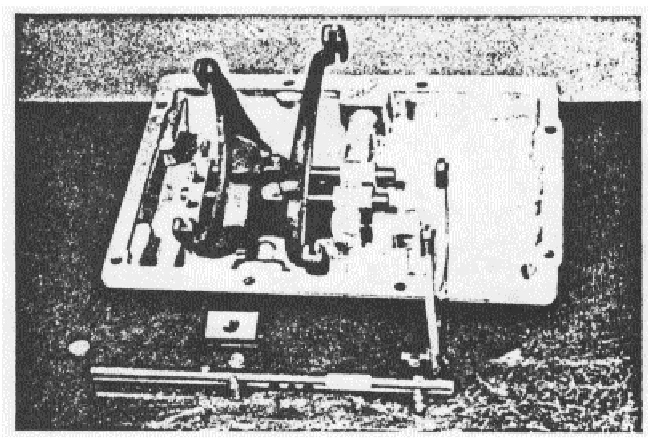
1. Install a key in the rod and bracket assembly. Install the unit into the remote housing, sliding the inner shift finger on the end of the rod.
2. Line up the setscrew hole and install the setscrew. Torque to 40-50 ft. lbs.
3. Install the joint shift rod through the cross holes and the outer finger. Make sure the finger is inserted into the bracket.
4. Align the setscrew hole and install the setscrew. Torque to 40-50 ft. lbs.
5. Install the end cover, and secure it with the four capscrews and lockwashers.
6. Install two new oil seals in the joint shift rod bores.
7. Install the joint assembly and secure it with a setscrew.



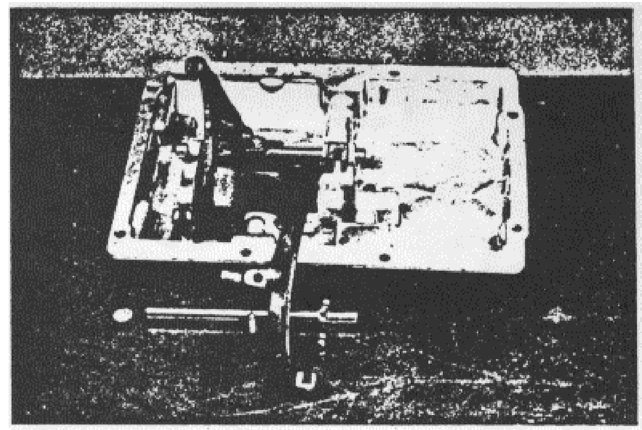

BREATHER
POPPET SPRING
CAPSCREW
POPPET BALL
LIFT HOOK
RETAINER
BALL
SPRING
PLUNGER
SHIFTER HOUSING
GASKET
PLUG
1ST-REVERSE FORK
PLUG
1ST-REVERSE
SHIFT ROD
CAPSCREW
PAD CLIP
PLUNGER
INTERLOCK
BALL
BRACKET
2ND-3RD
SHIFT ROD
INTERLOCK BALL
INTERLOCK
PIN
CAPSCREW
2ND-3RD FORK
CAPSCREW
4TH-5TH
SHIFT ROD
CAPSCREW
4TH-5TH FORK



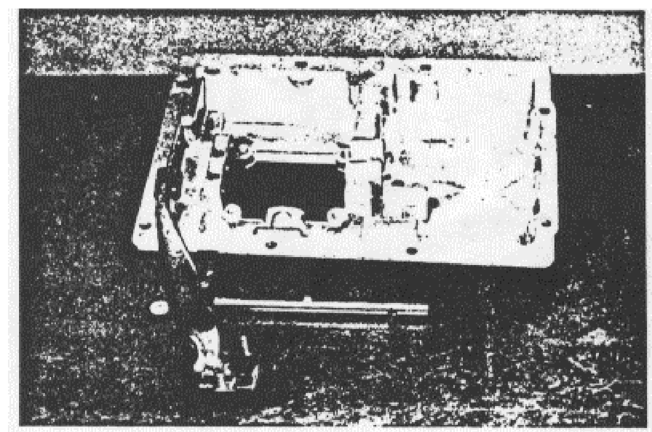
1. Remove the shifter housing and place it on a bench.



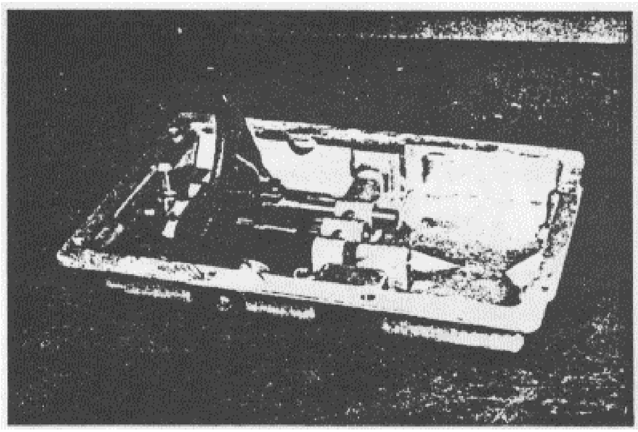
2. Now, remove the 1st-reverse shift fork and shift bracket.



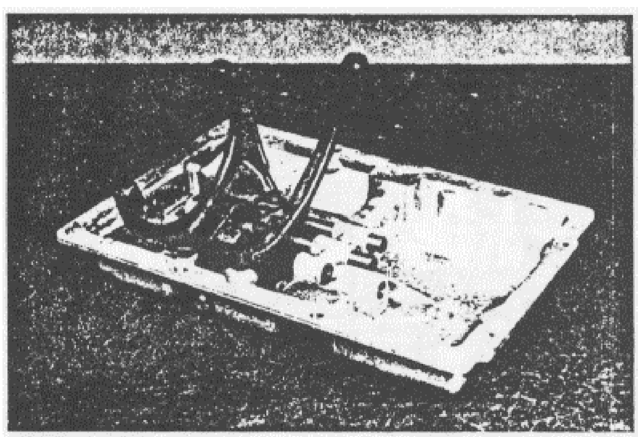
3. The 2nd-3rd speed shift fork may be removed. Do not lose the interlock balls or the interlock pin located in the shift rod.



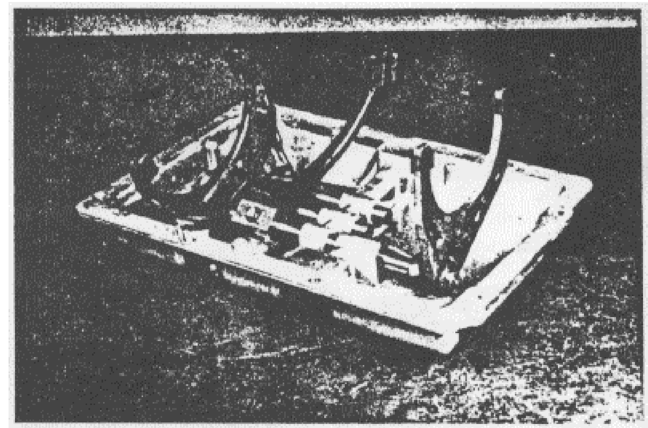
4. All that remains is the 4th-5th speed shift fork. Examine all the fork pad clips and the shift rods for excessive wear prior to reassembly.



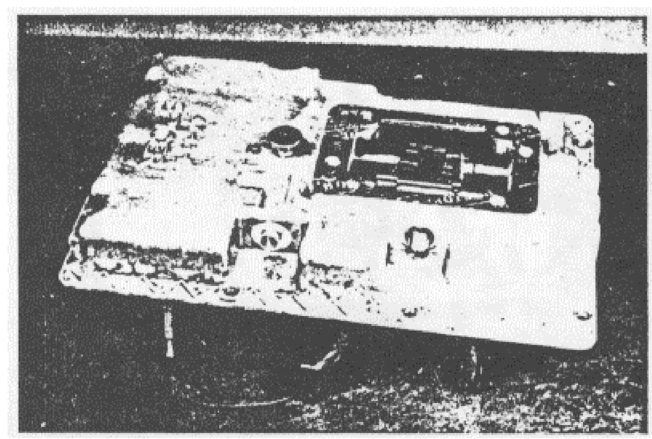
1. Begin the reassembly by installing the 4th-5th speed shift fork.



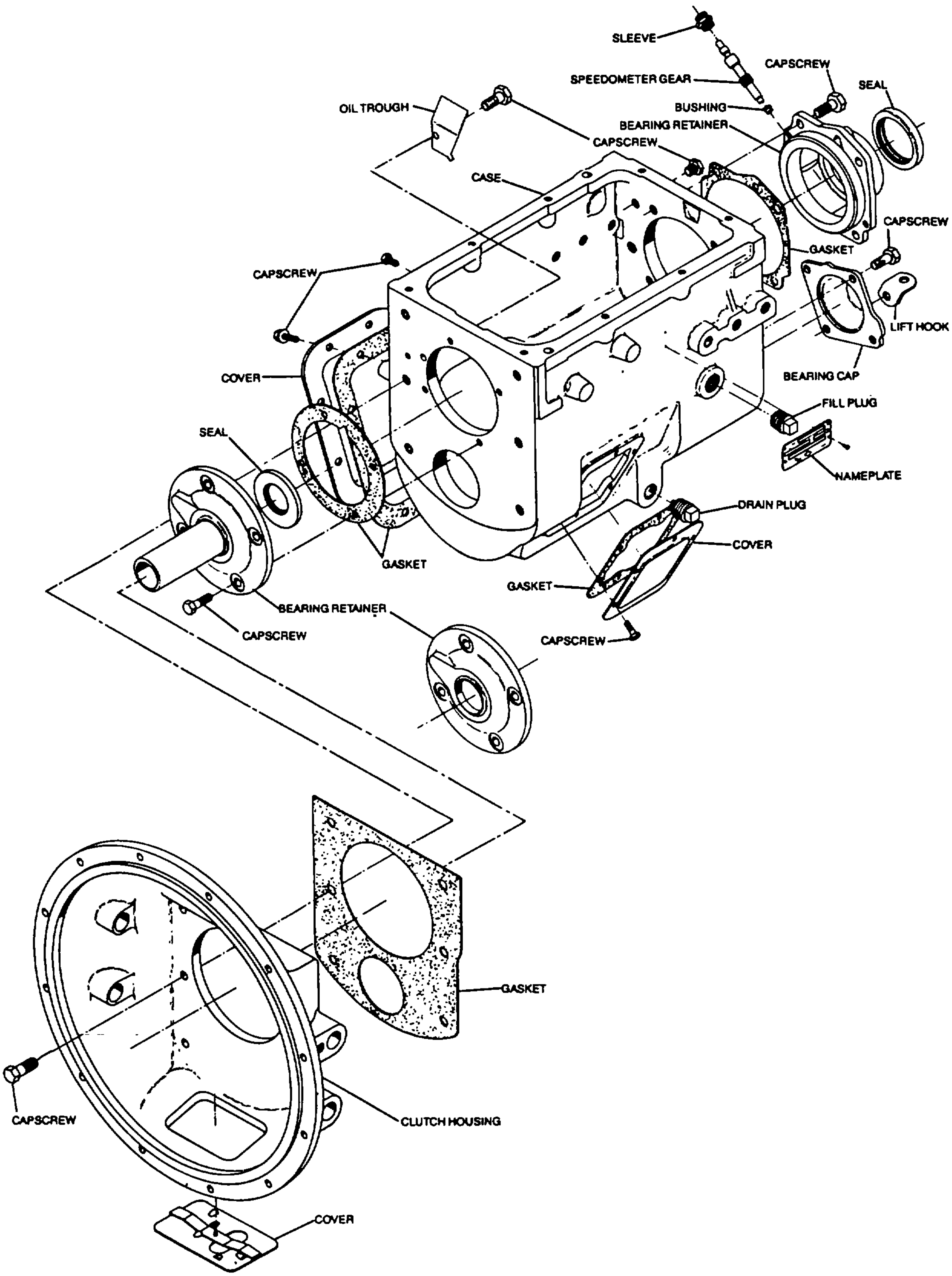
2. Install the 2nd-3rd speed shift fork and place all the interlocks into their proper position.

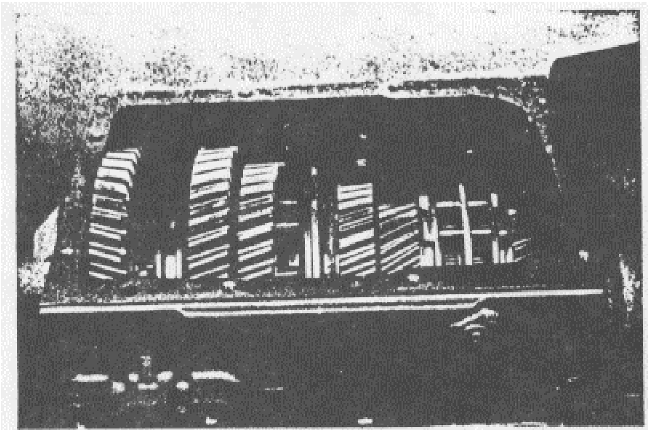


3. Next, install the 1 st-reverse shift fork with pad clips and the shift bracket.

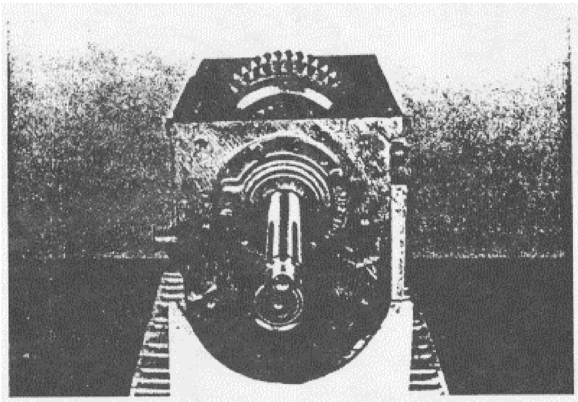


4. Finally, place all the poppet balls and poppet springs into the housing.

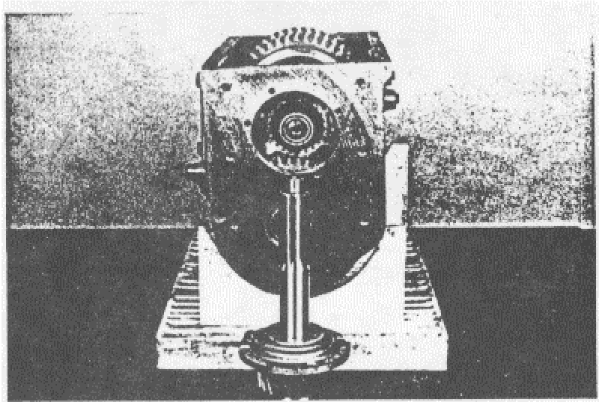

SLEEVE
SPEEDOMETER GEAR
CAPSCREW
SEAL
OIL TROUGH
BUSHING
BEARING RETAINER
CAPSCREW
CASE
CAPSCREW
GASKET
CAPSCREW
LIFT HOOK
COVER
BEARING CAP
FILL PLUG
SEAL
NAMEPLATE
DRAIN PLUG
GASKET
COVER
GASKET
BEARING RETAINER
CAPSCREW
CAPSCREW
GASKET
CAPSCREW
CLUTCH HOUSING
COVER



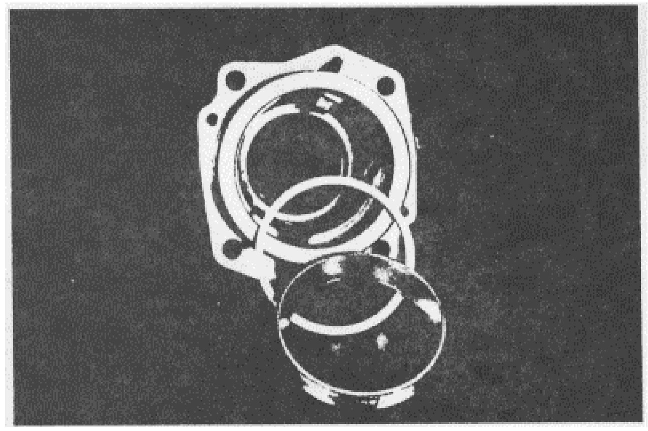
1. Remove the shifter housing.



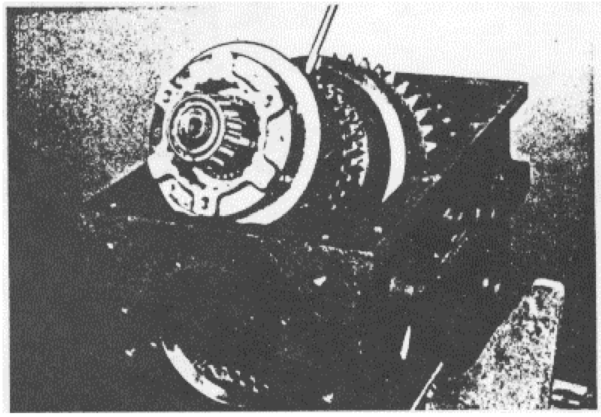
2. Continue by removing the clutch housing.



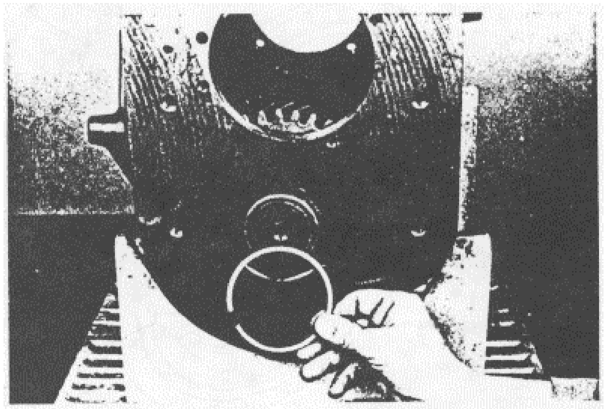
3. Remove the input bearing cap and the input gear.



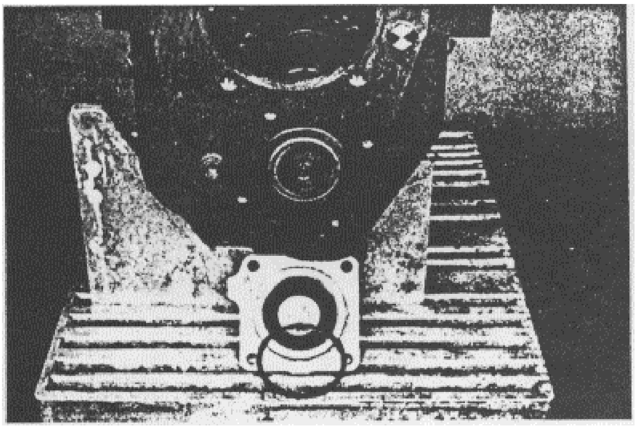
4. The output bearing cap and gasket should be removed next. Note that mainshaft end play is adjustable through a spacer and shims in this output bearing cap.



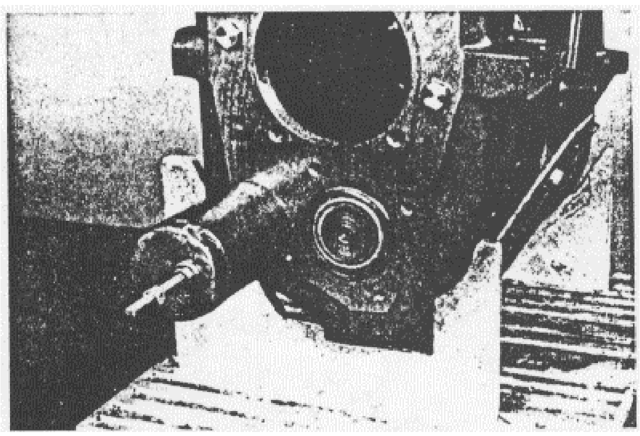
5. Lift the mainshaft subassembly from the case.



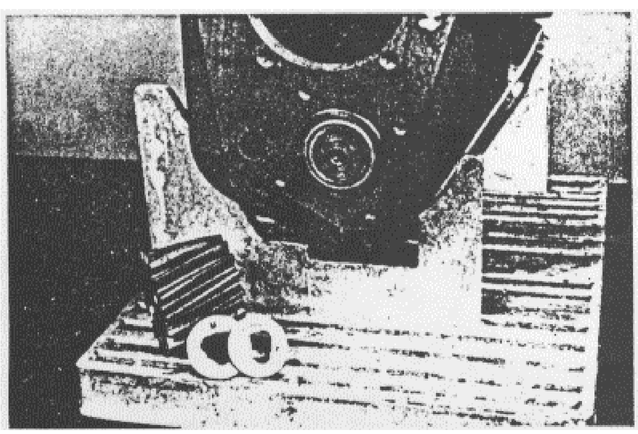
6. *Remove the countershaft lubrication spacer from the case bore.*



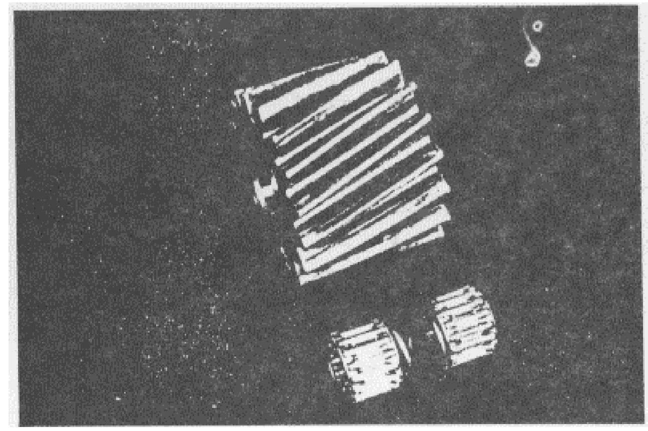
7. Now remove the countershaft rear bearing cap and shims.



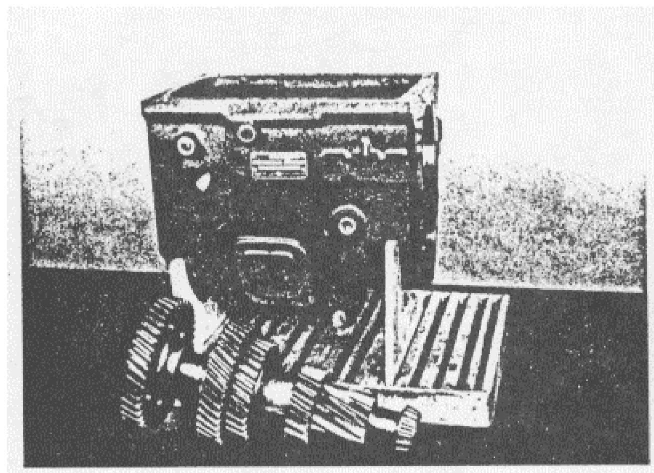
8. The reverse idler shaft may be removed. Kent Moore puller J-28668 is recommended.



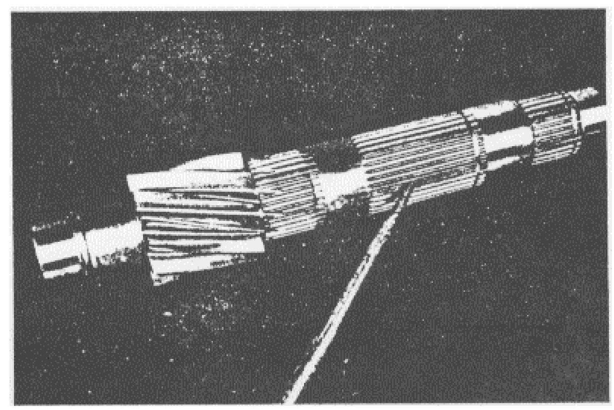
9. Lift the reverse idler gear and thrust washers out of the case.



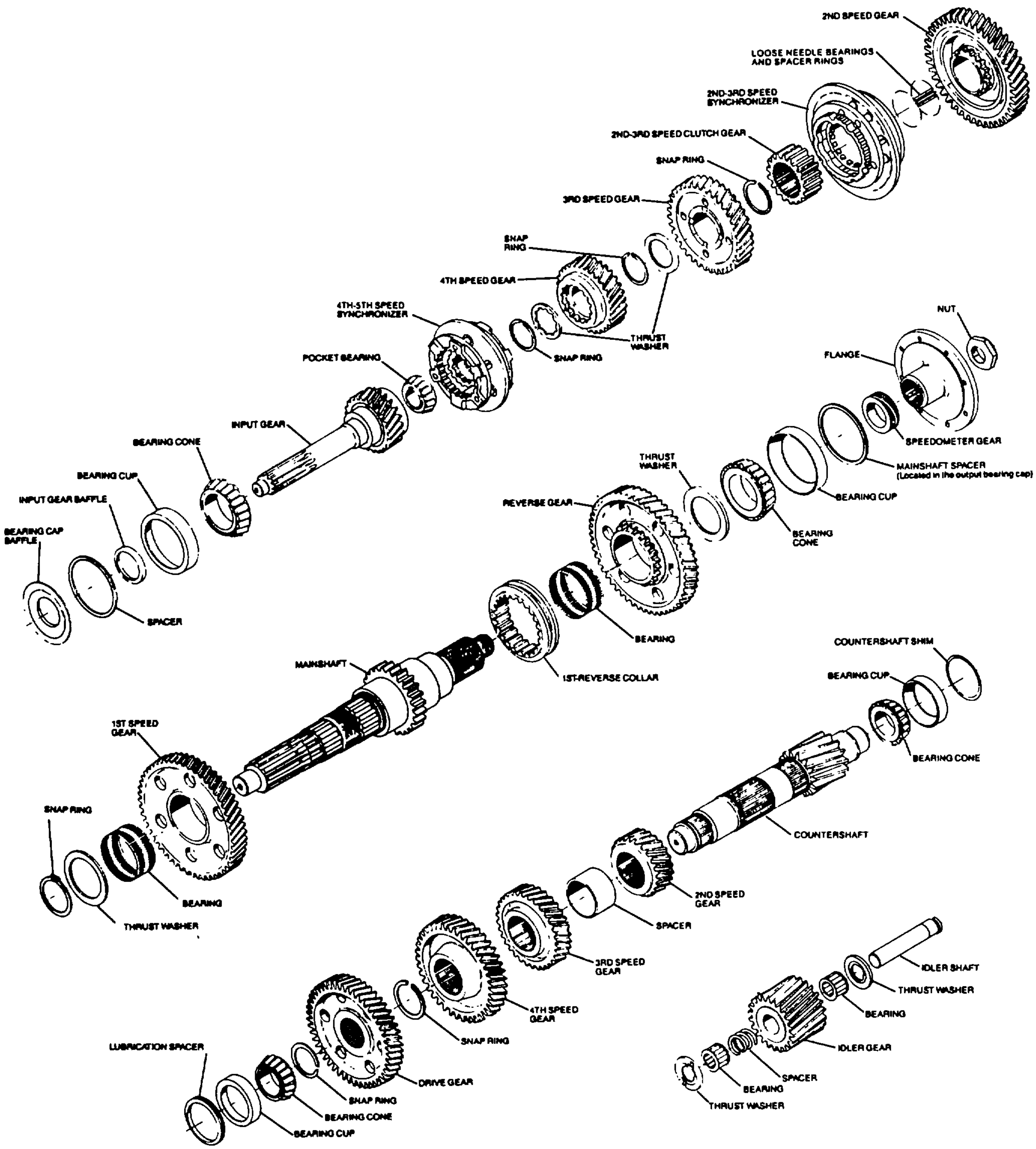
10. This idler gear contains two bearings and a spacer in its bore.

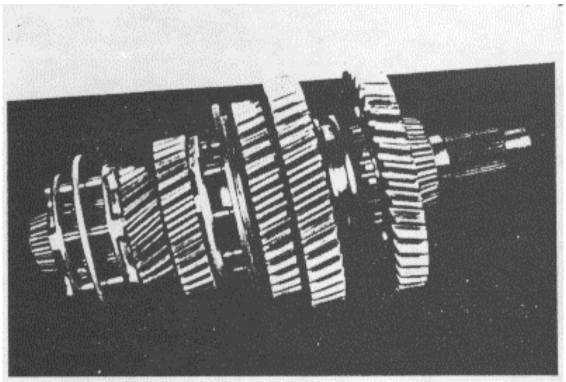


11. The countershaft subassembly may be removed now.

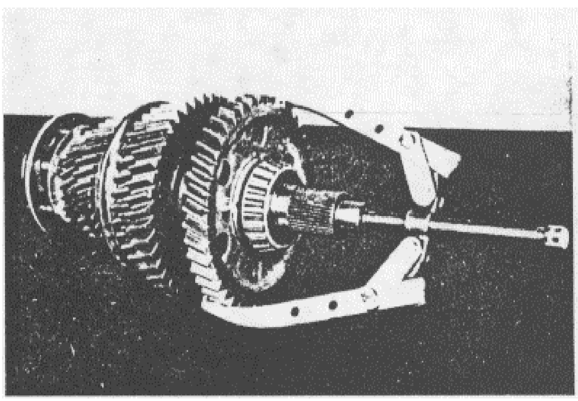


12. Rolled involute splines secure the countershaft gears.

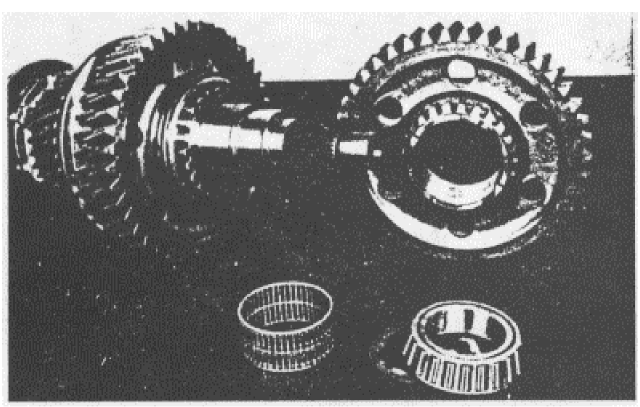

2ND SPEED GEAR
LOOSE NEEDLE BEARINGS AND SPACER RINGS
2ND-3RD SPEED SYNCHRONIZER
2ND-3RD SPEED CLUTCH GEAR
SNAP RING
3RD SPEED GEAR
SNAP RING
4TH SPEED GEAR
4TH-5TH SPEED SYNCHRONIZER
THRUST WASHER
SNAP RING
POCKET BEARING
NUT
FLANGE
INPUT GEAR
BEARING CONE
SPEEDOMETER GEAR
MAINSHAFT SPACER (Located in the output bearing cap)
THRUST WASHER
BEARING CUP
INPUT GEAR BAFFLE
REVERSE GEAR
BEARING CUP
BEARING CONE
BEARING CAP BAFFLE
SPACER
BEARING
COUNTERSHAFT SHIM
MAINSHAFT
1ST-REVERSE COLLAR
BEARING CUP
1ST SPEED GEAR
BEARING CONE
SNAP RING
COUNTERSHAFT
BEARING
2ND SPEED GEAR
THRUST WASHER
SPACER
3RD SPEED GEAR
IDLER SHAFT
THRUST WASHER
4TH SPEED GEAR
BEARING
SNAP RING
LUBRICATION SPACER
IDLER GEAR
DRIVE GEAR
SPACER
SNAP RING
BEARING
BEARING CONE
THRUST WASHER
BEARING CUP



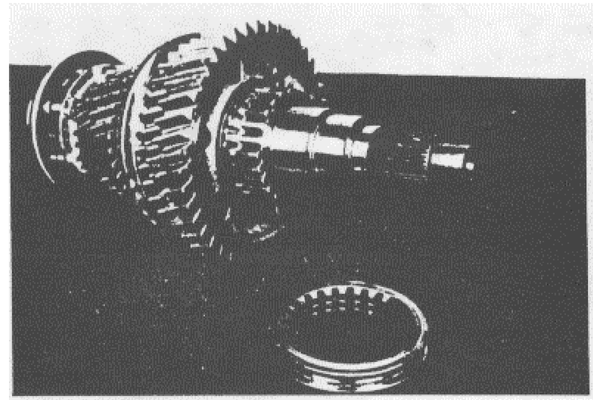
1. Place the mainshaft subassembly on a bench.



2. Use a suitable puller to remove the output bearing.

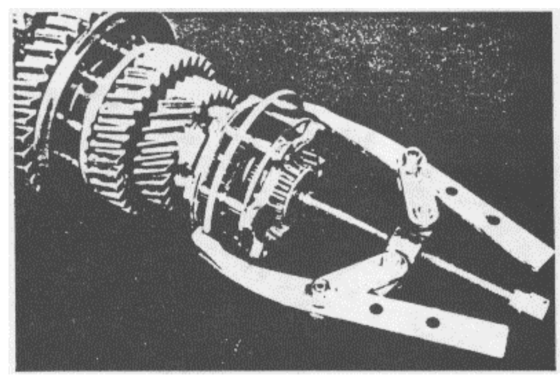


3. This method insures safe removal without bearing damage.



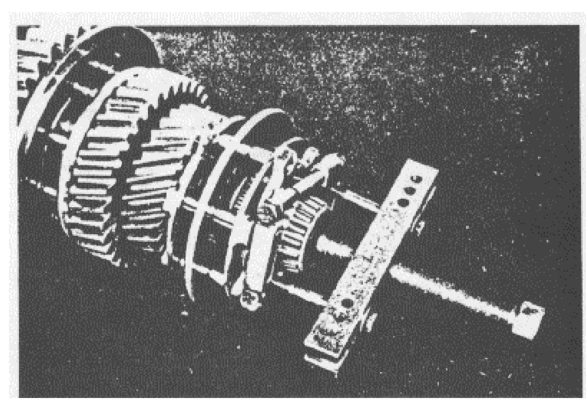
4. Remove the 1st-reverse clutch collar.

WRONG METHOD

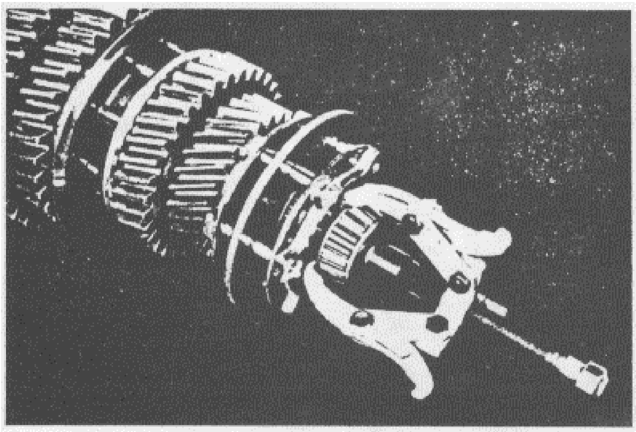


CAUTION:

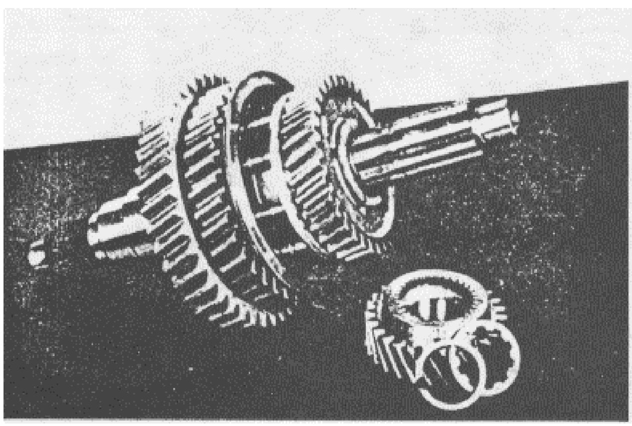
5. Due to the synchronizer's design, do not place a puller on it in an attempt to remove the input pocket bearing.



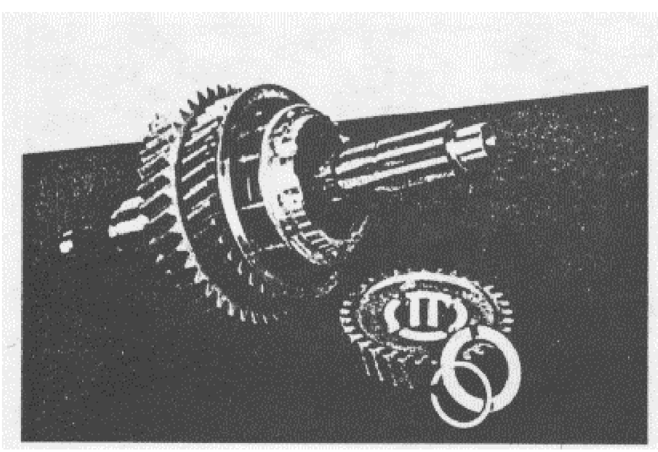
6. One of these methods should be used to remove the pocket bearing from the mainshaft pilot diameter.



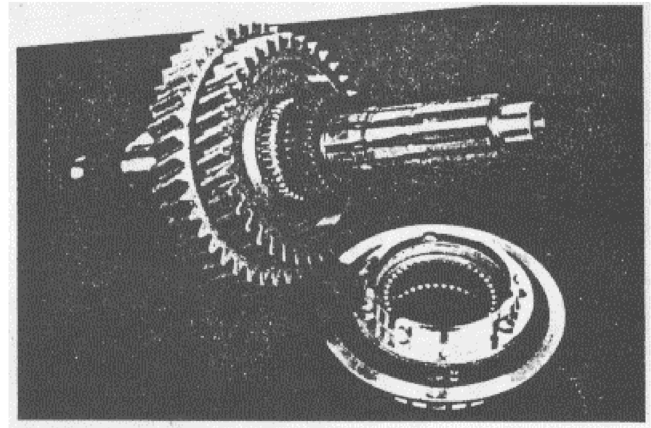
7. Alternate method for bearing removal.



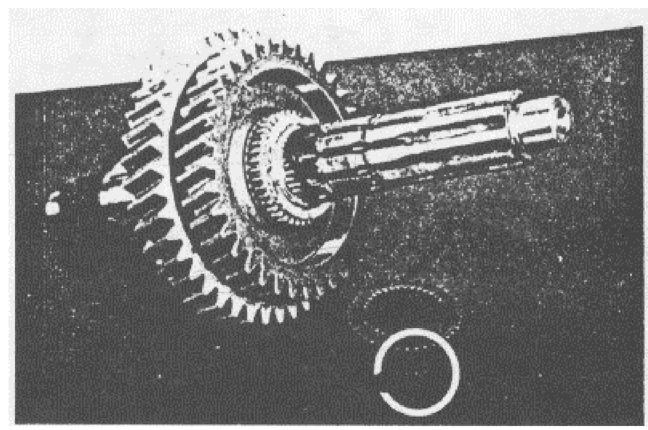
8. After removing the snap ring, the 4th speed gear and washer may be lifted from the mainshaft.



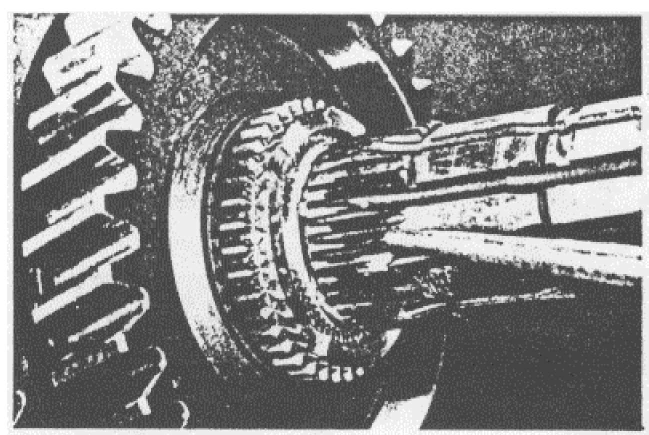
9. Remove the 3rd speed gear, thrust washer and snap ring.



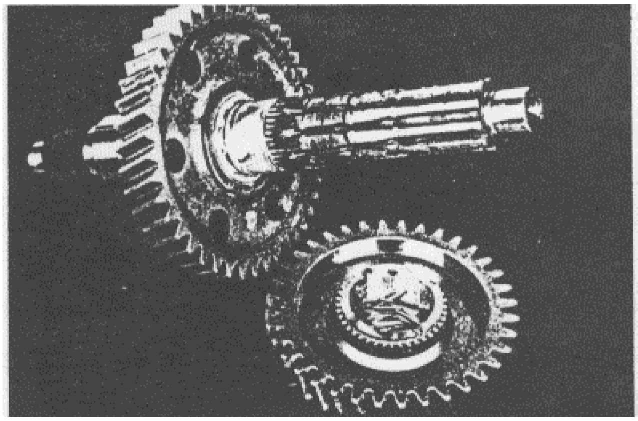
10. The 2nd-3rd speed synchronizer may be removed.



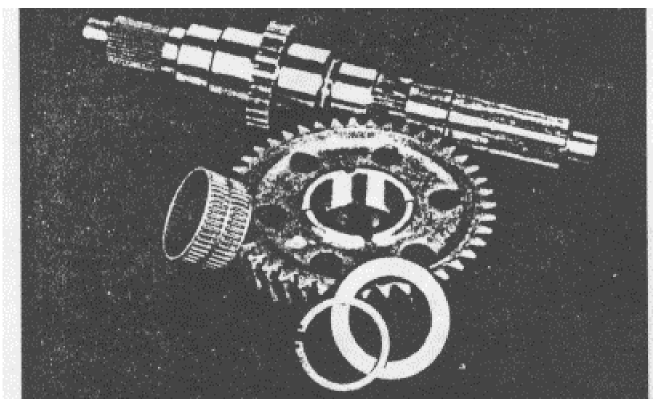
11. Remove the snap ring and the 2nd-3rd speed clutch gear.



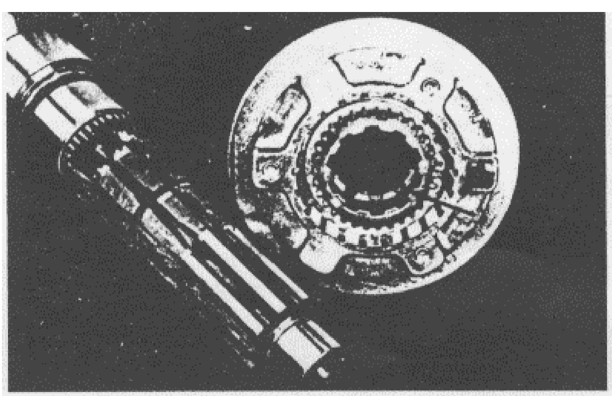
12. Rolled involute splines provide easier disassembly and reassembly.



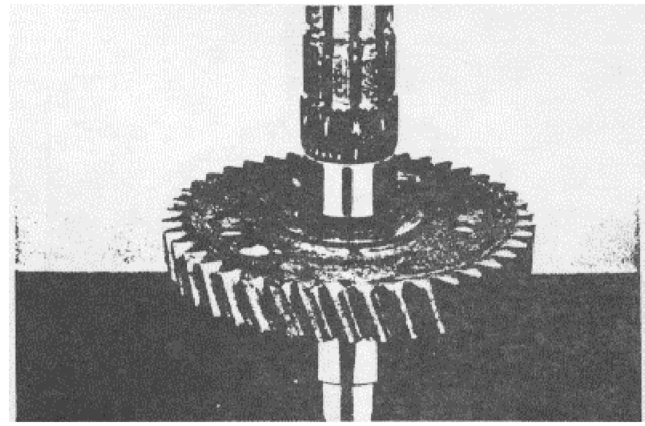
13. The 2nd speed gear contains loose needle bearings in its bore. They are used to meet the required load capacity of the 2nd speed gear.



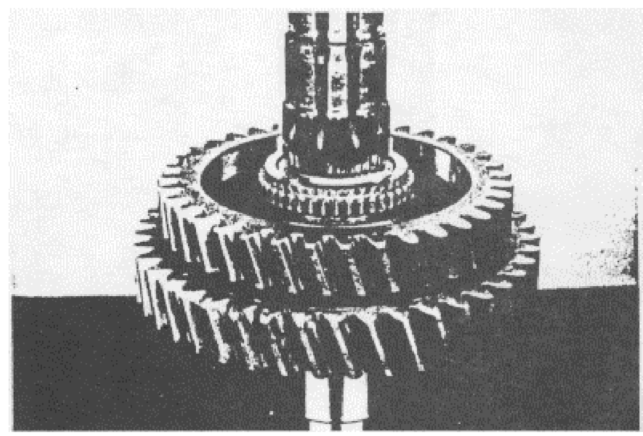
14. Remove the snap ring and 1st speed gear with the thrust washer and caged needle bearing.



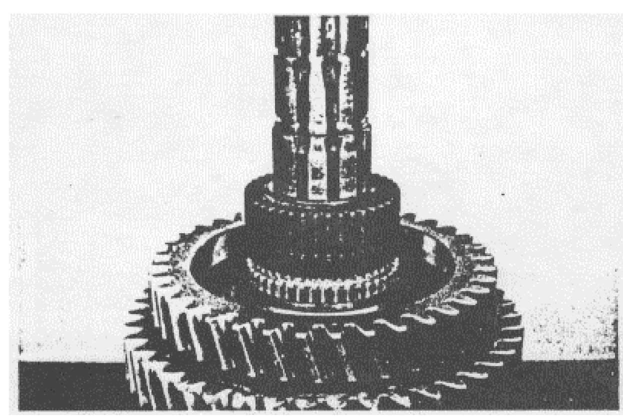
15. Examine the mainshaft gearlocks and the internal corners of the synchronizer clutching teeth for excessive wear that could produce gear jumping.



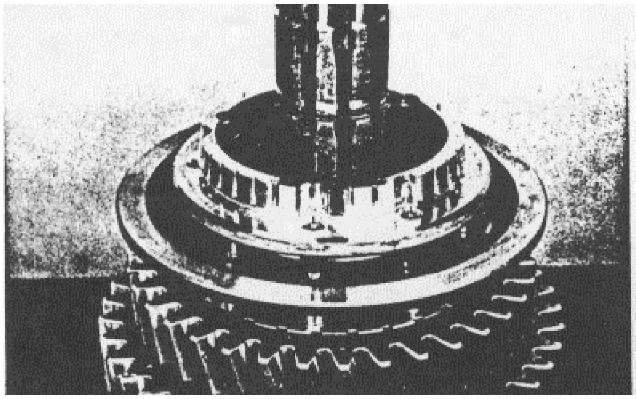
16. Mainshaft reassembly begins by placing the 1st speed gear and thrust washer on the mainshaft. Secure them with a snap ring.



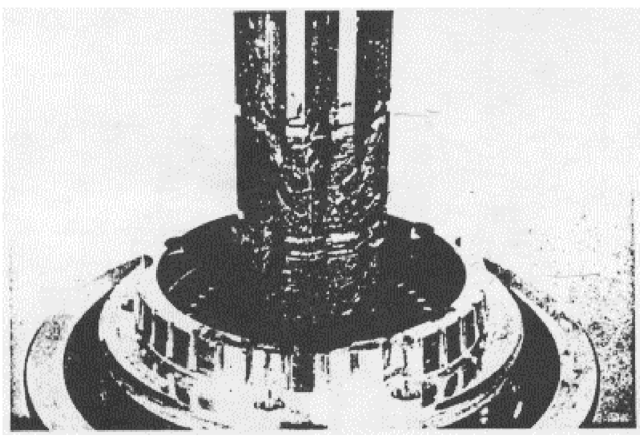
17. Place the 2nd speed gear on the mainshaft, over two rows of loose needle bearings.



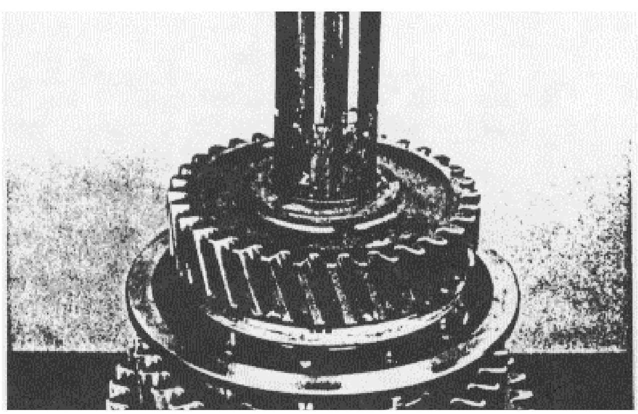
18. Install the 2nd-3rd speed clutch gear and secure it with a snap ring.



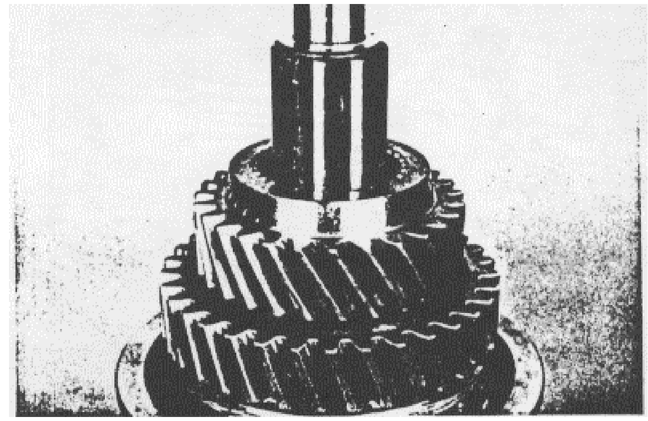
19. Place the 2nd-3rd speed synchronizer over the clutch gear.



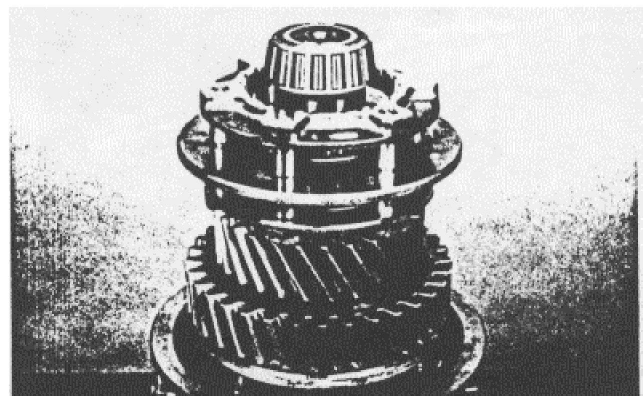
20. All fluted diameters should be coated with Moly #2 lube.



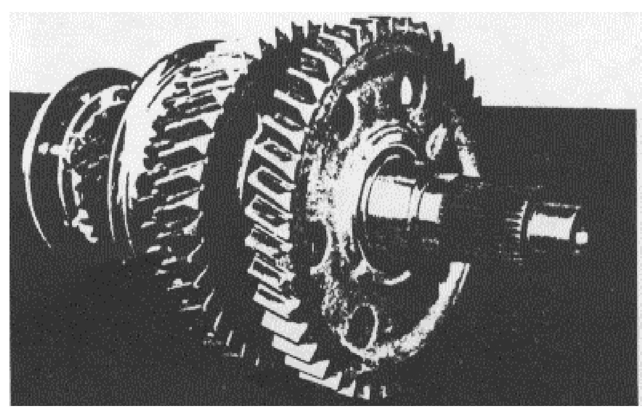
21. Assemble the 3rd speed gear and thrust washer. Secure them with a snap ring.



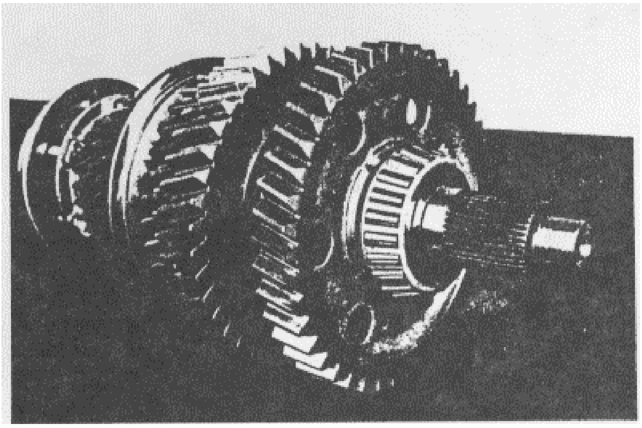
22. The 4th speed gear, complete with thrust washer, may be assembled to the mainshaft. Again, secure with a snap ring.



23. Place the 4th-5th speed synchronizer on the mainshaft. Then use a suitable driver to install the pocket bearing.



24. Set the mainshaft on a bench and install the 1st-reverse clutch collar and reverse gear with a caged needle bearing.



25. The output bearing must be seated firmly against the reverse gear thrust washer, so that the washer does not move.

Inspection

Prior to reassembling the mainshaft, certain individual parts should be examined. Parts damaged from previous service should be eliminated to insure maximum rebuild life.
We strongly suggest following these inspection procedures:

Synchronizers: Both the internal and external teeth must have sharp edges. Rounded corners or excessive chipping will cause gear jumping. Also, examine synchronizer rings for metal contamination.

Gears: Examine gears for broken or cracked operating teeth. Also, check for any unusual wear patterns. Clutching teeth must not show excessive wear.

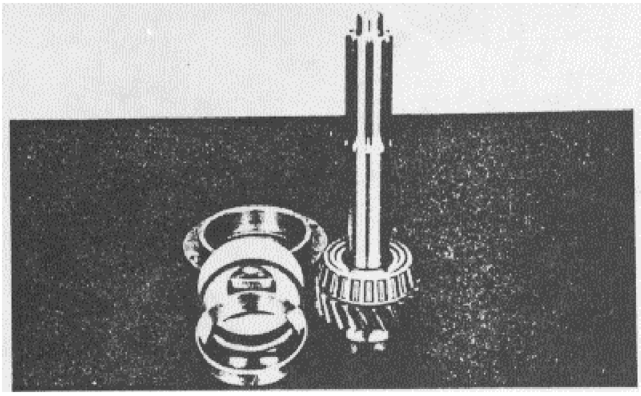
Thrust Washers: Check for flatness or excessive face wear, cracks or scoring.

Snap Rings: Examine these for distortion or loss of tension. We recommend using new snap rings with every rebuild. During installation, assemble snap rings with the die rolled side toward the needle bearing cage where applicable.

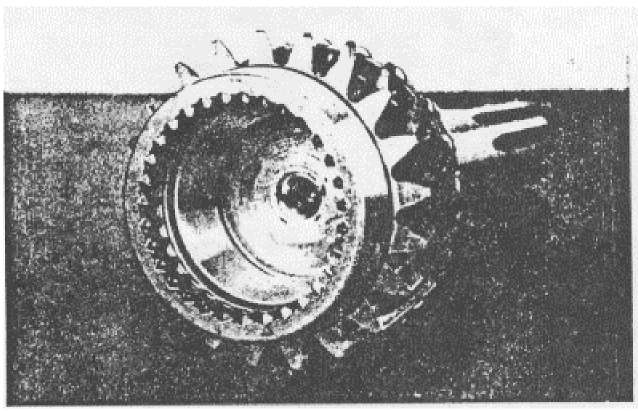
Mainshaft: Check clutch gear spline gear locks for sharp corners. Worn or ironed-out gear locks will produce gear jumping. Also, check for chipped splines at snap ring grooves. Apply a coat of moly grease to all bearings.

TORQUE SPECIFICATIONS FOR NUTS AND CAPSCREWS

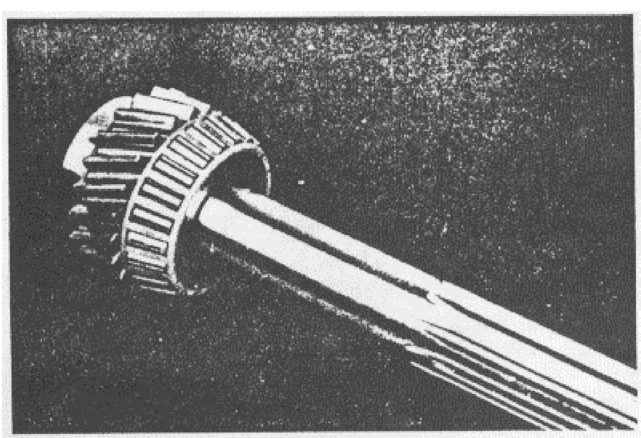
NOM. THREAD SIZE (DIA.)	PART NAME	WRENCH TORQUE FT. LBS. NON-LOCKING TYPE		LOCKING TYPE (Bonded Nylon Patch)	
		MIN.	MAX.	MIN.	MAX.
.250	Capscrew or Nut	7	10	10	13
.312	"	13	17	20	24
375	"	25	32	34	41
.438	"	40	50	52	62
.500	"	60	80	78	98
.562	"	90	115	112	137
.625	"	120	150	150	180
.750	"	200	250	240	290
1.250	Nut			500	550
1.375	"			550	600
1.750	"			550	600
	PTO Aperature Cover Capscrews				
.375	Capscrew	10	15	19	24
.438	"	20	25	32	37
	Shift Fork Or Bracket Setscrews	**Lockwire Type**			
.375	Setscrew	25	32	34	41
.438	"	40	50	52	62



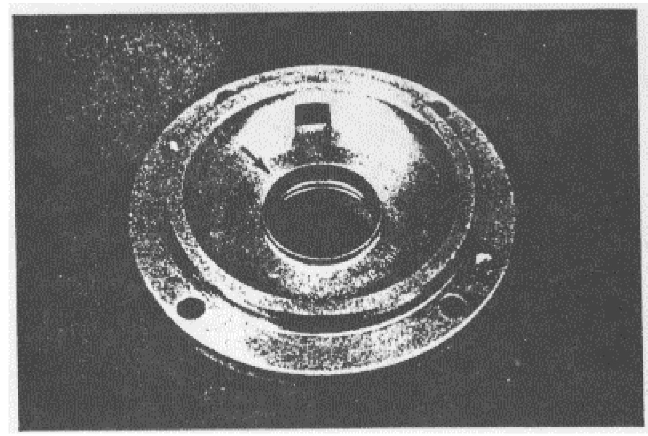
1. This input section provides the same lubrication system as the CM 55.



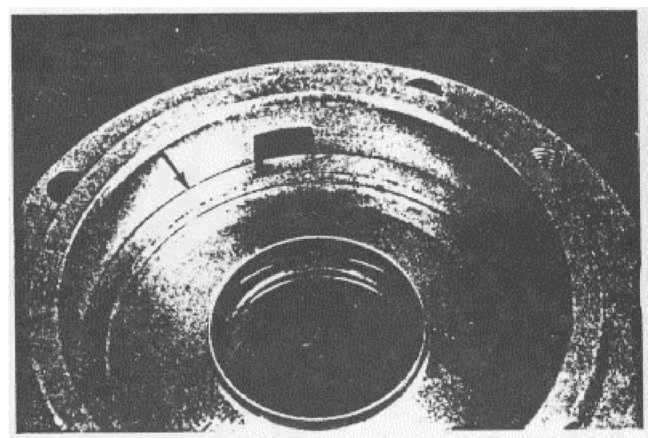
2. An axially drilled hole allows lubricant to flow to the pocket bearing.



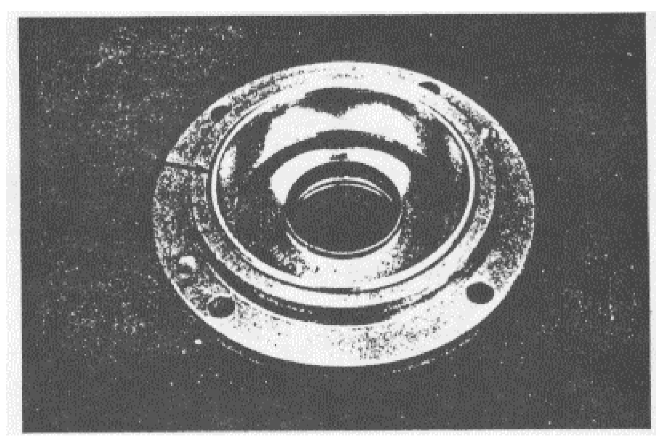
3. The input gear baffle is recessed into the input bearing to form a dam.



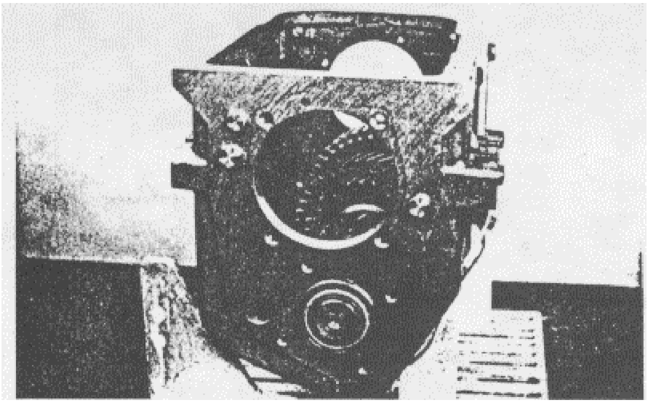
4. Place the baffle into the input bearing cap.



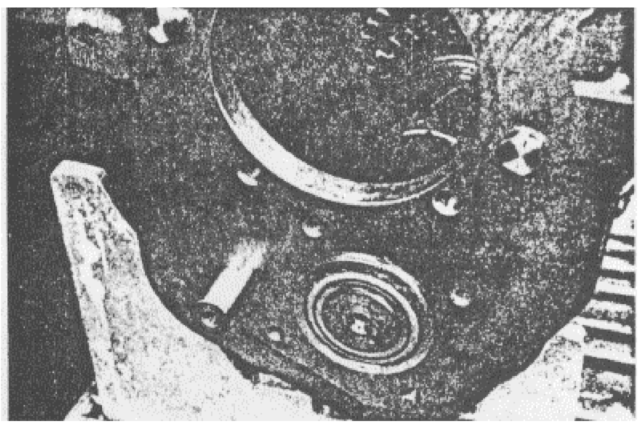
5. Next install the spacer.



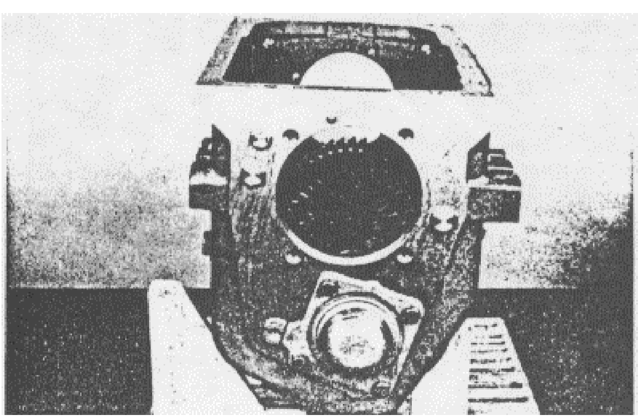
6. Insert the bearing race.



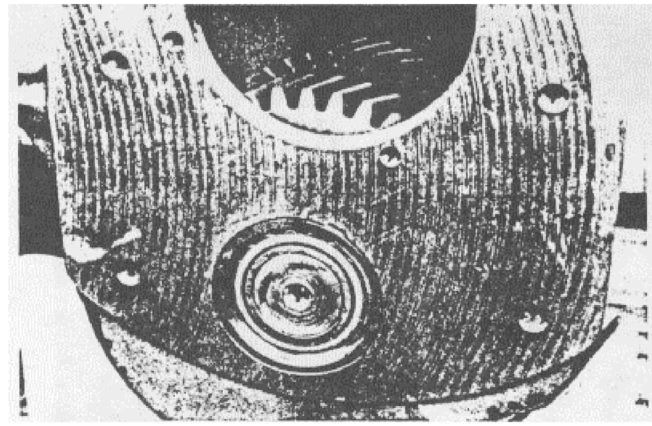
1. Place the countershaft subassembly into the case.



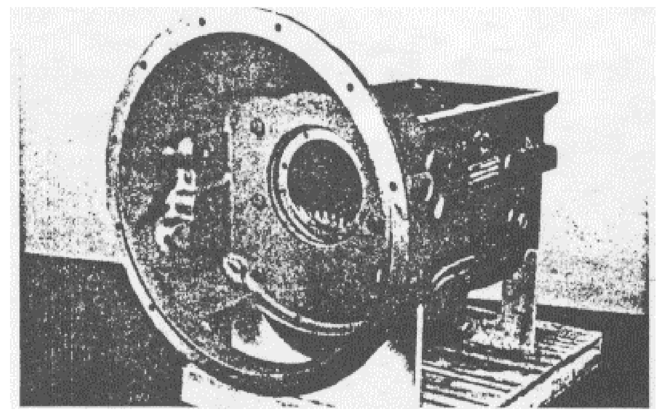
2. Position the reverse idler gear and thrust washers in the case Then, install the idler shaft with the flat side facing the bearing cap.



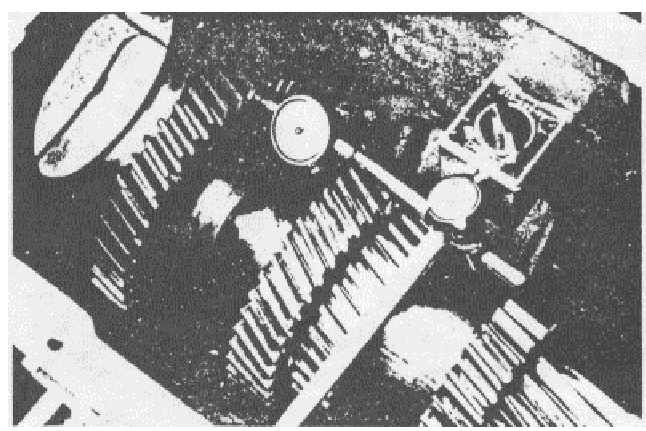
3. Assemble the countershaft rear bearing cap, gasket and shims.



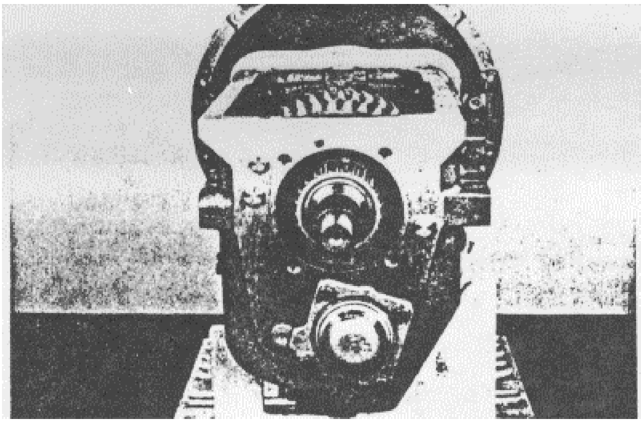
4. Install the lubrication spacer into the countershaft front bearing bore.



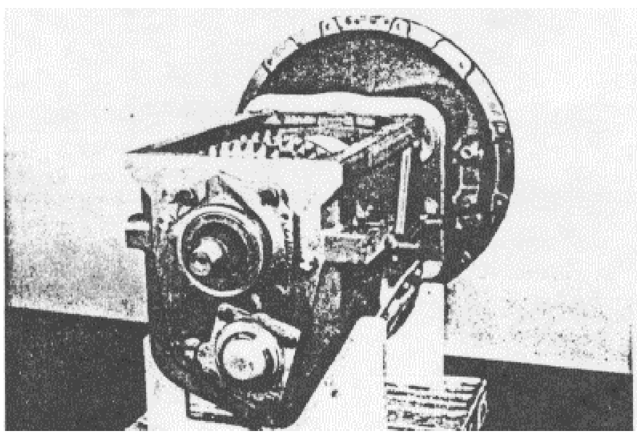
5. Assemble the clutch housing and gasket to the case.



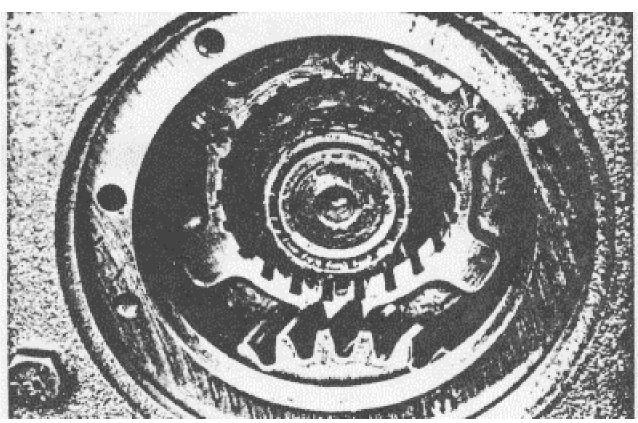
6. Check the countershaft end play. **End play must be set between .001" to .008"**. Adjustments can be made by re-shiming if necessary.



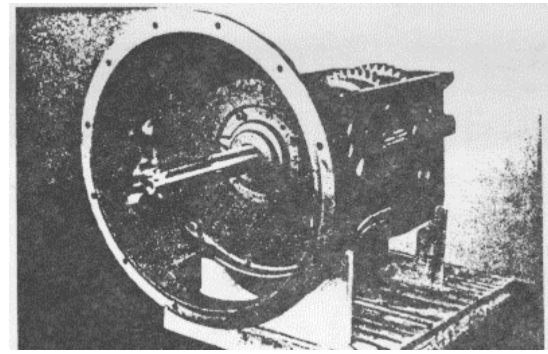
7. Lower the mainshaft subassembly into the case.



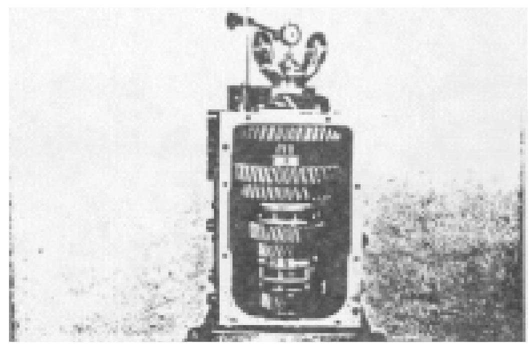
8. Install the output bearing cap and gasket. Remember, mainsha7ft end play is controlled by the spacer and the shims under the loose bearing race In this cap.



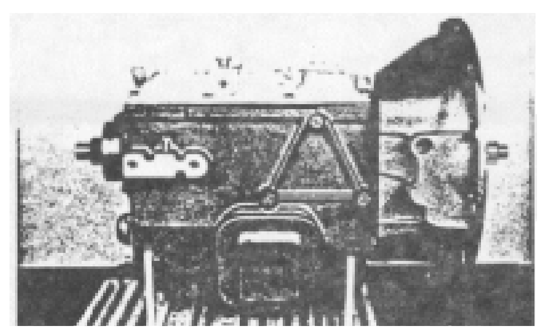
9. Pre-lube the input pocket bearing with a Moly #2 lubricant.



10. Install the input gear bearing cap and gasket. Secure them with capscrews. Torque to 34-41 ft. lbs.



11. Now stand the transmission upright to check the mainshaft end play. First assemble the end fitting and secure it with a washer and nut **Torque to 500-600 ft. lbs.** Rotate the mainshaft to properly seat the bearings Then place a dial indicator on the output end of the shaft and lift the mainshaft with pry bars **End play must be set between .003" - .008".**



12. Set the transmission back into a horizontal position and place all collars in neutral Install the shifter housing and gasket Secure them with capscrews, and torque to 20 - 30 ft. lbs.

Important Procedure

When locating and correcting unit power or auxiliary transmission troubles, a systematic procedure should be followed.

Road test whenever possible. Mechanics usually get second or third hand reports of trouble experienced with the unit. These reports do not always accurately describe the actual conditions. Sometimes symptoms seem to indicate trouble in the transmission, while actually the problem is with the axle, driveshaft, universal joints, engine or clutch. This is especially true of noise complaints. Therefore, before removing the transmission or related components to locate trouble, road test to check the possibility of trouble in other closely associated units. Road testing is most effective when the mechanic himself drives the vehicle. However, riding with the driver can be very informative.

Check Functioning
Prior to Disassembly

If a remote control is used, a careful check of the remote and connecting linkage must be made. The remote unit must be in good working order if the transmission is expected to shift satisfactorily.

Many times, the answer to the trouble is apparent when the unit is inspected prior to disassembly. But this evidence is often lost when the parts are separated. If possible, check the unit prior to disassembly. Bear in mind that a careful inspection of the unit should be made as each disassembly step is performed.

Inspect Thoroughly
During Disassembly

It is poor practice to disassemble a unit or the complete transmission as quickly as possible without examining the parts. The mechanic may completely disassemble a unit and fail to find the cause of the trouble, unless he examines the parts. After the transmission is disassembled, check the lubricant for foreign particles. This is a source of trouble often overlooked during the disassembly.

Repair or Replace Worn Parts

Many times the parts or critical adjustments causing the trouble are not replaced or corrected because the mechanic only inspects and replaces parts that have failed completely. All pieces should be accurately examined because broken parts are often just the result-not the cause-of the problem. All parts that are broken or worn and no longer meet specifications should be replaced.

Also, parts that are worn to the extent that they do not have a long service life remaining should be replaced. Replacing these parts now will avoid another teardown on the unit in the near future. Also at this time, make the recommended changes or modifications to bring the transmission up to date and increase the service life of the unit.

CAUTION: If the backup lights do not function, check the following:

1. Continuity of switch with ball fully depressed
2. Electrical plug connection
3. Wiring

Noisy Operation

Noise is usually a very elusive problem, and is generally not the fault of the transmission. Mechanics should road test the vehicle to determine if the driver's complaint of noise is actually in the transmission.

In numerous instances drivers have insisted noise was coming from the transmission, investigations revealed it was caused by one of the following conditions:

(a) Fan out of balance or blades were bent.
(b) Defective vibration dampers.
(c) Crankshaft out of balance.
(d) Flywheel out of balance.
(e) Loose flywheel mounting bolts.
(f) Rough engine idle producing rattle in gear train.
(g) Clutch assembly out of balance.
(h) Loose or broken engine mounts.
(I) Power take-off was engaged.
(j) Worn universal joints.
(k) Driveshaft out of balance.
(l) Universal joint angles out of plane or at excessive angles.
(m) Center bearings in driveline dry, not mounted properly.
(n) Wheels out of balance.
(o) Tire treads humming or vibrating at certain speeds.
(p) Air leaks on suction side of induction system, especially with turbo-chargers.

Mechanics should try to locate and eliminate noise by means other than a transmission removal or an overhaul. However, if the noise appears to be in the transmission, try to determine what position the gear shift lever is in when the noise occurs. If the noise is evident in only one gear position, the problem is generally traceable to the operating gears. Next, try to break the noise down into the following classifications:

(a) *Growling, humming and grinding*. These noises are caused by worn, chipped, rough or cracked gears. As gears continue to wear, the grinding noise will be noticeable, particularly in the gear position that throws the greatest load on the worn gear.
A lack of lubricant or use of improper lubricant can also result in growling and grinding noises. This is because there is insufficient lubricant to cool and cover the gears, which allows metal-to-metal contact.

(b) *Hissing, thumping and bumping*. Hissing noises can be caused by bad bearings. As bearings wear and retainers start to break up, etc., the noise could change to a thumping or bumping.

(c) *Gear whine*. This is usually caused by lack of backlash between mating gears. Improper PTO shimming is the big offender here.

(d) *Vibration.* Today's improved highways mean entire power trains are cruising at higher RPMs. These higher speeds mean damage caused by driveline vibration is more obvious than in the past.
When the maximum RPM of a shaft is reached, it begins to bow. A resonant hum can be heard, and a vibration will be set up. This type vibration can cause gear seizures, broken synchronizer pins, bearing failures, brinelling and corrosion.
During acceleration and deceleration, the shaft may pass through half-critical vibration (half the maximum RPM of the shaft). A whine or boom may be heard at this point.

(e) *Metallic rattles*. These noises within the transmission usually result from a variety of conditions. Engine torsional vibrations are transmitted to the transmission through the clutch. In heavy duty equipment, clutch discs with vibration dampers are not used, so a rattle-particularly in neutral-is common with diesel equipment.
In general, engine speeds should be 600 RPM or above to eliminate objectionable rattles and vibration during the idle. A defective or faulty injector would cause a rough or lower idle speed, and possibly a rattle in the transmission. A rattle can also be caused by excessive backlash between the PTO input gear and the transmission output gear.

Noise in Neutral

Possible Causes:
(a) Misalignment of transmission.
(b) Worn flywheel pilot bearing.
(c) Worn or scored countershaft bearings.
(d) Worn or rough reverse idler gear.
(e) Sprung or worn countershaft.
(f) Excessive backlash in gears.
(g) Worn mainshaft pilot bearing.
(h) Scuffed gear tooth contact surface.
(i) Insufficient lubrication.
(j) Use of incorrect grade of lubricant.

Noise in Gear

Possible Causes:
(a) Worn or rough mainshaft rear bearing.
(b) Rough, chipped, or tapered sliding gear teeth.
(c) Noisy speedometer gears.
(d) Excessive end play of countershaft gears.
(e) Refer to conditions listed under *Noise in Neutral.*

Oil Leaks

Possible Causes:
(a) Oil level too high.
(b) Wrong lubricant in unit.
(c) Non-shielded bearing used as front or rear bearing cap where applicable.
(d) Seals defective, wrong type or omitted from bearing cap.
(e) Transmission breather omitted or plugged internally.
(f) Capscrews loose, omitted or missing from remote control, shifter housing, bearing caps, PTO or covers.
(g) Oil drain-back openings in bearing caps or case plugged with varnish, dirt, or gasket material.
(h) Gaskets shifted or squeezed out of position, broken gaskets with pieces still under bearing cap, clutch housing, PTO and covers.
(i) Cracks or holes in castings.
(j) Loose drain plug.
(k) Oil leakage from engine.
(l) Loose speedometer adaptor or connections.

Walking or Jumping Out of Gear

If the units are walking out of gear, it could be caused by:
(a) External interference, such as the floorboard opening, preventing full engagement, or
(b) An internal malfunction, such as worn clutching teeth, allowing the transmission to shift out of position.

If a remote control is being used, make sure It is functioning properly before the transmission is blamed for the problem. Note whether the unit walks out of gear under drive while pulling a load, or on a coast load. Also, notice whether the gear hop occurs on smooth roads or only on rough roads. Items that would prevent full engagement of gears are:
(a) Improperly positioned forward remote control which limits full travel forward and backward from the remote neutral position.
(b) Improper length shift rods or linkage that limits travel of forward remote from neutral position.
(c) Loose bell cranks, sloppy ball and socket joints.
(d) Shift rods, cables, etc. , too spongy or flexible, or not secured properly at both ends.
(e) Worn or loose engine mounts If forward unit is mounted to frame.
(f) Forward remote mount too flimsy, or loose on the frame.
(g) Set screws loose at remote control joints, on shift forks inside remote or even inside transmission unit.
(h) Shift fork pad clips or groove in sliding gear or collar worn excessively.
(I) Worn taper on gear clutch teeth.
(j) Transmission and engine out of alignment either vertically or horizontally.

A few items which could move the gear or shaft out of proper position, particularly on rough roads are:
(a) Use of heavy shift lever extensions.
(b) Broken shift rod poppet springs.
(c) Worn shift rod poppet notches.
(d) Bent or sprung shift rods.
(e) Shift fork pad clips broken or missing.
(f) Excessive end-play in drive gear, mainshaft or countershaft, caused by worn bearings or retainers.

(g) Worn or missing thrust washers.

Hard Shifting

An improperly operating clutch will interfere with the proper shifting of gears in any transmission. It is also important that the hydraulic, air or similar release mechanism is In proper working order. If full and complete clutch release is being made, the following could be a few of the possible causes for hard shifting complaints:

(a) No lubricant in remote control unit. (Note The forward remote is isolated and is often overlooked. Many remote controls used on transmissions and auxiliaries require separate lubrication.)
(b) No lubricant in, or grease fittings on, u-joints or swivels of remote controls.
(c) Lack of lubricant or wrong lubricant used, causing buildup, of sticky varnish and sludge deposits on splines of shaft and gears.
(d) Badly worn or bent shift rods.
(e) Improper adjustment on shifter linkage.
(f) Sliding clutch gears tight on splines of shaft.
(g) Clutch teeth burred over, chipped or badly mutilated because of improper shifting.
(h) Binding or interference of shift lever with other objects or rods inside the cab or near the remote control island.
(i) Driver not familiar with proper shifting procedure for the transmission, or with 2-speed axle or auxiliary.
(j) Clutch or drive gear pilot bearing seized, rough, or dragging.
(k) Clutch brake engaging too soon when clutch pedal is depressed.
(l) Wrong lubricant, especially if extreme pressure type lubricant is added.
(m) Free running gears seized or galled on either the thrust face or diameters.

Sticking in Gear

(a) Clutch not releasing. Also check remote units such as hydraulic or air assist. Note: On some units employing a full air control for clutch release, air pressure of approximately 60 lbs. or more must be secured before the clutch can be released. **Do not leave these vehicles parked in gear.**
(b) Sliding clutch gears tight on splines.
(c) Chips wedged between or under splines of shaft and gear.
(d) Improper adjustment, excessive wear or lost motion in shifter linkage
(e) Clutch brake set too high on clutch pedal, locking gears behind hopping guards.

Bearing Failures

The service life of most transmissions, main and auxiliary, is governed by the life of the bearings. The majority of bearing failures can be attributed to vibration and dirt. Some other prominent reasons for unit bearing failures are:

(a) Fatigue of raceways or balls.
(b) Wrong type or grade of lubricant.
(c) Lack of lubricant.
(d) Broken retainers, brinelled races and fretting caused by vibration.
(e) Bearings set up too tight or too loose.
(f) Improper installation resulting in brinelled bearings.
(g) Improper fit of shafts or bore.
(h) Acid etching due to water in lube.
(i) Vehicle overload or too large an engine for the transmission resulting in overload.

Dirt

More than 90% of all ball bearing failures are caused by dirt, which is always abrasive.

Dirt may enter the bearings during assembly of units, or may be carried into the bearing by the lubricant while in service. Dirt also may enter bearings through seals, the breather or even dirty containers used for addition or change of lubricant.

Softer material, such as dirt or dust, usually forms abrasive paste or lapping compounds within the bearings. The pressure between the balls and raceways makes a perfect pulverizer: The rolling motion tends to entrap and hold the abrasives. As the balls and raceways wear, the bearings become noisy. The lapping action tends to increase rapidly as the fine steel from the balls and rollway adds to the lapping material.

