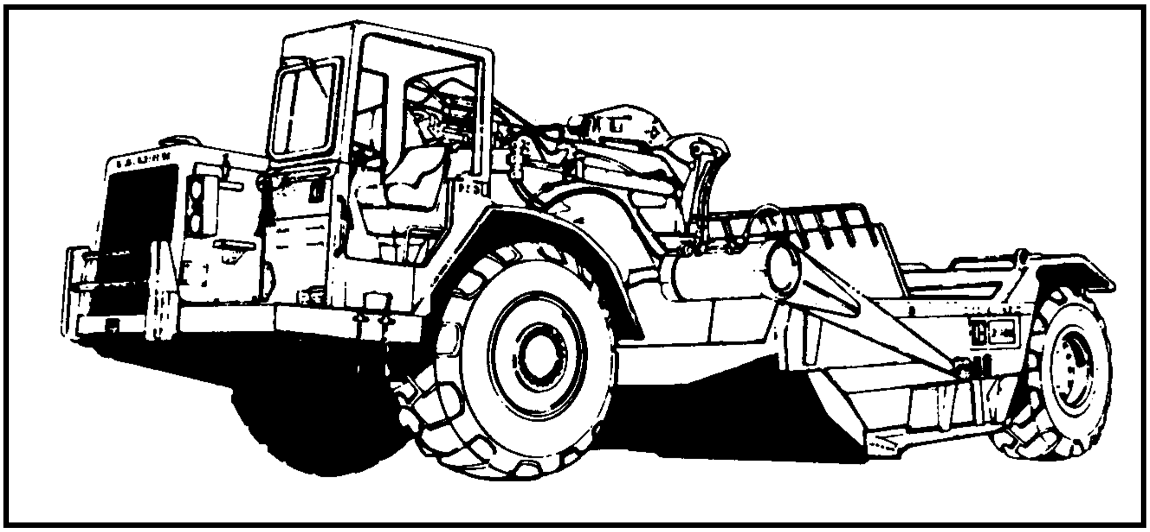
TECHNICAL MANUAL
FOR
SCRAPER, EARTH MOVING, MOTORIZED
DIESEL ENGINE DRIVEN
NSN 3805-01-153-1854



MAINTENANCE

HEADQUARTERS, DEPARTMENT OF THE ARMY
AUGUST 1985

⚠ WARNING

SAFETY

⚠ WARNING

The proper and safe lubrication and maintenance procedures for this machine, recommended by Caterpillar, are outlined in the Lubrication and Maintenance Guide for this machine.

Improper performance of lubrication or maintenance procedures is dangerous and could result in injury or death. Read and understand the LUBRICATION & MAINTENANCE GUIDE before performing any lubrication or maintenance.

The serviceman or mechanic may be unfamiliar with many of the systems on this machine. This makes it important to use caution when performing service work. A knowledge of the system and/or component is important before the removal or disassembly of any component.

Because of the size of some of the machine \components, the serviceman or mechanic should check the weights noted in the Manual. Use proper lifting procedures when removing any components.

Following is a list of basic precautions that should always be observed.

1. Read and understand all Warning plates and decals on the machine before operating, lubricating or repairing the machine.

2. Always wear protective glasses and protective shoes when working around machines. In particular, wear protective glasses when pounding on any part of the machine or its attachments with a hammer or sledge. Use welders gloves, hood/goggles, apron and other protective clothing appropriate to the welding job being performed. Do not wear loose-fitting or torn clothing. Remove all rings from fingers when working on machinery.

3. Disconnect battery and discharge any capacitors before starting to work on machine. Hang “Do Not Operate” tag in the Operator’s Compartment.

⚠ WARNING

Do not operate this machine unless you have read and understand the instructions in the OPERATOR’S GUIDE. Improper machine operation is dangerous and could result in injury or death.

4. If possible, make all repairs with the machine parked on a level, hard surface. Block machine so it does not roll while working on or under machine.

5. Do not work on any machine that is supported only by lift jacks or a hoist. Always use blocks or jack stands to support the machine before performing any disassembly.

6. Relieve all pressure in air, oil or water systems before any lines, fittings or related items are disconnected or removed. Always make sure all raised components are blocked correctly and be alert for possible pressure when disconnecting any device from a system that utilizes pressure.

7. Lower the bucket, blade, ripper or other implements to the ground before performing any work on the machine. If this cannot be done, make sure the buckets, blade, ripper, or other implement is blocked correctly to prevent it from dropping unexpectedly.

8. Use steps and grab handles when mounting or dismounting a machine. Clean any mud or debris from steps, walkways or work platforms before using. Always face machine when using steps, ladders and walkways. When it is not possible to use the designed access system, provide ladders, scaffolds,, or work platforms to perform safe repair operations.

9. To avoid back injury, use a hoist when lifting components which weigh 50 lb. (23 kg) or more. Make sure all chains hooks, slings, etc., are in good condition and are in the correct capacity. Be sure hooks are positioned correctly. Lifting eyes are not to be side loaded during a lifting operation.

WARNING

10. To avoid bums, be alert for hot parts on machines which have just been stopped and hot fluids in lines, tubes and compartments.

11. Be careful when removing cover plates. Gradually back off the last two bolts or nuts located at opposite ends of the cover or device and pry cover loose to relieve any spring or other pressure, before removing them completely.

12. Be careful when removing filler caps, breathers and plugs on the machines. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure. The danger is even greater if the machine has just been stopped because fluids can be hot.

13. Always use tools that are in good condition and be sure you understand how to use them before performing any service work.

14. Reinstall all fasteners with same part number. Do not use a lesser quality fastener if replacements are necessary.

15. Repairs which require welding should be performed only with the benefit of the appropriate reference information and by personnel adequately trained and knowledgeable in welding procedures. Make reference to "Techniques of Structural Repair Course" form number JEG03719. Determine type of metal being welded and select correct welding procedure and electrodes, rods or wire to provide a weld metal strength equivalent at least to that of parent metal.

16. Do not damage wiring during removal operations. Reinstall the wiring so it is not damaged nor will it be damaged in operation by contacting sharp corners, or by rubbing against some object or hot surface. Do not connect wiring to a line containing fluid.

17. Be sure all protective devices including guards and shields are properly installed and functioning correctly before starting a repair. If a guard or shield must be removed to perform the repair work, use extra caution.

18. Always use lift arm supports to keep bucket arms raised and bucket tilted down when maintenance or repair work is performed which requires the bucket in the raised position.

19. Loose or damaged fuel, lubricant and hydraulic lines, tubes and hoses can cause fires. Do not bend or strike high pressure lines or install ones which have been bent or damaged. Inspect lines, tubes and hoses carefully. Do not check for leaks with your hands. Pin hole (very small) leaks can result in a high velocity oil stream that will be invisible close to the hose. This oil can penetrate the skin and cause personal injury. Use cardboard or paper to locate pin hole leaks.

20. Tighten connections to the correct torque. Make sure that all heat shields, clamps and guards are installed correctly to avoid excessive heat, vibration or rubbing against other parts during operation. Shields that protect against oil spray onto hot exhaust components in event of a line, tube or seal failure must be installed correctly.

21. Do not operate a machine if any rotating part is damaged or contacts any other part during operation. Any high speed rotating component that has been damaged or altered should be checked for balance before reusing.

TECHNICAL MANUAL

NO. 5-3805-248-14&P-2

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC *19 Aug 1985*

TECHNICAL MANUAL
FOR
SCRAPER, EARTH MOVING, MOTORIZED
DIESEL ENGINE DRIVEN
NSN 3805-01-153-1854
MAINTENANCE

REPORTING OF ERRORS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms) or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Tank-Automotive Command, ATTN: AMSTA-MBP, WARREN, MI 48397-5000. A reply will be furnished direct to you.

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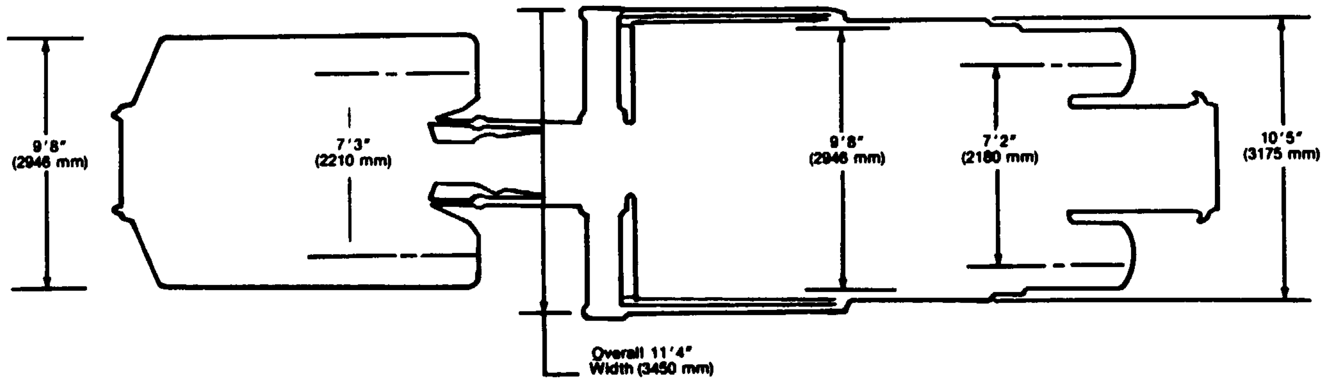
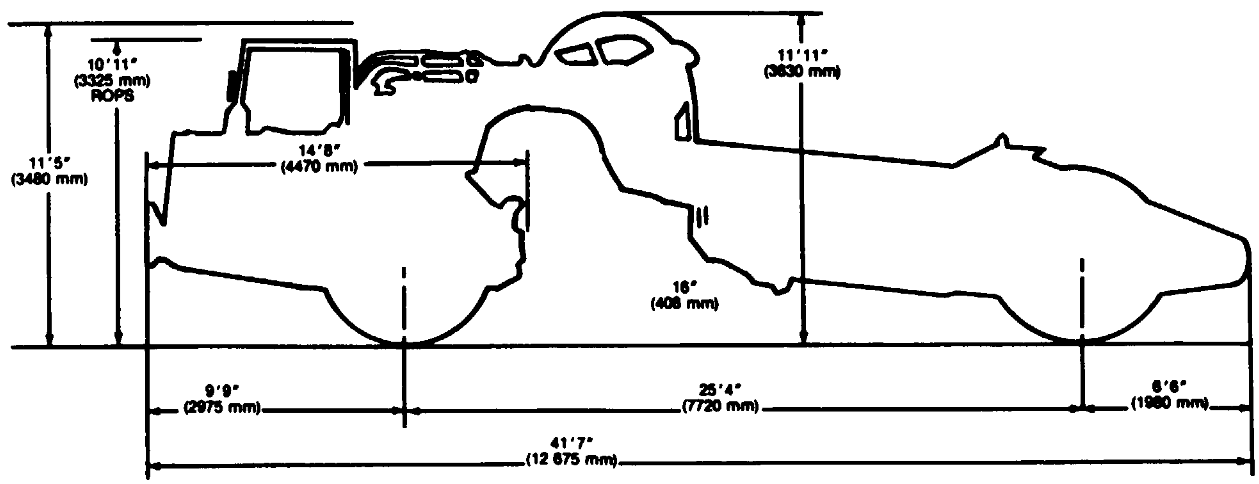
This technical manual is an authentication of the manufacturers commercial literature and does not conform with the format and content specified in AR 310-3, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of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


9'8"
(2946 mm)
7'3"
(2210 mm)
9'8"
(2946 mm)
7'2"
(2180 mm)
10'5"
(3175 mm)
Overall 11'4"
Width (3450 mm)


10'11"
(3325 mm)
ROPS
11'5"
(3480 mm)
14'8"
(4470 mm)
11'11"
(3630 mm)
16"
(406 mm)
9'9"
(2975 mm)
25'4"
(7720 mm)
6'6"
(1980 mm)
41'7"
(12 675 mm)

TECHNICAL DATA VEHICLE CHARACTERISTICS

1. NAME: SCRAPER, EARTH MOVING, MOTORIZED
2. DESIGN TYPE: WHEELED
3. WHEEL QUANTITY: 4
4. TIRE TYPE: PNEUMATIC
5. SCOOP OPERATION METHOD: HYDRAULIC
6. SCOOP CUT WIDTH: 119"/3022 mm
7. SCOOP MAXIMUM CUT DEPTH: 13.4"/340 mm
8. SCOOP STUCK CAPACITY: 14 cu. yds."/10.7 cu. m
9. SCOOP BOWL TYPE: OPEN
10. MAXIMUM SPREAD DEPTH: 18"/457 mm
11. HAULING GROUND CLEARANCE: 20.6"/523 mm
12. PRIME MOVER TYPE: DIESEL ENGINE
13. ENGINE MANUFACTURER'S NAME: CATERPILLAR TRACTOR CO.
14. ENGINE MODEL NUMBER: 3406
15. STEERING CONTROL METHOD: HYDRAULIC
16. VEHICULAR TURN RADIUS: 18'3" or 5.56 m
17. BOWL CAPACITY: 15.3 cu. m or 20 cu. yds.
18. MANUFACTURER'S MODEL NUMBER FOR THIS SCRAPER: 621B

INTRODUCTION

This publication has instructions and procedures for the subject on the front cover. The information and specifications in this publication are on the basis of information that was current at the time this issue was written.

Some photographs in this publication show details that may be different from your machine. Also, for some photographs, guards or covers may have been removed for illustrative purposes.

Correct operation, maintenance, test and repair procedures will give this product a long service life. Before starting a test, repair or rebuild job, the serviceman must read the respective chapters of the Service Manual, and know all the components he will work on.

Your safety, and the safety of others is at all times very important. When you see this symbol ⚠ in the manual, you must know that caution is needed for the procedure next to it. The symbol is a warning. To work safely, you must understand the job you do. Read all instructions to know what is safe and what is not safe.

It is very important to know the weight of parts. Do not lift heavy parts by hand. Use a hoist. Make sure heavy parts have good stability on the ground. A sudden fall can cause an accident. When lifting part of a machine, make sure the machine has blocks at front and rear. Never let the machine hang on a hoist, put blocks or stands under the weight.

When using a hoist, follow the recommendation in the manual. Use correct lift tools as shown in illustrations to get the correct balance of the component you lift. This makes your work safer at all times.

The specifications, torques, pressures of operation, measurements, adjustments, and other items can change at any time. These changes can effect the service given to the product. Get the complete and most current information before you start any job.

When the words "use again" are in the description, the specification given can be used to determine if a part can be used again. If the part is equal to or within the specification given, use the part again.

When the word "permissible" is in the description, the specification given is the "maximum or minimum" tolerance permitted before adjustment, repair and/or new parts are needed.

A comparison can be made between the measurements of a worn part, and the specifications of a new part to find the amount of wear. A part that is worn can be safe to use if an estimate of the remainder of its service life is good. If a short service life is expected, replace the part.

WARRANTY STATEMENT

The Caterpillar 621B Tractor-Scraper is warranted by Caterpillar Tractor Co. for 15 months or 1500 hours of operation, whichever occurs first. The warranty starts on the date found on the DA form 2408-9 in the log book. Report all defects in material or workmanship to your supervisor, who will take appropriate action through your organizational maintenance shop.