Hard, coarse material, such as metal chips, may enter the bearings during assembly from tools such as hammers, drifts, and power chisels. It may also be manufactured within the unit during service from raking teeth. These chips produce small indentations in balls and races. When these hard particles jam between the balls and races, it may cause the inner race to turn on the shaft, or the outer race to turn In the housing.

Fatigue

All bearings are subject to fatigue and must be replaced eventually. Your own operating experience. will dictate mileage replacement of bearings showing only normal wear.

Corrosion

Water, acid and corrosive materials formed by deterioration of lubricant, will produce a reddish-brown coating and small etched holes over outer and exposed surfaces of the race. Corrosive oxides also act as lapping agents.

Shaft Fits

Bearing fits on rotating shafts are usually specified as tight. Excessive looseness-even .001"-under a load, produces a creeping or slipping of the inner race on the rotating shaft. The result is that surface metal of the shafts scrub or wear off. The force causing the inner race to rotate disappears when the bearing fits properly.

Installation and Removal of Bearings

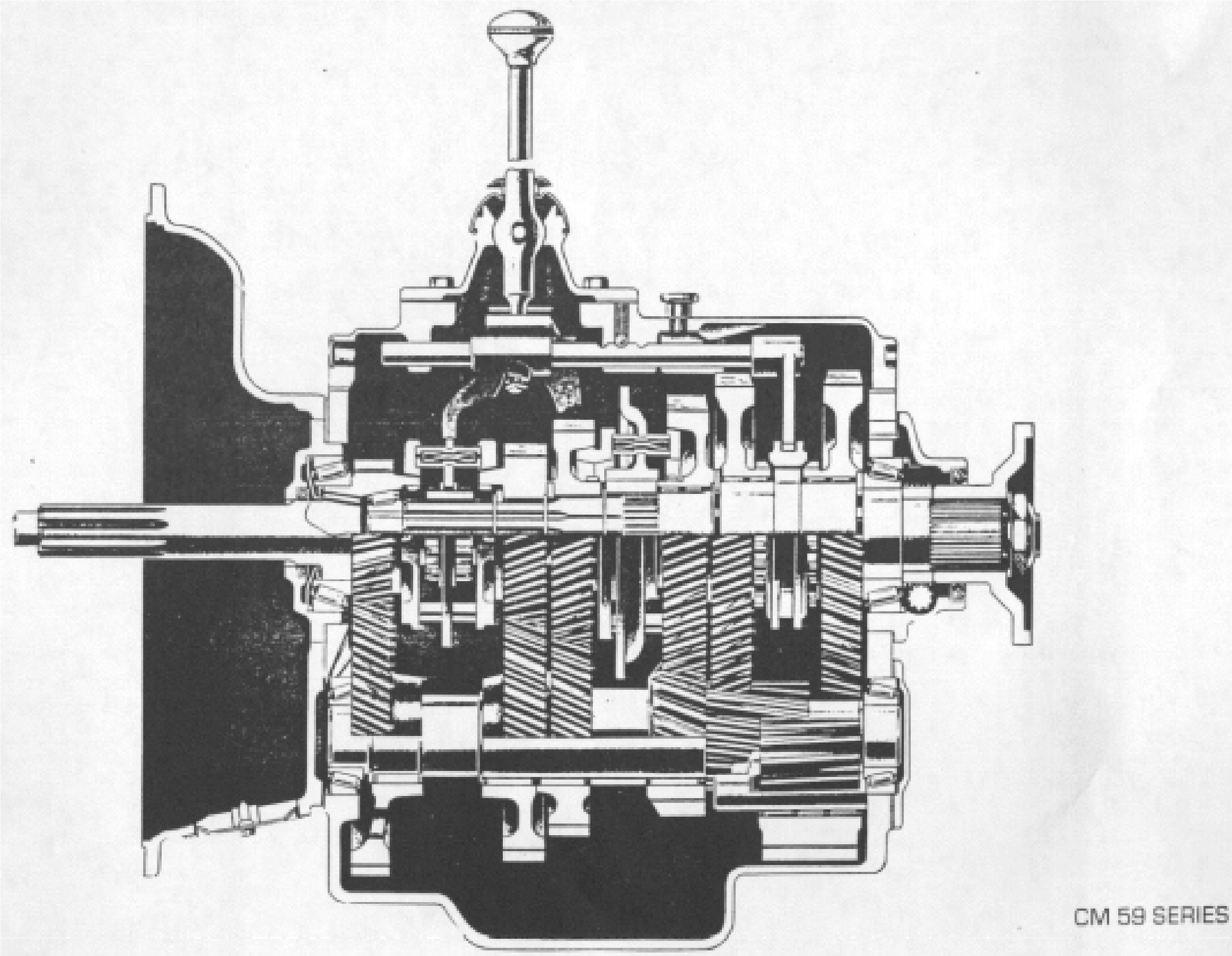
Improper installation or removal of bearings, especially hammering the bearing on the shaft with off-center blows, can result in brinelling. Since such damage is seldom visible, it does not become known until after failure or complete disassembly. The correct drivers (preferably under an arbor press) and pullers should be used.

Removing bearings is more difficult than installing them. In most cases, it is necessary to remove the bearing by pulling on the outer race, which can damage the balls or races. Therefore, it is a good Idea to replace bearings during an overhaul, to prevent problems. However, if a bearing is not going to be replaced, avoid removal during low mileage rebuilds.

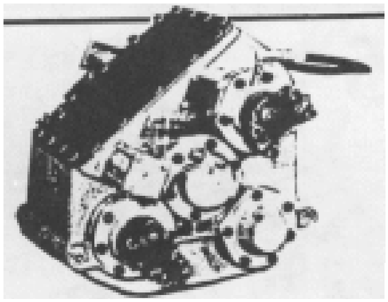
Interchangeability

All ball bearings, whether manufactured here or abroad, are interchangeable in regard to standardized dimensions, tolerances, and fits. However, for a given shaft size there are standard bearings for light, medium, and heavy duty service.

Numbers and symbols stamped on inner and outer races of bearings designate size and type. Note that the numbering systems of different bearing manufacturers have not been standardized. Consult interchangeable tables and use the proper bearings for replacement parts.



CM 59 SERIES



Kelsey-Hayes Company,
Fabco Division

TC-35

TRANSFER CASE

Service Manual and Parts Manual

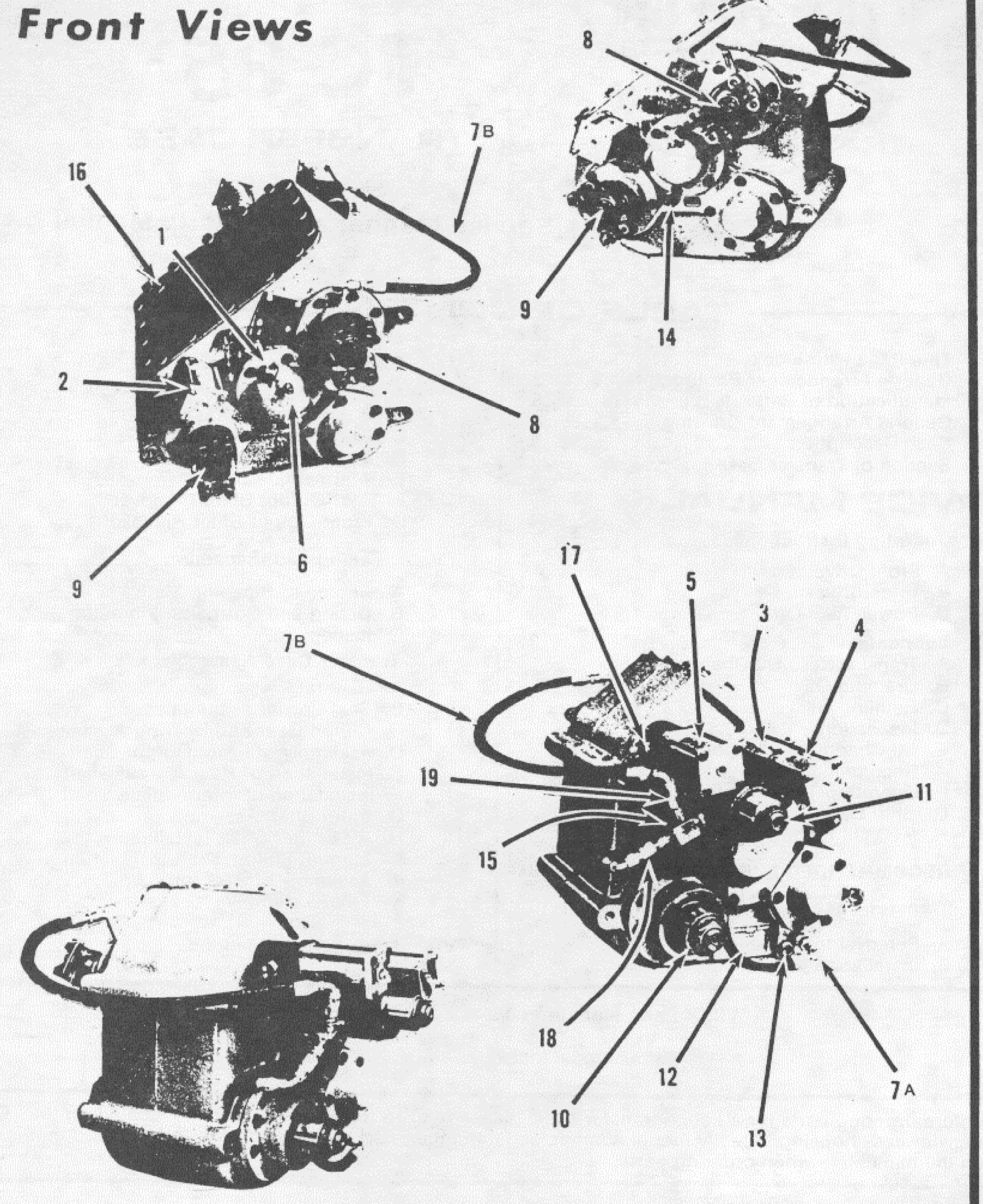
TABLE OF CONTENTS

Before ordering parts for a Fabco transfer case, please refer to the Fabco nameplate located on the transfer case housing. Specify model number, serial number, part number, or other information that is on the nameplate when ordering parts.

Part numbers contained in this manual were in effect at the time the manual was approved for printing and are subject to change without notice or liability. Kelsey-Hayes Co. Fabco Division reserves the right to change parts at any time.

TC 35

Front Views



Rear Views

GENERAL ARRANGEMENT

Refer To The Photographs On The Facing Page

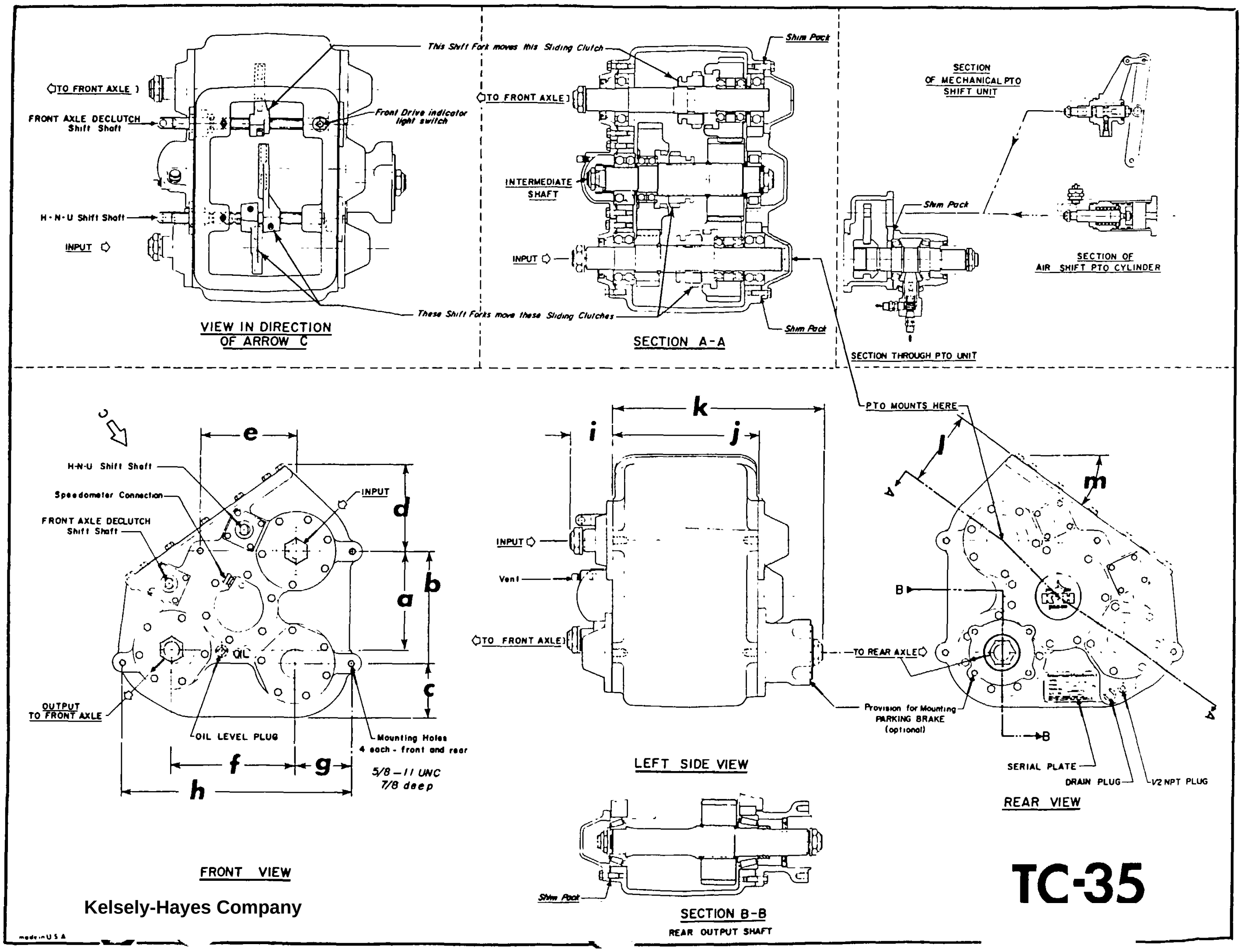
1. Connection, Speedometer
2. Cylinder, Front Drive Air Shift
3. Cylinder, High-Underdrive Air Shift
4. Cylinder, "Piggy-Back" Neutral Air Shift
5. Cylinder, PTO Air Shift
6. Fitting, Air Vent

7a. Hose, Oil Pump Suction Line

7b. Hose, Oil Pump Pressure Line

8. Input to Transmission
9. Output to Front Axle
10. Output to Rear Axle
11. PTO Output
12. Plate, Serial and Model No. Identification
13. Plug, Oil Drain
14. Plug, Oil Fill & Level
15. Pump, PTO Oil
16. Switch, Front Drive Engaged Indicator Light
17. Switch, PTO Engaged Indicator Light
18. Valve, PTO Oil Pump Inlet
19. Valve, PTO Oil Pump Outlet

Refer to the parts book section beginning on Page PM1 for complete parts identification.



Kelsely-Hayes Company

TC-35

DESCRIPTION
Model TC-35
Transfer Case

FEATURES

A four shaft transfer case with the front output off-set from the rear output
Single piece housing
Constant mesh gearing
Options include:
Manual Shift
Air Shift
Parking Brake Mounting Carrier
PTO Unit with Oil Pump

AVAILABLE IN THE FOLLOWING STANDARD CONFIGURATIONS				
Part No.	PTO	Shift	Neutral	Provision for Parking Brake
872 165 001	No	Air	No	No
872 165 002	Yes	Air	Yes	No
872 165 003	No	Manual	Yes	Yes
872 165 004	Yes	Manual	Yes	Yes
872 165 005	No	Manual	Yes	No
872 165 006	Yes	Manual	Yes	No

Additional configurations may be made to meet specific requirements.

DRY WEIGHT:
(005 Configuration) 400 lbs.
(006 Configuration) 439 lbs.

OIL CAPACITY:
7 Qts.

DIMENSIONS:

The following dimensions apply to the drawing on Page 4.	
a.	7.51
b.	8.49
c.	4.00
d.	6.50
e.	7.24
f.	9.28
9.	4.26
h.	17.38
i.	3.35
j.	11.00
k.	19.35
l.	6.75
m.	36°
Spline and seal sizes are shown on Page PM2	

A. Front Drive

When travelling through sand, loose dirt, mud, snow, ice, or when ascending grades where the rear wheels might spin, shift to front wheel drive for better traction. Shift before the truck is in trouble. Engagement and disengagement of the front drive axle can best be made while the engine is pulling lightly. It can be shifted at any speed provided the rear wheels are not spinning. The transfer case is equipped with a switch so that the shift is indicated by a pilot light. The light will come on when front drive is engaged.

B. Underdrive

When slow, positive pulling power is desired, shift to underdrive. Underdrive may be used to obtain a convenient combination with third or direct for climbing some grades. The transfer case should be shifted between high and low range only when the truck is stopped.

C. Power Take-Off

When the transfer case is equipped with a power take-off, the PTO can be operated without moving the vehicle. To engage, shift the automatic transmission into neutral and shift the PTO while the engine is idling. After the PTO has been engaged, shift the transmission to the desired gear. With a manual transmission equipped vehicle, depress the clutch pedal and shift into the desired transmission gear, shift the PTO and release the clutch.

To disengage the PTO, shift the transmission into neutral (manual and automatic), allow the machinery to come to rest, then disengage the PTO.

II. LUBRICATION

Note: For proper lubricant, refer to "Recommended Lubricants" chart page 9.

A. Transfer Case Oil Change

Transfer case lubricant should be changed on all new transfer cases after the first 3,000 to 5,000 miles (on-highway), or first 40 hours (off-highway); thereafter, oil changes should be done at the following Intervals:

On-Off Highway Service .... 10,000-15,000 miles

Off-Highway Service
(Logging, dirt moving, mining and
associated operations) .... 500-750 hours, as indicated by operation and contamination of lubricant.

B. Draining Oil

Draining is best accomplished after the vehicle has been operated briefly, allowing the oil to become warm and flow freely. Remove both drain and fill plugs and allow housing to empty completely. After transfer case has been drained and before it is refilled, the case should be thoroughly flushed with clean flushing oil or kerosene.

C. Refilling Oil

If the transfer case has been removed from the vehicle for service, it is best to refill the oil after the transfer case has been reinstalled into the vehicle.

Clean and replace drain plug and fill the transfer case with appropriate gear oil with the vehicle on level ground (See recommended lubricant chart). Fill transfer case to the level of the fill plug, metering approximately 7 qts. of gear oil into the transfer case. The exact amount may differ depending upon the inclination of the transfer case. Always fill to the level of the fill plug. Replace fill plug and examine transfer case for leaks around plugs and gasket sealed areas.

Do not overfill the transfer case. Overfilling may cause seepage around bearing caps.

D. Inspection

Gear oil level is to be maintained at the level of the fill plug at all times. Check at the following intervals:

Highway Service.................................. 1,000 miles
Off-Highway Service............................ 40 hours

E. Oil Change and Inspection Recommendations

The above oil change and inspection periods are based on the average use and operating conditions the transfer case may encounter. It is recommended that the individual owner make a periodic lab analysis of the lubricant to determine contamination based on the individual's own operating conditions. With this data the individual owner can better determine their own oil change and inspection periods.

F. Operating Temperature

The operating temperature of the transfer case should never exceed 250(F (120°C). Extensive operation at temperatures exceeding 250°F will result in rapid breakdown of the oil and shorten the transfer case life.

G. Shift Cylinder Inspection (Air Shift Cases Only)

With every oil change the air shift cylinder lines and valves should be inspected for leaks and possible malfunctioning. Low pressure conditions can cause partial clutch tooth engagement which may result in "gear jumping" and premature wear.

H. PTO Oil Pump Inspection

Check oil pump output at: Initial installation; reinstallation; if case over heats during extended PTO operation; at each oil change. Disconnect PTO oil pump output hose from the fitting at the front of the case. Block the truck wheels, set the parking brake, put the transfer case in neutral, engage the PTO. Make sure the output hose is clear of the transfer case input shaft. Use something to catch the oil. Keep hands away from rotating (and hot) parts under the truck. Operate the case at idle speed and observe the oil flow. Flow should be about 10-12 oz. per minute.

If no oil flow is observed, disconnect output hose at the output check valve (Refer to Page PM15 and to Fig. 39), remove the output check valve, prime pump with transfer case lubricant added through the hole exposed in the side of the oil pump. Reconnect the fittings at the PTO end of the case and repeat the test described above.

Refer to section VI J if difficulties are encountered.

On Highway Vehicles		
Type	**Grade**	**Temperature**
MIL-L-2104B Heavy-Duty Engine Oil	SAE 50 SAE 30	Above +10°F. Below +10°F.
Mineral Gear Oil	SAE 90 SAE 80	Above +10°F. Below +10°F.
MIL-L-2105B E.P. Oil, except Sulfur-chlorine-lead type.	SAE 90 SAE 80	Above +10°F. Below +10°F.

Heavy-duty engine oil. Make sure to specify heavy-duty type meeting MIL-L-2104B specifications.

Mineral gear oil inhibited against corrosion, oxidation and foam.

Extreme pressure oils under some conditions might form carbon deposits on gears, shafts, and bearings which will result in transfer case malfunctions and premature failure. It is suggested that if these conditions exist, and E.P. oil is being used, a change should be made to mineral gear oil or heavy-duty engine oil as recommended.

Off Highway & Mining Equipment		
Type	**Grade**	**Temperature**
MIL-L-2104B Heavy-Duty Engine Oil	SAE 50 SAE 30	Above +10°F. Below +10°F.

Special Recommendation

For extreme cold weather where temperature is consistently below 0°F.

MIL-L-2104B Heavy-Duty Engine Oil	SAE 20W	Below 0°F.

A. Removal from Vehicle

1. Remove fill and drain plugs and drain lubricant from transfer case.

2. Tag wires leading to monitor light and disconnect wires from transfer case.

3. Disconnect the air shift lines. Be sure to tag the lines for future identification (air shift cases only).

4. Disconnect mechanical linkage and tag for future identification (manual shift cases only).

5. Disconnect the speedometer cable if so equipped.

6. Disconnect drivelines at flanges or yokes.

7. Position a transmission jack of suitable capacity beneath the transfer case (400 lb. transfer case). Be sure that the transfer case is seated safely on the jack.

8. Disconnect transfer case mountings at rubber insulators. Since mountings vary, consult the vehicle service manual.

9. Check to ensure that all mountings and connections to the transfer case have been disconnected. Lower the transfer case to the floor and remove from under the vehicle.

B. Installation into Vehicle

1. Place transfer case on transmission jack and position jack and transfer case under the vehicle.

2. Raise transmission jack and position transfer case.

3. Connect transfer case mountings. Since mountings vary, consult the vehicle service manual.

4. Connect drivelines.

5. Connect shift cylinder air lines to air cylinders.

6. Connect mechanical shift linkage to shift shafts.

7. Connect monitor light lead wires to terminals.

8. Fill transfer case housing with appropriate lubricant to the correct level and install fill plug. If case is equipped with a PTO, prime the PTO oil pump. (Refer to Lubrication Section II especially paragraphs C and H).

9. Road test the vehicle by driving slowly with no load for the first few moments, then test at a higher speed listening for any problems.

10. Check transfer case for leaks around gaskets and seals.

IV. TRANSFER CASE DISASSEMBLY

Important: Read this section before starting the disassembly procedures.

A. General Precautions for Disassembly

1. After removing the transfer case from the vehicle, remove any mounting brackets still attached to the transfer case.

2. The outside of the unit should be cleaned before starting the disassembly. If steam cleaning, ensure that breather and air fittings are covered to prevent water from entering assembly.

3. Cleanliness provide a clean place to work. It is important that no dirt or foreign material enters the unit during repairs.

4. Position the transfer case horizontally, with the cover plate facing upwards. A specially fabricated stand is desirable.

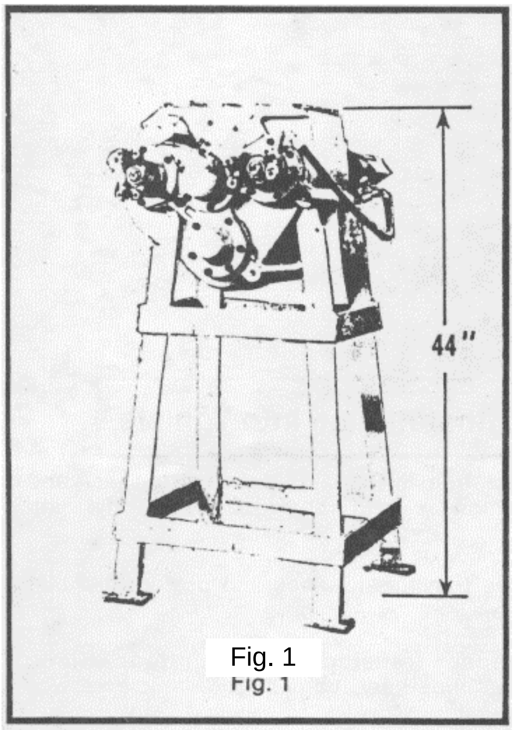


Fig. 1

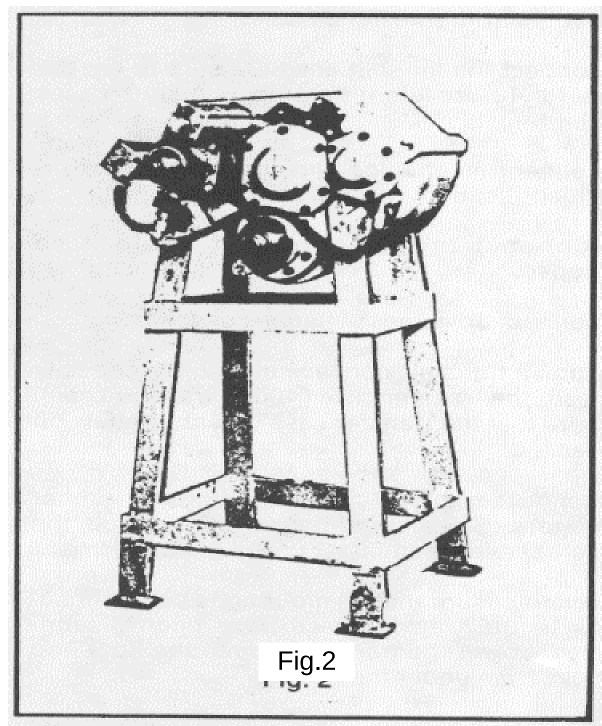


Fig.2

5. Assemblies - When disassembling the various assemblies, lay all parts on a clean bench in the same sequence as removed. This procedure will simplify reassembly and reduce the possibility of lost parts.

6. When necessary to apply a force to remove a part, use of a puller or press would be preferred. However, sometimes it may be necessary to use a soft hammer or mallet.

7. Bearings Carefully wash and relubricate all bearings as removed and protectively wrap until ready for use. Remove bearings with pullers designed for this purpose, or in a manner which will not damage those bearings that will be reused.

8. Follow each procedure closely in each section, making use of both text and pictures. Refer to exploded views located in Section VIII.

B. Preparation for Disassembly

1. Remove locknut and washer from each yoke or companion flange on the upper and lower shafts. Remove each companion flange or yoke from its shaft. A gear puller may be required for yoke or flange removal. Discard the used locknuts and replace with new nuts at assembly.

2. Remove bolts and lockwashers from cover plate. Tap cover plate to loosen and remove.

3. Remove hand brake assembly from lower shaft if case is so equipped.

C. Shift Shaft Disassembly

Air Shift Cases

1. Remove bolts and lockwashers from cover plate. Tap cover plate to loosen and remove.

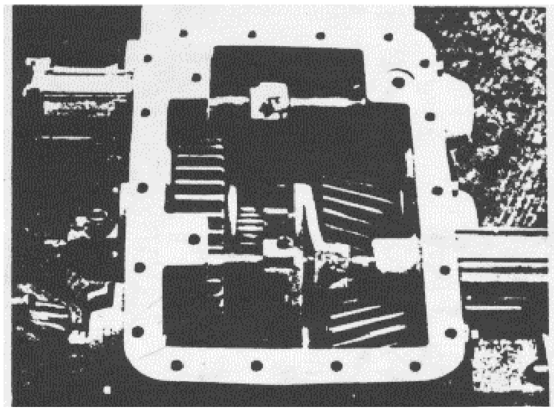


Fig. 3

2. Unscrew indicator light switch from the housing and remove spacer washers (Note amount of spacers removed). Remove plunger from inside housing using a magnet.

3. Cut the lockwires from the shift fork set screws on each shift fork. Remove the set screws from each shift fork.

4. Remove four bolts from the shift cylinder cap and remove cap from shift cylinder. Discard o-ring from cylinder cap, if replacement is necessary.

5. Remove shift cylinder tube from the shift cylinder adapter tube located in the housing, exposing piston (See fig. 4).

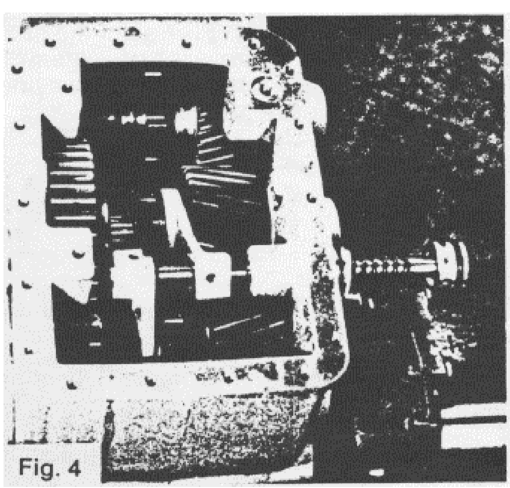


Fig. 4

6. Withdraw shift piston and shift shaft housing. As the shift shaft is withdrawn from the housing, remove each shift fork from the shaft.

7. Remove shift shaft spring and plastic stop ring from the shift shaft or from the shift cylinder adapter tube located in the housing.

8. Disassemble shift piston from the shift shaft (if necessary) and discard o-ring and felt wiper, if replacement is necessary.

9. Remove shift cylinder adapter tube from housing. Discard o-rings from the adapter, if replacement is necessary.

10. Remove shift forks from inside of housing.

Manual Shift Cases

1. Remove bolts and lockwashers from cover plate. Tap cover plate to loosen and remove (See fig. 3).

2. Unscrew indicator light switch from housing and remove spacer washers (Note the amount of spacers removed). Remove plunger from inside housing using a magnet.

3. Cut the lockwires from the shift fork set screws on each shift fork. Remove the set screws from each shift fork.

4. Remove each detent set screw from housing. Discard set screws and replace for reassembly. Remove each detent spring and each detent ball. Detent balls are removed by using a magnet.

5. Remove four bolts from each shift shaft seal carrier and remove seal carriers from housing.

6. Withdraw each shift shaft from housing. As the shift shaft is withdrawn from the housing, remove each shift fork from the shaft.

7. Remove seal from each seal carrier, if replacement is necessary.
8. Remove shift forks from inside of housing (Labeling the shift forks according to their position in the transfer case will aid in reassembly).

D. Input Shaft Disassembly

- Refer to Page PM2 and PM6

1. Remove the rear cover (Item 25) or, if so equipped, the PTO assembly.

2. Remove the front seal carrier (Item 5 or 6).

3. Use a brass rod or aluminum bar to protect the end of the shaft, tap threaded end enough to place the direct drive gear (Item 22) just against the inside back wall of the transfer case housing. Slide the underdrive pinion gear (Item 19) toward the front of the case. This will expose the split retaining ring (Item 20 See Fig. 5). Use a drift to drive the retaining ring from the shaft.

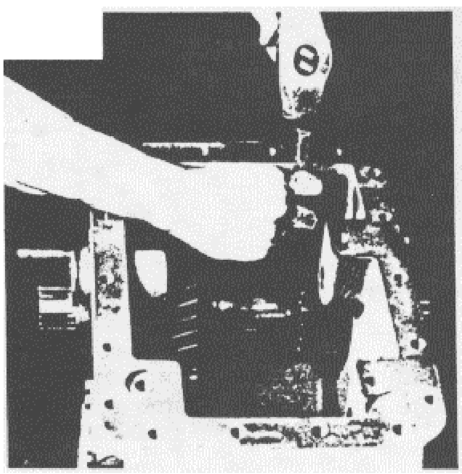


Fig. 5

4. Tap on the rear end of the shaft (See Fig. 6) and remove the shaft and the front bearing (Item 18) at the front of the case. Since the bearings (Item 11 and Item 24) are press fitted on the shaft, the shaft will not "just slip out".

5. Items 19,10, 22, 23 and 24 can now be removed from inside the case.

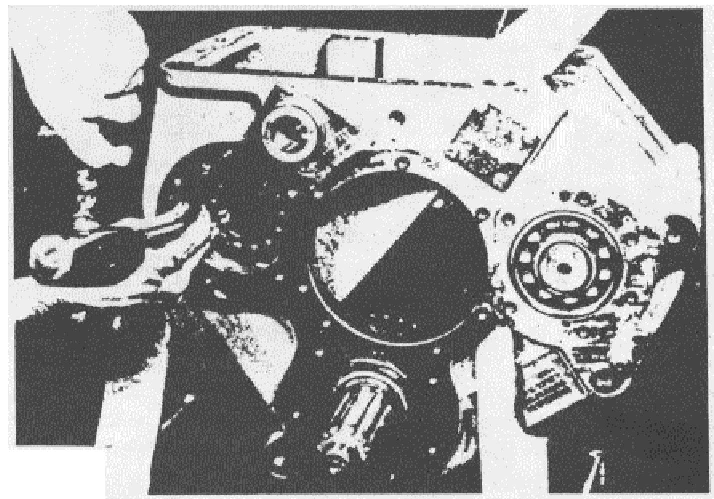


Fig. 6

E. Intermediate Shaft Removal

- Refer to Page PM2 and PM5.

1. Remove the capscrews from the front (Item 29) and rear (Item 45) caps. Remove the front (speedo) cap. Remove nut, speedo drive gear and spacer (Items 31, 32, and 33). Screw alignment tool (See Fig. 20 and 21) on to the end of the shaft. Place alignment studs (Fig. 28) in two holes of the rear cap (Item 45).

2. Drive on end of alignment tool until the rear cap is clear of the case housing. Remove the cap along with the outer race and roller assembly of Item 42.

3. Block between the underdrive gear (Item 36) and the rear of the case, continue driving the alignment tool until the shaft is free of the gear and the transfer case. Remove the gear (Item 36 with Item 35 still in place) and the spacer ring (Item 34) from the inside of the case.

F. Rear Output Shaft Removal

-Refer to Page PM2 and PM4

1. Remove the front (Item 17) and rear (Item 56 or 57) covers. Tap the output (rear) end of the shaft with a suitable tool. Remove bearing cup (Item 47) from the front of the case. Block between the gear (Item 50) and the case while continuing to drive the shaft out the front of the case.

2. Remove the gear, spacer ring (Item 51), bearing cone (Item 52) from inside the case.

3. Remove the split ring (Item 39) from the shaft only if it is being replaced.

G. Front Output Shaft Removal

- Refer to Page PM2 and PM3

1. Remove the seal carrier (Item 5) from the front of the case and the cap (Item 17) from the rear of the case.

2. Drive the shaft from the rear of the case until the front bearing (Item 8) is clear of the housing. Use a bearing puller or blocking between the bearing and the case to remove the bearing from the shaft.

3. The shaft and gear assembly may then be removed as shown in Fig. 7.

4. Remove the shaft from the gear in an arbor press.

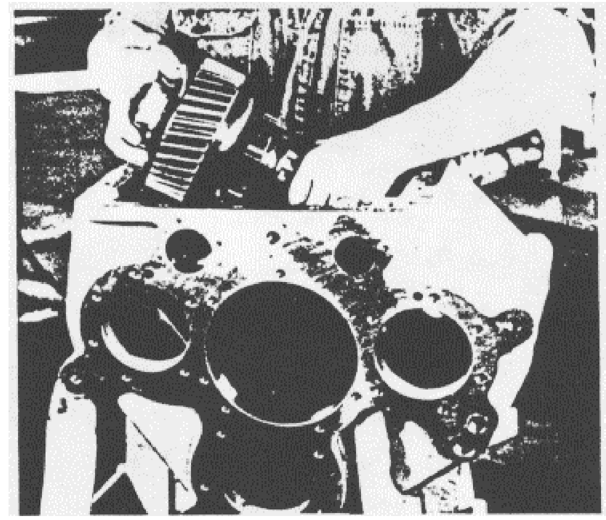


Fig. 7

V. CLEANING AND INSPECTION

A. Choice of Cleaning Methods

1. Steam may be used for external cleaning of completely assembled units. Care must be taken to ensure that water is kept out of the assembly by tightly closing breather caps and other openings.

2. Rough parts such as the housing, which are too large to conveniently clean with solvents, may be immersed in a hot solution tank containing a mild alkaline solution. Parts cleaned in hot solution tanks must be rinsed thoroughly to prevent damage by traces of alkaline material.

3. Parts with ground or polished surfaces, such as bearings, gears, and shafts, should be cleaned with emulsion cleaners or petroleum solvents. Alkaline hot solution tanks may damage the machined surfaces and such cleaning methods should be avoided.

B. Drying and Corrosion Inhibition

Soft, clean shop towels should be used to dry parts after cleaning. Compressed air may be used to clean inaccessible areas of large parts such as the housing. Bearings should not be spun dry with compressed air, as the lack of lubrication may cause damage to the mating surfaces.

Dried parts should be immediately coated with a light oil or corrosion inhibitor to prevent corrosion damage. Parts which are to be stored should also be wrapped in heavy waxed paper.

C. Inspection

Prior to reassembly, parts which are to be reused must be carefully inspected for signs of wear or damage. Replacement of such parts can prevent costly downtime at a future date.

All bearing surfaces, including ball bearing assemblies and roller bearing cups and cones, should be examined for pitting, wear, or overheating. Gears also may show pits, as well as scoring and broken teeth. Shafts may be nicked and marred, or may have damaged threads. Parts which show any signs of damage should be repaired or replaced.

Check all shift forks and slots in sliding clutches for extreme wear or discoloration from heat. Check engaging teeth of sliding clutches for partial engagement pattern.

VI. TRANSFER CASE ASSEMBLY

A. General Precautions

1. Read these instructions completely before starting reassembly. Refer to the appropriate exploded view (at the back of the manual). Assemble, adjust and check in the order shown.

2. Parts must be clean. Gasket surfaces must be free of old gasket material.

3. Select an area that will maintain the cleanliness of the parts and the assembly. Mount the case housing with the cover on top, cover surface in a horizontal plane. The cover side, the front and rear of the case should be accessible. The housing must be restrained. The cover should be approximately 44" above the floor. A sturdy work bench (preferably between 24" and 28" high) or a special stand should be used. The components of this transmission are heavy and positioning and installing them will be easier if the case is supported in the position indicated, refer to Fig. 1 and Fig. 2.

4. Lubricate housing bores, shaft spline and bearing mounting surfaces, sealing lips on oil seals with Lubriplate or equal. This is necessary to reduce the chances of galling or scoring and to provide initial lubrication for the oil seals. Use flanged end bearing drivers that apply equal force to both inner and outer races of bearings when installing bearings.

5. If tubular or sleeve type drivers are used, apply force to either inner or outer race or both as needed, depending on which will put the bearing in place without pushing through the bearing balls.

6. Installation of gaskets, bearing carriers, seal carriers and caps will be simplified if two guide studs are utilized (See Fig. 17). Guide studs may be made by cutting the head off a 7/16-14 bolt of about 2 inches in length. Point the non-threaded end and also slot the end to allow a screwdriver to be used, if necessary, for guide removal.

7. Universal joint yokes or companion flanges should be coated with Lubriplate on the seal operating area before installation. They should be tightened into place with the locknuts tightened to the proper torque before the cover is installed on the case and before the shim thickness is determined for both the input shaft and the rear output shaft. Universal joint yoke or companion flange retaining nuts can be tightened or loosened most easily when all components except shift forks are in place. At that time it is possible to engage both the direct drive and the underdrive clutch gears and effectively lock all the shafts against rotation.

8. Use Permatex Form-A-Gasket #2 or equal pliable setting sealant on bolt threads. If bolt threads are not sealed they will leak oil.

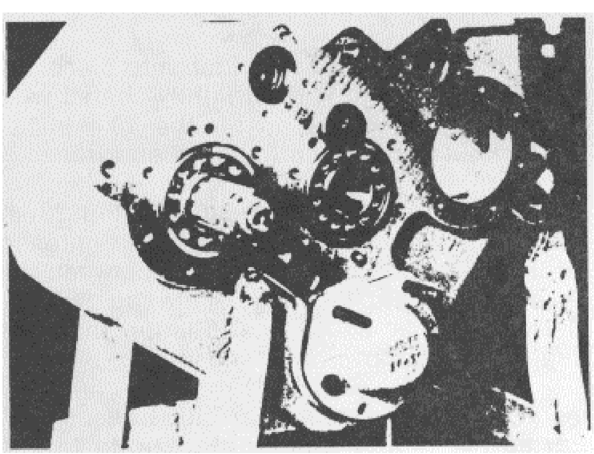


Fig. 8

B. Seal Carrier Assemblies

Seals supplied by Fabco are coated on the outside and should not be coated with Permatex before installation in their carriers. They should be coated on the sealing lip with Lubriplate. Installation can best be made with an arbor press. There are three or four input/output shaft seals and, if a mechanically shifted case, two or three shifter shaft seals, the quantity depending on whether the case does or does not have a PTO assembly installed.

C. Clutch Gear and Bearing Assemblies

Apply Lubriplate to the bearing bores of each of the three clutching gears. Press the bearings into place by applying force to the outer bearing race. Be sure to put the spacer ring in place before installing the second bearing in 35 tooth clutching gears (Item 22 on input shaft and Item 12 on front output shaft).

D. Assembly of Front Output Shaft

(See Page PM2 and Page PM3).

1. Insert plain end of front output shaft (Item 15) into the clutch gear assembly (Items 11, 12, and 13). Install the spacer ring (Item 14) and the rear bearing (Item 15) on the shaft. Slide the clutch (Item 10) onto the splined end of the shaft and engage its teeth with those in the clutch gear.

2. Lower this assembly into the cover opening of the case housing with the gear at the opposite side of the housing from the front output opening (See Fig. 9). Guide the threaded shaft end into the front output (See Fig. 10) opening and swing the gear end partially into the intermediate shaft rear opening. This will allow the other end of the shaft to enter the front output opening. Advance the shaft through the front output opening enough to permit backing the bearing into the rear case bearing bore (See Fig. 11).

3. Slip the front bearing (Item 8) over the end of the shaft and into the housing bore. The snap ring on the bearing should be on the outboard side of the bearing. Tap bearing into place (See Fig. 12).

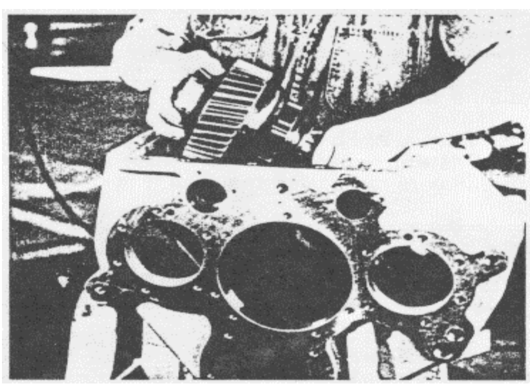


Fig. 9

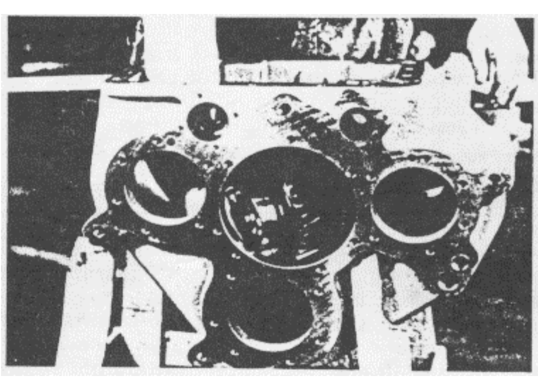


Fig. 10

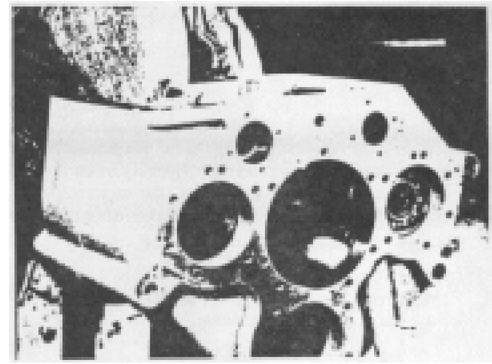


Fig. 11

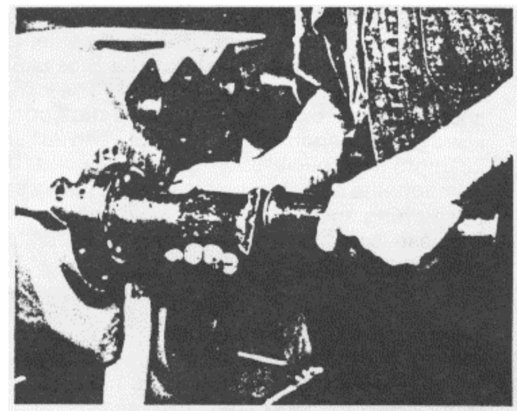


Fig. 12

4. Install the front output seal carrier gasket (Item 7) and the seal carrier (Item 5 with Item 4 in place). Permatex the bolt threads, tighten the bolts (Item 3) to the specified torque.

5. Coat the seal surface and splined hole of the front output yoke with Lubriplate.

6. Align the yoke on the shaft, tap into place. Install yoke retaining washer lightly coated with Permatex. Coated face next to the yoke. Install the locknut and tighten to specified torque.

7. Temporarily install the rear cap (See Fig. 13) in place with all six bolts, but with bolts tightened to 25 lbs. ft. torque. Measure gap between the case housing and the flange of the cap. Select a shim stack that is .010 to .015 larger than this dimension. Remove bolts and cap.

8. Install shims and cap, coat bolt threads with Permatex, install and tighten bolts to the specified torque.

9. Look inside the case and make certain the bearings are pulled tight against the shaft shoulders. Spin the shaft to be sure it rotates freely.

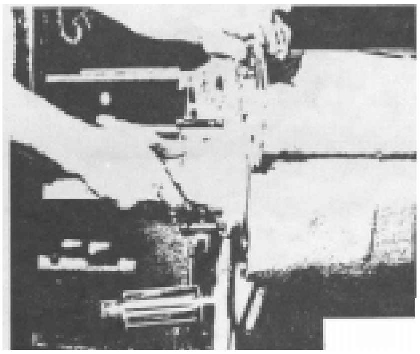


Fig. 13

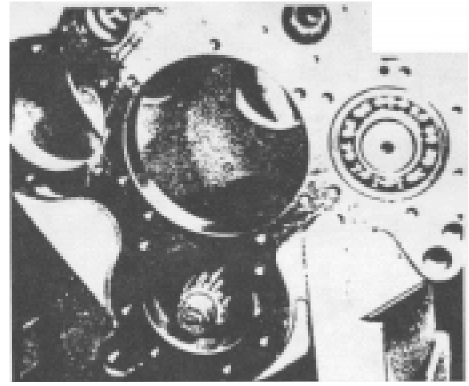


Fig. 14

E. Installation of Rear Output Shaft

(See Page PM2 and Page PM4).

1. Install split retaining ring (Item 39) on shaft (Item 49).
2. Press front bearing cone (Item 48) into place tight against shaft shoulder, install washer (Item 96) and locknut (Item 31). Torque locknut to specifications.
3. Coat the splined bore of the gear (Item 50) with Lubriplate.
4. Lower rear output gear (Item 50) into the case with flat face against the back wall of the case, the chamfered side toward the front of the case.
5. Coat the shaft splines with Lubriplate.
6. Insert the rear output shaft (Item 49 with Items 31, 46, and 39) through the proper hole in the front of the case and align the shaft splines with the gear splines (See Fig. 14). Use a brass or aluminum rod to protect the threaded shaft end and tap the shaft into the gear until the retaining ring (See Fig. 15) seats in the chamfer of the gear.

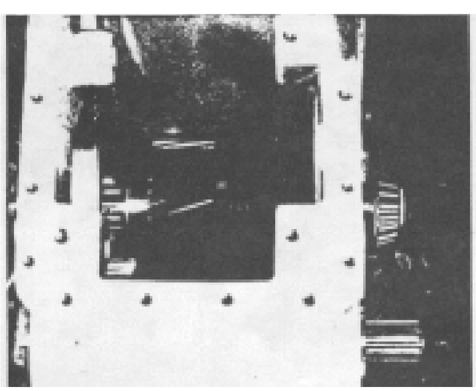


Fig. 15

7. Install the spacer ring (Item 51). Heat the rear bearing cone (Item 52) to approximately 250°. Use heat resistant gloves to handle the bearing (See Fig. 16). Install quickly tapping into place if necessary. Install the spacer tube (Item 54) on the shaft. The shaft can be moved toward the front of the case to allow a visual inspection of the mating parts.
8. Install both front (Item 47) AND REAR (Item 53) bearing cups allowing the rear cup to remain projecting from the case between 3/8 and ¼ inch.
9. Install the rear output carrier gasket (Item 55) and the rear output carrier (Item 40 or 57), including seal (Item 58). Dip the threaded portion of the 6 retaining bolts in Permatex before inserting and tightening them. Tighten the bolts to the specified torque.
10. Coat the seal surface and splined hole of the rear output companion flange with Lubriplate. Install the flange. Lightly coat one side of the retaining washer (Item 2) with Permatex. Place the washer on the shaft with the coated side next to the companion flange. Install the locknut. Tighten nut to the specified torque.

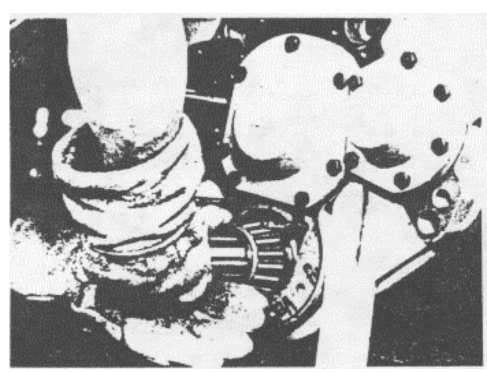


Fig. 16

11. Temporarily Install the rear output shaft front cover (See Fig. 17). Do not install shims. Tighten the mounting bolts to approximately 25 lb. ft. torque. Measure the gap between the rear output shaft front cover and the case housing with feeler gauges. Add . 010 to this figure and then select a shim pack that is equal to this calculated figure or up to . 005 larger. Install shim pack, Permatex threads of retaining bolts and tighten to the specified torque.

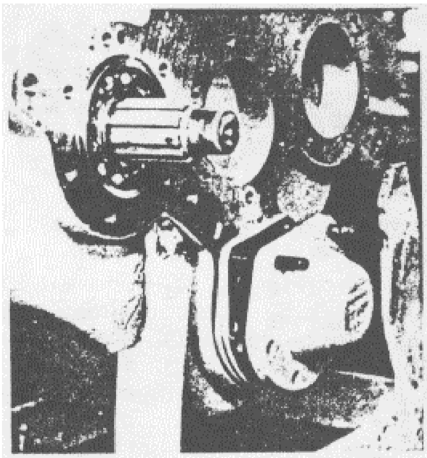


Fig. 17

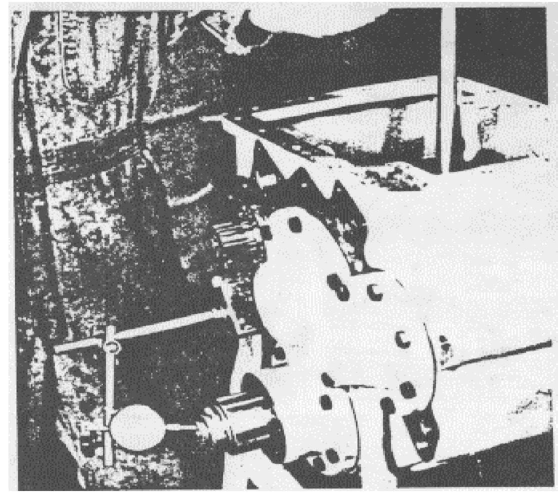


Fig. 18

12. Check rear output shaft end float between shaft and housing. End float should be between .010 and 015 inches (See Fig. 18).

F. Installation of the Intermediate Shaft

Refer to Page PM2 and Page PM5

1. Install the double row ball bearing In the housing bore opposite the large opening at the rear of the case. Retain the bearing with a bolt and washers as shown in Fig. 8.

2. Insert the alignment tool (866 271) which is shown in the accompanying sketch, Fig. 20, through the bearing with the tapped end toward the center of the case (See Fig. 21).

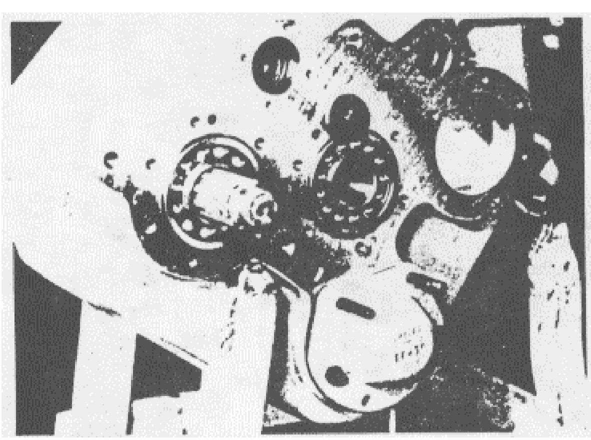


Fig. 19

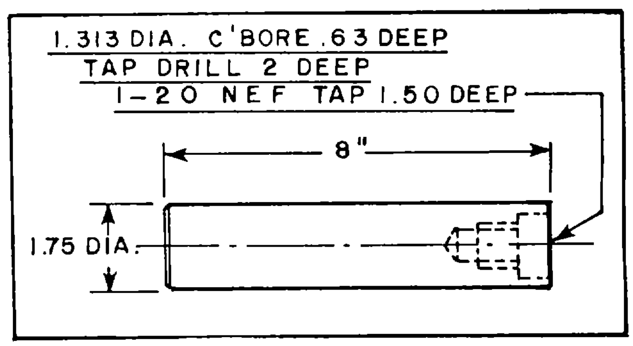


Fig. 20

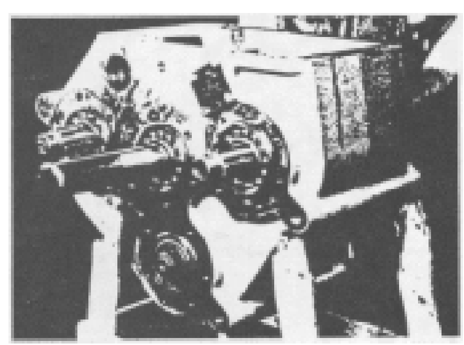


Fig. 21

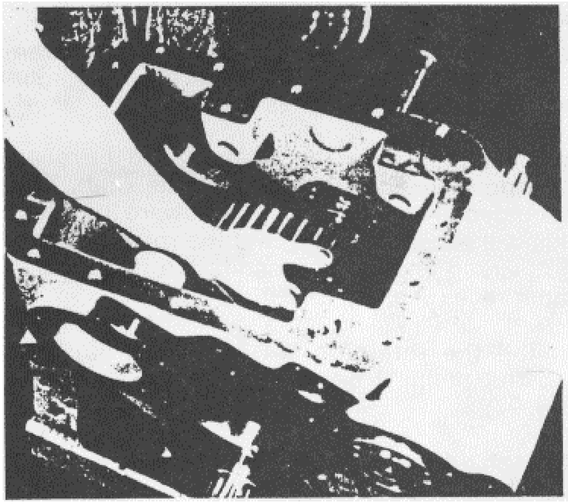


Fig. 22

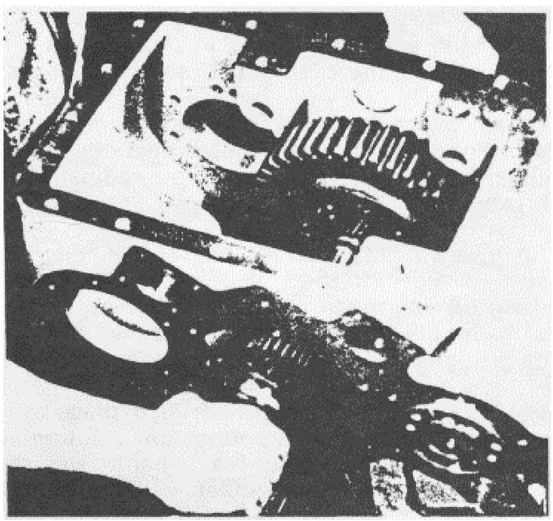


Fig. 23

3. Put the spacer washer (Item 34) in place on the alignment tool on the inside of the case. Put the underdrive driven gear and bearing assembly (Items 35 and 36) on the alignment tool (See Fig. 22). Insert the sliding clutch (Item 37) into the engaged position inside the underdrive driven gear.

4. Install the split retaining ring (Item 39) into the groove on the intermediate shaft (Item 38).

5. Insert the shaft through the large opening on the back of the case. Align with clutch splines and engage end of shaft in alignment tool. Screw tool and shaft together (See Fig. 23 and 24). Pull shaft through bearings. Remove alignment tool.

6. Install the spacer tube (Item 33), speedo gear (Item 32) and locknut (Item 31) on the end where the alignment tool was removed.

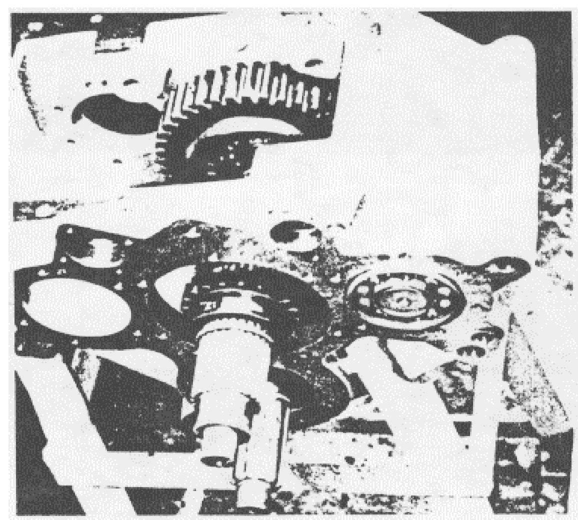


Fig. 24

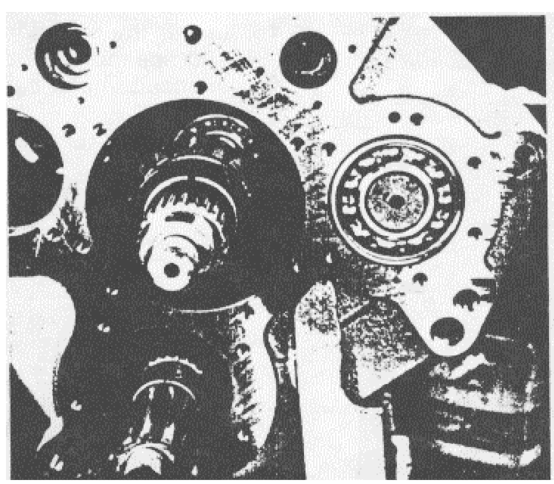


Fig. 25

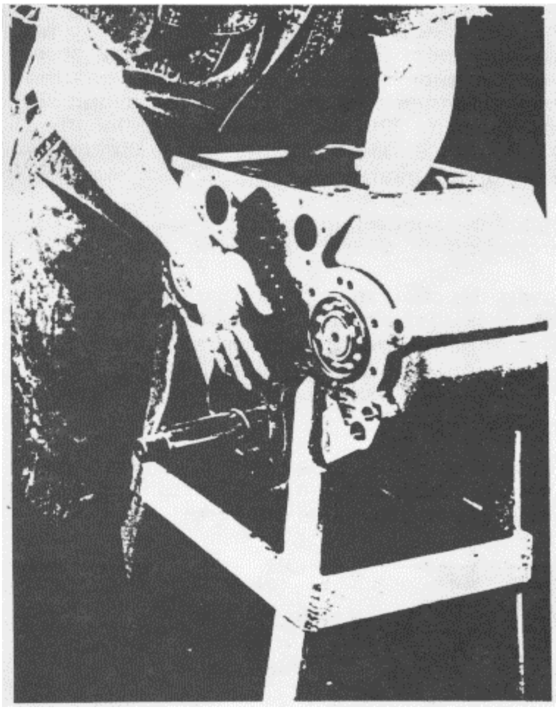


Fig. 26

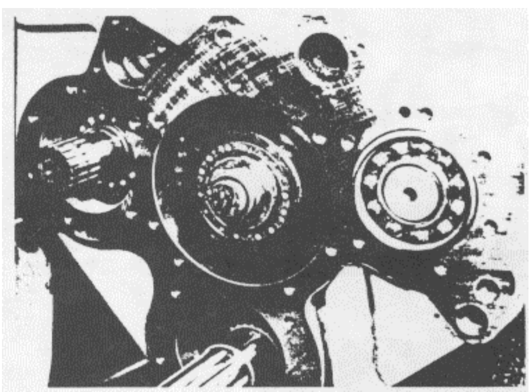


Fig. 27

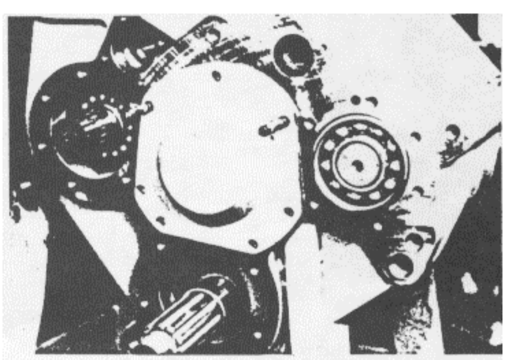


Fig. 28

7. Fit direct drive gear (Item 40) onto shaft with chamfered spline side toward the front of the case so the chamfer will fit up onto the split retaining ring (See Fig. 25 and Fig. 26).
8. Install the spacer washer (Item 41) and the roller bearing inner race (Item 42) on the shaft. The shoulder on the race should be toward the gear; this will allow the cover and the roller bearing outer race and roller assembly to fit over the inner race (See Fig. 27).
9. Install the retaining washer (Item 43) and locknut (Item 1) on the shaft (also shown in Fig. 27).
10. Tighten the nut on the speedometer gear end of the shaft to specifications while restraining the nut on the roller bearing end of the shaft.
11. The rear nut should be tightened to specifications while the front output yoke is restrained from turning.
12. Install the alignment studs in preparation for installation of the intermediate shaft rear cover.
13. Install cover gasket and cover pulling into place with Permatexed bolts. Tighten the bolts to the specified torque. Note: No end play adjustment is required.
14. Remove washers and bolt that were installed in step F1. Position the speedometer cap gasket (Item 30) over the front of the intermediate shaft with the oil return hole in the gasket and the case aligned.
15. Put the speedometer cap (Item 29) in place with the speedometer cable connection pointing in the same direction as it was when it was removed from the case. Attach with bolts that have been coated on their threads with Permatex; tighten bolts to correct torque.
16. Install the speedometer driven gear (Item 27) and speedometer driven gear sleeve (Item 26) in speedometer cap (See Fig. 29).
17. Install vent (Item 28) in speedometer cap.

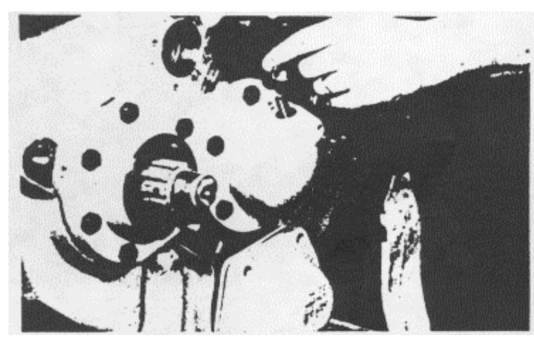


Fig. 29

G. Input Shaft Assembly

Refer to Page PM2 and Page PB6

1. Place the direct drive gear (Item 22), with bearings (Item 11) and spacer (Item 13) previously installed, in the housing against the back wall. The gear will mesh with the gear on the intermediate shaft and rest against the side wall of the case housing.

2. Insert the direct drive gear clutch (Item 10) in the direct drive gear (Item 22).

3. Insert the non-threaded end of the input shaft (Item 21) into the case housing from the front of the case. The shaft should project into the case between 3/4" and 2" and the shaft may rest against the bottom of the input bearing bore of the housing.

4. Slip the underdrive pinion gear (Item 19), with projecting face toward the shaft, onto the end of the shaft.

5. Slide input shaft through the underdrive pinion gear and into the direct drive sliding clutch (Item 10). When splines come into contact with the pinion gear, align splines, continue shaft installation, align splines with splines in underdrive gear sliding clutch (See Fig. 30), and again continue sliding shaft into place through the bearings (Item 11) and gear (Item 22). Slip spacer washer (Item 23) (. 06 thick) over rear end of input shaft.

6. Slide input shaft front (Item 18) and rear (Item 24) bearings onto the input shaft. Tap into the case housing bores and into place on the shaft with a suitable driver.

7. Push the input shaft as far to the rear of the case housing as it will go. Push the underdrive pinion gear toward the front of the case.

8. Install the split retaining ring (Item 20) in place in the half round groove that should now be exposed (See Fig. 31).

9 Install the input seal carrier gasket in place on the front of the case housing and install the input seal carrier seal assembly in place. Permatex the mounting screws and tighten to the specified torque (See Fig. 32).

10. Apply Lubriplate to the seal area and the splines of the input yoke. Install the yoke on the front of the input shaft. Put yoke retaining washer (Item 2) onto the shaft with the side that faces the input yoke lightly coated with Permatex. Install the input yoke retaining nut (Item 1) and tighten to specifications.

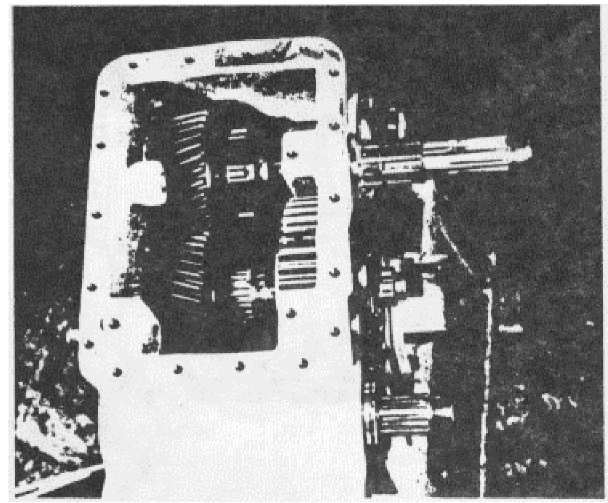


Fig. 30

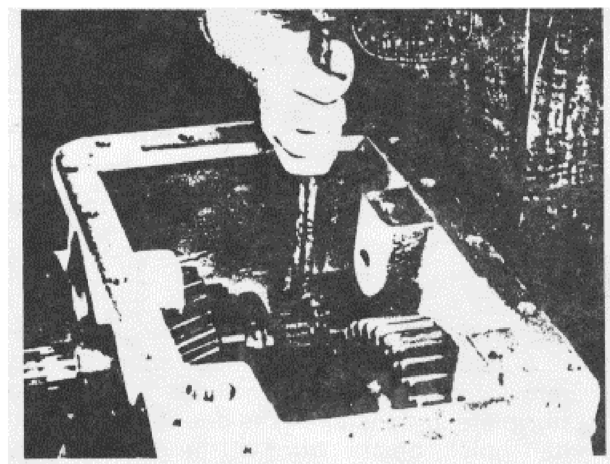


Fig. 31

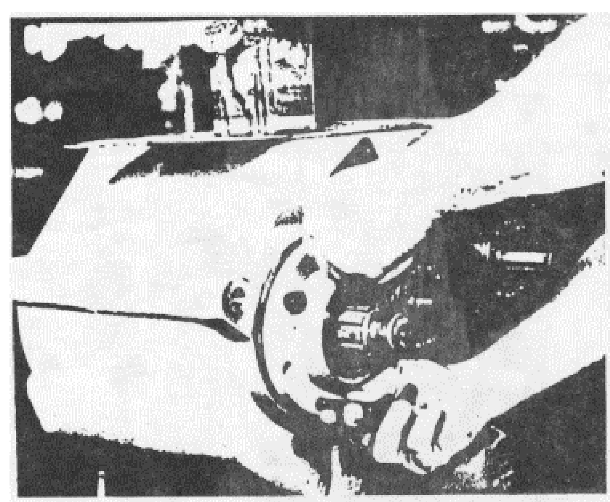


Fig. 32

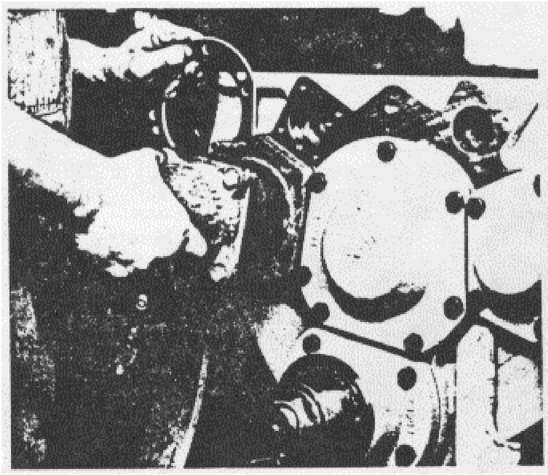


Fig. 33

11. Check fit between the split ring, underdrive pinion gear and the input shaft split ring groove.

12. Temporarily fasten the input shaft rear cover (Item 25) or the PTO assembly (See Section J for instructions on proper assembly of the PTO unit) in place with the mounting bolts torqued to 25 lb. in.

13. Use feeler gauges to measure the distance between the input shaft rear cap (or PTO assembly) and the case housing (See Fig. 33). Add .005" to this dimension and make a shim pack (Item 16) equal to the dimension thus calculated, or at a maximum, .005" larger than the calculated dimension.

14. Remove cap (or PTO), position shims, install cap (or PTO) attaching with screws that have been coated on the threads with Permatex. When installing the PTO unit, lightly coat under the heads of the two long cap screws.

H. Air Shifter Shaft Installation

Refer to Page PM7 and Page PM10

1. Install two o-rings (Item 3) into the grooves on the outside of the shift cylinder adapter tubes (Item 15). Coat adapters with gear lubricant or Lubriplate and install in the counterbored shift shaft holes, on the front of the case housing for the front drive shift and on the rear of the case housing for the high-underdrive or high neutral-underdrive-shift.

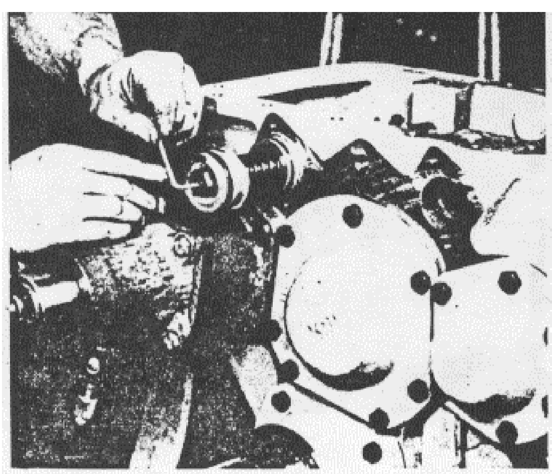


Fig. 34

2. Place a small (piston-to-shift-shaft sealing) o-ring (Item 11) over the threaded end of each shift shaft. The shallow counterbore in the piston (Item 9) should be toward the shoulder on the shift shaft; the deep counterbore provides room for the retaining nut. Install the piston retaining washers (Item 7) in the deep counterbore of the piston over the end of the shift shaft. Install piston retaining nut (Item 6 or 39). The nut used on the two groove shift shaft will be a special oversized nut (Item 39) if the transfer case is equipped with a PTO unit. Tighten nut to specification and tighten the nut locking set screw (Item 40) into the end of the special nut (Item 39-if case has a PTO unit). See Fig. 34.

3. Install a spring on the two main or longer shift shafts (Item 12 and 36) against the piston. Place a nylon stop ring (Item 13) over the end of each shift shaft.

4. Start the set screws into the shift forks. Put them in as far as possible and still allow the shift shaft to slide through the hole.

5. Install the 7 5/8" overall length underdrive shift fork (Item 35); it should fit into the groove of the underdrive shift clutch (on the intermediate shaft) the long hub section should be facing the rear of the case. Insert the two-groove shift shaft (Item 36) into the adaptor tube (Item 15) at the rear of the case housing (see 1 of this section). Slide end of shift shaft into underdrive shift fork (Item 35). Put 5 7/8" overall length shift fork (direct drive shift fork-Item 34) long hub toward front of the case, into the case with the forks in the groove in the direct drive clutch on the input shaft. Push shift shaft through this fork (See Fig. 35) and into the hole in the front wall of the case housing. Push on the end of the piston and compress the spring until the piston butts against the nylon stop ring and the adaptor. This will allow the set screw in the underdrive shift fork (Item 35) to be tightened into the proper groove on the shift shaft. Rotate both shift forks in either direction but in the same direction and, with the second fork in the proper place longitudinally, tighten set screws to specified torque and install the lockwire.

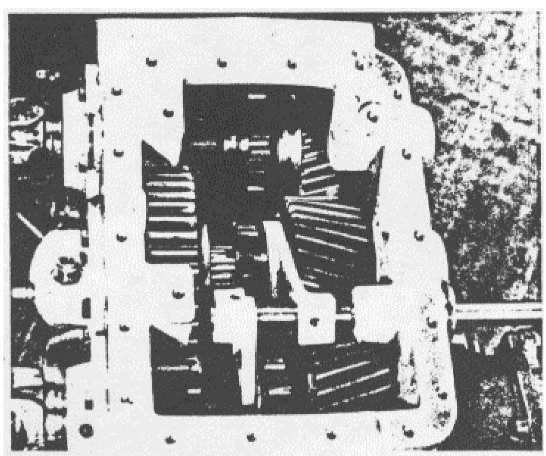


Fig. 35

6. Place the forks of the front drive shift fork (63/4" long overall Item 16) in the groove in the front drive clutch. Insert the front drive shift shaft (shaft with a single groove for the single shift fork Item 12), spring (Item 14) and nylon stop ring (Item 13) into the shift cylinder adapter previously installed in the front of the case housing. Pass the shaft (Item 12) through the shift fork and into the hole at the back of the case. Rotate the shaft to position the longitudinal groove away from the indicator light switch hole. Push on the piston enough to put the groove in the shaft under the set screw in the shift fork. Tighten the set screw to specifications and lockwire.
7. Soak the air shift piston felt washers (Item 10) with gear oil and install in the shallow groove of the piston (shift shaft side of piston). Install the shift piston o-ring (Item 8) in the deeper groove on the pistons (Item 9). Oil the rings.
8. The shift cylinder tubes are of differing lengths. The shortest tube (Item 4 which is 3-1/16" long) should be slipped over the front axle shift piston on the front of the case. The longest shift cylinder tube (Item 37 which is 3-13/16" long) should be fitted over the high-underdrive shift piston on the rear of the case.
9. If the transfer case is equipped with a PTO unit, the case must have a neutral position. Neutral is obtained through the use of a "piggy-back" cylinder mounted on the high-neutral cylinder (see Page PM7). This "piggy-back" cylinder, when actuated by properly connected air valves, provides this neutral position. The "piggy-back" cylinder consists of an adaptor (Item 41) into the grooves of which are installed oiled o-rings the adaptor may be put either end first (it is symmetrical) into the end of the high-neutral shift cylinder tube (See Fig. 36). The air inlet connection should point in the same direction as when removed. The "piggy-back" shift shaft piston assembly (with nylon stop ring over the end of the shaft) should now be inserted into the "piggy-back" adaptor. Slip the "piggy-back" shift cylinder tube (Item 43 which is 31/e" long) over this piston.
10. Insert o-rings in cylinder caps, install cylinder caps on cylinder tube open ends. Fasten to case housing with the appropriate bolts (Item 5 or 38) or studs (Item 44) and nuts (Item 45).
11. Install plunger (Item 22) into the front drive switch hole with the rounded end toward the shaft. Install the shift indicator switch (Item 20) with one copper washer (Item 21). Test switch operation with a circuit tester while shifting into and out of front drive. Add washers as necessary to make the switch operate properly.
12. Cover exposed end of shifter shafts with the gaskets (Item 23) and covers (Item 24) provided. Secure with 4 bolts (Item 25) each tightened to specifications.

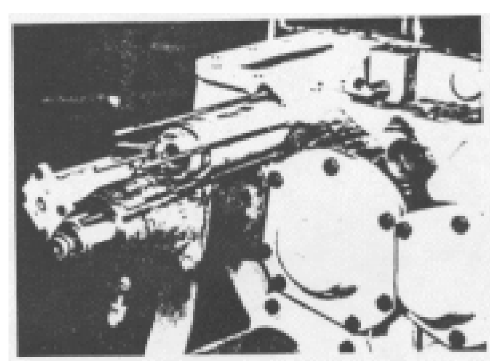


Fig. 36

I. Manual Shifter Shaft Installation

Refer to Page PM9 and Page PM11

1. There are three (each a different length) shift forks used in the TC-35 transfer case. Their lengths are indicated and their positions explained in the following paragraphs.

2. The shift shafts and shift forks must be installed after the drive shafts and gears are in place.

3. Insert the H-N-U shift shaft (Item 46 with 5 grooves) into the shift shaft hole next to the input shaft. Once the end of the shift shaft is visible through the cover opening, position the direct drive clutch shift fork (Item 34, which is 5t/s over-all in length) into the groove in the clutch on the input shaft with the long hub portion of the shift fork toward the shift shaft (front of the case). Slide the shift shaft through the shift fork just enough to clear the underdrive shift fork (Item 35, which is 7 5/8 long) that is to be installed at this time with hub end facing the rear of the case and with the forked end in the groove in the clutch on the intermediate shaft. Slide the shifter shaft through this fork and into the hole on the back of the case.

4. Align the underdrive shift fork (Item 35) retaining screw hole with the rear-most groove in the shift shaft. Install a shift fork set screw (Item 17) into this fork, position the flat face of the eye end of the shift shaft parallel to a line through the input and rear output shaft centerlines. This will put flat side in a vertical plane on the installed case. Tighten the set screw to specifications.

5. Slide the direct drive fork (Item 34) and clutch to position the fork's set screw hole over the next shifter shaft groove, install the set screw (Item 17). As the set screw is tightened, hold the two shift forks (both either clockwise or counter clockwise) to insure maintenance of fork-to-clutch clearance. Tighten both set screws to specification and safety wire.

6. Insert the front drive shift shaft (Item 29, or-three-groove shaft) into the hole closest to the, front drive output.

7. Slip the shift travel limiting tube (Item 33) onto the end of the front drive shift shaft as it emerges on the inside of the case.

8. Place the forks of the front drive shift fork (Item 16, which is 6 3/4" overall in length) in the groove in the front drive clutch.

9. Align hub end of shift fork with the front drive shift shaft which should be inserted through the fork and into the hole in the back of the case housing inner wall.

10. Rotate shaft so flat face of the eye end of the shaft is parallel to a line connecting the centerline of the input shaft with the rear output shaft centerline and with the flat or longitudinally grooved portion (on the rear end of the shift shaft) away from the front drive indicator switch hole. Failure to do this may result in improper switch operation.

11. Align the shift shaft rear most circumferential groove under the shift fork set screw hole. Install set screw (Item 17), tighten to specifications and lockwire.

12. Insert seal (Item 27) in cylinder caps (Item 28) with lip facing down. Install cylinder caps on front of case (over shift shaft ends) with the seal to the outside. Fasten to case housing with the appropriate bolts (Item 26).

13. Install plunger (Item 22) into the front drive switch hole with the rounded end toward the shaft. Install the shift indicator switch (Item 20) with one copper washer (Item 21). Test switch operation with a circuit tester while shifting into and out of front drive. Add washers as necessary to make the switch operate properly.

14. Cover exposed end of shifter shafts with the gaskets (Item 23) and covers (Item 24) provided. Secure with 4 bolts (Item 25) each tightened to specifications.

15. Insert each detent ball and detent spring into proper bore in top of housing. Install each detent set screw and tighten until it takes a force of 25-40 lbs. to push the shift shaft out of detent.

J. Assembly of PTO Unit

(On Cases so Equipped)

Refer to Illustration on Page PM12

1. Put shift fork (Item 59) into housing (Item 61) with the chamfered side of the shift shaft hole toward the two opening ends of the housing, put clutch collar (Item 60) into the housing (with the chamfered end pointing as indicated and into the forked section of the shift fork.

2. Install the shift shaft (Item 49 on Page PM13) or (Item 53 on Page PM14). Install locknut (Item 47 on Page PM13 or PM14). Restrain nut with a box wrench and turn the shaft with an open end wrench.

3. Press bearing cones (Item 64) onto shaft (item 65). Press seal (item 69) into bearing carrier (Item 67). Press one cup (Item 63) into carrier.

4. Install shaft (Item 65) with bearing cones into the carrier sub-assembly and install the second bearing cup (Item 63).

5. Install the bearing carrier shaft assembly onto the housing (Item 61) with the shaft passing into the shift collar. Temporarily bolt the carrier to the housing. With bolts (Item 68) tightened to 15 ft. lbs. , measure gap between the parts. Select a shim stack that measures .005 to .010 larger than the gap measurement.