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PART TWO
POWER TRAIN

PART THREE
VEHICLE SYSTEMS

CHAPTER 1
ENGINE
SYSTEMS OPERATION, TESTING AND ADJUSTING

TORQUE SPECIFICATIONS: You will find instances in this publication where the manufacturer has used "Meter-Kilograms" or "Centimeter-Kilograms" In page of "Newton-Meters" for the metric torque. In these Instances, use the following conversion factors to obtain the metric torque in "Newton-Meters."

lb. ft. x 1.355819 = N•m
lb. in. x 0.1129848 - N•m

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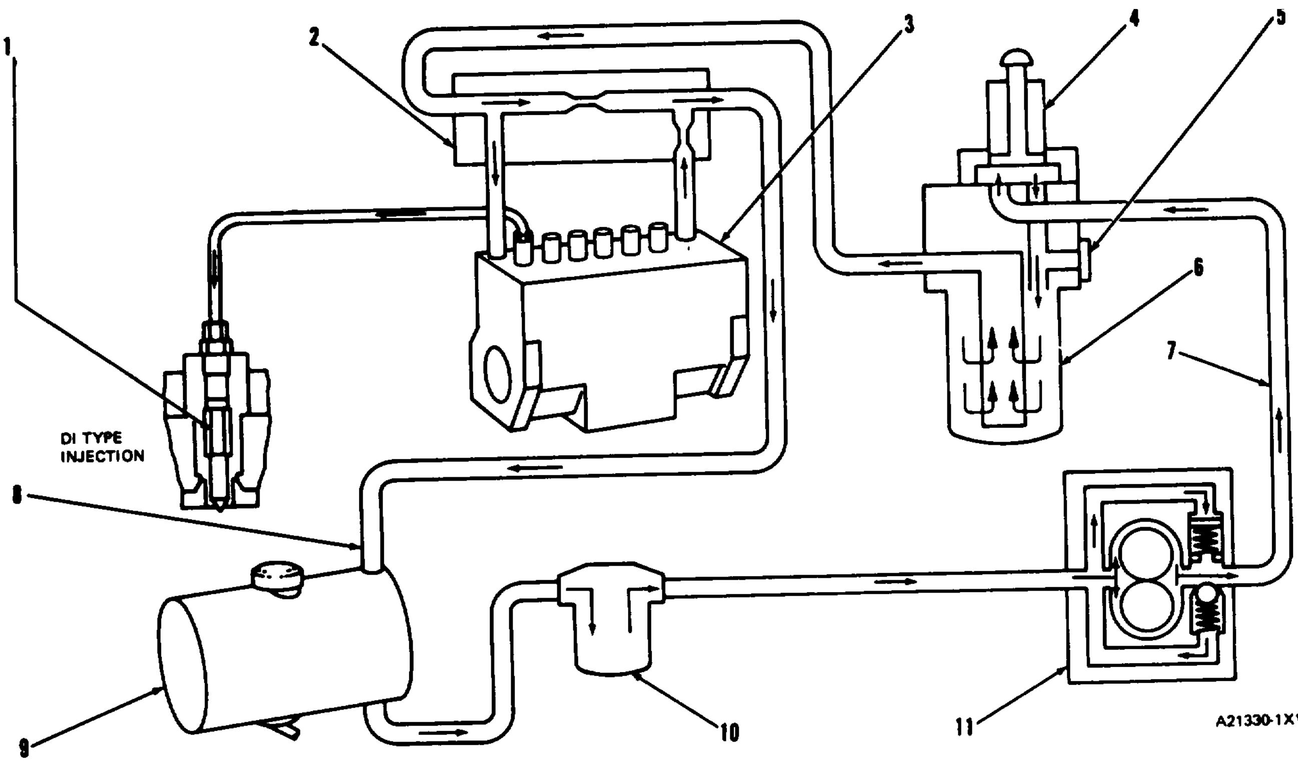
SYSTEM OPERATION

TESTING AND ADJUSTING

Page

FUEL SYSTEM



FUEL SYSTEM

1. Injection valve. 2. Anti-siphon block. 3. Injection pump housing. 4. Priming pump. 5. Plug. 6. Secondary filter. 7. Fuel line. 8. Return line to tank. 9. Fuel tank. 10. Primary filter. 11. Transfer pump.

This engine has a pressure type fuel system. There is a single injection pump and injection valve (1) for each cylinder. The injection pumps are in the pump housing (3) on the left side of the engine. The injection valves are in the precombustion chambers or adapters, under the valve cover.

The transfer pump (11) pulls fuel from the fuel tank (9) through the primary filter (10) and sends it through the base of the priming pump (4) and the secondary filter (6), through the anti-siphon block (2) and to the manifold of the injection pump housing. When priming pump (4) is not used, the position of fuel line (7) and plug (5) are reversed. The fuel in the manifold of the injection pump housing goes to the injection pumps. The injection pumps are in time with the engine and send fuel to the injection valves under high pressure.

Some of the fuel in the manifold is constantly sent back through the anti-siphon block (2) and through the return line (8) to the fuel tank to remove air from the system. Orifices in the anti-siphon block control the amount of fuel that goes back to the fuel tank.

The priming pump (4) is used to remove air from the fuel filter, fuel lines and components.

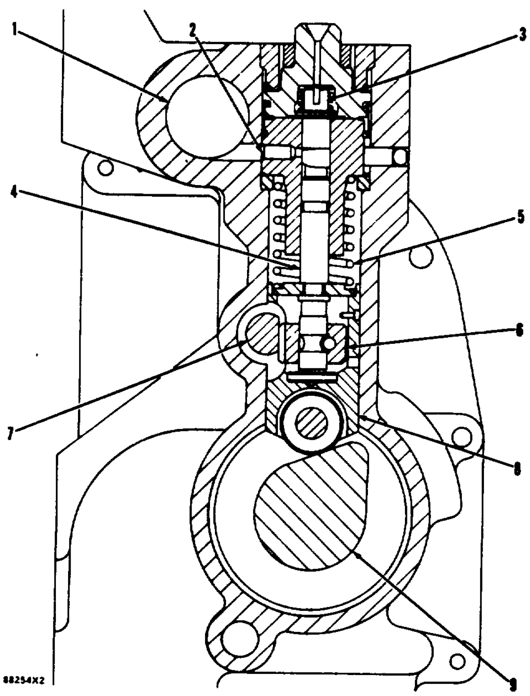
The transfer pump has a bypass valve and a check valve. The bypass valve (lower side) gives control to the pressure of the fuel. The extra fuel goes to the inlet of the pump.

FUEL INJECTION PUMP OPERATION

Injection pump plungers (4) and lifters (8) are lifted by cams on camshaft (9) and always make a full stroke. The force of springs (5) hold the lifters (8) against the cams of the camshaft.

Fuel from fuel manifold (1) goes through inlet passage (2) in the barrel and then into the chamber above plunger (4). During injection, the camshaft cam moves plunger (4) up in the barrel. This movement will close inlet passage (2) and push the fuel out through the fuel lines to the injection valves.

The amount of fuel sent to the injection valves is controlled by turning plunger (4) in the barrel. When the governor moves fuel rack (7), the fuel rack moves gear (6) that is fastened to the bottom of plunger (4).



CROSS SECTION OF THE HOUSING FOR THE FUEL INJECTION PUMPS

1. Fuel manifold. 2. Inlet passage in pump barrel. 3. Check valve. 4. Pump plunger. 5. Spring. 6. Gear. 7. Fuel rack. 8. Lifter. 9. Camshaft.

FUEL INJECTION VALVE

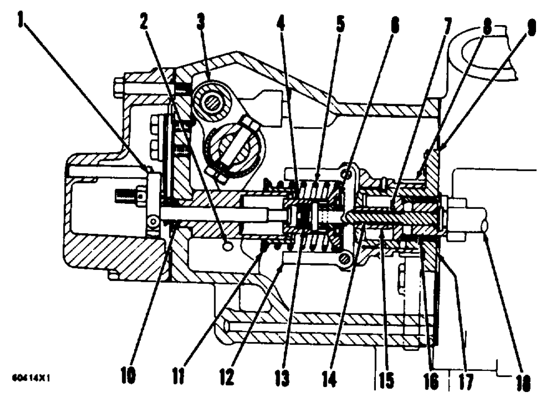
Fuel, under high pressure from the injection pumps, is sent through the injection lines to the injection valves. The injection valves change the fuel to the correct fuel characteristic (spray pattern) for good combustion in the cylinders.

The fuel injection valves are installed in an adapter. The adapters are installed in the cylinder heads.

HYDRA-MECHANICAL GOVERNOR

The accelerator pedal, or governor control, is connected to the control lever on the engine governor. The governor controls the amount of fuel needed to keep the desired engine rpm.

The governor has governor weights (12), driven by the engine, governor spring (5), valve (14) and piston (15). The valve and piston are connected to fuel rack (18). The pressure oil for the governor comes from the engine oil pump. Pressure oil goes through passage (17) and around sleeve (16). The accelerator pedal, or governor control, controls only the compression of governor spring (5). Compression of the spring always pushes to give more fuel to the engine. The centrifugal force (rotation) of governor weights (12) is always pulling to get a reduction of fuel to the engine. When these two forces are in balance, the engine runs at the desired rpm (governed rpm).



HYDRA-MECHANICAL GOVERNOR
(Typical Example Shown at Full Load Condition)

1. Collar. 2. Speed limiter plunger. 3. Lever assembly. 4. Seat. 5. Governor spring. 6. Thrust bearing. 7. Oil passage. 8. Drive gear (weight assembly). 9. Cylinder. 10. Bolt. 11. Spring seat. 12. Governor weights. 13. Spring. 14. Valve. 15. Piston. 16. Sleeve. 17. Oil passage. 18. Fuel rack.

Governor valve (14) is shown in the position when the force of the governor weights and the force of the governor spring are in balance.

When there is an increase in engine load, there will be a decrease in engine rpm and the rotation of governor weights (12) will get slower. (The governor weights will move toward each other.) Governor spring (5) moves valve (14) forward (toward the right in picture shown). When valve (14) moves forward, an oil passage around valve (14) opens to pressure oil. Oil now flows through passage (7) and fills the chamber behind piston (15) (the rear end of the valve stops oil flow through the rear of the cylinder, around the valve). This pressure oil pushes the piston and rack forward to give more fuel to the engine. Engine rpm goes up until the rotation of the governor weights is fast enough to be in balance with the force of the governor spring.

there is a reduction in engine load, there will be an increase in engine rpm and the rotation of governor weights (12) will get faster. This will move valve (14) backwards (toward the left in picture shown). This movement stops oil flow from the forward passage through piston (15) and allows the oil behind the piston to go out through a passage at the rear of the piston, around valve (14). Now, the pressure oil between sleeve (16) and piston (15) pushes the piston and fuel rack backwards. There is now a reduction in the amount of fuel to the engine. Engine rpm goes down until the centrifugal force (rotation) of the governor weights is in balance with the force of the governor spring. When these two forces are in balance, the engine will run at the desired rpm (governed rpm).

When engine rpm is at LOW IDLE, a spring-loaded plunger in lever assembly (3) comes in contact with a shoulder on the adjustment screw for low idle. To stop the engine, pull back on the governor control. This will let the spring-loaded plunger move over the shoulder on the low idle adjusting screw and move the fuel rack to the fuel closed position. With no fuel to the engine cylinders, the engine will stop.

After the engine has stopped, spring (13) moves valve (14) and piston (15) to the full load position. This moves the rack to full travel position and gives full fuel flow through the fuel injection pump when starting the engine.

Oil from the engine gives lubrication to the governor weight bearing. The other parts of the governor get lubrication from "splash-lubrication" (oil thrown by other parts). Oil from the governor runs back into the housing for the fuel injection pumps.

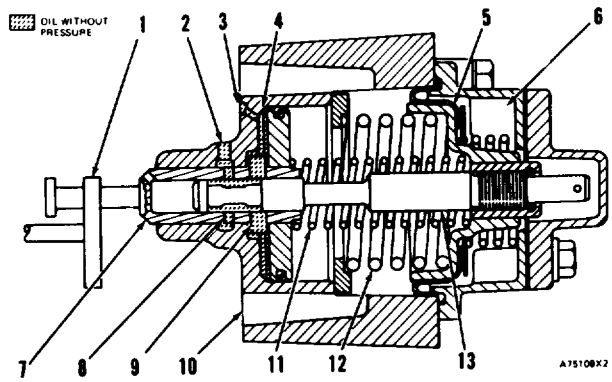
A small force from spring (13) moves fuel rack (18) to give a little more fuel for engine start. With the engine running, the rotation of governor weights (12) will put spring (13) in compression and cause fuel rack (18) to move back. (Spring (13) is extended only when the engine is stopped or at start.) When the engine is running, spring (13) is in compression.

HYDRAULIC AIR-FUEL RATIO CONTROL

The hydraulic air-fuel ratio control automatically controls the amount of travel of the fuel rack, in the FUEL-ON direction, until the air pressure in the inlet manifold is high enough to give complete combustion.

The hydraulically operated fuel ratio control has two valves (7 and 13). A hose assembly connects inlet air chamber (6) to the inlet manifold. Air pressure from the inlet manifold works against diaphragm (5) which moves valve (13) to control oil pressure against valve (7). Engine oil pressure works against valve (7) to control movement of the fuel rack.

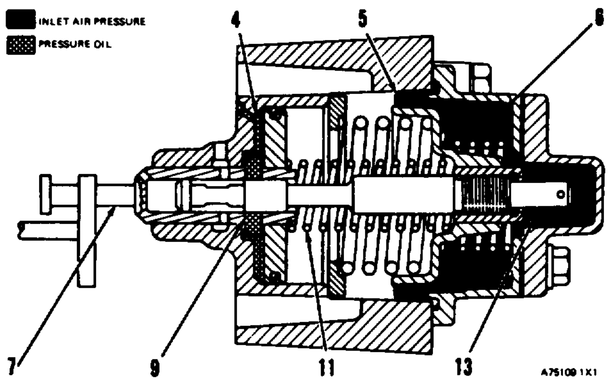
When the engine is stopped, there is no pressure on either of the valves. Springs (11 and 12) move both valves to the ends of their travel. In this position, there is no restriction to fuel rack movement. Also in this position, oil outlet passage (2) is open to let oil away from valve (7).



AIR-FUEL RATIO CONTROL (Engine Stopped)

1. Fuel rack linkage. 2. Oil outlet. 3. Oil inlet. 4. Pressure oil chamber. 5. Diaphram assembly. 6. Inlet air chamber. 7. Valve. 8. Small oil passages. 9. Large oil passages. 10. Oil drains. 11. Spring. 12. Spring. 13. Valve.

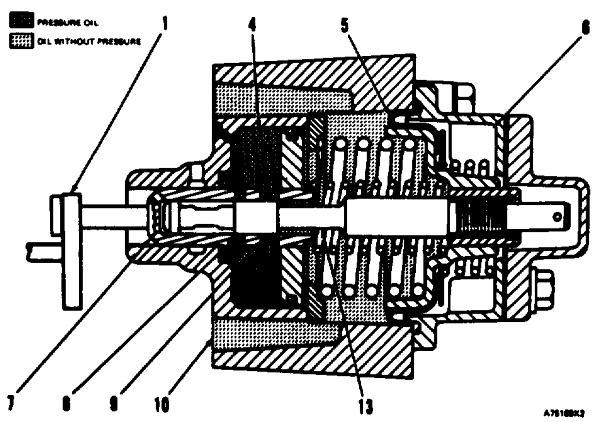
When the engine is started, engine oil flows through oil inlet (3) into pressure oil chamber (4), through large oil passages (9) to inside of valve (7), and out small oil passages (8) to oil outlet passage (2). Oil outlet passage (2) prevents oil pressure against valve (7) until air pressure from the inlet manifold is high enough to move valve (13) to close large oil passages (9). The control will not activate until there is some boost (inlet air pressure) available from the inlet manifold. This boost is made by the turbocharger when a load is applied during engine acceleration.



AIR-FUEL RATIO CONTROL (Engine Started)

4. Pressure oil chamber. 5. Diaphram assembly. 6. Inlet air chamber. 7. Valve. 9. Large oil passages. 11. Spring. 13. Valve.

As the inlet air pressure increases, it causes diaphragm assembly (5) to move left against spring (12). Valve (7), connected to diaphragm assembly (5), also moves left to close large oil passages (9). With these passages closed, chamber (4) is now charged with pressure oil, and valve (7) is pushed to the right against spring (1). The control is now activated, and will continue to operate until the engine is stopped. In the activated position, excess oil will go out pressure oil chamber (4) through large oil passages (9) past the land of valve (13) and then out through oil drains(10).

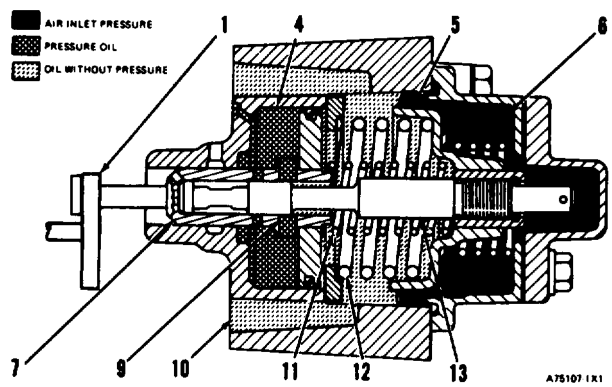


AIR-FUEL RATIO CONTROL (Control Activated)

1. Fuel rack linkage. 4. Pressure oil chamber. 5. Diaphram assembly. 6. Inlet air chamber. 7. Valve. 8. Small oil passages. 9. Large oil passages. 10. Oil drains. 13. Valve.

When the governor control is moved to increase fuel to the engine with the control activated, valve (7) limits the movement of fuel rack linkage (1) in the FUEL-ON direction. Charged oil pressure chamber (4) acts as a restriction to the movement of valve (7) until inlet air pressure increases.

As inlet air pressure increases, valve (7) moves to the left [away from springs (11 and 12)] and lets pressure oil from chamber (4) drain through large oil passages (9) past the land of valve (13), through inside of valve (7), and out through oil drains (10). This reduction of oil pressure behind the piston of valve (7) lets spring (12) move valve (7) to the left so that fuel rack linkage (1) can move gradually to increase fuel to the engine. The control is designed not to let the fuel increase until the air pressure in the inlet manifold is high enough for complete combustion. This prevents large amounts of black exhaust smoke caused by an air-fuel mixture with too much fuel.



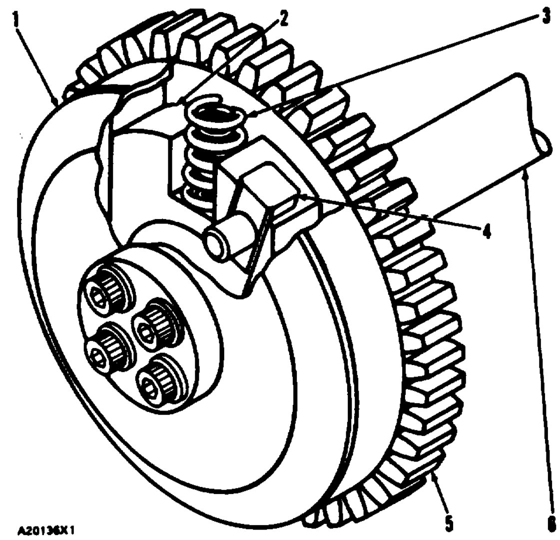
AIR-FUEL RATIO CONTROL (Engine Acceleration)

1. Fuel rack linkage. 4. Pressure oil chamber. 5. Diaphram assembly. 6. Inlet air chamber. 7. Valve. 9. Large oil passages. 10. Oil drains. 11. Spring. 12. Spring. 13. Valve.

These movements of the control take a very small amount of time. No change in engine acceleration (rate at which speed increases) can be felt.

AUTOMATIC TIMING ADVANCE UNIT

The automatic timing advance unit is installed on the front of the drive shaft (6) for the fuel injection pump and is gear driven through the timing gears. The drive gear (5) for the fuel injection pump is connected to the drive shaft for the fuel injection pump through a system of weights (2), springs (3), slides (4) and a flange (1). Two slides that are fastened to the flange fit into notches made on an angle in the weights. As centrifugal force (rotation) moves the weights outward against spring pressure, the movement of the notches in the weights causes the slides to make the flange turn through a small angle in relation to the gear. Since the flange is connected to the drive shaft for the fuel injection pump, the fuel injection timing is also changed. The automatic timing advance unit is held in place on the drive shaft (6) by four bolts.

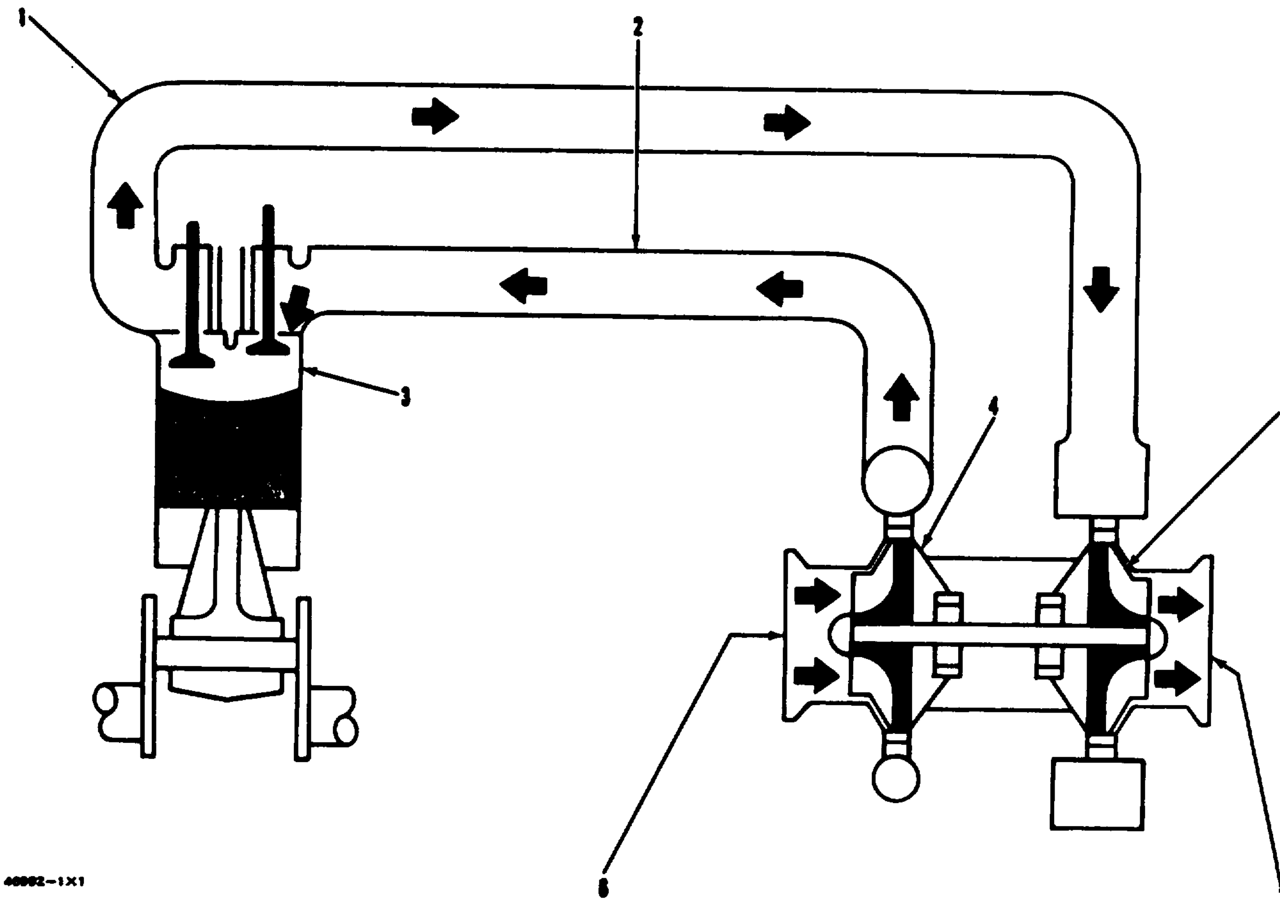


AUTOMATIC TIMING ADVANCE UNIT

1. Flange. 2. Weight. 3. Springs. 4. Slide. 5. Drive gear. 6. Drive shaft.

The unit advances the timing 2 1/40 between approximately low idle and I100 rpm. No adjustment can be made to the automatic timing advance units.

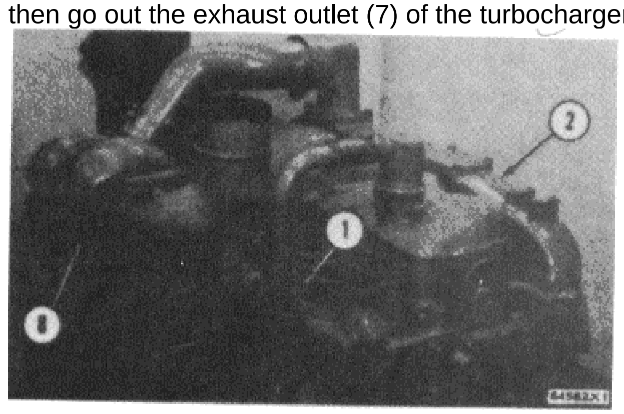
AIR INLET AND EXHAUST SYSTEM



AIR INLET AND EXHAUST SYSTEM
1. Exhaust manifold. 2. Inlet manifold. 3. Engine cylinder. 4. Turbocharger compressor wheel. 5. Turbocharger turbine wheel. 6. Air inlet. 7. Exhaust outlet.

The air inlet and exhaust system components are: air cleaner, inlet manifold, cylinder head, valves and valve system components, exhaust manifold, and turbocharger.

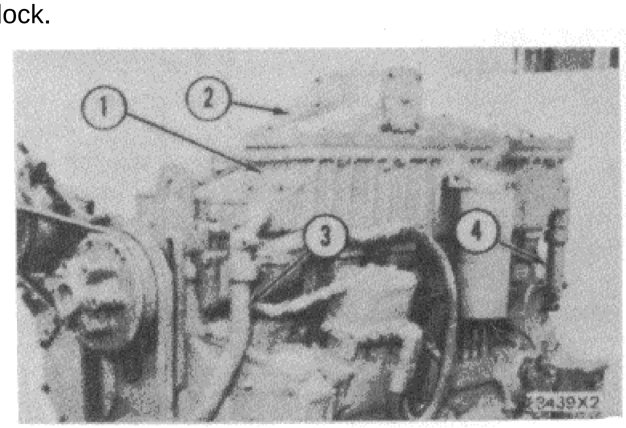
Clean inlet air from the air cleaner is pulled through the air inlet (6) of the turbocharger by the turning compressor wheel (4). The compressor wheel causes a compression of the air. The air then goes to the inlet manifold (2) of the engine. When the intake valves open, the air goes into the engine cylinder (3) and is mixed with the fuel for combustion. When the exhaust valves open, the exhaust gases go out of the engine cylinder and into the exhaust manifold (1). From the exhaust manifold, the exhaust gases go through the blades of the turbine wheel (5). This causes the turbine wheel and compressor wheel to turn. The exhaust gases then go out the exhaust outlet (7) of the turbocharger.



AIR INLET AND EXHAUST SYSTEM
1. Exhaust manifold. 2 Inlet manifold. a Turbocharger.

AFTERCOOLER

The aftercooler (1) has a coolant charged core assembly. Coolant from the water pump flows through coolant inlet (3) into the aftercooler. Coolant flows through the core assembly and out of the aftercooler through coolant outlet (4) into the rear of the cylinder block.



AIR INLET SYSTEM
1. Aftercooler. 2. Air inlet pipe. 3. Coolant inlet. 4. Coolant outlet.

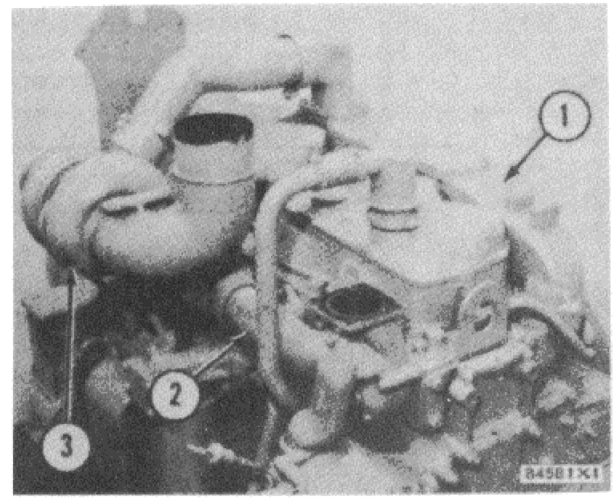
Inlet air from the compressor side of the turbocharger is forced into the aftercooler through air inlet pipe (2). The air passes over the core assembly which lowers the air temperature to approximately 2000 F (93° C). The cooler air goes out the bottom of the aftercooler into the cylinder head. The advantage of the cooler air is greater combustion efficiency.

TURBOCHARGER

The turbocharger (3) is installed on the center section of the exhaust manifold (2). All the exhaust gases from the engine go through the turbocharger.

The exhaust gases go through the blades of turbine wheel (6). This causes the turbine wheel and compressor wheel (5) to turn, which causes a compression of the inlet air.

When the load on the engine is increased, more fuel is put into the engine. This makes more exhaust gases and will cause the turbine and compressor wheels of the turbocharger to turn faster. As the turbocharger turns faster, it gives more inlet air and makes it possible for the engine to burn more fuel and will give the engine more power.

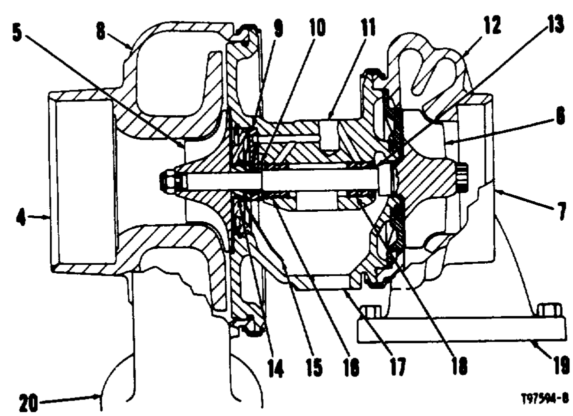


TURBOCHARGER
1. Inlet manifold. 2. Exhaust manifold. 3. Turbocharger.

Maximum rpm of the turbocharger is controlled by the rack setting, the high idle speed setting and the height above sea level at which the engine is operated.

CAUTION

If the high idle rpm or the rack setting is higher , than given in the FUEL SETTING INFORMATION (for the height above sea level at which the engine is operated), there can be damage to engine or turbocharger parts.



TURBOCHARGER
(Typical Example)

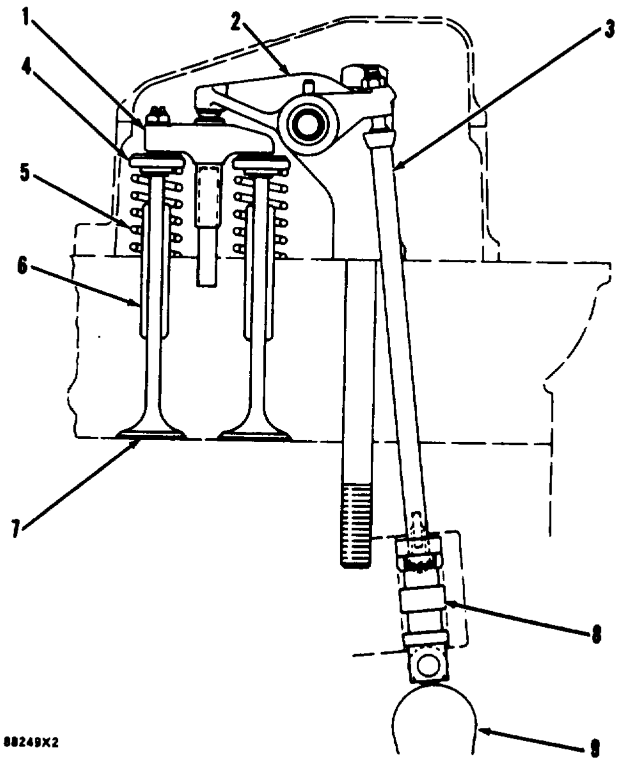
4. Air inlet. 5. Compressor wheel. 6. Turbine wheel. 7. Exhaust outlet. 8. Compressor housing. 9. Thrust bearing. 10. Sleeve. 11. Lubrication inlet port. 12. Turbine housing. 13. Sleeve. 14. Sleeve. 15. Oil deflector. 16. Bearing. 17. Oil outlet port. 18. Bearing. 19. Exhaust inlet. 20. Air outlet.

Bearings (16 and 18) for the turbocharger use engine oil under pressure for lubrication. The oil comes in through the oil inlet port (11) and goes through passages in the center section for lubrication of the bearings. Oil from the turbocharger goes out through the oil outlet port (17) in the bottom of the center section and goes back to the engine lubrication system.

The fuel rack adjustment is done at the factory for a specific engine application. The governor housing and turbocharger are sealed to prevent changes in the adjustment of the rack and the high idle speed setting.

VALVES AND VALVE SYSTEM COMPONENTS

The valves and valve system components control the flow of inlet air and exhaust gases into and out of the cylinder during engine operation.

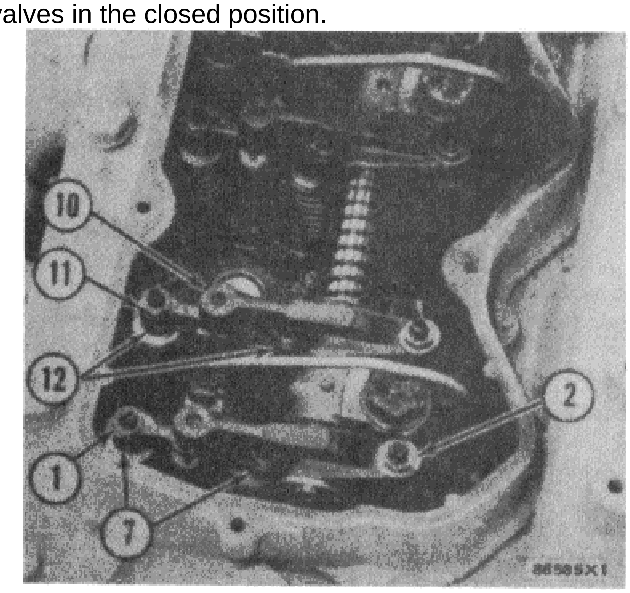


VALVE SYSTEM COMPONENTS

1. Intake bridge. 2. Intake rocker arm. 3. Push rod. 4. Rotocoil. 5. Valve spring. 6. Valve guide. 7. Intake valves. 8. Lifter. 9. Camshaft.

The intake and exhaust valves are opened and closed by movement of these components: crankshaft, camshaft, lifters, push rods, rocker arms, bridges and valve springs. Rotation of the crankshaft causes rotation of the camshaft. The camshaft gear is timed to, and driven by, a gear on the front of the crankshaft. As camshaft (9) turns, the cams of the camshaft also turn and cause lifters (8) to go up and down. This movement makes push rods (3) move rocker arms (2). Movement of the rocker arms will make intake and exhaust bridges (1 and 11) move up and down on dowels mounted in the cylinder head.

These bridges let one rocker arm operate two valves (intake or exhaust) for each cylinder. There are two intake and two exhaust valves in each cylinder. Movement of the bridges will make the intake and exhaust valves in the cylinder head open and close according to the firing order (injection sequence) of the engine. One valve spring (5) for each valve holds the valves in the closed position.