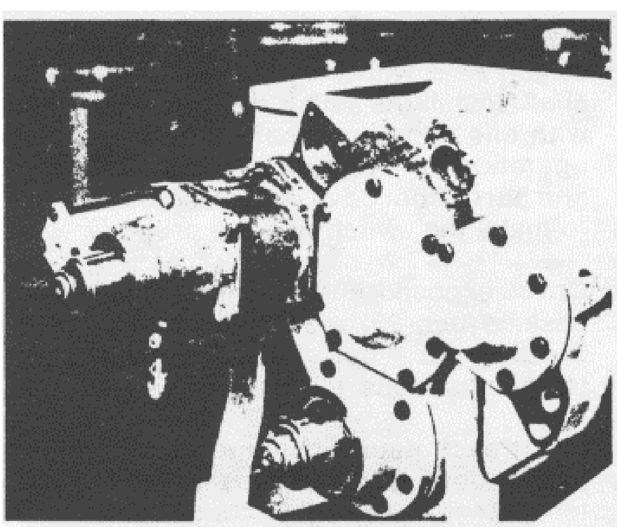
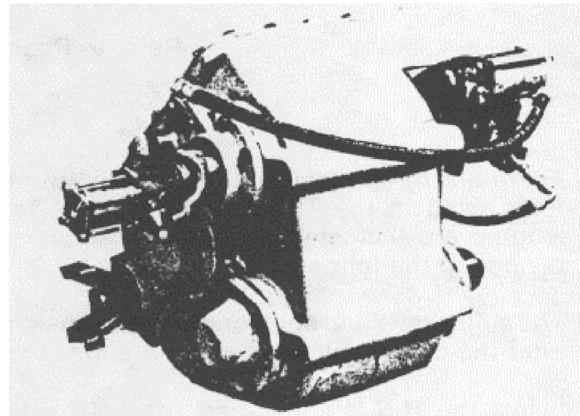


Fig. 37



6. Remove bolts (Item 68), install shim, reinstall bolts with Permatex on their threads. Tighten to the specified torque. *Skip to J8 if case is equipped with an air operated PTO shift.*

7. Refer to Page PM14. Install the manual shift linkage as follows:

   a. Oil and install o-ring (Item 3) on seal carrier (Item 52). Install seal (Item 27). Lubricate inside of seal carrier and the seal with Lubriplate or transfer case oil.

   b. Fit seal carrier onto the shift shaft and into the shift opening on the PTO housing. The detent ball opening should be facing in the same general direction as the indicator light switch hole. Install the four bolts (Item 54), tightening to specifications.

   c. Put nut (Item 56) on eye (Item 57). Install (Item 57) onto end of shift shaft (Item 53). Install detent ball (Item 32), detent spring (Item 31) and set screw (Item 30). Tighten set screw until it takes a force of 25-40 lbs. to push the shift shaft out of detent.

   d. Position lever (Item 58) on eye (Item 57) with pin (Item 59) washers (Item 60) and cotter pin installed as illustrated on the oil line and fitting illustration (Page PM15). Install link (Item 55) as illustrated. Check shift action before tightening lock nut (Item 56). The eye should be adjusted as necessary to make the lever angles approximately even in the engaged and disengaged positions. *Skip section J8 and proceed with step J9.*

8. Refer to Page PM13, install the Air Operated PTO Shift as follows: Oil o-rings (Item 3), install on adaptor (Item 50). Place adaptor over shift shaft and into the PTO housing with the counterbored end outboard. Place o-ring (Item 11) carefully over the end of the shift shaft. Position spring (Item 51) over the shift shaft and into the adaptor (Item 50). Place bump ring (Item 13) over spring (Item 51). Move shift collar and restrain to make shift shaft project as far as possible. Install piston (Item 9), washer (Item 7) and nut (Item 6). Tighten nut to specified torque. Install felt ring (Item 10) (after soaking in transfer case lubricant) in wide groove of piston. Oil o-ring (Item 8) and install in the outboard groove of the piston. Install cylinder cap. Slip the shift cylinder tube (Item 43) (31/8" long) over the piston, onto the adapter. Fit the shift cylinder cap into place and install the four capscrews that retain the assembly to the PTO unit, tighten to the specified torque.

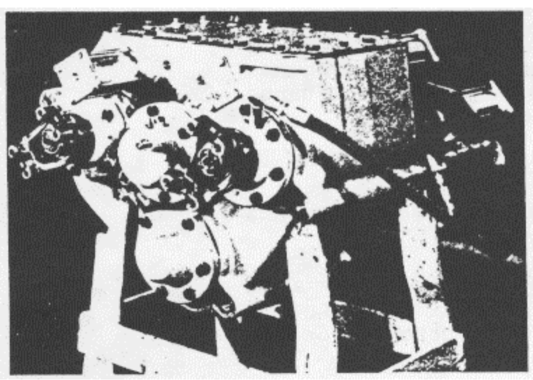


Fig. 38

9. Install the indicator light switch (Item 20) with same washers (Item 21) as were removed during disassembly. Check switch operation with a continuity tester (and air pressure applied to the shift cylinder, if so equipped).
10. Install the blanking sleeve (Item 70) on the PTO output to seal the output shaft section of the PTO, if a yoke is not to be installed immediately.
11. The PTO unit includes an oil pump that consists of items 73 through item 80 on Page PM12. Also refer to Fig. 39. The piston (Item 73) is driven by the eccentric section of shaft (Item 65). A check valve (Item 74) is retained within the piston by a spring type retaining ring (Item 75). This check valve must be installed with the free flow direction and arrow direction pointing toward the PTO shaft. This allows a small portion of the oil pump output to be directed onto the shaft's eccentric surface. Screw nut (Item 77) onto cylinder (Item 79) with nylon portion pointing away from the hexagon section of the cylinder. Coat the piston, check valve and retaining ring assembly with transfer case lubricant. Put the spring (Item 76) into the counterbore of the piston and then put the cylinder over the spring and piston. Push the piston into the cylinder until the end of the cylinder is just even with the port in the side of the cylinder. The piston should move freely without binding. Screw the cylinder into the PTO bearing carrier (See Fig. 39). Rotate the PTO shaft to place the high point

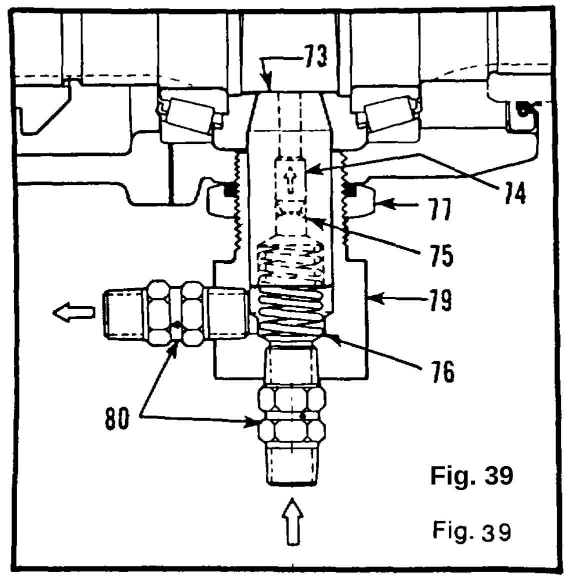


Fig. 39

Fig. 39

of the cam under the piston, screw the cylinder in until the outer end of piston is visible short of the cylinder side port. Rotate the PTO shaft to verify that it is indeed on the high point of the cam. Screw the cylinder in until the outer end of the piston is just even with the side port; unscrew cylinder at least one turn, but not more than one and one half turns; tighten lock nut against the PTO bearing carrier with one side port of the cylinder pointing in the direction shown on Page PM15. Use pipe dope on all pipe threaded fittings. Screw check valves (Item 80) into place in the cylinder. The inlet check valve should be installed (with the arrow pointing into cylinder) in the end of the cylinder. The outlet valve should have the arrow pointing away from the cylinder and should be in the position shown on Page PM15 to allow the hose (Item 4) to be used to connect the pump to fitting (Item 5) at the front of the case.

8. Refer to section VI G, paragraph 12 for installation of the PTO unit on the transfer case. Also See Fig. 33 and Fig. 37.
9. Refer to Page 2 and Page PM15 for the proper installation of the oil lines. Also see Fig. 1, 2, and 38.
10. Check oil flow out of oil pump upon installation. Refer to Section III B of this manual.

K. Final Assembly

Refer to Page PM16

1. Rotate all shafts with shift shafts shifted to all positions. Observe through cover opening. Make sure there are no loose tools, bolts or other foreign objects in the assembly.

2. Install cover gasket and cover, coat bolt threads with Permatex, use a lockwasher on each bolt and tighten to the specified torque.

3. If the transfer case was equipped with a parking brake, remove output flange (installed in step E10) and reinstall brake assembly, output flange and drum.

4. Install drain and fill plugs.

5. Refer to Section "J" if case is equipped with a PTO unit.

6. Attach all mounting brackets before reinstalling case in the truck. *Refer to Section III B of this manual for installation instructions, to Section II for lubricant instructions.*

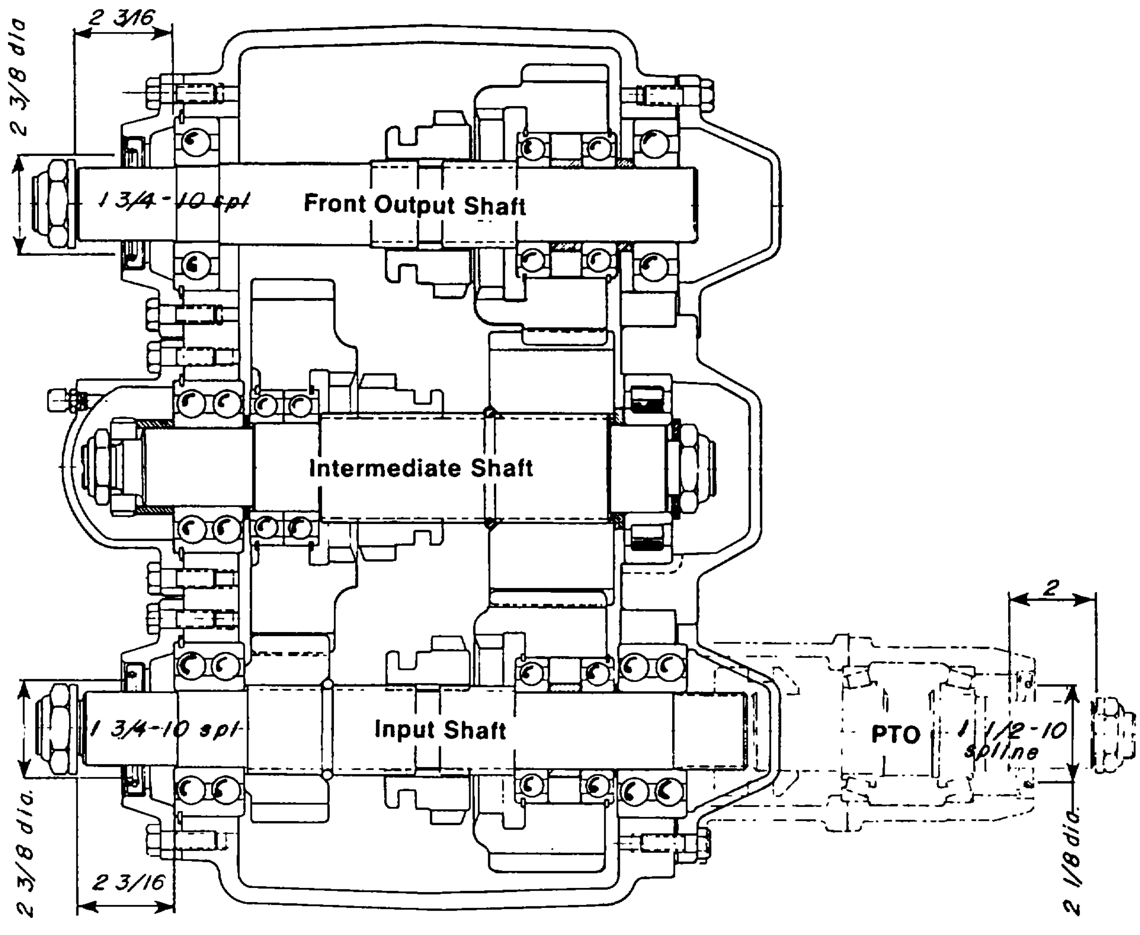
VII. TORQUE SPECIFICATIONS

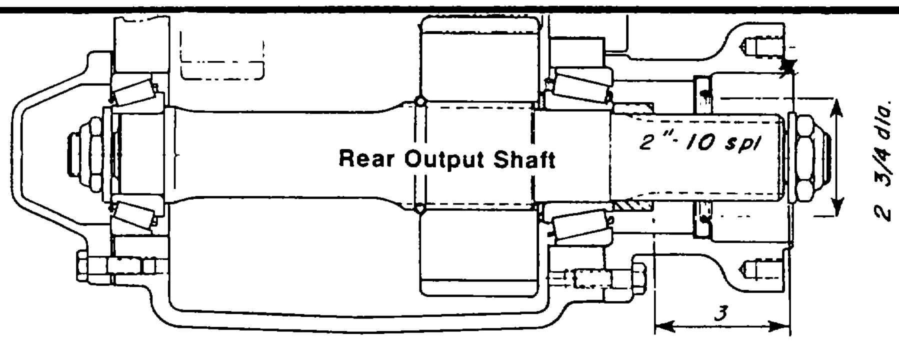
DESCRIPTION	LOCATION	FT. LBS. TORQUE	SIZE
A. FRONT OUTPUT SHAFT			
Front Seal Carrier Bolts }		45	7/16-14
Rear Cap Bolts			
Front Output Yoke Locknut		300	1 1/4-18
B. REAR OUTPUT SHAFT			
Front Cap Bolts }			
Rear Carrier Bolts		45	7/16-14
Parking Brake Carrier Bolts			
Front Bearing Retaining Nut		175	1-20
Rear Yoke or Flange Locknut		300	1 1/4-18
C. INTERMEDIATE SHAFT			
Speedo Cap Mounting Bolts }		45	7
Roller Bearing Carrier Bolts			
Front Bearing and Speedo Gear Locknut		175	1-20
Rear Bearing Locknut		300	1 1/4-18
D. INPUT SHAFT			
Front Seal Carrier Bolts }			
Rear Cap Bolts		45	7/16-14
PTO Mounting Bolts			
Input Yoke Retaining Locknut		300	1 1/4-18
E. PTO UNIT			
Mounting Bolts to Case Housing		45	7/16-14
Bearing & Seal Carrier to PTO Housing		30	3/8-16
PTO Shift Shaft Fork Retaining Nut 30		3/8-24	
Manual Shift Seal Carrier Mounting }			
Air Shift Cylinder Mounting		15	1/4-20
Set Screw, Detent Ball		See Section VI-J Paragraph 7	
Output Yoke Locknut		175	1-20
F. SHIFT SHAFTS			
Shift Fork Set Screws		25	3/8-24
Set Screw, Detent Balls		See Section ZII Paragraph 15	
Seal Carrier & Cap Mounting Bolts 15		1/4-20	
Air Cylinder Bolts, Studs or Nuts 15		1/4-20	
Air Shift Piston Retainer Nut		30	3/8-24
G. COVER			
Cover Mounting Bolts		45	7/16-14

TC-35

PARTS MANUAL INDEX

TC-35
Shafts, Gears, Bearings, Spacers, Seals
Carriers and Caps





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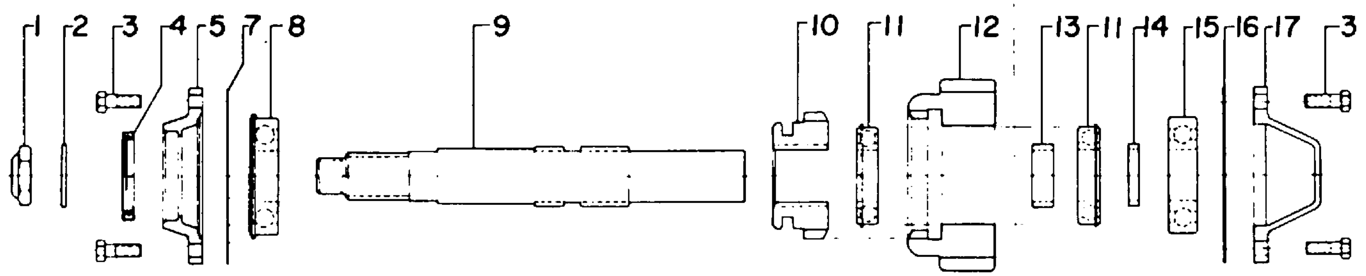
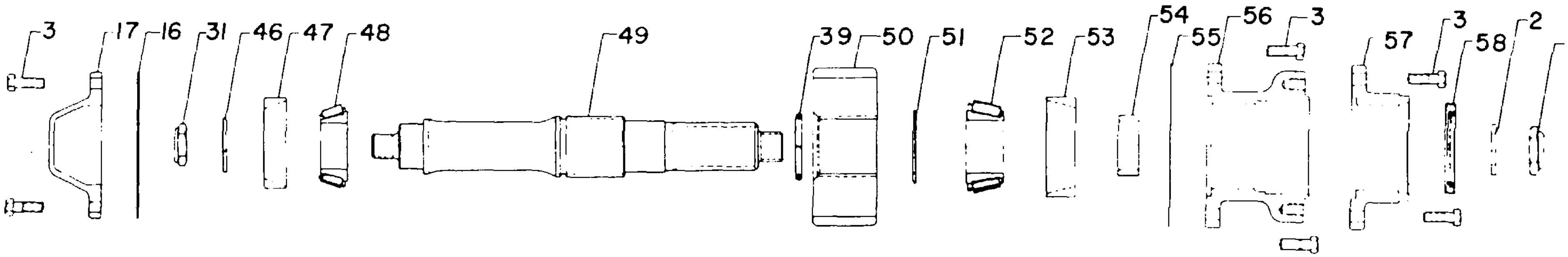
FRONT OUTPUT SHAFT



ITEM	PART NO.	DESCRIPTION	QUANTITY
1	688 633	Nut, 11/4-18 Nylon Lock	1
2	927 775 004	Washer, 15/16-10 I.D.	1
3	265 238	Capscrew, 7/16-14 x 1 1/4	12
4	732 246	Seal	1
5	237 435	Carrier, Oil Seal	1
7	427 339	Gasket	1
8	232 252	Bearing	1
9	769 277	Shaft, Front Output	1
10	432 236	Clutch	1

ITEM	PART NO.	DESCRIPTION	QUANTITY
11	232 234	Bearing	2
12	432 237	Gear	1
13	736 235	Spacer Ring	1
14	736 948	Spacer Ring	1
15	232 229	Bearing	1
16	7441322	Shim, Coral .031	AIR
	7442322	Shim, Pink .016	*A'R*
	7443322	Shim, Blue .005	AKR
	17235 484	Cover, Fos Rear, Ros Front	1



ITEM	PART NO.	DESCRIPTION	QUANTITY
1	688 633	Nut, 1 1/4-18 Nylon Lock	1
2	927 775 004	Washer, 15/16-10 I.0.	1
3	265 238	Capscrew, 7 1/16-14 x 1 1/4	12
			12
16	7441322	Shim, Coral 031	AIR
	7442322	Shim, Pink .016	*AIR*
	7443322	Shim, Blue .005	A/R
17	235 484	Cover, Ros Front	1
31	688 634	Nut. 1-20 Nylon Lock	1
39	762 292	Ring, Split	1
46	927 775 001	Washer, 1 1/16 D.0.	1
47	233 456	Bearing Cup	1

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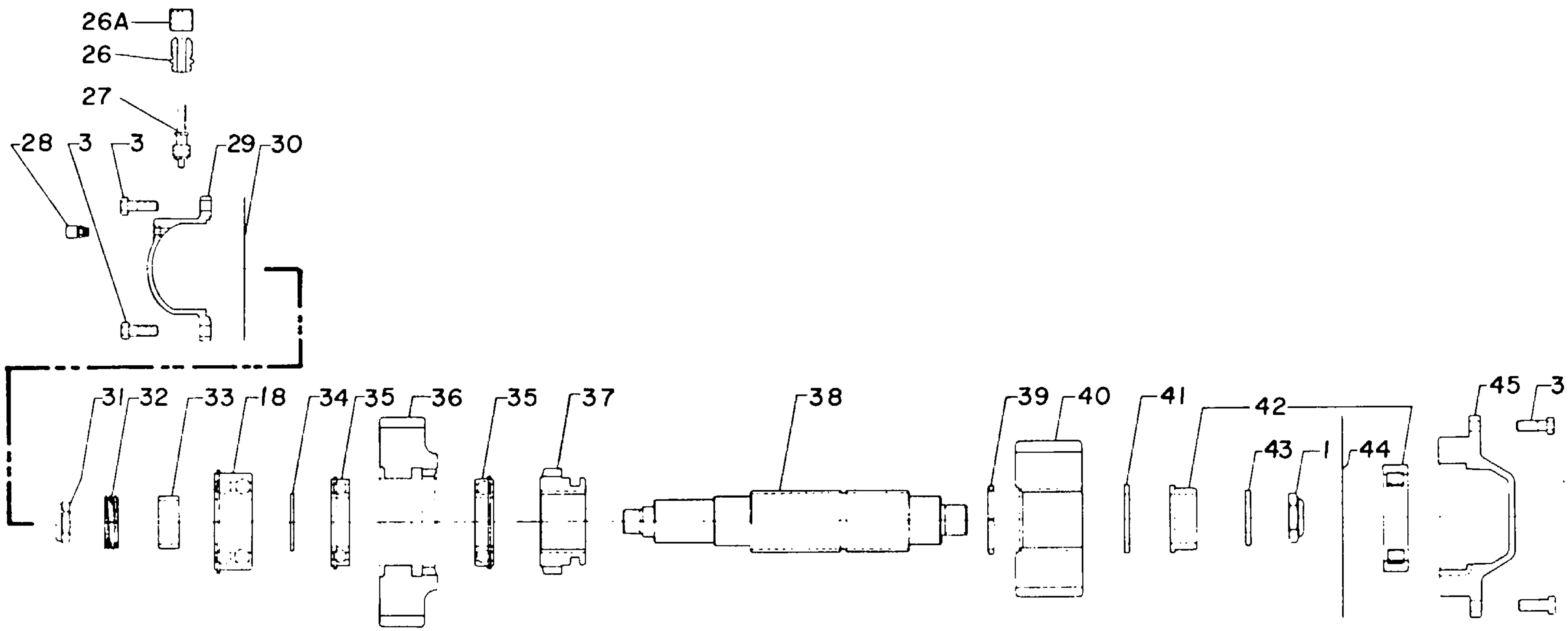
ITEM	PART NO.	DESCRIPTION	QUANTITY
48	233 455	Bearing Cone	1
49	769 276	Shaft, Rear Output	1
50	432 554	Gear, Rear Output	1
51	927 758	Washer, Bearing Spacer	1
52	233 457	Bearing Cone	1
53	233 458	Bearing Cup	1
54	736 949	Ring, Spacer	1
55	427 466	Gasket, Rear Output Carrier	1
56	237 432	Carrier, Rear Output Shaft (Case w/ P. Brake)	1
57	237 434	Carrier, Rear Output Shaft (Case w/o P. Brake)	1
58	732 372	Seal, Rear Output Shaft	1

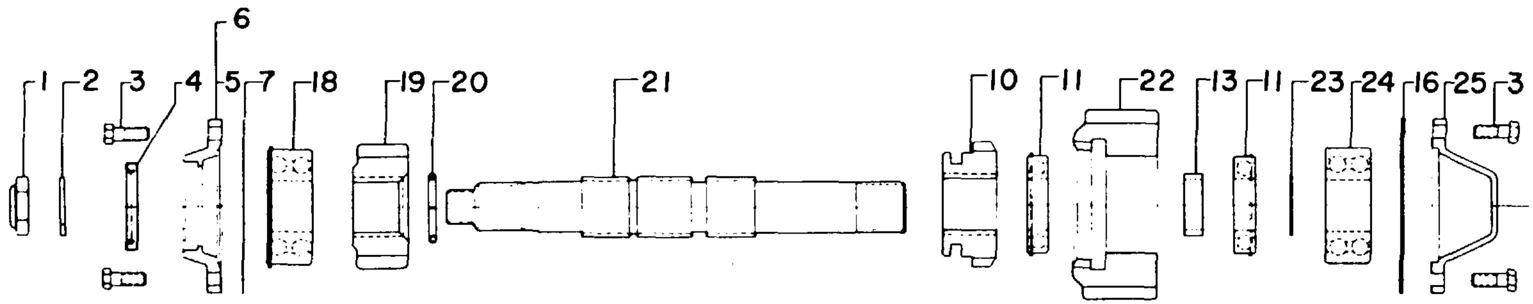
REAR OUTPUT SHAFT

INTERMEDIATE SHAFT



ITEM	PART NO	DESCRIPTION	QUANTITY
1	688 633	Nut, 1 1/4-18 Nylon Lock	1
3	265 238	Capscrew, 7/16-14 x 11/4	13
26	883 473	Connector, Speedo	1
26A	235 529	Cap, Plastic	1
27	432 235	Gear, Speedo Driven	1
28	836 222	Vent	1
29	235 446	Cap, Speedo	1
30	427 338	Gasket	1
31	688 634	Nut, 1-20 Nylon Lock	1
32	432 234	Gear, Speedo Drive	1
33	736 229	Ring, Speedo Drive Gear Spacer	1
34	927 756	Washer, Brg Spacer	1

ITEM	PART NO.	DESCRIPTION	QUANTITY
35	232 388	Bearing	2
36	432 559	Gear, Underdrive 41T	1
37	432 556	Clutch Gear, Intermediate Shaft	1
38	769 275	Shaft, Intermediate	1
39	762 292	Ring, Spilt	1
40	432 558	Gear, 34T	1
41	927 757	Washer, Intermediate Shaft Spacer	1
42	233 454	Bearing, Roller (Complete)	1
43	927 775 003	Washer, 1 1/4 ID	1
44	427 465	Gasket, Intermediate Shaft Rear	1
45	235 487	Cap, Intermediate Shaft Rear	1



ITEM	PART NO.	DESCRIPTION	QUANTITY
1	688 633	Nut, 11/4-18 Nylon Lock	1
2	927 775 004	Washer, 15/16-10 I.D.	1
3	265 23	8Capscrew, 7/16-14 x 11/4(Cases w/PTO)	10
		(Cases w/o PTO)	12
4	732 246	Seal	1
5	237 435	Carrier, Oil Seal(Cases w/o PTO)	1
6	237 443	Carrier w/Oil Line Connection (Cases w/PTO)	1
7	427 339	Gasket	1
10	432 236	Clutch	1
11	232 234	Bearing	2
13	736 235	Spacer Ring	1

ITEM	PART NO.	DESCRIPTION	QUANTITY
16	7441322	Shim, Coral .031	A/R
	7442322	Shim, Pink .016	AIR
	7443322	Shim, Blue .005	A/R
18	232 245	Bearing	1
19	432 478	Gear 19T	1
20	736 833	Split Ring	1
21	769 279	Shaft, Input	1
22	432 557	Gear, 35T w/lnt. Clutch	1
23	927 224	Washer	1
24	232 238	Bearing	1
25	235 485	Cap, Input Shaft Rear(w/o PTO)	1

INPUT SHAFT

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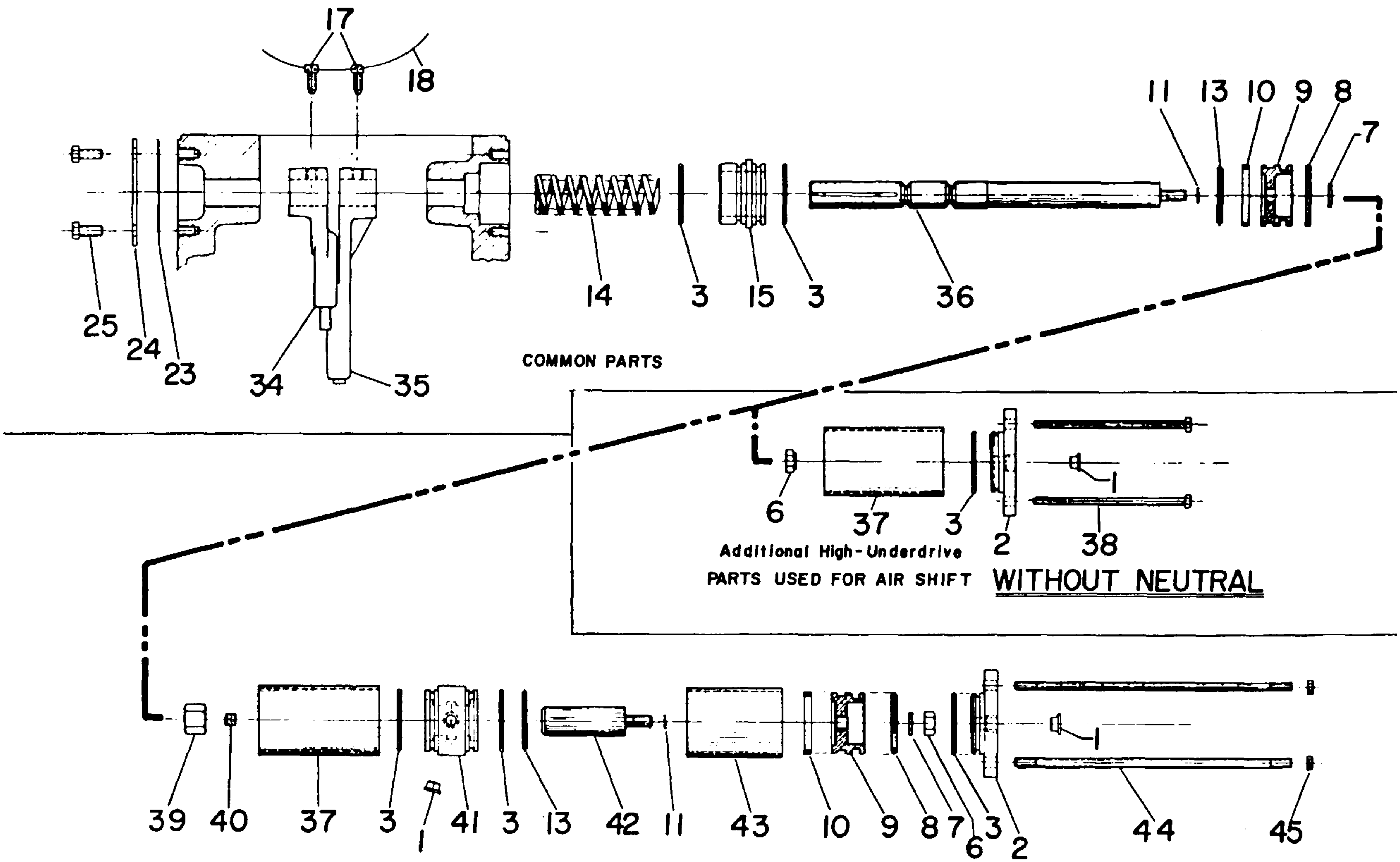
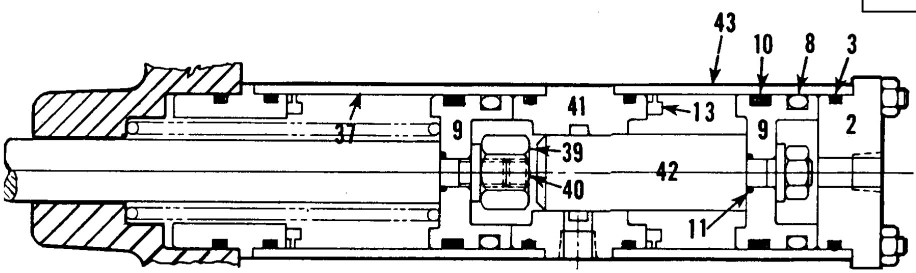


ADDITIONAL HIGH-NEUTRAL-UNDERDRIVE PARTS WITH NEUTRAL (Required with PTO and Shift)

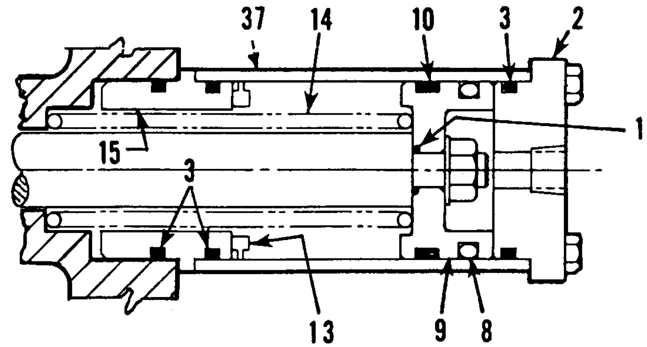
H-N-U Air Shift

ITEM	PART NO.	DESCRIPTION	QUANTITY
1	758 338	Plastic Plug	2
2	235 372	Cap, Air Shift Cyl.	1
3	675 224	O-Ring, Air Shift Cap & Adaptor	5
6	688 464	Nut, Shift Piston	1
7	927 643	Washer, Shift Piston	2
8	675 326	O-Ring, Shift Piston	2
9	753 232	Piston, Shift	2
10	339 223	Felt Ring, Shift Piston	2
11	782 288	O-Ring, Shift Shat	2
13	736 747	Ring, Nylon Bump	2
14	777 485	Spring, Air Shift Return	1
15	883 479	Adaptor, Air Shift Cyl.	1
17	724 222	Set Screw	2
18	947 223	Lockwire	2
23	427 399	Gasket, Shift Shaft Cap	1
24	235 372	Cap, Shift Shaft	1
25	265 343	Capscrew, 1/4-20 x 1/2	4
34	367 259	Fork, Direct Drive Shift	1
35	367 268	Fork, Under Drive Shift	1
36	742 877	Shaft, H-N-U Air Shift	1
37	883 887 003	Tube, Shift Cyl,.	1
39	688 643	Nut, Special	1
40	724 582	Set Screw, 3/8-24 x 1/4 Allan Head	1
41	883 893	Adaptor, Piggyback Cyl.	1
42	769 286	Shaft, Piggyback Cyl.	1
43	883 887 007	Tube, Piggyback Cyl. & PTO Cyl.	1
44	788 546 006	Stud, Piggyback Cyl. Mtg.	4
45	688 323	Nut, 1/4-28	



H-U Air Shift

ITEM	PART NO.	DESCRIPTION	QUANTITY
1	758 338	Plastic Plug	1
2	235 372	Cap, Air Shift Cyl.	1
3	675 224	O-Ring, Air Shift Cap & Adapter	3
6	688 464	Nut, Shift Piston	1
7	927 643	Washer, Shift Piston	1
8	675 326	O-Ring, Shift Piston	1
9	753 232	Piston, Shift	1
10	339 223	Felt Ring, Shift Piston	1
11	782 288	O-Ring, Shift Shaft	1
13	736 747	Ring, Nylon Bump	1
14	777 485	Spring, Air Shift Return	1
15	883479	Adaptor, Air Shift Cyl.	1
17	724 222	Set Screw	2
18	947 223	Lockwire	2
23	427 399	Gasket, Shift Shaft Cap	1
24	235 372	Cap, Shift Shaft	1
25	265 343	Capscrew 1/4-20 x 1/2	4
34	367 259	Fork, Direct Drive Shift	1
35	367 268	Fork, Under Drive Shift	1
36	742 877	Shaft H-N-U Air Shift	1
37	883 887 003	Tube, Shift Cyl.	1
38	265 982	Capscrew, Air Shift Cyl. 1/2-20 x 4 3/4	4



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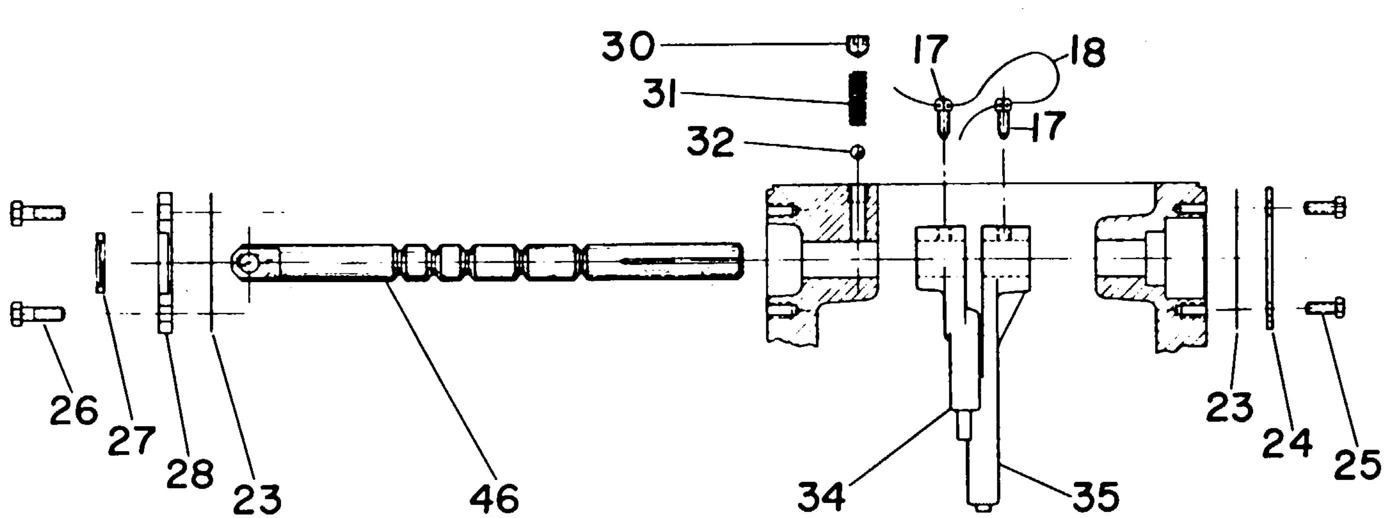
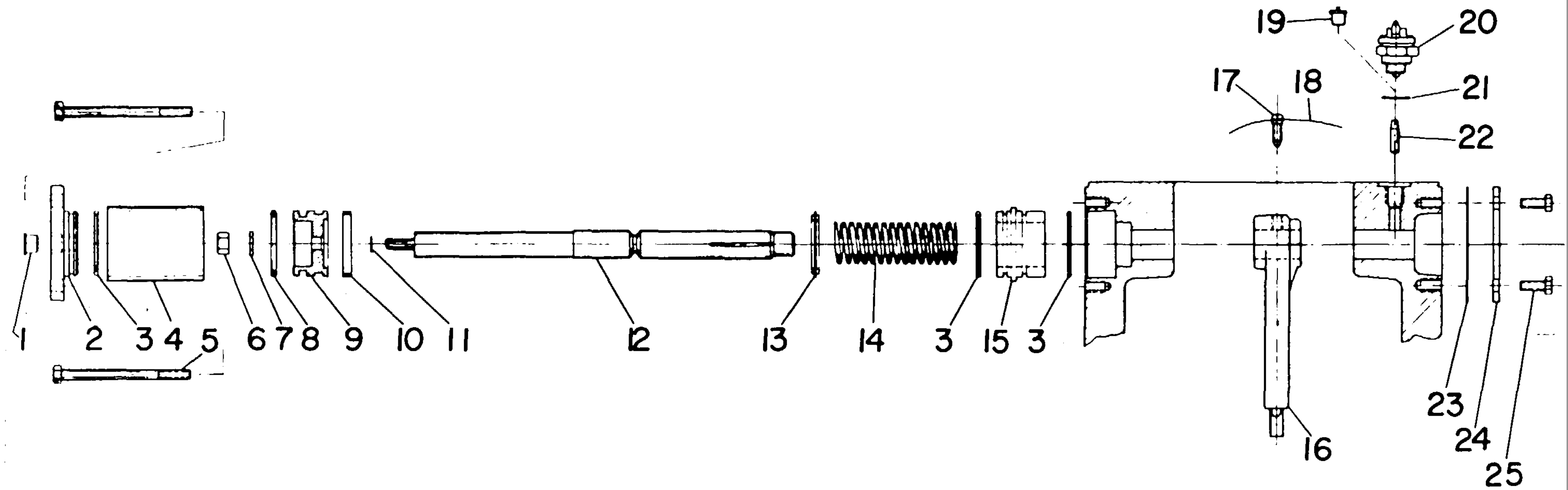


TEM	PART NO.	DESCRIPTION	QUANTITY
17	724 222	Set Screw	2
18	947 223	Lockwire	2
23	427 399	Gasket, Shift Shaft Cap	2
24	235 372	Cap, Shift Shaft	1
25	265 343	Capscrew, 1/4-20 x 1/2	4
26	265 366	Capscrew, 1/4-20 x 1	4
27	732 357	Seal, Shift Shaft	1

ITEM	PART NO.	DESCRIPTIONQUANTITY	
28	237 383	Carrier, Seal	1
30	724 585	Set Screw, Nylock	1
31	777 225	Spring, Detent	1
32	225 222	Ball, Detent	1
34	367 259	Fork, Direct Drive Shift	1
35	367 268	Fork, Under Drive Shift	1
46	742 945	Shaft, H-N-U Mechanical Shift	1

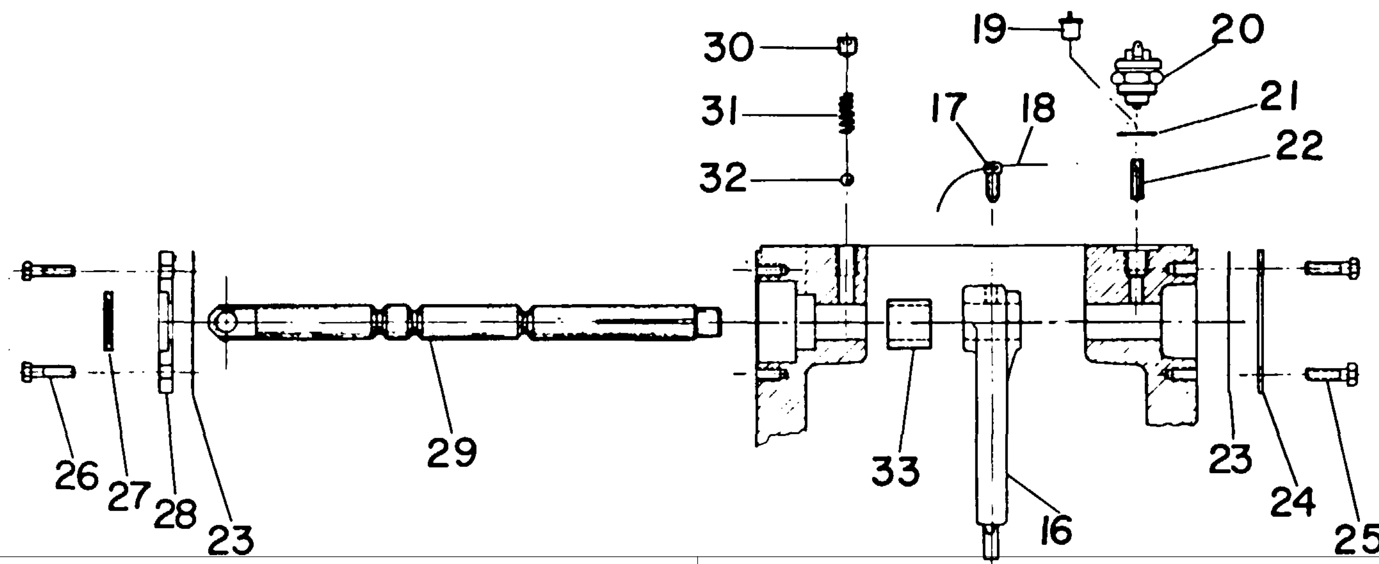


ITEM	PART NO	DESCRIPTION	QUANTITY
1	758 338	Plastic Plug	1
2	235 372	Cap, Air Shift Cyl.	1
3	675 224	O-Ring, Air Shift Cap & Adaptor	3
4	883 887 006	Tube, Air Shift	1
5	265 892	Capscrew, Shift Cyl. Mtg.	4
6	688 464	Nut, Shift Piston	1
7	927 643	Washer, Shift Piston	1
8	675 326	O-Ring, Shift Piston	1
9	753 232	Piston, Shift	1
10	339 223	Felt Ring, Shift Piston	1
11	782 288	O-Ring, Shift Shaft	1
12	769 285	Shaft, Air Front Drive Shift	1
13	736 747	Ring, Nylon Bump	1

ITEM	PART NO.	DESCRIPTION	QUANTITY
14	777 485	Spring, Air Shift Return	1
15	883 479	Adaptor, Air Shift Cyl.	1
16	367 264	Fork, Front Drive Shift	1
17	724 222	Set Screw	1
18	947 223	Lockwire	1
19	758 364	Plastic Plug	1
20	798 245	Switch, Indicator	1
21	927 427	Washer, Copper	1
22	746 678	Dowel, Switch Operating	1
23	427 399	Gasket, Shift Shaft Cap	1
24	235 372	Cap, Shift Shaft	1
25	265 343	Capscrew, 1/4-20 x 1/2	4

AIR OPERATED FRONT DRIVE DECLUTCH

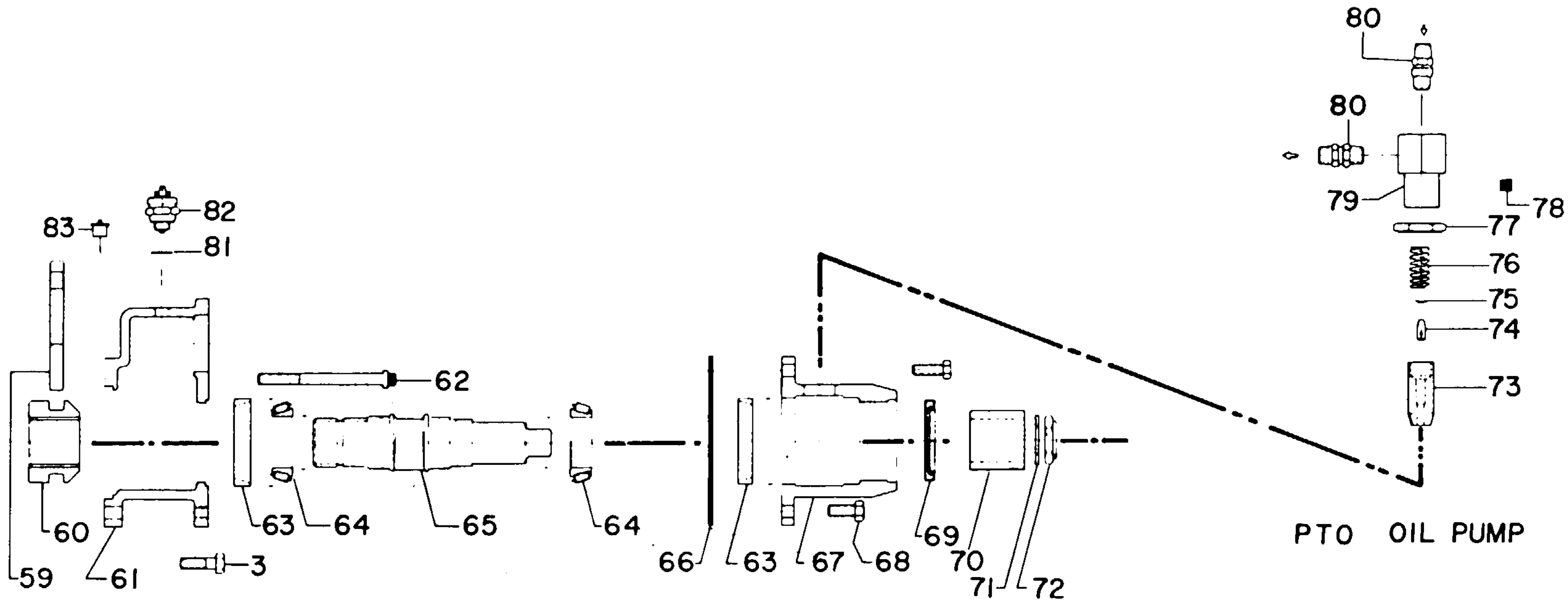
FABCO DIV. KELSEY HAYES



ITEM	PART NO.	DESCRIPTION	QUANTITY
16	367 264	Fork, Front Drive Shift	1
17	724 222	Set Screw	1
18	947 223	Lockwire	1
19	758 364	Plastic Plug	1
20	798 245	Switch, Indicator	1
21	927 427	Washer, Copper	1
22	746 678	Dowel, Switch Operating	1
23	427 399	Gasket, Shift Shaft Cap	2
24	235 372	Cap, Shift Shaft	1

ITEM	PART NO.	DESCRIPTION	QUANTITY
25	265 343	Capscrew, 1/4-20 x 1/2	4
26	265 366	Capscrew, 1/4-20 x 1	4
27	732 357	Seal, Shift Shaft	1
28	237 383	Carrier, Seal	1
29	769 278	Shaft, Shift	1
30	724 585	Set Screw, Nylock	1
31	777 225	Spring, Detent	1
32	225 222	Ball, Detent	1
33	882 982	Tube, Front Drive Limit	1

The following parts are for PTO equipped cases:

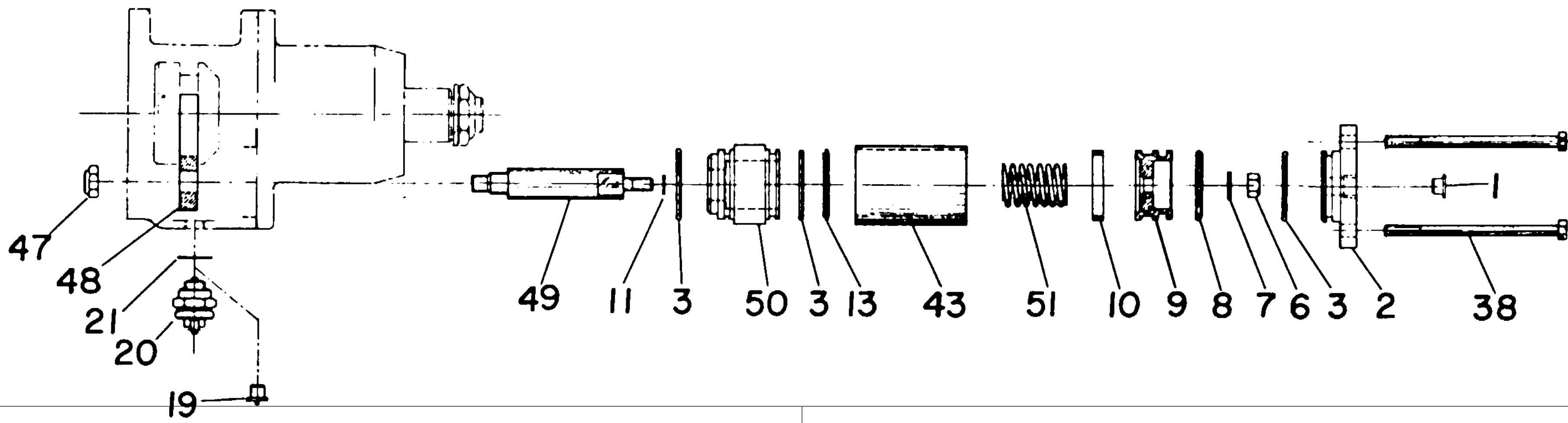


ITEM	PART NO.	DESCRIPTION	QUANTITY
59	367 267	Fork, PTO Shaft	1
60	432 552	Collar, Sliding Clutch	1
61	468 799	Housing, Main PTO	1
62	724 335	Capscrew, 7/16 x 4 1/2 (12) Point	2
63	233 439	Bearing Cup	2
64	233 442	Bearing Cone	2
65	769 237	Shaft, PTO	1
66	7441323	.031 Coral Shim	A/R
	7442323	.016 Pink Shim	*A/R*
	7443323	.005 Blue Shim	A/R
67	237 425	Carrier, Bearing & Seal	1
68	265 242	Capscrew, 3/8-16 x 1	4
69	732 368	Seal, PTO Output	1
70	883 944	Tube, PTO Output (Temporary)	1
71	927 762	Washer, PTO Output Yoke	1
72	688 634	Nut, PTO Output Yoke	1

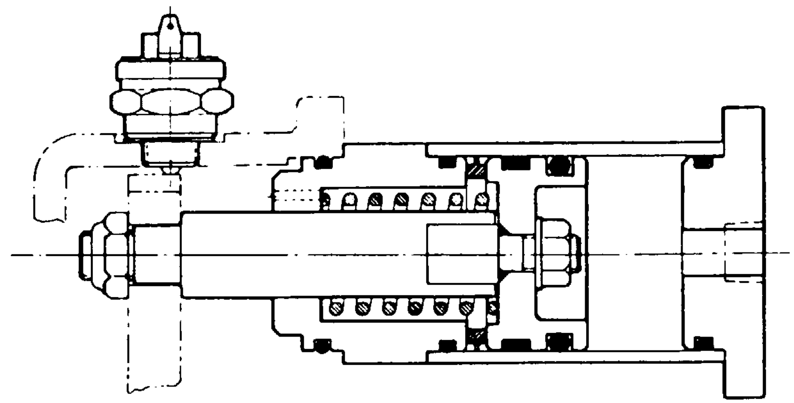
ITEM	PART NO.	DESCRIPTION	QUANTITY
73	753 244	Piston, PTO Oil Pump	1
74	825 367	Valve, PTO Piston Check	1
75	762 299	Retaining Ring, PTO Piston Check Valve	1
76	777 535	Spring, PTO Oil Pump	1
77	688 688	Nut, PTO Oil Pump Cyl. Lock & Seal	1
78	758 232	Plug, 1/4 NPT PTO Oil Pump Cyl.	1
79	295 389	Cylinder, PTO Oil Pump	1
80	825 737	Valve, PTO Oil Pump In & Out Check	2
81	927 427	Washer, Copper	1
82	798 245	Switch (If Specified)	1
83	758 364	Plug, 9/16-18 Plastic	1

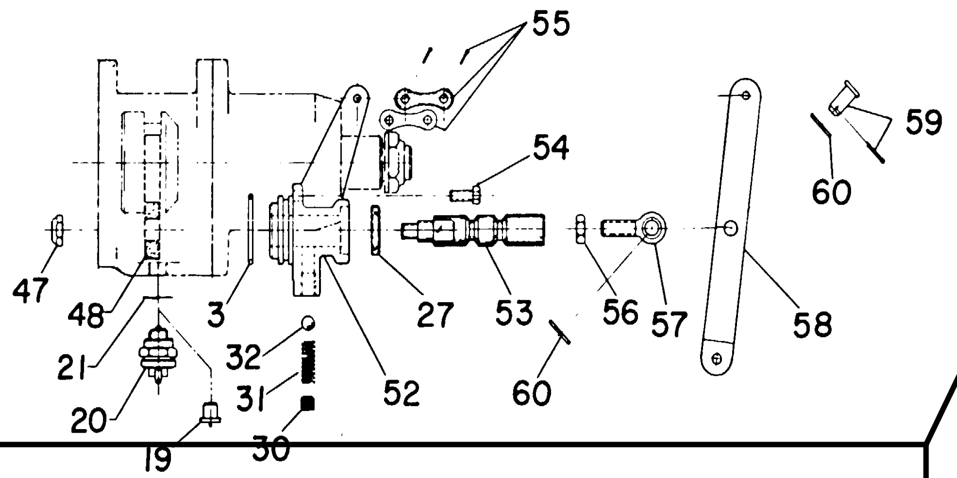
PTO

AIR OPERATED PTO SHIFT

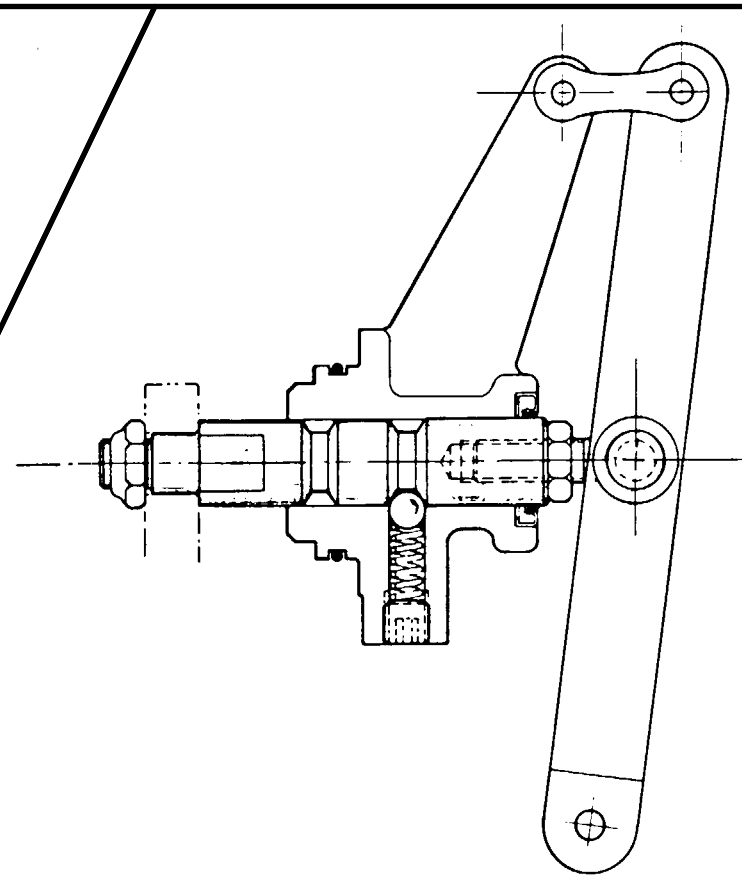


ITEM	PART NO.	DESCRIPTION	QUANTITY
1	758 338	Plastic Plug	1
2	235 372	Cap, Air Shift Cyl.	1
3	675 224	O-Ring, Air Shift Cap & Adaptor	3
6	688 464	Nut, Shift Piston	1
7	927 643	Washer, Shift Piston	1
8	675 326	O-Ring, Shift Piston	1
9	753 232	Piston, Shift	1
10	339 223	Felt Ring, Shift Piston	1
11	782 288	O-Ring, Shift Shaft	1
13	736 747	Ring, Nylon Bump	1
19	758 364	Plastic Plug	1
20	798 245	Switch, Indicator	1
21	927 427	Washer, Copper	1
38	265 982	Capscrew, Air Shift Cyl. 1/2-20 x 4 3/4	4
43	883 887 007	Tube, Piggyback Cyl. & PTO Cyl.	1
47	688 684	Nut, PTO Shift Shaft	1
48	367 267	Fork, PTO Shift	1
49	769 236	Shaft, PTO Air Shift	1
50	883 852	Adaptor, PTO Air Shift Cyl.	1
51	777 534	Spring, PTO Air Shift Cyl.	1





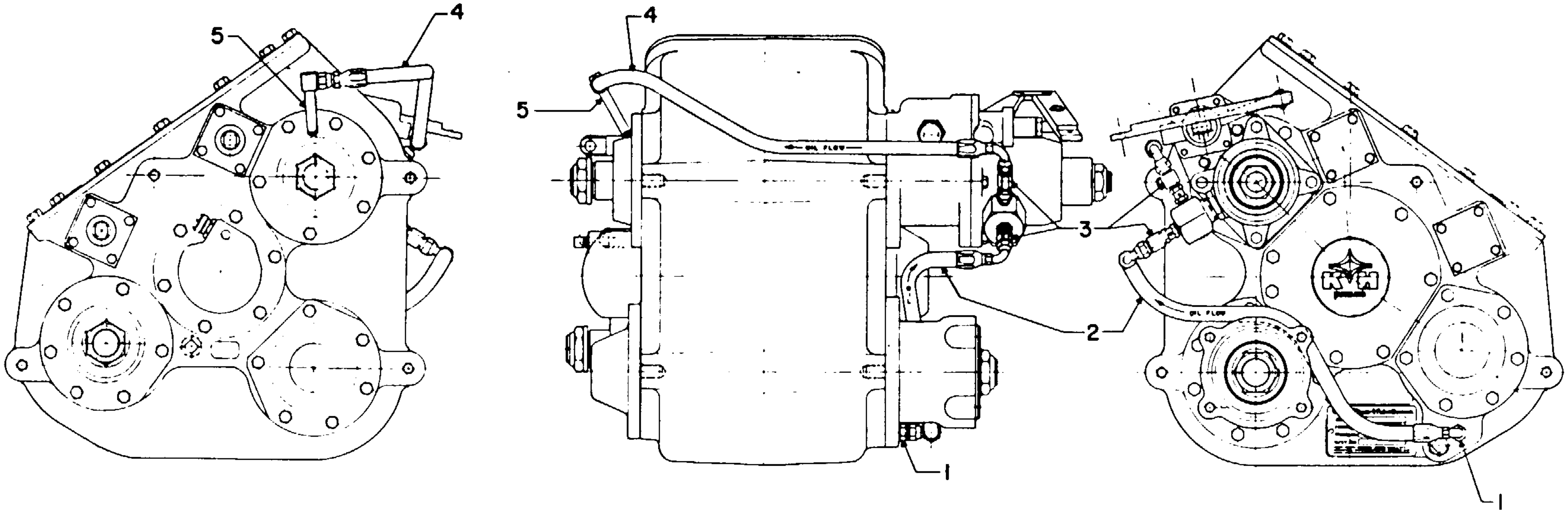
ITEM	PART NO.	DESCRIPTION	QUANTITY
3	675 224	O-Ring, Air Shift Cap & Adaptor	1
19	758 364	Plastic Ring	1
20	798 245	Switch, Indicator	1
21	927 427	Washer, Copper	1
27	732 357	Seal, Shift Shaft	1
30	724 585	Set Screw, Nylock	1
31	777 225	Spring, Detent	1
32	225 222	Ball, Detent	1
47	688 684	Nut, PTO Shift Shaft	1
48	367 267	Fork, PTO Shift	1
52	235 466	Carrier, Shift Shaft & Seal	1
53	769 238	Shaft, PTO Shift-Manual	1
54	265 386	Bolt, 1/4-20 x 3/4	4
55	246 289	Link, Connecting	1
56	688 237	Nut, 7/16-20 Jam	1
57	393 222	Eye Bolt	1
58	538 476	Lever, PTO Shift	1
59	746 352	Pin, Clevis w/Cotter Pin	1
60	927 347	Washer	2

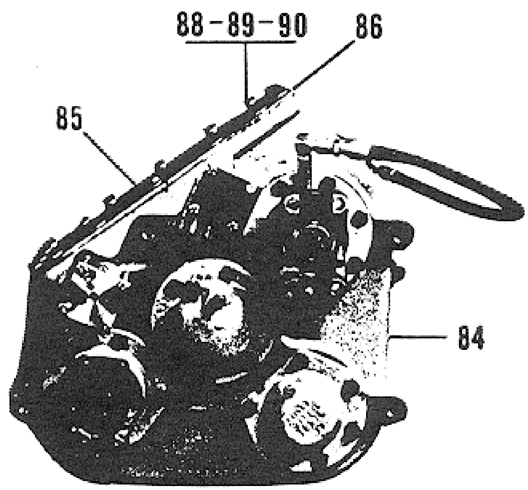


MANUAL PTO SHIFT

Oil Lines & Fittings - PTO

ITEM	PART NO.	DESCRIPTION	QUANTITY
1	357 288	Fitting, 1/2 MP 3 3/4 H JIC	1
2	469 794	Hose Assembly, Suction	1
3	357 939	Fitting, 1/4 FP 3/4 H JIC	2
4	469 826	Hose Assembly, Pressure	1
5	357 948	Elbow, 1/4 MP 3/8 H	1





Parts not designated on the drawing.
Used on all cases - unless otherwise specified.

ITEM	PART NO.	DESCRIPTION	QUANTITY
84	468 896	Housing, Main Case	1
85	793 377	Cover, Main Case	1
86	427 464	Gasket, Main Cover	1
87	273 687	Bracket, Case Lifting	2
88	265 239	Capscrew, Cover Mtg. 7/16-14 x 1	16
89	265 238	Capscrew, Cover Mtg. 7/16-14 x 11/4	2
90	927 749	Washer, Cover Mtg. Screw 7/16 Lock	18
91	626 228	Label, Serial Plate	1
92	724 276	Screw, Serial Plate Mtg. Drive	2
93	758 274	Plug, 3/4 NPT Magnetic Drain	1
94	758 229	Plug, 3/4 NPT Fill	1
95	758 293	Plug, 1/2 NPT Return Line Hole	1(w/o PTO)

SERVICE MANUAL
REAR AXLE

CONTENTS

Subject	CTS No.

14

*Not provided with Service Manual. Purchase separately if desired.
**Not available at printing. Refer to CTS-4044 and CTS-4042.

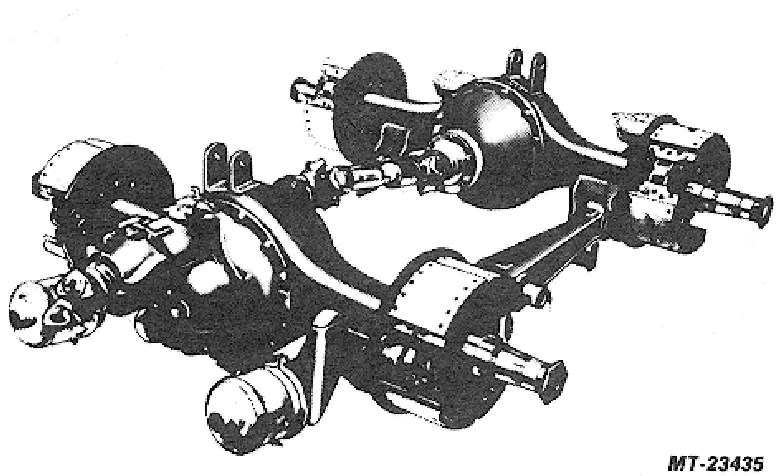
REAR AXLE
IH SINGLE REDUCTION TANDEM

(CONE TYPE CARRIER)

IH MODEL	IH CODE
RA-355	14355

CONTENTS

CTS-4044
PRINTED IN UNITED STATES OF AMERICA



MT-23435

Fig. 1. IH Single Reduction Tandem Rear Axle

GENERAL

This service manual covers rebuild procedures and specifications for the IH built Single Reduction Tandem Axle. Both forward rear and rear rear axles of the models RA-341, 351 and 355 rear axles are included. The repairs are performed principally on the power divider and differential carrier of the forward axle and the differential carrier of the rear rear axle after they are removed from the axle housing.

DESCRIPTION

The IH thru-drive tandem rear axle consists of a heavy-duty single reduction axle with integral power divider and inter-axle differential for the forward rear axle and a conventional heavy-duty single reduction axle for the rear -rear axle. Differential parts, ring gear and pinion sets, bearings, and axle shafts are common between the forward and rear axles.

The forward axle has the power divider anc inter-axle differential mounted on the forward side of the differential carrier. A thru-shaft carries driving torque through the forward axle housing to the rear rear axle. Driving torque is delivered to the forward rear axle via the intermediate idler gear and a driven gear mounted on the pinion shaft of the forward axle.

The complete differential carrier and power divider may be removed from the forward axle housing as a unit with the axle mounted in the truck as well as when the axle is removed. Also the power divider may be removed individually without removing the differential carrier. This permits servicing the power divider without disturbing the forward axle differential.

REMOVAL

FORWARD REAR AND REAR REAR AXLES

Remove Axle Shafts From Wheels and Housings

1. Drain lube from both axle housings and the power divider. To drain power divider, remove plug from bottom of intermediate case.
2. Take off all nuts from studs around rear wheel hub.
3. Loosen shaft from hub by striking center of axle shaft flange with 2.3 - 2.7 Kg (5-6 lb.) hammer or sledge.
4. Pull axle shafts from housing.

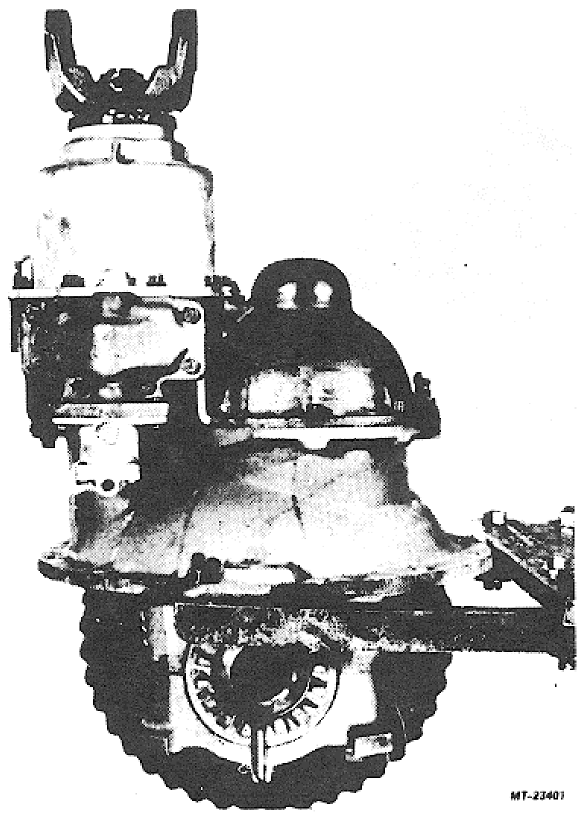


Fig. 2. Power Divider and Diff Carrier In Rebuild Stand

Remove Propeller Shafts

1. Separate universal joints from companion flanges of input and output shafts of forward rear axle.

2. Repeat for input shaft of rear rear axle.

Remove Output Shaft From Forward Rear Axle

1. Remove output shaft bearing retainer bolts.

2. Use soft hammer and loosen bearing retainer from axle housing.

3. Withdraw bearing retainer and output shaft from axle housing.

Remove Diff Carriers From Axle Housings

1. Loosen differential carrier-to-axle housing bolts. Remove all bolts except top two. These two bolts will prevent carrier assembly from falling.

2. Support carrier assembly on roller jack. Secure as necessary to prevent carrier from falling from jack when removed from housing.

3. Remove top two carrier bolts. Loosen locknuts and turn puller screws in to break carrier away from housing. A small pinch bar may be used to straighten carrier assembly in housing, but be careful to avoid damage to carrier flange. Remove carrier assembly from axle housing.

4. Roll jack and carrier assembly from under truck. Mount carrier assembly in suitable rebuild stand (Fig. 2).

DISASSEMBLY

FORWARD REAR AXLE

Disassemble Power Divider From Diff Carrier

1. Remove lockout control assembly (Fig. 3).

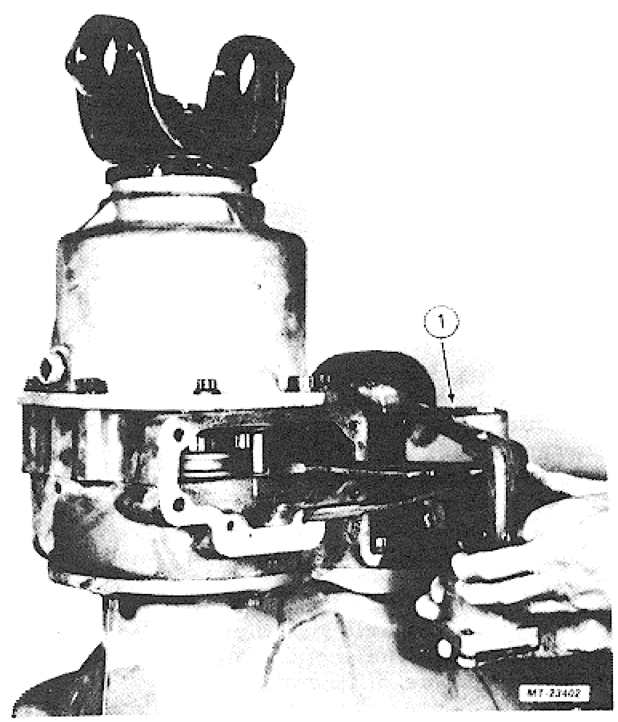


Fig. 3. Removing Power Divider Lockout Control

1 Power Divider Lockout Control Assembly

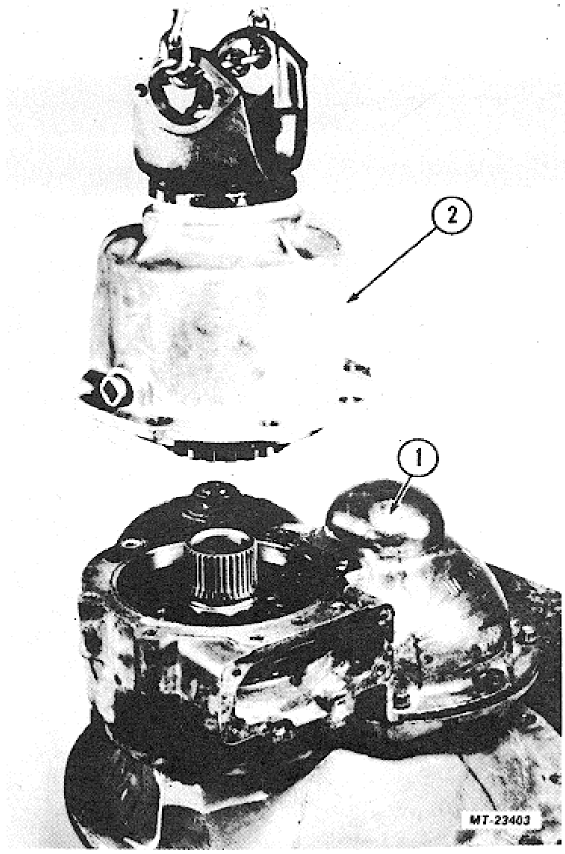


Fig. 4. Removing Inter-Axle Diff

1 Intermediate Case
2 Inter-Axle Differential Assembly

2. Remove inter-axle diff cover bolts and lift inter-axle diff assembly from power divider intermediate case (Fig. 4).

3. Remove intermediate case-to-diff carrier bolts and lift intermediate case from diff carrier (Fig. 5).

Disassemble Inter-Axle Differential

1. Secure input (companion) flange with a flange holder tool or by clamping in vise (Fig. 6).

2. Use torque multiplier wrench (SE-1933) as shown in Fig. 6 and remove input flange nut.

3. Use puller tool (Fig. 7) or press and remove inter-axle diff assembly from cover (nose cone) and input flange.

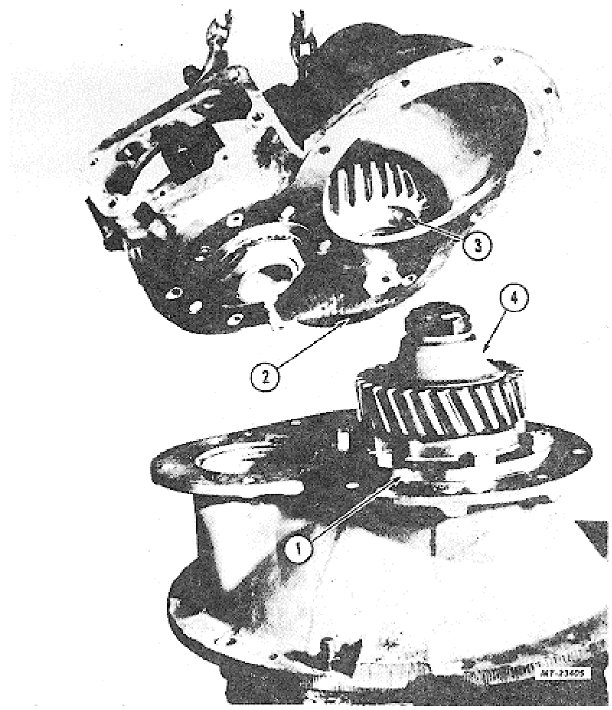


Fig. 5. Removing Power Divider Intermediate Case Assembly

1 Pinion Bearing Cage 3 Idler Gear
2 Intermediate Case 4 Driven Gear

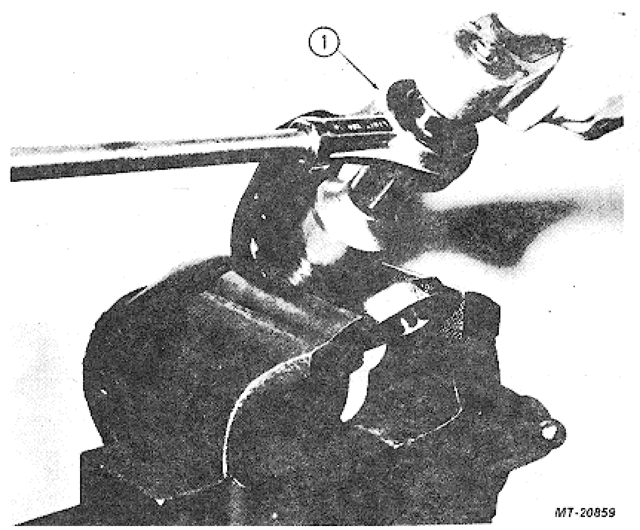


Fig. 6. Removing Input Flange Nut

1 Torque Multiplier Wrench

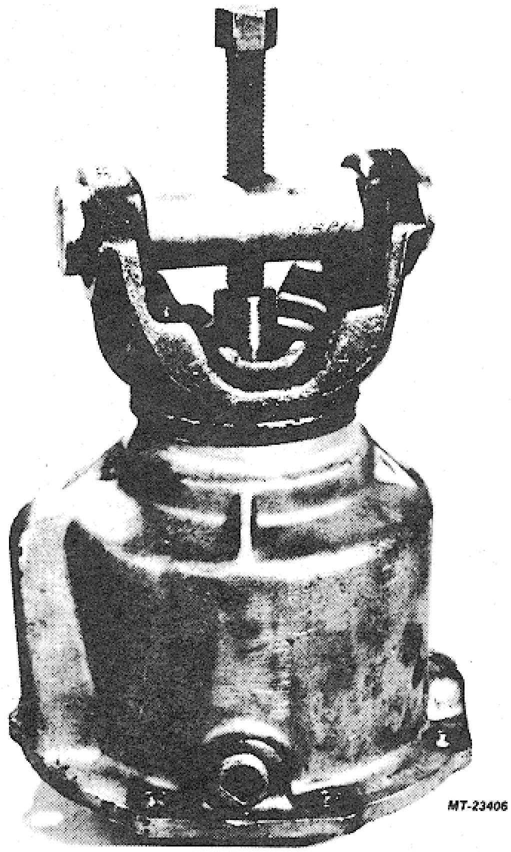


Fig. 7. Removing Inter-Axle Differential From Cover

4. Note and retain shims located between front bearing and cover. These shims limit end play of differential assembly in cover (Fig. 8).

5. If necessary to remove bearings from diff case, pull bearings using suitable pullers (Fig. 9).

6. Match mark diff case halves with a punch or chisel to assure correct alignment upon reassembly.

7. Remove diff case bolts and separate case halves.

8. Remove diff spider, spider pinion gears, side gears, and thrust washers (Fig. 10).

9. Remove oil seal from inter-axle diff cover.

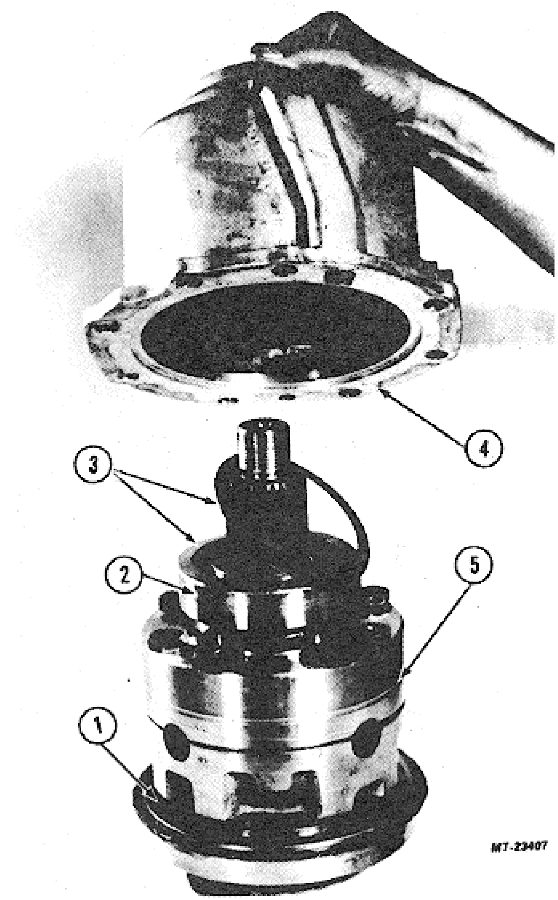


Fig. 8. Cover Removed. Note Shims Which Limit Dlff Cose to to Cover End Play

1	Rear Bearing	4	Cover
2	Front Bearing	5	Inter-Axle Differential
3	Shims		

10. If necessary to remove bushing from rear half of diff case, collapse bushing inward by inserting point of chisel between bushing and case at seam of bushing. Avoid damaging case.