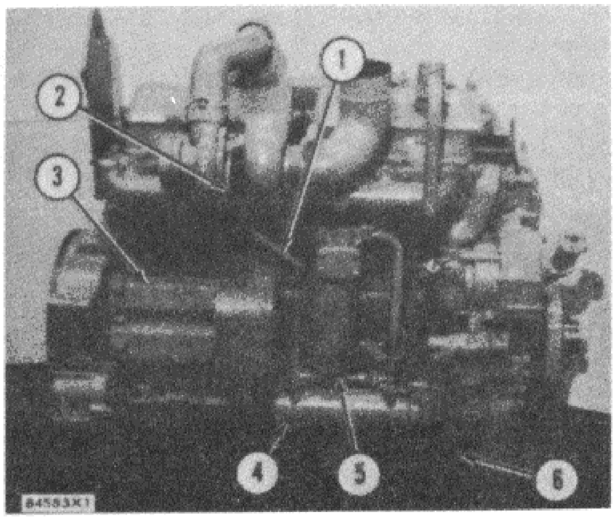


VALVE SYSTEM COMPONENTS

1. Intake bridge. 2. Intake rocker arm. 7. Intake valves. 10. Exhaust rocker arm. 11. Exhaust bridge. 12. Exhaust valve.

Rotocoil assemblies (4) cause the valves to have rotation while the engine is running. This rotation of the valves keeps the deposit of carbon on the valves to a minimum and gives the valves longer service life.

LUBRICATION SYSTEM



LUBRICATION SYSTEM COMPONENTS

1. Oil return line from turbocharger. 2 Oil supply line to turbocharger. 3 Oil manifold in cylinder block. 4. Oil cooler. 5. Oil filter. 8. Oil pan.

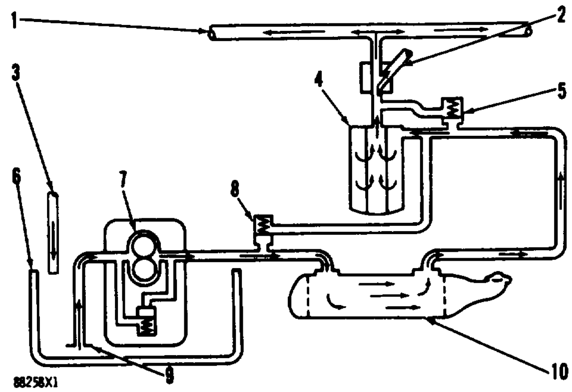
The lubrication system has the following components: oil pan, oil pump, oil cooler, oil filter, oil lines to and from the turbocharger and oil passages in the cylinder block.

OIL FLOW THROUGH THE OIL FILTER AND OIL COOLER

With the engine warm (normal operation), oil comes from the oil pan (6) through the suction bell (9) to the oil pump (7). The oil pump sends warm oil to the oil cooler (10) and then to the oil filter (4). From the oil filter, oil is sent to the oil manifold (1) in the cylinder block and to the oil supply line (2) for the turbocharger. Oil from the turbocharger goes back through the oil return line (3) to the oil pan.

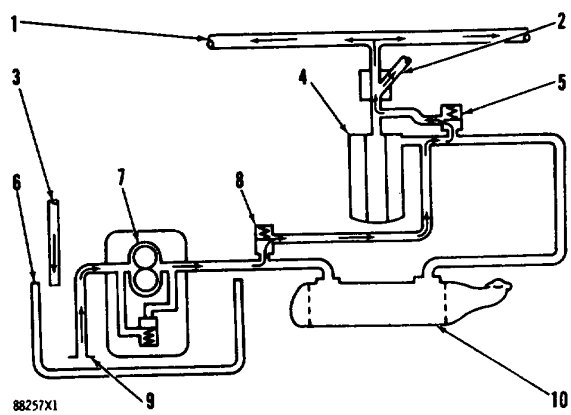
With the engine cold (starting conditions), oil comes from the oil pan (6) through the suction bell (9) to the oil pump (7). When the oil is cold, an oil pressure difference in bypass valves (5) and (8) will cause the bypass valves to open. These bypass valves give immediate lubrication to all components when cold oil with high viscosity causes a restriction to the oil flow through the oil cooler (10) and oil filter (4). The oil pump then sends the cold oil through the bypass valve (8) for the oil cooler and through the bypass valve (5) for the oil filter, to the oil manifold (1) in the cylinder block and to the supply line (2) for the turbocharger. Oil from the turbocharger goes back through the oil return line (3) to the oil pan.

When the oil gets warm, the pressure difference in the bypass valves decrease and the bypass valves close. Now there is a normal oil flow through the oil cooler and oil filter.



FLOW OF OIL (ENGINE WARM)

1. Oil manifold in cylinder block. 2. Oil supply line to turbocharger. 3. Oil return line from turbocharger. 4. Oil filter. 5. Bypass valve for the oil filter. 6. Oil pan. 7. Oil pump. 8. Bypass valve for the oil cooler. 9. Suction bell. 10. Oil cooler.

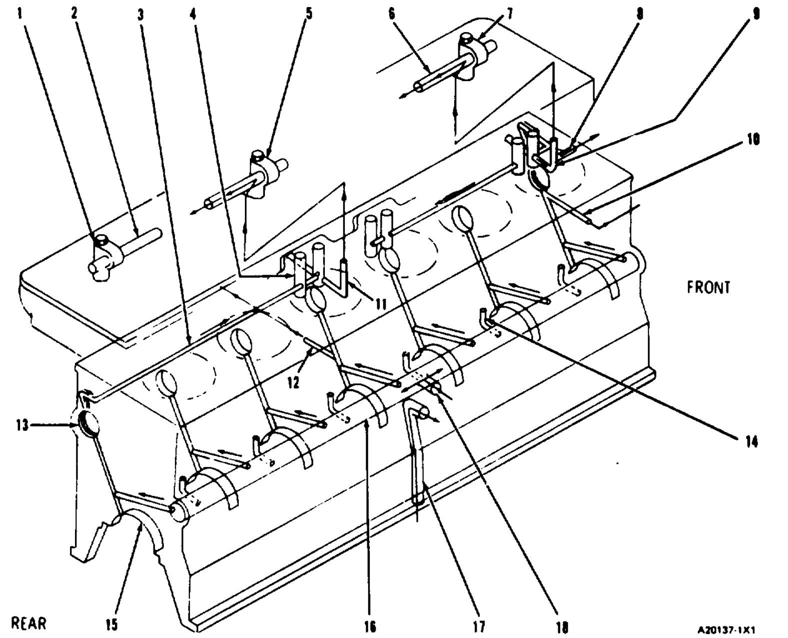


FLOW OF OIL (ENGINE COLD)

1. Oil manifold in cylinder block. 2. Oil supply line to turbocharger. 3. Oil return line from turbocharger. 4. Oil filter. 5. Bypass valve for the oil filter. 6. Oil pan. 7. Oil pump. 8. Bypass valve for the oil cooler. 9. Suction bell. 10. Oil cooler.

The bypass valves will also open when there is a restriction in the oil cooler or oil filter. This action does not let an oil cooler or oil filter with a restriction prevent the lubrication of the engine.

OIL FLOW IN THE ENGINE



ENGINE OIL FLOW SCHEMATIC

1. Bracket for rocker arm.
2. Rocker arm shaft.
3. Oil passage to lifters.
4. Valve lifter bore.
5. Oil supply rocker shaft bracket.
6. Rocker arm shaft.
7. Oil supply rocker shaft bracket.
8. Oil passage to accessory drive.
9. Oil passage to rocker shaft bracket.
10. Oil passage to idler gear shaft.
11. Oil passage to rocker shaft bracket.
12. Oil passage to the fuel injection pump and governor.
13. Camshaft bearing.
14. Oil jet tubes.
15. Main bearing.
16. Oil manifold.
17. Oil passage from the oil pump to the oil cooler and filter.
18. Oil passage from the oil cooler and filter.

From the oil manifold (16) in the cylinder block, oil is sent through drilled passages in the cylinder block that connect the main bearings (15) and the camshaft bearings (13). Oil goes through drilled holes in the crankshaft to give lubrication to the connecting rod bearings. A small amount of oil is sent through oil jet tubes (14) to make the pistons cooler. Oil goes through grooves in the bores for the front and rear camshaft bearings and then into oil passages (3) that connects the valve lifter bores (4). These passages give oil under pressure for the lubrication of the valve lifters.

Oil is sent from lifter bores (4) through passage (1) to an oil passage in bracket (5) (next to cylinder No. 4.) to supply pressure lubrication to rear rocker arm shaft (2). Oil is also sent from front lifter bore through passage (9) to an oil passage in front bracket (7) for front rocker arm shaft (6). Holes in the rocker arm shafts lets the oil give lubrication to the valve system components in the cylinder head.

The air compressor gets oil from passage (8) in the cylinder block, through passages in the timing gear housing and the accessory drive gear.

The idler gear gets oil from passage (10) in the cylinder block through a passage in the shaft for the idler gear installed on the front of the cylinder block.

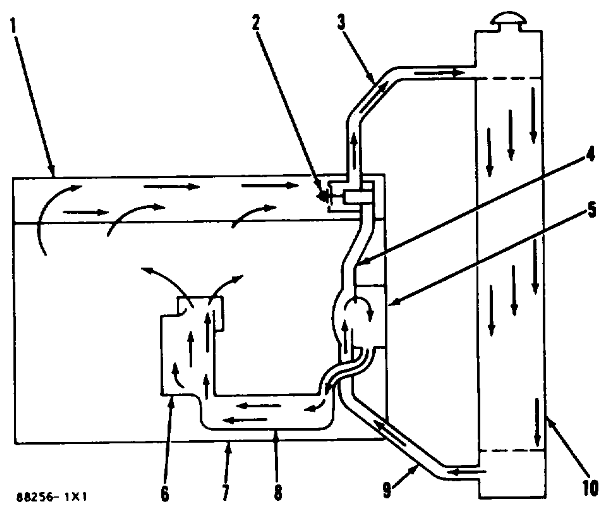
The fuel injection pump and governor gets oil from passage (12) in the cylinder block. The automatic timing advance unit gets oil from the fuel injection pump through the drive shaft for the fuel injection pump.

There is a pressure control valve in the oil pump. This valve controls the pressure of the oil coming from the oil pump. The oil pump can put more oil into the system than is needed. When there is more oil than needed, the oil pressure goes up and the valve will open. This allows the oil that is not needed to go back to the inlet oil passage of the oil pump.

After the lubricating oil has done its work, it goes back to the engine oil pan.

COOLING SYSTEM

This engine has a pressure type cooling system. A pressure type cooling system gives two advantages. The first advantage is that the cooling system can have safe operation at a temperature that is higher than the normal boiling (steam) point of water. The second advantage is that this type system prevents cavitation (the sudden making of low pressure bubbles in liquids by mechanical forces) in the water pump. With this type system, it is more difficult for an air or steam pocket to be made in the cooling system.



COOLING SYSTEM (ENGINE WARM)

1. Cylinder head. 2. Water temperature regulator. 3. Outlet hose. 4. Water elbow. 5. Water pump. 6. Transmission oil cooler. 7. Cylinder block. 8. Engine oil cooler. 9. Inlet hose. 10. Radiator.

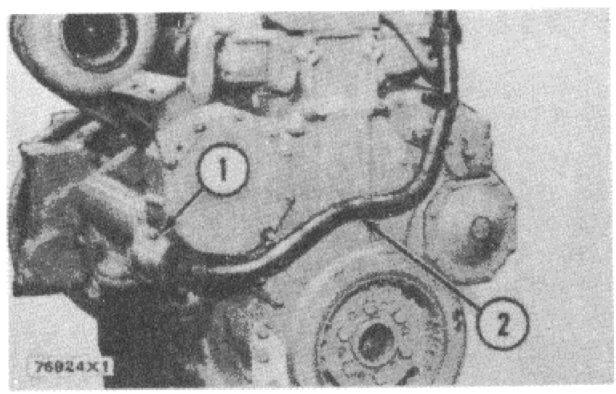
In normal operation (engine warm) the water pump (5) sends coolant through the engine oil cooler (8), the transmission oil cooler (6), and into the cylinder block (7). Coolant moves through the cylinder block into the cylinder head (1) and then goes to the housing for the temperature regulator (2). The temperature regulator is open and the coolant goes through the outlet hose (3) to the radiator (10). The coolant is made cooler as it moves through the radiator. When the coolant gets to the bottom of the radiator, it goes through the inlet hose (9) and into the water pump.

NOTE: The water temperature regulator (2) is an important part of the cooling system. If the water temperature regulator is not installed in the system, the coolant will not go through the radiator and overheating (engine runs too hot) will be the result.

When the engine is cold, the water temperature regulator (2) is closed, and the coolant is stopped from going to the radiator. The coolant goes from the housing for the temperature regulator back to the water pump (5) through water elbow (4).

ENGINE AFTERCOOLER

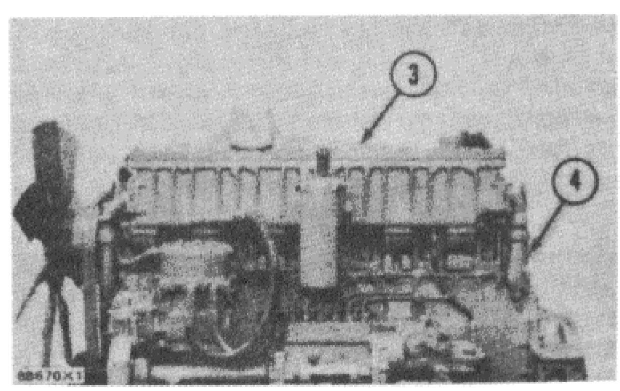
The flow of coolant is the same as the flow through engines that do not have an aftercooler with one addition. A small amount of coolant comes out of the bonnet (1) for the oil cooler and goes through tube (2) to the aftercooler (3). This coolant goes through the aftercooler and out elbow (4) and back into the cylinder block.



COOLANT FLOW TO AFTERCOOLER
(Typical Example)

1. Oil cooler bonnet. 2. Tube to aftercooler.

001

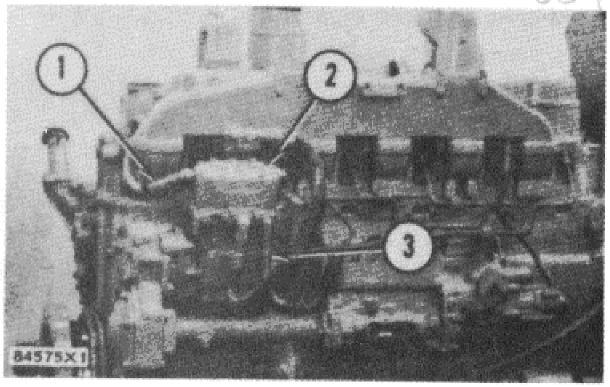


COOLANT FLOW FROM AFTERCOOLER
(Typical Example)

3. Aftercooler. 4. Elbow.

COOLANT FOR AIR COMPRESSOR

The coolant for the air compressor (2) comes from the cylinder block through hose (3) and into the air compressor. The coolant goes from the air compressor through hose (1) back into the front of the cylinder head.



COOLANT FLOW IN AIR COMPRESSOR
1. Outlet hose. 2. Air compressor. 3. Inlet hose.

COOLANT CONDITIONER

Some conditions of operation have been found to cause pitting (small holes in the metal surface) from corrosion or cavitation erosion (wear caused by air bubbles in the coolant) on the outer surface of the cylinder liners and the inner surface of the cylinder block next to the liners. The addition of a corrosion inhibitor (a chemical that gives a reduction of pitting) can keep this type of damage to a minimum.

The "spin-on" coolant conditioner elements, similar to the fuel filter and oil filter elements, fasten to a base that is mounted on the engine or is remote mounted. Coolant flows through lines from the water pump to the base and back to the block. There is a constant flow of coolant through the element.

The element has a specific amount of inhibitor for acceptable cooling system protection. As coolant flows through the element, the corrosion inhibitor, which is a dry material, dissolves (goes into solution) and mixes to the correct concentration. Two basic types of elements are used for the cooling system, and they are called the "PRECHARGE" and the "MAINTENANCE" elements. Each type of element has a specific use and must be used correctly to get the necessary concentration for cooling system protection.

The "PRECHARGE" element has more than the normal amount of inhibitor, and is used when a system is first filled with new coolant (unless Dowtherm 209 Antifreeze is used). This element has to add enough inhibitor to bring the complete cooling system up to the correct concentration.

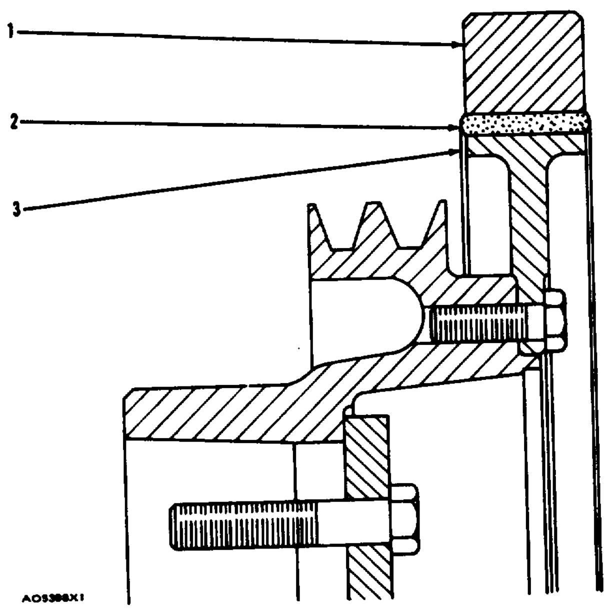
The "MAINTENANCE" elements have a normal amount of inhibitor and are installed at the first change interval and provide enough inhibitor to keep the corrosion protection at an acceptable level. After the first change period, only "MAINTENANCE" elements are installed at specified intervals to give protection to the cooling system.