11. Keep inter-axle diff parts together and protect from damage while removed.

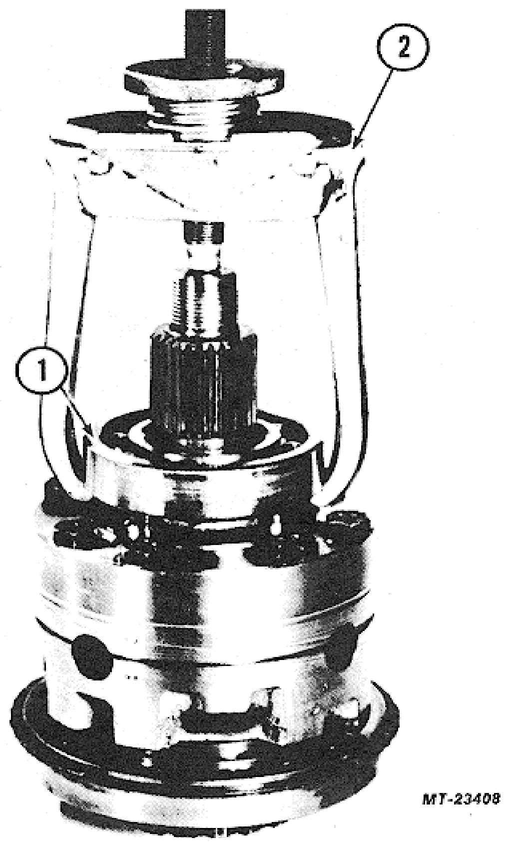


Fig. 9. Removing Front Bearing From Inter-Axle Differential

1 Front Bearing   2 Puller Tool

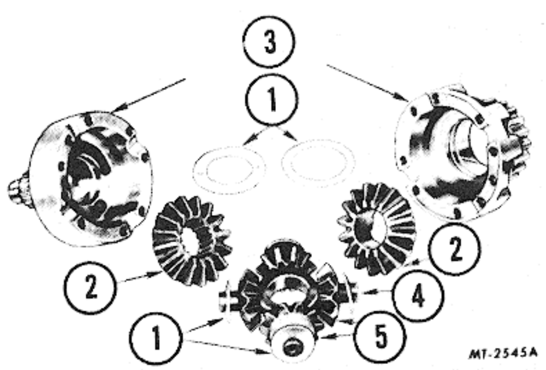


Fig. 10. Components of Inter-Axle Differential

1	Thrust Washers	4	Spider
2	Side Gear	5	Spider Gears
3	Case Halves		

Disassemble Power Divider Intermediate Case

1. Lift inter-axle clutch shift collar from input gear (Fig. 11).
2. Remove and disassemble input gear.

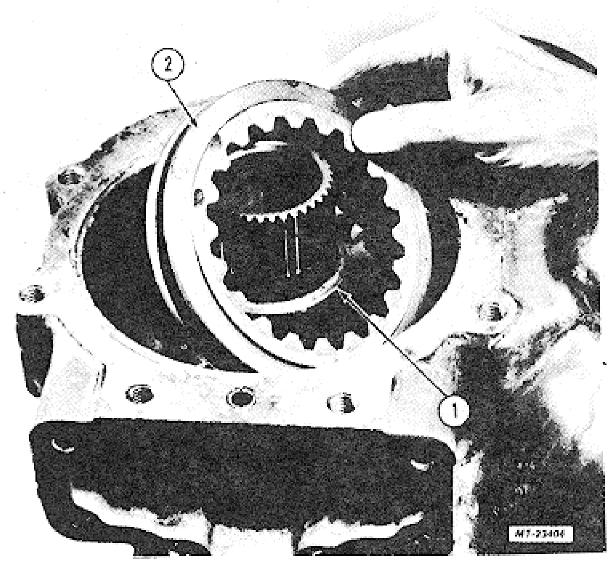


Fig. 11. Removing Clutch Shift Collar

1 Input Gear   2 Clutch Shift Collar

RA-341

a. Press input gear to rear sufficiently to free bearing snap ring. Remove snap ring.

b. Remove input gear and bearing by pressing forward to free bearing from bore.

c. Clamp input gear in soft jawed vise.

d. Remove bearing retainer nut using bearing nut wrench (SE 2247). See Fig. 12.

e. Pull bearing from input gear with puller tool.

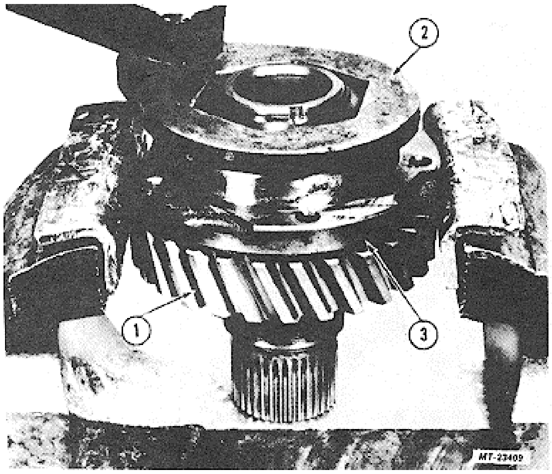


Fig. 12. Removing Input Gear Bearing Retainer Nut (RA-351, 35 Shown - RA-341 Similar)

1 Input Gear
2 Bearing Nut Wrench
3 Bearing Retainer

RA-351, 355

a. Remove bearing retainer mounting bolts from rear of intermediate case and tap input gear bearings and retainer assembly out toward front.

b. Remainder of input gear disassembly is same as for RA-341.

IMPORTANT
Inner bearing is a press fit on gear and will most likely be damaged if removed. Remove only if to replace.

3. Loosen idler shaft end nut using torque multiplier wrench. Use flats provided on shaft end to hold shaft from turning while nut is being loosened. Remove nut and washer.

4. Support rear face of intermediate case and press idler shaft from case.

5. Remove idler shaft gear and bearings from case (Fig. 13 and 14). Separate bearings, bearing races and bearing spacer from idler gear. Note that models RA-351 and 355 use two bearing spacers.

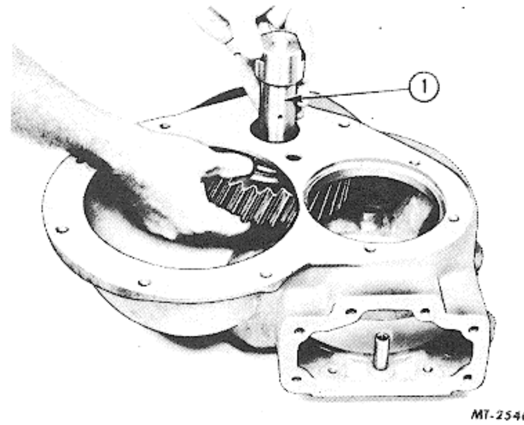


Fig. 13. Removing Idler Shaft and Gear

1 Idler Shaft

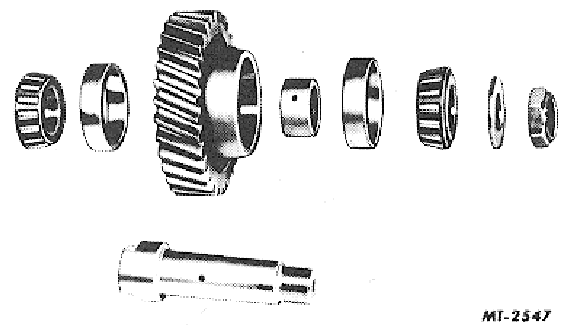


Fig. 14. Idle Gear Components (RA-341 Shown)

Disassemble Output Shaft Assembly

1. Clamp companion flange of output shaft in vise.

2. Remove companion flange nut and flange.

3. Remove bearing retainer (with seal).

FORWARD REAR AND REAR REAR AXLES

Disassemble Diff Carrier Assembly

1. Remove cotter pins from bearing adjuster locks and remove locks.

2. Mark one bearing cap and leg of carrier with a punch or chisel to identify each for cqrrect reassembly.

3. Remove bearing cap bolts and take off bearing caps and adjusters (Fig. 15).

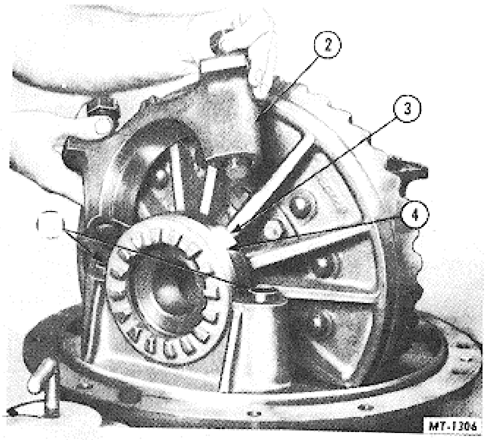


Fig. 15. Removing Differential Bearing Caps

2 Differential Bearing Cap
3 Differential Bearing Cup
4 Bearing Adjuster

4. Lift differential assembly from diff carrier (Fig. 16). Tilt differential assembly to allow ring gear to pass pinion radial bearing. Place differential assembly on bench.

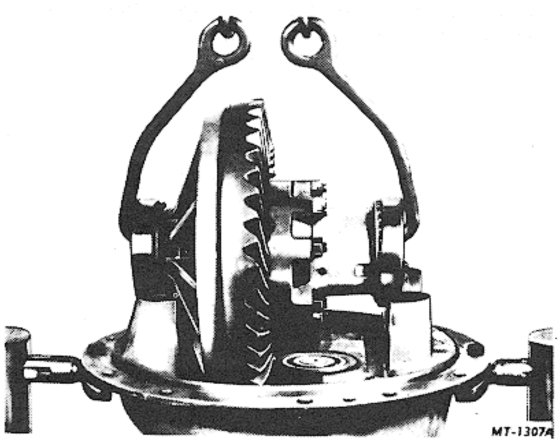


Fig. 16. Lifting Differential From Carrier

Disassemble Differential

1. If necessary, remove diff beariings from diff case using suitable puller.
2. Match mark diff case halves with a punch or chisel to assure correct alignment upon reassembly.
3. Remove self-locking nuts from diff case bolts and separate the diff case halves (Fig. 17).

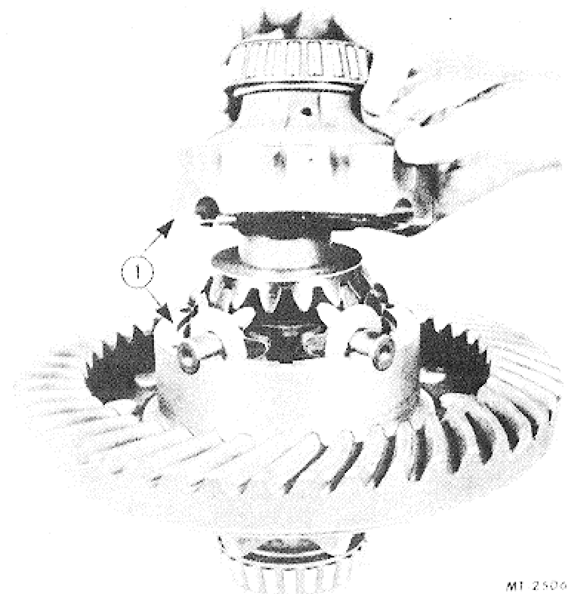


Fig. 17. Separating Diff Case Halves

1 Differential Case Halves

4. Remove diff spider shaft, spider gears, side gears and thrust washers from diff case halves (Fig. 18).

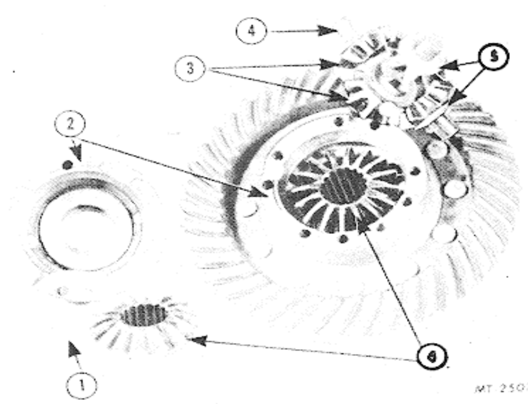


Fig. 18. Differential Component Parts

1 Thrust Washer (2)
2 Differential Case Halves
3 Spider Gears (4)
4 Differential Spider
5 Thrust Washers (4)
6 Side Gears (2)

5. If necessary to remove ring gear from diff case, carefully center punch each rivet head on the ring gear side and drill through the rivet head with a drill 0.8 mm (1/32") smaller than the rivet body (Fig. 19). Use a punch to press out the remaining portion of rivet. Never use a chisel to cut off rivet heads as damage to the diff case might result.

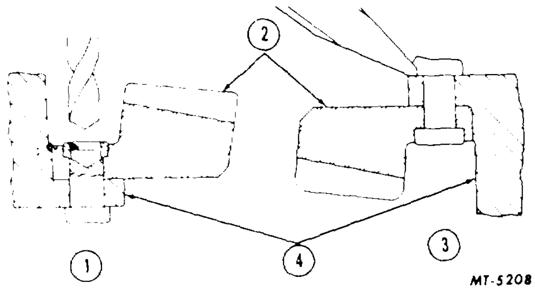


Fig. 19. Drive Gear Rivet Removal

1	Right	3	Wrong
2	Drive Gear	4	Differential Case

Remove Pinion And Cage From Diff Carrier

1. Remove bolts holding pinion cage to diff carrier.

2. Strike against rear of pinion shaft with a brass drift and hammer to start pinion and cage out of carrier Fig. 20).

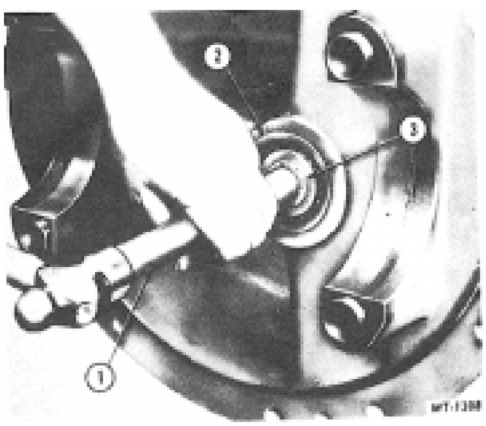


Fig. 20. Starting Pinion And Cage From Carrier

1 Brass Drift
2 Pinion Shaft Pilot Bearing
3 Pinion Shaft Face

3. Remove pinion and cage assembly from carrier (Fig. 21 Temporarity install stud bolts to aid in removal.

CAUTION
Be careful to avoid dropping the pinion and cage assembly. Personal injury or damage to parts may result if assembly is allowed to fall.

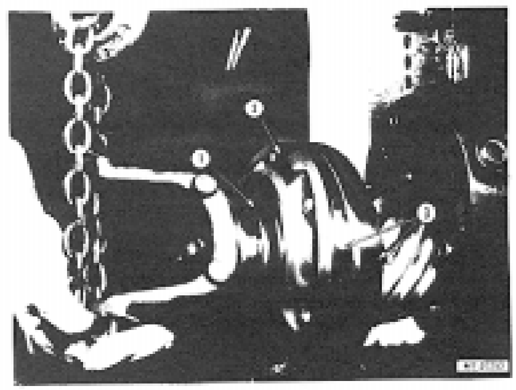


Fig. 21. Removing Pinion And Cage (Rear Rear Shown)

1	Oil Seal Retainer	2	Pinion Cage
		3	Shims

4. Retain pinion cage shims to aid in readjustment upon reassembly. Do not reuse damaged shims.

Disassemble Pinion And Cage

1. Mount pinion and cage assembly in a heavy duty vise or holding tool (Fig. 22).
2. Because of the high torque load on pinion end nut, use the torque multiplier wrench (SE-1933) and another long handle wrench to remove nut.
3. Pull pinion shaft driven gear or companion flange from pinion.
4. Remove spacer from pinion shaft,
5. Tap pinion from cage.
6. Remove forward pinion bearing from cage.
7. Remove bearing spacer from pinion shaft.
8. Remove rear pinion bearing and pinion radial bearing from pinion shaft.

IMPORTANT
When axle disassembly is complete, keep parts in order and undamaged. Be especially careful to protect the finely machined surfaces that are now exposed.

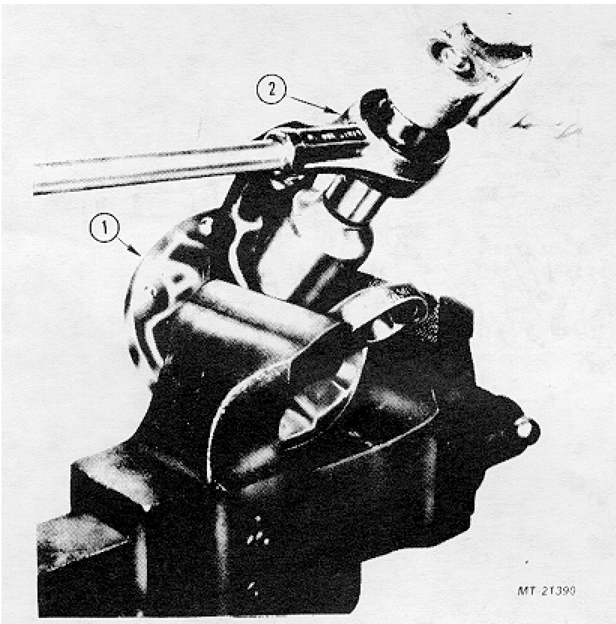


Fig. 22. Removing Pinion End Nut (Rear Rear Shown)

1 Pinion Bearing Cage
2 Torque Multiplier Wrench

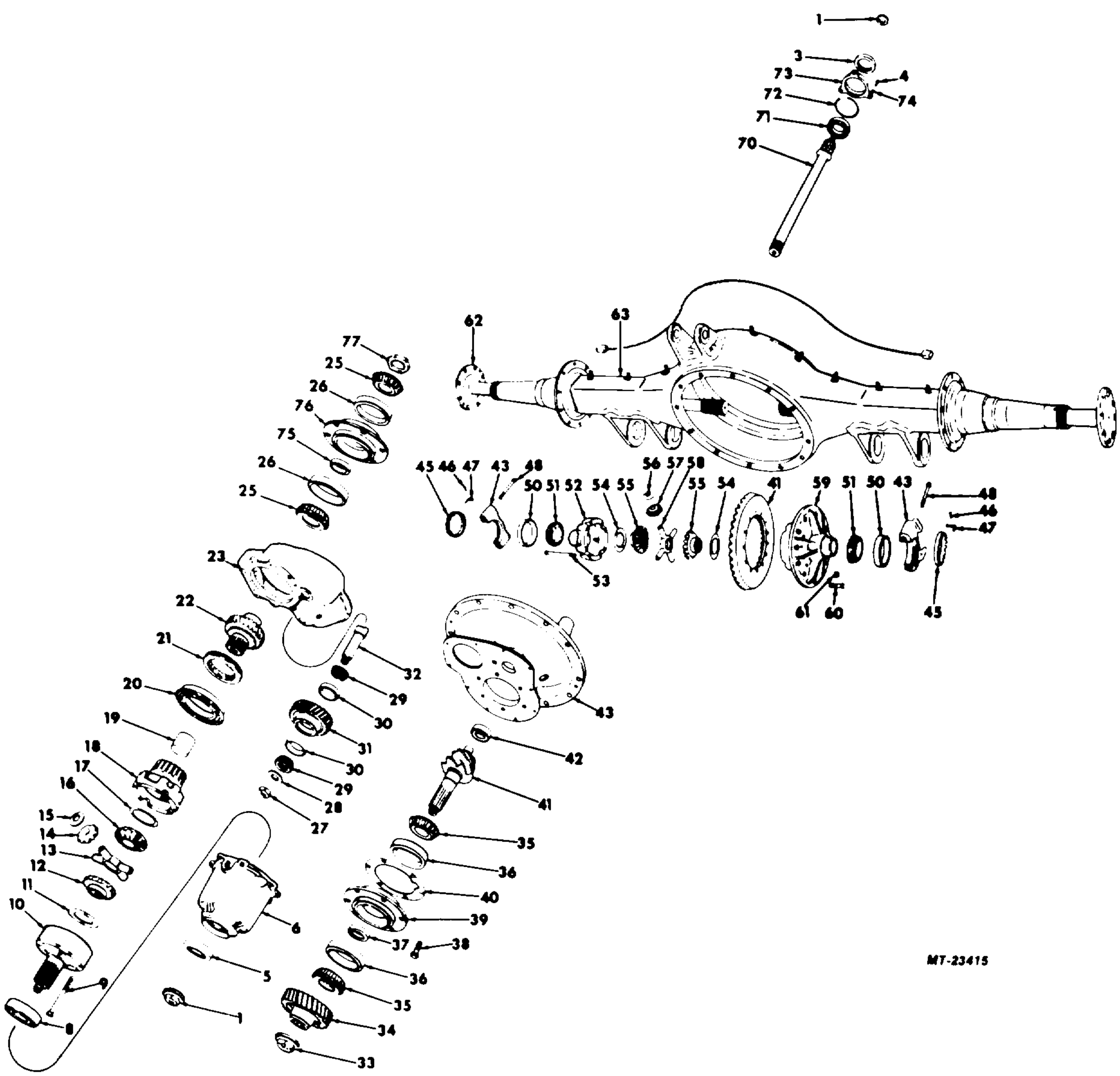


Fig. 23. Forward Rear Axle (Exploded View)

Key	Description
1	Nut, Companion Flange
2	Not Used
3	Seal, Output Shaft Oil
4	Bolt, Retainer
5	Seal, Inter-Axle Diff Oil
6	Cover, Inter-Axle Diff
7	Not Used
8	Bearing, Diff Front
9	Bolt, Inter-Axle Diff Case
10	Case, Diff, Front Half
11	Washer, Front Side Gear Thrust
12	Gear, Diff, Front Side
13	Spider, Diff
14	Gear, Pinion
15	Washer, Pinion Thrust
16	Gear, Diff, Rear Side
17	Washer, Rear Side Gear Thrust
18	Case, Diff, Rear Half
19	Bushing, Diff Case Rear Half
20	Bearing Diff Case Rear Half
21	Collar, Clutch Shift
22	Gear, Input Drive
23	Case, Intermediate
24	Not Used
25	Bearing, Input Gear, Cone
26	Bearing, Input Gear, Cup
27	Nut, Idler Shaft
28	Washer, Idler Shaft
29	Bearing, Idler Gear, Cone
30	Bearing, Idler Gear, Cup
31	Gear, Idler
32	Shaft, Idler Gear
33	Nut, Pinion End
34	Gear, Pinion Shaft Driven
35	Bearing, Pinion Cone
36	Bearing, Pinion Cup
37	Spacer, Pinion Bearing
38	Bolt, Pinion Bearing Cage
39	Cage, Pinion Bearing

Key	Description
40	Shim
41	Pinion And Gear Set
42	Bearing, Pilot (Radial)
43	Carrier Diff, with Caps
44	Not Used
45	Adjuster, Diff Bearing
46	Pin Cotter
47	Lock, Diff Bearing Adjuster
48	Bolt, Diff Bearing Cap
49	Not Used
50	Bearing, Diff Cup
51	Bearing, Diff Cone
52	Case, Diff, Plain Half
53	Bolt, Diff Case
54	Washer, Diff Side Gear Thrust
55	Gear, Diff Side
56	Washer, Diff Pinion Thrust
57	Gear, Diff Pinion
58	Spider, Diff
59	Case, Diff, Flanged Half
60	Rivet, Ring Gear To Case
61	Nut, Diff Case Bolt
62	Shaft, Axle
63	Housing, Axle Assembly
64	Not Used
65	Not Used
66	Not Used
67	Not Used
68	Not Used
69	Not Used
70	Shaft, Output
71	Bearing, Output Shaft
72	Ring, Snap, Bearing Retainer
73	Retainer, Output Shaft Bearing
74	Washer, Flat
75	Not Used
76	Retainer Input Gear Bearing
77	Nut, Input Gear Bearing Retainer

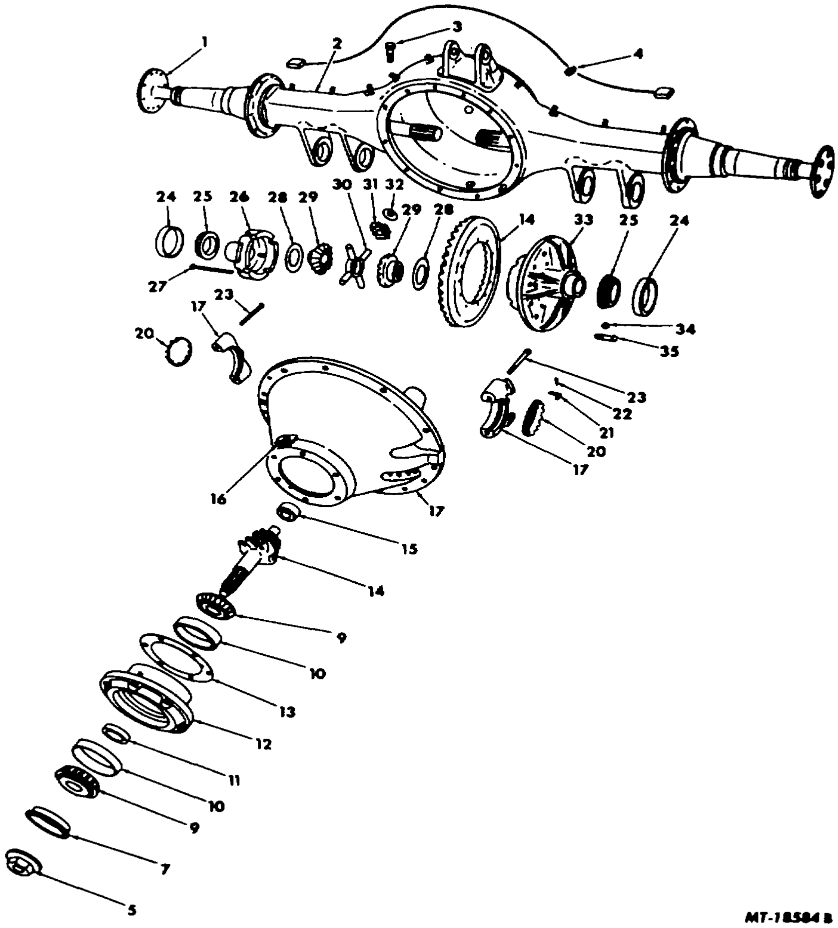


Fig. 24. Rear Rear Axle (Exploded View)

Key	Description
1	Shaft, Axle
2	Housing, Axle, Assembly
3	Breather
4	Plug, Filler
5	Nut, Companion Flange
6	Not Used
7	Seal
8	Not Used
9	Bearing, Pinion Cone
10	Bearing Pinion Cup
11	Spacer
12	Cage, Pinion Bearing
13	Shim
14	Pinion And Gear Set
15	Bearing, Pilot (Radial)
16	Plug, Filler
17	Carrier, Diff with Caps
18	Not Used
19	Not Used
20	Adjuster, Diff Bearing
21	Lock, Adjuster
22	Pin, Cotter
23	Bolt, Bearing Cap
24	Bearing, Diff Cup
25	Bearing, Diff Cone
26	Case, Diff, Plain Half
27	Bolt, Diff Case
28	Washer, Thrust
29	Gear, Diff Side
30	Spider, Diff
31	Gear, Diff Pinion
32	Washer, Thrust
33	Case, Diff, Flanged Half
34	Nut, Diff Case Bolt
35	Rivet

CLEANING, INSPECTINO AND REPAIR

Remove all dirt, old lubricant, and liquid gasket material from components of the rear axle. Immerse in cleaning solvent and use a stiff brush if necessary. Bearings should be cleaned separately in clean solvent and special efforts taken to protect their finely machined surfaces. If compressed air is used for drying, do not spin bearings while drying.

Examine all bearings for roughness, damage or wear by rotating each bearing slowly in the hand. If in doubt as to bearing condition, replace. Ring gear, drive pinion, differential pinions and any other gears should be checked for damaged teeth, worn spots, or distortion. Inspect diff case assembly for cracks, damage or distortion. Make sure splined ends of axle shafts are neither twisted nor cracked. Shim packs should be uniform thickness. Discard thrust washers and obtain new even when only slight wear is indicated.

ADJUSTMENTS

The principal adjustments made on the diff carrier assembly are devised for establishing the proper gear tooth contact and thereby obtaining a long wearing, quiet running rear axle. Fundamentally, there are five adjustments to be covered and these are accomplished as the diff carrier assembly is assembled. To emphasize their importance, these five steps or adjustments are listed here as well as in the actual assembly procedure. These adjustments are:

1. Preload the pinion bearings.
2. Set pinion nominal dimension.
3. Set gear lash.
4. Preload the diff bearings.
5. Check gear tooth contact.

REASSEMBLY

When reassembling the rear axles, see also the exploded views (Figs. 23 and 24) for correct installation of parts.

FORWARD REAR AND REAR AXLES

Assemble Pinion and Cage

1. Place rear pinion bearings on pinion shaft and press into place against pinion.
2. Place pilot bearing on stud end of pinion shaft and press firmly against shoulder of pinion. Stake face of pinion shaft in six (6) evenly spaced places to secure pilot bearing in place (Fig. 25)

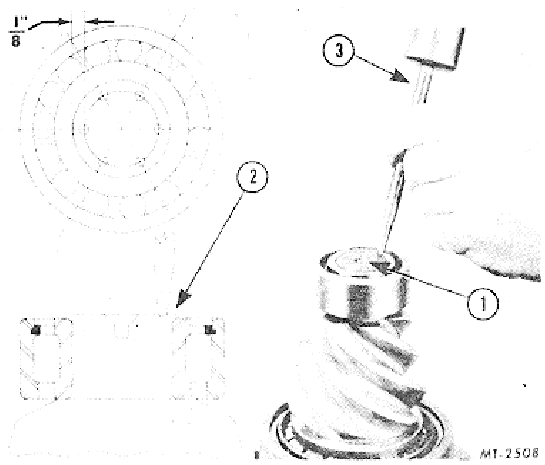


Fig. 25. Staking Pinion Pilot Bearing

1 Ground Face of Pinion
2 Metal Displaced to Secure Bearing
3 Blunt Point Punch

3. Pre-lubricate the bearings with rear axle gear lubricant.
4. Place bearing spacer on pinion shaft and press against rear pinion bearing.

> **IMPORTANT**
> The bearing spacer is furnished in various thicknesses in graduations of .025 mm (.001") to permit changing of spacer thickness to obtain correct pinion bearing preload.

5. Insert pinion (with rear pinion bearing and spacer) into pinion cage.
6. Mount pinion and cage in arbor press. Place pre-lubricated front pinion bearing on pinion.
7. Press bearing into place firmly against bearing preload spacer.
8. Revolve pinion cage around pinion several times to seat bearings correctly.
9. Remove pinion and cage from press.

Preload Pinion Bearing

Pinion bearing preload is established by selecting the correct size spacer located between the two pinion thrust bearings and tightening pinion end nut to the specified torque (see "Torque Chart").

1. Temporarily install companion flange on end of pinion shaft.

IMPORTANT

When preloading pinion bearings of forward rear axle, a spare companion flange and non-locking end nut in lieu of driven gear and flange nut for temporary installation on pinion.

Do not use flange type lock nut during bearing preload procedure.

2. Clamp pinion assembly in a vise so as to hold companion flange.

3. Rotate pinion cage while tightening end nut to specified torque (see "Torque Chart"). Rotation of cage is important so as to seat and align bearings, otherwise, a false condition of bearing load could exist. Bearing rollers must be seated against face of bearing cone (Fig. 26).

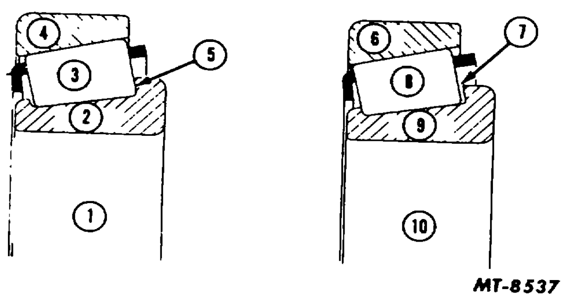


Fig. 26. Pinion Bearing Roller Position

1	Correct	6	Cup
2	Cone	7	Clearance
3	Roller	8	Roller
4	Cup	9	Cone
5	Roller Against Face of Cone	10	Incorrect

4. Measure bearing preload by wrapping a strong cord or soft wire about the pinion

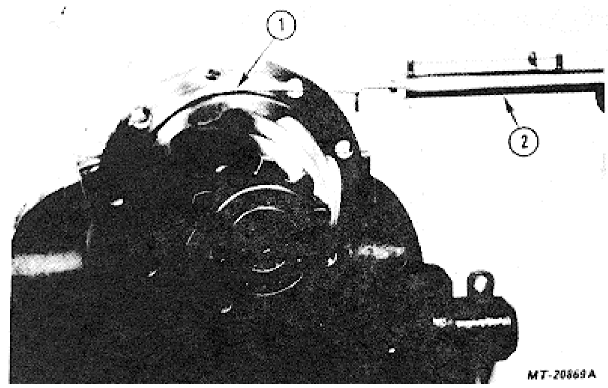


Fig. 27. Measuring Pinion Bearing Preload

1 Cord or Soft Wire Wrapped Around Pinion Cage
2 Spring Scale

cage and attach end to spring scale (Fig. 27). Read scale only while cage is rotating. Compare this scale reading with the figure shown in "Specifications".

When preload does not agree with Specifications bearing load may be increased by installing a thinner spacer or decreased by using a thicker spacer. Determine spacer thickness using a micrometer (Fig. 28) and make a new selection accordingly. Closer adjustment may be obtained by working spacer to desired thickness, using emery cloth on a flat surface.

5. Wash spacer clean of emery cuttings before installing on pinion.

After pinion bearing preload is established, good practice would be to check bearing roller ends to see whether they are in contact with bearing cone face. Use a feeler gauge ribbon. There must be no clearance at ends of rollers (Fig. 26).

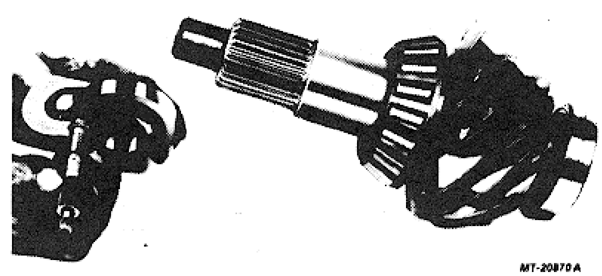


Fig. 28. Measuring Spacer Thickness

6. Remove end nut and companion flange.
7. FORWARD AXLE: Install pinion shaft driven gear and flange nut. Clamp pinion shaft driven gear in fixture or jaws of vise using jaw shields or other soft material to avoid damage to gear.

   REAR REAR AXLE: Install seal in pinion cage and place companion flange and flange nut on pinion shaft.
8. Tighten pinion flange nut to specified torque (see "Torque Chart").
9. Recheck pinion bearing preload.

Assemble Pinion and Cage to Differential Carrier

1. Place original shim pack on pinion cage and mount cage in diff carrier. Tap cage into place with a soft hammer.
2. Install pinion cage bolts and tighten to specified torque (see "Torque Chart").

Set Pinion Nominal Dimension

To establish pinion nominal dimension, which is the distance from the face or finished end of the installed pinion to the centerline of the ring gear or cross shaft, proceed as follows:

Obtain step plate and clamp assembly from SE-1065 Pinion Setting Gauge set and attach it to diff carrier flange, locating step plate clamp screw over center of pinion (Fig. 29).

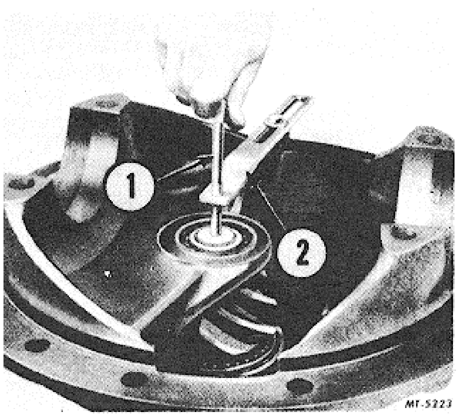


Fig. 29. Locating Step Plate Clamp

1 Step Plate Clamp Screw
2 Step Plate Clamp Asm.

Install step plate under clamp screw and tighten screw to hold step plate securely in position (Fig. 30).

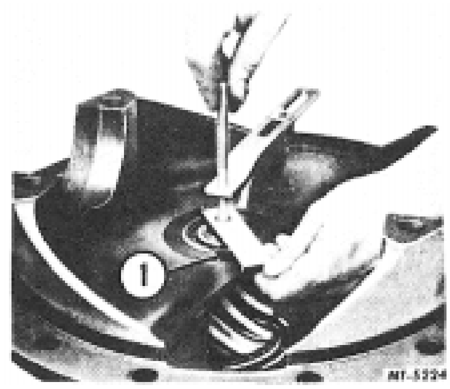


Fig. 30. Installing Step Plate

1 Step Plate

The step plate is necessary to project the face of the pinion where it can be measured by the gauge which is on the centerline of the drive gear.

IMPORTANT

Be certain lugs on step plate straddle the bearing staking indentations on end of pinion.

Mount assembled SE-1065 gauge in bearing bores of carrier (Fig. 31). See "Specifications" for correct disc size.

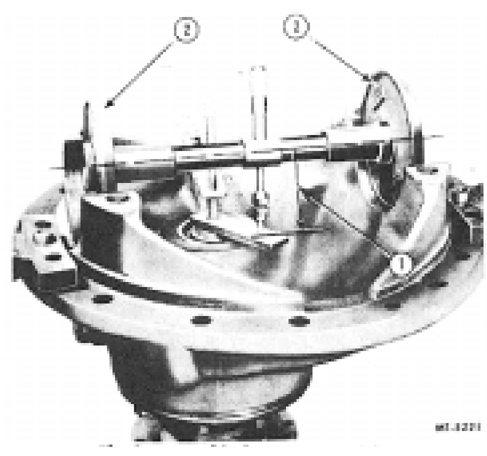


Fig. 31. Assembled Gauge In Position

1 Nominal Dimension Measured Here
2 Adapter Discs

Make certain that bearing bores are clean and free of nicks and burrs. Adjust micrometer so it is directly over end at a 90 deg. angle to step plate.

Run micrometer thimble down to measure distance between center of ring gear and step plate. Make a note of this reading along with the nominal dimension given in "Specifications". Locate on pinion the etched marking which indicates variation from zero cone setting. If it is a minus figure, subtract it from specified dimension, and if a plus figure, add it to specified dimension. Results of calculation will provide the corrected pinion nominal dimension to which pinion must be set. Comparison of corrected nominal dimension with the actual or measured-dimension indicates amount of change necessary for correct pinion position. It may be necessary to add or remove shims between pinion cage and diff carrier to provide correct pinion nominal dimension.

Remove gauge and prepare to install ring gear and differential to diff carrier.

Assemble Differential

1. If ring gear was removed from diff case, rivet gear to diff case flange. Use riveting fixture SE-2222 with hydraulic press (Fig. 32). Rivet pressures (tons) should be within the range given in "Specifications".

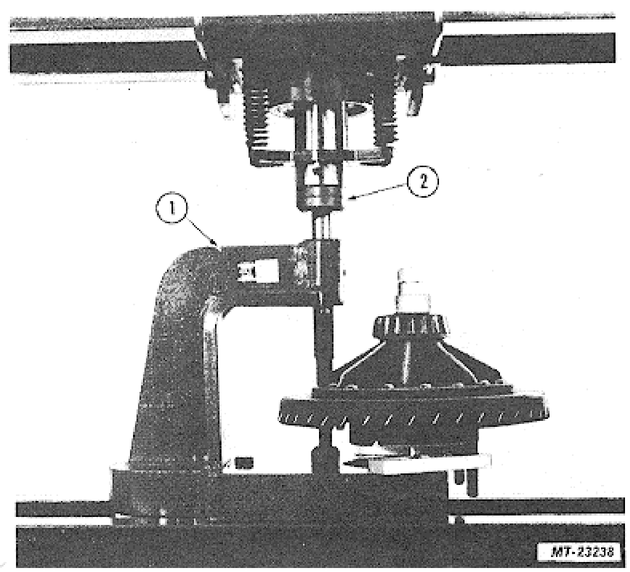


Fig. 32. Installing Drive Gear to Diff Case

1 Riveting Fixture SE-2222
2 Press Ram

2. Apply rear axle lubricant to the inner walls of the diff case halves and to all differential component parts.
3. Place side gear thrust washer and side gear in flanged half of diff case and assemble spider, spider gears and spider gear thrust washers to side gear.
4. Place opposite side gear and thrust washer in other half of diff case.
5. Align the match marks and assemble the diff case. Draw assembly together with four equally spaced bolts and nuts. Make sure side gears and spider gears mesh correctly.
6. Check for free rotation of side gears and spider gears. If satisfactory, install remaining diff case bolts and nuts.
7. Tighten diff case bolt nuts to specified torque (see "Torque Chart").
8. Install diff bearings by pressing them squarely onto diff case.

Install Differential On Diff Carrier

1. Pre-lubricate diff bearings with rear axle lubricant and place bearing cups over bearings.
2. Lift differential assembly and place into position in diff carrier. Tilt differential assembly to allow ring gear to pass pinion pilot bearing.
3. Place bearing adjusters in carrier and turn hand tight against bearing cups.
4. Assemble bearing caps to carrier. Align identifying marks on bearing cap and carrier leg.
5. Install bearing cap bolts and washers. Tighten to specified torque (see "Torque Chart").
6. Tighten bearing adjusters alternately until all end play is eliminated. Revolve differential while tightening bearing adjusters to correctly seat bearings.

Set Gear Lash

A special effort should be made to set the backlash between pinion and ring gear to the same amount as was originally built into them (.15-.3 mm or .006-.012"). Generally the amount of backlash is stamped or etched on the ring gear. When installing new gears, backlash is measured with a dial indicator mounted on differential housing (Fig. 33). To adjust the backlash move the ring gear toward or away from the pinion. This is done by backing off one adjusting ring and advancing the opposite ring the same amount.

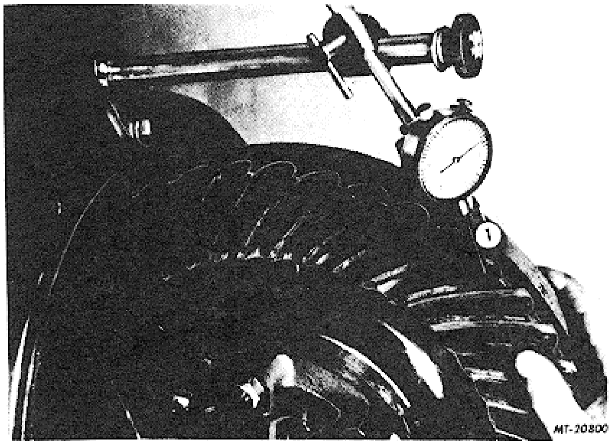


Fig. 33. Setting Gear Lash

1 Dial Indicator

When original gear and pinion sets are being reinstalled the wear pattern of the gear teeth must be considered in the backlash adjustment. Gears that have been in service for long periods form running contacts which should not be greatly changed. If, in checking backlash, the amount measured is in excess of the amount shown on the ring gear, the lash may be reduced only in the amount that will avoid overlap of the worn tooth section (Fig. 34). A slight overlap at the worn section will cause gear operation to be noisy and rough.

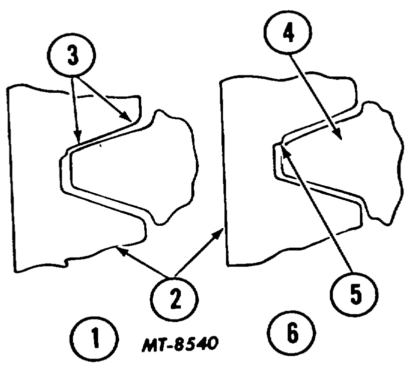


Fig. 34. Examples of Lash Adjustment Where Worn Gears Are Reinstalled

1 Correct
2 Ring Gear
3 Worn Section of Ring Gear
4 Pinion Too Deep in Ring Gear
5 Overlap
6 Incorrect

Preload Diff Bearings

To set the bearing preload, mount dial indicator at side of ring gear (Fig. 35). With the bearing capscrews loosened to permit bearing movement, loosen adjusting nuts only enough to notice end play on indicator.

> **IMPORTANT**
>
> While gear is held in .000 end play and before loading bearings, check gear for runout by revolving ring gear. If runout exceeds .2 mm (.08"), remove differential and check for cause.

Tighten both adjusting nuts from .000 end play to preload the differential bearings (see "Specifications").

Tighten bearing cap bolts to specified torque (see "Torque Chart").

Recheck gear lash to make certain that the lash setting has not been changed.

Install adjusting ring locks and cotter pins.

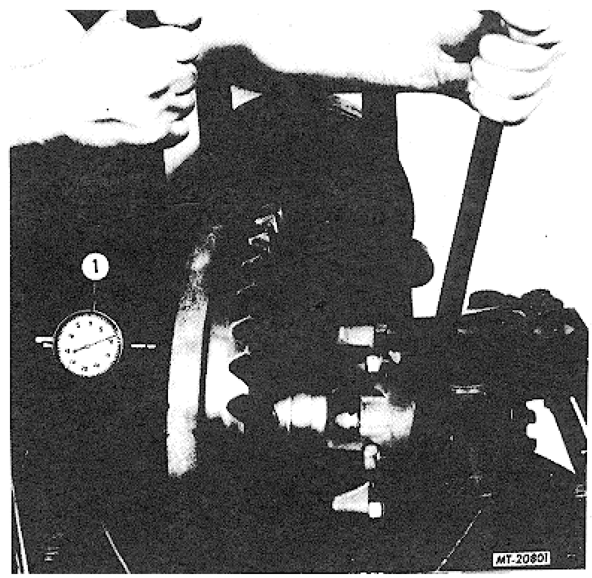


Fig. 35. Adjusting Bearing Preload

1 Dial Indicator

Check Gear Tooth Contact

The final check of differential assembly adjustment is checking the gear tooth contact by the paint impression method.

Apply oiled red lead lightly to the hypoid gear teeth. When the pinion is rotated, the red lead is squeezed away by the contact of the teeth, leaving bare areas the exact size, shape and location of the contacts (Fig. 36).

Sharper impressions may be obtained by applying a small amount of resistance to the gear with a flat steel bar and using a wrench to rotate the pinion. When making adjustments, check the drive side of the gear teeth. Coast side should be correct when drive side is correct. Generally, coating approximately twelve teeth is sufficient for checking purposes.

With adjustments properly made, a correct tooth contact similar to that shown in Fig. 36 will be secured. The area of contact starts near the toe of the gear and extends about 62 1/2 percent of the tooth length. This adjustment results in a quiet running gear and pinion set which, because the load is distributed over the teeth within the proper area, will deliver all the long service built into it.

When checking paint impressions on gear teeth of an axle under heavy load, the impressions usually spread out somewhat longer than the patterns obtained from a bench test. This can be considered as normal. Ring gears when mounted should show a bearing toward the toe or small end of the tooth, but never at the heel or large end. The reason being that it is practically impossible to make gears and gear mounting so rigid that no deflection will occur when full torque is applied. This deflection causes the bearing to approach the heel of the tooth. And when gears are adjusted so that the bearing is toward the heel of the tooth, it results in a concentration of load on the top corner of the heel and breakage will follow.

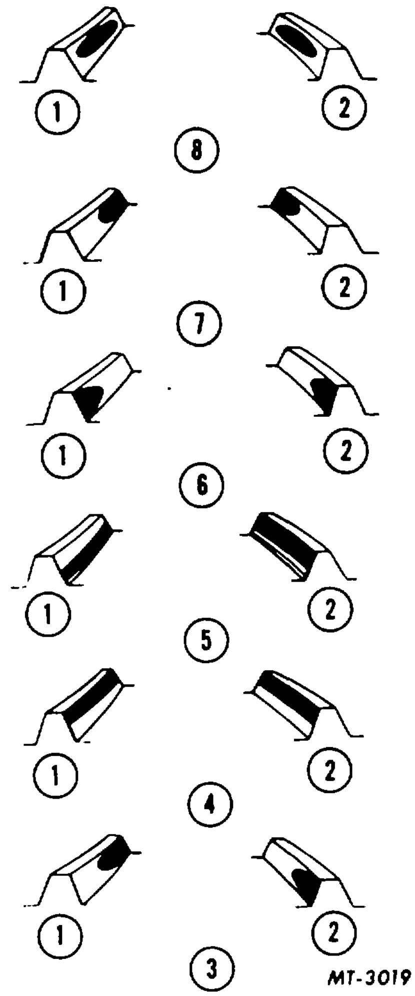


Fig. 36. Tooth Contact Impressions

1 Drive
2 Coast
3 Cross Bearing
4 Bearing Too High
5 Bearing Too Low
6 Too Much Heel Bearing
7 Too Much Toe Bearing
8 Proper Tooth Contact

FORWARD REAR AXLE

Assemble Inter-Axle Differential

1. If removed, apply a coating of rear axle lubricant to bushing and install in rear half of diff case using installer tool (SE-2024) and proper disc from (SE-1905) set to support diff case half. (Fig. 37).

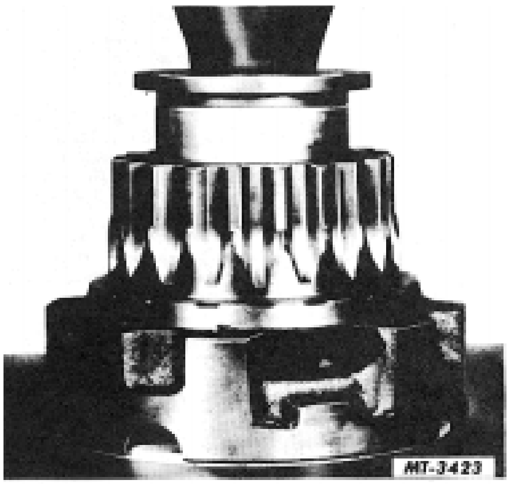


Fig. 37. Installing Bushing In Rear Half of Diff Case

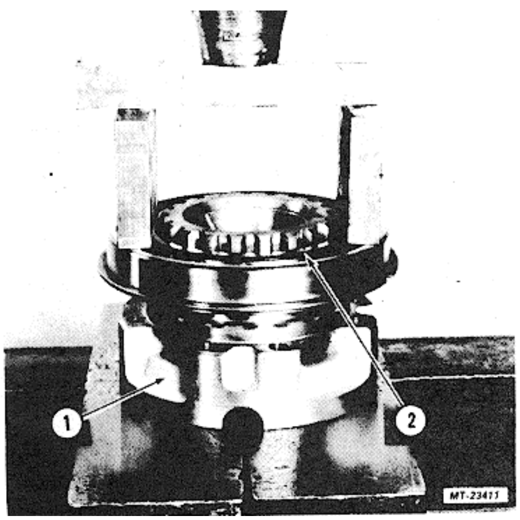


Fig. 38. Pressing Rear Bearing On Inter-Axle Diff Case - Rear Half

1 Diff Case (Rear Half)
2 Rear Bearing Inner Race

2. Press front and rear bearings onto case halves using suitable adapters and support blocks for inner bearing races (Figs. 38 and 39). When pressing front bearing on to case be certain large radius on inner race of bearing is next to case.

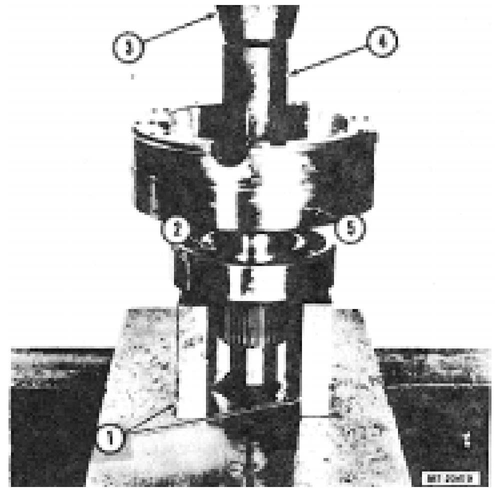


Fig. 39. Pressing Front Bearing On Inter-Axle Diff Case - Front Half

1	Support Blocks	4	Adapter
2	Front Bearing Inner Race	5	Diff Case (Front Half)
3	Press Ram		

3. Apply rear axle lubricant to diff case halves and to all differential component parts.

4. Position thrust washer and rear side gear in rear half of diff case.

5. Place spider, spider pinion gears and pinion gear thrust washers in position in rear half of diff case.

6. Position thrust washer and front side gear in front half of diff case.

7. Align the notch marks and assemble the diff case. Draw assembly together with four equally spaced bolts. Make sure side gears and spider pinion gears mesh correctly.

8. Check for free rotation of gears. If satisfactory, install remaining diff case bolts.

9. Tighten case bolts to specified torque (see "Torque Chart").

Establish Inter-Axle Diff-To-Cover (Now Cone) End Play

Diff case-to-cover (nose cone) end play is controlled by shims placed between the front bearing and the diff cover, as shown in Fig. 40. The instructions below tell how to determine the thickness of shims required to keep end play within specified limits.

The following instructions show the intermediate case removed from the diff carrier; however, a similar procedure can be followed to determine the shim thickness while the intermediate case is mounted on the diff carrier. Be careful to prevent differential from falling to avoid personal injury or damage to parts.

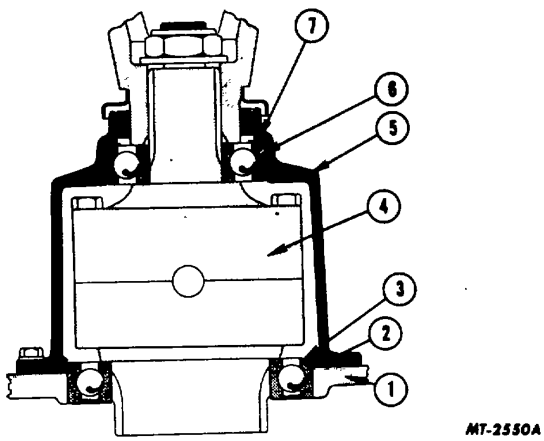


Fig. 40. Cross-Section Showing Shims Used To Control Inter-Axle Diff End Play

1 Intermediate Case
2 Snap Ring
3 Rear Bearing
4 Inter-Axle Differential
5 Cover
6 Front Bearing
7 Shims

1. Position diff case in intermediate case by inserting rear bearing into bearing bore of intermediate case. Tap on end of input shaft with a fiber or plastic hammer (do not use soft metal hammer) to seat rear bearing snap ring firmly against intermediate case.
2. Assemble diff cover to diff case. Do not include shims, diff cover gasket, or diff cover oil seal. Tap cover with a soft hammer to seat cover firmly against intermediate case.
3. Using a feeler gauge, measure clearance between front bearing and cover. This clearance represents the total amount of case-to-cover end play. Note and record this amount.
4. To determine the thickness of shims required to obtain the specified end play, subtract the amount of permissible end play .00-.12 mm (.000-.005") from the total end play found in step 3 above. For Example:

Total End Play (per step 3) .70 mm (.028")
Minus Specified End Play .000-.12 mm
(.000-.005")
Leaves Required Shim .58-.70 mm
Thickness Range of . . . (.023-.028")

Shims are furnished in thicknesses of .13 to .25 mm (.005 and .010"). Select a shim pack with a total thickness within the range of required thickness found above.

Two .25 mm (.010") shims
plus one .13 mm (.005")
shim total . . . . 63 mm (.025")
Which is within the required
thickness range of. . . . 58-.70 mm
(.023-.028")

Thus:
Total End Play (per step 3) .70 mm (.028")
Minus Thickness of Shim
Pack .63 mm (.025")
Leaves Final End Play of .07
mm (.003") and is within the
specified limits of .000-.12 mm
(.000-.005") . . . . . . .07 mm (.003")

5. Remove the differential cover from intermediate case and position shim pack (as determined above) between front bearing and cover (Fig. 41).
6. Replace cover on intermediate case making sure shims are centered on bearing race to avoid pinching shims between cover and O.D. of bearing. Tap cover with a soft hammer to seat cover firmly against intermediate case.
7. Check end play by measuring clearance between the shims and the cover. Clearance (end play) should be within specified limits.

   While .000 end play is permissible, it is important that the bearings not be loaded with side thrust. Therefore, end play between specified limits is desired.

8. After determining amount of shims required to obtain correct end play, remove diff cover and remove the inter-axle differential (with bearings) from the intermediate case.

9. Press oil seal into diff cover (see Fig. 42). Press oil seal into cover until outer face of seal is flush with end of cover.

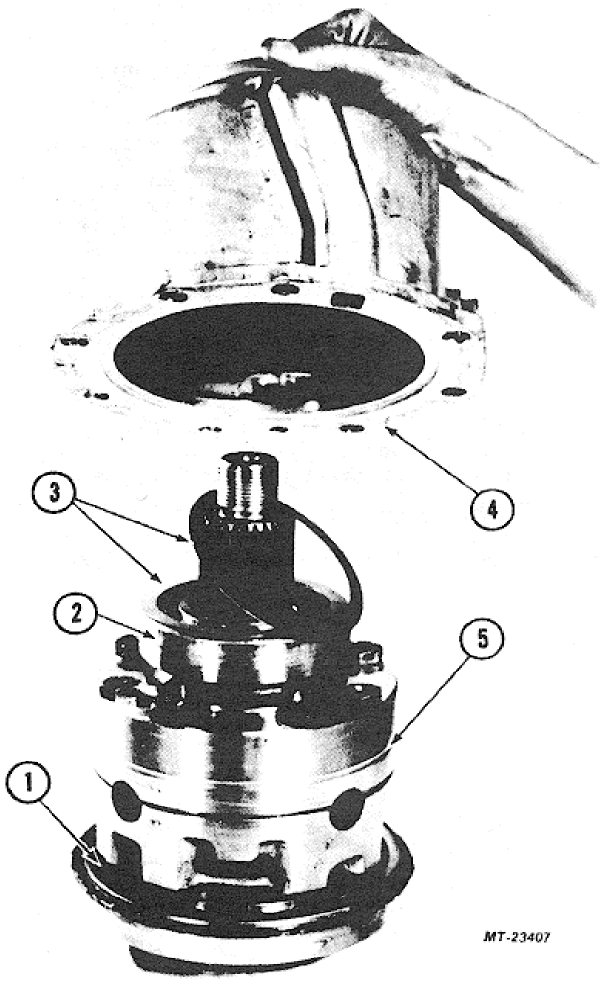


Fig. 41. Shims for Limiting Differential Case-To-Cover (Nose Cone) End Play

1 Rear Bearing
2 Front Bearing
3 Shims
4 Cover
5 Inter-Axle Differential

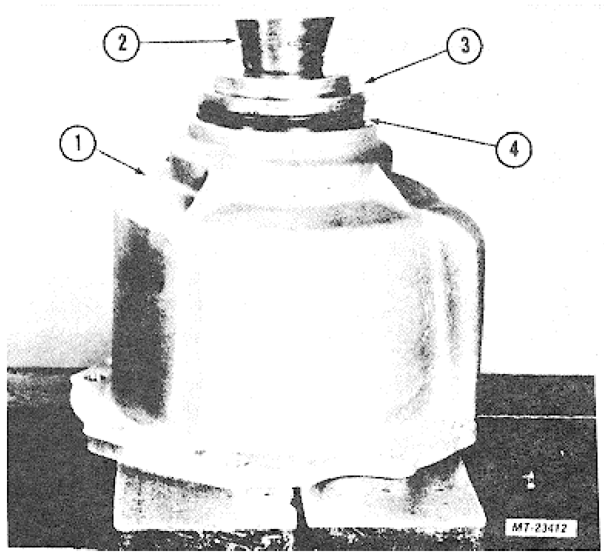


Fig. 42. Installing Inter-Axle Diff Cover oil Seal

1	Cover	3	Installer
2	Press Ram	4	Seal

10. With shim pack in position on bearing, install diff cover (with oil seal) on diff case.

11. Install input flange, washer and end nut.

12. Using suitable flange holder tool or by clamping assembly in vise (Fig. 43), tighten end nut to specified torque. (see "Torque Chart")

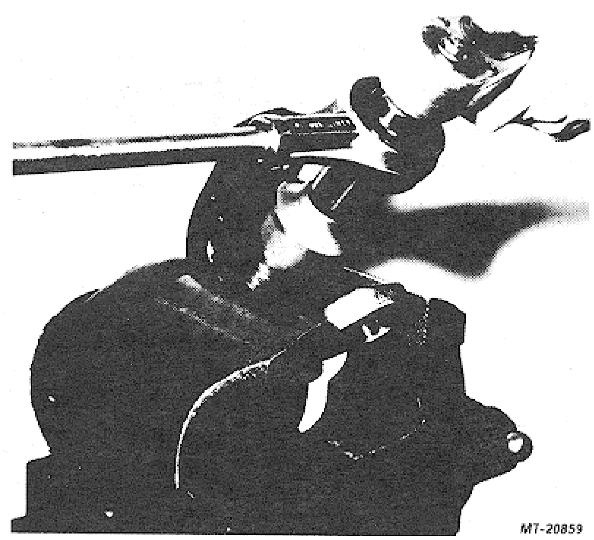


Fig. 43. Tightening Companion Flange Nut

Assemble Power Divider Intermediate Case

1. Assemble idler shaft bearings, bearing races and bearing spacer to idler gear. On models RA-351 and 355, position the bearing spacers correctly to index oil groove in rear spacer with oil passage in idler shaft (see Fig. 44).

2. Position idler shaft in intermediate case so flats on rear of shaft will index with flats in differential carrier.

3. Support front face of intermediate case and press idler shaft into position.

4. Install idler shaft end nut and washer. Tighten nut to specified torque, Use flats on end of shaft to hold shaft from turning while tightening nut.

5. Using a dial indicator, check end play of idler gear. End play should be within specified limits. (See "Specifications. ")

6. If end play is not within specified limits, remove idler shaft and idler gear and change the bearing spacer. End play can be reduced by installing a thinner spacer or increased by installing a thicker spacer. Determine spacer thickness with micrometer and make new selection accordingly.

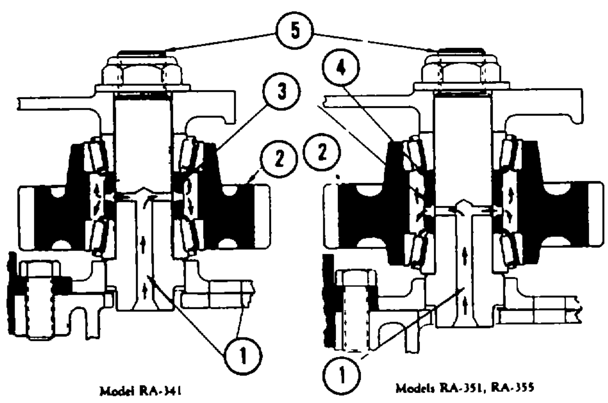


Fig. 44. Cross Section Of Idler Shaft Installation

1 Lubricant Passage
2 Idler Gear
3 Spacer - End play controlled by thickness of this spacer
4 Thin spacer must be installed in this location
5 Idler Shaft

While .000 end play for idler shaft is permissible, it is important that bearings not be loaded with side thrust. Therefore, end play between specified limits is desired.

7. Assemble and install input gear.

<u>RA-341:</u>

a. Press bearing on input gear.
b. Install bearing retaining nut. Clamp gear in vise and tighten retainer nut using SE-2247 wrench (Fig. 45). Tighten to specified torque. Use punch to stake nut to gear end.
c. Check input gear bearing end play with a dial indicator ,025-.076 mm (.001-.003"). Use bearing spacers as required to obtain correct end play.
d. When end play is correct and retainer nut is final torqued, stake retainer nut at milled slot in input gear.
e. Position gear and bearing assembly in intermediate case. Support rear face of case and press bearing into case bearing bore. Press bearing to rear sufficiently to install bearing snap ring.
f. Install snap ring on bearing and press bearing and gear forward until snap ring seats firmly against shoulder of case.

<u>RA-351 and 355:</u>

a. Using bearing spacer previously removed for a trial assembly, install bearings and cage on input gear and clamp assembly in vise.
b. Install bearing retaining nut and, using SE-2247 bearing nut wrench, tighten to specified torque (Fig. 45). Use punch to stake nut to gear end.
c. Install input gear bearings and bearing retainer into intermediate case. Secure cage with six hex bolts. (See "Torque Chart") .

Assemble Output Shaft

1. Support output shaft bearing and press output shaft into bearing.
2. Tap bearing case of retainer over bearing and secure with snap ring.
3. Install seal in bearing case.
4. Install flange and end nut.

5. Clamp flange in vise or use flange holder tool and tighten output shaft end nut to specified torque. (See "Torque Chart".)

Assemble Inter-Axle Differential To Intermediate Case

1. Position diff lock clutch shift collar on input gear (Fig. 46).

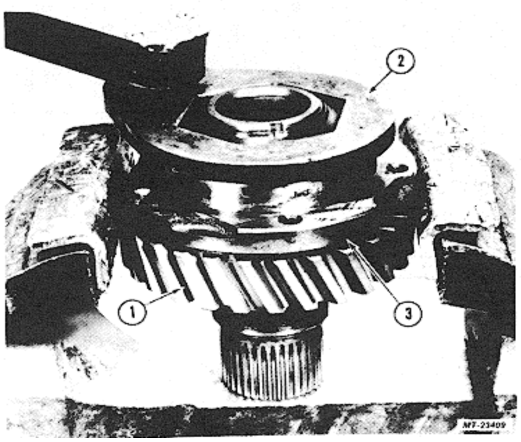


Fig. 45. Tightening Input Gear Bearing Retaining Nut (RA-351, 355 Shown RA-341 Similar)

1 Input Gear
2 Bearing Nut Wrench
3 Bearing Retainer

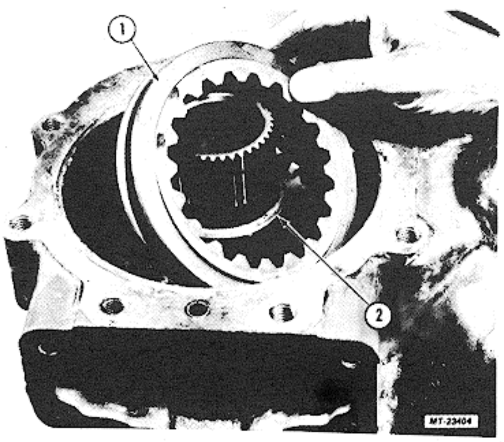


Fig. 46. Installing Clutch Shift Collar

1 Clutch Shift Collar
2 Input Gear

2. Apply a 3 mm (1/8") bead of gasket sealant on intermediate case.

3. Position inter-axle differential assembly on intermediate case (Fig. 47). Make sure teeth on rear of differential mesh with clutch shift collar previously installed.

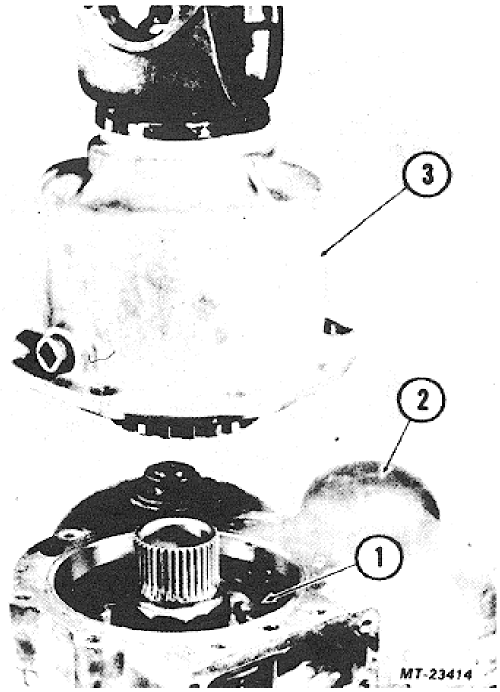


Fig. 47. Installing Inter-Axle Differential

1 Clutch Shift Collar
2 Intermediate Case Assembly
3 Inter-Axle Differential Assembly

4. Install diff cover bolts. Tighten to specified torque. (See "Torque Chart".)

Install Intermediate Case And Inter-Axle Differential To Diff Carrier

1. Apply a 3 mm (1/8") bead of gasket sealant on intermediate case.

2. Position intermediate case assembly on diff carrier (Fig. 48). Make sure flats on end of idler shaft index with flats in carrier.

3. Install intermediate case bolts. Tighten evenly to specified torque. (See "Torque Chart".)

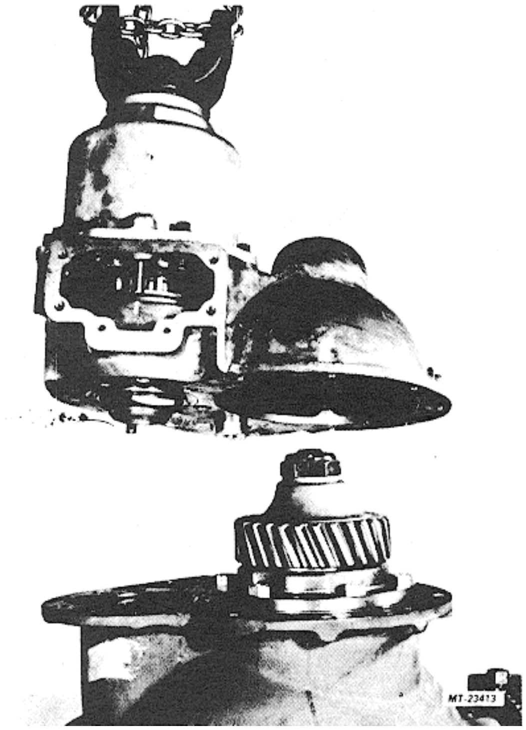


Fig. 48. Installing Intermediate Case To Diff Carrier

Install Power Divider Lockout Control Assembly

1. Apply 3 mm (1/8") bead of gasket sealant on intermediate case opening and install lockout control housing assembly.
2. Install lockout control housing mounting bolts. Tighten to specified torque (See "Torque Chart").

Assemble Power Divider And Diff Carrier To Axle Housing

1. Support carrier assembly on roller jack. Secure as necessary to prevent carrier assembly from falling from jack.
2. Apply 3 mm (1/8") bead of gasket sealant on axle housing.
3. Align carrier assembly with axle housing and roll into position. A small pinch bar may be used to straighten carrier in housing but be careful to avoid damage to carrier or axle housing.
4. Install carrier mounting stud nuts and tighten evenly to specified torque. (See "Torque Chart".)
5. Place liquid gasket on axle housing mounting face and insert output shaft into position. Rotate output shaft slightly to mesh shaft splines with inter-axle differential side gear.
6. Install bearing retainer bolts. Tighten to specified torque 41-52 N-m (30-38 ft. lbs.)
7. Install axle shafts. Tighten axle flange bolts to 295-326 N-m (217-240 ft. lbs.)
8. Connect propeller shaft to output shaft.

IMPORTANT

When installing propeller shaft connecting forward and rear rear axles of the tandem, the slip yoke splines of shaft must be toward front.

9. Connect power divider lockout control. Refill axle with lubricant (See Lubrication).

REAR REAR AXLE

Install Diff Carrier To Axle Housing

1. Using chain sling and hoist, move diff carrier from rebuild stand to roller type floor jack.
2. Apply liquid gasket to carrier flange and roll the carrier into position on axle housing.
3. Install housing bolts and tighten to specified torque 217-240 N-m (160-175 ft. lbs.).
4. Connect propeller shaft to companion flange and install axle shafts.
5. Insert drain plugs and fill housing with prescribed quantity and type of new lubricant.

POWER DIVIDER LOCK

OPERATION

During normal operation the power divider lock is kept in the disengaged position. In this position the inter-axle differential of the power divider allows both axles of the tandem to differentiate or drive independent of each other.

When maximum traction is required such as for pulling through deep sand, mud or snow, the lockout control on dash is operated to engage the power divider lock. This activates the shift fork shaft and fork in power divider to lock up the inter-axle differential and provide positive drive to both forward and rear axle units.

The lockout mechanism must be engaged only when the truck is standing still. It should be kept engaged only as long as positive traction is required. Continuous unnecessary engagement will result in excessive tire wear and may damage the axles.

The power divider lockout is controlled by either a valve or switch on the vehicle instrument panel. A "tell-tale" warning light is also provided on instrument panel to indicate when power divider lock is engaged.

Three different kinds of power shift systems are used to actuate the power divider lock. These systems are covered in paragraphs which follow.

ELECTRIC SHIFT SYSTEM

The electric shift system consists of an electric powered motor unit mounted on the forward rear axle with a control switch on dash.

For complete information on the electric shift system (Maintenance, Trouble Shooting, Rebuild, etc. See REAR AXLES CTS-4041 in the Service Manual).

VACUUM SHIFT SYSTEM

The vacuum shift system consists of a vacuum power unit mounted on the forward rear axle with a control valve located on the instrument panel. The power source for the vacuum shift system is vacuum from the engine intake manifold for gasoline engines or a vacuum pump for diesel engines. If either the vacuum power unit or vacuum control valve are defective they must be replaced.

AIR SHIFT SYSTEM

The air shift system consists of an air power cylinder mounted on the forward rear axle with an air control valve on the instrument panel. The power divider lock is disengaged by air pressure and spring controlled for engagement ("lock in").

When the PDL (Power Divider Lock) control is placed in the "lock" position air in the system is exhausted and the PDL will shift to the "lock" mode.

When the PDL control is placed in the "unlock" position, air pressure will hold the PDL in the disengaged mode.

The air control valve, control cylinder, hoses and pipe connections of air control systems should be inspected periodically for leakage and other repairs. At time of axle overhaul, control cylinder and control valve should be inspected carefully and worn or damaged parts replaced.

MAINTENANCE

AXLE SHAFTS

Axle failure can also be attributed to the axle shaft. For this reason it is most important that shafts be installed properly, be of correct size and lengths for splines to engage fully and be kept free from runout or bends.

AXLE HOUSING

The axle housing is of one piece construction with an opening in the center for mounting the diff carrier. A flange is welded to the outer ends of the axle housing for mounting the brake backing plates. A bent axle housing can be the cause of early axle failure and whenever an axle is rebuilt this condition should always be checked before going ahead with the assembly.

The condition of axle housing cover weld should also be checked. If cover weld is cracked, oil seepage from housing can occur. Re-welding of housing cover is permitted providing special cleaning precautions and recommended welding procedures are observed.

Procedure for repairing cracked weld or leaking housing cover is as follows:

1. Drain differential and remove diff carrier assembly.
2. Clean lube from inside of housing and burn remaining lube from inside with torch.
3. Clean residual lube from housing with solvent.
4. Grind or air arc cracked weld from outside of cover weld to base metal.
5. Weld three passes around outside of cover using 1/8" Spec. No. E7016 Weld Rod and supplier’s recommended amperage and voltage. Thoroughly clean weld area between passes.

6. Weld one pass around cover (360 degree) inside housing using same weld rod as above.

7. Remove all weld splatter and slag from inside of housing and return housing to service.

LUBRICATION

Draining And Refilling Instructions

To drain axle lubricant from forward axle and power divider, remove drain plugs from bottom of axle housing and bottom of the power divider intermediate case.

To drain the rear rear axle, remove the drain plug from the axle housing.

To fill the forward rear axle, make sure all drain plugs are tight. Pour 0.5 liter (1 pint)of lubricant into the power divider at plug on top of inter-axle diff cover. Fill axle housing to the level of filler hole.

To fill rear rear axle, make sure all drain plugs are tight. Fill to level of filler hole. On initial lubrication of new or rebuilt axles, pour 0.5 liter (1 pint) of lubricant into pinion bearing cage at filler plug provided in differential carrier.

To assure initial lubrication of rebuilt axle assemblies, it is recommended that the axles be "run-in" to distribute the lubricant. This is accomplished by raising and securely blocking all rear wheels off the floor and operating the axles at medium speed for approximately two to three minutes. After running in axles, recheck lubricant level.

Slip Joints

The propeller shaft slip joint splines must be free to slip as required to compensate for articulation of the axles. Keep slip joints lubricated. When operating under dusty, wet or muddy conditions, more frequent lubrication of the propeller shaft may be required. Inspect slip yoke dust seals and replace worn or damaged seals to prevent entry of dirt or moisture which might cause binding or seizing of slip joint splines.

SPECIAL TOOLS	
SE-1065-A	Pinion Gauge
SE-1065-64	Pinion Gauge Discs
SE-1905	Remove and Installer Set
SE-1933	Torque Multiplier Wrench
SE-2024	Installer Tool
SE-2222	Riveting Fixture
SE-2247	Bearing Nut Wrench

TROUBLE SHOOTING

Serious trouble in a rear axle can be prevented if sufficient attention is given to the various causes of trouble and the proper remedy is applied. The following list gives most of the common kinds of axle trouble and suggests a possible cause to be corrected.

Constant Noise

1. Lubricant not to specified level.
2. Incorrect kind and weight of lubricant.
3. Wheel bearings out of adjustment or defective.
4. Drive gear and pinion not in adjustment for correct tooth contact.
5. Teeth of drive gear and pinion chipped or worn.
6. Too much or too little pinion to gear backlash or overlap of wear pattern.
7. Loose or worn pinion bearings.
8. Loose or worn side bearings.

Intermittent Noise

1. Drive gear does not run true.
   - (a) Uneven pressure on drive gear rivets.
   - (b) Warped drive gear.
2. Loose or broken differential bearings in either axle or in inter-axle differential.

Noisy On Turns Only

1. Differential pinion gears tight on differential spider.
2. Side gears tight in differential case.
3. Differential pinion or side gears defective.
4. Thrust washers worn or damaged.
5. Excessive backlash between side gears and pinions.

It should be noted that noises from other units of the truck such as propeller shafts, universal joints, tires and even transmissions are often incorrectly diagnosed as rear axle noise. This possibility should not be disregarded when trouble shooting.

Lubricant Leaks

1. Loss through axle shafts.
   - (a) Lubricant above specified level.
   - (b) Incorrect kind and weight of lubricant.
   - (c) Restricted axle housing breather valve.
   - (d) Worn or incorrectly installed axle shaft oil seal.
2. Loss at pinion shaft.
   - (a) Lubricant above specified level.
   - (b) Incorrect kind and weight of lubricant.
   - (c) Restricted axle housing breather valve.
   - (d) Pinion oil seal worn or incorrectly installed.
   - (e) Lubricant return passage in diff carrier housing restricted.
   - (f) Universal joints companion flange loose on pinion shaft.
3. Loss at axle housing cover.
   - (a) Insufficient or defective seam weld.
   - (b) Cracked seam weld.

Rear Wheels Do Not Drive (Propeller Shaft Rotating)

1. Broken axle shaft.
   - (a) Loose wheel bearings.
   - (b) Axle shaft too short.
   - (c) Loose flange studs or nuts.
   - (d) Bent housing.
2. Drive gear teeth stripped.
3. Side gear or differential pinion broken in either axle or in inter-axle differential.
4. Differential spider broken in either axle or in inter-axle differential.

SPECIFICATIONS

IH MODEL / IH CODE		RA-341 14341	RA-351 14351	RA-355 14355
LOAD RATING:	Metric Ton lbs	13.5 30000	15.2 34000	17.3 38000
PINION:				
Nominal Dimension	mm in	88.20 3.4725	95.75 3.7695	
SE-1065 Disc (Pinion Setting Gauge)		D(2)	0(2)	
Pinion Bearing Preload (Cage Rotating Torque)	Kgs lbs	1.35-3.6 3-8		
DIFFERENTIAL:				
Bearing Preload (Notches)		1 Ea. Side	1 1/2 Total Both Sides	
Drive Gear To Pinion Backlash	mm in	.20 .008	.25 .010	
Drive Gear Rivet Pressures	Metric Ton U.S. Ton	40.8-45.3 45-50		
POWER DIVIDER:				
Idler Gear Bearing End Play	mm in	.00-.07 .000-.003		
Inter-Axle Diff End Play	mm in	.000-.012 .000-.005		
Input Gear Bearing End Play	mm in	.03-.08 .001-.003		
AXLE HOUSING:				
Lubricant Capacity Forward Rear Axle*	liters pints	11.4 24	10.4 22	
Rear Rear Axle*	liters pints	12.3 26	11.4 24	
SERIAL NUMBER LOCATION		On Bolt Circle of Diff Carrier		

* Pour 0.5 Liter (1 pint) of total through filler hole in top of nose cone on forward axle or top of pinion on rear- rear axle.

TORQUE CHART

IH MODEL	RA-341		RA-351		RA-355	
	N-m	Ft lbs	N-m	Ft lbs	N-m	Ft lbs
Input Shaft End Nut	1 1/4-12		1 1/4-12		1 1/4-12	
	510-575	375-425	510-575	375-425	510-575	375-425
Inter-Axle Diff Case Bolts	1/2-13		1/2-13		1/2-13	
	102-115	75-85	102-115	75-85	102-115	75-85
Inter-Axle Diff Cover Bolts	1/2-13		1/2-13		1/2-13	
	96-115	70-85	96-115	70-85	96-115	70-85
Idler Shaft Nut	1 1/8-12		1 1/8-12		1 1/8-12	
	339-407	250-300	339-407	250-300	339-407	250-300
P.D. Case to Diff Carr. Bolts	1/2-13		1/2-13		1/2-13	
	96-115	70-85	96-115	70-85	96-115	70-85
P.D. Input Gear Brg. Ret. Nut	2 1/2-16		2 1/2-16		2 1/2-16	
	540(min)	400(min)	540(min)	400(min)	540(min)	400(min)
Pinion End Nut	1 1/8-18		1 3/4-12		1 3/4-12	
	441(min)	325(min)	1225-1675	900-1200	1225-1675	900-1200
Pinion Cage to Carrier Bolts	9/16-12		9/16-12		9/16-12	
	155-170	115-125	155-170	115-125	155-170	115-125
Diff Carrier to Housing Bolts	5/8-11		5/8-11		5/8-11	
	217-240	160-175	217-240	160-175	217-240	160-175
Diff Case Bolts	9/16-18		9/16-18		9/16-18	
	162-176	120-130	162-176	120-130	162-176	120-130
Diff Brg. Cap to Carrier Bolts	3/4-10		3/4-10		3/4-10	
	370-405	275-300	370-405	275-300	370-405	275-300
Axle Flange to Wheel Stud Nuts	5/8-18		5/8-18		3/4-16	
	170-195	125-145	170-195	125-145	236-290	175-215
Inter Axle Lockout Cyl. Mtg. Bolts	3/8-16		3/8-16		3/8-16	
	41-51	30-38	41-51	30-38	41-51	30-38
Output Shaft Brg Retainer Bolts	3/8-16		-/8-16		3/8-16	
	41-51	30-38	41-51	30-38	41-51	30-38
Output Shaft End Nut	1 1/4-12		1/4-12		1 1/4-12	
	510-575	375-425	510-575	375-425	510-575	375-425
Lockout Cylinder Piston Bolt	3/8-24		3/8—24		3/8-24	
	21-27	15-20	21-27	15-20	21-27	15-20
Lockout Cylinder Cover Bolt	1/4-20		1/4-20		1/4-20	
	9.5-12	7-9	10-12	7-9	10-12	7-9

FUEL TANKS

CONTENTS

Subject	CTS No.