If Dowtherm 209 Antifreeze is used when a cooling system is first filled with new coolant, only a "MAINTENANCE" element should be used. The "PRECHARGE" element is not necessary.

BASIC BLOCK

VIBRATION DAMPER

The twisting of the crankshaft, due to the regular power impacts along its length, is called twisting (torsional) vibration. The vibration damper is installed on the front end of the crankshaft. It is used for reduction of torsional vibrations and stops the vibration from building up to amounts that cause damage.



CROSS SECTION OF A VIBRATION DAMPER (Typical Example)

1. Flywheel ring. 2. Rubber ring. 3. Inner hub.

The damper is made of a flywheel ring (1) connected to an inner hub (3) by a rubber ring (2). The rubber makes a flexible coupling between the flywheel ring and the inner hub.

CRANKSHAFT

The crankshaft changes the combustion forces in the cylinder into usable rotating torque which powers the machine. There is a gear at the front of the crankshaft to drive the timing gears and the oil pump.

The crankshaft is supported by seven main bearings. Pressure oil is supplied to all bearing surfaces through drilled holes in the crankshaft.

Lip seals and wear sleeves are used at both ends of the crankshaft for easy replacement and a reduction of maintenance cost.

This engine uses a single, forged camshaft that is driven at the front end and is supported by seven bearings. Each lobe on the camshaft moves a roller follower, which in turn moves a push rod and two valves (either exhaust or intake) for each cylinder.

CYLINDER BLOCK AND LINERS

A steel spacer plate is used between the cylinder heads and the block to eliminate liner counterbore and to provide maximum liner flange support area (the liner flange sits directly on the cylinder block).

Engine coolant flows around the liners to cool them. Three O-ring seals at the bottom and a filler band at the top of each cylinder liner form a seal between the liner and the cylinder block.

PISTONS, RINGS AND CONNECTING RODS

The cast aluminum piston has three rings; two compression rings and one oil ring. All rings are located above the piston pin bore. The two compression rings are of the KEYSTONE type and seat in an iron band that is cast into the piston. KEYSTONE rings have a tapered shape and the movement of the rings in the piston groove (also of tapered shape) results in a constantly changing clearance (scrubbing action) between the ring and the groove. This action results in a reduction of carbon deposit and possible sticking of rings.

The oil ring is a standard (conventional) type and is spring loaded. Holes in the oil ring groove provide for the return of oil to the crankcase.

The direct injection piston has a full skirt aid uses a special shape (cardioid design) of the top surface to help combustion efficiency.

The full floating piston pin is retained by two snap rings which fit in grooves in the pin bore.

Oil spray tubes, located on the cylinder block main webs, direct oil to cool and lubricate the piston components and cylinder walls.

The electrical system can have three separate circuits: the charging circuit, the starting circuit and the low amperage circuit. Some of the electrical system components are used in more than one circuit. The batteries, circuit breaker, ammeter, cables and wires from the battery are all common in each of the circuits.

The charging circuit is in operation when the engine is running. An alternator makes electricity for the charging circuit. A voltage regulator in the circuit controls the electrical output to keep the battery at full charge.

The starting circuit is in operation only when the start switch is activated.

The low amperage circuit and the charging circuit are both connected through the ammeter. The starting circuit is not connected through the ammeter.

CHARGING SYSTEM COMPONENTS

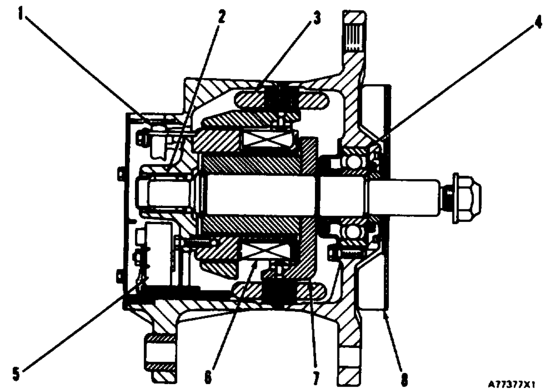
Alternator (Delco-Remy)

The alternator is driven by V-type belts from the crankshaft pulley. This alternator is a three phase, self-rectifying charging unit, and the regulator is part of the alternator.

This alternator design has no need for slip rings or brushes, and the only part that has movement is the rotor assembly. All conductors that carry current are stationary. The conductors are: the field winding, stator windings, six rectifying diodes, and the regulator circuit components.

The rotor assembly has many magnetic poles like fingers with air space between each opposite pole. The poles have residual magnetism (like permanent magnets) that produce a small amount of magnet-like lines of force (magnetic field) between the poles. As the rotor assembly begins to turn between the field winding and the stator windings, a small amount of alternating current (AC) is produced in the stator windings from the small magnetic lines-of force made by the residual magnetism of the poles. This AC current is changed to direct current (DC) when it passes through the diodes of the rectifier bridge. Most of this current goes to charge the battery and to supply the low amperage circuit, and the remainder is sent on to the field windings. The DC current flow through the field windings (wires around an iron core) now increases the strength of the magnetic lines of force. These stronger lines of force now increase the amount of AC current produced in the stator windings. The increased speed of assembly also increases the current and voltage output of the alternator.

The voltage regulator is a solid state (transistor, stationary parts) electronic switch. It feels the voltage in the system and switches on and off many times a second to control the field current (DC current to the field windings) for the alternator to make the needed voltage output.

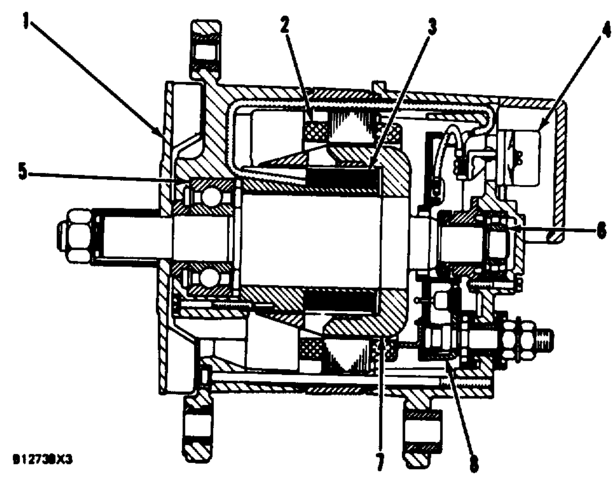


DELCO-REMY ALTERNATOR

1. Regulator. 2. Roller bearing. 3. Stator winding. 4. Ball bearing. 5. Rectifier bridge. 6. Field winding. 7. Rotor assembly. 8. Fan.

Alternator (Bosch)

The alternator is driven by V-type belts from the crankshaft pulley. This alternator is a three phase, self-rectifying charging unit, and the regulator is part of the alternator.



BOSCH ALTERNATOR

1. Fan. 2. Stator winding. 3. Field winding. 4. Regulator. 5. Ball bearing. 6. Roller bearing. 7. Rotor. 8. Rectifier assembly.

ELECTRICAL SYSTEM

This alternator design has no need for slip rings or brushes, and the only part that has movement is the rotor assembly. All conductors that carry current are stationary. The conductors are: the field winding, stator windings, six rectifying diodes, and the regulator circuit components.

The rotor assembly has many magnetic poles like fingers with air space between each opposite pole.
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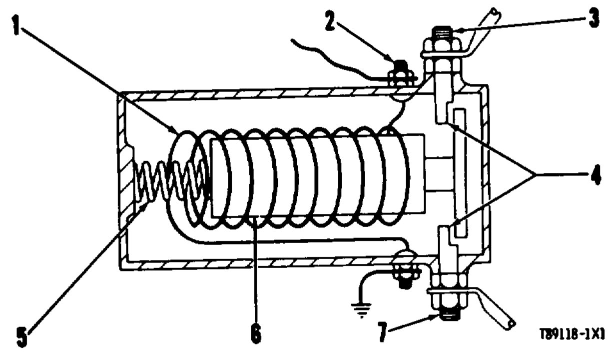
The voltage regulator is a solid state (transistor, stationary parts) electronic switch. It feels the voltage in the system and switches on and off many times a second to control the field current (DC current to the field windings) for the alternator to make the needed voltage output.

STARTING CIRCUIT COMPONENTS

Solenoid

A solenoid is a magnetic switch that uses low current to close a high current circuit. The solenoid has an electromagnet with a core (6) which moves.

There are contacts (4) on the end of core (6). The contacts are held in the open position by spring (5) that pushes core (6) from the magnetic center of coil (1). Low current will energize coil (1) and make a magnetic field. The magnetic field pulls core (6) to the center of coil (1) and the contacts close.

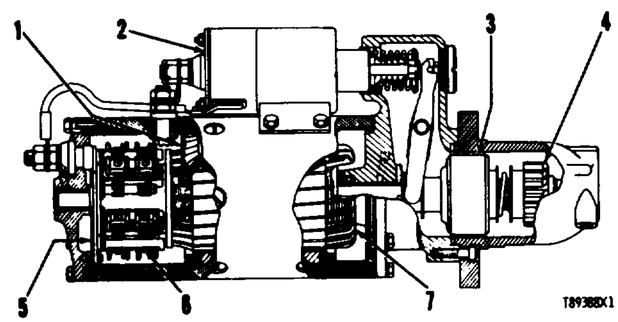


SCHEMATIC OF A SOLENOID

1. Coil. 2. Switch terminal. 3. Battery terminal. 4. Contacts. 5 Spring. 6. Core. 7. Component terminal.

Starter Motor

The starter motor is used to turn the engine flywheel fast enough to get the engine running.



STARTER MOTOR

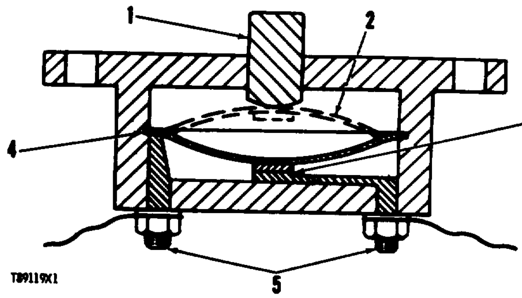
1. Field. 2. Solenoid. 3. Clutch. 4. Pinion. 5. Commutator. 6. Brush assembly. 7. Armature.

The starter motor has a solenoid. When the start switch is turned to the ON position, the solenoid will be activated electrically. The solenoid core will now move to push the starter pinion, by a mechanical linkage, to engage with the ring gear on the flywheel of the engine. The starter pinion will engage with the ring gear before the electric contacts in the solenoid close the circuit between the battery and the starter motor. When the circuit between the battery and the starter motor is complete, the pinion will turn the engine flywheel. A clutch gives protection for the starter motor so that the engine, when it starts to run, can not turn the starter motor too fast. When the start switch is released, the starter pinion will move away from the flywheel ring gear.

OTHER COMPONENTS

Circuit Breaker

The circuit breaker is a safety switch that opens the battery circuit if the current in the electrical system goes higher than the rating of the circuit breaker.



CIRCUIT BREAKER SCHEMATIC

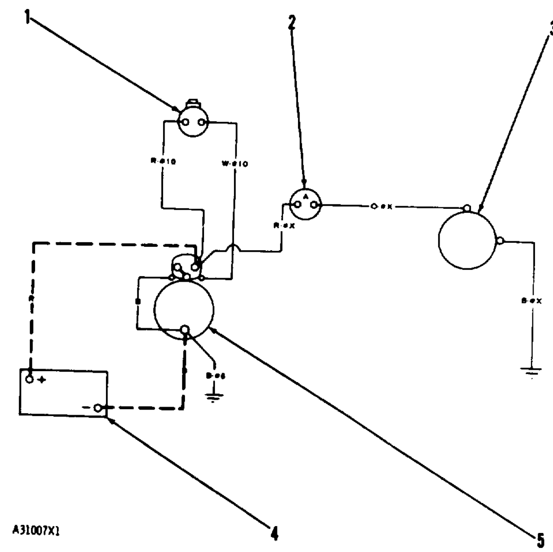
1. Reset button. 2. Disc in open position. 3. Contacts. 4. Disc. 5. Battery circuit terminals.

A heat activated metal disc with a contact point completes the electric circuit through the circuit breaker. If the current in the electrical system gets too high, it causes the metal disc to get hot. This heat causes a distortion of the metal disc which opens the contacts and breaks the circuit. A circuit breaker that is open can be reset after it cools. Push the reset button to close the contacts and reset the circuit breaker.

Fuel Pressure Switch

A fuel pressure switch is used in all systems with an external regulator. The switch prevents current discharge (field excitation) to alternator from the battery when the engine is not in operation. In systems where the regulator is part of the alternator, the transistor circuit prevents current discharge to the alternator and the fuel pressure switch is not required.

(Regulator Inside Alternator)



CHARGING SYSTEM WITH ELECTRIC STARTER MOTOR

1. Start switch. 2. Ammeter. 3. Alternator. 4. Battery. 5. Starter motor.

ELECTRICAL SYSTEM SCHEMATICS

The chart that follows gives the correct wire sizes and color codes for the electrical system wiring schematics.

COLOR CODE	MAXIMUM RECOMMENDED TOTAL BATTERY CABLE LENGTH		WIRES MARKED # X	
	CABLE SIZE	ELECTRIC STARTING	CHARGING UNIT OUTPUT	WIRE SIZE
B - Black W -White				
R - Red				
O-Orange			0-18 amps	#14
BR - Brown	0	24-32 VOLT	19-30 amps	#10
LTGN - Light Green	00	15.0 FEET	31-45 amps	#8
PU - Purple	000	18.0 FEET	46-65 amps	#6
W/B1 White with	0000	21.0 FEET	NUMBER FOLLOWING COLOR	
W/SJ Black Stripe		27.0 FEET	CODE IS	
X3560-1X1			RECOMMENDED WIRE SIZE	

TROUBLESHOOTING

Troubleshooting can be difficult. The TROUBLESHOOTING INDEX gives a list of possible problems. To make a repair to a problem, make reference to the cause and correction on the pages that follow.

This list of problems, causes and corrections will only give an indication of where a possible problem can be, and what repairs are needed. Normally, more or other repair work is needed beyond the recommendations in the list.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts. This list is only a guide and can not give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs.

TROUBLESHOOTING INDEX

Item	Problem	Item	Problem
1.	Engine Will Not Turn When Start Switch Is On	16.	Oil at the Exhaust.
2.	Engine Will Not Start	17.	Little or No Valve Clearance.
3.	Engine Misfires or Runs Rough	18.	Engine Has Early Wear.
4	Stall at Low rpm	19.	Coolant In Lubrication Oil.
5.	Sudden Changes In Engine rpm	20.	Too Much Black or Gray Smoke.
6.	Not Enough Power	21.	Too Much White or Blue Smoke.
7.	Too Much Vibration	22.	Engine Has Low Oil Pressure.
8.	Loud Combustion Noise	23.	Engine Uses Too Much Lubrication Oil.
9.	Valve Train Noise (Clicking)	24.	Engine Coolant Is Too Hot.
10.	Oil In Cooling System	25.	Exhaust Temperature Is Too High.
11.	Mechanical Noise (Knock) In Engine	26.	Starter Motor Does Not Turn.
12.	Fuel Consumption Too High	27.	Alternator Gives No Charge.
13.	Loud Valve Train Noise	28.	Alternator Charge Rate Is Low or Not Regular.
14.	Too Much Valve Lash	29.	Alternator Charge Rate is Too High.
15.	Valve Rotocoil or Spring Lock is Free	30.	Alternator Has Noise.
		31.	Rack Solenoid Does Not Stop Engine.

1. ENGINE CRANKSHAFT WILL NOT TURN WHEN START SWITCH IS ON

Cause	Correction
Battery Has Low Output	Make Reference to Item 26.
Wires or Switches Have Defect	Make Reference to Item 26.
Starter Motor Solenoid Has A Defect	Make Reference to Item 26.
Starter Motor Has A Defect.	Make Reference to Item 26.
Inside Problem Prevents Engine	If the crankshaft can not be turned after the drive equipment is Crankshaft From Turning disconnected, remove the fuel nozzles and check for fluid in the cylinders while the crankshaft is turned. If fluid in the cylinders is not the problem, the engine must be disassembled to check for other inside problems. Some of these inside problems are bearing seizure, piston seizure, wrong pistons installed in the engine and valves making contact with pistons.

2. ENGINE WILL NOT START

Cause	Correction
Starter Motor Turns Too Slow	Make Reference to Items 26 and 27.
Dirty Fuel Filter	Install new fuel filter.
Dirty or Broken Fuel Lines	Clean or install new fuel lines as necessary.
Fuel Transfer Pump	At starting rpm, the minimum fuel pressure from fuel transfer pump must be 5 psi (35 kPa). If fuel pressure is less than 5 psi (35 kPa), change the fuel filter element. Look for air in the fuel system. If fuel pressure is still low, install a new fuel transfer pump.
No Fuel To Cylinders	Put fuel in fuel tank. "Prime" (remove the air and/or low quality fuel) the fuel system.
Wrong Fuel Injecting Timing	Make adjustment to timing.
Bad Quality Fuel or Water in Fuel	Remove the fuel from the fuel tank and fuel system. Install a new fuel filter element. Put a good grade of the correct clean fuel in the fuel tank.

3. ENGINE MISFIRES OR RUNS ROUGH

Cause	Correction
Fuel Pressure is	Low Make sure there is fuel in the fuel tank. Look for leaks or bad bends in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system. On earlier fuel systems, look for sticking, bending or defective fuel bypass valve. Check the fuel pressure. The outlet pressure of the earlier fuel system transfer pump is 33 $\pm$ 5 psi (230 ± 35 kPa) at full load speed. The outlet pressure of the later scroll fuel system transfer pump should be between 25 and 42 psi (170 and 290 kPa) at full load speed.
Air in Fuel System	If fuel pressure is lower than 20 psi (140 kPa), install a new filter element. If fuel pressure is still low, install a new fuel transfer pump.
Find the air leak in the fuel system	If air is in the fuel system, it will probably get in on the suction side of and correct it fuel transfer pump.
Leak or Break in Fuel Line Between Injection Pump and Injection Valve	Install a new fuel line.
Wrong Valve Clearance	Make adjustment according to the Subject, VALVE CLEARANCE SETTING.

(Cont. next page)

3. ENGINE MISFIRES OR RUNS ROUGH (Cont.)

Cause	Correction
Defect in Fuel Injection Valve(s) or Injection Pump(s)	Run at rpm that causes engine to misfire the most or run the roughest. Then loosen a fuel injection line nut at the valve cover base for each cylinder, one at a time. Find the cylinder where a loosened s fuel line nut does not change the way the engine runs. Test the injection pump and injection valve for that cylinder. Install new parts where needed.
Wrong Fuel Injection Timing	Make adjustment to timing.
Bent or Broken Push Rod	Replacement of push rod is necessary.
Fuel Has "Cloud Point" Higher Than Atmospheric Temperature ("Cloud Point" = Temperature Which Makes Wax Form in Fuel)	Drain the fuel tank, lines and fuel injection pump housing. Change the fuel filter. Fill the tank with fuel which has the correct "cloud point" and remove the air from the system with the priming pump.
Bad Quality Fuel or Water in Fuel	Remove the fuel from the fuel tank and fuel system. Install a new fuel filter element. Put a good grade of the correct clean fuel in the fuel tank.

4. STALL AT LOW RPM

Cause	Correction
Fuel Pressure is Low	Make sure there is fuel in the fuel tank. Look for the leaks or bad bends in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system. On earlier fuel systems, look for sticking, bending or defective fuel bypass valve. Check the fuel pressure. The outlet pressure of the earlier fuel system transfer pump is 33 + 5 psi (230 + 35 kPa) at full load speed. The outlet pressure of the later scroll fuel system transfer pump should be between 25 and 42 psi (170 and 290 kPa) at full load speed. If fuel pressure is lower than 20 psi (140 kPa), install a new filter element. If fuel pressure is still low, install a new fuel transfer pump.
Idle rpm Too Low	Make adjustment to governor so idle rpm is the same as given in the FUEL SETTING INFORMATION.
Defect in Fuel Injection Valve(s)	Install a new fuel injection valve.
Engine Accessories	Check engine accessories for damage and correct adjustment. If necessary, disconnect the accessories and test the engine.
Defect in Fuel Injection Pump(s)	Install new parts if needed.

5. SUDDEN CHANGES IN ENGINE SPEED (rpm)

Cause	Correction
Failure of Governor or Fuel Injection Pump	Look for damaged or broken springs, linkage or other parts. Remove the governor. Check for free travel of the fuel rack. Be sure fuel injection pumps are installed correctly. Check for correct governor spring. Install new parts for those that have damage or defects.

6. NOT ENOUGH POWER

Cause	Correction
Bad Quality Fuel or Water in Fuel	Remove the fuel from the fuel tank and fuel system. Install a new fuel filter element. Put a good grade of the correct clean fuel in the fuel tank.
Fuel Pressure is Low	Make sure there is fuel in the fuel tank. Look for leaks or bad bends in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system. On earlier fuel systems, look for sticking, bending or defective fuel bypass valve. Check the fuel pressure. The outlet pressure of the earlier fuel system transfer pump is 33 ± 5 psi (230 ± 35 kPa) at full load speed. The outlet pressure of the later scroll fuel system transfer pump should be between 25 and 42 psi (170 and 290 kPa) at full load speed. If fuel pressure is lower than 20 psi (140 kPa), install a new fuel filter element. If fuel pressure is still low, install a new fuel transfer pump.
Leaks in Air Inlet System	Check the pressure in the air inlet manifold. Look for restrictions in the air cleaner.
Governor Linkage	Make adjustment to get full travel of linkage. Install new parts for those that have damage or defects.
Wrong Valve Clearance	Make adjustment according to the Subject, VALVE CLEARANCE SETTING.
High Exhaust Back Pressure	Check the exhaust system for restrictions.
Defect in Fuel Injection Valve(s) or Fuel Injection Pump(s)	Run at rpm that causes engine to misfire the most or run the roughest. Then loosen a fuel line nut on the injection pump for each cylinder, one at a time. Find the cylinder where a loosened fuel line nut does not change the way the engine runs. Test the injection pump and injection valve for that cylinder. Install new parts where needed.
Wrong Fuel Injection Timing	Make adjustment to timing.
Rack Setting Too Low	Make reference to the FUEL SETTING INFORMATION.
Air-Fuel Ratio Control	Control either needs an adjustment or it is damaged and a new control is needed.
Turbocharger Has Carbon De-	Inspect and repair turbocharger as necessary. posit or Other Causes of Friction

7. TOO MUCH VIBRATION

Cause	Correction
Loose Bolt or Nut for Pulley or Damper	Tighten bolt or nut.
Pulley or Damper Has A Defect	Install a new pulley or damper.
Engine Supports Are Loose, Worn, or Have A Defect	Tighten all bolts that hold engine supports. Install new components if necessary.
Engine Misfires or Runs Rough	Make Reference to Item 3.
Fan Blade Not in Balance	Loosen or remove fan belts and operate engine for a short time at the rpm that the vibration was present. If vibration is not still present, make a replacement of the fan assembly.

8. LOUD COMBUSTION NOISE (SOUND)

Cause	Correction
Bad Quality Fuel	Remove the fuel from the tank. Install a new fuel filter element. Put a good grade of clean fuel in the fuel tank.
Defect in Fuel Injection Valve(s)	Install new fuel injection valve(s).
Defect in Fuel Injection Pump(s)	Install new fuel injection pump(s).
Wrong Fuel Injection Timing	Make adjustment to timing.

9. VALVE TRAIN NOISE (CLICKING)

Cause	Correction
Damage to Valve Spring(s), Locks, or Broken or Worn Valve Lifter	Install new parts where necessary. Broken locks can cause the valve to get into the cylinder. This will cause much damage.
Not Enough Lubrication	Check lubrication in valve compartment. There must be a strong flow of oil at engine high rpm, but only a small flow of oil at low rpm. Oil passages must be clean, especially those that send oil to the cylinder head.
Too Much Valve Clearance	Make adjustment according to the Subject, VALVE CLEARANCE SETTING.

10. OIL IN COOLING SYSTEM

Cause	Correction
Defect In Core of Engine Oil Cooler or Transmission Oil Cooler	Install a new engine oil cooler or transmission oil cooler. Drain and flush cooling system and refill with new coolant.
Defect in Spacer Plate Gasket	Install new spacer plate gasket.
Failure of Cylinder Head Gasket	Install a new head gasket.

11. MECHANICAL NOISE (KNOCK) IN ENGINE

Cause	Correction
Failure of Bearing For Connecting Rod	Inspect the bearing for the connecting rod and the bearing surface (journal) on the crankshaft. Install new parts where necessary.
Damaged Timing Gears	Install new parts where necessary.
Damaged Crankshaft	Make replacement of the crankshaft.
Defect in Attachment	Repair or install new components.

12. FUEL CONSUMPTION TOO HIGH

Cause	Correction
Wrong or Poor Quality Fuel	Remove the fuel from the fuel tank and fuel system. Install a new fuel filter element. Put a good grade of the correct clean fuel in the fuel tank.
Fuel System Leaks	Large changes in fuel consumption may be the result. Inside leaks probably will cause low engine oil pressure and an increase in oil level in the engine. Tighten loose connections or make a replacement of the component that leaks.
Fuel and Combustion Noise (Knock)	Make Reference to Items 3 and 6.
Wrong Fuel Injection Timing	Make adjustment to timing.

13. LOUD VALVE TRAIN NOISE

Cause	Correction
Damage to Valve Spring(s)	Make replacement of parts with damage.
Damage to Camshaft	Make replacement of parts with damage. Clean engine thoroughly. If replacement of camshaft is made, new valve lifters are also necessary.
Damage to Valve Lifter	Clean engine thoroughly. Make a replacement of the damaged valve lifters. Inspect camshaft cams (lobes) for damage. Look for valves that do not move freely. Make an adjustment to valve clearance according to the Subject, VALVE CLEARANCE SETTING.
Damage to Bridge for Valves or Bridge Dowel	Make a replacement of the bridge and/or bridge dowel, and adjust as necessary.

14. TOO MUCH VALVE LASH

Cause	Correction
Not Enough Lubrication	Check lubrication in valve compartment. There must be a strong flow of oil at engine high rpm, but only a small flow at low rpm. Oil passages must be clean, especially those that send oil to the cylinder head.
Rocker Arm Worn at Face That Makes Contact With Bridge	If there is too much wear, install new parts or rocker arms. Make adjustment of valve clearance according to the Subject, VALVE CLEARANCE SETTING.
Bridge or Bridge Dowel for Valves Worn	Make replacement of the bridge and/or bridge dowel, and adjust as necessary.
End of Valve Stem Worn	If there is too much wear, install new valves. Make adjustment to valve clearance according to the Subject, VALVE CLEARANCE SETTING.
Worn Push Rods	If there is too much wear, install new push rods. Make adjustment of valve clearance according to the Subject, VALVE CLEARANCE SETTING.
Broken or Worn Valve Lifters	Install new valve lifters. Check camshaft for wear. Check for free movement of valves or bent valve stem. Clean engine thoroughly. Make adjustment of valve clearance according to the Subject, VALVE CLEARANCE SETTING.
Worn Cams (Lobes) on Camshaft	Install a new camshaft. Install new valve lifters if damaged. Check for free movement of valves or bent valve stems. Make adjustment of valve clearance according to the Subject, VALVE CLEARANCE SETTING.

15. VALVE ROTOCOIL OR SPRING LOCK IS FREE

Cause	Correction
Broken Locks	Broken locks can cause the valve to get into the cylinder. This will cause much damage.
Broken Valve Spring(s)	Install new valve spring(s).
Broken Valve	Replace valve and other damaged parts.

16. OIL AT THE EXHAUST

Cause	Correction
Too Much Oil in the Valve Compartment	Look at both ends of the rocker arm shaft. Be sure a plug is in each end of the shaft.
Worn Valve Guides	Reconditioning of the cylinder head is needed.
Worn Piston Rings	Inspect and install new parts as needed.

17. LITTLE OR NO VALVE CLEARANCE

Cause	Correction
Worn Valve Seat or Face of Valve	Reconditioning of cylinder head is needed. Make adjustment of valve clearance according to the Subject, VALVE CLEARANCE SETTING.

18. ENGINE HAS EARLY WEAR

Cause	Correction
Dirt in Lubrication Oil	Remove dirty lubrication oil. Install new oil filter elements. Put clean oil in the engine.
Air Inlet Leaks	Inspect all gaskets and connections. Make repairs if leaks are found.
Fuel Leakage Into Lubrication Oil	This will cause high fuel consumption and low engine oil pressure. Make repairs if leaks are found. Install new parts where needed.

19. COOLANT IN LUBRICATION OIL

Cause	Correction
Failure of Engine Oil Cooler Core	Install a new engine oil cooler. Drain crankcase and refill with clean engine oil. Install new oil filter elements.
Failure of Cylinder Head Gasket or Water Seals	Check cylinder liner projection. Install a new spacer plate gasket and new water seals in the spacer plate. Install a new cylinder head gasket. Tighten the bolts that hold the cylinder head according to the Specifications.
Crack or Defect in Cylinder Head	Install a new cylinder head.
Crack or Defect in Cylinder Block	Install a new cylinder block.
Failure of Liner Seals	Replace seals.
Crack or Defect in Cartridge of Turbocharger	Install a new turbocharger cartridge.

20. TOO MUCH BLACK OR GRAY SMOKE

Cause	Correction
Not Enough Air For Combustion	Check air cleaner for restrictions.
Bad Fuel Injection Valve(s)	Install new fuel injection valve(s).
Wrong Fuel Injection Timing	Make adjustment to timing.
Defect in Fuel Ratio Control	Make adjustment to or install new control.

21. TOO MUCH WHITE OR BLUE SMOKE

Cause	Correction
Too Much Lubrication Oil in Engine	Remove extra oil. Find where extra oil comes from. Put correct amount of oil in engine.
Engine Misfires or Runs Rough	Make Reference to Item 3.
Wrong Fuel Injection Timing	Make adjustment to timing.
Worn Valve Guides	Reconditioning of cylinder head is necessary.
Worn Piston Rings	Install new piston rings. Check condition of cylinder liners.
Failure of Turbocharger Oil Seal	Check inlet manifold for oil. Replace seals and repair turbocharger if necessary.

Coolant in Combustion System Check for cracked head.

22. ENGINE HAS LOW OIL PRESSURE

Cause	Correction
Dirty Oil Filter or Oil Cooler	Check the operation of bypass valve for the filter. Install new oil filter elements if needed. Clean or install new oil cooler core. Remove dirty oil from engine. Put clean oil in engine.
Diesel Fuel In Lubrication Oil	Find the place where diesel fuel gets into the lubrication oil. Make repairs as needed. Remove the lubrication oil that has diesel fuel in it. Install new oil filter elements. Put clean oil in the engine.
Too Much Clearance Between Rocker Arm Shaft and Rocker Arms	Check lubrication in valve compartment. Install new parts as necessary.
Oil Pump Suction Pipe Has A Defect	Replacement of pipe is necessary.
Relief Valve for Oil Pump Does Not Operate Correctly	Clean valve and housing. Install new parts as necessary.
Oil Pump Is Worn or Has A Defect	Repair or make replacement of necessary parts.
Too Much Clearance Between Crankshaft and Crankshaft Bearings	Check the clearance between the crankshaft and the rod bearings and the main bearings. Install new parts as necessary.
Too Much Clearance Between Camshaft and Camshaft Bearings.	Install new camshaft bearings. Install new camshaft if necessary.
Defect in Oil Pressure Gauge	Install new gauge.
Too Much Bearing Clearance for Idler Gear	Inspect bearings and make replacement as necessary.

23. ENGINE USES TOO MUCH LUBRICATION OIL

Cause	Correction
Too Much Lubrication Oil in Engine	Remove extra oil. Find where extra oil comes from. Put correct amount of oil in engine.
Oil Leaks	Find all oil leaks. Make repairs as necessary.
Oil Temperature is Too High	Check operation of engine oil cooler. Clean the core of the engine oil cooler. Install new parts if necessary.
Too Much, Oil in the Valve Compartment	Look at both ends of the rocker arm shaft. Be sure a plug is in each end of the shaft.

(Cont. next page)

23. ENGINE USES TOO MUCH LUBRICATION OIL (Cont.)

Cause	Correction
Worn Valve Guides	Reconditioning of the cylinder head is necessary.
Worn Piston Rings and Cylinders	Inspect and install new parts as necessary. Reconditioning of the cylinder block can be necessary.
Failure of Seal Rings in Turbo-charger	Check inlet manifold for oil and make repair to turbocharger if necessary.

24. ENGINE COOLANT IS TOO HOT

Cause	Correction
Restriction To Flow of Coolant Through Radiator Core Tubes	Clean and flush radiator.
Restriction to Air Flow Through Radiator	Remove all restrictions to air flow.
Low Fan Speed	Check for worn or loose fan belts.
Not Enough Coolant in System	Check for the cause of the loss of coolant and repair as necessary. Add coolant to the cooling system. See KNOW YOUR COOLING STYSTEM.
Pressure Relief Valve Has A De-fect	Check operation of pressure relief valve. Install a new pressure relief valve if necessary.
Combustion Gases in Coolant	Find out where gases get into the cooling system. Make repairs as necessary.
Water Temperature Regulators (Thermostats) or Temperature Gauge Has A Defect	Check water temperature regulators for correct operation. Check temperature gauge operation. Install new parts as necessary.
Water Pump Has A Defect	Make repairs or replacement of the water pump as necessary.
Too Much Load On The System	Make a reduction to the load.
Wrong Fuel Injection Timing	Make adjustment to timing.
Torque Converter or Transmis-sion Does Not Operate Correctly. This Can Cause An Increase In The Coolant Temperature	Make corrections for torque converter or transmission running too hot.

25. EXHAUST TEMPERATURE IS TOO HIGH

Cause	Correction
Air Inlet or Exhaust System Has A Restriction	Remove restriction.
Wrong Fuel Injection Timing	Make an adjustment to the timing.