NOTE: No Service Manual Section with FUEL TANKS application available at this time.

CABS

CONTENTS

CAB

S-SERIES

CONTENTS

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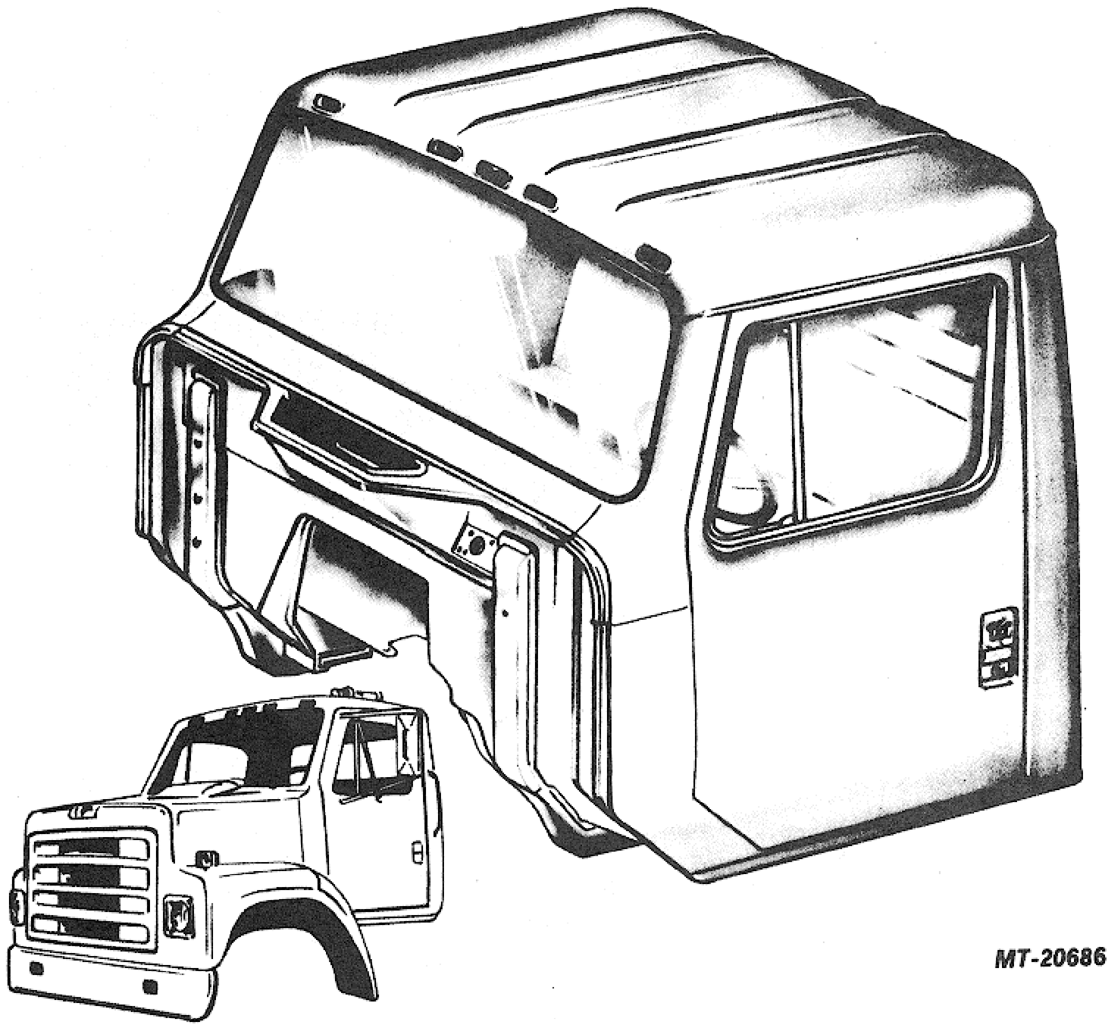

Fig. 1. S-Series Conventional Cab

GENERAL

The S-Series mid-range conventional cab shown here in Figure 1 and covered in this manual is available in either 200 or 230 cm width (80 or 90 inch) and for three different bumper to back of cab (B. B. C.) dimensions.

This manual has been prepared to help servicemen maintain cab in its original condition or restore cabs which may have sustained damage.

CONTROLS - INSTRUMENT PANEL

While there is a wide range of optional equipment available on the S-Series models for which this cab is used, all instruments, gauges and driver controls are located for driver convenience. Fig. 2 shows the cab interior and a typical instrument panel installation. Removable panels provide for easy access to speedometer, cables, gauges, bulbs, wiring, plumbing, switches, valves, etc.

CAUTION
Always disconnect battery ground before servicing or removing instrument panel.

For further information on S-Series instrument panel see INSTRUMENTS.

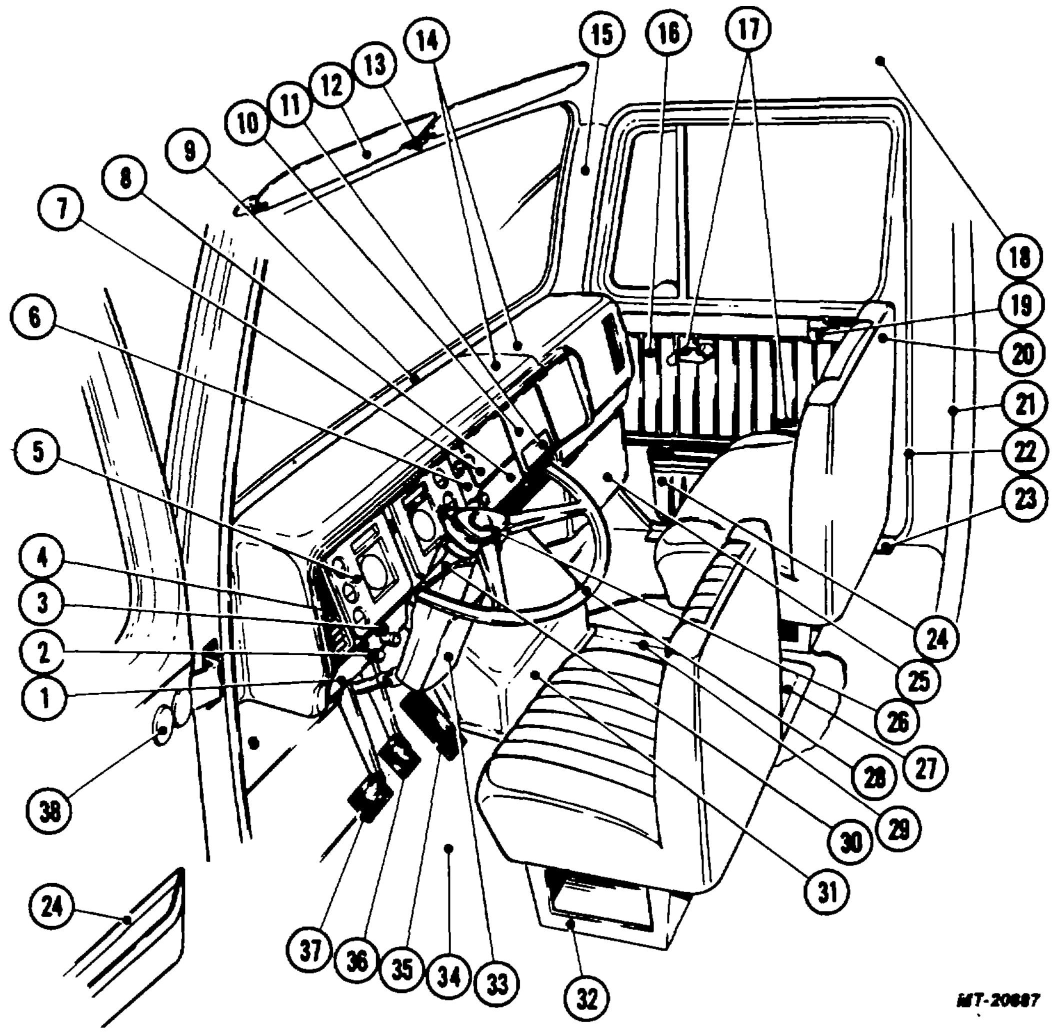

Fig. 2. S-Series Cab Interior View (Typical)

Key	Description	Key	Description	Key	Description
1	Lower Instrument Panel	14	Instrument Panel Cover	27	Transmission Cover
2	Control Knobs	15	Hinge Pillar Access Cover	28	Steering Wheel
3	Name Plate	16	Door Trim Panel (Custom)	29	Shift Lever
4	Air Conditioning Louver	17	Door Hardware	30	Turn Signal Lever
5	Instrument Cluster	18	Headliner	31	Engine Cover
6	Instrument Panel	19	Arm Rest	32	Seat Riser
7	Air Control Cluster	20	Seat	33	Steering Column
8	Heater/Air Conditioner Control	21	Back Inner Trim Panel	34	Floor Mat
9	Defroster Panel	22	Door Trim Strip	35	Accelerator Pedal
10	Radio Panel	23	Scuff Plate	36	Brake Pedal
11	Ash Tray	24	Manifest Pocket, Vinyl or Metal	37	Clutch Pedal
12	Sun Visor	25	Heater	38	Button Plug, Hinge Cover
13	Sun Visor Clip	26	Horn Button		

SERIAL NUMBER LOCATIONS

Serial numbers are necessary if the need for replacement parts should occur. For this reason you will want to know the location for these important numbers. S-Series chassis serial numbers are located on face of cab lock pillar. S-Series cab serial numbers are located at top right of cow-front panel.

MAINTENANCE

Most service requirements, disassembly procedures or adjustments, on this cab and hood can be performed with ordinary mechanic's hand tools. Illustrations and suggested procedures for helping the mechanic are covered in paragraphs which follow.

HOOD AND HINGE MOUNTINGS

Tilt type hoods (Figs. 3 & 4) used with S-Series cabs are one-piece molded fiberglass units. While they may vary slightly in size, appearance and hinge mounting, they are similar in servicing as follows:

HOOD OPENING (TILTING)

The hood assembly is hinged near bumper and can be tilted by releasing hood latches on cowl panels. Place foot on bumper step, grasp handle recess and pull complete hood, fenders and grille assembly to front. There are two hood stop cables to prevent over-travel of hood.

To lower hood, push the hood towards cab and at the same time hold back at handle recess to ease the hood into traveling position. Secure both hood latches at cowl panels. Do not allow hood to drop into place or damage can result.

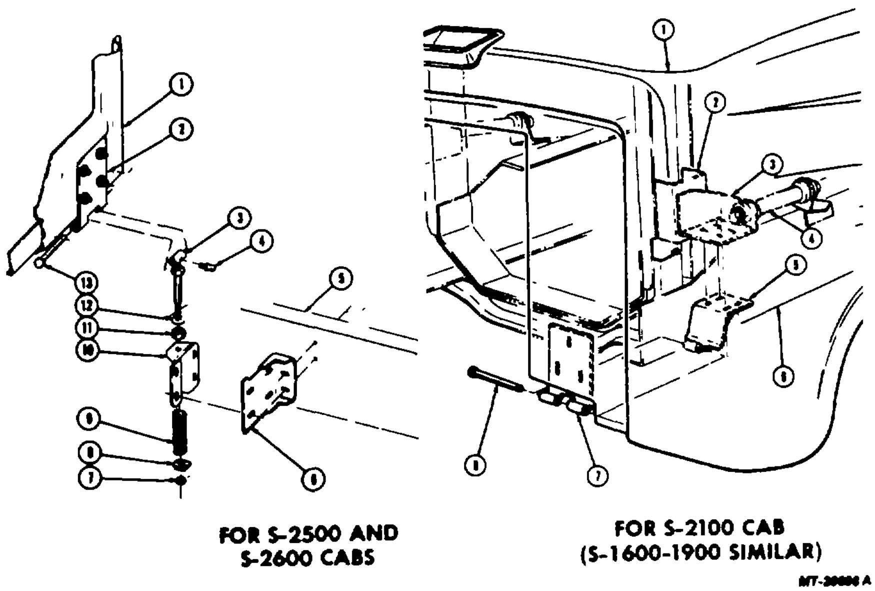

Fig. 4. Hood Hinge Types For 200 Cm (80 Inch) Wide Cabs

Key	Description
1	Hood, Assembly
2	Hinge, Hood Half
3	Hinge, Frame Half
4	Lubricator
5	Sidemember, Frame
6	Bracket, Hinge-to-Frame
7	Nut, Slotted
8	Spacer
9	Spring, Tension
10	Bracket, Hinge
11	Insulator
12	Washer
13	Pin, Hood Hinge

Key	Description
1	Hood, Assembly
2	Support, Radiator
3	Bracket, Stay Rod Mounting
4	Rod, Stay
5	Hinge, Frame Half
6	Sidemember, Frame
7	Hinge, Hood Half
8	Pin, Hood Hinge

HOOD REMOVAL

1. Release hood latches on each side of cowl and tilt hood assembly forward.
2. Support tilted hood on floor stands or saw horse to relieve tension on hood stop cables. Protect paint from scratches.
3. Remove spring type pins and cable end pins (one for each cable) and detach stop cables from hood stop brackets at top of radiator.
4. Disconnect headlight wiring harness from connector on underside of hood.
5. Remove spring type pin and hinge pin from the two hood hinge assemblies and detach hood from chassis.
6. Hood-to-frame hinge mounting details for the various size hoods are shown in Figs. 3 and 4.

FIBERGLASS REPAIR

Refer to fiberglass repair instruction section.

HOOD INSTALLATION

Hood installation is the reverse of the foregoing removal procedure. Before final tightening of hood mounting bolts, check hood adjustment.

HOOD ADJUSTMENT

When making any adjustment to tilt hood, inspect hood alignment and clearance between hood and cowl. Elongated mounting holes in frame half of hood to frame hinges provide for hood adjustment. If adjustment is required, loosen hinge to frame mounting bolts and adjust hood to cowl clearance as necessary. Tighten mounting bolts to specified torque (see Torque Chart).

CAB DOORS (FIG. 5)

Doors used on the S-Series cab are of all steel-welded construction with access panel and button plug openings for making hinge adjustments or removal as required. The door is mounted on concealed leaf type hinges and door adjustment is provided by elongated holes in hinge leaves. Door stop is integral with upper hinge. Door striker pin is also adjustable on lock pillar. Service on the door and its components is covered in paragraphs which follow.

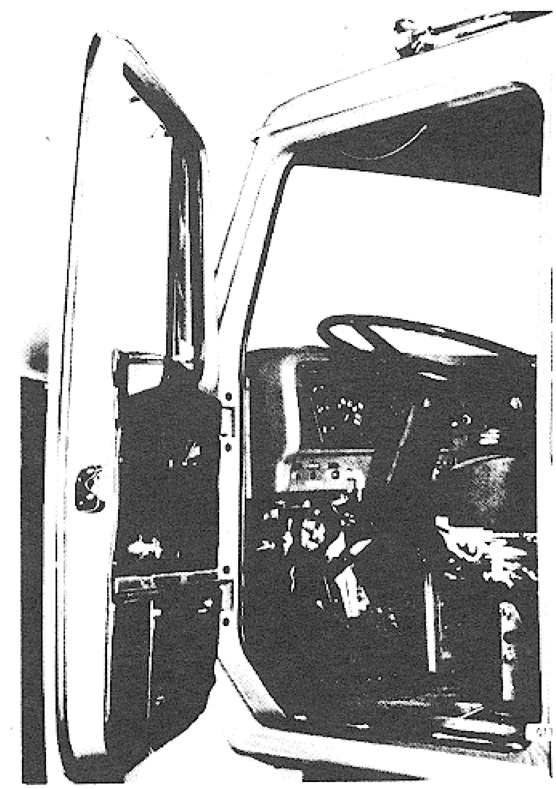

Fig. 5. Custom Trimmed Door

DOOR HARDWARE AND TRIM (FIG. 6)

Components of door assembly can be removed while door is either on cab or removed. They can also be removed individually without having to remove other components for access. Servicemen should have little difficulty in making a complete door disassembly or a removal of any of its component parts. (Most components do require the prior removal of door hardware and trim.)

REMOVE

1. Remove window regulator handle and door remote control handle by removing socket head screws from handles.

2. Remove two screws and detach arm rest.

3. Remove door trim screws and detach door trim panel (custom trim model only).

INSTALL

Door hardware and trim installation is the same as reverse of removal procedures.

> **IMPORTANT**
>
> Be careful when reinstalling arm rests so as to avoid stripping out mounting screws. Torque for mounting screws is 2.3 N•m (20 in. lbs.).

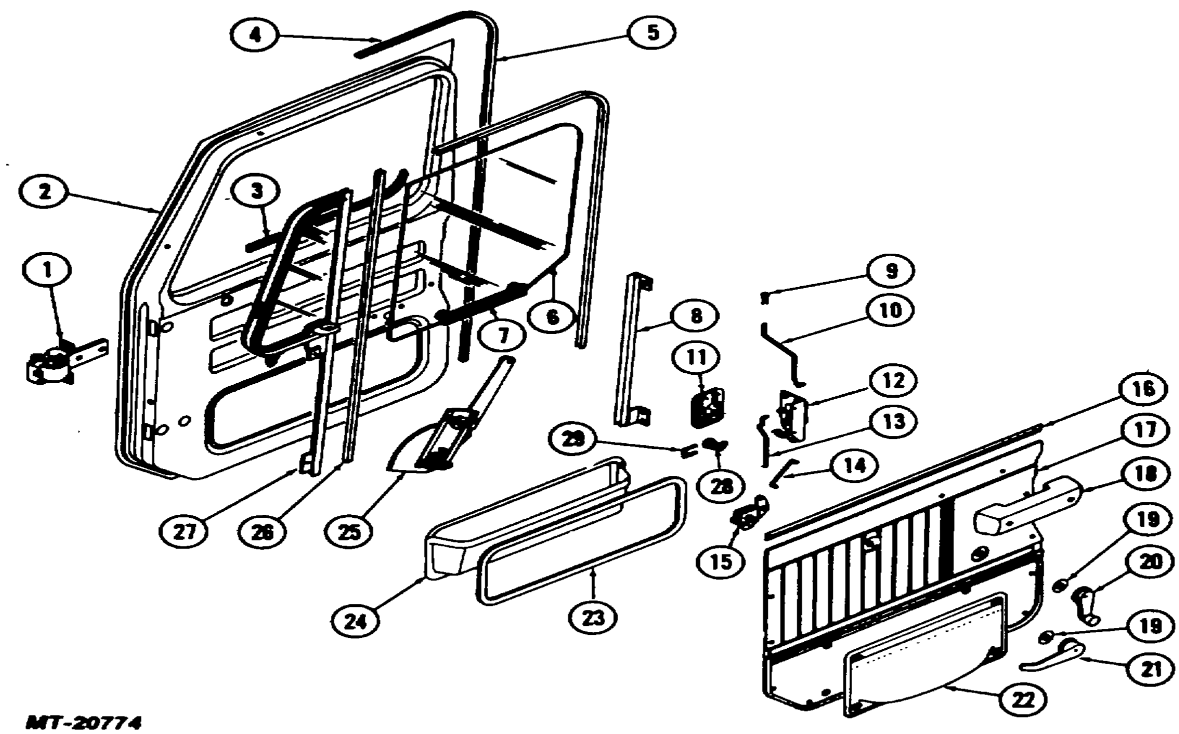

Fig. 6. Door Hardware, Trim and Internal Components - Exploded View

Key	Description	Key	Description
1	Hinge, Cab Door	15	Control Assembly, Remote
2	Door, Assembly, Cab	16	Retainer, Door Trim
3	Seal, Door Glass	17	Panel, Door (Custom Trim)
4	Seal, Door	18	Arm Rest
5	Seal, Door Glass Rear Channel	19	Washer, Door Trim
6	Glass, Door Window	20	Handle, Window Regulator
7	Guide, Door Window	21	Handle, Door Remote
8	Channel, Rear Run	22	Pocket, Manifest (Custom Trim)
9	Knob, Door Lock	23	Retainer, Access Door
10	Rod, Lock Knob to Latch	24	Pocket, Manifest (Standard Trim)
11	Handle, Assembly Door Outer	25	Regulator, Assembly, Window
12	Latch, Assembly, Door	26	Seal Door Glass Front Channel
13	Rod, Remote Control to Latch	27	Vent, Assembly Window Glass
14	Rod, Lock Cylinder to Latch		

SERVICE MANUAL

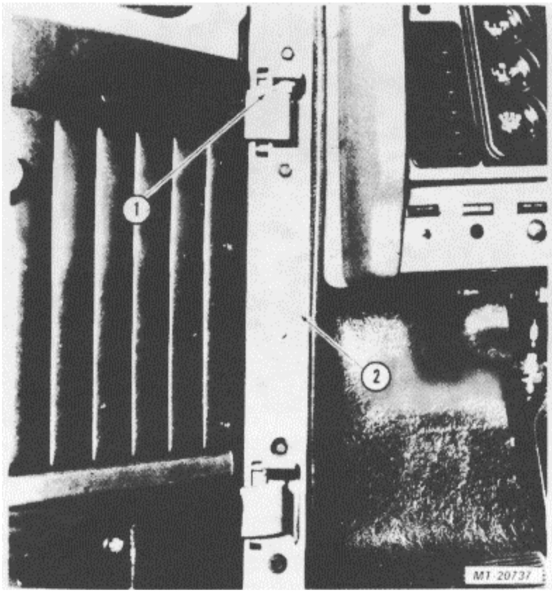

Fig. 7. Door and Hinge Details

1. Integral Door 2. Hinge Pillar Check in Hinge

DOOR HINGES

An integral door check (Fig. 7) is included in the upper hinge used with this door. If door is removed, upper and lower hinges should not be interchanged. There is no disassembly of hinges since they are serviced as a complete unit. It should also be noted that hinge mounting holes are elongated to provide adjustment for positioning cab door in door opening.

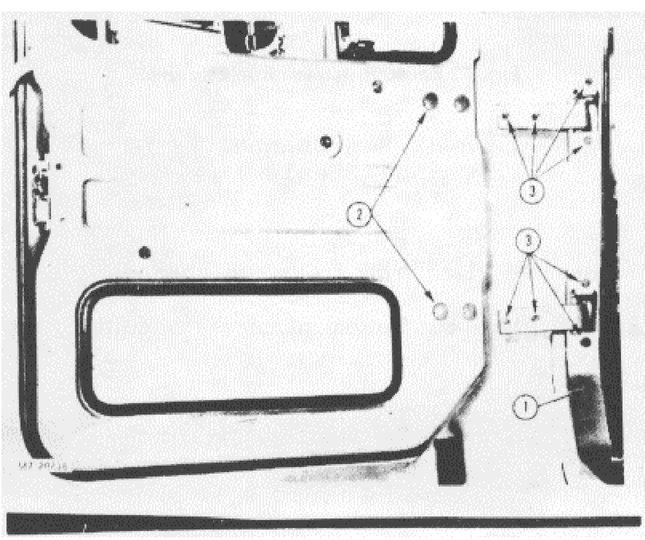

Fig. 8. Removing Door From Cab

1. Hinge Pillar
2. Access to Hinge Mounting
3. Enlarged Mounting Holes For Door Adjustment

REMOVE

1. Remove door hardware and trim as covered previously.
2. Using a rope sling (or padded chain) through window opening, attach sling to overhead lift and support door.
3. Remove four button plugs for access to hinge bolts.
4. Remove the four flange head hinge bolts and lift door assembly from hinges (Fig. 8).
5. Place door on saw horses or similar support. Protect paint from scratches.
6. To simplify door adjustment on reassembly, mark hinge position on hinge pillar with scratch awl before loosening hinges. Remove the three flange head bolts and detach door hinge from hinge pillar (Fig. 9).

IMPORTANT

Flange head bolt inside pillar can best be removed with a flex socket. Also be careful when extracting bolt so as to avoid its loss inside pillar.

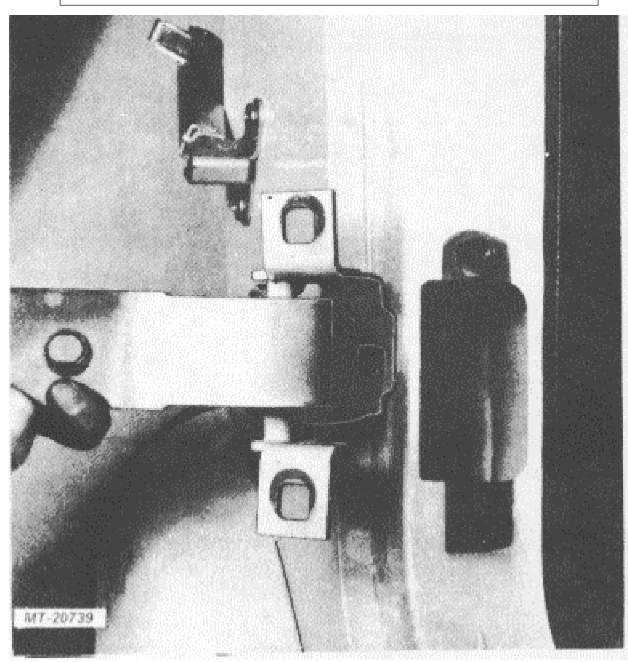

Fig. 9. Removing Cab Door Hinge From Hinge Pillar

INSTALL

Cab hinge and door installation is accomplished by reversing the foregoing removal procedures. Before final tightening hinge mounting bolts, check the door adjustment. See CAB DOOR ADJUSTMENT for complete details.

DOOR GLASS

REMOVE

1. Remove door trim as covered previously.

2. Remove rubber insert from around door access cover. Use blunt nose screwdriver or seal tool as shown (Fig. 10). Lift out cover and remove seal from access opening.

3. Lower window glass to bottom of its channel.

4. Working thru access opening remove two glass fastener screws from window guide and detach guide from glass and window regulator lever (Fig. 11).

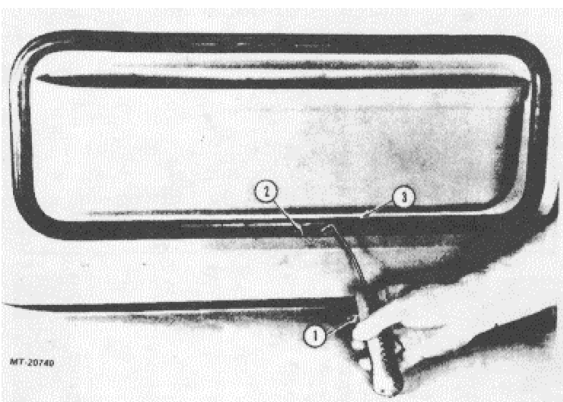

Fig. 10. Removing Access Panel from Door

1. Seal Tool
2. Insert
3. Seal

5. Remove button plug from side of door for access to rear glass run channel upper retaining bolt. Remove bolt.

6. Remove two retaining bolts from lower end of glass rear run channel. Remove channel and channel seal (Fig. 12) from glass and lay aside in door.

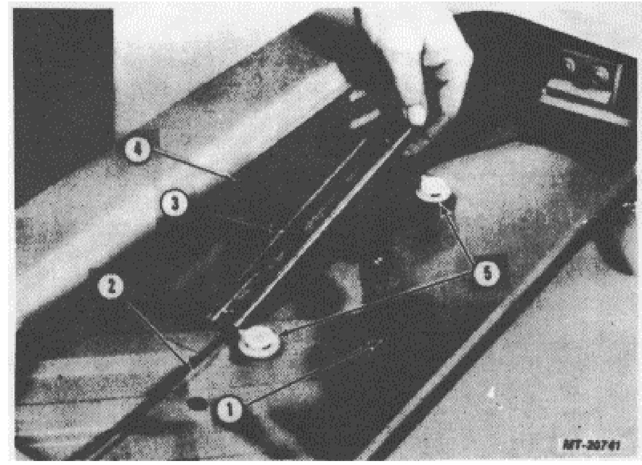

Fig. 11. Removing Window Guide from Window Glass

1. Regulator Lever
2. Window Glass
3. Window Guide
4. Door Access Opening
5. Fasteners

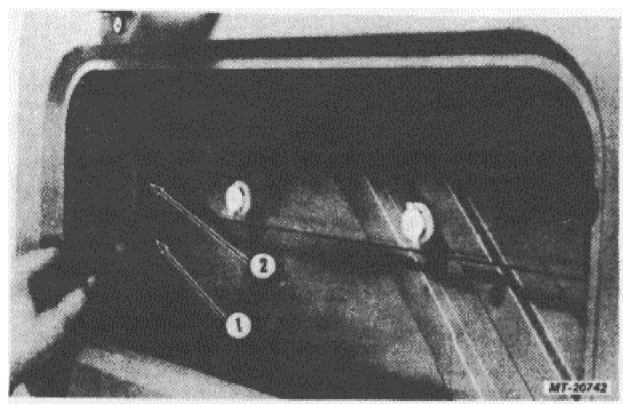

Fig. 12. Removing Rear Run Channel

1. Rear Run Channel
2. Channel Seal

7. Remove glass from front run channel.

8. Pull glass out bottom of access opening (Fig. 13).

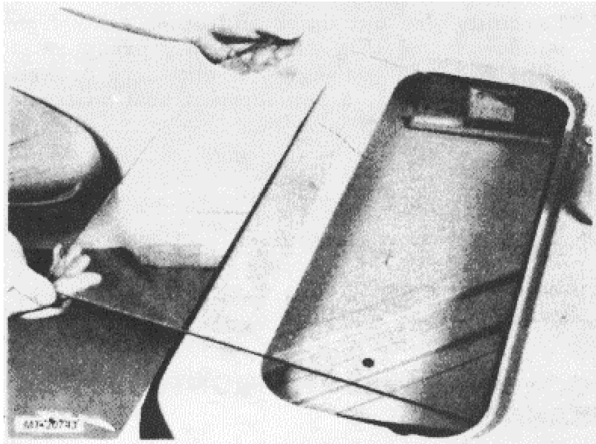

Fig. 13. Removing or Installing Window Glass

INSTALL

1. Insert window glass through access opening (Fig. 13).
2. Enter glass into front run channel.
3. Slide rear run channel and channel seal onto rear edge of glass.
4. Secure rear run channel retainer to upper and lower mounting brackets with bolts and washers.
5. When assured that glass will slide easily from top to bottom in window channels, move window to lowered position.

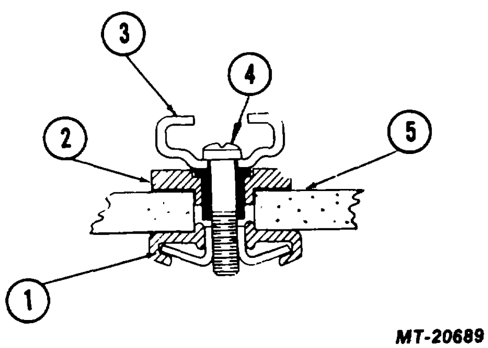

Fig. 14. Window lass Fastener Crow Section

1. Fastener, Lower Half
2. Fastener, Upper Half
3. Window Guide
4. Screw
5. Window Glass

6. Temporarily install regulator handle and turn regulator lever to engage with bottom edge of window.
7. Install window guide and regulator lever stud to window glass using the two fastener assemblies (Fig. 14) through holes provided in glass.
8. Operate regulator handle to make sure all components have been assembled correctly.
9. Reinstall access door.

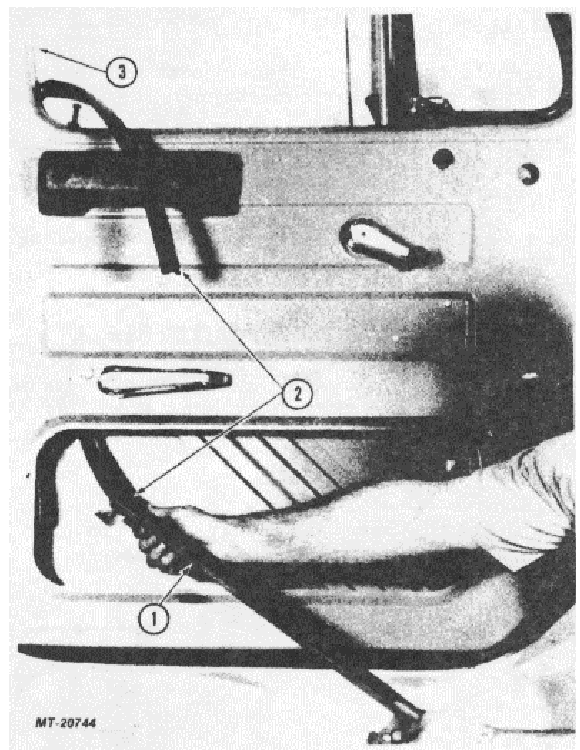

Fig. 15 Removing Rear Run Channel and Seal

1. Rear Run Channel
2. Channel Seal
3. Door Window Frame

DOOR GLASS REAR RUN CHANNEL AND CHANNEL SEAL

The door glass rear channel seal (weather stripping) is moulded for a compression fit in window frame as well as in glass rear run channel. No clips are required to retain it. Channel and seal are removed together.

REMOVE

1. Remove cab door glass as outlined under "DOOR GLASS". Glass may be left in bottom of door or removed through access opening as desired.
2. Pry out channel seal from door window frame (Fig. 15).
3. Since rear run channel is already loosened as outlined under "DOOR GLASS", remove channel and seal through door access opening (Fig. 15).

INSTALL

1. Obtain replacement channel seal and insert lower end in rear run channel.
2. Place channel and seal assembly inside door and press upper end of seal into window frame.
3. Procedure for mounting rear run channel to door is same as covered under "DOOR GLASS".

DOOR GLASS INNER AND OUTER SEALS

Door glass inner and outer seals are retained in bottom of window frame by clips (Fig. 16).

REMOVE

1. Remove cab door glass as outlined under "DOOR GLASS". Glass may be left in bottom of door or removed through access opening as desired.

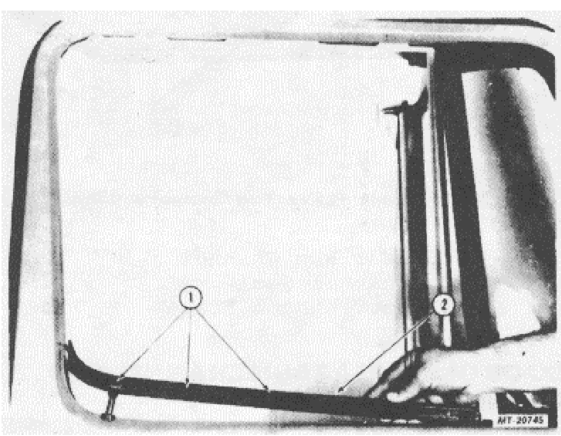

Fig. 16. Door Glass Inner Seal

1. Clips
2. Door Glass Inner Seal

2. Carefully pry out inner and outer seals from window frame (Fig. 16). Apply pressure at clips to avoid damage. If clips are broken during removal, a replacement seal will be necessary.

INSTALL

To install door glass inner and outer seals, simply align seals in place and press clips into openings provided. Avoid damage to seal by applying pressure at clip locations only.

DOOR VENT GLASS AND FRONT RUN CHANNEL

The door vent-glass and front run channel (Fig. 17) is serviced as one assembly. It is held in place in door by two pan head screws and two hex head bolts.

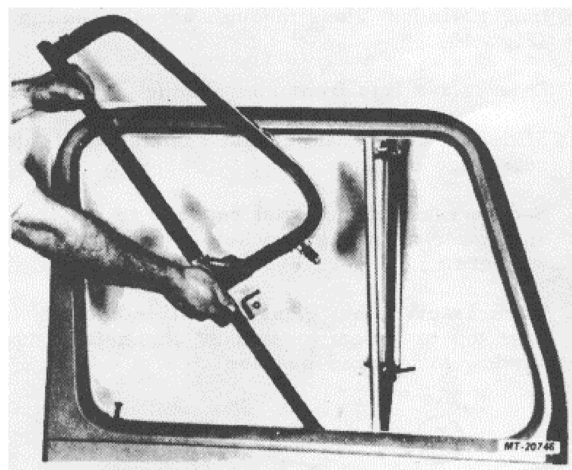

Fig. 17. Removing or Installing Door Vent Glum and front Run Channel

REMOVE

1. Remove door glass and door glass window seals as outlined previously.
2. At the outside of door remove two pan head mounting screws, one from top and one from front edge.
3. From inside of door remove two hex head bolts and detach vent glass and front run channel from door.

4. Lift out vent glass and front run channel as an assembly through window frame (Fig. 17).

INSTALL

Door vent glass and front run channel installation is accomplished by reversing the foregoing removal procedure.

DOOR GLASS REGULATOR

The cab door glass regulator is serviced as a complete unit with the door glass either in place or removed. If it is not desired or necessary to replace door glass, simply lower glass sufficiently to detach regulator lever from glass and then push glass back up into window frame. Secure glass temporarily to top of door with tape.

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).
2. Lower glass to bottom of door and remove the two glass fastener screws and regulator lever from window guide.
3. Remove window guide by sliding it from regulator lever.
4. Push door glass up in window frame and secure glass to top of door with tape.
5. Remove the four retaining screws which hold regulator assembly in door.
6. Push regulator shaft through hole in door inner panel and remove regulator assembly through access opening (Fig. 18).

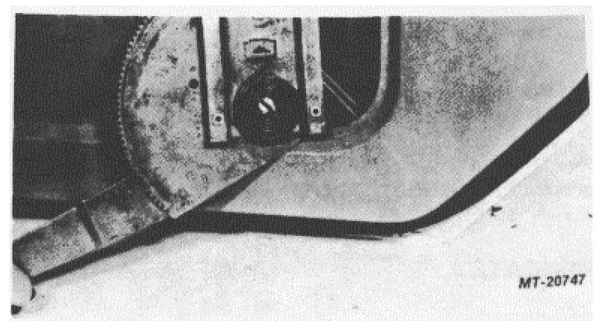

Fig. 18 Removing or Installing Door Glass Regulator

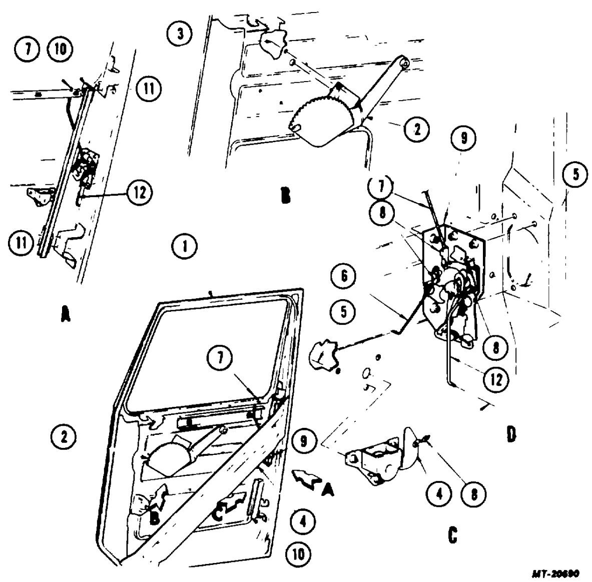

Fig. 19. Door Glass Regulator and Latch Details

Key	Description	Key	Description	Key	Description
1	Door, Assembly, Cab	5	Screw, Mounting	9	Latch, Assembly Door
2	Regulator, Assembly, Window	6	Rod, Remote Control to Latch	10	Retainer, Rear Run Channel
3	Screw, Mounting, Pan Head	7	Rod, Lock Knob to Latch	11	Bolt, Mounting, Hex Head
4	Control Assembly, Remote	8	Clip, Rod End	12	Rod, Lock, Cylinder to Latch
A.	View in Direction of Arrow A	C.	View in Direction of Arrow C		
B.	View in Direction of Arrow B	D.	To Lock Cylinder		

IMPORTANT
Be careful when reinstalling door glass, door glass regulator and related parts to avoid glass breakage. Door 'glass inner and outer seals, channel seals and glass mounting fasteners have been designed to protect glass through rugged operating conditions. Make sure the reassembly of these parts will maintain this same glass protection.

INSTALL

Cab door glass regulator installation is accomplished by reversing the foregoing removal procedure. See Fig. 19 for door internal component details.

LUBRICATE

Lubricate cab door glass regulator gear teeth, arm pin and slide at installation. See Lubrication.

DOOR LATCH ASSEMBLY AND REMOTE CONTROL

The cab door latch assembly (Figs. 19 and 20) used with this door features positive no- rattle latch jaws which engage with striker pin on cab lock pillar. Latch assembly mounts to a small opening in edge of door and connects to remote control, lock cylinder and lock knob by relay control rods.

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).
2. Remove lock knob from relay control rod through window frame.
3. Unfasten rod end clips and remove relay control rods from remote control assembly and from lock cylinder assembly. Opposite ends of the three relay control rods can remain attached to latch assembly.

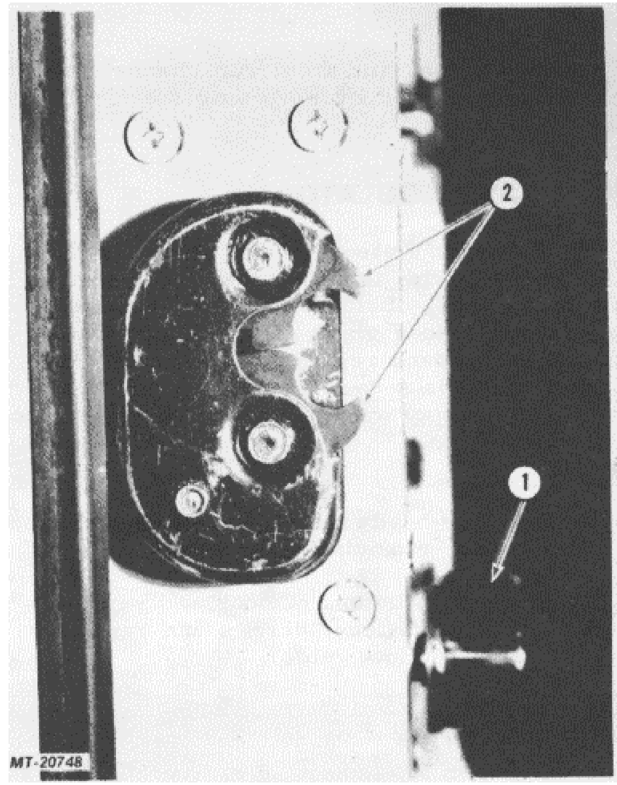

Fig. 20. Door Latch Assembly

1. Remote Control Handle
2. Latch Jaws

4. Remove three socket head screws and detach remote control from inside of door (Fig. 21).

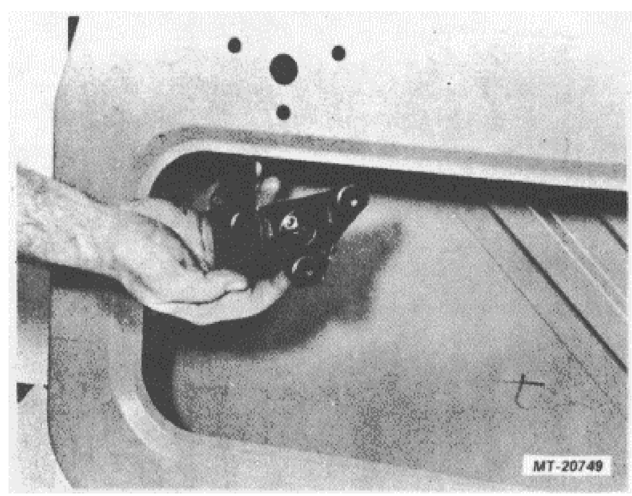

Fig. 21. Removing Remote Control Assembly

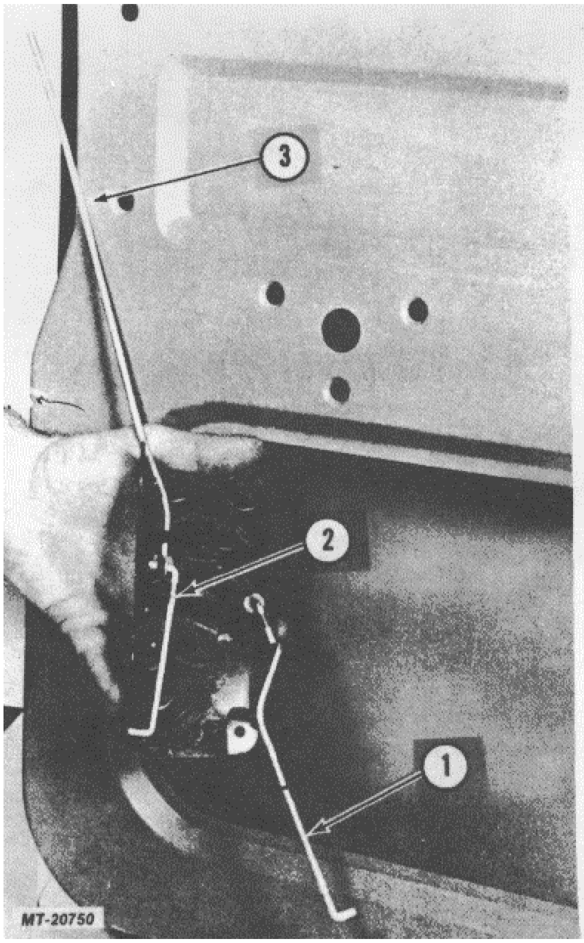

Fig. 22. Removing Latch Assembly

1. Remote Control to Latch Rod
2. Lock Cylinder to Latch Rod
3. Lock Knob to Latch Rod

5. Remove five socket head screws and detach door latch assembly from inside of door frame (Fig. 22). Latch jaws should be closed.

INSTALL (Refer to Fig. 19 for Component Details)

1. Position latch assembly to inside of door. Latch jaws must be closed and the three relay control rods should be preassembled to latch.
2. Pilot threaded end of upper lock knob rod through lock knob hole in window frame while positioning latch. Install lock knob.
3. Secure latch assembly in door with five socket head screws.
4. Position remote control assembly in door and secure with three socket head screws.
5. Connect the two remaining relay control rods to remote control assembly and to lock cylinder lever. Secure rods with rod end clips.
6. Operate latch assembly to assure correct assembly.

DOOR OUTER HANDLE

The door outer handle (Fig. 23) is a combination handle and lever operating assembly that connects with the latch assembly mechanism inside door to actuate the latch jaws. Outer handle can be removed without removing latch assembly.

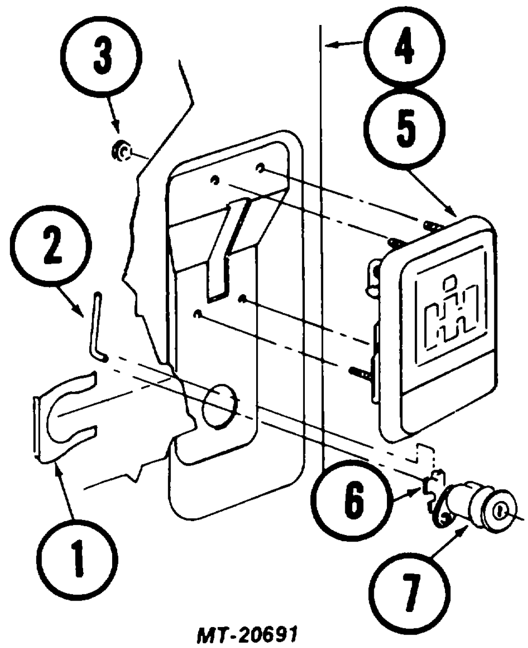

Fig. 23. Door Outer Handle & Lock Cylinder

1. Lock Cylinder Retainer
2. Lock Cylinder to Latch Rod
3. Nut with Washer
4. Door
5. Door Outer Handle Assembly
6. Rod End Clip
7. Lock Cylinder Assembly

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).

2. Remove three hex nuts from studs through door from rear of handle.
3. Remove door outer handle from door (Fig. 24).

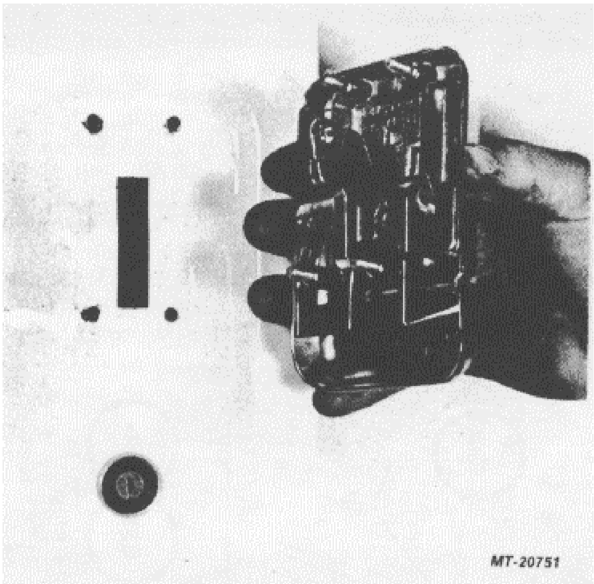

Fig. 24. Removing Door Outer Handle

INSTALL

To install outside door handle, reverse foregoing removal procedure.

DOOR LOCK CYLINDER ASSEMBLY

The door lock cylinder (Fig. 23) is key coded to key switch on instrument panel so that one key operates both. If keys are lost or a replacement of lock cylinder is desired, see special instructions under "KEY SWITCH AND DOOR LOCK CYLINDER REPLACEMENT".

REMOVE

1. Remove door hardware, trim and access door (same as for removing door glass).
2. Disconnect rod end clip and detach control rod from door lock cylinder assembly.
3. Working through door access opening pry lock retainer from lock cylinder assembly (Fig. 25) with a small pry bar or screwdriver .
4. Rotate lock cylinder assembly slightly and remove from door.

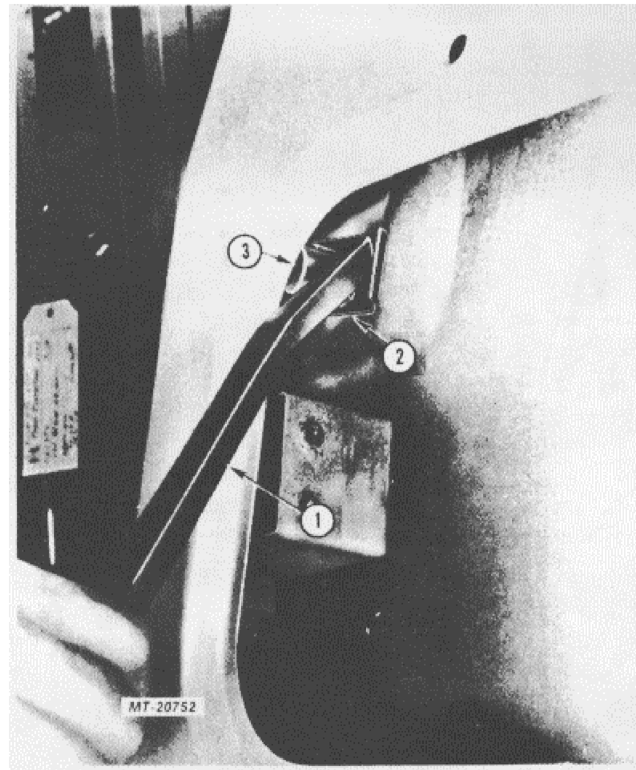

Fig. 25. Removing Lock Cylinder Retainer

1. Pry Bar
2. Lock Cylinder Retainer
3. Lock Cylinder Assembly

IMPORTANT

Lock cylinder retainer can be removed without removing glass rear run channel. Channel removed in Fig. 25 for clarity.

INSTALL

To install door lock cylinder assembly, reverse foregoing removal procedure.

KEY SWITCH AND DOOR LOCK CYLINDER REPLACEMENT

The instrument panel mounted key switch and the lock cylinder in the door are coded so that one key operates both. Code number is stamped on key switch body just back of cap nut. Door lock cylinder assembly does not have a code number stamped on body since this cylinder is coded to the key switch.

To locate code number on key switch, remove key switch mounting cap nut and detach key switch from instrument panel.

The key switch cylinder can be replaced providing the regular key is used.

REMOVE

To remove key switch cylinder from switch body, place key in switch cylinder' and insert a piece of stiff wire or rod 1.5 mm (1/16") dia. in the small hole behind cap nut in switch body. Turn key to left (accessory position) and press the cylinder retainer down with the wire. The switch cylinder can then be pulled out of switch body.

INSTALL

To install a new switch cylinder, simply push cylinder into switch body and turn to right ("ON" position) until the cylinder retainer snaps into place.

Door lock cylinder replacement is by the complete assembly. Lock cylinder itself (tumbler unit) is not removable. If door lock replacement is required, lock cylinder assemblies should be replaced in pairs.

If a replacement of key switch cylinder is necessary and the operator wants to use the original key, the tumblers on the new switch cylinder can be coded accordingly.

This is accomplished by inserting original key in new cylinder (cylinder removed from body) and filing off the tumblers that protrude from cylinder. When making this change, be sure no burrs are left on tumblers and all filings are blown out with air. Apply a small quantity of powdered graphite to tumblers and reinsert cylinder in key switch body.

IMPORTANT

If keys are lost, switch cylinder must be drilled out using a 7.9 mm (5/16") drill, 12.7-19 mm (1/2-3/4") deep. This will permit tumblers to drop out and free lock.

DOOR WEATHER SEAL

A one piece rubber weatherseal is secured to cab door flange with plastic fasteners and provides a weather-tight seal around door when door is closed.

REMOVE

Pry up old weather seal at fastener locations and remove complete seal from cab door flange.

INSTALL

1. Obtain new seal.
2. Be sure all old fasteners have been removed and door flange is free of dirt.
3. Place new weather seal into place on door flange and align fasteners over mounting holes.
4. Apply pressure to each fastener to secure weatherseal.

DOOR STRIKER PIN

Door striker pin (Fig. 26) mounted on lock pillar provides for positive engagement with the door latch assembly (Fig. 20). Striker pin removal and installation requires a special driver tool. Enlarged mounting hole in lock pillar permits adjustment.

For complete details on striker pin adjustment, see "CAB DOOR ADJUSTMENT".

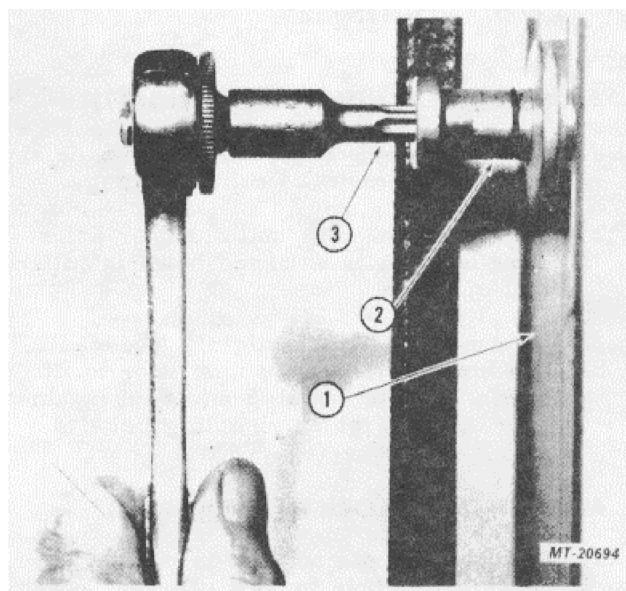

Fig. 26. Removing or Installing Door Striker Pin

1. Lock Pillar
2. Door Striker Pin
3. Driver Tool

CAB DOOR ADJUSTMENT

Getting a good cab door to door opening fit requires a knowledge of where the various adjustments are located and what effect each adjustment has on door fit. These adjustments apply whether door has been removed or door adjustment is simply being changed or improved.

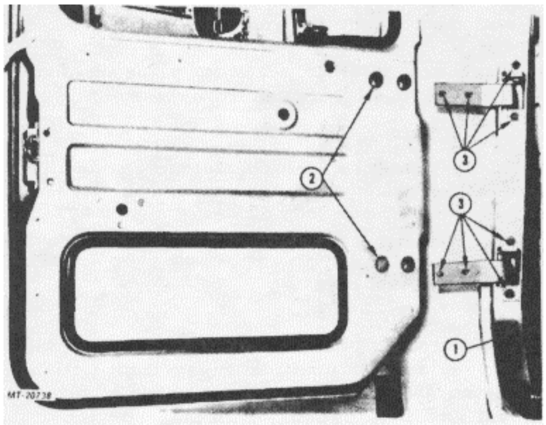

Fig. 27. Location for Door Adjustments at Hinge Pillar

1. Hinge Pillar
2. Access to Hinge Mounting
3. Enlarged Mounting Holes for Door Adjustment

1. ADJUSTMENT AT HINGE PILLAR (FIG. 27)

a. Fore and aft door adjustment is made at enlarged holes in door half of hinge.
b. Up and down or in and out door adjustment is made at enlarged holes in pillar half of hinge.
c. With mounting bolts slightly loosened, one hinge at a time, adjust door to fit evenly in door opening and snug against door seal. Tighten mounting bolts to specified torque (see Torque Chart).

2. ADJUSTMENT AT LOCK PILLAR (FIG. 26)

a. Door striker pin or stud is mounted in an enlarged hole in lock pillar. Loosen pin to move pin up or down and in or out as required.
b. Fore and aft adjustment is by spacer shim between striker pin and pillar.
c. Make final adjustment of striker pin and tighten to specifications (See Torque Chart)

When adjusted (1) door weatherseal should contact door frame all around with slight pressure but without damage to seal (2) door should latch, lock and release without undue effort, and (3) door should be rattle free when vehicle is in motion.

DRIVER AND PASSENGER SEATS

Seat types available with S-Series cabs are determined by cab width and by the kind of equipment (engine, transmission, auxiliary, etc.) furnished with the truck. Full width bench seat and individual driver and passenger seats are available in the 200 cm (80 inch) wide cab. Individual driver and passenger seats only are available in the 230 cm (90 inch) wide cab. Mechanical and air suspension seats are also available optionally.

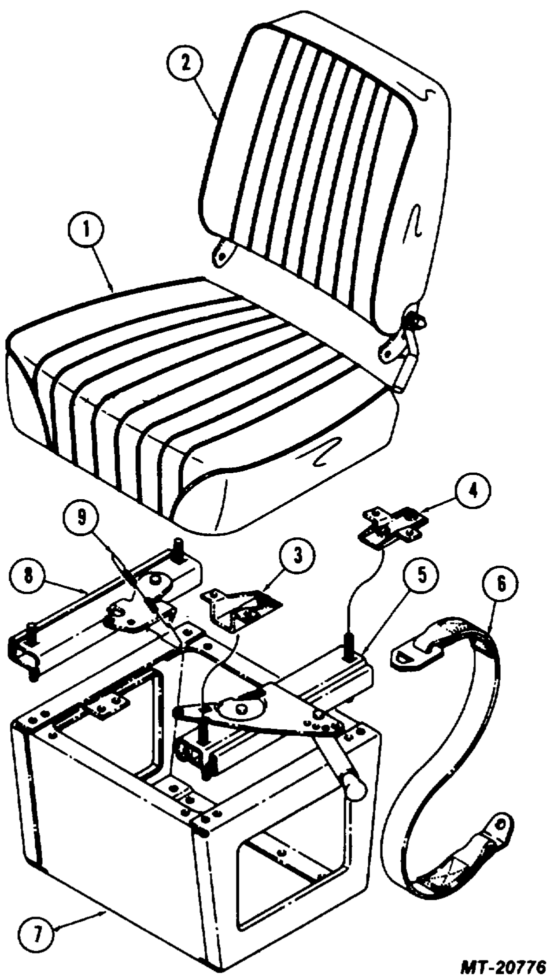

Fig. 29. Individual Drivers Seat - Custom Trim Exploded View

Key	Description
1	Cushion, Seat Assembly
2	Cushion, Back with Support
3	Bracket, Seat Adjuster Front
4	Bracket, Seat Adjuster Rear
5	Adjuster with Handle, Seat Left
6	Belt, Seat
7	Riser, Seat
8	Adjuster, Seat, Right
9	Wire, Seat Adjuster

INDIVIDUAL DRIVERS SEAT (FIG. 29)

Individual drivers seats are similar in construction to the bench seat and have the same adjustment features and mechanisms. Individual passenger seats however are fixed in one floor position.

Removal and installation procedures which follow apply to both the full width bench seat and the individual drivers seat.

REMOVE

1. Remove the four bolts which secure the upper adjuster rails to seat bottom on right and left side and detach seat and back assembly. Slide seat fore and aft as necessary for access to mounting bolts.

2. Unlock seat adjuster wire between the two rails.

3. Remove two bolts which secure lower half of each seat adjuster to seat riser and remove right and left seat adjusters.

4. Clean seat adjusters as required. Apply a light coat of multi-purpose lube (IH 251 HEP) to rails to assure a smooth operation on reassembly. Wipe away excess lube.

INSTALL

Seat installation procedure is the reverse of removal. See Torque Chart for specified mounting torques.

WINDSHIELD

The windshield used with the S-Series cab is either one or two piece flat glass type depending on whether cab is the 200 or 230 cm (80 or 90 inch) width model. A molded weatherseal (weatherstrip) with either an integral or detached insert fits perimeter of glass to retain glass in windshield opening. Seam between halves of two piece windshield is closed with inner and outer division bars and seals. When replacing windshield always use a new weatherseal since a used weatherseal is likely to be stretched or deteriorated and susceptible to leaks.

REMOVE

If either windshield or weatherseal must be replaced, procedure is as follows:

1. Remove washer hose from fittings on top of cowl.
2. Remove cap nut and detach windshield wiper arms (Fig. 30).

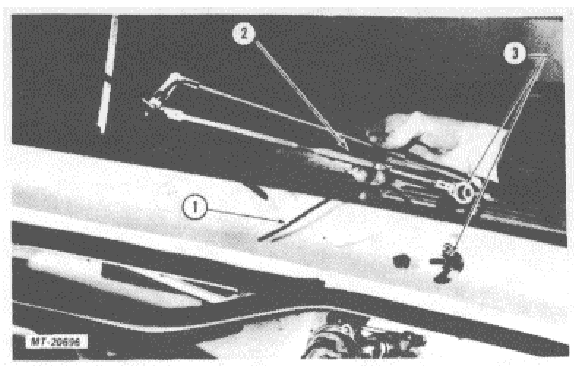

Fig. 30. Removing Windshield Wiper Arm

1. Washer Hose   3. Serrations
2. Wiper Arm

3. Pry integral or detached insert from weatherseal with a thin blade screwdriver or sealtool (SE-2442) (Fig. 31) around entire glass. See Fig. 32 for details of weatherseal.
4. If windshield is two piece type remove inner and outer division bars and seals (Fig. 33).

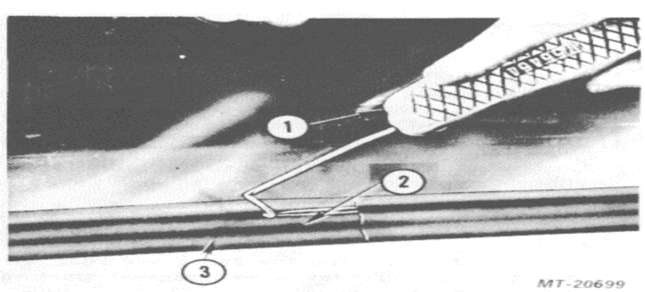

Fig. 31. Removing Windshield Weatherseal Insert

1. Seal Tool   3. Seal
2. Insert

5. Working with one man outside cab and an assistant inside apply light pressure on windshield from inside of cab to push glass from seal. Be careful during this operation since heavy pressure at any one point can lead to glass breakage.
6. Lift glass from opening and peel weatherseal from fence (weld flange).

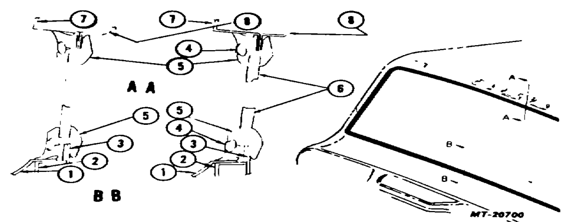

Fig. 32. Windshield Weatherseal (Retainer)

1. Cowl Outer   5. Seal
2. Cowl Inner   6. Glass
3. Cowl Bar   7. Panel Outer
4. Insert   8. Panel Inner

A-A Section thru upper portion of windshield and seal
B-B Section thru lower portion of windshield and seal

INSTALL

IMPORTANT

Before installing new weatherseal or windshield, clean body flange and glass free of dirt, old sealing compound, wax, etc.

1. Coat weatherseal with a soapy solution or rubber lubricant for ease of assembly.
2. Install weatherseal carefully around edge of windshield opening flange. Position splice joint of seal ends at centerline of cab and on lower flange.
3. Working from outside the cab, place windshield in channel of weatherseal, starting at lower edge of opening.
4. For two piece type windshield install inner .and outer division bars and seals. Check seal details (Fig. 33).

5. Work weatherseal insert (Fig. 31) down into groove provided around entire weatherseal. Use seal tool or a dull screwdriver to seat insert in groove. A second coat of rubber lubricant in groove will simplify installation.

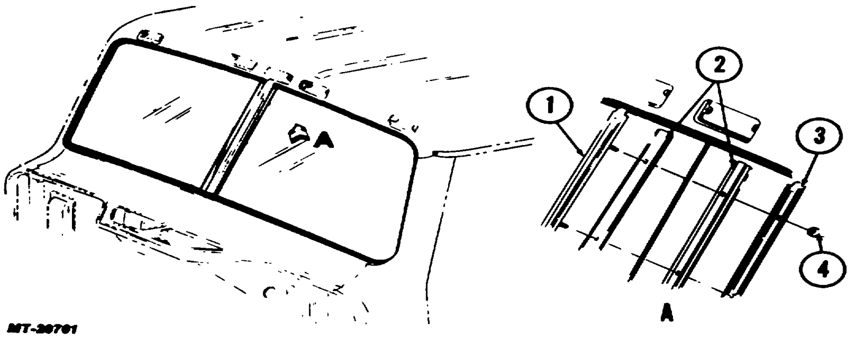

Fig. 33. Details of Windshleld Division Bar (230 cm or 90 Inch Cob Only)

1. Outer Division Bar
2. Seals
3. Inner Division Bar
4. Crown Nut

A. View in direction of Arrow A

REAR WINDOW GLASS

Cab rear window glass (Fig. 34) is secured in cab rear window opening with a molded one piece weatherseal with integral insert similar to that used for windshield. The weatherseal fits around edge of glass and is so formed, that it retains the glass in window opening by fitting over the window opening flange. Old or deteriorated weatherseals should not be reused whenever window glass is replaced.

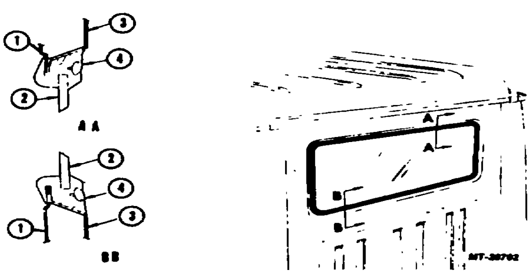

Fig. 34. Cab Rear Window Glee end Weatheriseal

1. Panel Inner
2. Glass
3. Panel Outer
4. Insert

A-A Section thru upper portion of rear window glass

B-B Section thru lower portion of rear window glass

REMOVE

1. Pry out integral insert of weatherseal with seal tool or a thin blade screwdriver around entire perimeter of glass.
2. Working with an assistant, one man inside cab and one man outside, gently push glass from inside out.
3. Lift glass from opening.

INSTALL

IMPORTANT

Before installing new weatherseal or window glass, body flange and glass must be cleaned free of dirt, old sealing compound, wax, etc.

1. Coat weatherseal with a soapy solution or rubber lubricant for ease of assembly.
2. Position weatherseal carefully around edge of rear window glass opening flange.
3. Working from outside the cab place rear window glass in channel of weatherseal starting at lower edge of opening.
4. With glass completely seated in weatherseal channel start working weatherseal insert down into groove provided with seal tool or dull screwdriver. A second coat of rubber lubricant will expedite this step.

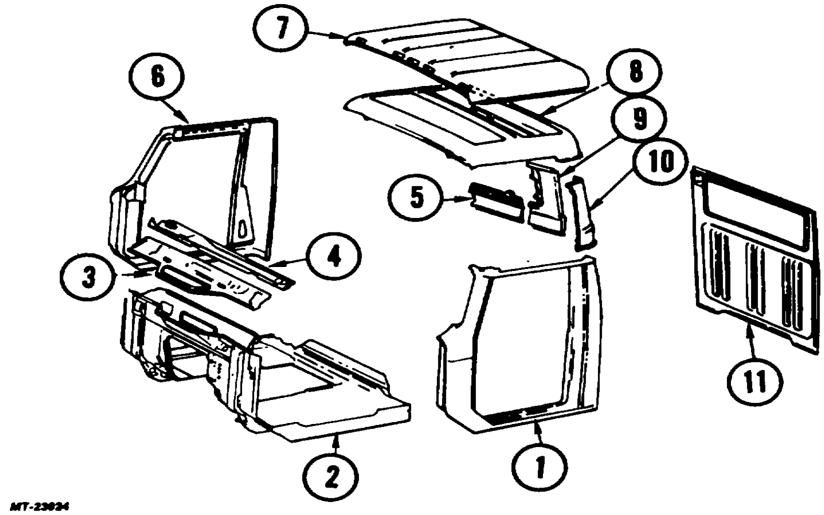

Fig. 35. S-Series Cab Panels

1. Side Panel Assembly
2. Underbody (Not Serviced)
3. Cowl Top Inner Panel
4. Cowl Rear Panel
5. Back Inner Panel
6. Side Panel Assembly
7. Roof Panel
8. Roof Inner Panel
9. Inner Corner Panel Extension (90 x 90 Cab Only)
10. Inner Corner Panel
11. Back Outer Panel

SHEET METAL REPAIRS

A special feature of the S-Series Cab is the availability of complete body panels for repairing the cab. The types of panels available are shown in Fig. 35. These panels enable a service man to restore a damaged cab to new condition without the usual problems associated with cab rebuilding. Extensive metal refinishing is not required and most restoration welds are in areas of low stress.

SHEET METAL TOOLS

To perform the necessary cab sheet metal disassembly and rebuild work, the special tools listed here should be on hand. Most of these are common to any cab or body rebuilding shop.

1. Electric or pneumatic drill.
2. Sheet metal drill bits. -
3. Pneumatic chisel (SE-2664 or SE-2129).
4. An assortment of C-clamps.
5. MIG welder (SE-2640).
6. Weld wire Spec. No. E70S-3.

PREPARING CAB FOR PANEL REMOVAL

Before sheet metal repairs to cab can be started some mechanical work must be performed. This will depend on cab damage and which panel is being replaced. Since the side panel (Fig. 36) or door frame is a commonly replaced panel, let us use the left side panel replacement as an example for what mechanical work is required. The following items must be removed:

1. Left door, seat and interior trim.
2. Dash pad and instrument panel left side mounting.
3. Roof and back panel liners.
4. Left scuff plate and floor mat.
5. Windshield and rear window glass.
6. Junction boxes, relays, dimmer switch, wiring harness and brake piping.
7. Marker light harness and air horn supply line.
8. Fuse block, junction block and starter solenoid.
9. Fuel or air tanks.
10. Cowl top outer panel.

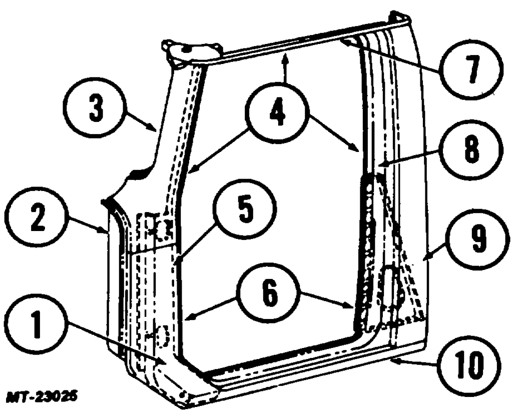

Fig. 36. Components of Side Panel Assembly

1. Cowl Side Panel
2. Dash Filler Panel
3. Windshield Side Inner and Outer Panels
4. Door Frame
5. Hinge Pillar
6. Inner Side Panels
7. Drip Moulding
8. Lock Pillar
9. Outer Corner Panel
10. Rocker Panel

REMOVING SPOT WELD'

The actual side panel removal requires the drilling out of spot welds which attach the side panel to other panels of the cab. Sheet metal drill bits should be used. These are drill bits, the ends of which have been ground for this special purpose. An example of a sheet metal drill bit as compared to a regular drill bit is shown in Fig. 37. When spot welds have been removed, a pneumatic chisel is then used to open seams which have been clinched together.

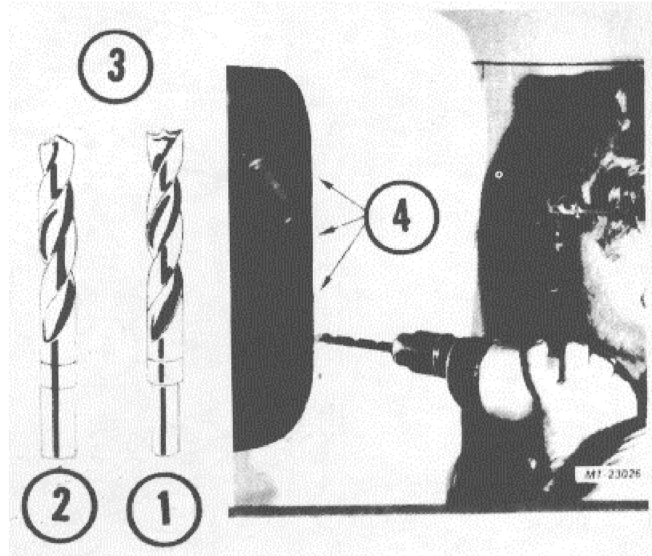

Fig. 37. Removing Cob Inner Corner Panel

1. Sheet Metal Grind
2. Regular Grind
3. Drill Bits
4. Spot Welds

SIDE PANEL REMOVAL

1. For access to back panel joint, remove cab inner corner panel. Remove trim strip between corner panel and inner roof panel and drill out spot welds (Fig. 37) around panel. Separate corner panel from back panel, inner roof panel and side panel assembly.

2. Separate inside panel of side panel assembly from sill side inner panel. Free inside panel of side panel assembly by cutting through MIG weld (Fig. 38) at bottom of panel. (On 80" wide cabs remove spot weld used at cowl side inner panel).

3. Drill out spot welds along drip moulding from front to rear and around corner to end of side panel. Separate side panel from outer roof panel (Fig. 39).

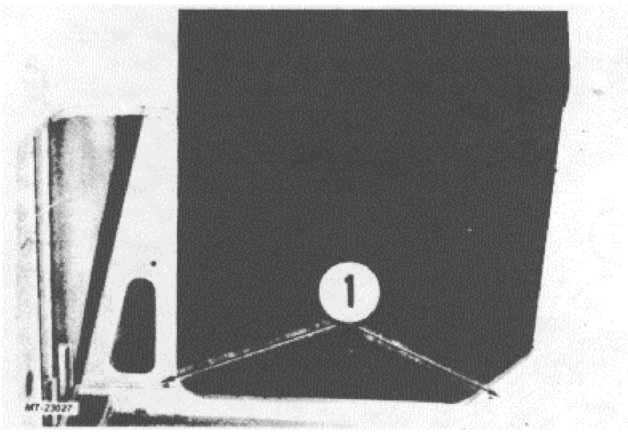

Fig. 38 Location of MIG Weld Seams

1. MIG Welds

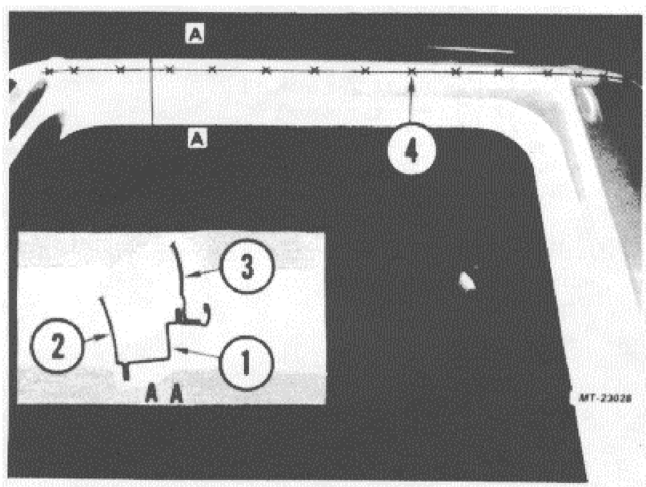

Fig. 39. Side Panel to Outer Roof Panel Spot Welds

1. Side Panel Assembly
2. Inner Roof Panel
3. Outer Roof Panel
4. Drill Out Welds Along Drip Moulding

A-A. Section thru Side Panel and Outer Roof Panel

4. Drill out spot welds along seam between back panel and side panel and separate rear of side panel from back panel (Fig. 40). Drill at outer seam if for 90" wide cab.

5. Drill out spot welds along seam at bottom of cab and separate rocker panel from sill side inner panel (Fig. 41).

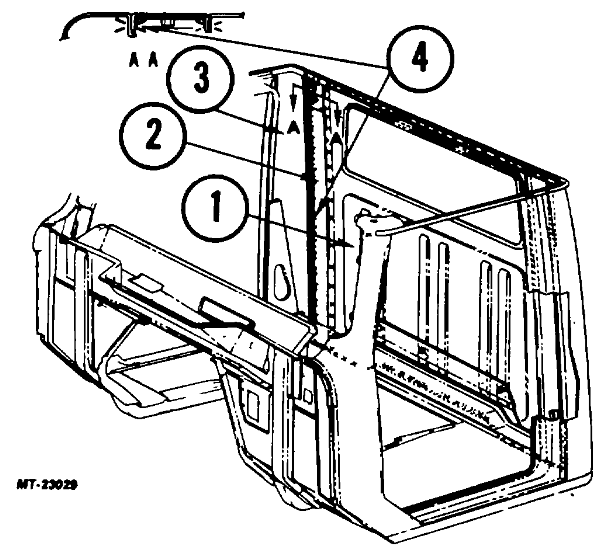

Fig. 40. Side Panel to Back Panel Spot Welds (Right Corner 90" Wide Cob Shown)

1. Back Panel
2. Back Panel Filler
3. Side Panel Assembly
4. Drill Out Welds (Outer Seams Only)

A-A Section thru Back Panel and Side Panel

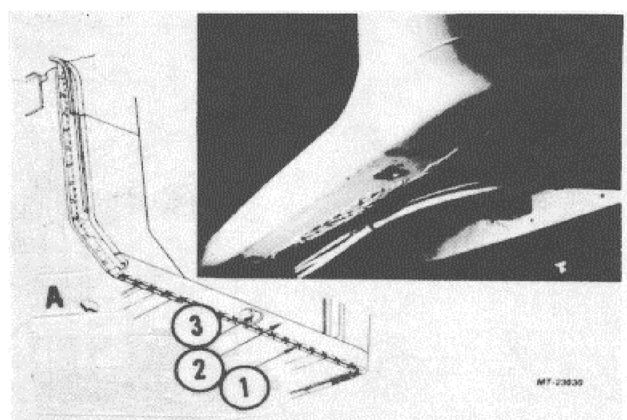

Fig. 41. Rocker Panel to Sill-Slide Inner Panel Spot Welds

1. Drill Out Welds
2. Rocker Panel
3. Sill Side Inner Panel

A. Front

6. Drill out spot welds at seam between dash filler panel and dash panel. Separate filler panel from dash panel (Fig. 42).