26. STARTER MOTOR DOES NOT TURN

Cause	Correction
Battery Has Low Output	Check condition of battery. Charge battery or make replacement as necessary.
Wires or Switch Has Defect	Make repairs or replacement as necessary.
Starter Motor Solenoid Has A Defect	Install a new solenoid.
Starter Motor Has A Defect	Make repair or replacement of starter motor.

27. ALTERNATOR GIVES NO CHARGE

Cause	Correction
Loose Drive Belt For Alternator	Make an adjustment to put the correct tension on the drive belt.
Charging or Ground Return Circuit or Battery Connections Have A Defect	Inspect all cables and connections. Clean and tighten all connections. Make Replacement of parts with defect.
Rotor (Field Coil) Has A Defect	Install a new rotor.

28. ALTERNATOR CHARGE RATE IS LOW OR NOT REGULAR

Cause	Correction
Loose Drive Belt For Alternator	Make an adjustment to put the correct tension on the drive belt.
Charging or Ground Return Circuit or Battery Connections Have A Defect	Inspect all cables and connections. Clean and tighten all connections. Make replacement of parts with defects.
Alternator Regulator Has A Defect	Install a new Alternator regulator.

(Cont. next page)

28. ALTERNATOR CHARGE RATE IS LOW OR NOT REGULAR (Cont.)

Cause	Correction
Alternator Regulator Not Adjusted Correctly	See ELECTRICAL SYSTEM in Testing and Adjusting. Some alternator regulators can be adjusted and some can not be adjusted.
Rectifier Diodes Have A Defect	Make replacement of rectifier diode that has a defect.
Rotor (Field Coil) Has A Defect	Install a new rotor.

29. ALTERNATOR CHARGE RATE IS TOO HIGH

Cause	Correction
Alternator or Alternator Regulator Has Loose Connections	Tighten all connections to alternator or alternator regulator.
Alternator Regulator Has A Defect	Install a new alternator regulator.

30. ALTERNATOR HAS NOISE

Cause	Correction
Drive Belt For Alternator is Worn or Has A Defect	Install a new drive belt for the alternator.
Loose Alternator Drive Pulley	Check groove in pulley for key that holds pulley in place. If groove is worn, install a new pulley. Tighten pulley nut according to Specifications.
Drive Belt and Drive Pulley For Alternator Are Not in Alignment	Make an adjustment to put drive belt and drive pulley in correct alignment.
Worn Alternator Bearings	Install new bearings in the alternator.
Rotor Shaft is Bent	Make a replacement of the rotor shaft.
Rectifiers in the Alternator Are Shorted	Make a replacement of the diode assembly.

31. RACK SOLENOID DOES NOT STOP ENGINE

Cause	Correction
Electrical Connections Are Not Correct	Correct electrical connections and wiring.
Adjustment for Plunger Shaft is Not Correct	Make an adjustment to the plunger shaft.
Wrong Plunger in Solenoid	Install the correct plunger in the solenoid.
Not Enough Plunger Travel	Make an adjustment to the plunger shaft or make a replacement of the solenoid if necessary.
Defect in Solenoid Wiring	Make a replacement of the solenoid.

FUEL SYSTEM

Either too much fuel or not enough fuel for combustion can be the cause of a problem in the fuel system.

Many times work is done on the fuel system when the problem is really with some other part of the engine. The source of the problem is difficult to find, especially when smoke comes from the exhaust. Smoke that comes from the exhaust can be caused by a bad fuel injection nozzle, but it can also be caused by one or more of the reasons that follow:

a. Not enough air for good combustion.
b. An overload at high altitude.
c. Oil leakage into combustion chamber.
d. Not enough compression.

FUEL SYSTEM INSPECTION

A problem with the components that send fuel to the engine can cause low fuel pressure. This can decrease engine performance.

1. Check the fuel level in the fuel tank. Look at the cap for the fuel tank to make sure the vent is not filled with dirt.

2. Check the fuel lines for fuel leakage. Be sure the fuel supply line does not have a restriction or a bad bend.

3. Install a new fuel filter. Clean the primary fuel filter, if so equipped.

4. To remove air from the fuel system, use the procedure that follows:

   (a) Use the priming pump to remove air from the low pressure side of the fuel system.
   (b) Loosen one-half turn the fuel injection line nuts at the adapter in the valve cover base. Use the starter motor to turn the engine until fuel without air flows from the loose connections. Tighten the nuts.

5. Inspect the fuel bypass valve to see that there is no restriction to good operation.

ENGINE CYLINDERS CHECKED SEPARATELY

An easy check can be made to find the cylinder that runs rough (misfires) and causes black smoke to come out of the exhaust pipe.

Run the engine at the speed that is the roughest. Loosen the fuel line nut at the adapter in the valve cover base. This will stop the flow of fuel to that cylinder. Do this for each cylinder until a loosened fuel line is found that makes no difference in engine performance. Be sure to tighten each fuel line nut after the test before the next fuel line nut is loosened. Check each cylinder by this method. When a cylinder is found where the loosened fuel line nut does not make a difference in engine performance, test the injection pump and nozzle for that cylinder.

Temperature of an exhaust manifold port, when the engine runs at low idle speed, can also be an indication of the condition of a fuel injection nozzle. Low temperature at an exhaust manifold port is an indication of no fuel to the cylinder. This can possibly be an indication of a nozzle with a defect. Extra high temperature at an exhaust manifold port can be an indication of too much fuel to the cylinder, also caused by a nozzle with a defect.

The most common defects found with the fuel injection nozzles are:

1. Carbon on tip of the nozzle or in the nozzle orifice.

2. Orifice wear.

3. Dirty nozzle screen.

TEST SEQUENCE - DIRECT INJECTION (DI) FUEL NOZZLE

To test DI capsule-type fuel nozzles. use the sequence that follows:

I. Nozzle Installation
II. Pressure Loss Test
III. Valve Opening Pressure (VOP) Test
IV. Flush the Nozzle
V. Tip Leakage Test
VI. Orifice Restriction Test

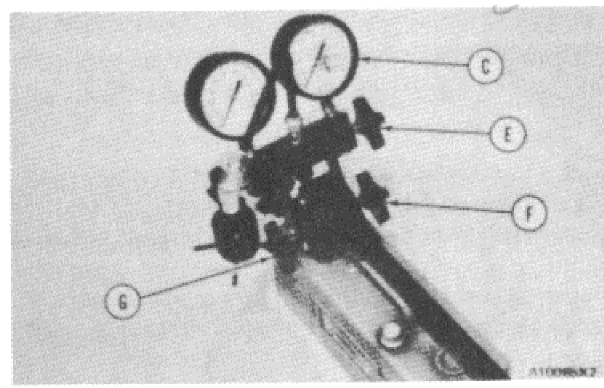
CAUTION

Do not use a drill or reamer on the orifice of a nozzle. Do not use a steel brush or a wire wheel to clean the tip of the nozzle. The orifice and the valve can be damaged easily.

I. Nozzle Installation

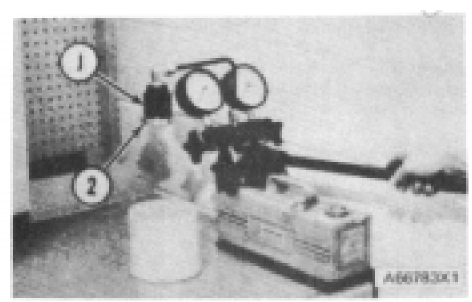
1. Put one of the nozzles to be tested in the bottom part (2) of adapter (J). Install and tighten bottom part (2) to top part of adapter (J).

2. Close on-off valve (F). Open gauge protector valve (E) one-half turn. Open pump isolator valve (G) one-half turn.



TESTER NOMENCLATURE
C. 2P2324 Gauge, 0 to 5000 psi (0 to 34 500 kPa). E. Gauge protector valve. F. On-off valve. G. Pump isolator valve.

3. Bleed (remove) air from the tester as follows:
   a. Loosen bottom part (2) of adapter (J) one-half turn.
   b. Operate the pump until clear test fluid (free of air bubbles) leaks past the threads at top of adapter (J). I



AIR REMOVAL FROM TESTER
2. Bottom part of adapter (J). J. 5P8744 Adapter.

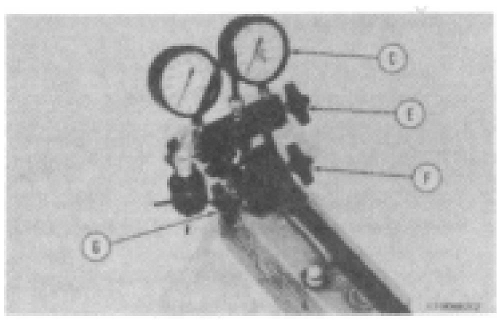
NOTE: With some 5P8744 Adapters, pressure may start to increase before there is an indication of clear test fluid. To correct this condition, do Step C.

c. Tighten bottom part (2) of adapter (J).

NOTE: The 5P8744 Adapter makes its own seal, and normally needs very little force when turned on bottom part (2) of the adapter. It is possible, however, that it will be necessary to use a IP2853 Spanner Wrench and a 1 1/8" open end wrench to tighten the adapter to prevent excessive leakage from some DI fuel nozzles.

II. Pressure Loss Test

1. Open gauge protector valve (E) an extra amount of one-half turn (the total amount is now one turn open).



TESTER NOMENCLATURE

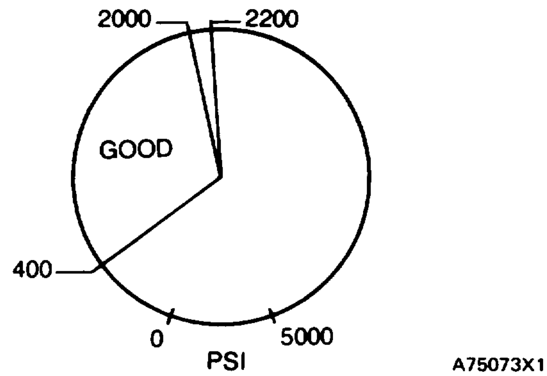
C. 2P2324 Gauge, 0 to 5000 psi (0 to 34 500 kPa). E. Gauge protector valve. F. On-off valve. G. Pump isolator valve.

2. Operate pump to increase pressure slowly to 2200 psi (15 200 kPa), and close pump isolator valve (G). Now turn gauge protector valve (E) to adjust pressure again to 2200 psi (15 200 kPa).

3. After 30 seconds, take a pressure reading from the gauge. The pressure at this time must be within specifications that follow:

PRESSURE LOSS SPECIFICATIONS		
Time Period	Minimum Loss	Maximum Loss
	200 psi	1800 psi
30 seconds	(1380 kPa)	(12 400 kPa)

4. If the pressure loss is not within the 1600 psi (1 050 kPa) range shown as GOOD, stop the test sequence. **Do not use the fuel nozzle again.**

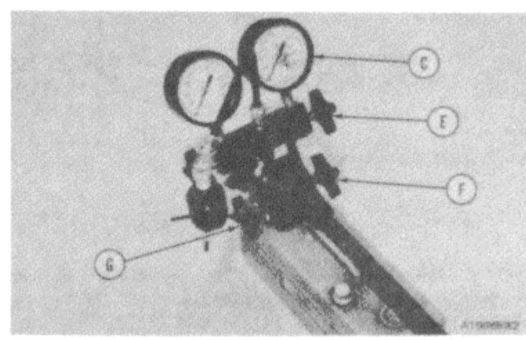


PRESSURE LOSS RANGE FOR A GOOD NOZZLE

5. If nozzle is in the specification range, see VALVE OPENING PRESSURE (VOP) TEST.

III. Valve Opening Pressure (VOP) Test

1. Open pump isolator valve (G) one-half turn.



TESTER NOMENCLATURE

C. 2P2324 Gauge, 0 to 5000 psi (0 to 34 500 kPa). E. Gauge protector valve. F. On-off valve. G. Pump isolator valve.

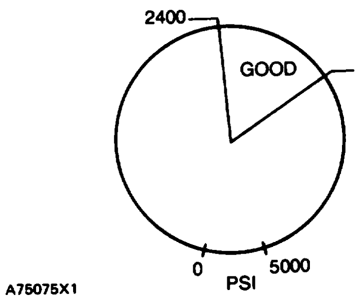
⚠ WARNING

When a fuel injection nozzle is to be tested, keep the tip of the nozzle pointed away from the operator and into the FT1384 Extension and 8S2270 Fuel Collector. Test fluid from the orifices in the tip of the nozzle is under high pressure and can cause injury to the operator.

2. Operate the pump to increase the pressure **slowly** until test fluid comes from the nozzle tip.

3. The pressure reading on the gauge at this time must be in the pressure range that follows:

VOP SPECIFICATIONS	2400 to 3100 psi (16 500 to 21 390 kPa)



VOP RANGE FOR A GOOD NOZZLE

4. If the valve opening pressure (VOP) is not in the 2400 to 3100 psi (16 550 to 21 390 kPa) range shown as GOOD, do not use the fuel nozzle again.

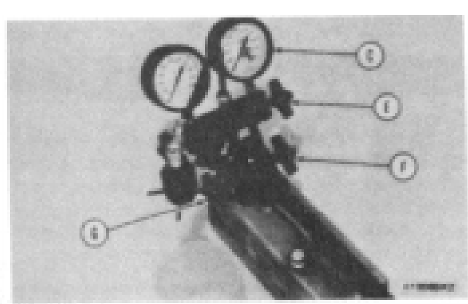
5. If the fuel nozzle is within specification range, see subject FLUSH THE NOZZLE.

IV. Flush the Nozzle

1. Close gauge protector valve (E). Close on-off valve (F). Open pump isolator valve (G).

NOTE: Make sure the nozzle tip extends inside and below the top of FT1384 Extension.

2. Operate the pump rapidly for three full strokes.



TESTER NOMENCLATURE

C. 2P2324 Gauge, 0 to 500 pi (0 to 34 500 kPa). E. Gauge protector valve. F. On-off valve. Pump isolator valve.

V. Tip Leakage Test

1. Remove all fuel from the nozzle tip and adapter with a cloth.

2. Open gauge protector valve (E). Be sure the nozzle tip is completely dry.

3. Make and hold for 30 seconds a pressure of 2200 psi (15 200 kPa).

TIP LEAKAGE SPECFICATION
A drop may form, but must not fall from nozzle tip.

4. If nozzle is not within specification, **do not use the nozzle again.**

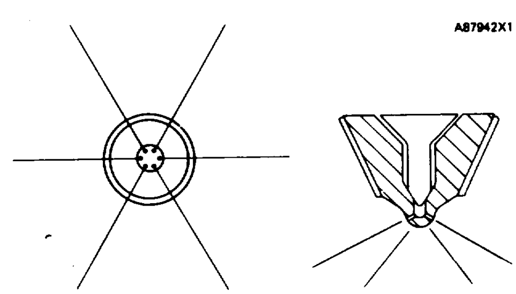
5. If fuel injection nozzle is within specification, see subject ORIFICE RESTRICTION TEST.

VI. Orifice Restriction Test

1. Close gauge protector valve (E) and on-off valve (F). Open pump isolator valve (G).

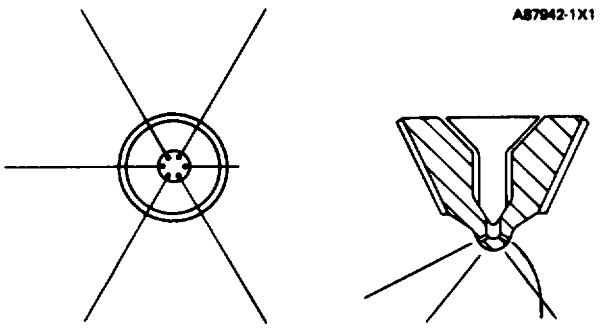
2. Point the tip of the fuel injection nozzle into the 8S2270 Fuel Collector and FT1384 Extension.

3. Make a slow increase in pressure and look at the orifice discharge pattern (shape of discharge) when fluid begins to flow from the nozzle tip. The discharge must be the same through all six - orifices. Any change, either vertically or horizontally, is an indication of a bad nozzle.

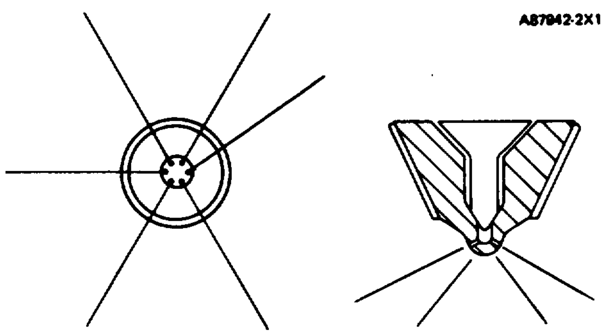


GOOD NOZZLE
(USE AGAIN)

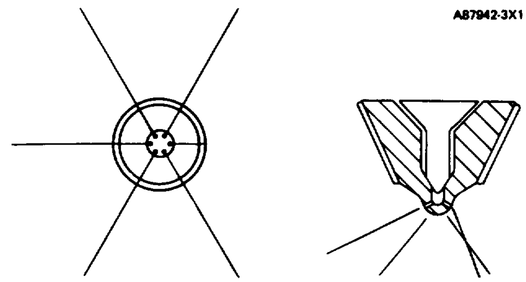
4. Use the 8S2258 Brass Wire Brush from 8S2245 Cleaning Kit to remove any loose carbon from the nozzle tip.