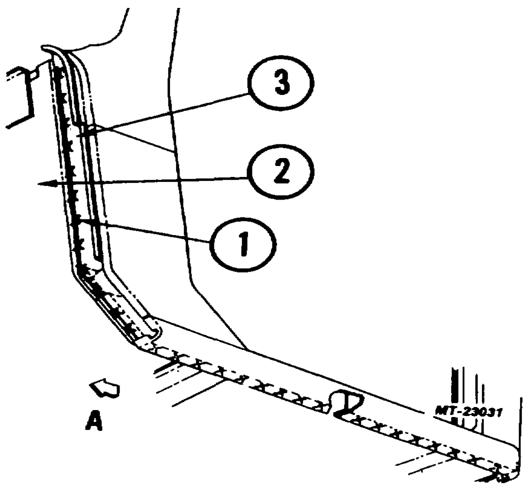

Fig. 42. Filler Panel to Dash Panel Spot Welds

1. Drill Out Welds
2. Dash Panel
3. Dash Filler Panel

A. Front

7. Drill out five spot welds and separate windshield side outer panel from cowl top inner panel (Fig. 43).

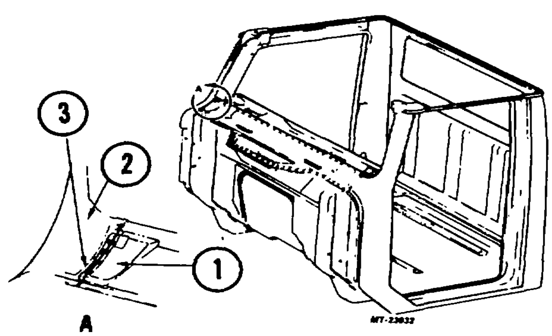

Fig. 43. Windshield Outer Panel to Cowl Inner Panel pot Welds (Rt. Side Shown)

1. Cowl Top Inner Panel
2. Windshield Side Outer Panel
3. Drill Out Welds

A. View in Circle A

8. Drill out six spot welds and separate windshield side outer panel from cowl rear panel and bracket (Fig. 44).

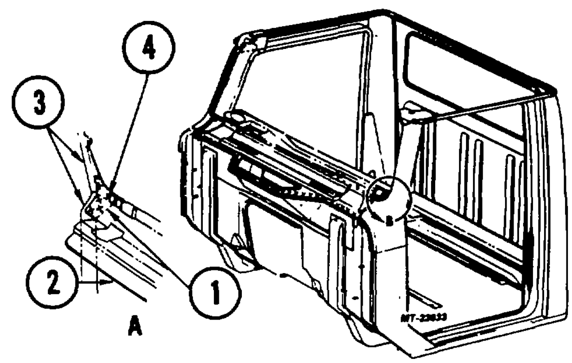

Fig. 44. Windshield Side Outer Panel to Cowl Rear Panel and Bracket Spot Welds

1. Cowl Rear Bracket
2. Cowl Rear Panel
3. Windshield Side Outer Panel
4. Drill Out These Welds

A. View in Circle B

9. Drill out three spot welds and separate side panel from roof outer and inner panels (Fig. 45).

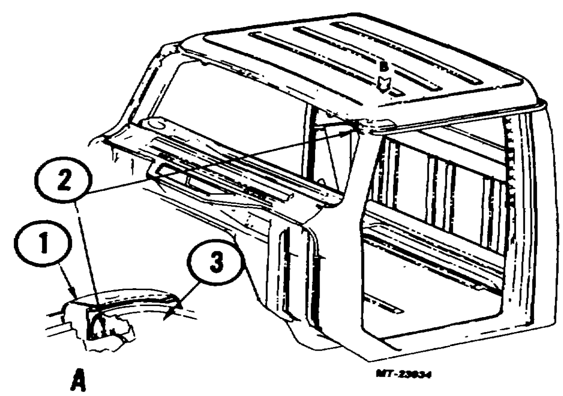

Fig. 45. Side Panel to Roof Outer and Inner Panel Spot Welds (Outer Roof Panel not Shown)

1. Side Panel Assembly
2. Drill Out 3 Welds
3. Roof Inner Panel

A. View in Direction of Arrow B

10. Drill out fourteen spot welds along top of door opening and separate side panel from roof inner panel (Fig. 46).

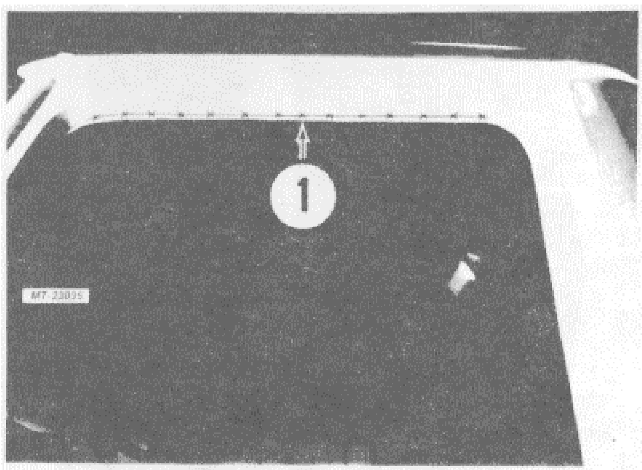

Fig. 46. Side Panel to Roof Inner Panel Spot Welds

1. Drill Out These Welds

11. Drill out fifteen spot welds along bottom of door opening and separate side panel from sill side inner panel (Fig. 47). Note that on 80" wide cabs there are additional spot welds to be removed at lower front corner of door opening.

12. Drill out three or four additional welds along top edge of windshield opening as required to separate roof panels and raise roof panel sufficiently to permit removal of side panel from cab.

IMPORTANT

Be careful while removing side panel so as to avoid damage to roof panel.

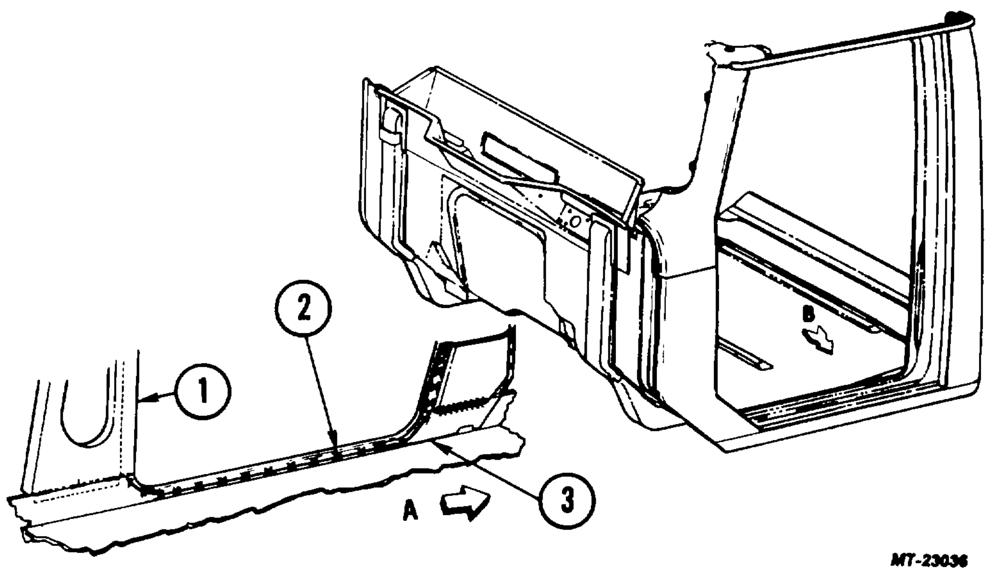

Fig. 47. Side Panel to Sill Side Inner Panel Spot Welds

1. Side Panel Assembly
2. Drill Out Welds
3. Sill Side Inner Panel

A. Front
B. View in Direction of Arrow B

INSPECT CAB STRUCTURE FOR DAMAGE

With side panel removed, inspect remainder of cab for damage. Look especially for and repair:

1. Damage to cab sill welds.
2. Loosening of floor panels.
3. Underbody bent out of alignment. (This step can vary with each job. Keep in mind you are trying to return cab to its original condition.)

Reweld any cracked or missing welds. The sill side inner panel on the cab underbody must be straight and flat.

ALIGN NEW SIDE PANEL TO CAB

1. Position and clamp new side panel assembly to side of cab.
2. Raise roof outer panel sufficiently to insert windshield pillar top corner between inner and outer roof panels.
3. Apply heat expanding type sealer (Plastisol or equivalent) to this seam.
4. Align panels to establish windshield opening and install "C" clamps to secure.
5. Align remaining joints at dash panel, cowl, roof panel and back panel using "C" clamps to hold new side panel in place.

WELDING SIDE PANEL TO CAB

1. Using MIG welder inside cab (Fig. 48), plug weld around door opening through holes drilled out of original cab panels during side panel removal.

CAUTION

Adjust welder so as not to damage or burn sheet metal when performing these welds.

2. Where drilled holes are not accessible such as at bottom of rocker panel, use 2.5 cm (1 inch) seam welds spaced 7.5 cm (3 inches) apart to secure rocker panel to sill side inner panel.

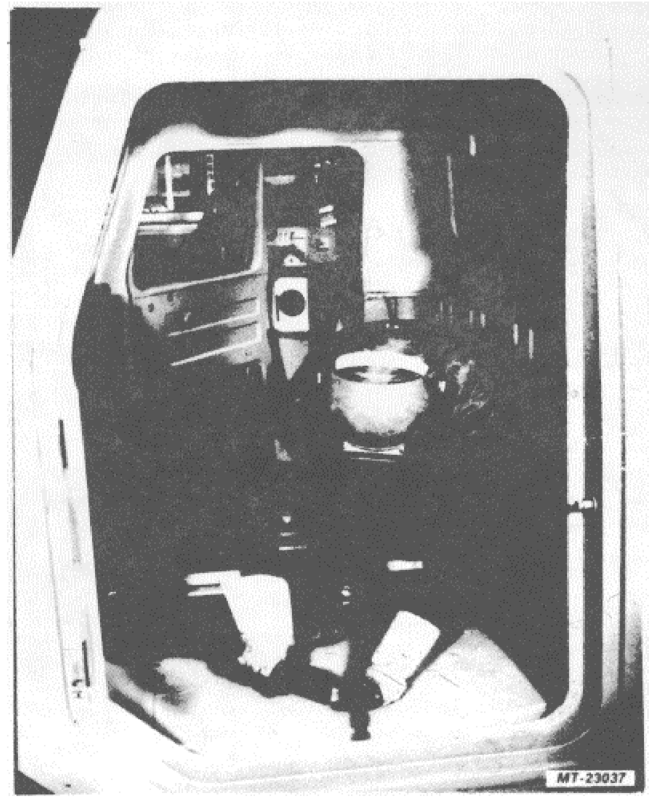

Fig. 48. Using MIG Welder For Plug Welds

3. At inside of cab weld base of inner side panels to sill side inner panel (Fig. 49). Note: 80" wide cabs do not use a seam weld at cowl seam joint but have a panel extension on sill side inner panel to be plug welded to inside of side panel.

Fig. 49. Seam Weld At Inside Of Side Panel

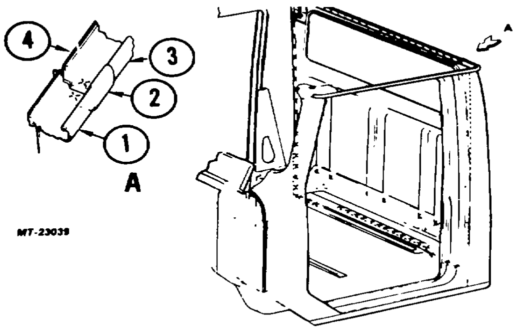

Fig. 50. Securing Drip Moulding Clip

1. Side Panel Drip Moulding
2. Drip Moulding Clip
3. Rear Drip Moulding
4. Back Panel

A View in Direction of Arrow A

4. Obtain drip moulding clip and position clip so as to close joint between old drip moulding on back of cab and drip moulding on new side panel (Fig. 50). Secure with one plug weld at each side of joint.

5. Clamp outer roof panel to drip moulding of new side panel assembly and plug weld roof panel to moulding (Fig. 51).

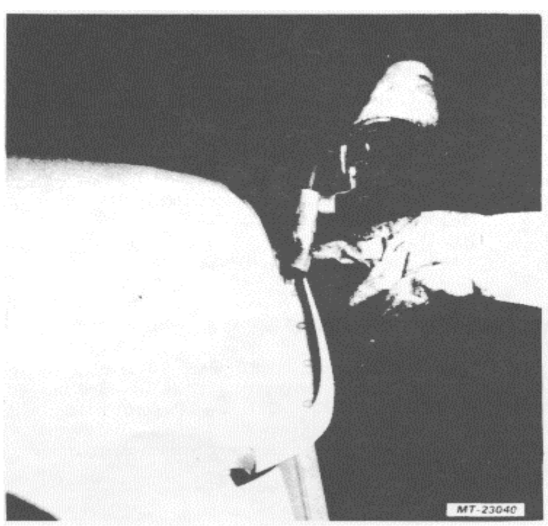

Fig. 51. Fastening Roof Panel To New Side Panel

6. Plug weld through holes drilled for removing to replace inner corner panel to inside of cab (Fig. 52). If new inner corner panel is used, plug weld holes must be drilled into new panel before welding.

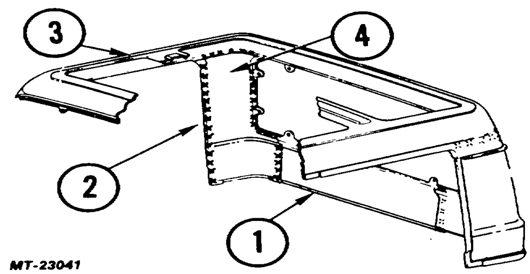

Fig. 52. Installing Inner Corner Panel (Right Side - 80" Wide Cab Shown)

1. Inner Back Panel
2. Plug Weld at these Locations
3. Inner Roof Panel
4. Inner Corner Panel

7. Grind, sand or wire brush away any excess weld or weld ash from all newly welded areas.

8. Obtain body sealant (Plastisol Type 1 or equivalent) and apply to the following locations:

   a. Roof panel to drip moulding seam.
   b. Side panel to back panel joint at rear of cab.
   c. Dash filler panel to dash panel joint at front of cowl.
   d. Drilled out holes on upper side of sill side inner panel to rocker panel seam (under cab).

9. Apply primer paint to affected areas to assure good protection from rust. Finish paint as required.

OTHER PANEL REPAIRS

Since each cab panel component contributes to the overall strength of the cab, proper welding, sealing and rust-proofing practices must be observed for any other panel replacement. Under-cab components especially should be rust-proofed whenever cab repair operations are performed.

When rust-proofing cab components, use a good quality air-dry zinc rich primer. Combination type primer-surfacer paints are not recommended. Finish paint *as* required.

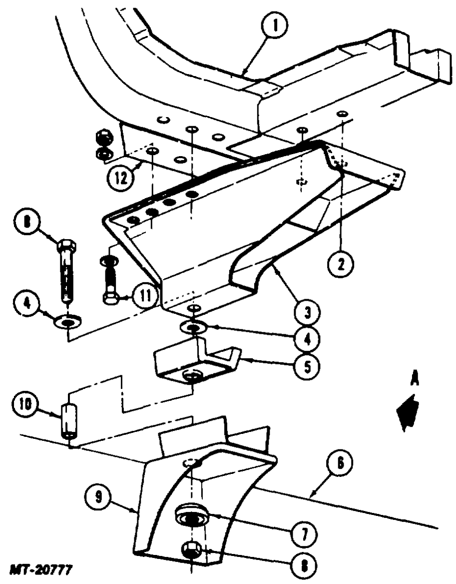

Fig. 53. Cab Front Mounting Bracket (Left Front View)

Key	Description
1	Sill, Cab Underbody
2	Bolt, Intermediate Bracket
3	Bracket, Intermediate
4	Washer, Flat
5	Insulator, Water Type
6	Sidemember, Frame
7	Insulator, Donut Type
8	Bolt and Nut (Cab Mounting)
9	Bracket, Cab Front Mounting
10	Bushing
11	Bolt, Nut and Washer
12	Reinforcement
A	View in Direction of Arrow A

CAB MOUNTING

A four point rubber cushioned mounting is used for securing cab to frame. This mounting has been designed to give a firm foundation to cab and at the same time provide enough flexibility in mounting to prevent severe road shock from being transferred from frame to cab. The hard rubber insulators used are maintenance free.

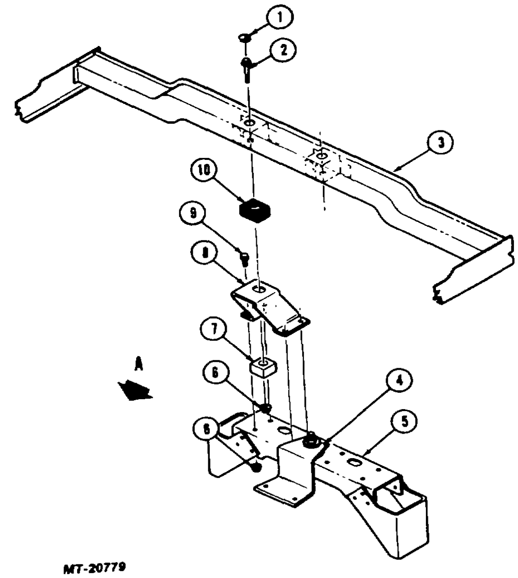

Fig. 54. Cab Rear Mounting (200 cm - 80 Inch Wide Cab)

Key	Description
1	Plug, Button
2	Bolt, Cab Mounting
3	Sill, Cab Underbody
4	Bracket, Transmission Mounting
5	Crossmember, Cab Rear Mounting
6	Nut, Flange Type
7	Insulator, Lower
8	Bracket, Cab Rear Mounting
9	Bolt, Flange Head
10	Insulator, Upper
A	View in Direction of Arrow A

CAB FRONT MOUNTING

Both 200 and 230 cm (80 and 90 Inch) wide cabs use a cab front mounting that is similar to that shown in Fig. 53. Cab width mounting differences are accommodated by using different mounting holes in the intermediate mounting bracket.

CAB REAR MOUNTING

The different cab rear mountings used for the 200 and 230 cm (80 and 90 inch) wide cabs are shown in Figs. 54 and 55.

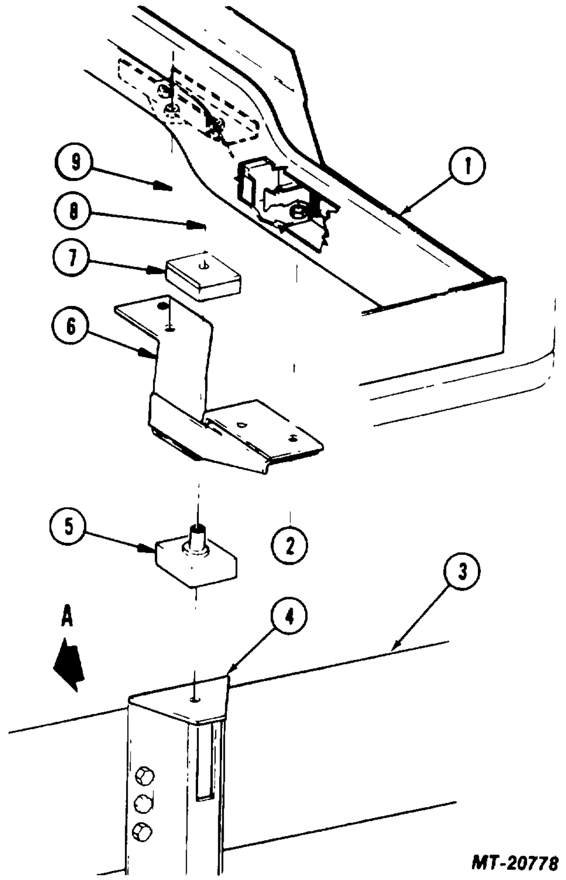

Fig. 55. Cab Rear Mounting (230 cm - 90 inch Wide Cab)

Key	Description
1	Sill, Cab Underbody
2	Bolt
3	Sidemember, Frame
4	Bracket, Frame
5	Insulator, Lower
6	Bracket, Intermediate
7	Insulator, Upper
8	Bolt, Flange Head, Cab Mounting
9	Bolt, Hex Head
A	Forward

CAB STAY RODS

Cab stay rods which add stability and provide more comfortable ride characteristics are also used with S-Series cabs. Stay rods for the different cab models are shown in Figs. 56 and 57.

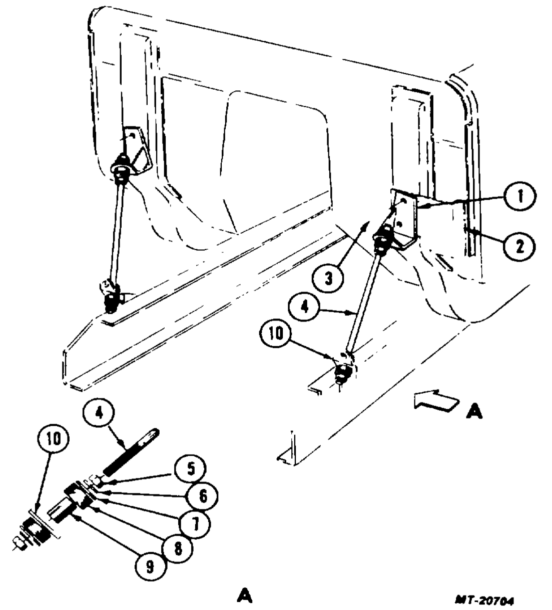

Fig. 56. Stay Rod Details for 200 x 280 cm (80 x 112 Inch) Cab

Key	Description
1	Bracket, Cab Stay Rod, Upper
2	Bracket, Washer Bottle Mounting
3	Bolt, Bracket Mounting
4	Rod, Cab Stay
5	Nut, Hex 5/8-11
6	Washer, Lock
7	Washer, Flat
8	Insulator, Stay Rod
9	Spacer, Stay Rod
10	Bracket, Cab and Radiator Stay Rod
A	View in Direction of Arrow A

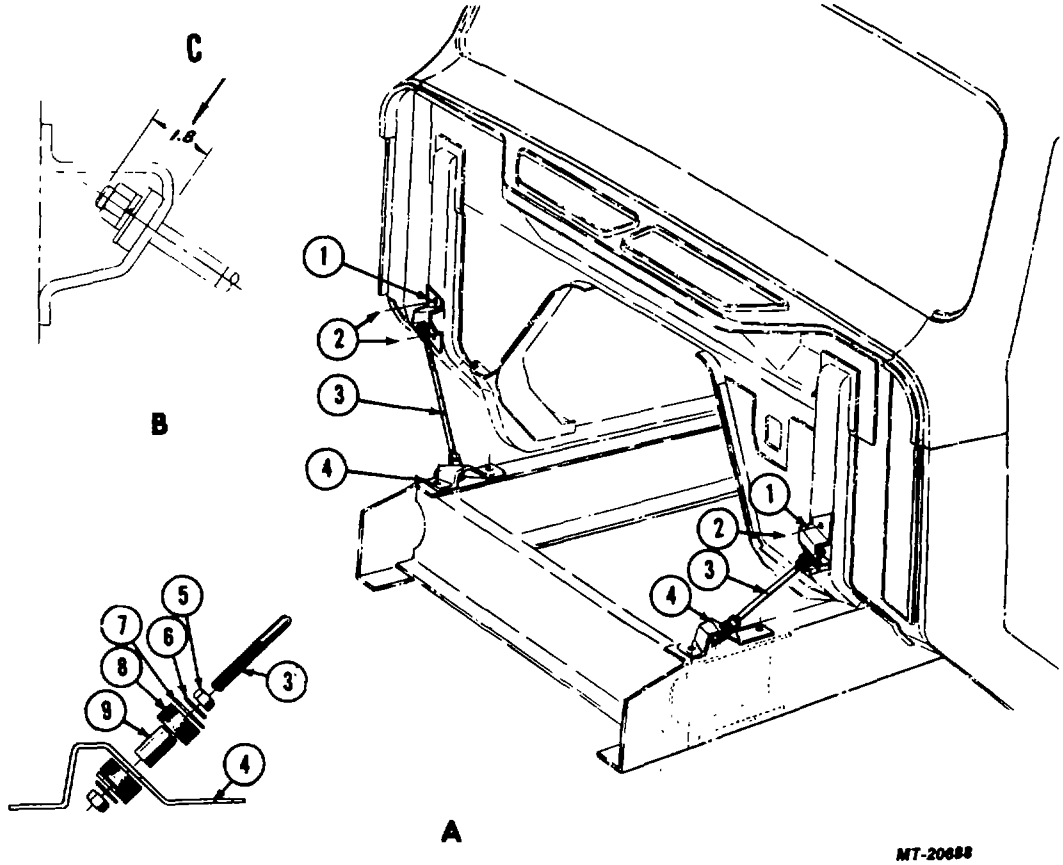

Fig. 57. Stay Rod Details for 230 x 230 cm (90 ·x 90 Inch) Cob

Key	Description	Key	Description
1	Bracket, Cab Stay Rod, Upper	6	Washer, Lock
2	Bolt, Bracket Mounting	7	Washer, Flat
3	Rod, Cab Stay	8	Insulator, Stay Rod
4	Bracket, Cab Stay Rod, Lower	9	Spacer, Stay Rod
5	Nut, Hex 5/8-11		
A	View in Direction of Arrow A		
B	View in Direction of Arrow B		
C	Install Rod to this Dimension Upper Brackets Only		

CAB REMOVAL

The removal of the S-Series cab from chassis can be performed providing an overhead crane and cab lifting fixture are available. Removal procedures may vary for various models depending on type of equipment and accessories.

The following steps may be used as a guide.

1. Block wheels of truck and release parking brake.
2. Tilt or remove hood.
3. Disconnect battery ground cable.
4. Drain radiator and disconnect heater hose.
5. Disconnect steering shaft at gear.
6. Disconnect accelerator linkage.
7. Disconnect electrical connections and ground wire.
8. Disconnect clutch linkage.
9. Disconnect brake system (air or hydraulic).
10. Disconnect speedometer and tachometer drive cables.
11. Disconnect air conditioning lines (if so equipped).
12. Remove shift lever from transmission.
13. Detach exhaust system from cab if system is vertical type.
14. Install cab lifting fixture. Make sure fixture is padded to prevent damage to cab.
15. Remove cab to frame stay rods.
16. Partially lift cab so cab weight will be sup- ported on lifting fixture.
17. Remove cab to frame mounting bolts and nuts at front and rear locations.

CAUTION

Inspect all cab to frame attaching points to be sure they are disconnected or damage can result.

18. Carefully lift cab from chassis.

CAB INSTALLATION

Cab installation is the reverse of the fore- going removal procedure. No special adjustment is required for cab to frame mounting bolts and nuts other than the application of specified torques. Connect all wiring harnesses, plumb- ing and controls. Start engine and check all systems and controls before returning truck to service.

LUBRICATION

Cab hardware and other mechanisms require a periodic application of lubricant to increase service life and prevent objectionable squeaking. New cabs are lubricated at factory and before they are delivered to customer. After the cab is placed in service, regular lubricating intervals based on type of service should be established. Thorough lubrication at definite intervals adds greatly to cab service life and reduces overall expense.

For specified lubrication intervals refer to Operator’s Manual

Wipe off all lubricant points before applying new lube to prevent lube contamination. Apply lube sparingly and wipe away excess.

TORQUE CHART

APPLICATION	SIZE	N•M	FT.LBS.
Door Hinge Mounting Bolts	5/16-18	27-30	20-22
Hood Hinge Mounting Bolts	5/16-18	27-30	20-22
Door Striker Pin	1/2-13	60-80	45-60
Cab to Frame’ Mounting Bolts (Front)	1/2-13	95-115	70-85
Cab to Frame Mounting Bolts (Rear)	1/2-13	95-115	70-85
Seat Riser to Floor Mounting Bolts	5/16-18	27-30	20-22
Seat Adjuster to Seat Mounting Bolts	5/16-18	27-30	20-22
Seat Belt to Cab Sill Mounting Bolts	1/2-13	95-115	70-85
Arm Rest to Door Mounting Screws	1/4-20	2-2.5	1.5-2
Stay Rod Bracket to Dash Mounting Bolt	3/8-16	26-37	19-27
Splash Shield Bracket To Cab Mounting Bolt	5/16-18	18-21	12-16

BODIES AND CABS

Insert this new Section in your CTS-4001 Service Manual.

REPAIR INSTRUCTIONS USING FIBER GLASS MATERIAL

CONTENTS

CONTENTS (Continued)

Subject **Page**

Portions of Text and Illustrations Courtesy of Owens/Corning Fiberglas

FIBER GLASS TYPES

HAND LAY-UP TYPE

In the past, most fiber glass parts have been made from a hand lay-up type fiber glass. This material is made of woven fiber glass cloth which has been impregnated with a molding resin and molded to a desired shape. Much of the manufacturing process is done by hand as the name implies.

SHEET MOLDING COMPOUND (SMC) TYPE

Currently, various parts are made from a newer type fiber glass called Sheet Molding Compound (SMC).
This compression molded fiber glass differs from hand lay-up fiber glass in that it is made from a resin molding compound to which short or shredded glass fibers have been added. The resulting plastic mass can be compression molded to any desired shape without using cloth as is used for the hand lay-up type.

RESIN TRANSFER MOLDING (RTM) TYPE

A third kind of fiber glass called Resin Transfer Molding (RTM) is also being used. This type fiber glass is similar to both hand lay-up and SMC types in that it uses a glass mat or cloth in a closed mold to which the resin molding compound is added. A room temperature catalyst (curing or hardening agent) is also used. This type fiber glass also lends itself to production method of manufacture.

NOTE - The external surface appearance of all three types of fiber glass material Is similar. However, the hand lay-up type material Is rough textured on Its Internal surface (back side) while "SMC" and "RTM" materials are smooth.

FIBER GLASS REPAIRS

All types of fiber glass repairs, whether cosmetic or structural, are covered on the following pages. The procedures are illustrated using the Sheet Molding Compound (SMC) type fiber glass. These procedures are also applicable and recommended for repairs to the hand lay-up type and Resin Transfer Molding (RTM) type fiber glass.

NOTE - The Illustrations used in this write-up are typical and do not necessarily represent a particular part or model.

TOOLS

Most of the hand and power-type tools (Figure 1) required to repair fiber glass or sheet metal body components with fiber glass material are common tools that can be found in any automotive body repair shop and include:

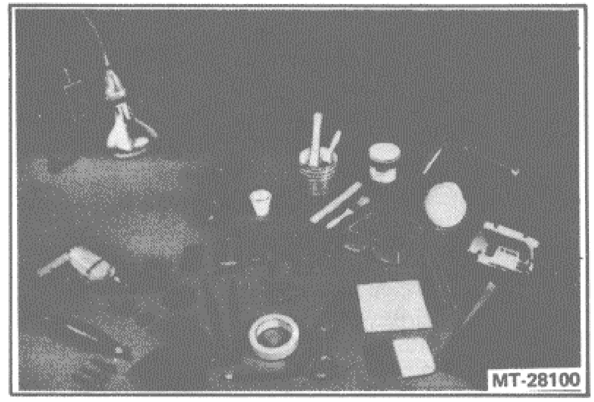

Figure 1. - Tools Required

- Pneumatic or electric drill with sanding attachment, burr bits and tapered bits.
- Sandpaper and sanding discs (24-80 grit and 360- 600 grit).
- Electric sander and sanding block.
- Masking tape.
- Sabre saw or hacksaw.
- Assortment of clamps.
- Assortment of files.
- Plastic separating film.
- Safety goggles & respirator mask.
- Xylol, acetone or equivalent solvent.

SAFETY PRECAUTIONS

Observe the following when making repairs with fiber glass:

1. Avoid spilling the resin or hardener on skin or clothing. If this occurs, remove with paint thinner or denatured alcohol. Then wash with soap and water. If the mixture contacts the eyes, flush thoroughly with water Immediately. Continue flushing for at least 15 minutes and contact a physician as soon as possible.
2. In some cases, some Individuals may have skin sensitivity to the use of these materials. Because of this, protective creams can be applied to the hands to guard against Irritation.
3. When protective creams are not available, rubber gloves may be used to protect the hands. The gloves can be removed quickly leaving the hands clean for other work.

4. When working with fiber glass, always work In a well ventilated area. DO NOT SMOKE OR EXPOSE FLAME WHERE KITS ARE BEING USED OR STORED. If possible, obtain a kit of material large enough to accommodate only one or two Jobs to avoid storing any quantity of the material. Resin liquid must be kept In a metal container or cabinet when not being used.
5. Repairs must be ground or sanded to match surrounding contours. When grinding or sanding, It Is advisable to use an approved type respirator during the operation. Suitable respirators are available under equipment number SE-1 798 and SE-1799. The ground dust or particles of resin or fiber glass must not be Inhaled, or irritation may occur.

MATERIALS REQUIRED

Fiber Glass Mat (Figure 2)

This blanket of randomly arranged fibers is the repair material you will use in all repairs requiring a backing patch. Its weight is measured in ounces per square foot. For most of your repairs, a 1-1/2 oz. mat is required.

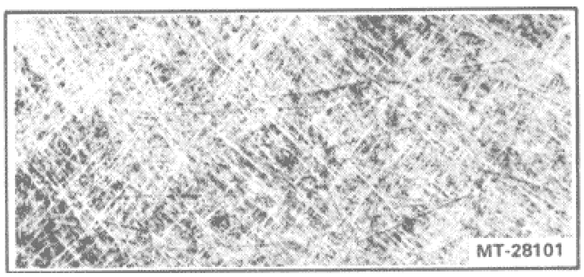

Figure 2. - Fiber Glass Mat

Fiber Glass Cloth (Figure 3)

This material is made from continuous filament glass fibers that are commercially woven on regular textile machinery. Fiber glass cloth is used where the most strength and the least thickness is needed. Its weight is measured in ounces per square yard. A 10 oz. cloth is recommended for most automotive repairs.

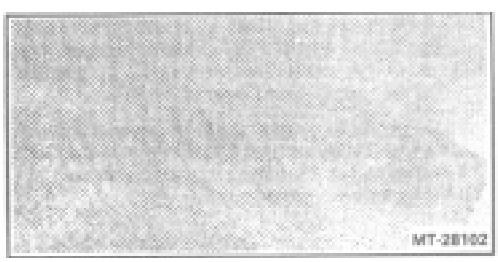

Figure 3. - Fiber Glass Cloth

Resin (Figure 4)

Resin is a liquid plastic that hardens when combined with another substance known as a catalyst or hardener. The resin used for most automotive fiber glass repairs is polyester resin. Because it is inexpensive and has a short hardening (curing) time, it is used for repairs requiring the pre-forming of a backing patch and is available from:

Polycomp 5116
Neo-Pruf Industrial Coatings, Inc.
3085 W. Market St.
Akron, Ohio 44313

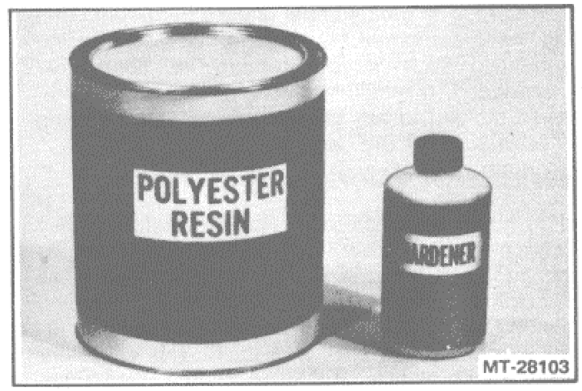

Figure 4. - Resin

Epoxy Adhesive (Figure 5)

This is the bonding cement used to create a strong durable bond between back side of repair area and the backing patch. It is also used for bonding reinforcement panels to the back side of an outer panel. It is available from:

REN Plastics 1258 Epoxy or
REN Plastics Fastweld No. 10 Epoxy
REN Plastics
A Ciba-Geigy Co.
5556 S. Cedar
Lansing, MI 48909

Figure 5. - Epoxy Adhesive

Body Fillers (Figure 6)

Polyester body filler is used in most automotive repair shops because it is easy to apply and shape to the contour of the surrounding piece. Machining of the body filler surface can be followed if necessary by an application of glazing putty to eliminate porosity and provide a smooth surface for painting. It is available from:

Acryl Green Spot Putty
Minnesota Mining & Mfg. Co.
St. Paul, Minnesota 55101
Ditzler Red Oxide Putty
PPG Industries, Inc., Ditzler Auto Finishes
Detroit, MI 48235

Figure 6. - Body Fillers

As a matter of economy and to maintain the curing properties of the resin, store the resin in a sealed container within a cool, dry enclosure. This precaution will reduce aging caused by changing temperatures. Keep a record of each purchase of resin. In this way, you can always use the oldest stock first.

NOTE - The shelf life of resin varies; therefore, they should be tested before using and discarded if not up to specifications.

WARNING - FIBER GLASS REPAIRS ARE AS SAFE AS ANY OTHER AUTOMOTIVE SHOP REPAIRS, PROVIDED YOU TAKE THE PROPER PRECAUTIONS. THE FOLLOWING ITEMS SHOULD BE PARTICULARLY NOTED:

1. BEFORE USING ANY MATERIALS, READ THE MANUFACTURER'S INSTRUCTIONS.
2. BE SURE WORK ROOM IS ADEQUATELY VENTILATED. PROLONGED EXPOSURE TO RESIN FUMES IS IRRITATING TO SKIN AND EYES.
3. PROTECT YOUR EYES, FACE, AND BODY FROM THE FINE DUST THAT DEVELOPS DURING GRINDING AND SANDING OPERATIONS. WEAR GOGGLES, RESPIRATOR MASK AND PROTECTIVE CLOTHING.
4. DO NOT RUB YOUR FACE OR EYES WHEN WORKING WITH FIBER GLASS.

PREPARATION PROCEDURE

Prepare for all body repairs using fiber glass by following these steps:

1. Check shop temperature and humidity and compare with specifications on the label for the material being used. A temperature of 21 °C (70°F) and 70% humidity are considered ideal.
2. Gather required materials.
3. Clean and inspect damaged area.
4. Push on surrounding area and underneath damaged area to determine extent of damage.

REPAIR PROCEDURES -
FIBER GLASS BODY COMPONENTS

COSMETIC REPAIRS

Scratches and Gouges

In general, a scratch or gouge is minor damage that penetrates the paint but only slightly into the laminate (Figure 7).

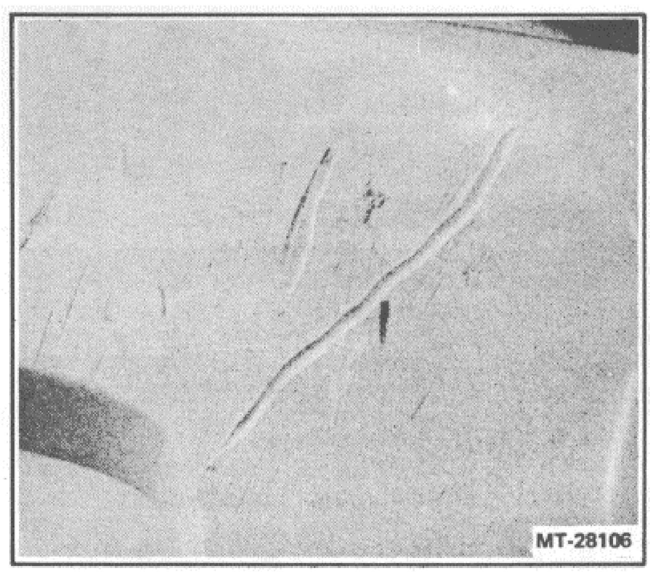

Figure 7. - Scratches and Gouges

Perform the steps listed under Preparation Procedures, and then proceed with the repair as follows:

1. Use a burr bit on a power drill to form a V-groove for the length of the scratch or gouge (Figure 8). The sides of the V should be tapered no more than 45 degrees.

   WARNING - WEAR GOGGLES AND RESPIRA-TOR WHEN CUTTING, GRINDING OR SANDING.

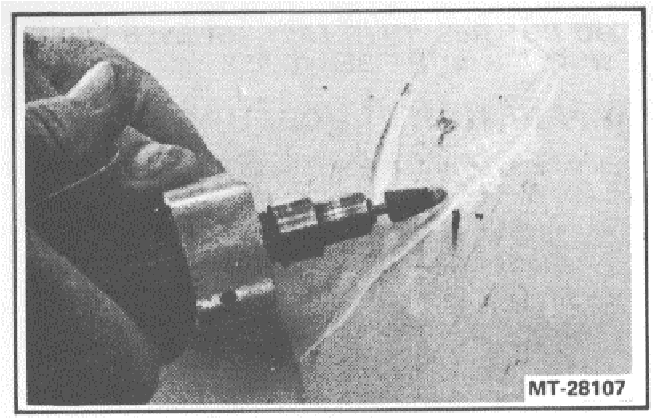

Figure 8. - V-Groove

2. Remove flaky edges and feather the painted surface back about 1/2 inch beyond the damaged area by hand-sanding or power-sanding with 360 grit sandpaper (Figure 9).

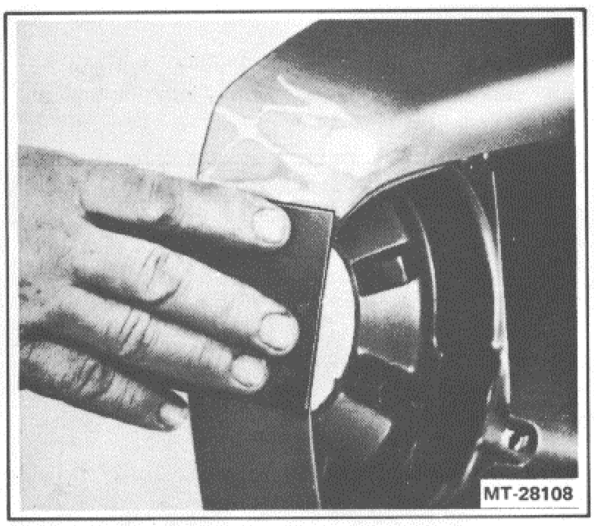

Figure 9. - Surface Preparation

Clean the area with a dry cloth or air.

CAUTION - DO NOT WIPE WITH SOLVENT.

3. Mask off the undamaged surface, leaving a working area of approximately 5 inches surrounding the repair area (Figure 10).
4. Following the manufacturer's instructions, mix enough body filler to re-establish the surface (Figure 11). CAUTION - MIX FILLER ON FORMICA, TEFLON OR OTHER HARD SURFACE. DO NOT WORK ON A POROUS SURFACE SUCH AS CARDBOARD.

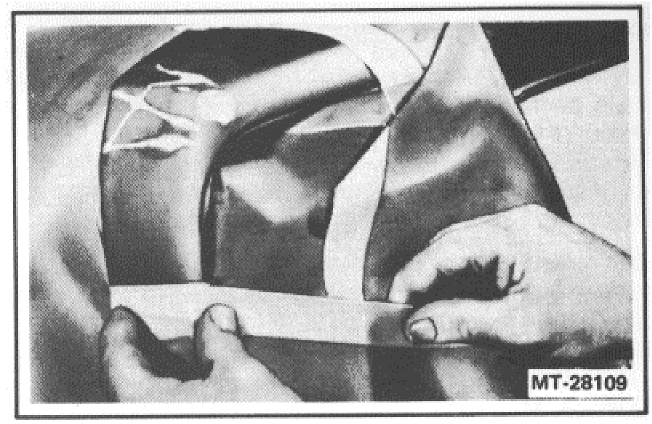

Figure 10. - Masking Undamaged Area

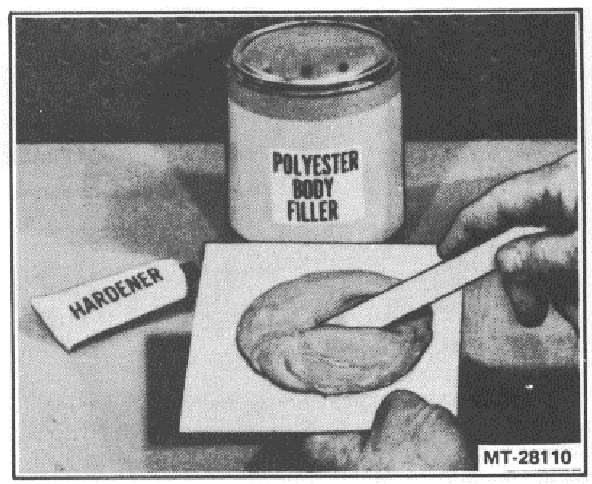

Figure 11. - Preparing Body Filler

5. Apply and spread filler with a plastic squeegee making sure to remove large air bubbles (Figure 12).

NOTE - Allow filler to extend above original surface to allow for shrinkage.

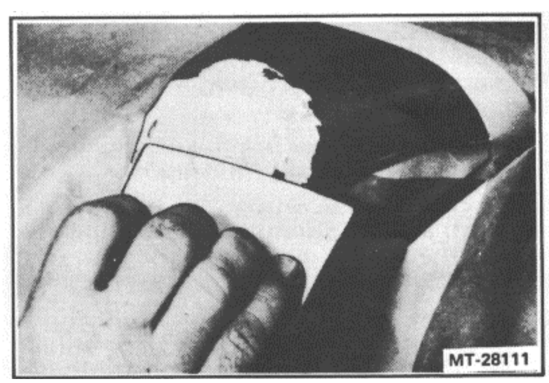

Figure 12 . - Applying Body Filler

6. Let filler set up until it is rubbery but not fully hardened. Then re-establish original contour by filing off excess.

NOTE-When filing excess, leave the filler level slightly higher than that of the original surface (Figure 13).

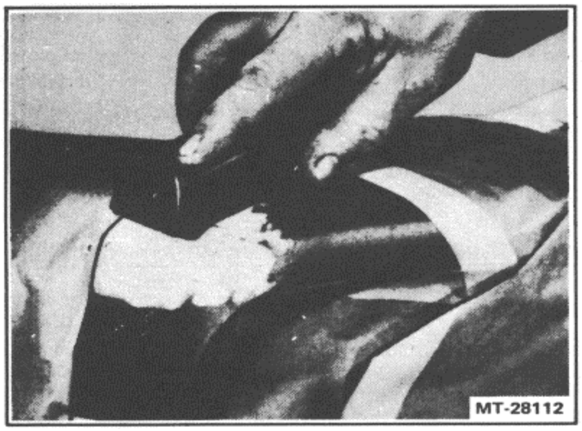

Figure 13. - Establishing Surface Contour

7. Pre-shrink filler, using a heat gun or heat lamp (Figure 14). A minimum temperature of 49°C (120°F) is required for shrinkage.

WARNING-KEEP HEAT SOURCE AT LEAST 12 INCHES AWAY FROM REPAIR AREA.

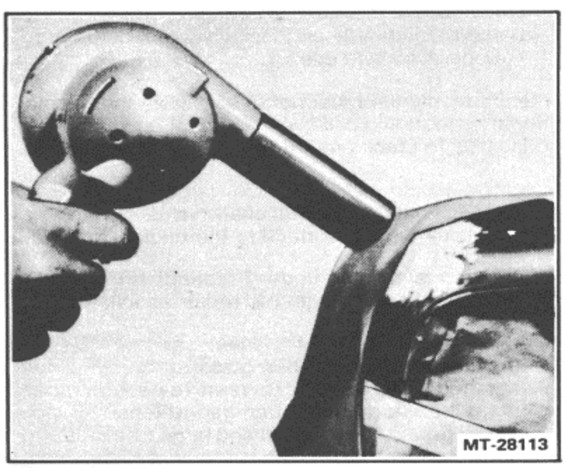

Figure 14. - Shrinking Body Filler

8. Now power-sand the filler with 360 grit sandpaper until it is smooth and even with the original surface

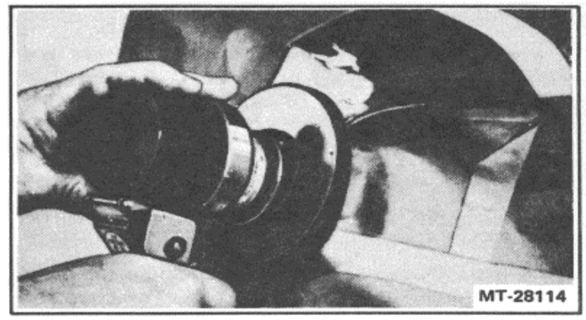

Figure 15. - Sanding Surface

9. If the filler is slightly porous (has fine pinholes), apply a thin coat of glazing putty (Figure 16).

NOTE-If the filler is pockmarked, do not use glazing putty. Instead, apply another layer of body filler, following steps 4 through 8 before continuing.

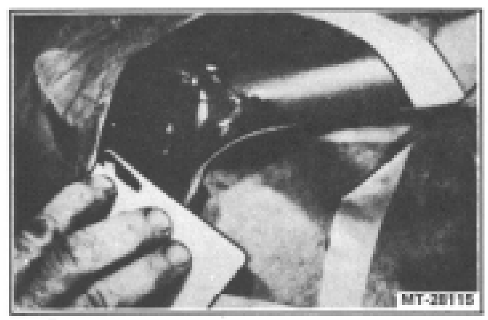

Figure 16. - Applying Glazing Putty

10. Clean the area with air, and remask if necessary. Then spot prime the surface and wet sand with 400 to 600 grit sandpaper. Complete the repair by painting the surface (Figure 17).

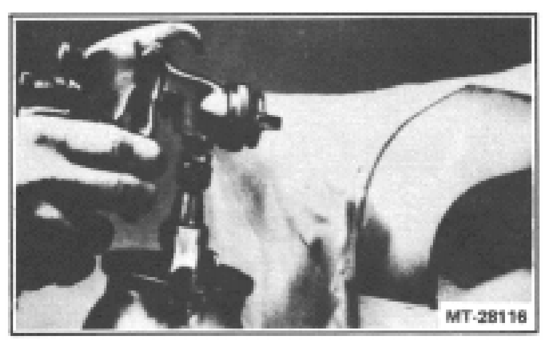

Figure 17. - Painting the Surface

STRUCTURAL REPAIRS

The procedures given under Structural Repairs are used for repairing various types of damage to the fiber glass laminate cracks, large and small fractures, panel separation, etc. that can affect the structural soundness of the laminate.

Cracks, Small and Large Fractures

Cracks, small fractures and large fractures are identified as follows: A crack is an obvious separation extending completely through the laminate (Figure 18). Cracks, which result from stress beyond normal operation, can occur in the center of the laminate or extend from the laminate edge.

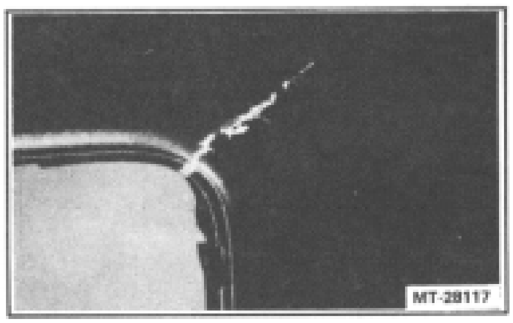

Figure 18. - Crack

Small fractures are punctures that are 3 inches or less in size (Figure 19).

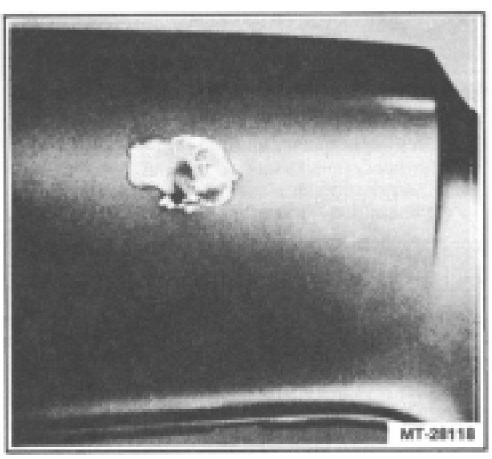

Figure 19. - Small Fractures

Large fractures are punctures that are 3 inches or more in length (Figure 20).

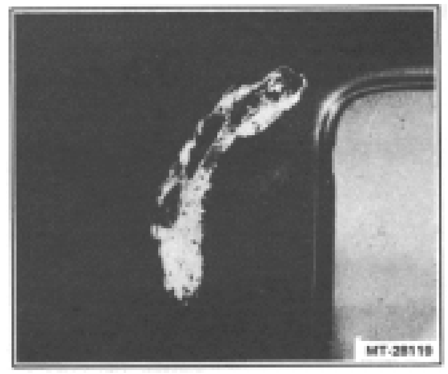

Figure 20. - Large Fractures

Cracks, small fractures and large fractures are repaired following the same basic procedure. All require backing patches or backup strips. These are simple laminates that are formed to the shape of the surface being repaired and bonded with epoxy cement to the back side of the repair area. The backing patch serves two functions:

1. It provides the foundation on which the exterior surface is built up and formed to match the original contour.

2. It provides the mechanical strength needed to keep a repair structurally and visually intact during normal operation and use.

A repaired laminate must be as strong as the original material surrounding it. If it is not, the repair will not last and is likely to crack around the edge of the patch.

In addition to the backing patch, large fractures will require additional mat laminations which are used as a filler in building up the surface to the original contour.

Perform the steps listed under Preparation Procedure (page 5), then proceed with the repair as follows:

1. Using a tapered bit or a saber saw, remove the cracked and flaked fiber glass surrounding the damaged area. For cracks, remove enough material so that there is an open gap at least 1/8 inch wide (Figure 21). For small and large fractures, cut away as much material as is required to provide a solid edge (Figures 22 and 23).

WARNING - WEAR GOGGLES AND RESPIRATOR WHEN CUTTING, GRINDING OR SANDING.

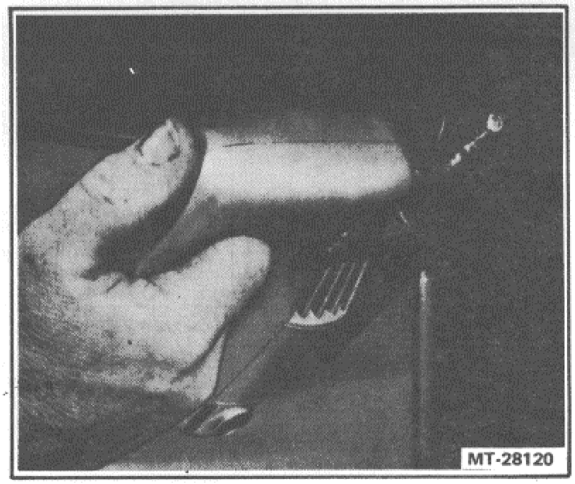

Figure 21. - Opening Cracked Area

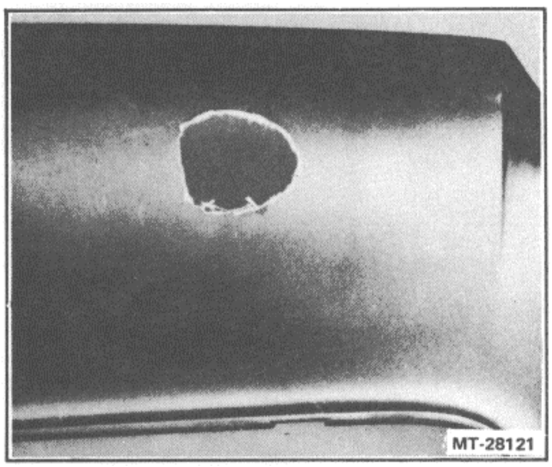

Figure 22. - Small Fracture - Damaged Material Removed

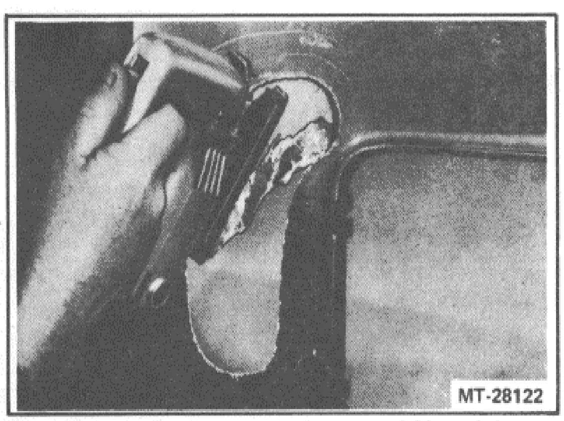

Figure 23 - Cutting Away Damaged Material - Large Fracture

2. If panel is out of alignment, realign it with C-clamps or other clamping device (Figure 24).

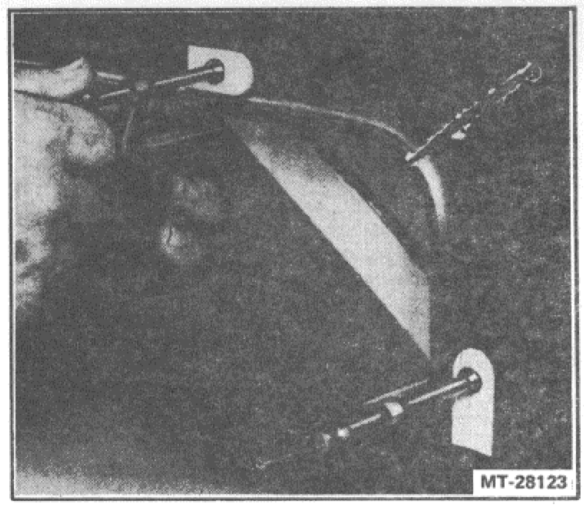

Figure 24. - Aligning Panel - (Crack Shown - Typical)

3. Mask off undamaged surface, leaving a working area of approximately 5 inches surrounding the damaged area (Figure 25).

NOTE - Steps 4 through 10 describe the procedure for forming a backing patch using the outside surface of the damaged area. If the Inner surface of the damaged area Is accessible, it is preferable to form the patch to the Inner surface In the same manner.

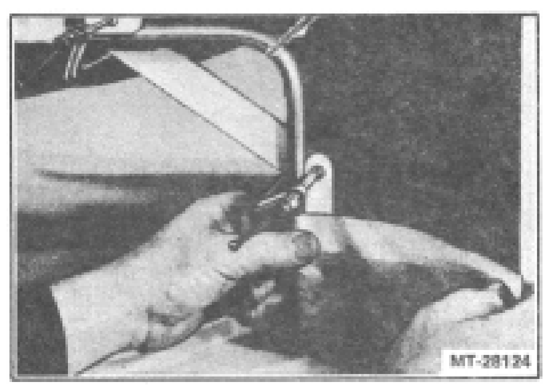

Figure 25. - Masking Undamaged Area

4. Cut a piece of plastic separating film large enough to extend approximately 3 inches beyond the edge of the repair area. Tape the film to the outside repair surface (Figure 26).

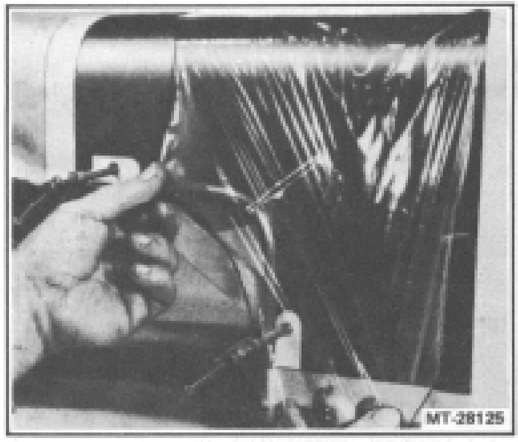

Figure 26. - Covering Repair Area with Separating Film

5. Then, using a cardboard template (Figure 27), cut the required pieces of mat large enough to extend 2 inches beyond the edges of the repair area.

NOTE-The number of layers of mat used in the backing patch depends on the thickness of the body panel being repaired. Refer to Figure 28 to determine the number of layers required. Automotive parts are normally 2.5 mm (0.100 In.) thick. Therefore, the minimum backing patch thickness must be 3.2 mm (0.126 In.) or three layers of 42g (1-1/2 oz.) mat.

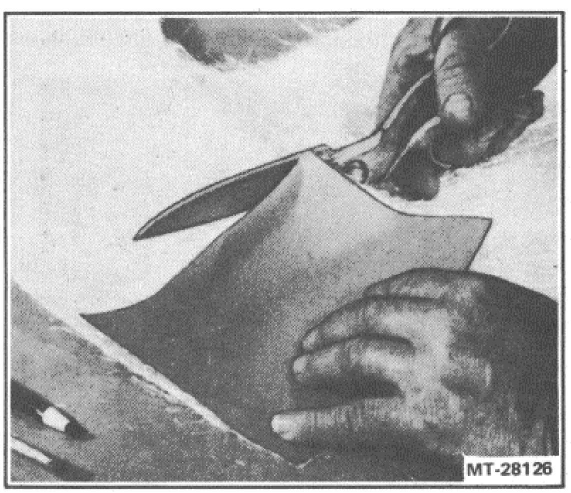

Figure 27. - Cutting Fiber Glass Mat

THICKNESS OF ORIGINAL PIECE		**LAYERS OF FIBER GLASS MAT REQUIRED FOR PATCH**		
mm	Inch	quant	g	OZ
2.5	0.100	3	42	1-1/2
2.8	0.110	3	42	1-1/2
3.0	0.120	2	42	1-1/2
		1	57	2
3.3	0.130	1	42	1-1/2
		2	57	2
3.6	0.140	3	57	2
4.3	0.170	2	42	1-1/2
		2	57	2

Figure 28. - Backing Patch Mat Layer Requirements

6. Mix the recommended amount of polyester resin according to the manufacturer's instructions.

7. Apply some resin to the working area of the separating film (Figure 29).

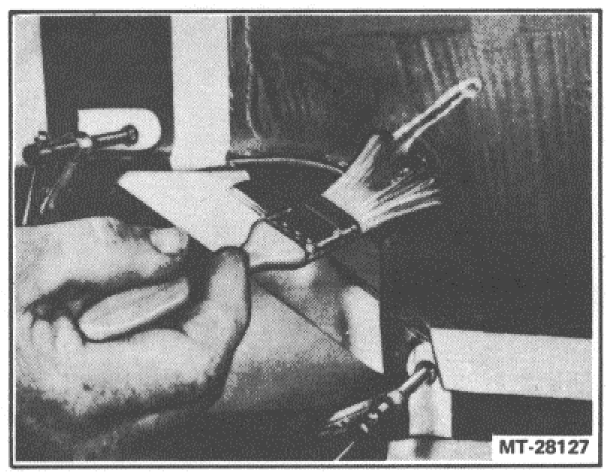

Figure 29. - Applying Resin to Separating Film

8. Soak the first layer of mat in resin; then' place it over the repair area and allow it to harden slightly.

9. Now lay-up by hand the remaining piece or pieces of resin-soaked mat (Figure 30).

NOTE-To prevent the patch from sliding on a vertical surface, tape a piece of plastic film over the patch.

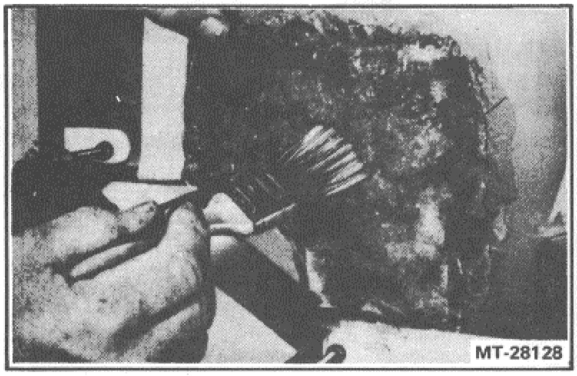

Figure 30. - Mat Lay-Up

10. Allow the patch to harden; then pop it off (Figure 31) and remove the separating film.

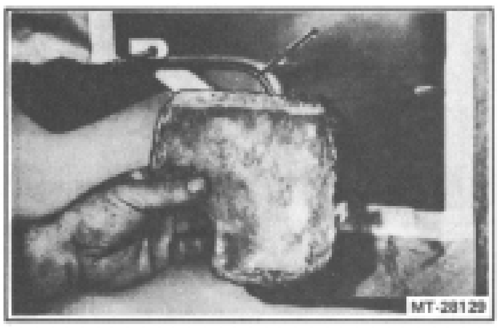

Figure 31. - Backing Patch

11. Working from the outside and using a file or grinder, taper the edges of the damaged area at an angle of no more than 45 degrees (Figure 32).

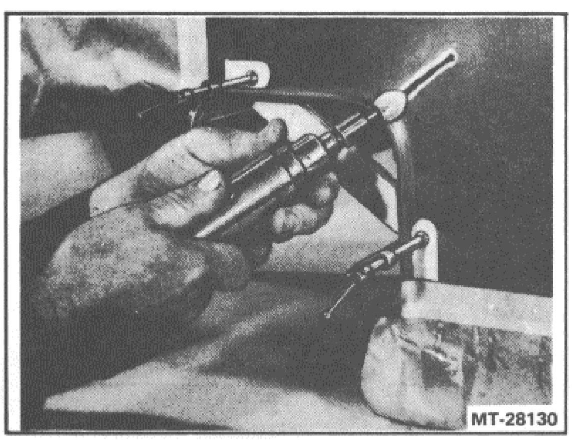

Figure 32. - Tapering Edges (Crack Shown - Typical)

12. Remove flaky edges and feather the painted surface back about 1/2 inch beyond the damaged area by hand-sanding or power-sanding with 360 grit sandpaper (Figure 33).

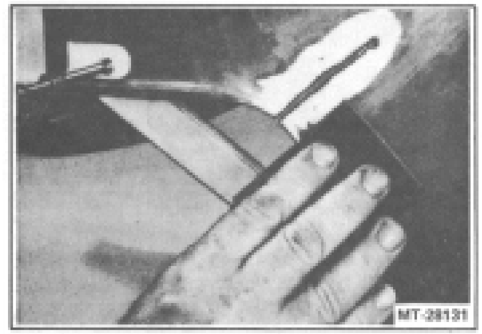

Figure 33. - Sanding Exterior Damaged Surface (Crack Shown - Typical)

13. Clean the area with a dry cloth or air.

CAUTION - DO NOT WIPE WITH SOLVENT.

14. Sand the underside of the repair area with 80 grit (or less) sandpaper to create a rough bonding surface approximately 2 inches from the center of a crack (Figure 34) or 2 inches back from the edge of a fracture.

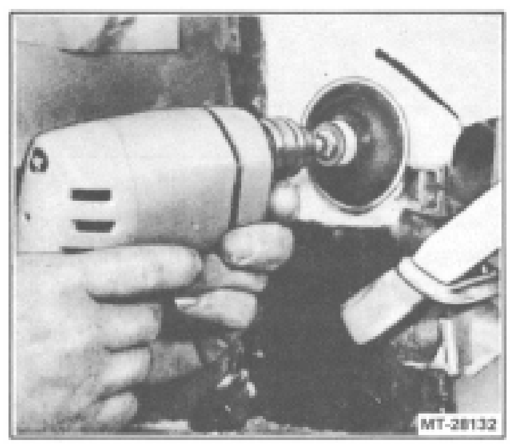

Figure 34. - Sanding Underside of Repair Area (Crack Shown - Typical)

15. Trim the perimeter and sand the mating surface of the backing patch (Figure 35) with 80 grit sandpaper (or less), checking for smooth fit to the underside. Clean all surfaces with air.

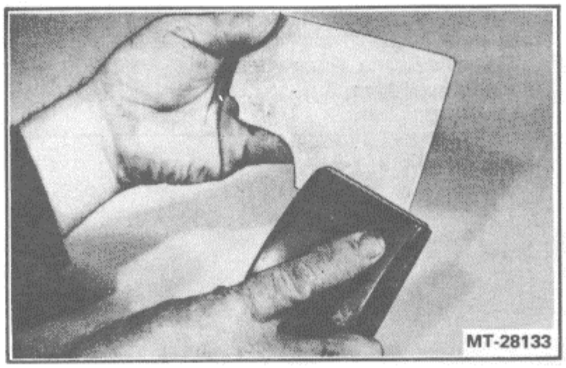

Figure 35. - Sanding Backing Patch

16. Now determine a method of holding the backing patch in place (C-clamps, self-tapping screws, etc.) and trial test the method (Figure 36).

    NOTE-If you use self-tapping screws, predrill the holes. Then before finishing the surface, remove the screws and fill the holes with body filler.

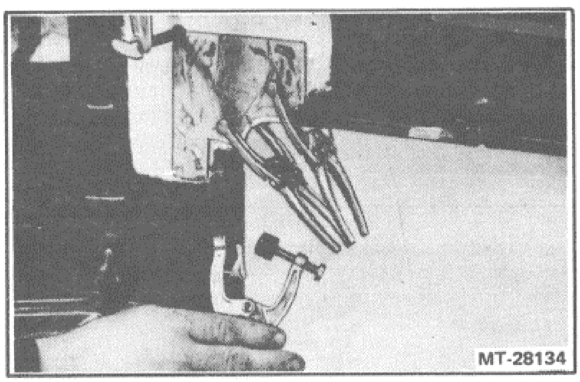

Figure 36. - Attaching Backing Plate

17. Mix epoxy adhesive according to the instructions.
18. Apply the adhesive to underside of the repair area and also to the patch (Figure 37). Press patch in place until epoxy squeezes out from all edges.
19. Hold backing patch' with clamps or screws and allow the adhesive to harden for the time given in the manufacturer's instructions (Figure 38).

    NOTE-If the adhesive Is squeezed into the tapered groove or hole during bonding, clean it out before the adhesive sets, and roughen any remaining adhesive with 360 grit sandpaper after It hardens.

Steps 20 through 23 apply for large fractures only. For cracks or small fractures, omit Steps 20 through 23 and go on to Step 24.

Figure 37. - Applying Epoxy Adhesive

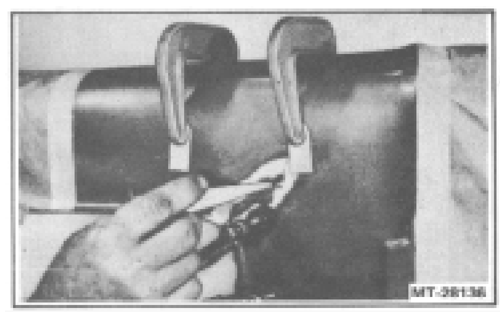

Figure 38. - Cleaning Excess Adhesive From Damaged Area

20. While the adhesive is hardening, cut some pieces of mat to fit into the hole in the panel (Figure 39). The mat is not a structural reinforcement, but a filler.

    NOTE-Cut enough pieces of mat which when layered will fill the hole to Just below the surface of the original panel.

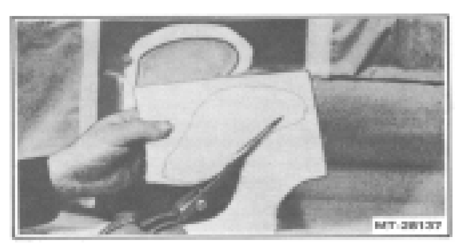

Figure 39. - Cutting Mat For Filler

21. Following the manufacturer's instructions, mix enough resin to saturate the piece(s) of mat.
22. Using a stippling motion of your brush, lay-up the resin-soaked mat by hand (Figure 40), one piece at a time, until the top layer is just below the surface of the panel.

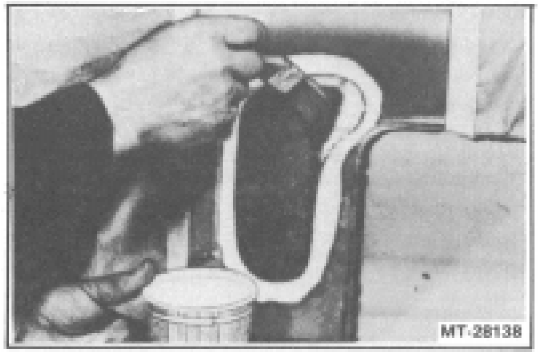

Figure 40. - Filler Mat Lay-Up

23. Allow the mat to harden. Then, rough sand with 80 grit sandpaper (Figure 41).

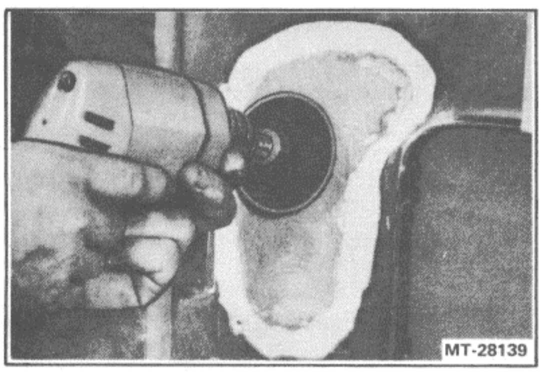

Figure 41. - Sanding Filler Mat

24. To complete the repair, use the procedure for Surface Filling and Finishing on page 16.

Panel Bond Separation

Panel separation is a fiber glass structural defect that occurs when the adhesive bond between panels fails. It can be caused by fatigue, abuse or improper assembly.

1. Perform the steps listed under Preparation Procedure on page 5.
2. Separate fiber glass panels until the separation reaches the point where bonding is secure. Use wood block, screwdriver or putty knife, etc. to hold panels apart (Figure 42).

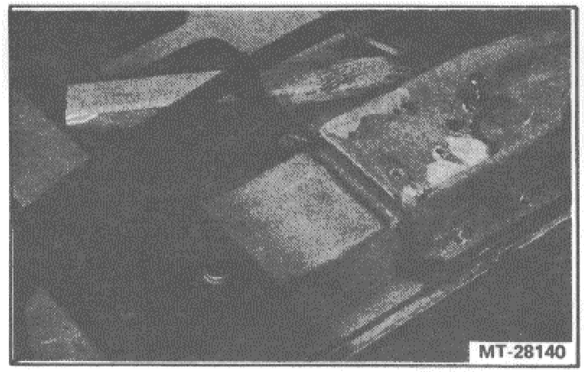

Figure 42. - Separating Panels

3. Use a coarse grinder or burr to clean old adhesive from between panels (Figure 43). Use an air gun to remove dust from the bonding surfaces. Then, wipe the surfaces clean using an acetone solvent.

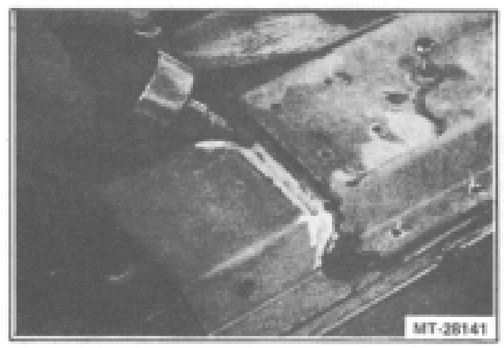

Figure 43. - Removing Old Adhesive From Panels

4. Obtain an epoxy adhesive repair kit and mix the adhesive following the instructions supplied with the kit (Figure 44).

Figure 44. - Mixing Epoxy Adhesive

WARNING-BEFORE MIXING AND USING ADHESIVE, OBSERVE THE SUPPLIER INSTRUCTIONS FOR HANDLING AND DISPOSING OF THIS MATERIAL.

5. Use an applicator or make a craft paper cone dispenser to spread adhesive on or between the panels (Figure 45). Make sure the bond area is completely covered.

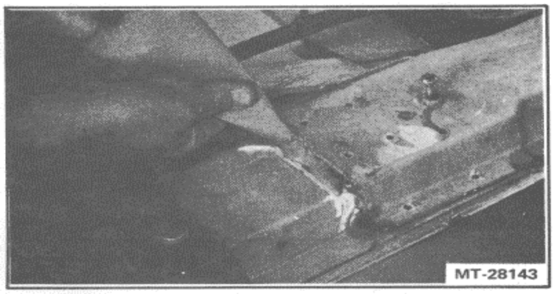

Figure 45. - Applying Adhesive

6. Press panels together and use clamps or weights to hold panels in place (Figure 46).

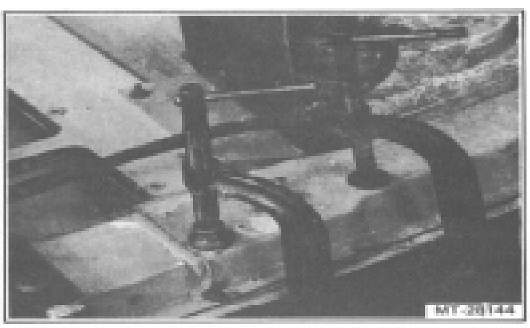

Figure 46. - Holding Panels In Place

7. Use a rag and acetone to remove any excess adhesive squeezed out. After adhesive has cured, it will be difficult to remove except by grinding or sanding.

Allow sufficient time for adhesive to cure before removing clamps or weights. Heat lamp or gun will speed up curing time.

WARNING - KEEP HEAT SOURCE AT LEAST 12 INCHES AWAY FROM THE REPAIR AREA.

REPAIR PROCEDURES - SHEET METAL/ALUMINUM BODY COMPONENTS

Repairs to sheet metal and aluminum body components can be made using fiber glass mat, cloth resin and/or the polyester body filler and glazing putty. Torn holes, rust holes or damaged surfaces which are difficult to refinish with the usual sheet metal or aluminum repair procedures can be repaired using the materials listed above.

A combination fiber glass mat and cloth patch can be used to repair holes in metal. However, a metal patch, where practical, provides a more permanent repair. Procedures are given for both types of repair patches and also for dents.

HOLES

Repair Using Fiber Glass Cloth and Mat Patch

The following procedure can be used to repair both small holes (under 3 inch diameter) and large holes (over 3 inch diameter).

1. Perform the steps listed under Preparation Procedure (page 5).
2. Clean metal to bare surface with 16 or 24 grit sandpaper approximately 6 inches beyond area being repaired.
3. Dent in area being repaired about 2 inches beyond damaged area.
4. Cut a piece of fiber glass mat about 1 inch larger than the surface being repaired, then a piece of fiber glass cloth (two or three pieces of mat may be used to fill the indented area).
5. Brush the resin mixture on the damaged area and then saturate the layers of mat and cloth being used. Allow the resin mixture to get tacky.

NOTE - When repairing large holes, prepare the patch as follows:

On a piece of polyethylene film, position a piece of cloth larger than the hole being repaired. Saturate the cloth with resin mixture. Apply two layers of mat (Figure 47) saturating both with the resin mixture.

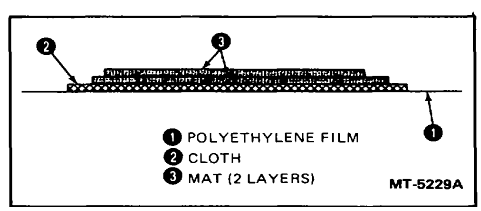

Figure 47. - Preparing Fiber Glass Patch

6. Apply the mat and cloth patches, pressing the laminations down tightly with a sheet of polyethylene film to produce a tight bond (Figure 48). (The closest patch is installed last.)

   NOTE - When repairing large holes, place the entire patch (including plyethylene film) as prepared in Step 5, on the repair surface and press the patch onto the metal. Leave the polyethylene film as a cover over the patch until the resin has cured (Figure 49).

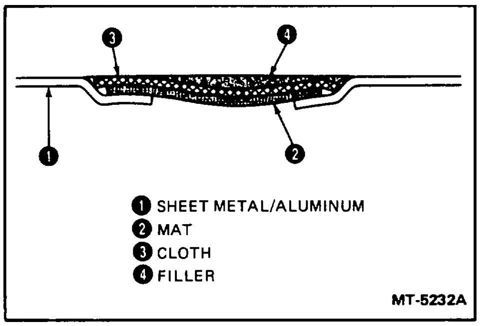

Figure 48. - fiber Glass Mat and Cloth Patch Installation

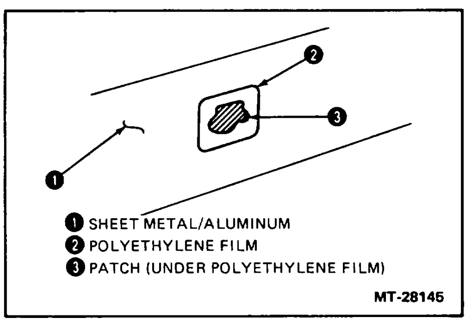

Figure 49. - Applying fiber glass Patch

7. Allow the material to cure. Then, peel off the polyethylene film if it was not removed earlier.

8. Sand and file surface after the patches have cured.

9. To complete the repair, use the procedure for surface filling and Finishing (page 15.

Repair Using Metal Insert

1. Perform the steps listed under Preparation Procedure (page 5).

2. Using the appropriate tools, cut the rusted or damaged material from the panel.

3. Using an air hammer and a panel crimper, form a step in the original panel so that the new sheet metal or aluminum insert will set flush with the original panel (Figure 50).

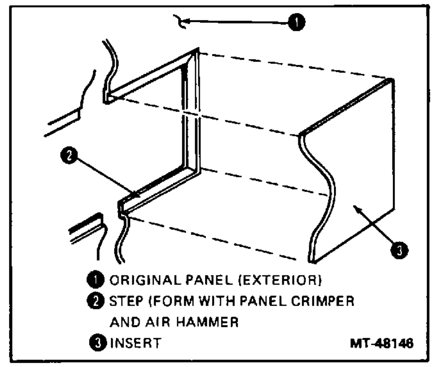

Figure 50. - Forming Insert Step in Original Panel

4. Cut a new sheet metal or aluminum insert to fit within the step area of the panel being repaired.

5. Attach the insert to the original panel by spot or tack welding it in place or by securing it with pop rivets (Figure 51).

   NOTE - If pop rivets are used, countersink the holes in the insert so that the rivet heads when installed are near flush with the exterior surface of the insert.

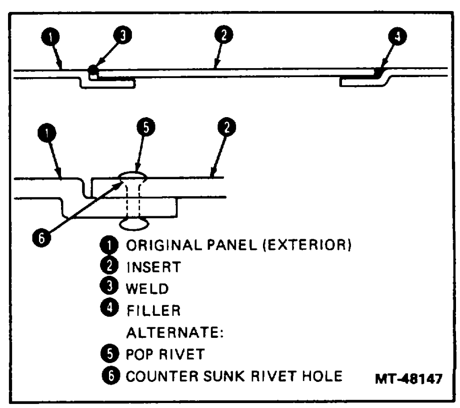

Figure 51. - Panel Metal Insert Attachment.

6. Using a grinder, cut down the welds or rivet heads flush with the exterior surface of the repair area.

7. To complete the repair, use the procedure for Surface Filling and Finishing (page 16).

DENTS

1. Perform the steps listed under Preparation Procedure (page 5).

2. Clean metal to the bare surface.

3. Drill or punch 1/2 inch holes in the dent to assure a good anchor for the filler (Figure 52).

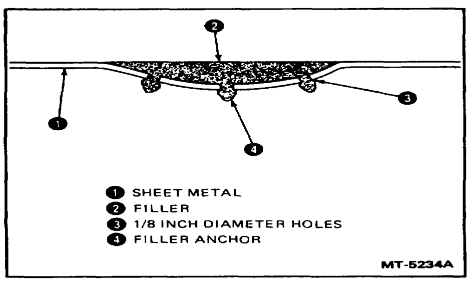

Figure 52. - Repairing Dents

4. If the dent is over 1 inch, cover dent with a piece of fiber glass cloth and saturate it with resin mixture. Allow the resin to cure.

5. To complete the repair, use the procedure for Surface Filling and Finishing (page 16).

SURFACE FILLING AND FINISHING

After repairing the damaged area, apply filler and finish the surface using this procedure:

1. Following the manufacturer's instructions, mix enough body filler to re-establish the surface.

   CAUTION-MIX FILLER ON FORMICA, TEFLON OR OTHER HARD SURFACE. DO NOT WORK ON A POROUS SURFACE SUCH AS CARDBOARD.

2. Work the filler into the repaired surface with a squeegee, making sure to fill all voids and remove large air bubbles (Figure 53).

NOTE - Allow filler to extend above the original surface to allow for shrinkage.

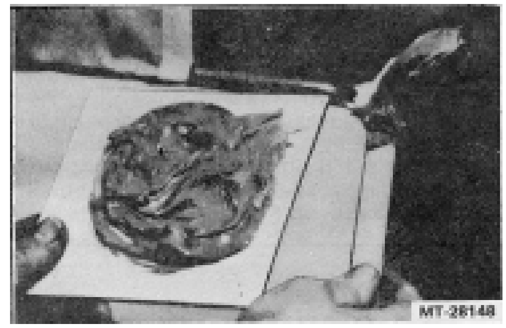

Figure 53. - Applying Body Filler

3. When the filler is firm to the touch, plane and/or file off the excess, still leaving the filler level slightly above that of the original surface (Figure 54).

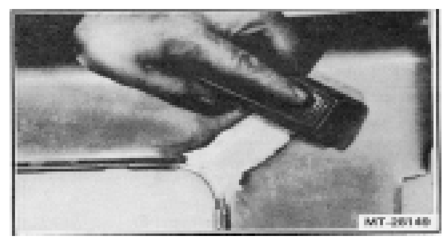

Figure 54. - Filling Repaired Surface

4. Now, pre-shrink the filler, using a heat gun or heat lamp. A minimum temperature of 49°C (120°F) is required for shrinkage (Figure 55).

WARNING-KEEP HEAT SOURCE AT LEAST 12 INCHES AWAY FROM THE REPAIR AREA.

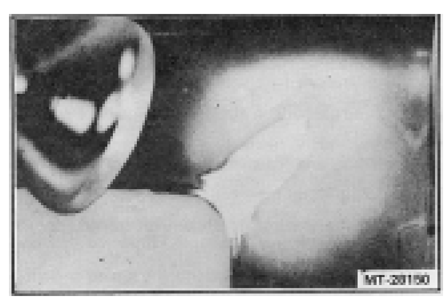

Figure 55. - Shrinking Body Filler

5. Power-sand the filler with 360 grit sandpaper until it is smooth and even with the original surface.

6. If the filler is slightly porous (has fine pinholes), apply a thin coat of glazing putty (Figure 56). If the filler is pockmarked, do not use glazing putty. In-stead, apply another layer of body filler as covered in Steps 1 through 5 before applying the glazing putty.

7. Allow the glazing putty to cure under heat gun or heat lamp. Finish by sanding with a sanding block and 360 grit sandpaper.

8. Clean the area with air and remask, if necessary. Then spot prime the surface and wet sand with 400 to 600 grit sandpaper. Complete the repair by painting the surface.

NOTE - If you have used screws to align the panel, remove them and fill the holes with body filler be-fore finishing the panel.

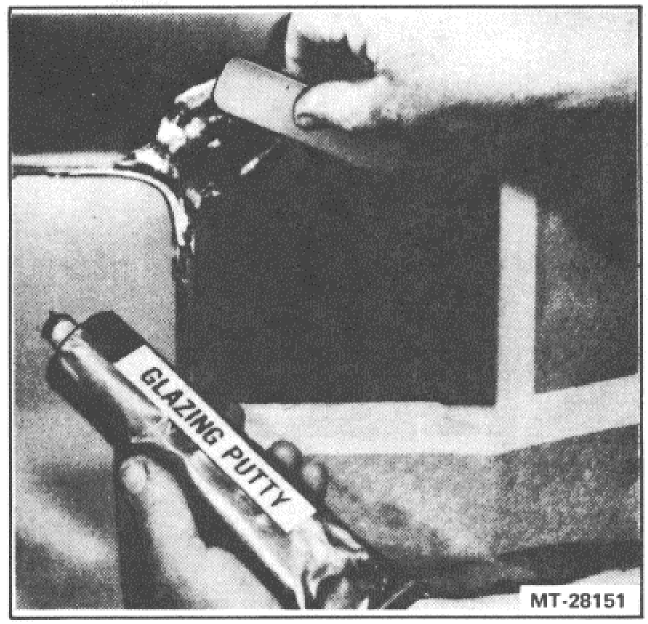

Figure 56. - Applying Glazing Putt

CAB

Replace old Section with this revised Section In your CTS4001 Manual.

-- HEATER SYSTEM

S-SERIES

CONTENTS

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CONTENTS (Continued)

Subject **Page**

Heater Components

1. Heater Core
2. Hot Water Flow Control Valve
3. Heater Hoses
4. Control Unit, Switch and Cables
5. Blower
6. Air Ducts
7. Intake Air Box

HEATER (ONLY) SYSTEM

The heater only system is provided in a unit of different construction from the Blend-Air System. The list of components is the same as the heater portion of the combined system, although the configuration of some of them is different. Since most are the same, the service of both systems will be covered as one, with the exceptions noted where they occur.

COMPONENTS
Heater Core

The heater core, constructed of ribbon fins (Figure 5), is mounted in the unit housing. Engine coolant is circulated through the core and heat from the coolant is dissipated by air circulated through the core fins.

Hot Water Flow Control Valve

The hot water flow control valve (heater shutoff) is attached to the floor of the blend-air unit housing. It is placed in the heater core inlet hose and serves to meter the flow of hot engine coolant through the core. The flow control is accomplished by an adjustable link connecting the valve to the blend-air door which is controlled by a cable connected to the control panel HTR lever.

Blower

The blower fan (Figure 6) provides air circulation through the heater and delivers the treated air to the cab interior.

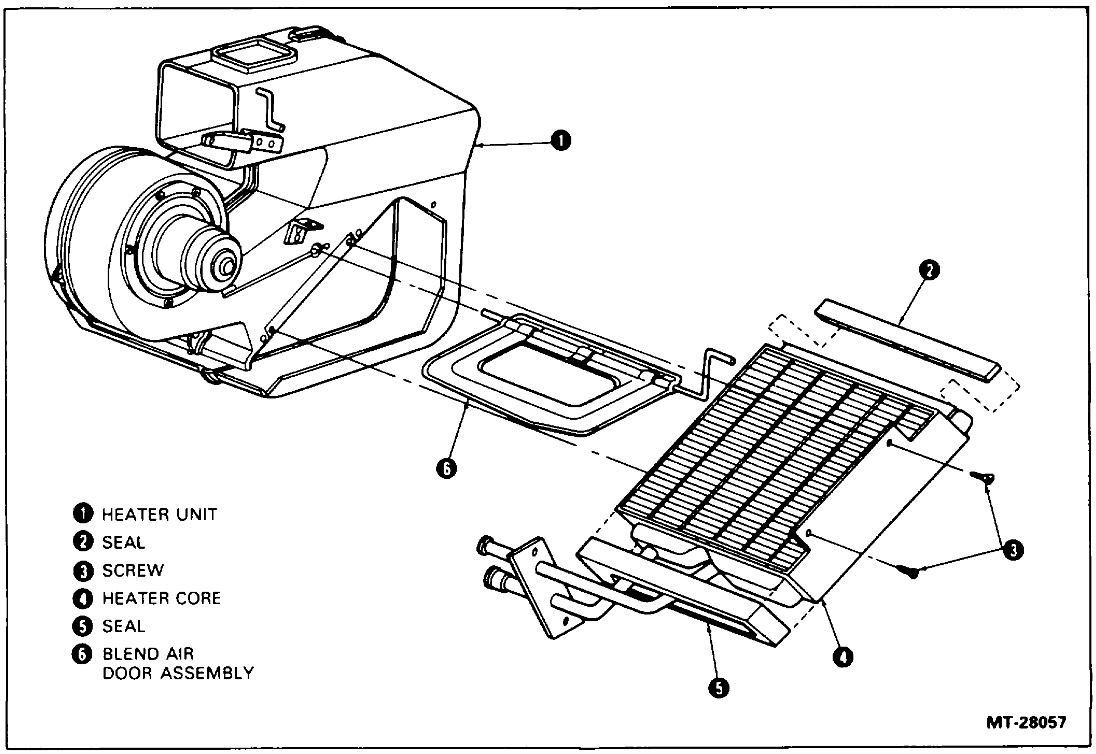

Figure 5. - Heater (Only) Unit Heater Core - Exploded View

On vehicles with heater only, a permanent magnet type motor is used.

Blower Speed-Control Resistor

A resistor assembly (Figure 6) is used in the blower motor circuit to provide three speed settings: LOW, MEDIUM, and HIGH. The resistor is located in the blower air stream to prevent overheating.

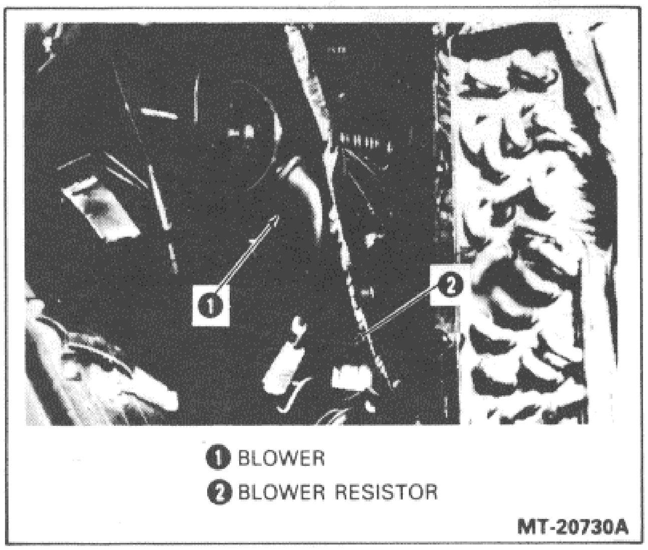

Figure 6. - Blower and Resistor

Control Unit, Switch and Cables

Major functions of the heater systems are controlled from the control unit assembly (Figure 13). The control panel has two levers and a blower switch.

The HTR lever operates the hot water flow control valve and the blend door to regulate cab heating. The lower (AIR CONTROL) lever divides air flow between DEFROST and CAB AIR outlets.

Separate controls (not in the control unit) are provided for operating the fresh air ventilation system and the driver floor heat dumps.

The blower switch is a four-position switch to control the blower motor to OFF, L, M, or H.

The ventilation system is controlled by rotating the VENT knob located to the left of the center instrument panel air outlets. The driver floor heat dump is cable operated from a push-pull control located at the upper left hand corner of the instrument panel.

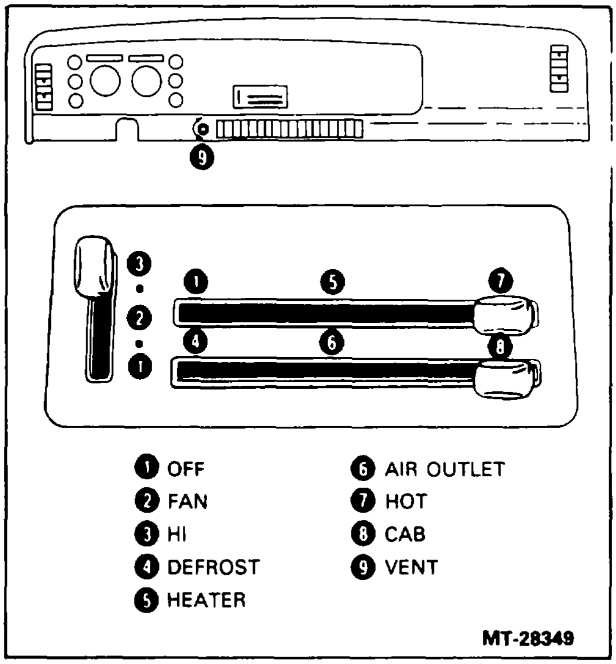

Figure 13. - Heater (Only) Control Unit

OPERATION

FRESH AIR VENTILATION

Fresh air enters the cab through either an independent ventilation system or through the heater system itself.

When the VENT knob is turned counterclockwise, air enters the cab from the hoodscoop and flows through the instrument panel outlets and floor dump. Except for the ventilation mode, the knob should be rotated to its full clockwise position (vent door closed) for all other modes of operation.

To Increase the quantity of air entering the cab in the ventilation mode, the fan may be used to power ventilate. The fan speed and air outlets can be adjusted for the desired air flow.

HEATING

For proper cold weather operation, the heat should be directed toward the floor. Therefore, close all instrument panel outlets and fully open the floor dump outlet.

Heating is controlled with the HTR (heat) lever. The full right HOT position provides the maximum heat. Move the AIR OUTLETS control lever either to the full cab position or to any of the other three detented positions in order to obtain the desired air flow distribution between cab heat and defrost requirements. For the maximum air flow, set the fan switch on the H I position. The heater will also operate with the fan motor in the OFF position. Air flow is provided by ram air when the truck is being driven.

DEFROSTING

To obtain maximum defrosting, move the HTR lever to the HOT position and place the AIR OUTLETS lever on DEF. Adjust the fan speed to provide the desired air flow.

To clear the system of humid air, operate blowers for 30 seconds at HI speed before moving the AIR OUTLETS lever to the DEF position. This will minimize rapid fogging of glass, which can occur if humid air is blown onto a cold windshield.

To improve defroster efficiency, remove ice and/or snow from glass area.

ADJUSTMENTS

HEATER ONLY

Control Cable Adjustment

The heater cables on the Heater Only system are self-adjusting (Figure 18). After the cables have been installed, move the control levers through two complete cycles as follows:

Defroster Cable

Move Defrost lever from Defrost mode to Cab mode and back to Defrost mode.

Heater Cable

Move Heat lever from Heat Off mode to Heat On mode and back to Heat Off mode.

Repeat each step twice, checking for complete sealing of the doors in each position.

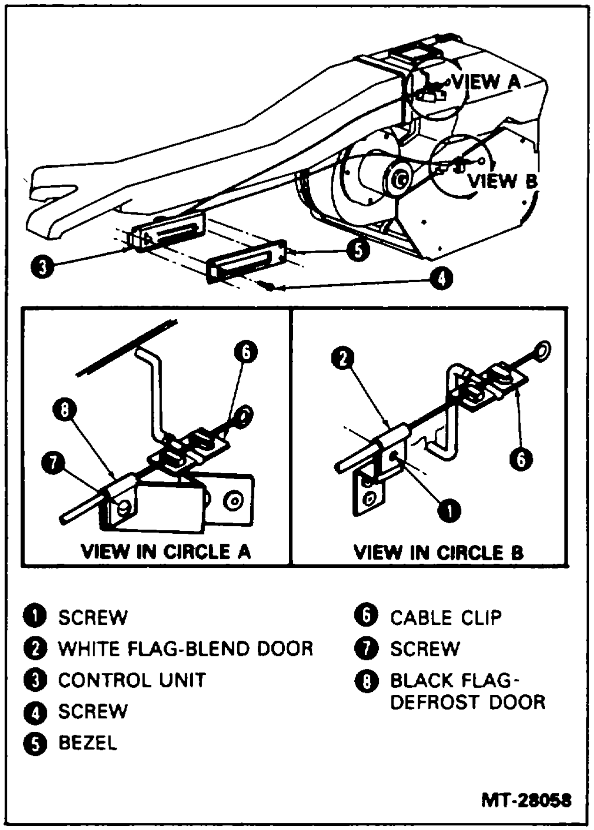

Figure 18. - Control Cable Adjustment - Heater Only Models

REMOVAL AND INSTALLATION

Before performing any service operations, set the parking brake and disconnect battery power.

HEATER CORE - HEATER ONLY SYSTEM

Refer to Figure 20.

Removal

1. Raise hood and fender assembly.
2. Drain engine cooling system.
3. Loosen hose clamps at heater core and remove hoses.
4. Remove cover from right side of instrument panel.
5. Remove screws attaching cover to heater housing and remove cover.
6. Remove four screws attaching heater core to heater housing.
7. Remove two screws attaching heater core pipes to dash panel and remove heater core.
8. Inspect hoses and seals. Replace if damaged or deteriorated.

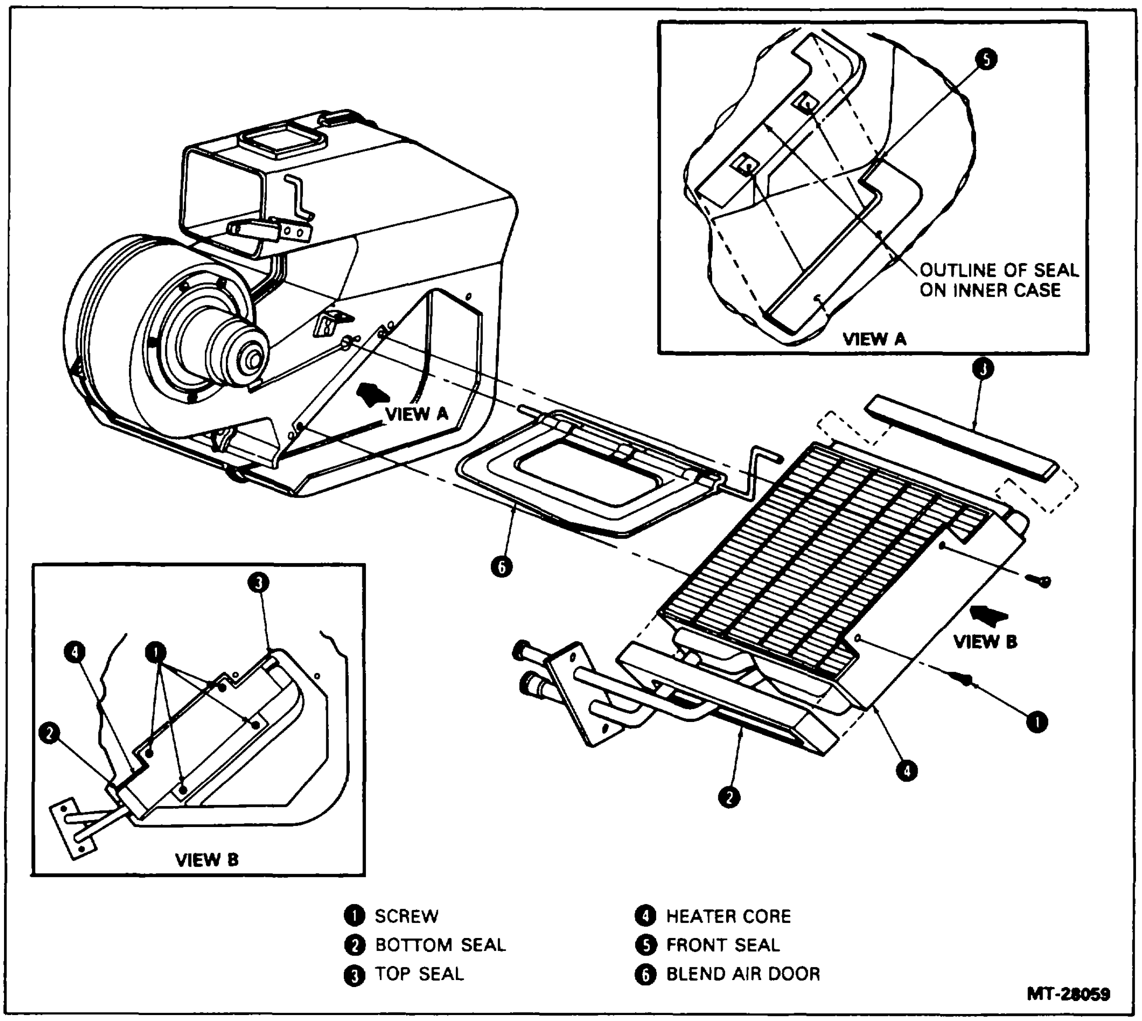

Figure 20. - Heater Core Removal - Heater Only Models

Installation

1. Position heater core in heater housing making sure front, top and bottom seals are in position.

2. Install four screws attaching heater core to heater housing.

3. Install two screws attaching heater core pipes to dash panel.

4. Install heater hoses on heater core pipes and tighten hose clamps.

5. Refill engine cooling system.

6. Set heater (HTR) control lever at HOT. Operate engine. Check for coolant leaks and coolant flow through heater core.

7. Install covers in heater unit housing and instrument panel.

8. Lower hood and fender assembly.

HOT WATER FLOW CONTROL VALVE

Refer to Figures 22 and 23.

1. Raise hood and fender assembly.

2. Drain engine cooling system.

3. Remove cover from right side of instrument panel.

4. Remove cover from blend-air unit.

5. Remove heater core as outlined in this Section.

6. Remove control cable mounting screw from mounting bracket (Figure 22). Disconnect control cable from blend-air door.

7. Loosen hose clamp and disconnect inlet hose (located under blend-air unit housing) from neck of flow control valve.

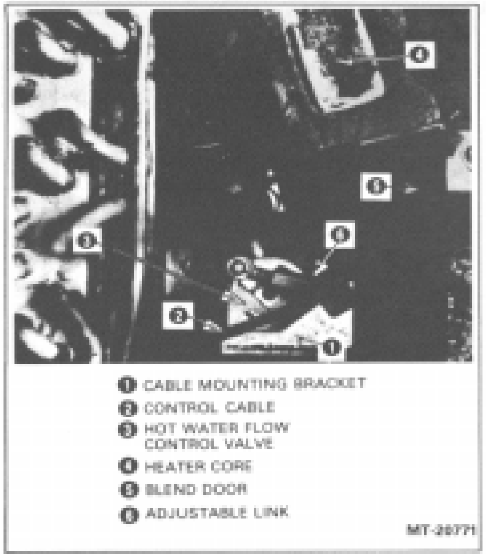

Figure 22. - Hot Water Flow Control Valve Connections

8. Remove flow control valve mounting screws. (Screw heads are located on bottom of blend-air unit housing.)
9. Remove control cable mounting bracket.
10. Disconnect adjustable link from blend-air door.
11. Rotate control valve assembly as necessary to withdraw lower neck of valve through grommet in bottom of blend-air unit housing. Remove valve (Figure 23).
12. Disconnect hose clamp and remove valve-to-heater core hose from valve.
13. Inspect all hoses and control valve inlet neck grommet in bottom of unit housing. Replace if damaged or deteriorated.

Installation

1. Position control valve-to-heater core hose on valve and tighten hose clamp.
2. Insert lower neck of flow control valve through grommet in bottom of blend-air unit housing and rotate valve assembly into position.
3. Connect adjustable link to blend-air door.
4. Insert flange of cable bracket between flange of hot water flow control valve bracket and inside wall of unit housing. Align screw holes.
5. Insert screws from outside of unit housing, thru cable mounting bracket and into tapped holes in valve bracket. Tighten screws.
6. Connect inlet hose to lower neck of flow control valve and tighten hose clamp.
7. Install heater core as outlined in this Section.
8. Connect control cable to blend-air door and install cable mounting screw.
9. Adjust control cable as outlined under Control Cable Adjustment.
10. Refill engine cooling system.
11. Set heater (HTR) control at HOT. Operate engine and check for coolant leaks and for proper operation of flow control valve.
12. Install covers on blend-air unit and instrument panel.
13. Lower hood and fender assembly.

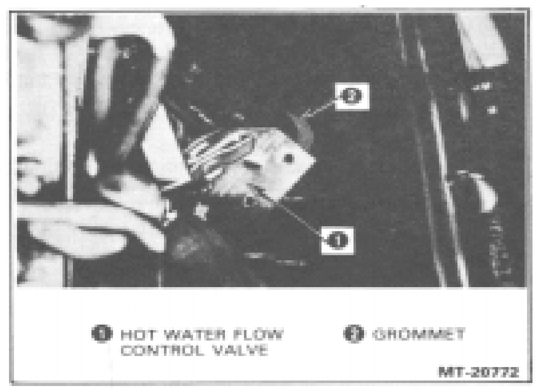

Figure 23. - Hot Water Flow Control Valve Removal

CONTROL ASSEMBLY

Removal

1. Make sure key switch is OFF.
2. Remove control assembly mounting screws. Remove control assembly trim plate. Pull control assembly outward (Figure 24). It may be necessary to remove ash tray to allow movement of control assembly.
3. Disconnect wiring harness connector from blower switch.

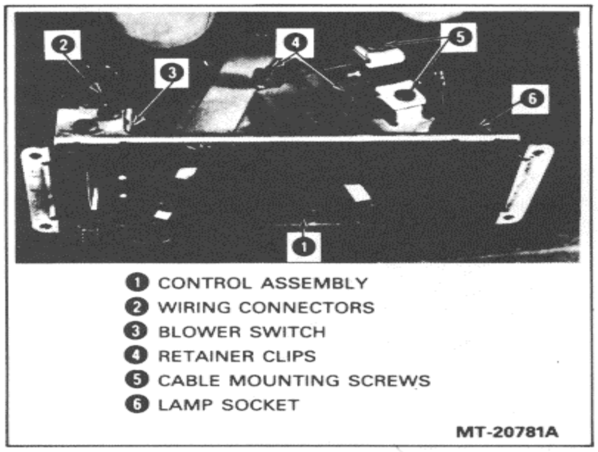

Figure 24. - Control Assembly and Cables

4. Disconnect instrument panel lamp socket from control assembly as follows:

   a. Rotate lamp socket clockwise (as viewed from rear of vehicle).
   b. Pull lamp socket (with bulb) from control assembly.

5. Remove control cable to control lever retaining clips. Remove control cable mounting screws and disconnect control cables from control levers.
6. Remove Control assembly.

Installation

1. Connect control cables to control assembly levers as follows:

   b. Cable with white mounting tab to center (HTR) lever.
   c. Cable with black mounting tab to lower (AIR OUTLET) lever.

   Install control cable mounting screws and cable retaining clips.

2. Connect instrument panel lamp socket to control assembly.
3. Connect wiring harness connector to blower switch.
4. Position control assembly in instrument panel and install trim plate and mounting screws.
5. Check operation and adjustment of control cables as outlined under Control Cable Adjustment.

7. Lower hood and fender assembly.

8. Reinstall radiator grille.

BLOWER MOTOR ASSEMBLY AND FAN

Removal

1. Make sure key and blower motor switch is OFF or battery ground strap has been disconnected.

2. Remove cover from right side of instrument panel.

3. Remove cover from blend-air unit housing.

4. Disconnect blower motor wiring connector and ground wire.

5. Disconnect motor cooling air hose from blower housing (where equipped).

6. Remove mounting screws and remove blower motor assembly from blower housing (Figure 27).

7. Remove fan lock nut and lift fan and spacer from motor shaft.

Installation

1. Install fan on motor shaft as follows:

    a. Position metal spacer in shaft hole In fan (motorside).

    b. Position fan on motor shaft.

    c. Install fan lock nut and tighten to 1.4 to 1.7 N•m (12-15 lb-in).

2. Install blower motor assembly on blower housing and install mounting screws.

3. Connect motor cooling air hose to outlet on blower housing (where equipped).

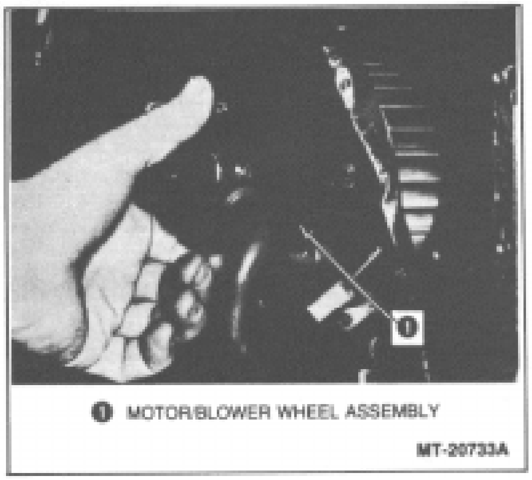

Figure 27. - Blower Motor Removal

4. Connect blower wiring connector and ground wire.
5. Reconnect battery, turn key and blower fan switches ON and check motor operation. Turn switches OFF after operation Check.
6. Install covers on blend-air unit housing and instrument panel.

BLOWER RESISTOR

Removal

1. On vehicles equipped with air conditioning:

   a. Remove cover from right side of instrument panel.
   b. Remove cover from blend-air unit housing.

NOTE - Cover removal Is not required on vehicles with heater only.

2. Disconnect wiring harness connectors from blower resistor (Figure 28).

3. Remove resistor mounting screws and remove resistor from blower housing.

Installation

1. Position resistor in blower housing. Make sure resistor terminal locations correspond with wiring harness terminals (Figure 28). Install mounting screws.
2. Connect wiring harness connector to resistor.
3. Turn key switch ON. Operate blower switch and check resistor operation. Turn key switch OFF after operation check.
4. Install covers on blend-air unit housing and instrument panel.

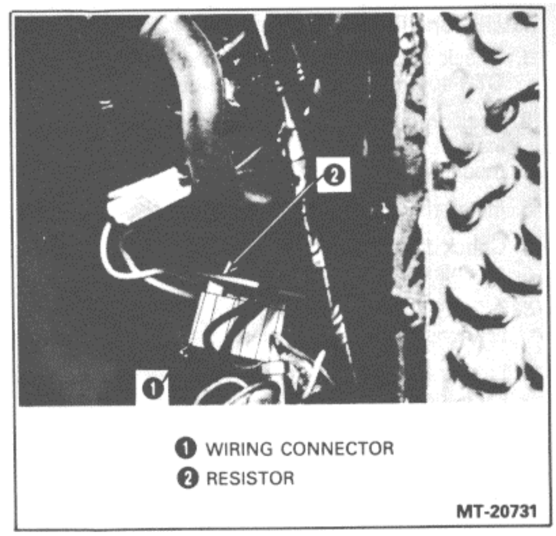

Figure 28. - Blower Resistor Removal

BLOWER SWITCH

Removal

1. Make sure key switch is OFF.
2. Pull knob from blower switch lever on instrument panel control.
3. Remove control assembly mounting screws. Remove ash tray to allow movement of control assembly, if necessary. Pull control assembly outward

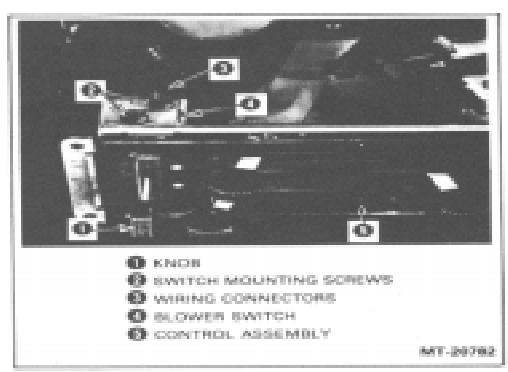

Figure 29. - Blower Switch

4. Disconnect wiring harness connector from blower switches.

5. Remove blower switch mounting screws and remove switch from control assembly.

Installation

1. Position blower switch to control assembly, and install switch mounting screws.

2. Connect wiring harness connector to blowerswitch.

3. Position control assembly in instrument panel and install trim plate and mounting screws. Reinstall ash tray, if removed.

4. Install knob onto blower switch lever.

5. Tum key switch ON and check operation of blower switch. Tum key switch OFF after operation test.

HIGH-SPEED AND LOW PRESSURE SWITCH RELAYS Removal

1. Disconnect battery cable.

2. Remove cover from right side of instrument panel.

3. If relays are accessible, proceed to step 4. If relays cannot be reached, remove radio/ash tray panel, as follows, to gain access to the relays.

   a. Remove radio/ash tray panel mounting screws and pull panel outward.

   b. Disconnect radio power feed wire, speaker leads and antenna lead from radio.

   c. If necessary, disconnect hourmeter, front wheel drive warning light, engine oil temperature gauge and transmission oil temperature gauge wiring.

   d. Disconnect ash tray light from ash tray frame.

   e. Remove radio/ash tray panel.

4. Using offset screwdriver or screwdriver socket, remove relay mounting screws and remove relay(s) from air duct (Figure 30).

5. Disconnect wiring harness connectors from relay(s).

Installation

1. Connect wiring harness connectors to relay(s).

2. Position relay(s) on air duct and install mounting screws. Use offset screwdriver or screwdriver socket to tighten screws.

3. Reinstall radio/ash tray panel and related parts (if removed).

4. Reconnect battery cables.

5. Tum key switch ON and check operation of relay(s). Turn key switch OFF after operation check.

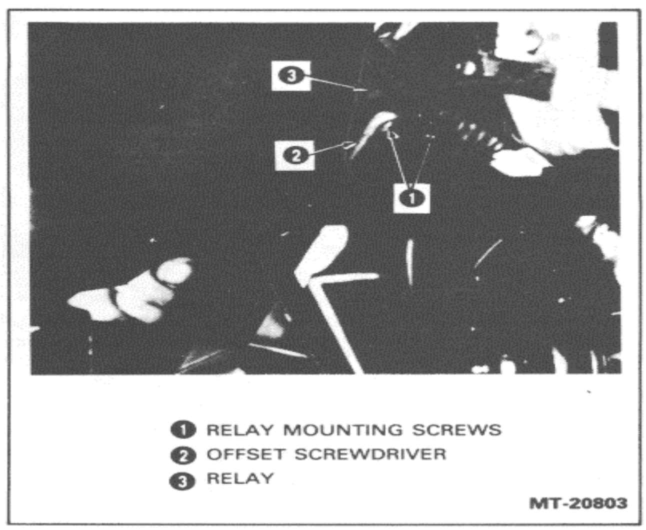

Figure 30. - Removing Relay

6. Install instrument panel cover.

CONTROL CABLE REPLACEMENT - HEATER ONLY

Removal and Installation

1. Disconnect battery ground cable.

2. Remove cover from right side of instrument panel.

3. Remove control assembly mounting screws and trim plate. Pull control assembly away from instrument panel (Figure 24).

4. Remove screw retaining cable flag to bracket (Figure 24).

   White Flag: Heater Cable
   Black Flag: Defrost Cable

5. Slide cable adjuster off of door rod.

6. Disconnect cable end from control assembly lever.

7. Remove cable assembly from vehicle.

8. To install cable, reverse steps 1 through 7.

9. Adjust cables. See Cable Adjustment.

TORQUE CHART

All refrigerant fittings must be lubricated with refrigerant oil prior to tightening. Do not exceed specified torque. Use two wrenches where applicable.

		TORQUE	
	THREAD SIZE	N•m	FT.-LB.
Condenser Inlet	3/4"-16	30-35	(22-26)
Condenser Outlet	5/8"-18	20-26	(15-19)
Filter-Dehydrator Inlet	11/16"-16	15-20	(11-15)
Filter-Dehydrator Outlet	5/8"-18	15-20	(11-15)
Compressor Suction Line	1"-14	54-60	(40-44)
Compressor Discharge Line	1"-14	54-60	(40-44)
Fan Drive Override Switch	7/16"-20	9-15	(7-11)
Refrigerant Supply Line to Heater-A/C (Evaporator) Unit	5/8"-18	20-26	(15-19)
Refrigerant Return Line from Heater-A/C (Evaporator) Unit	1-1/16"-14	89-95	(66-70)
Expansion Valve Inlet	5/8"-18	20-27	(15-20)
Expansion Valve Outlet	3/4"-16	20-27	(15-20)
Expansion Valve Equalizer Line	7/16"-24	14-20	(10-15)
Low Pressure Switch	7/16"-20	9.5-20	(7-15)
Heater-Evaporator-Blower Unit Mounting Nuts	1/4"-20	8-11	(6-8)
Condenser Mounting Bolts	5/16"-18	15-19	(11-14)
Filter-Dehydrator Mounting Clamp	5/16"-18	15-19	(11-14)
Clutch Retainer Bolt	5/16"-24	20-27	(15-20)
Compressor Oil Level Plug	------	5-15	(4-11)
Compressor-to-Mounting Bracket Bolts: w/CAT 3208 Engine	3/8"-16	24-27	(18-20)
All Other Engines	3/8"-16	26-31	(19-23)
Compressor Mounting Bracket-to-Engine Bolts	3/8"-16	41-51	(30-38)
	3/8"-24	41-51	(30-38)
	7/16"-14	68-81	(50-60)
	1/2"-13	95-115	(70-85)

SPECIAL SERVICE TOOLS

The special service tools and equipment required to service the S-Series Air Conditioning-Heater System are the same as those used on IH A/C-Heater Systems in general. Refer to Section CTS-4194 of the Service Manual for description and illustrations of special service tools.

CAB

WINDSHIELD WIPERS (ELECTRIC)

CONTENTS

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CAB

CHAPTER II

CAM ACTUATED TYPE

CONTENTS

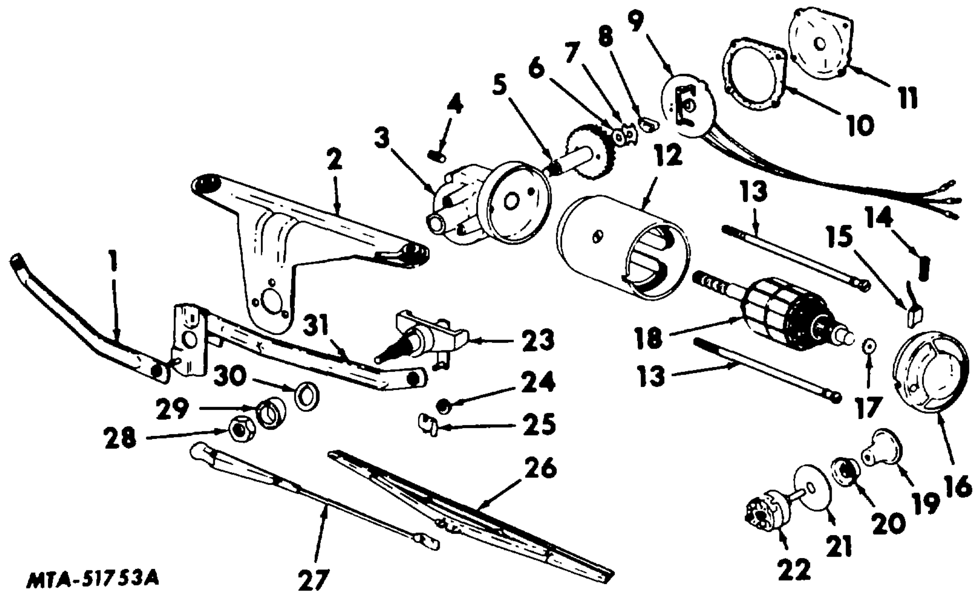

Fig. 7. Exploded View of Cam Actuated Parking Type Motor (American Bosch)

KEY	DESCRIPTION
1	Link, pivot arm shaft
2	Bracket, motor mtg.
3	Housing, drive end
4	Screw, set, armature
5	Shaft, drive
6	Washer, spacing
7	Plate, drive
8	Cam, parking
9	Plate, contact
10	Gasket, cover
11	Cover, drive end
12	Housing, wiper motor
13	Bolt, thru
14	Spring, brush
15	Brush, wiper motor
16	Frame, commutator end
17	Washer, thrust
18	Armature
19	Knob, wiper switch
20	Nut, switch mounting
21	Escutcheon, control knob
22	Switch, wiper motor
23	Shaft, pivot arm
24	Washer, flat
25	Clip, spring
26	Blade, wiper
27	Arm, wiper blade
28	Nut, pivot arm shaft
29	Spacer, pivot arm shaft
30	Gasket, spacer
31	Link, pivot arm shaft

DESCRIPTION AND OPERATION

The windshield wiper circuit is composed of the battery, a fractional horsepower motor, a three-position control switch (off, slow speed and high speed) with thermal overload protection.

The wiper motor incorporates self-aligning armature shaft bushings and has automatic parking of the wiper blades.

When the control switch is turned to the slow speed, the resistor is shorted out and the motor receives the full shunt field. When turned to the high speed position, the resistor is inserted in the shunt field circuit.

The armature shaft has a worm gear on the end opposite the commutator which drives a fiber gear mounted on the crank arm shaft. This provides the reciprocating action to the wiper arms and blades.

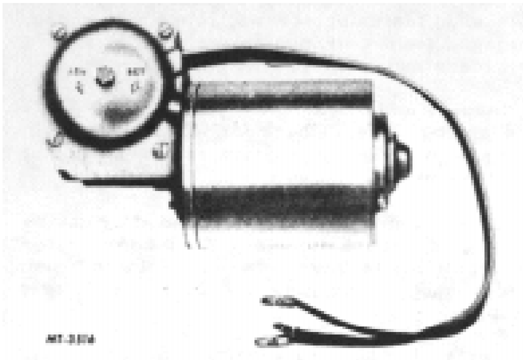

Fig. 8. Electric Windshield Wiper Motor (External View)

CAUTION: DO NOT attempt to move the wiper blades through their sweep by grasping the wiper arm. This action may result in the teeth being broken off the drive gear or the linkage bent. If blades are frozen to wind- shield, do not operate control switch until they have been freed.

DISASSEMBLY

To facilitate reassembly of the wiper, it is suggested that parts be laid on a clean bench in the order in. which they are removed. All key numbers used in "Disassembly" and "Reassembly" procedures refer to Fig. 7.

Disconnect linkage from wiper motor and remove bolts holding mounting bracket to cowl. Remove wires from control switch and lift out motor assembly. Remove bolts holding mounting bracket to drive end housing (3). Remove drive end cover (11). Take out parking switch contact plate (9) from drive end housing (3). See Fig. 9.If parking switch assembly is to be replaced, unsolder the field coil leads from the switch terminals. It is important that you note to which terminal each Lead is connected.

Remove drive gear shaft nut and washer. Take crank arm off of drive shaft. When removing nut from drive shaft, crank arm must be supported to prevent stripping of the gear teeth. This may be done by inserting crank arm in a vise or grasping it with pliers.

Remove drive gear and shaft assembly (5). Take parking cam (8) and spring washer from gear and shaft assembly (5), if necessary. Take notice of the direction in which the dotted end of the cam faces (Fig. 9).

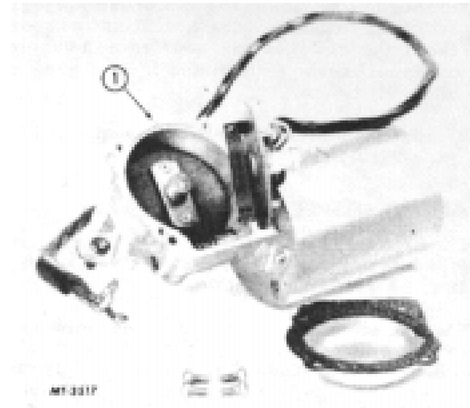

Fig. 9. Removing Drive Housing Cover Plate and Switch Contact Plate

1. Reassembly Matching Mark

Remove the two thru bolts holding the drive end housing (3) and commutator end frame (16) to the wiper motor housing (12). See Fig. 10.

Separate the commutator end frame (16) from the motor housing (12). Carefully lift the brushes (15) clear of the armature commutator and hold them in this position until the commutator end frame (16) is removed from the armature shaft (18).

A tool for holding the brushes in the holders may be made from .040"-.050" diameter piano wire approximately 10" long. Form each end of the wire into a U-shaped hook. By inserting the hooks under the brush shunts, the brushes will be forced back into the holders. If a field coil lead is soldered to a terminal on the insulated brush holder, it will be necessary to unsolder this lead to replace the commutator end frame (16).

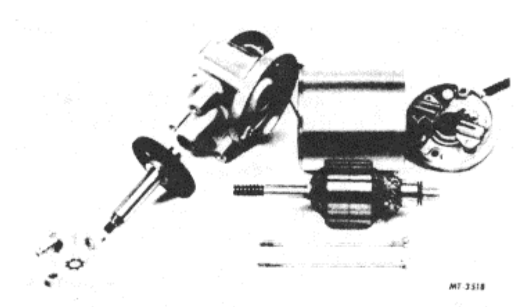

Fig. 10. Motor Housing and Related Parts

Remove the brushes (15) and brush springs (14) from the brush holders and thrust washer (17) from the commutator end frame bushing bore. Keep brushes clean and free of grease and oil at all times.

Remove armature (18) and drive end housing (3). See Fig. 10.

CLEANING, INSPECTION AND REPAIR

The field coils, armature, and brushes may be wiped with a clean, dry cloth. Compressed air may be used if available.

Bushing equipped parts must not be immersed in the cleaning fluid. These parts should be cleaned with a brush dipped in a good grade of mineral spirits, making certain that none contacts the bushings. The parking cam, parking switch assembly, and gear and shaft assembly may be cleaned in a good grade of mineral spirits. Be certain the mineral spirits do not contact the resistor on the parking switch.

Thoroughly dry all parts that have been washed.

Inspect the armature for damage to worm gear, overheated windings, condition of soldered connections and commutator. If necessary, dress commutator with number 7/0 sandpaper. Be certain that the commutator slots are clean.

Check brushes for wear. Replace any brush that is worn down to 5/16", as measured on the short side of the brush, or that has come in contact with grease or oil. When replacing brushes, make certain that solder is not allowed to run up the brush shunt. Check for faulty or annealed brush springs. Inspect thrust washer for wear.

Check commutator end frame for worn bushing (should swivel slightly in its holder), damaged brush holders or brush holder insulation plate .

Inspect drive end housing for worn armature shaft bushing (should swivel slightly in its holder), worn drive gear shaft bushing, and damaged or worn set screw. Check parking switch assembly for loose connections, cracked, or damaged plate, loose parking stud, damaged resistor and dirty or misaligned contact points (align top of contact point spring flush with or slightly below top of contact bracket).

Inspect drive gear and shaft assembly for damaged or worn gear teeth, damaged threads on shaft or gear loose on shaft.

Check motor housing assembly for loose pole shoe fastening screws, loose pole shoes, damaged field coil insulation, worn or frayed coil leads and loose ground connection.

Inspect and replace all worn linkage parts and spring clips. Check for worn "D" hole in crank arm. Use a new drive end cover gasket in reassembling the unit.

Test armature for being grounded or having an open or short circuit. Test commutator end frame for leakage between insulated brush holder and ground (use a 110-volt A.C. test lamp).

Testmotor housing assembly for continuity in coil leads or an open circuit in field coils. Test field coil resistance by measuring ampere draw. Connect power supply between yellow coil lead and housing. See "Field Coil Draw" under "Specifications." Test parking switch assembly for continuity between cable terminal s.

REASSEMBLY

If coil leads were unsoldered from terminals on p a r kin g switch during disassembly, thread the leads through the hole in the drive end housing (3). Resolder black or red lead (depending on motor being reassembled) to parking switch terminal to which both the resistor and contact point spring are connected. The yellow lead should be soldered to the terminal at the opposite end of the resistor.

Position drive end housing (3) on motor housing (12). Insert armature (18), worm gear end first, into motor housing (12). Insert thrust washer (17) into commutator end frame bushing bore. Both nylon and metal thrust washers should be assembled with the metal disc at the bottom of the bore.

Install brush springs (14) and brushes (15) into brush holders (refer to "Disassembly" procedure for method of holding brushes in holders).Brushes must move freely in brush holders.

If the coil lead has been unsoldered, resolder it to insulated brush holder and reassemble the commutator end frame (16) to the motor housing (12). Insert thru bolts (13). Tighten thru bolts to a torque of 18-22 in. lbs. Be certain that the armature retains some end play as bolts are tightened. If necessary, back out the set screw (4) to retain this end play (see "Specifications" for proper end play). After adjusting the end play, be certain that the set screw is restaked in place through the staking hold located above the lower left hand fastening screw hole. Recheck the armature end play to be sure it is within specifications.

Install spring washer, if applicable, to the drive gear and shaft (5) with the convex surface facing the drive gear. Install parking cam (8) on drive gear and shaft assembly(5). Face dotted end of cam in same direction as was noted in "Disassembly."

Place drive gear and shaft assembly (5) in drive end housing bushing bore. Install spacer washer and crank arm. Install nut and tighten to a torque of 55-60 in. lbs. Be certain to support crank arm while tightening nut to prevent stripping gear teeth (see "Disassembly").

Install gasket (10) and parking switch contact plate (9). Position drive end housing cover (11) on the drive end housing (3) and insert retaining screws. Install mounting bracket (2) on drive end housing (3).

TESTING

Before installing the windshield wiper motor on the vehicle, check the operation of the unit as follows:

Be certain that the required crank arm or drive plate and spacing washers are assembled to the drive shaft when testing the motor.

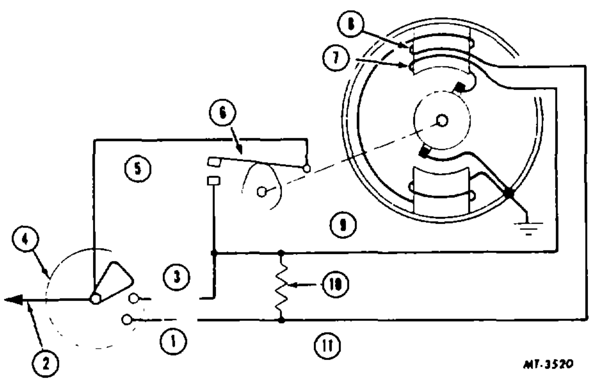

Fig. 11. Windshield Wiper Motor Wiring Schematic

1. Red
2. To Battery
3. Black
4. Control Switch
5. Green
6. Parking Switch
7. Series Winding
8. Shunt Winding
9. Black
10. Resistor
11. Yellow

Temporarily connect either terminal of a fully charged battery to the motor housing. Connect the remaining battery terminal and the wiper motor wiring harness to a control switch as follows: Connect red cable to "A" terminal, green cable to "F" terminal, black cable to "P" terminal, and remaining battery cable to "B" terminal.

The wiper motor should meet specifications when operated through control switch. If not, tap commutator end frame lightly with a rawhide mallet to make certain that the armature is aligned. If unit still does not meet specifications, it will be necessary to disassemble the unit to locate the trouble.

INSTALLATION

Place wiper motor in position and insert bolts holding motor and bracket assembly to cowl. Connect wiper arm Linkage. Connect wiring harness to control switch.

ADJUSTING AUTOMATIC PARKING

The wiper blade parking position should be adjusted after the motor has been installed in the vehicle. Adjust parking as follows:

Operate motor through control switch. When switch is turned to "OFF" position, motor should stop with Linkage fully extended. If necessary, this position can be obtained by adjusting the parking stud which protrudes through the drive end housing cover. Install the wiper arm and blade to the wiper arm shaft assembly so that the blade is in the desired parking position. Operate the wiper and note the automatic parking position of the blades when the unit is turned off. If the blades do not now park in the required position, readjust by moving the parking stud.

LUBRICATION

During reassembly, apply two or three drops of SAE-10 oil to the armature shaft bushing felts.

Place 1/3 ounce of Lubri-Plate Aero Lubricant or its equivalent in the drive end housing worm cavity. No lubricant should be placed between the gear and housing. If the housing has two bushings in the crank arm shaft bore, fill the space between the bushings with the above specified lubricant.

Fill groove in gear and shaft assembly with lubricant, if applicable. Apply a thin film of lubricant to the cam, spring washer and spacing washer. Apply a thin film of Lubri-Plate No. 10 or its equivalent to the connecting link bushings.

Fill the space between the bushings in the inner spacer with Lubri-Plate Aero Lubricant or its equivalent.

TROUBLE SHOOTING

PROBLEM	PROBABLE CAUSE	SOLUTION
Stripped Gear Teeth	1. Wiper blades striking windshield molding during operation	1. Adjust automatic parking.
	2. Binding connecting links.	2. Correct.
	3. Excessive armature end play.	3. Readjust.
	4. Operator stopping blades manually when wiper is operating.	4. Caution operator.
	5. Gear and shaft assembly not properly supported when drive plate securing nut is tightened.	5. Hold drive arm or drive plate in a vise or by hand when tightening nut.
Wiper Will Not Operate	1. Binding condition in wiper arm shaft assemblies, connecting links, gear and shaft assembly or armature.	1. Eliminate binding condition.
	2. Field coil ground connection broken.	2. Clean coil lead and spot weld it to housing or solder a terminal to the lead, drill a small hole in the housing and rivet the terminal to the housing.
	3. Series coil open or grounded (insulated coil)	3. Replace motor housing assembly.
	4. Brushes binding in holders or not seated properly. Insulated brush grounded.	4. Correct.
	5. Faulty manual switch.	5. Replace switch.
	6. Shorted, open, or grounded armature.	6. Replace armature.
	7. Rivets fastening drive dog to drive gear striking contact point spring, thus shorting out the motor.	7. Grind rivets down to a minimum height of .023".
Wiper Will Not Shut Off	1. Faulty parking switch assembly-	1. Readjust points if possible or replace switch assembly.
	2. Faulty cam.	2. Replace cam.
	3. Faulty manual switch.	3. Replace manual switch.
Wiper Continually Shutting Off	1. Binding condition in wiper arm shaft assemblies, connecting links, gear and shaft assembly, or armature	1. Eliminate binding condition.
	2. Electrical overload due to faulty field coils or armature which causes the overload protection switch to continually make and break the electrical circuit.	2. Repair or replace the faulty part.
	3. Faulty overload switch.	3. Replace switch.
	4. Faulty cable connections	4. Correct.
	5. Brushes binding slightly in holders or not seating properly.	5. Correct.
	6. Dirty or oily armature commutator.	6. Clean commutator.

PROBLEM	PROBABLE CAUSE	SOLUTION
Wiper Operates At One Speed Only	1. Cable harness connected incorrectly to parking switch or resistor open. 2. Faulty manual switch.	1. Replace the parking switch assembly. 2. Replace switch.
Burnt Armature Windings, Field Coils, and Brush Holder Insulation Plate, or Annealed Brush Springs .	1. Electrical overload caused by a shorted or grounded armature, shorts or grounds in the field circuit at points other than the ground connection or a binding condition in the wiper arm shaft assemblies, connecting links, gear and shaft assembly or armature 2. Operator turning wiper on when blades are frozen to the windshield or manually stopping the blades when the wiper is operating.	1. Eliminate overload condition. Replace brush springs, brushes and damaged or faulty parts Check overload protection switch. Warn operator to turn switch to "OFF" position whenever an overload Condition is indicated 2. Caution operator.
Burnt Armature Commutator	1. Dirt, grease or oil in Commutator. 2. Open circuit in armature.	1. Clean and dress commutator. Replace brushes and springs. 2. Replace armature, brushes and springs. Check overload switch.
Wiper Motor Speed Exces- sive Under Light Load But Motor Stalls Under Heavy Load	1. Broken field coil ground connection.	1. Clean coil lead and spot weld it to housing or solder a terminal to the lead, drill a small hole in the housing and rivet the terminal to the housing.
Wiper Motor Noisy	1. Dirty or rough armature commutator. 2. Improperly seated brushes. 3. Excessive armature end play. 4. Lack of lubrication. 5. Loose pole shoes.	1. Clean and dress commutator. 2. Correct. 3. Readjust. 4. Relubricate. 5. Replace motor housing.

SPECIFICATIONS

MOTOR TYPE	Electric-Direct Current
VOLTS	12
POLES	2
BRUSHES	2
BUSHINGS	Absorbent Bronze
ARMATURE END PLAY	.002"- .007"
FIELD COIL DRAW (Amperes)	1.6 @12 Volts
NO LOAD DRAW (Amperes)	3.6 @13.5 Volts
CONTACT POINT SPRING PRESSURE (Ozs.) *	4
RESISTANCE (Ohms)	21.0
ROTATION:	
Motor	Clockwise At Drive End
Crank Arm Shaft	Clockwise Viewed From Crank Arm

* Pull at right angles to the parking switch spring nearest the contact point.

CAB
WINDSHIELD WIPERS AND WASHER - S-SERIES

CONTENTS

CTS-4061
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CAB
CHAPTER I
WINDSHIELD WIPER (ELECTRIC)

CONTENTS

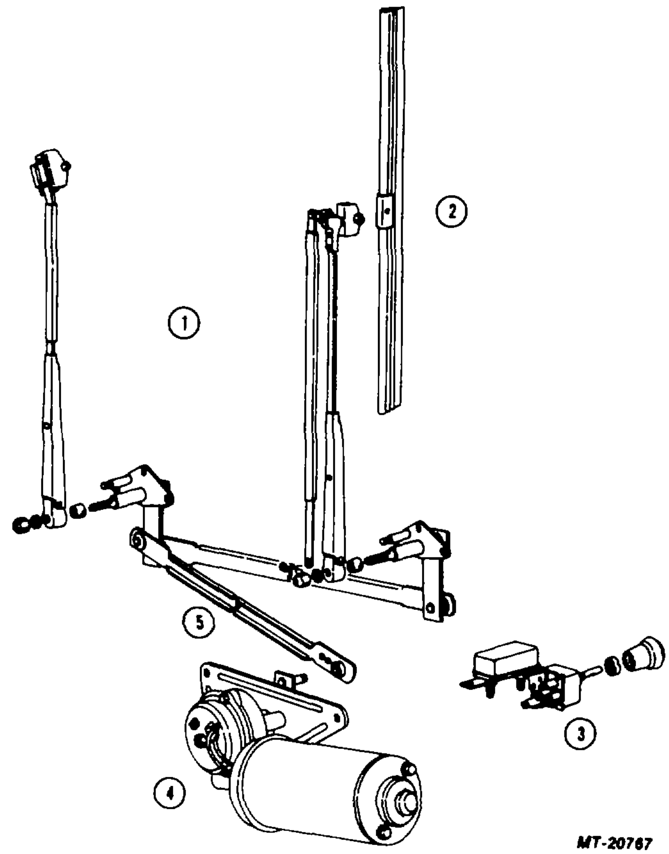

Fig. 1. Electric Windshield Wiper Components

1. Arms, Wiper
2. Blade
3. Switch, Control
4. Motor, Electric
5. Linkage, Assembly

DESCRIPTION

The standard windshield wiper available on S-Series Trucks is the electric cowl mounted dual wiper system shown in Fig. 1. Except for the control switch, which is mounted on the instrument panel, all service on the wiper system is performed at front of cab.

OPERATION

When control switch is turned to "LO" or "HI" wiper speed is controlled accordingly. When control switch is turned off, wiper blades move automatically to "park" position on wind- shield (50 mm or 2 inches up from bottom of windshield). Reciprocating action of wiper arms results from rotation of drive lever on wiper motor.

IMPORTANT

Do not attempt to move wiper blades through their arc by grasping wiper arm. This action can damage motor internal parts or bend wiper linkage. Also, if blades are frozen to wind- shield, do not operate control switch until blades have been freed.

REMOVAL

LINKAGE

1. Remove windshield washer hose from fittings on top of cowl.
2. Remove wiper blades and arms (Fig. 2).
3. Remove seven mounting screws and detach cowl cover panel from top of cowl (Fig. 3).

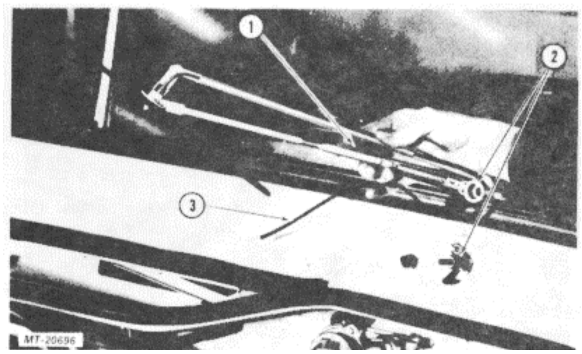

Fig. 2. Removing Wiper Arms

1. Arm, Wiper
2. Serrations
3. Hose, Washer

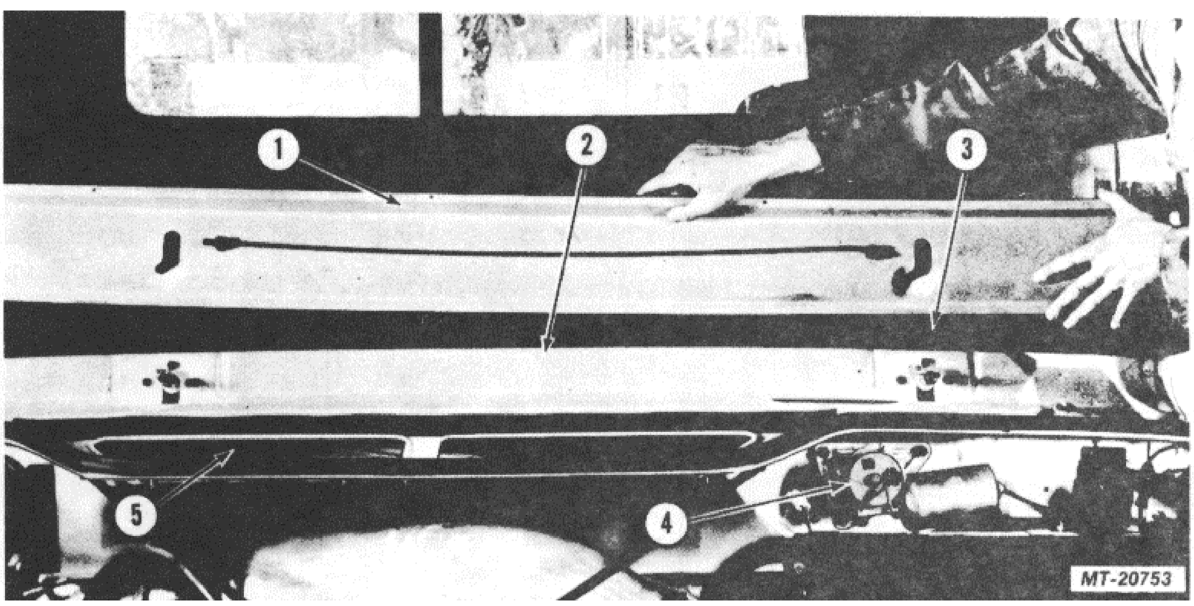

Fig. 3. Removing Cowl Cover Panel

1. Panel, Cowl Cover
2. Cowl
3. Seal, Windshield
4. Motor, Wiper
5. Chamber, Air Intake

4. Disconnect washer hose from fitting on bottom of cowl cover panel.
5. Reaching into cowl air intake chamber, unfasten retainer clip from wiper motor drive lever pin and detach linkage rod from drive lever.
6. Remove three mounting bolts from each pivot bracket and lift out complete pivot brackets and wiper linkage assembly from inside air intake chamber (Fig. 4).

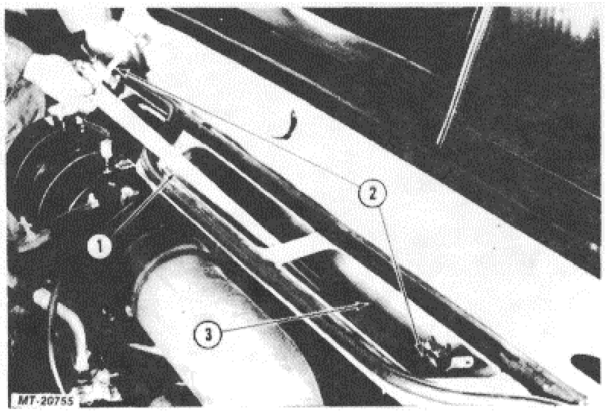

Fig. 4. Removing Windshield Wiper Linkage

1. Linkage
2. Brackets, Pivot
3. Chamber, Air

ELECTRIC MOTOR

1. Disconnect wiring harness from wiper motor.
2. If wiper linkage has not previously been disconnected from motor, reach into cowl air intake chamber and unfasten clip from wiper motor drive lever.

IMPORTANT

Where motor only is being removed, stop wiper blades (with key switch) at their opposite to "PARK" position and loosen motor bracket to cowl mounting bolts. This will facilitate detaching of wiper linkage from motor drive lever.

3. Remove wiper motor bracket mounting bolts and detach motor assembly. Drive lever should remove through hole in cowl (Fig. 5).

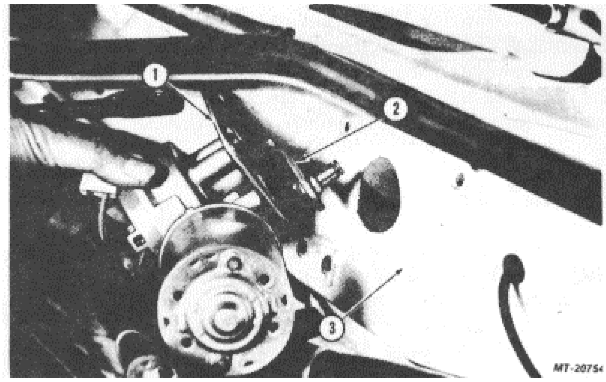

Fig. 5. Removing Windshield Wiper Motor

1. Bracket, Mounting
2. Lever, Drive
3. Cowl

IMPORTANT

Always disconnect battery ground strap before servicing or removing electrical components.

CONTROL SWITCH

1. Remove control knob for electric control switch by depressing retaining clip on back of knob with offset or small screw- driver (Fig. 6).

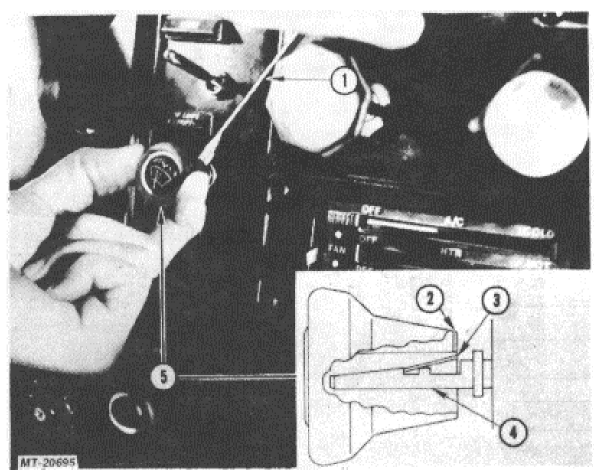

Fig. 6. Removing Control Knob from Switch

1. Screwdriver
2. Indent
3. Clip, Spring
4. Shaft, Switch
5. Knob, Control

2. Remove mounting screws and detach panel to right of wiper control switch and above heater controls.
3. Remove mounting nut from switch shaft and demount switch assembly from instrument panel (Fig. 7).
4. Disconnect wiring leads and remove switch.

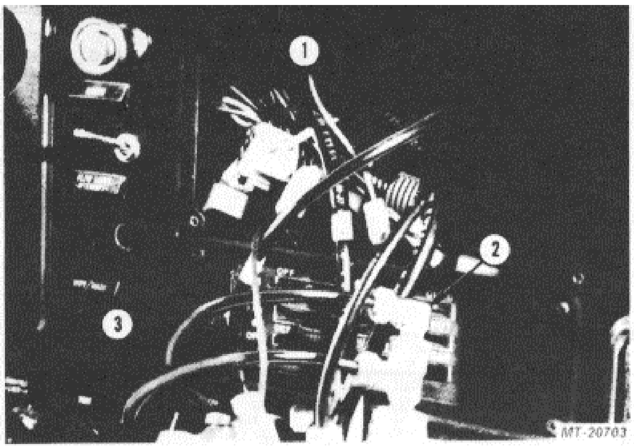

Fig. 7. Removing Wiper Switch

1. Switch, Wiper Control
2. Cluster, Air Control
3. Hole, Control Switch Mounting

INSTALLATION

Reinstalling of windshield wiper system components is the reverse of removal. Be careful when installing cowl cover panel so as to protect windshield seal from damage. When returning wiper arms to drive shafts, control switch should be in "off" position and blades should be positioned in "park" position on windshield (50 mm or 2 inches up from bottom of windshield). If blades do not park as specified, see "ADJUSTMENT". When blades are correctly positioned, install cap nut and tighten to 6-7 N-m (55-60 in. lbs.).

MAINTENANCE

Service on the windshield wiper system is limited to the replacement of components shown in Fig. 1. Disassembly of either the electric wiper motor or the control switch is not recommended.

ADJUSTMENT

1. Operate wiper motor and turn control switch on instrument panel to "OFF". Wiper blades should automatically move to "park" position on windshield (50 mm or approx. 2 inches up from bottom of windshield).
2. If adjustment is required, loosen motor cover mounting screws and turn cover clockwise or counterclockwise as required to set correct "park" position (Fig. 8). Retighten cover screws. (Length of stroke is fixed and can- not be changed.)

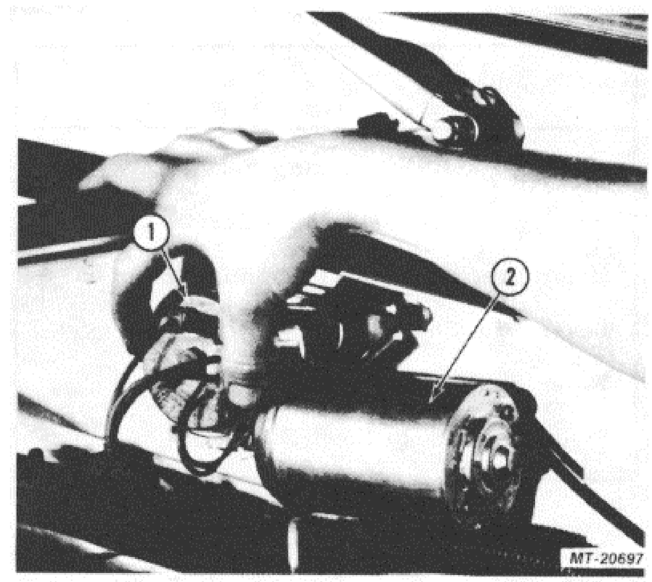

Fig. 8. Adjusting Wiper Blade Park Posit on

1. Cover - Turn to Adjust Park Position
2. Motor, Wiper

SPECIFICATIONS

MOTOR TYPE	Electric, direct current
MANUFACTURER	American Bosch
VOLTAGE	12 Volts
CRANK ARM ROTATION	Counter-clockwise
WIPER BLADE LENGTH	36 cm (14 inches)

TORQUE CHART

Application	N•m	In. Lbs.
Adjusting Cover Mounting Screws	2-2.5	18-22
Bracket to Motor Mounting Screws	4.5-7	40-62
Motor Bracket to Cowl Mounting Bolts	27-30	240-265
Lever Arm Shaft Nut *	8-10	70-88
Wiper Shaft Cap Nut	6-7	54-62
Pivot Brackets to Cowl Bolts	13-16	115-140

* Hold drive lever in position while nut is torqued or drive gear can be stripped.

TROUBLE SHOOTING (ELECTRIC)

PROBLEM	PROBABLE CAUSE	SOLUTION
Wiper will not operate.	1. No voltage to wiper motor	1. Check for open circuit or blown fuse
	2. Binds in wiper arm, shafts or linkage.	2. Eliminate binds.
	3. Link rod loose from drive lever.	3. Secure rod end clip.
	4. Faulty switch.	4. Replace switch.
	5. Faulty motor assembly.	5. Replace motor.
Damaged gear teeth.	1. Wiper blades striking windshield molding during operation.	1. Adjust wiper arm park position.
	2. Binding in connecting links.	2. Correct linkage.
	3. Operator stopping blades manually when wiper is operating.	3. Caution operator.
	4. Drive arm not held when drive arm nut is tightened	4. Hold drive arm in vise or by hand when tightening nut
Wiper will not shut off.	Faulty switch.	Replace switch.
Wiper continually shutting off.	1. Binding condition in wiper arm shafts, connecting links or drive gear and shaft.	1. Eliminate binds.
	2. Faulty harness connections.	2. Correct wiring harness connectors and terminals.
	3. Faulty motor assembly.	3. Replace motor.
Wiper operates at one speed only.	1. Faulty switch.	1. Replace switch.
	2. Faulty connection.	2. Correct wiring.
Wiper motor speed excessive under light load but stalls under heavy load.	Faulty motor assembly.	Replace motor.
Wiper motor noisy.	Faulty motor assembly.	Replace motor.

SERVICE MANUAL

WHEELS

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CAB
CHAPTER III

WINDSHIELD WASHER (ELECTRIC)

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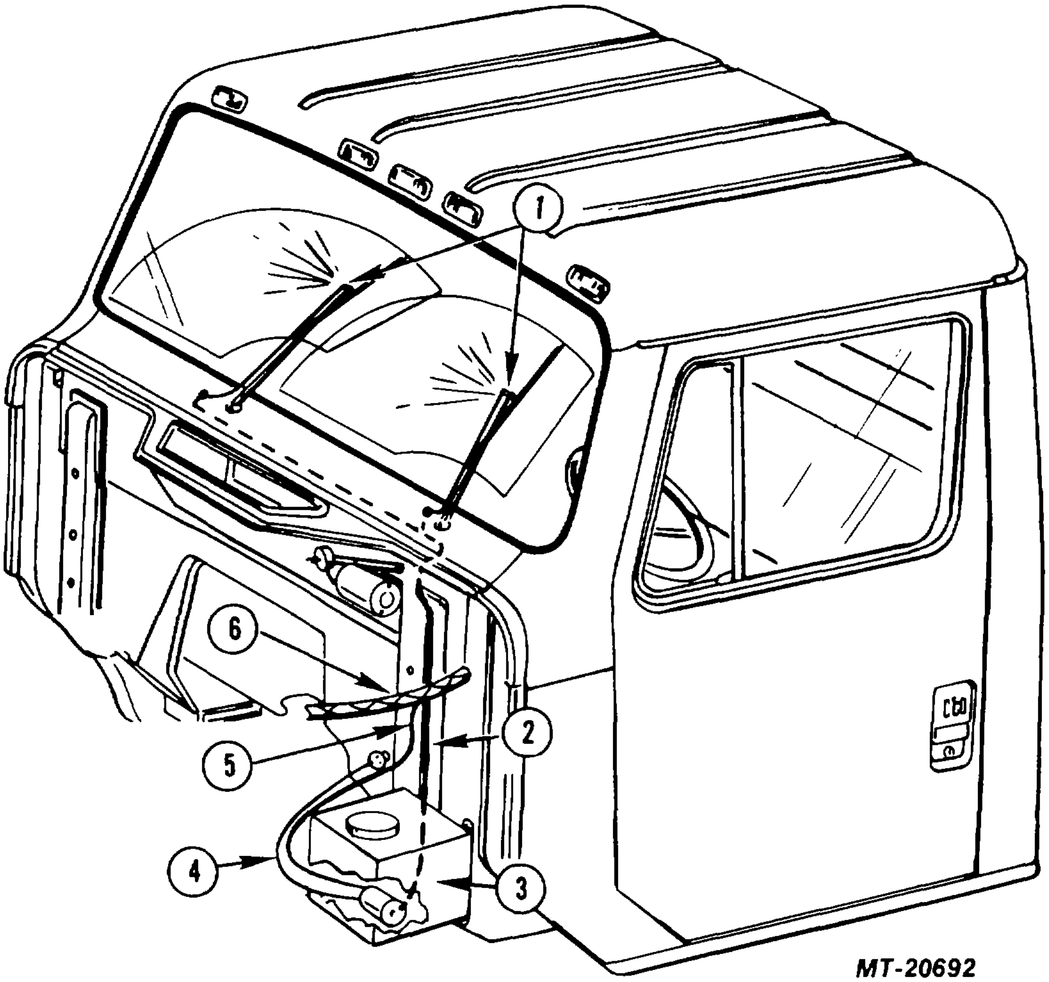

Fig. 1. Windshield Washer Installation (80" Wide Cab Shown)

1. Nozzles
2. Hose, Pump to Wiper Nozzles
3. Pump Motor Reservoir Assembly
4. Wire, Motor to Ground
5. Wire, Panel Switch to Motor
6. Harness, Wiring

DESCRIPTION

The windshield washer (Fig. 1) consists of a reservoir mounted motor driven displacement type pump that delivers washer solution to the windshield through hoses and nozzles in the wiper arms. Pump motor may be integral with reservoir or detached.

OPERATION

Two types of controls are used with the windshield washer namely - an integral with wiper control switch type for electric wipers and an independent control type for air wipers. (Independent switch is mounted on instrument panel directly below wiper control valve.) You can operate windshield washer with either type control simply by pushing in on control switch for as long as you want nozzles to spray. Spray will stop as soon as control is released.

MAINTENANCE

A minimum of service is required to keep windshield washer operating. Keep reservoir filled with IH No. 996726-R2 windshield washer solvent and keep wiper nozzles clean. If dirt enters reservoir, remove reservoir and flush out with clean water. Refill reservoir with specified solvent after reinstalling.

REMOVAL AND INSTALLATION

1. Remove the reservoir-to-cowl mounting bolts and lift complete pump, motor and reservoir from cowl.
2. Separate wiring connector for instrument panel switch-to-motor wire and motor-to- ground wire from pump motor.
3. Disconnect pump-to-wiper nozzle hose from pump outlet fitting.
4. Since two different types of pump-motor-reservoir assemblies may be found on S- Series cabs, always check Parts Catalog before disassembling pump motor from reservoir. Figure 2 shows the installation where pump motor is serviced separately. Installation of windshield washer is the reverse of removal procedure. Test the operation of unit and check for leaks after installing.

IMPORTANT

Be sure an ample supply of IH No. 996726-R2 windshield washer solvent is maintained in reservoir to insure satisfactory operation of windshield washer.

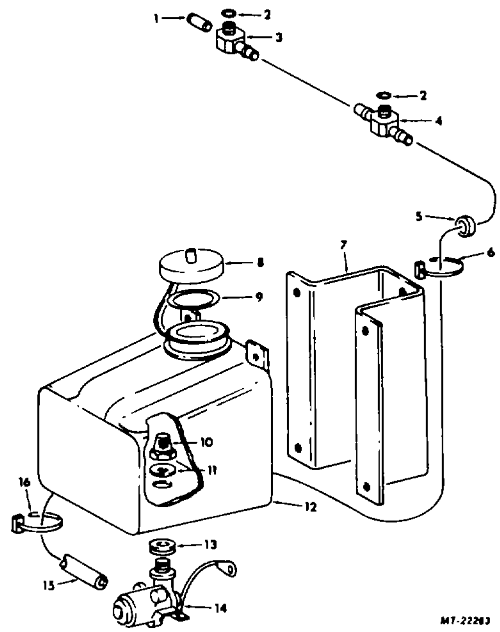

Fig. 2. Pump, Motor Reservoir Assembly (Detachable Pump Motor Type)

1. Cap, Tube
2. Seal, O-ring
3. Block, Junction
4. Block, Junction
5. Grommet, Hose
6. Strap, Cable Lock
7. Bracket, Reservoir
8. Cap, Reservoir
9. Gasket, Cap
10. Filter, Reservoir
11. Washer, Nylon
12. Reservoir
13. Grommet
14. Pump Motor, Assembly
15. Hose
16. Strap, Cable Lock

TROUBLE SHOOTING

PROBLEM	PROBABLE CAUSE	SOLUTION
Pump will not operate.	1. No voltage to pump motor. 2. Defective switch. 3. Defective motor.	1. Check for open circuit or blown fuse. 2. Replace switch. 3. Replace pump/motor assembly
Pump operates but pressure is weak.	1. Hoses loose, kinked or damaged. 2. Nozzles plugged or dirt in reservoir. 3. Defective motor or pump.	1. Reinstall or replace hose. 2. Clean nozzles and service reservoir as required. 3. Replace pump/motor assembly.
Pump operates but no washer solution delivered.	1. No solution in reservoir. 2. Hoses loose, kinked or damaged. 3. Nozzles plugged or dirt in reservoir. 4. Solution frozen 5. Defective pump.	1. Fill reservoir. 2. Reinstall or replace hoses. 3. Clean nozzles or reservoir as required. 4. Thaw out system and replace washer solvent. 5. Replace pump/motor assembly

WHEELS

Replace old Section with this revised Section in your CTS-4001 Manual.

WHEELS, RIMS AND TIRES

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CONTENTS

GENERAL

The information herein covers wheels and hubs for medium and heavy duty vehicles. Various types of wheels (cast spoke or disc) are available and vary in size, types and materials (steel or aluminum).

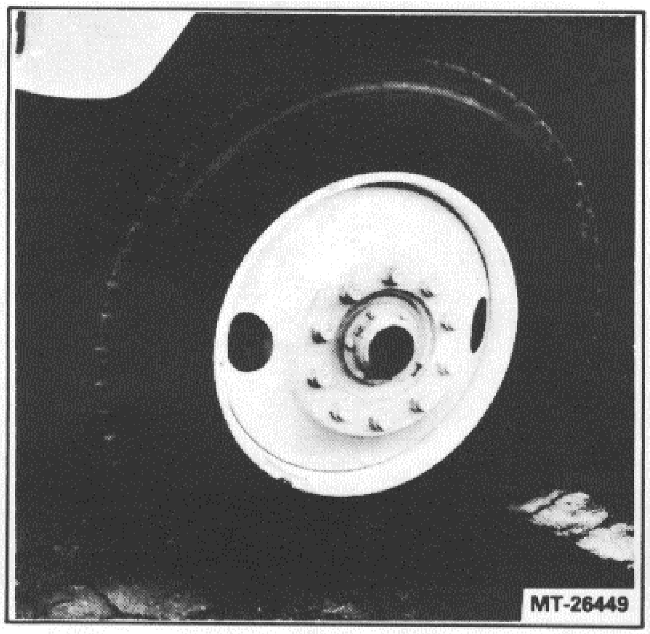

Figure 2. - Disc Front Wheel

Two different configurations of drum mountings will also be found:

1. Inboard mounted drum will be secured to hub on brake group side of hub (Figure 3). Inboard mounted drums can be used with cast or disc wheels.

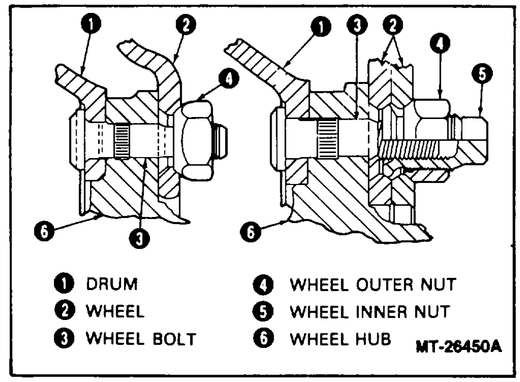

Figure 3. - Inboard Mounted Drum

2. Outboard mounted drum is secured between the wheel and hub (Figure 4). Outboard mounted drums will be used only with disc wheels.

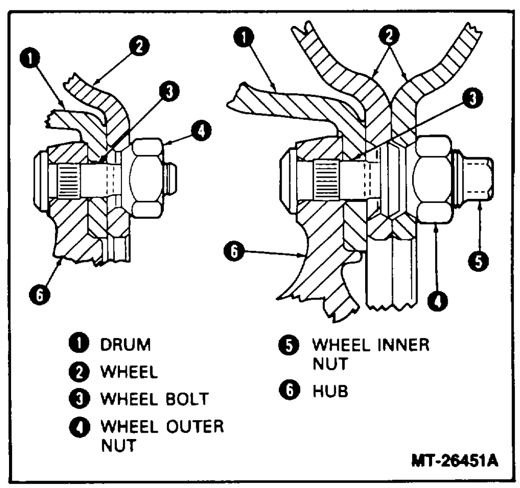

Figure 4. - Outboard Mounted Drum

The upper view of Figure 5 illustrates another version of an inboard mounted drum. This installation has a second flange inboard of the wheel mounting flange. The lower view illustrates a typical rear axle with outboard mounted brake drum.
All cast spoke wheels (front and rear) will have inboard mounted drums.

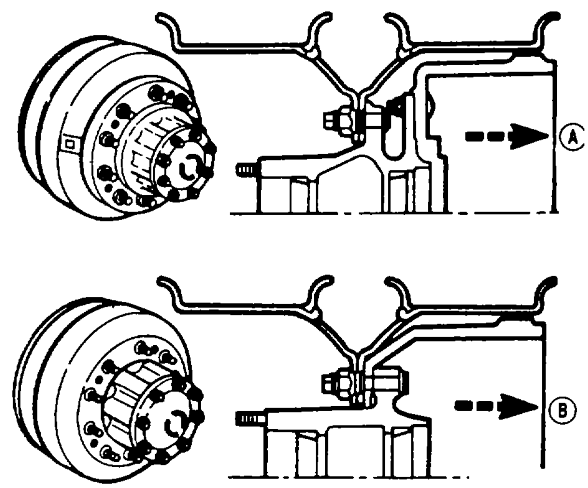

Figure 5. - Cross Section of Inboard and Outboard Mounted Drum

PRECAUTIONS

Always loosen rim clamps before complete removal of nut from stud (cast spoke wheels). With loosened nuts on stud, strike clamps with a heavy hammer and be sure each clamp is loose.
Always deflate tires completely before removing locks or side rings.
Always inspect and clean all parts before assembly.
Always inflate tires in a safety cage.
Always use a "clip-on" air chuck with remote control valve to inflate tires.
Never strike cast spokes of wheel assembly when loosening rim clamps.
Never mix rim side rings or lock rings of different types or size.
Never use cracked, bent or badly rusted parts.
Never reinflate flat tires on vehicle - use the spare.
Never add air until certain each side or lock ring is fully seated.
Never hammer side or lock ring on a partially or fully inflated tire.
When installing the tire and rim assembly on disc braked axles, make sure the tire valve stem clears the brake caliper. The use of an I.H. valve stem retainer or tire manufacturer's stem-forming tool are the only acceptable methods of obtaining clearance when necessary.

REMOVE AND REINSTALL

When servicing wheels, different procedures will be required for particular service applications.

Examples:

Tire service will require removal of wheel and tire on vehicles with disc wheels. On vehicles with cast spoke wheels, tire and rim assembly will be removed for tire service.

Brake service (except disc brakes) will require different procedures depending upon inboard or outboard mounted drums.

A. Vehicles with cast spoke wheels or disc wheels and inboard mounted brake drums (single or dual tires): remove wheel, hub and drum as an assembly.

B. Vehicles with disc wheels (single or dual tires) with outboard mounted brake drums: remove wheel or dual wheels. Then remove brake drum leaving hub assembly intact on vehicle. Wheel bearing service will not be required with this application.

Refer to the GENERAL topic for further identification of wheels and to application of inboard and outboard mounted drums.

When installing wheel, hub and drum assemblies, refer to the following: WHEEL BEARING ADJUSTMENT, WHEEL SEALS, and WHEEL BEARING.

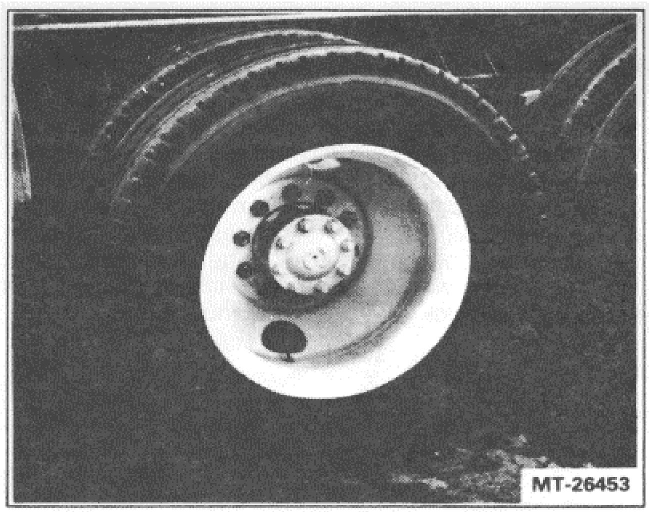

Figure 9. - Disc Rear Wheel Assembly

DISC WHEELS (FIGURES 2 AND 9)

Tire and Wheel Service, Inboard and Outboard Mounted Drum

Brake Service, Outboard Mounted Drum

1. Set parking brake or block wheels to prevent vehicle from moving.
2. Position vehicle on floor stand(s).
3. If brake service is to be performed, loosen or back off brake adjustment so that it will move freely with- out drag.
4. Remove wheel nuts (outer nuts with dual wheels at rear) (Figure 10).

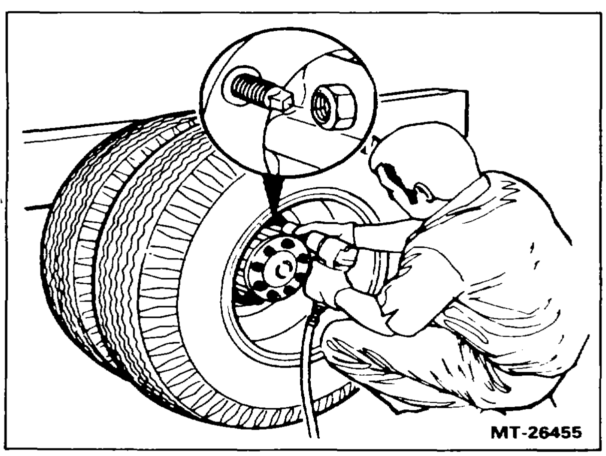

Figure 10. - Remove Outer Wheel Nuts

5. Remove wheel from wheel studs.
6. On dual wheel installations, remove the inner wheel nuts (Figure 11).

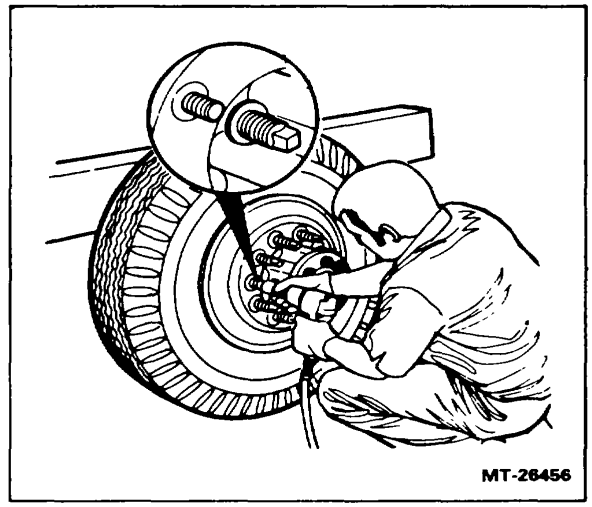

Figure 11. - Remove Inner Wheel Nuts

7. The brake drum can now be removed, if outboard mounted (Figure 12). The brakes can now be serviced after the wheel and tire assembly has been removed.

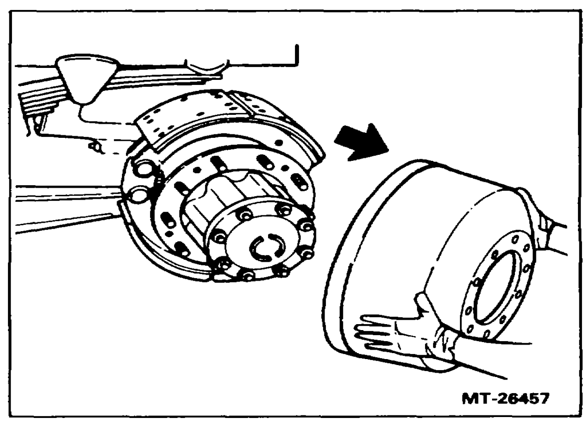

Figure 12. - Remove Drum Assembly

8. Installation of wheel and tire assembly is essentially the reverse of the removal procedure. Special attention must be given to the following:

A. Before mounting wheel assemblies on vehicles, be sure all parts are clean and free from foreign matter. Excess paint on wheel stud hole perimeters can permit wheel mounting nuts to loosen with use.

B. Be certain wheel bolt threads are clean to allow correct torquing of nuts. Do not apply any lubricant on threads.

Refer to INSTALLATION, TIGHTENING AND ALIGNMENT OF DISC WHEELS OR RIMS in this section for proper procedure for installing disc wheels. Refer to TORQUE CHART for correct values of wheel nuts.

9. Adjust both brakes on axle where brake drums were removed.
10. Remove floor stands.

WHEEL BEARING ADJUSTMENT

Satisfactory wheel seal operation as well as long bearing life depends on correct wheel bearing installation, lubrication and adjustment. The following will help you perform these required services for wheels and hubs.

Wheels or hubs, bearing cups, nuts, locks, hub caps, shafts and spindles are to be free from any foreign matter. Bearing cones must be packed with specified lubricant. Refer to LUBRICATION Section. Also, refer to LUBRICATION OF WHEEL BEARINGS found in this same section.

WHEEL BEARING ADJUSTMENT PROCEDURE

Front and Rear Axle Adjusting Nut

After wheel hub and bearings are assembled on the spindle or axle tube, tighten the bearing adjusting nut to 68 N•m (50 ft. lbs.) while rotating the wheel and hub assembly. Then back off adjusting nut 1/4 turn. If adjusting, lock or cotter key can be installed at this point, do so. If not, tighten nut to nearest locking position and insert lock or pin. Refer to Cotter Key Installation. On front axles which use locks without pierced lock washer, bend lock over adjusting nut.

COTTER KEY INSTALLATION

The cotter key should be inserted with the long tang toward the end of the spindle. Bend long tang of cotter key over end of spindle. Clip remaining tang leaving just enough stock to bend down against side of nut. A correctly installed cotter key should have the appearance as shown in Figure 13.

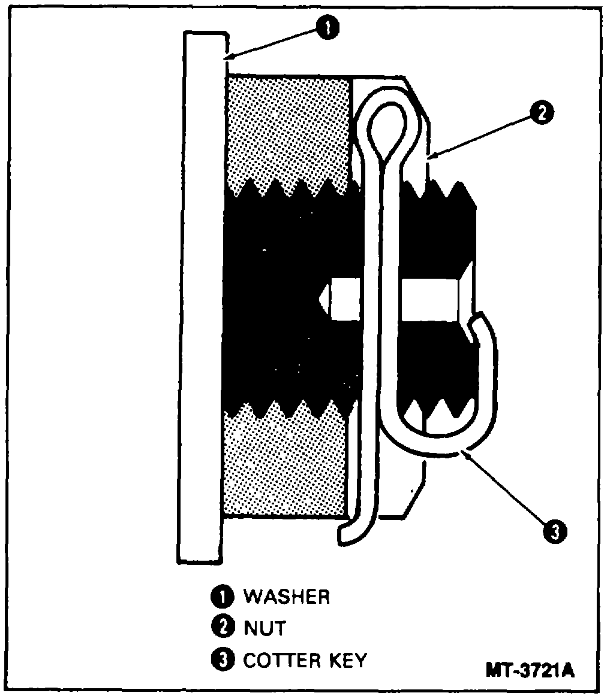

Figure 13.

WHEEL SEALS

To Insure satisfactory performanceof wheel seals, various precautions are necessary Whether the vehicle is equipped with grease or oil lubricated wheel bearings.

Always replace wheel seals whenever the wheel and hub assembly is removed. Seals establish a wear patter after a period of usage and a reused seal may not be positioned back in its original location and leakage could result.

Due to various types of wheel seals, it is important that the seal installation and position be checked at the time of disassembly to be assured that the new seals are properly installed.

The types of wheel seals used are designed to be used with grease packed wheel bearings and oil lubricated wheel bearings.

GREASE LUBRICATED WHEEL BEARING

For the most part the seals used with grease lubricated wheel bearings will be of the lip type seal similar to that shown in Figure 14. The seal is installed with lip toward the inner wheel bearing.

Scot unitized seals and Barrier unitized seals can also be used with grease lubricated wheel bearings.

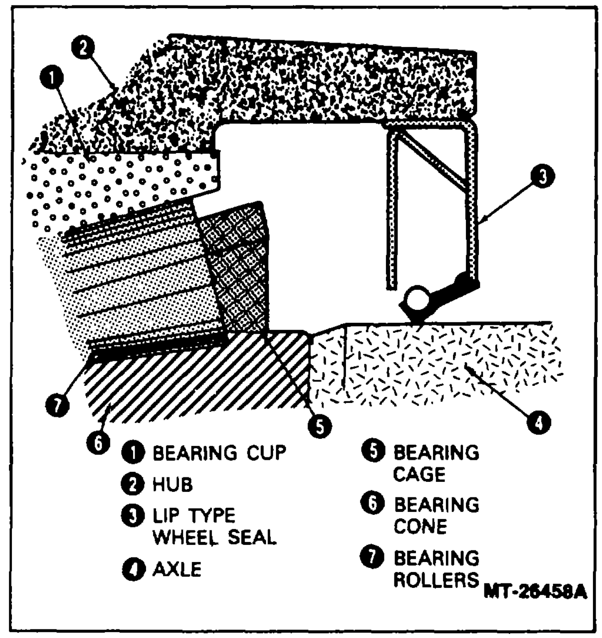

Figure 14. - Wheel Seals Used With Grease Lubricated Wheel Bearings

OIL LUBRICATED WHEEL BEARING

Different versions of oil lubricated wheel bearings will be found, and they are:

Stemco Lip Type Seal With Wiper Ring The metal encased lip type seals shown in Figures 15 and 16 have a wiper ring or wear sleeve mounted on the axle or spindle. The wiper ring provides a smooth contact surface for the lip of the seal, which is also replaced when seals are replaced. The lip of a seal can wear a groove in the axle or spindle at that point where the lip makes contact. The oil lubricated seal shown in Figure 16 has an added feature called grit guard. The grit guard is a shielded extension on the wiper ring to prevent grit and road splash entering the seal.

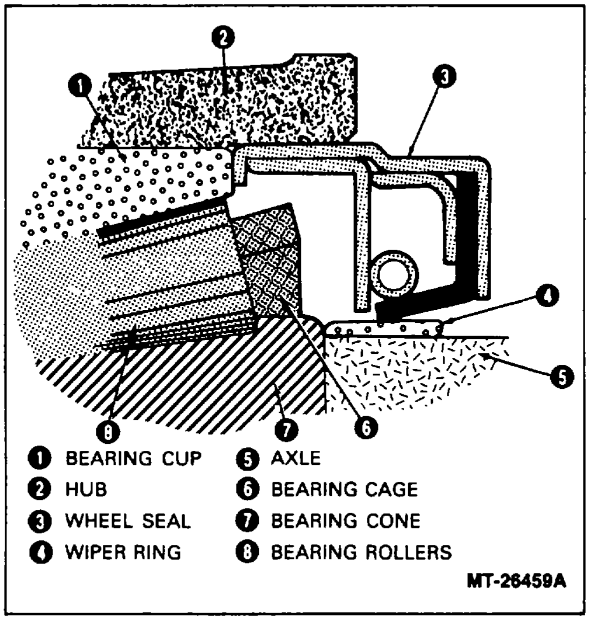

Figure 15. - Oil Lubricated Wheel Seal With Wiper Ring

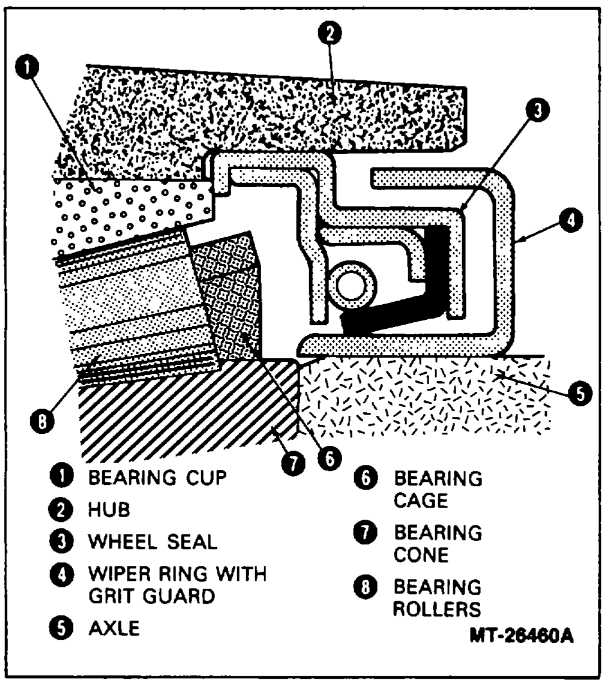

Figure 16. - Oil Lubricated Wheel Seal and Wiper Ring With Grit Guard

Unitized Scot or National Seals

Unitized seals (Figure 17) in most installations do not require axle wiper rings and minimize wear on the axle spindle as follows. The outer shell of the seal being pressure fit in the wheel hub rotates with the wheel around the sealing element which is pressure fit on the axle spindle. With the unitized seal when replacement is made, the worn surface created by the sealing lip is also replaced by virtue of a new seal.

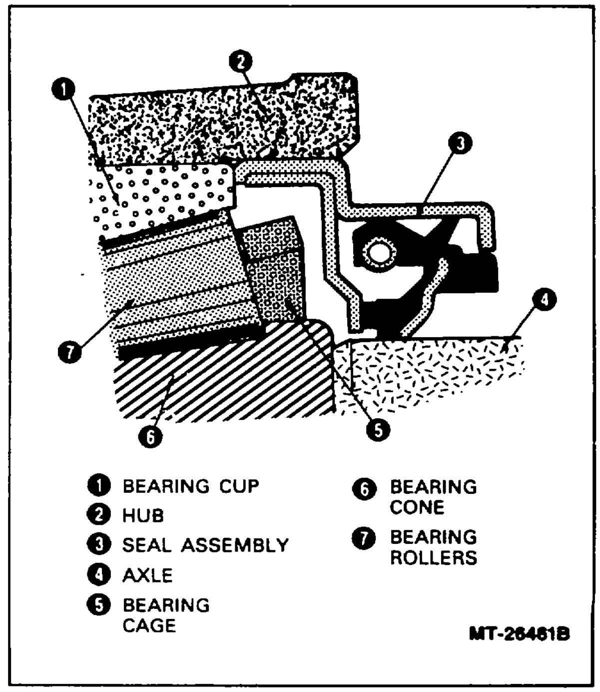

Figure 17. - Unitized Scot or National Seal

Barrier Unitized Seal

The rubber encased seal shown in Figure 18 Is a barrier type seal. The seal effect is between the lips and encased metal ring. This type of seal is installed by hand and should not normally have any lubricant or sealant added to the inner or outer surfaces when installed.

New seals have a lubricant applied to the mounting surfaces to aid in the installation. Do not apply grease to these surfaces. If grease should be applied to the outer surface of seal, the seal could slip in the hub or on spindle or axle tube.

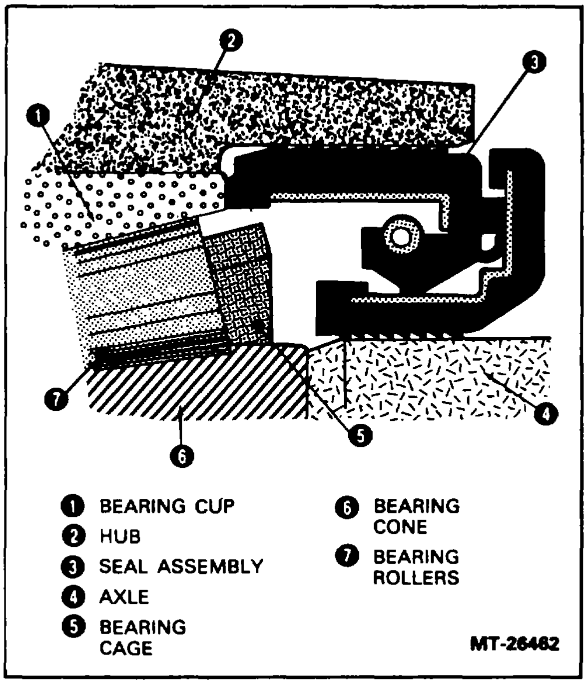

Figure 18. - Unitized Barrier Seal

Guardian Oil Seal

The rubber encased lip type seal with wiper ring shown in Figure 19 is known as the Guardian oil seal. It has the grit guard feature similar to the seal shown in Figure 16, with the advantage of a direct contact between the seal and wiper ring to further guard against entrance of foreign matter. The wiper ring provides a smooth contact for the lip of the seal. The lip of the seal retains the oil in the bearing cavity. The rubber encasement has grooves around its circumference which retains the seal in place in the hub. Pay special attention to the installation of this seal found elsewhere in this section.

REMOVE

The wheel seals are removed using a brass drift and hammer. Position the drift through the outer opening of hub and against bearing. Tap bearing and seal out through the brake drum side of hub. Take care so that seal bore is not damaged.

The wiper or wear ring used with oil lubricated wheel bearing is removed by using a ball peen hammer and tapping on the ring to fatigue it. Do not use a chisel to cut ring since it could damage the machined surface on the axle.

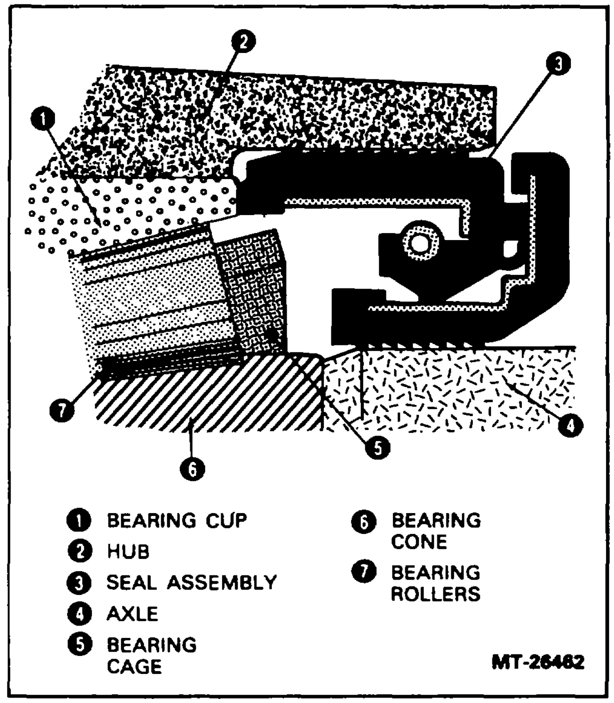

Figure 19. - Guardian Seal

CLEAN AND INSPECTION

1. Thoroughly clean all parts: axle tube or spindle, bearings, nuts and inside of wheel hub.
2. All burrs from inside back edge of hub must be removed. Hub must be smooth and free from burrs which will scratch the outside diameter of seal.
3. Remove burrs from axle tube or spindle shoulder. Shoulder must be smooth.
4. Inspect for porous or cracked hub which could allow oil leakage. This is important where leakage has been encountered.
5. Replace all parts as warranted. More information pertaining to lubricant leakage causes and corrections will be found in the Wheel Seal Leakage Chart in this section.

INSTALL

Wheel seal Installing tools are no longer available through Serv-Equip program. However, special seal and wiper ring installation tools are available through Truck Parts Marketing program.

Wiper Ring (Oil Lubricated Bearings)

1. Apply a thin coat of Loctite Gasket Eliminator (purple) to shoulder on spindle or axle tube, and place wiper ring on axle tube or spindle using an installing tool (Figure 20). Remove excess Gasket Eliminator sealant.

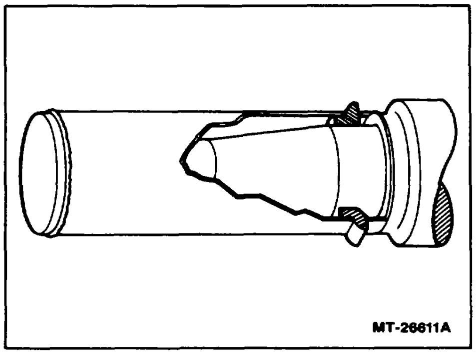

Figure 20. - Installing Wiper Ring on Axle Shoulder

The care with which the axle ring is Installed cannot be over-emphasized. Damage to this ring will result in shortened seal life.

2. Tap on end of axle tool driving axle ring firmly on shoulder until axle tool contacts shoulder.
3. Check position of axle ring to make sure edge of ring is parallel with shoulder.

Lip Type Seal (Grease Packed Bearings)
Lip Type Seal With Wiper Ring (Oil Lubricated Bearings) - Not Guardian Oil Seals

The following instructions pertain to lip type wheel seal used with grease lubricated bearings as well as lip type seals with wiper ring used with oil lubricated bearings.

1. Apply a thin coat of Loctite Gasket Eliminator (purple) hub seal bore. The coating must be very light, yet cover press fit area. Gasket Eliminator should never be allowed to contact lip of seal nor contaminate oil.
2. Lay wheel flat on a steady surface with brake drum up. Place inner wheel bearing into bearing cup and place hub seal Into starting position on hub.
3. Install hub seal using SE-1905 Installer Set to prevent cocking seal (Figure 21). Select the size disc which will apply force to outer edge of hub seal and prevent seal from becoming distorted or damaged.

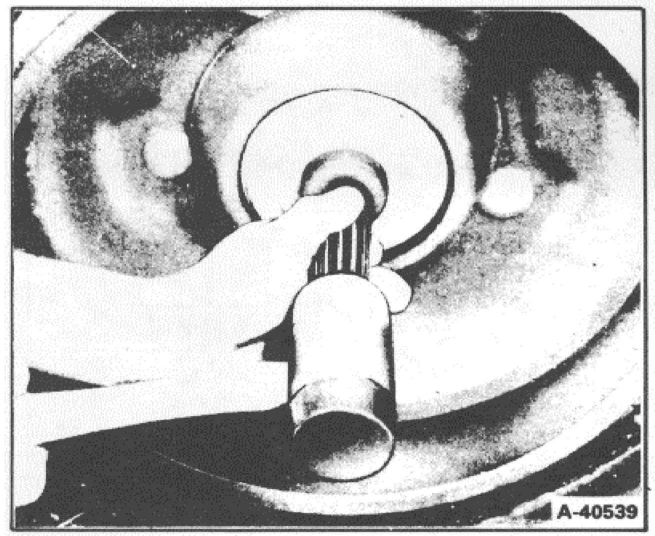

Figure 21.

Drive hub seal into hub until it bottoms in hub bore. Do not continue to drive after seal is once seated as this will distort or damage the seal. After removal of seal installer tool, clean off excess Gasket Eliminator. Be sure to confirm uniform seating of seal (Figure 22).

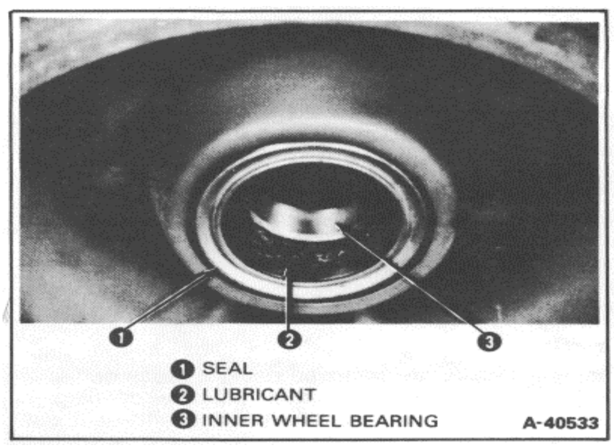

Figure 22.

Unitized Scot Seal

1. If seal is being changed to a unitized seal from another type, remove wear rings if present. Do not use a chisel to remove wiper ring since the chisel could mar the axle. Use a ball peen hammer and tap the ring lightly on the seal lip surface. Do this in a small area, causing the ring to expand, and allowing the ring to slip off the axle housing.

2. Apply a thin coat of Loctite Gasket Eliminator (purple) hub seal bore. The coating must be very light, yet cover the press fit area.

3. To install unitized seal in wheel, seat outer face of seal in the recess of tool adapter (Figure 23). Insert centering plug of tool in bore of inner bearing cone (Figure 24). Using the centering plug aids in prevention of seal cocking in-wheel bore.

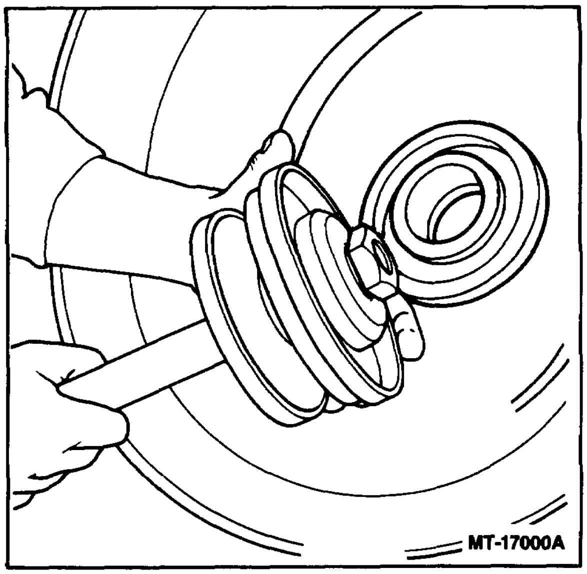

Figure 23.

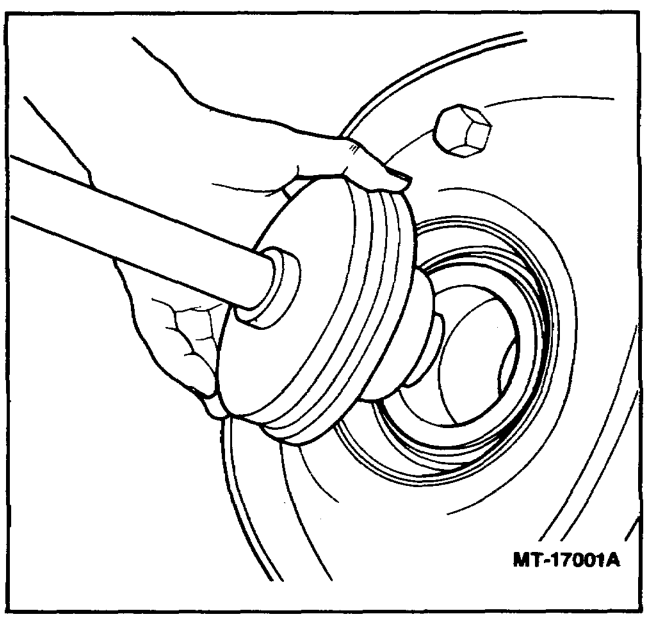

Figure 24.

4. Hold tool handle firmly and strike until sound of impact changes when seal is seated (Figure 25). Then inspect seal to be sure it is uniformly seated but not crushed. Remove excess sealant.

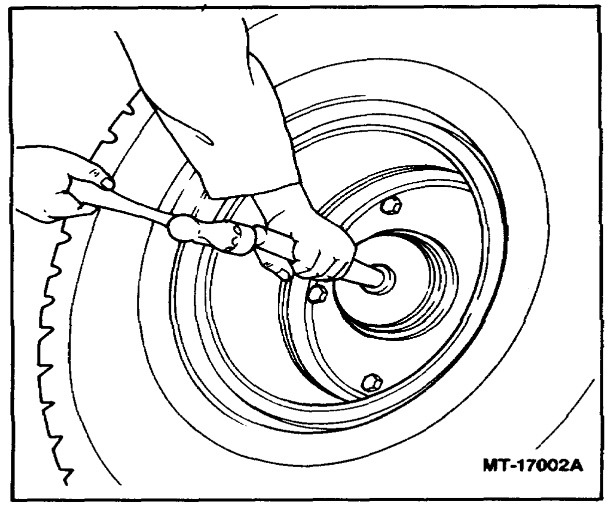

Figure 25.

IMPORTANT Any time wheel Is removed with a Scot Unitized Seal for any purpose, the seal must be replaced.

A good check of proper seal installation is to move the synthetic sealing member with your fingers after installation in wheel hub. There should be a slight in and out movement possible. If wheel seal parts requirements require a wiper ring installation, refer to installation of wiper ring in preceding text.

Unitized Barrier Seal

The barrier type seal (Figure 18) is installed by hand and new seals do not require any special lubricant or sealer to outer or inner surfaces, except when new seal appears to be free of lubricant. Then it is permissible to wipe the leading edge of inside and outside diameters sparingly with light bearing oil. These seals do not require any special tools for installation.
Position seal over hub and use care so that the seal is not cocked when pushed into place.
Push seal into the hub by hand until it is completely bottomed and uniformly seated in the bore.
Do not use wheel bearing or chassis grease to install seals, since grease could result in seal slipping in hub or on spindle or axle tube.

If the inner wheel bearing is smaller than the opening in the seal, it is permissible to assemble the bearing on the spindle first, then install hub assembly with seal. However, do not leave excessive lubricant contact seal as it will erroneously appear as a leaking seal.

Should it be necessary to remove the wheel assembly from the spindle due to hang-ups, it is necessary to recheck the seal for proper installation. In some cases the seal will be separated. The inner half must be removed by hand from the spindle shoulder. Reinsert inner half in outer wheel seal by snapping together. Then reinstall seal assembly.

Guardian Oil Seal

The Guardian oil seal grit guard is installed in the same manner as the wiper ring, previously described and shown in Figure 20.

The seal is then positioned on the wiper ring assembly with lip of seal toward the bearing cavity of the hub. The hub assembly is then positioned over the axle tube or spindle and seal assembly. This assures that the seal is in place over the wiper ring, as shown in Figure 19.

Do not install the Guardian seal in the hub first since the seal could be pushed into the hub deep enough so that the installation could result as shown in Figure 26, and the seal effect would not be accomplished (arrows).

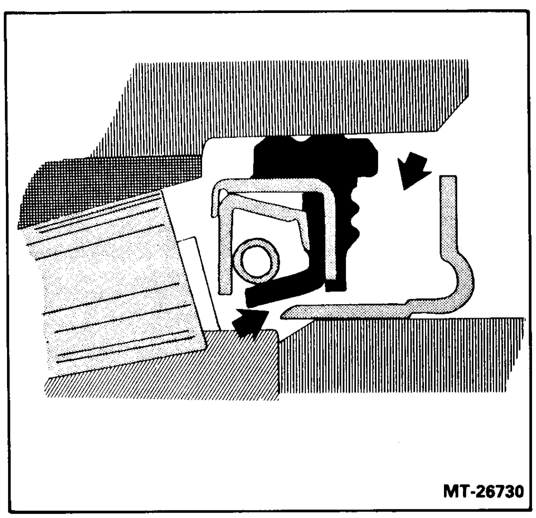

Figure 26. - Improper Installation of Guardian Oil Seal

WHEEL BEARING INSPECTION

Inspect inner and outer wheel bearing cups, cones and roller for wear or damage. If any following conditions exist, the bearing must be replaced If:

Large ends of rollers are worn flush to recess, or radii at large ends of rollers are worn sharp (Figure 27).

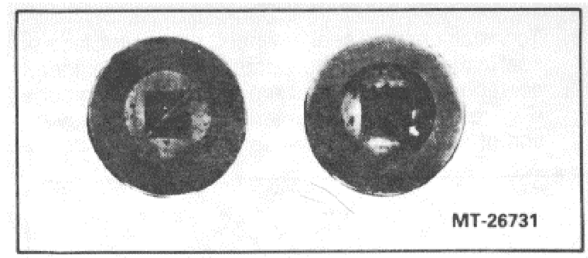

Figure 27.

There is a visible wear step, particularly at the large end of roller and roller track, or deep indentations, cracks or breaks in bearing cup and/or cone surfaces (Figure 28).

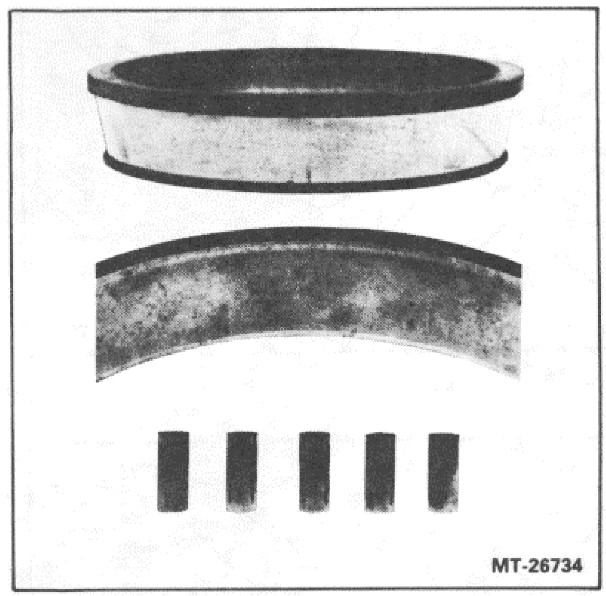

Figure 28.

There are bright rubbing marks on the dark phosphate surfaces of the bearing cage (Figure 29).

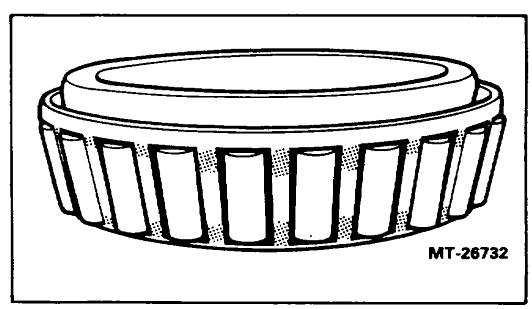

Figure 29.

There is an etching or pitting on contact surfaces of cup, cone or rollers (Figure 30).

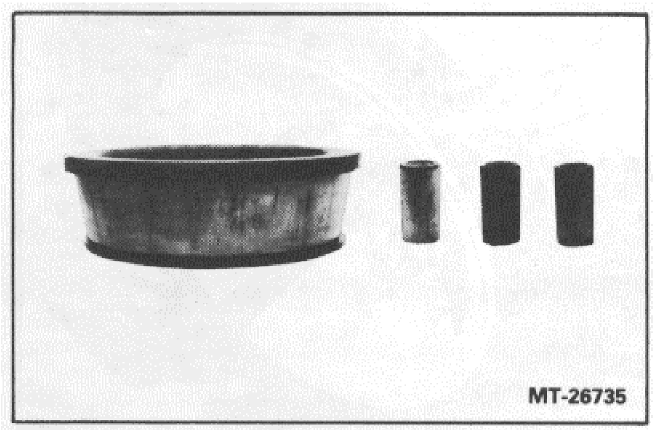

Figure 30.

There is any spalling or flaking on either the bearing cup and/or cone surfaces (Figure 31).

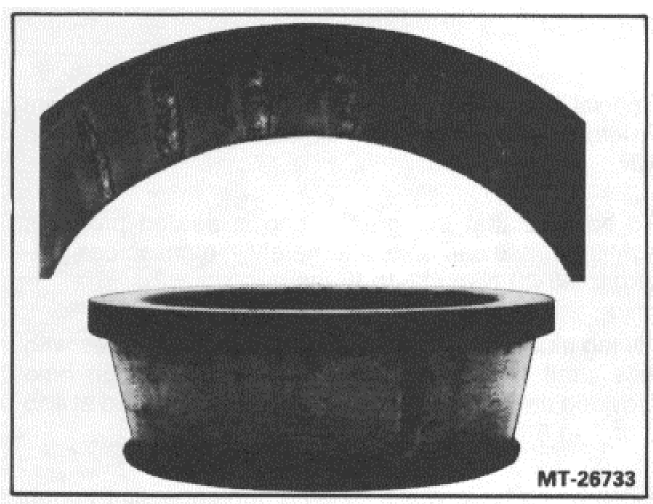

Figure 31.

LUBRICATION

Wheel bearings will either be grease or oil lubricated. Refer to the LUBRICATION Section for type of lubricant to use.

Always use a wheel dolly to place wheel(s) on spindle or axle tube. Care must be taken so that the seal is not damaged, especially when positioned over the end of the spindle or axle (Figure 32).

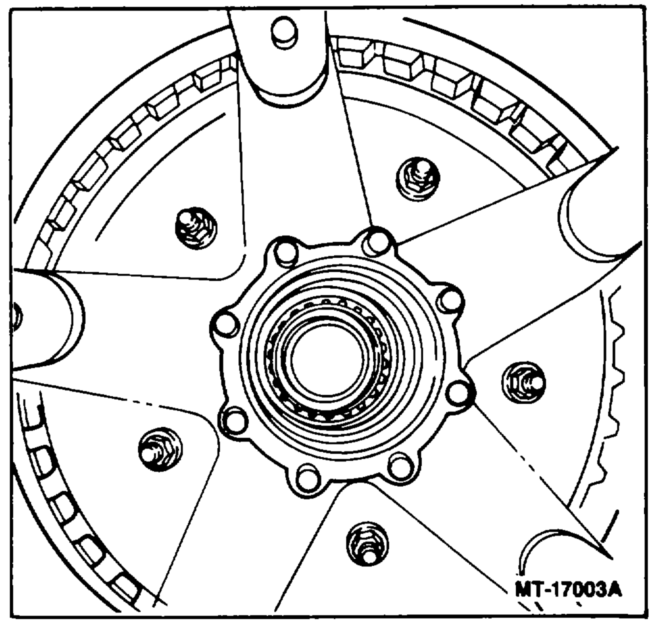

Figure 32.

GREASE LUBRICATED

1. Pressure lubricate inner and outer bearing assemblies, so that grease is forced between the cone and cage until grease is expelled between the cage and rollers (Figure 33).

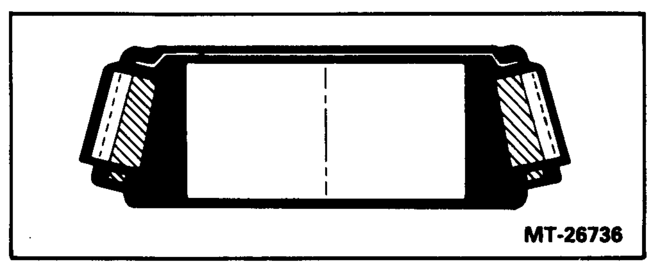

Figure 33.

2. Apply grease to wheel or hub cavity so that it is even with inside diameter of bearing cups.
3. Assemble bearings and seal and adjust bearings as directed elsewhere in this section.
4. When bearing maintenance is performed on rear drive axle bearings, the procedures in oil lubricated bearings can be used. It is important that the rear axle lube level be inspected since that lube also aids in lubricating the bearings.

OIL LUBRICATED

Special attention must be given to the type of lubricant used on front and rear axle wheel bearings, since different type of lubricants will be used.

Front Axles

1. Prelubricate bearings by applying a light coating of recommended lube to bearings.
2. To be assured that the grease cap is uniformly seated, tighten cap bolts alternately in a crisscross pattern to 16-20 N•m (12-15 ft. lbs.).
3. After grease cap has been installed and bearings adjusted, oil level is to be from oil level line to 9.525 mm (3/8") above line.
   IMPORTANT Apply sealant to threaded type plug. Insure that rubber plug is seated. Wipe excess lubricant from bearing cap which could appear as a leaking cap after vehicle operation.
4. A light coating of grease may be applied to bearing cone and matching surface of cup to promote cone to cup adhesion to facilitate assembly.

Rear Drive Axles

1. Prelubricate bearings by applying a light coating of recommended lube to bearings.
2. Fill wheel or hub cavity with differential lubricant to level of largest bearing cup.
3. Apply a very light coat of lube to lip of oil seal with exposed lip.
4. Check differential for proper lubricant level.

IMPORTANT To assure good sealing when Installing axle shaft (Fig. 34), observe the following precautions.

1. Both mating surfaces must be free of nicks or burrs.
2. Both mating surfaces must be clean and dry before Installing either an acetate gasket or Loctite Gasket Eliminator.
3. When Installing axle shafts, tighten flange mounting nuts evenly to specified torque.
4. Wipe excess lubricant from axle flange since lube could appear as a leak after operation.

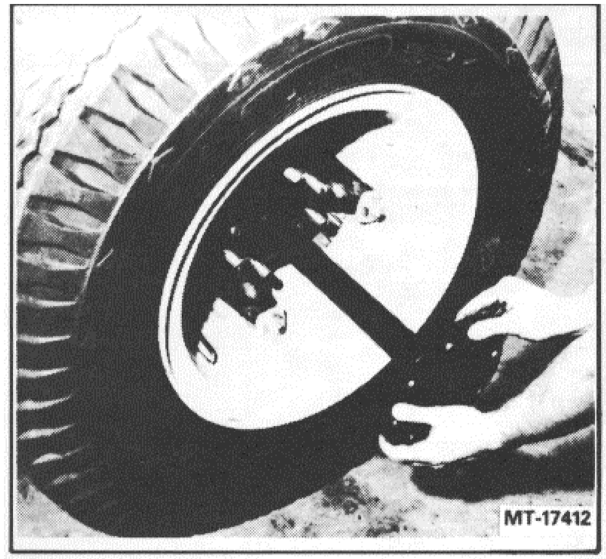

Figure 34.

Special Instructions for Rear Rear Axle or Tag Tandem Axles, Rear Axle Models RA 429, 430, 431, 432 and 437. To be sure that the grease cap is seated properly, tighten grease cap bolts alternately in a crisscross patter to 16-20 N•m (12-15 ft. lbs.).

Fill tag axle wheel ends with gear lubricant. Axles with axle shaft ends used as hub caps, fill through hole provided until oil runs out when hole is positioned at 4 to 5 or 7 to 8 o'clock.

Axles which have visual oil level hub caps, fill through provided hole to oil level line on hub cap.

IMPORTANT Apply sealant to threaded type. Insure that rubber plug Is seated. Wipe excess lubricant from bearing cap which could appear as a leaking cap after operation.

WHEEL BEARING SEAL AND BEARING CAP DIAGNOSTIC CHART

Prior to replacing a leaking wheel seal or front wheel hub cap, the actual cause of the leakage should be diagnosed to insure that the leakage problem will not reoccur.
You will note that the chart has four categories where the leakage could occur; do not overlook all four situations.
Possible contributory causes of apparent wheel seal leakage are:

CAUSE	CORRECTION
WHEEL SEAL	
Seal Cocked or Not Properly Seated in Hub	Be sure to confirm uniform seating of seal after installation. Use proper installation procedures.
Seal Lip Cut or Rough on Open Lip Type Seals. Inside and Outside Diameter Damaged on Unitized Seals	New seal could have been damaged prior to installation. Inspect lips of new seals before and after installation in hub. Seal can also be damaged due to abuse during installation of hub assembly by contact with spindle or axle end or threads.
Worn or Damaged Wiper Ring and Seal	Normal wear of seal lip to wiper ring contact area or improper installation of wiper ring. Replace seal and wiper ring using correct installation tools.
Seal Loose or Too Tight in Hub Bore or Seal Lip Over Size	Check for correct application of seal assembly.
Sealant Not Applied to Seal Outside Diameter When Required	Use Loctite Gasket Eliminator when instructed to do so.
Grease On Inside or Outside Diameter of Mechanix Barrier Seal	Grease may cause seal to move in hub bore or at axle housing or spindle. Seal is designed to grip hub bore and axle housing or spindle. Remove grease from inside and outside diameter.
Brake Cam Shaft Seal Leakage	Excessive lubrication of brake cam shaft can cause grease to enter brake groups and may be mistaken for faulty wheel seal. Do not overlubricate brake cam shafts.
GREASE CAP	
Lubricant on Exterior of Grease or Hub Cap	Lubricant spillage either at initial fill or lube added. Steam clean lubricant from grease cap so that it is not mistaken as a faulty sight glass, bearing cap or gasket.
Over Fill of Lubricant	Excessive lubricant can cause lube to be expelled from grease cap plug. Maintain proper fill level mark on window.

CAUSE	CORRECTION
GREASE CAP (Cont'd.)	
Cracked Housing	Grease cap can be damaged by mishandling or improper tightening of cap bolts. Replace cap if cracked. Tighten cap bolts alternately in a crisscross pattern to 16-20 N•m (12-15 ft. lbs.).
Sight Glass Cracked or Broken	Sight glass can be damaged through abuse in handling cap or object striking it. Replace bearing cap or window kit.
Gasket Leaking at Hub or Wheel Mounting Face	Tighten bolts to 16-20 N•m (12-15 ft. lbs.) alternately in a criss-cross pattern. Use proper length bolts and lockwashers. Replace gasket.
Sight Glass Gasket Leaking	Replace sight glass kit or cap assembly.
Rubber Vent Plug Not Seated	After filling with lubricant be sure that the rubber vent plug is seated in cap window. Early Stemco vent plug (with molded part number) are easily misinstalled. Later type vent plugs without part number do not have this tendency.
Threaded Filler Plug Leaking Lubricant	Apply thread sealant to threaded plug. Tighten plug.
WHEELS AND BEARINGS	
Wheel Hub Bore Has Burrs, Rust or Nicks	Hub must be smooth and free of excessive rough finish which could scratch outside diameter of seal. Clean up if possible or replace hub.
Hub Bore Diameter	Seal should be press fit. Check for correct application of seal.
Porous or Cracked Hub	Leakage which would appear at the hub (not at bearing cap or axle flange) is an indication of a possible crack or porous opening allowing lube leakage. To correct this condition a new hub must be installed.
Loose Wheel Bearing Adjustment	Loose wheel bearing adjustment will permit side movement of seal and cause abnormal wear or shaft to bore misalignment. Oil pumping past seal will result. Set and maintain proper wheel bearing adjustment. Adjusting wheel bearings too tight can cause early bearing failure.
AXLE HOUSING AND SPINDLE	
Spindle or Axle Housing Has Burrs or Nicks	Remove all burrs and nicks. Correct rough finish. Do not use chisel to remove wiper ring (wear sleeve).
Leakage at Axle Shaft Flange	Missing or fractured axle gasket or lack of sealing compound. Replace gasket or apply silastic sealing compound.
Cosmolene on Spindle or Axle Housing	Thoroughly clean all cosmolene from sealing surfaces and bearing shoulder.
Axle Breather Inoperative	Excessive lube pressure could cause wheel seal leakage. Clean or replace breather.

RIM, WHEELS AND TIRES GENERAL

The Occupational Safety and Health Administration (OSHA) has established rules and regulations pertaining to servicing Multi-Piece Rim Wheels.

The text herein refers to selected excerpts from the OSHA standard. For complete details, refer to the complete OSHA standard 1910.177 to ensure compliance.

Basically, the regulations state that it is up to the employer to provide employee training to instruct all employees who service multi-piece rims in the safety hazards involved and safety procedures to be followed.

The employer shall see that no employee services multi-piece or single piece rim wheels unless trained, and demonstrates and maintains the ability to service multi-piece rim wheels safely.

This shall include the following tasks:

1. Demounting of tires which includes deflation.
2. Inspection of components.
3. Mounting of tires which includes Inflator with re-straining device.
4. Use of restraining device.
5. Handling of wheels.
6. Inflation of tires when a wheel is mounted on the vehicle.
7. An understanding of the necessity of standing out-side the trajectory both during inflation of the tire and during inspection of the rim wheel following inflation.
8. Installation and removal of wheels.

OSHA also states the type of tire servicing equipment to be used.

1. Restraining device (inflation cage).
2. Clip-on-chuck with enough hose to permit employees to stand clear of potential trajectory of wheel components. An in-line valve with gauge or pressure regulator preset to a desired value must also be provided.
3. Current charts must also be posted in service area.
4. Current rim manual containing instructions for types of rims being serviced shall be available in service area.
5. The employer must assure that only tools recommended in the rim manual are used to service multi- piece rim wheels.

WALL CHARTS

National Highway Traffic Safety Administration (NHTSA) has prepared two charts which are to be posted in the rim wheel service area. These charts alert service personnel of the hazards involved when working with multi-piece wheels.

One chart is called 'Safety Chart" which illustrates the proper safety precautions to be followed when servicing truck and bus multi-piece wheels.

The second chart is called 'Matching Chart" which provides the guidance of various wheel makes and components which can be safely interchanged.

These charts are available to all persons who service multi-piece wheels as follows:

Individuals who service such wheels may obtain a single copy of each chart, without cost, by writing to the General Services Division/Distribution, National High- way Traffic Safety Administration, 400 Seventh Street, S.W. Washington, D.C. 20590.

Establishments and other organizations desiring these charts may order same in any quantity desired from the Superintendent of Documents, Government Printing Office (GPO) Washington, D.C. 20402 at a cost established by the GPO.
The GPO ordering number for charts are:

Safety Chart #050-003-0315-8
Matching Chart #050-003-00316-6

CARE AND MAINTENANCE

Wheel rims should be periodically inspected both on the vehicle and during tire changes for cracks, loose wheel studs, worn mounting holes or being bent.
Disc wheels (Figures 2 and 9) have rims which are integral with the wheel itself; the important thing to note is that the wheel stud nuts must be kept tight. This means they should be inspected and tightened at regular intervals. When checking the mounting studs and nuts on dual disc wheels (Figure 35), the outer nut should be backed off before attempting to tighten the inner nut. Try all cap nuts after the first trip or any wheel change. When properly installed, they should remain tight indefinitely.
Cast spoke wheels (Figures 1 and 6) have rims that are demountable with the tire; the rim clamp nuts should also be kept tight. Rim and tire to wheel alignment should be checked frequently to make sure the tire Is running true. Some left-hand thread nuts can be identified by the small groove machined around the flats. Left-hand studs can be identified by the letter "L" stamped on the head. Use left-hand nuts on the left side of the truck.

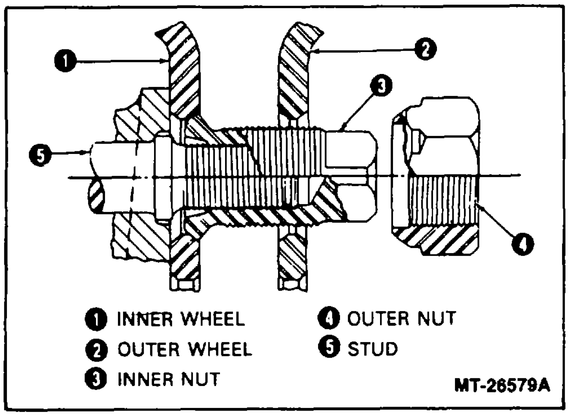

Figure 35. - Dual Disc Wheel Installation

Whenever a tire is removed, clean off all grease and road dirt. Use a wire brush or steel wool to remove the rubber from the bead seat.

Projections on the side wall of the gutter may cause uneven seating of the side ring and lead to chipping of the gutter. Remove these and other projections in the mounting area to assure the best possible fits.

Nicks and gouges in the vicinity of the fixed flange may lead to rim fracture.

Do not heat or weld wheels in an attempt to straighten or repair severe road damage. The special alloy used in these wheels is heat-treated, and uncontrolled heating from welding torch affects the properties of the material.

To avoid possible corrosive effects to aluminum wheels, use only a slight amount of water and neutral soap (similar to Ivory Snow, Dreft, etc. no detergents) when mounting tires. Do not use commercial rubber lubricants.

Do not allow dirt to enter the mounting area during installation. See 'TORQUE CHART" for correct torque values.

WHEEL STUDS AND MOUNTING NUTS

Maintaining wheel stud and mounting nut tightness does much to insure safe and satisfactory wheel operation. Loose wheel mounting can cause vibration, shimmy, tire wear, stud breakage, worn studs, mounting nuts (Figure 36) and worn or elongated stud holes (Figure 37). Parts with these characteristics must be replaced. Always keep wheel stud nuts tightened to specified torque.

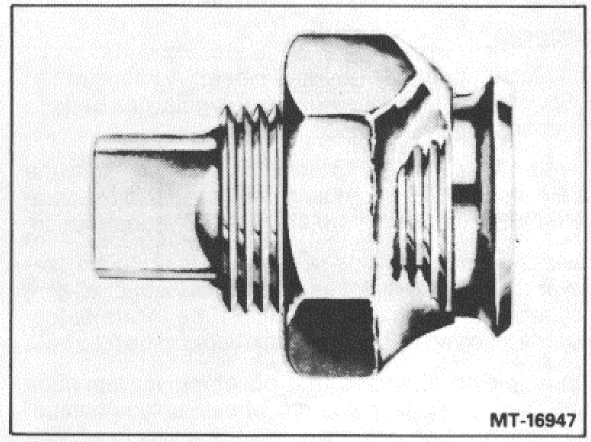

Figure 36.

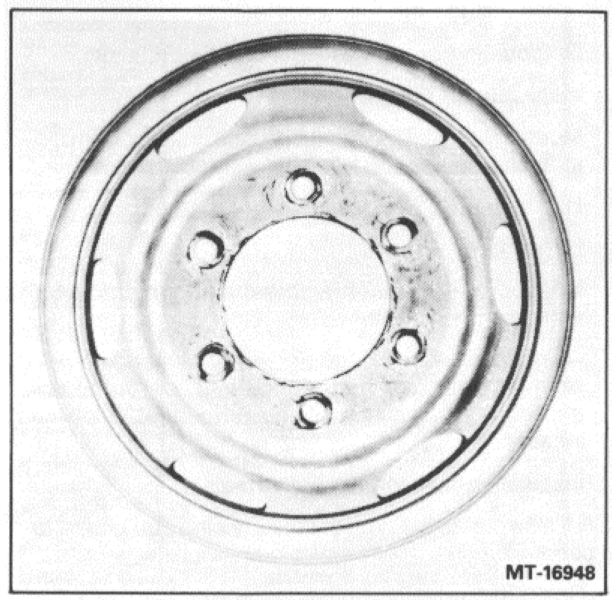

Figure 37.

Rust streaks (Figure 38) from stud holes is a good indication that mounting nuts are not tightened to-the specified torque.

Before mounting wheel assemblies on vehicle, make sure all parts are clean and free from foreign matter.

Excess paint on wheel mounting face or stud hole perimeters can permit wheel mounting nuts to loosen with use.

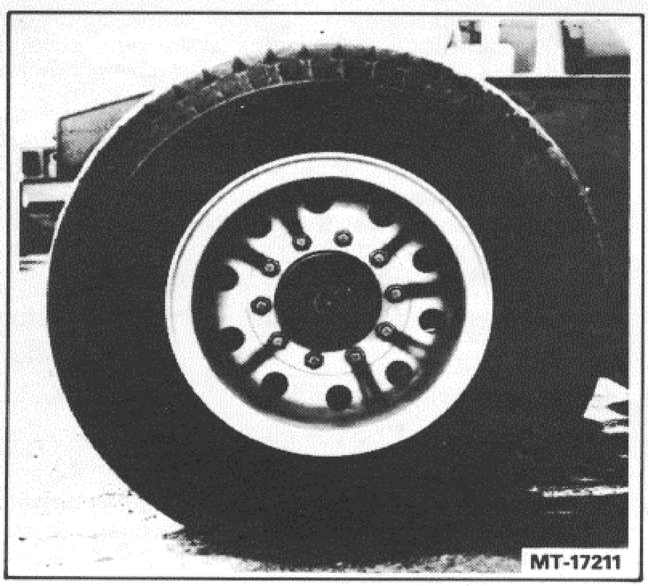

Figure 38.

INSTALLATION, TIGHTENING AND ALIGNMENT OF DISC WHEELS AND RIMS

When installing disc wheels or demountable rims with cast spoke wheels, be certain that the threads on studs and nuts are clean to permit correct torquing of nuts. The mounting surfaces of rims, wheels, spacer rings and clamps are free of dirt, rust or damage.

Use a wire brush to clean mounting contact surfaces. Do not use lubricant on threads.

After rim or wheel has been properly torqued, it should be checked for alignment. This can be accomplished by rotating wheel with a piece of chalk attached to a steady, firm surface and placed to just barely clear outside surface of tire bead seat. This procedure will point out the "high spot." Keep in mind, however, that a "high spot" does not necessarily mean that lug nuts have been unevenly tightened. This condition or misalignment can also result from a bent wheel.

The checking of the alignment of the wheel/rim installation is more important on cast spoke rims since the rims can be drawn out of alignment when improperly tightened. Therefore it is important that the following installation procedures be followed.

Disc Wheels With Conical Nuts

1. Slide inner/rear or front tire and wheel in position over studs and push back as far as possible. Use care to avoid damage to threads on studs and inspect the valve stem to caliper for clearance.
2. Install the outer wheel nut on front wheels and inner wheel nut on rear dual wheels. Run nuts on studs until the nuts start to contact the wheel. Rotate wheel a half turn to allow parts to seat naturally.

3. Draw up stud nuts alternately following the sequence (crisscross pattern) illustrated in Figure 40. Do not fully tighten the nuts at this time. This procedure will allow a uniform seating of nuts and insure the even face-to-face contact of wheel and hub.
4. Continue tightening the nuts to the torque specifications in the Torque Chart using the same alternating method shown in Figure 40.
5. Install the outer rear wheel and repeat the preceding method. Be sure that both inner and outer tire valve stems are accessible.

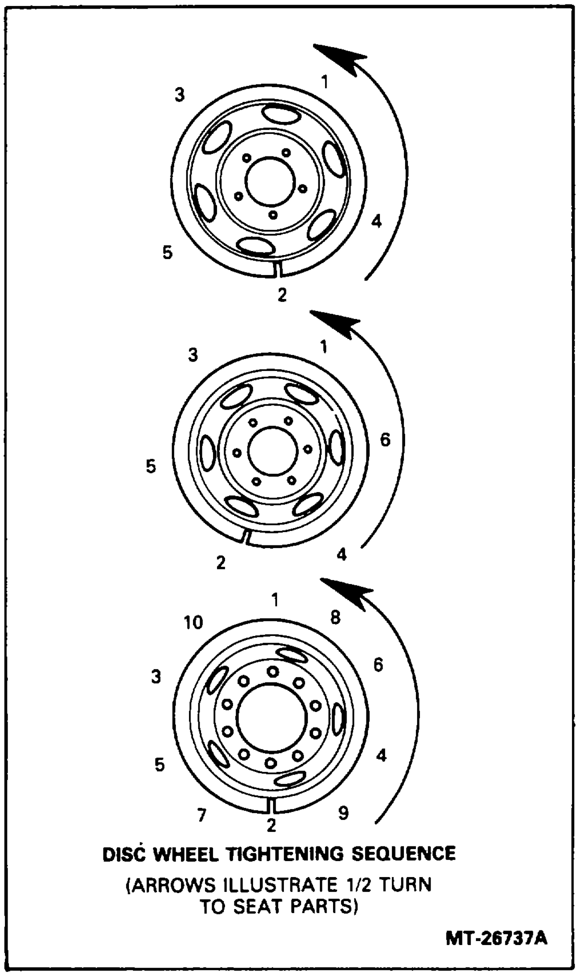

Figure 40. - Disc Wheel Tightening Sequence

6. After operating the vehicle approximately 80 km (50 miles) check the stud nuts for tightness. Some natural seating of parts may be encountered and the torque on nuts will drop. Retighten all nuts to specified torque.

To check and tighten the Inner wheel to proper torque, first loosen the outer wheel nuts several turns and tighten the Inner nuts, then retighten the outer nuts.

To prevent losing the seating of the outer wheel when checking the Inner wheel torque, It is suggested that alternates outer nuts be loosened and retighten, the outer nuts. Then loosen the remaining outer nuts, tighten inner nut and then retighten the outer nuts.

Once each week Inspect and retorque wheel stud nub.

Disc Wheels with Flange Nuts
Refer to Figure 41 for cross section view of flange nut

1. Slide inner rear or front tire and wheel in position over Suds and push back as far as possible. Use over so that the threads on studs are not damaged.
2. Position outer rear tire and wheel In place over the *studs* and push back as far as possible. Again use care so that the threads on studs are not damaged.
3. Run the nuts on the studs until nuts contact the wheel or wheels. Rotate wheel assembly a half turn to permit parts to seat.
4. Draw up nuts alternately following the (crisscross) sequence Illustrated in Figure 40. Do not fully tighten nuts at this time. This will allow uniform seating of nuts and assure even face-to-face contact of wheel and hub.
5. Continue tightening the nuts to torque specifications in the Torque Chart using the same alternating sequence shown in Figure 40.

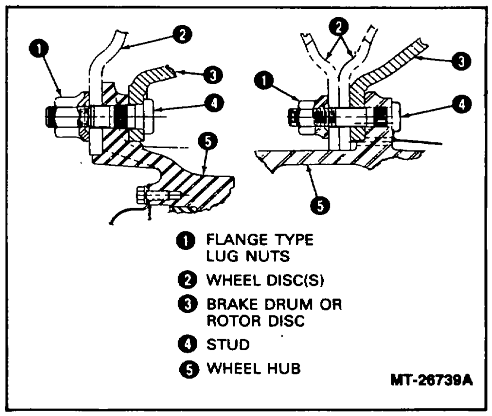

Figure 41

WHEEL AND TIRE BALANCING

Front wheel and tire assemblies must be balanced to prevent wheel vibrating and bounce. While the correct front wheel alignment is necessary for easy steering and maximum tire life, the cause of unstable steering can frequently be traced to improper balance of front wheels. When this condition exists, the wheel and tire assembly should be properly balanced.

A vulcanized or retreaded tire, or a tire that has a boot in it, may cause an unbalanced condition that cannot be corrected by balancing. In such cases the tire should be replaced before attempting to balance the assembly.

Static Balancing

A wheel out of balance statically has a tendency to bounce up and down, resulting in rapid tire wear in round or oblong spots.

Static balancing is performed while wheel is stationary by attaching weights to rim flange to offset an opposite heavy point.

Static balancing may be sufficient in some instances where vehicle is operated only at slow speeds, however, dynamic balancing (in motion) balances the wheel and tire assembly statically as well as dynamically, thereby eliminating vibrations and wheel bounce at both low and high speeds.
A wheel may be perfectly balanced statically (not in motion) but may still vibrate and bounce at high speed rotation because of its being out of balance dynamically.

Dynamic Balancing

Dynamic balancing is complete wheel balancing of which static balancing is only a part.

Dynamic balancing (in motion) takes into consideration the distribution of weight to be added to the wheel. This Is accomplished by rapidly rotating (normal truck operating speed) the wheel and tire assembly either on the vehicle or with the wheel assembly removed and placed on a dynamic balancing machine. This determines heavy point on wheel.

When the amount of weight required to offset a heavy part in a wheel assembly is known, it is sometimes necessary to attach one-half of the weight to the outside rim flange and the remaining half to the inside rim flange.

With the weight properly distributed on the wheel assembly, the wheel should be in balance both statically and dynamically and should rotate free of vibration and bounce at normal truck operating speeds.

TIRE CARE

Proper tire inflation, tire loads, and road speeds are important determining factors governing tire mileage, and also affect steering ease and maneuverability. How much these three factors affect tire wear is illustrated in the paragraphs which follow.

INFLATION

Tire pressures should be checked at regular and frequent intervals and the pressures maintained to specifications. Use an accurate tire pressure gauge and check when tires are cool.

Over inflated or under inflated tires will reduce the service life of the tire.

"Bleeding" of air from hot tires should never be practiced. The pressure will be reduced but an increase in temperature will result as soon as driving continues.

LOADS

Loading tires beyond their rated capacity is expensive because tire mileages are rapidly decreased with overloads.

TIRE MATCHING

Dual Tires

Use care in matching dual tires. Tires which differ more than 6.35 mm (1/4") in diameter or 19.05 mm (3/4") In circumference should not be mounted on the same dual wheel. Should it become necessary to mount two tires of unequal size on the same dual wheel, place the larger or less worn tire on the outside.

Tandem Drive Axles

When mounting tires on tandem drive axles follow the same instructions as specified for dual tires. However, never install the four largest tires on one driving axle and the four smallest on the other. This method of tire mounting will cause high lubricant temperatures which may lead to premature axle failures.

BIAS AND RADIAL TIRE LOAD AND INFLATION CHART (NOT MICHELIN)
(FOR TRUCKS, BUSES AND TRAILERS IN NORMAL HIGHWAY SERVICE)

Tire Size Designations		*	TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES (PSI)															
Tube	Tubeless	**	40 45	45 50	50 55	55 60	60 65	65 70	70 75	75 80	80 85	85 90	90 95	95 100	100 105	105 110	110 115	115 120
7.50x20	8-22.5	D	2070	2220	2350	2490	2620	2750D	2870	2990	3100E	3210	3320	3430F	3540	3640G		
		S			2360	2530	2680	2840	2990	3140D	3270	3410	3530E	3660	3780	3910	4040	4150G
8.25x20	9-22.5	D	2460	2640	2800	2960	3120	3270	3410	3550E	3690	3820	3950F	4070	4200	4320G		
		S			2800	3010	3190	3370	3560	3730	3890	4050E	4210	4350	4500F	4640	4790	4920G
9.00x20	10-22.5	D		3120	3310	3510	3690	3870	4040E	4200	4360	4520F	4670	4820	4970G			
		S				3560	3770	4000	4210	4410	4610E	4790	4970	5150F	5320	5490	5670G	
10.00x20	11-22.5	D			3760	3970	4180	4380	4580	4760F	4950	5120	5300G	5470	5630	5800H		
		S					4290	4530	4770	4990	5220	5430F	5640	5840	6040G	6240	6430	6610H
10.00x22	11-24.5	D			4000	4230	4450	4660	4870	5070F	5260	5450	5640G	5820	6000	6170H		
		S					4560	4820	5070	5310	5550	5780F	6000	6210	6430G	6630	6840	7030H
11.00x20	12-24.5	D			4100	4330	4560	4780	4990	5190F	5390	5590	5780G	5960	6150	6320H		
		S					4670	4940	5200	5450	5690	5020F	6140	6370	6570G	6790	7010	7200H
11.00x22	12-24.5	D			4350	4600	4840	5080	5300	5520F	5730	5940	6140G	6330	6530	6720H		
		S					4960	5240	5520	5790	6040	6290F	6530	6770	7000G	7220	7440	7660H
11.00x24		D			4620	4890	5140	5390	5630	5860F	6090	6310	6520G	6730	6930	7130H		
		S					5270	5570	5860	6140	6420	6680F	6940	7190	7430G	7670	7900	8130H
12.00x20		D				4930	5190	5440	5680	5910	6140G	6360	6580	6790H	7000	7200J		
		S						5620	5920	6200	6480	6740	7000G	7250	7500	7740H	7980	8210J
12.00x24		D				5500	5840	6120	6390	6650	6910G	7160	7410	7640H	7870	8100J		
		S						6330	6660	6980	7280	7580	7880G	8160	8450	8710H	8970	9230J
	15-22.5	D		5000E	5320	5620	5910F	6200	6480	6740G	7000	7250	7500H					
		S				5680E	6040	6390	6720F	7040	7360	7660G	7950	8240	8520H	8790	9060	9230J
	16.5-22.5	D		5800	6170	6520	6860	7190	7520	7820	8120H							
		S				6590	7010	7410	7790	8170	8540	8890	9230H	9570	9890	10210J		
	18-22.5	D		6430	6850	7230	7610G	7980	8330	8680H	9010	9340	9650J					
		S				7310	7780	8220	8650G	9070	9470	9860H	10240	10610	10970J			

Letters listed with weight are the maximum lad for load range of tire.
Do not exceed rim loads and/or inflation limits.
For applicable load limits for other than normal highway service, for other size designations and for size designations with suffixes such as "ML" (mining and logging) consult the tire manufacturer.

* Cold Inflation Pressure for Bias Tires.
** Cold Inflation Pressure for Radial Tires. Radial Tires have an "R" In the Size Designation; example 10.00R20.

D = Dual Tire Usage
S = Single Tire Usage

LOW PROFILE RADIAL TIRE LOADS AND INFLATIONS (NOT MICHELIN)
(FOR TRUCKS, BUSES AND TRAILERS IN NORMAL HIGHWAY SERVICE)

TIRE SIZE DESIGNATIONS		*	TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES (PSI)								
TUBE TYPE	TUBELESS		70	75	80	85	90	95	100	105	110
	295/75R22.5	D	4500	4690	4885	5075	5260	5440	5675(G)		
		S	4500	4725	4945	5155	5370	5575	5780	5980	6175(G)
	285/75R22.5	D	4540	4740	4930	5205	5310	5495	5675(G)		
		S	4545	4770	4990	5210	5420	5675	5835	6040	6175(G)
13/80R20		D			6130	6380	6640	6890	7160(J)		
		S			6880	7170	7450	7790	8050(J)		
14/80R20		S				7590	7890	8200	8500	8810	9090(J)

* D = Dual Tire Usage
S = Single Tire Usage

Letters listed with weight designate the maximum load for that load range.
Do not exceed rim load and/or inflation limits.

TIRE LOAD AND INFLATION CHART (MICHELIN)
(FOR TRUCKS, BUSES AND TRAILERS IN NORMAL HIGHWAY SERVICE)

Tire Size Designations			TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES (PSI)													
Tube	Tubeless		55	60	65	70	75	80	85	90	95	100	105	110	115	120
7.50R20		D S	2305 2405	2506 2615	2695 2810	2873 2995	3058 3197	3250 3217	3350E 3530E							
	8R 22.5	D S	2622 2722	2805 2915	2987 3107	3157 3300	3356 3495	3550 3692	3730 3887	3800F 3970F						
8.25R20	9R 22.5	D S	2610 2860	2840 3090	3114 3317	3261 3502	3474 3700	3671 3912	3830E 4050E	4050 4307	4220F 4500F					
9.00R20	11R 22.5	D S					3914 4255	4131 4490	4349 4725	4566 4962	4740F 5150F	4995 5430	5080G 5510G			
10.00R20	10R 22.5	D S				3992 4435	4224 4692	4455 4950	4692 5215	4922 5470	5180 5755	5440 6040	5620G 6245G	5782 6427	5950H 6610H	
11.00R20	12R 22.5	D S				4145 4680	3990 4957	4635 5235	4880 5512	5130 5705	5361 6055	5575 6295	6000G 6590	6180 6895	6360H 7200H	
12.00R20		D S					4629 5197	4905 5512	5181 5827	5435 6117	5725 6447	5966 6725	6255 7055	6500 7330	6755 7605	7160J 8100J
13.00R20		D S				5800 6445	6125 6805	6449 7165	6802 7557	7132 7925	7504 8337	7512 8680	8150 9055	8450J 9370J		

Letters listed with weight are the maximum load for load range of tire.
Do not exceed rim load and/or inflation limits.
For applicable load limits for other than normal highway service, for other size designations consult the Michelin dealer.

D = Dual Tire Usage
S = Single Tire Usage

TIRE LOAD AND INFLATION CHART (MICHELIN) CONTINUED
(FOR TRUCKS, BUSES AND TRAILERS IN NORMAL HIGHWAY SERVICE)

Tire Size Designations			TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES (PSI)													
Tube	Tubeless		55	60	65	70	75	80	85	90	95	100	105	110	115	120
13/80R20		D S						5122 5690	5512 5995	5792 6285	6075 6610	6355 6880	6625 7210	6907 7500	7160J 8000J	
14.00R20		D S							8077 8832	8473 9287	8887 9782	9232 10197	9645 10692	9900M 11000M		
14/80R20		D S							6045 6710	6325 7020	6660 7395	6937 7700	7242 8040	7562 8395	7992 8875	8140J 9040J
10.00R 22		D S				4285 4705	4534 4960	4740 5235	4976 5512	5200F 5708F	5495 6105	5790G 6430G				
11.00R 22		D S				4492 4935	4787 5265	5042 5555	5302 5845	5544 6120	5806 6435	6060 6720	6300G 7000G	6489 7237	6650H 7400H	
12.00R 22		D S						5346 5952	5642 6267	5912 5660	6221 6890	6462 7165	6800H 7550H			
11.00R 24		D S					5070 5637	5346 5952	5622 6267	5877 6560	6166 6890	6407 7165	6750H 7500H			
12.00R 24		D S					5871 6435	6193 6787	6325 7027	6635 7370	7006 7785	6316 8130	7689 8542	7950J 8840J		
	11R 24.5	D S				4087 4465	4285 4705	4534 4960	4740 5235	4976 5512	5200F 5780F	5495 6105	5790G 6430G			
	275/80R22.5	D S				3992 4435	4224 4692	4455 4950	4692 5215	4922 5470	5180 5755	5510G 6005G				
	275/80R24.5	D S				3992 4435	4224 4692	4455 4950	4692 5215	4922 5470	5180 5755	5510G 6005G				
	13/75R22.5	D S							5417 6045	5707 6365	5990 6680	6247 6970	6552 7310	6822 7610	7160 8000	

Letters listed with weight are the maximum load for load range of tire.
Do not exceed rim load and/or inflation limits.
For applicable load limits for other than normal highway service, for other size designations consult the Michelin dealer.

D = Dual Tire Usage
S = Single Tire Usage

TIRE AND RIM COMBINATIONS
TIRES DESIGNED FOR NORMAL HIGHWAY SERVICE

TUBE TYPE		TUBELESS	
TIRE SIZE	RIM WIDTH	TIRE SIZE	RIM WIDTH
7.50x20	6.00, 6.50	8-22.5	6.75
8.25x20	6.50, 7.00	9-22.5	6.75
9.00x20	7.00, 7.50	10-22.5	6.75, 7.50
10.00x20	7.50, 8.00	11-22.5	7.50, 8.25
10.00x22	7.50, 8.00	11-24.5	7.50, 8.25
11.00x20	7.50, 8.00	12-22.5	8.25
11.00x22	7.50, 8.00	12-24.5	8.25
11.00x24	7.50, 8.00	15-22.5	12.25, 13.00
12.00x20	8.50	16.5-22.5	12.25, 13.00
13/80R20	8.50	18-22.5	13.00, 14.00
14/80R20	10.00	275/80R22.5	7.50, 8.25
275/80R22.5		7.50, 8.25	
285/75R24.5		7.50, 8.25	
295/75R22.5		7.50, 8.25	

CAUTION: ALWAYS USE APPROVED TIRE AND RIM COMBINATIONS FOR DIAMETERS AND CONTOURS. AFTER MOUNTING DUAL TIRES, INSURE TIRES DO NOT CONTACT EACH OTHER UNDER A LOADED CONDITION.

CAUTION: NOT APPLICABLE FOR ML (MINING & LOGGING) TIRES.

CONVERSION OF PLY RATING TO
LOAD RANGE DESIGNATION

LOAD RANGERE	PLACES PLY RATING
D	8
E	10
F	12
G	14
H	16
J	18
L	20
M	22
N	24

TORQUE CHART

DISC WHEELS			
		Torque	
Size	**Nut Mounting**	**N•m**	**Ft-Lbs**
11/16”	Flange	475-543	350-400
3/4	Standard Square Cap: 13/16" Across Flats	610-678	450-500
	1-1/2" Across Flats	610-678	450-500
1-1/8”	Standard Hex Cap: 1-1/2" Across Flats	610-678	450-500
	Heavy Duty Hex Cap: 1-3/4" Across Flats	882-949	650-700
15/16”	Heavy Duty Square Cap: 15/16" Across Flats	1017-1221	750-900
1-5/16”	Heavy Duty Cap: 1-3/4" Across Flats	1017-1221	750-900
CAST WHEELS			
5/8”	Rim Clamp Nut	217-237	160-175
3/4"	Rim Clamp Nut	258-285	190-210

DRY THREADS - NO LUBRICATION

Where excessive corrosion exists, a light coat of lubricant on first three threads of stud on bolt is permitted. Keep lubricant away from cap nut ball faces or ball seats of disc wheels and rim clamps of cast wheels.

By Order of the Secretary of the Army

CARL E. VUONO
General United States Army
Chief of Staff

Official:

WILLIAM J. MEEHAN, II
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:

To be distributed in accordance with DA Form 12-25A, Unit and Intermediate Direct Support and Intermediate General Support Maintenance requirements for Drilling Machine, Well, Combination Rotary/Percussion, Semitrailer Mounted, Diesel, 1500 Ft. MOdel CF-15-S

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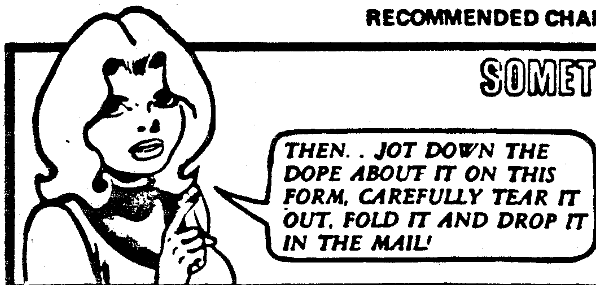
RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS



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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.

TEAR ALONG PERFORATED LINE

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 grams = .35 ounce
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3.38 fl. ounces
1 liter = 10 deciliters = 33.81 fl. ounces
1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	*To*	*Multiply by*
inches	centimeters	2.540
feet	meters	.305
yards	meters	.914
miles	kilometers	1.609
square inches	square centimeters	6.451
square feet	square meters	.093
square yards	square meters	.836
square miles	square kilometers	2.590
acres	square hectometers	.405
cubic feet	cubic meters	.028
cubic yards	cubic meters	.765
fluid ounces	milliliters	29,573
pints	liters	.473
quarts	liters	.946
gallons	liters	3.785
ounces	grams	28.349
pounds	kilograms	.454
short tons	metric tons	.907
pound-feet	newton-meters	1.356
pound-inches	newton-meters	.11296

To change	*To*	*Multiply by*
ounce-inches	newton-meters	.007062
centimeters	inches	.394
meters	feet	3.280
meters	yards	1.094
kilometers	miles	.621
square centimeters	square inches	.155
square meters	square feet	10.764
square meters	square yards	1.196
square kilometers	square miles	.386
square hectometers	acres	2.471
cubic meters	cubic feet	35.315
cubic meters	cubic yards	1.308
milliliters	fluid ounces	.034
liters	pints	2.113
liters	quarts	1.057
liters	gallons	.264
grams	ounces	.035
kilograms	pounds	2.205
metric tons	short tons	1.102

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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