TYPICAL DISCHARGE PATTERN FOR ORIFICE WITH RESTRICTION (REPLACEMENT NECESSARY)



TYPICAL DISCHARGE PATTERN WITH HORIZONTAL DISTORTION (REPLACEMENT NECESSARY)



TYPICAL DISCHARGE PATTERN WITH VERTICAL DISTORTION (REPLACEMENT NECESSARY)

CAUTION

Do not use a steel brush or a wire wheel to clean the nozzle body or the nozzle tip. Use of these tools can cause a small reduction of orifice size, and this will cause a large reduction in engine horsepower.

Removal of Injection Pumps

Tools Needed:
5P144 Socket.
8S4613 Wrench.
8S2244 Extractor.
9S8S21 Rod (Earlier Models).
9S8519 Plug (Earlier Models).

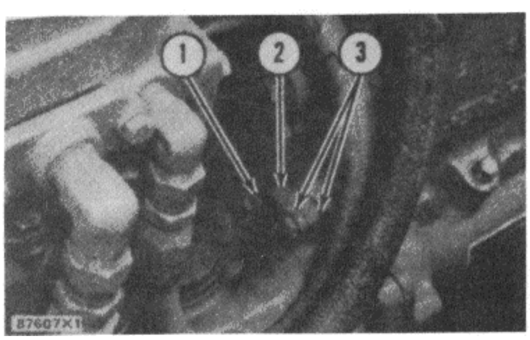
Before the fuel injection pumps can be removed the fuel rack must be in the center position. To put fuel rack in the center position, the procedure that follows is necessary.

1. If the governor has a speed limiter (earlier models), put a 9S8519 Plug in place of original plug. Identification of later models without a speed limiter is made when no plug or hole is found on governor housing.

2. Put a 9S8521 Rod through the hole in the 9S8519 Plug.

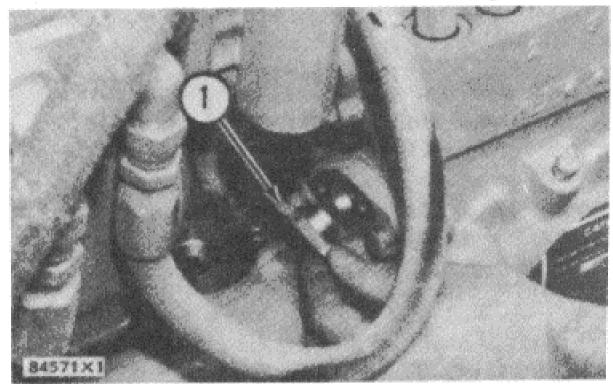
3. Push in on the 9S852 1 Rod to get compression of the speed limiter spring. Hold the rod in this position and tighten the 9S8519 Plug enough to hold the rod.

4. Remove stop(1), spacer(2) and both gaskets(3) from the end of fuel injection pump housing.



RACK STOP
1. top. 2 Spear. 3. Gaskets.

5. Move the governor control all the way in the fuel-on direction or until the end of the fuel rack can be felt with the finger to be past (toward outside of housing) the counterbore in the housing where stop (1) is installed. Fasten the governor control in this position.



RACK STOP
1. Stop.

6. Install stop (I) as shown back on to the housing without spacer (2) or gaskets (3). Two bolts with shorter length must be used to hold stop (1) against housing. The fuel rack is now in the center position against stop (1), and the fuel injection pumps can be removed.

7. Remove fuel injection line from the injection pump.

8. Put 8S4613 Wrench (5) into spline of bushing that holds the fuel injection pump in the housing. Remove the bushing.

9. Install 8S2244 Extractor (4) on the threads of the injection pump. Pull the pump straight up out of the bore.

When an injection pump has been removed, make reference to subject CHECKING FUEL INJECTION PUMP LIFTER WASHER AND PUMP PLUNGER.

Be careful when injection pumps are disassembled. Do not damage the surface on the plunger. The plunger and barrel for each pump are made as a set. Do not put the plunger of one pump in the barrel of another pump. If one part is worn, install a complete new pump assembly. Be careful when putting the plunger in the bore of the barrel.

Installation of Injection Pumps

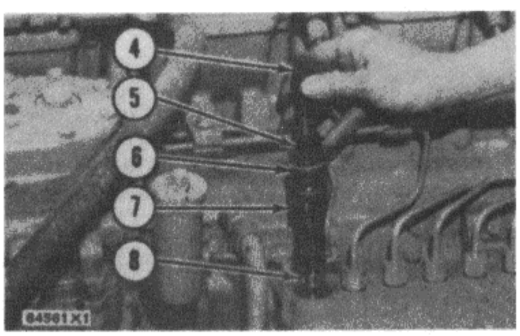
To install a fuel injection pump back into the housing bore, use the procedure that follows:

CAUTION

The fuel rack MUST BE IN THE CENTER POSITION before the correct installation of an injection pump is possible.

1. Put 8S2244 Extractor (4) on threads of injection pump.

2. Put groove of barrel (7) in alignment with slot of gear segment (8) (slot is on opposite side of gear segment teeth).



FUEL PUMP INSTALLATION

4. 8S2244 Extractor. 5. 8S4613 Wrench. 6. Bushing. 7. Barrel. 8. Gear segment.

3. Look inside the bore of the injection pump housing to find the dowel. Put groove of the barrel in alignment with the dowel and put the injection pump straight down into the bore.

4. Push down on extractor (4) (hand force only) and install bushing (6) that holds the injection pump in the pump housing. If the pump is in the correct position, the bushing will turn into the threads of the injection pump housing with the fingers until it is even with the top of the housing (except for the pump that is in position to fire). When bushing is installed correctly, tighten the bushing to 150 ± 10 lb. ft. (205 ± 14 N-m).

CAUTION

Damage to the housing will be the result if the bushing is too tight. If the bushing is not tight enough, the pump will have leakage.

5. Install fuel injection line to the pump with 5P144 Socket and tighten to a torque of 30 ± 5 lb. ft. (40 ± 7 N-m).

6. Remove stop (1) from end of housing. Put spacer (2) and gaskets (3) between housing and stop (1) and install the original bolts.

7. Move governor control back to shut-off position. Check to be sure governor control moves freely between fuel-on and shut-off position.

Check for the correct installation of injection pump with the engine stopped. Rack travel from the center position in the fuel-on direction can be checked with governor installed, but the governor and governor piston must be removed to check for full rack travel. Use 9S240 Rack Position Tool Group and the chart that follows to check rack travel. Make reference to FUEL RACK SETTING for installation of 9S240 Rack Position Tool Group.

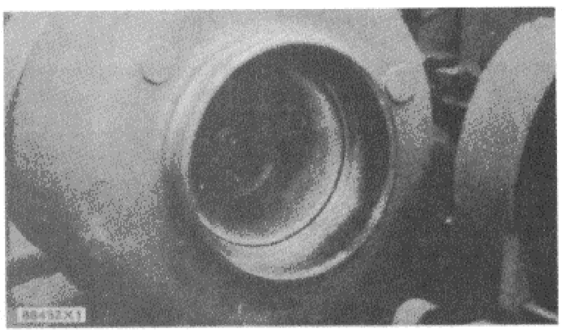
EXAMPLE OF RACK TRAVEL						
	TOTAL RACK TRAVEL		TRAVEL FROM CENTER POSITION		TOTAL REDUCTION OF TRAVEL	
TEETH OFF	in.	mm	in.	mm	in.	mm
0	.8	20	.4	10	0	0
1	.6	15	.3	7	.2	5
The same results can be obtained for 2 and 3 teeth off. Reduction of rack travel is greater but will not have a constant ratio A663NX 1						

With the governor piston and valve removed, the total amount of fuel rack travel (from shut-off position to full load position) is approximately .800 in. (20.32 mm). If the pump is installed wrong (center tooth of gear segment is not in correct notch of fuel rack) fuel rack travel will be less than .800 in. (20.32 mm). The injection pump will have to be removed and then installed correctly.

CAUTION

If one or more of the fuel injection pumps have been installed wrong, it is possible for the engine to run out of control when started. When any of the fuel injection pumps have been removed and installed with the fuel injection pump housing on the engine, take the precautions (steps) that follow to stop the engine if it starts to overspeed (run out of control).

a. Remove the air cleaner pipe from the turbocharger leaving the air inlet open as shown.



TURBOCHARGER AIR INLET OPENING

b. Set the governor control at low idle.

⚠ WARNING

Be careful when plate is put against air inlet opening. Due to excessive suction, the plate can be pulled quickly against air inlet opening. To avoid crushed fingers, do not put fingers between plate and air inlet opening.

c. Start the engine, and if engine starts to over-speed (run out of control), put a steel plate over the air inlet as shown to stop the engine.

STOPPING THE ENGINE

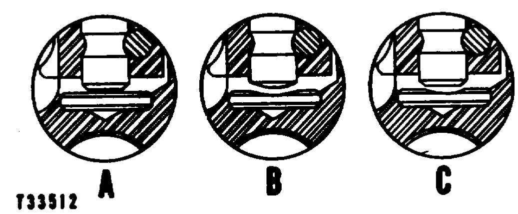
Checking the Plunger and Lifter Washer on an Injection Pump

Check timing dimension for the fuel injection pumps. Make an adjustment if necessary, with the pump housing off the engine. When an adjustment to the timing dimension is done correctly, fuel injection in the cylinder will be at the correct time. If the timing dimension is too small, fuel injection will be early. If the timing dimension is too large, fuel injection will be late.

An injection pump can have a good fuel flow coming from it but not be a good pump because of slow timing that is caused by wear on the bottom end of the plunger. When making a test on a pump that has been used for a long time, use a micrometer and measure the length of the plunger. If the length of the plunger is shorter than the minimum length (worn) dimension given in the chart, install a new pump.

FUEL PUMP PLUNGER LENGTH		
Engine Type		DI
Fuel inj Pump P/N		86633
Length (New)		2.7212 ± .0015 in. (69.118 ± 0.038 mm)
Min. Permissible Length (Worn)		2.7197 in. (69.080 mm)

Look for wear at the top part of the plunger. Check the operation of the plunger according to the instructions for the Fuel Injection Test Bench.



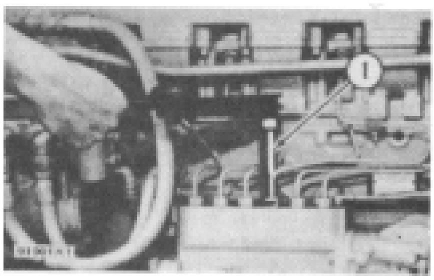
WEAR BETWEEN LIFTER WASHER AND PLUNGER

Fig. A shows the contract surfaces of a new pump plunger and a new lifter washer. In Fig. B the pump plunger and lifter washer have worn a large amount. Fig. C shows how the flat end of a new plunger makes bad contact with worn lifter washer, causing rapid wear to both parts.

When there is too much wear on the pump plunger, the lifter washer may also be worn and there will not be good contact between the two parts. To stop fast wear on the end of a new plunger, install new lifters in the place of lifters that have washers with wear.

Fuel Injection Lines

Fuel from the fuel injection pumps is sent through the fuel injection lines to the fuel injection valves. Each fuel injection line of an engine has a special design and must be installed in a certain location. When fuel injection lines are removed from an engine, put identification marks or tags on the fuel lines as they are removed, so they can be put in the correct location when they are installed.



TIGHTENING THE NUT OF A FUEL INJECTION LINE
1. 5P144 Fuel Line Socket.

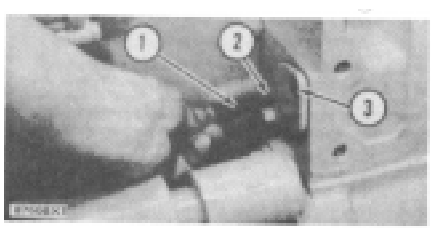
The nuts that hold a fuel injection line to an injection valve and injection pump must be kept tight. Use a torque wrench and the 5P 144 Fuel Line Socket (1) to tighten the fuel line nuts to 30 ± 5 lb. ft (40 ± 7 N•m).

Fuel Bypass Valve

The fuel bypass valve controls fuel pressure to the fuel injection pump at full speed to a pressure of 30 psi (205 kPa).

FINDING TOP CENTER COMPRESSION POSITION FOR NO. 1 PISTON

Tools Needed:
9S9082 Turning Tool.



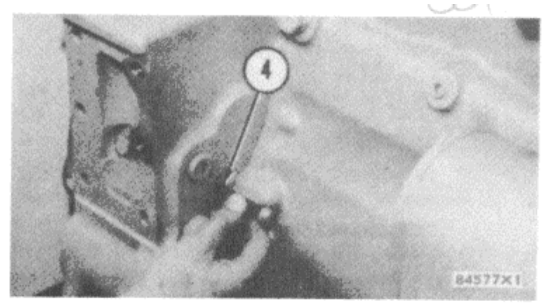
LOCATING TOP CENTER (LEFT SIDE OF ENGINE)
1. Timing bolt. 2. Timing bolt location 3. storage location.

No. 1 piston at top center (TC) on the compression stroke is the starting point of all timing procedures.

The timing bolt (1) is kept in storage at location (3) and can be installed in either the left side of the engine at location (2) or in the right side of the engine at location (4).

NOTE: There are two threaded holes in the flywheel. These holes are in alignment with the holes with plugs in the left and right front of the flywheel housing. The two holes in the flywheel are at a different distance from the center of the flywheel so the timing bolt cannot be put in the wrong hole.

Remove bolts and cover from flywheel housing.



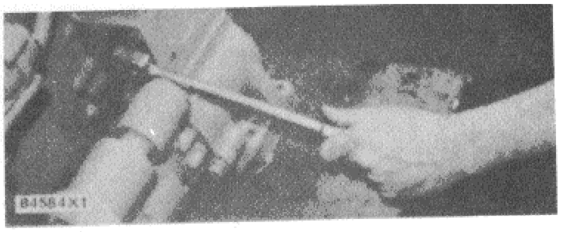
LOCATING TOP CENTER (RIGHT SIDE OF ENGINE)
4. Timing bolt location.

Install 9S9082 Engine Turning Tool as shown into housing until shoulder of tool is against housing. Attach a 1/2" drive ratchet to tool and turn flywheel while holding timing bolt in position in hole location (2) or (4) where plug was removed. Stop rotation when timing bolt (1) can be installed in threaded hole of flywheel.

To see if No. 1 piston is on the compression stroke, remove the front valve cover and look at the valves of No. 1 cylinder. The valves will be closed if No. 1 cylinder is on the compression stroke. You should be able to move the rocker arms up and down with your hand.

If No. 1 piston is not on the compression stroke, turn the flywheel 3600 and install the timing bolt.

If the flywheel was not turned in the direction of normal engine rotation, or was turned past the timing hole, turn the flywheel clockwise (opposite the direction of normal engine rotation) approximately 30 degrees. The reason for this step is to be sure the play is removed from the timing gears when the engine is put on top center.



USING 9S9082 ENGINE TURNING TOOL

NOTE: The engine is seen from the flywheel end when direction of crankshaft rotation is given.

Next, turn the flywheel counterclockwise until the hole in the flywheel is in alignment with the timing bolt. When the timing bolt can be turned freely in the threaded hole in the flywheel, the No. 1 piston of the engine is on top center.

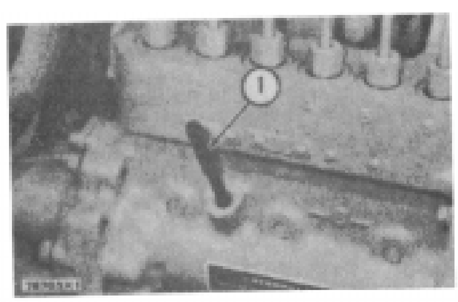
If the hole in the flywheel is turned beyond the hole in the flywheel housing, turn the flywheel back (clockwise) a minimum of 300 beyond the hole in the flywheel. Now turn the flywheel counterclockwise toward the hole again.

FUEL SYSTEM ADJUSTMENTS: ON ENGINE

Camshaft Timing For The Fuel Injection Pump

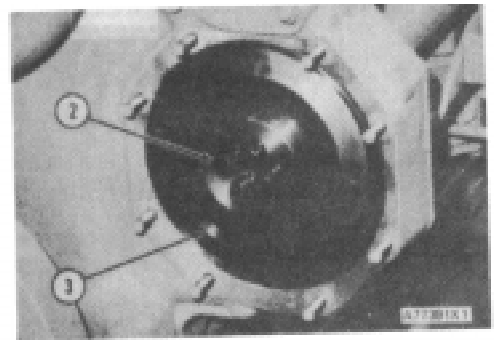
Tools Needed:
8S2291 Timing Pin.

1. Install timing pin (1) through the hole in the pump housing and into the notch in the camshaft.



TIMING PIN INSTALLED
1. Timing pin.

2. Loosen four bolts (2) [one bolt on earlier engines] holding the automatic timing advance unit (3) to the drive shaft for the fuel injection pump.



AUTOMATIC TIMING ADVANCE UNIT
2. Bolts. 3. Automatic Timing Advance Unit

3. Hit the automatic timing advance unit with a soft hammer to make it come loose from the end of the drive shaft for the fuel injection pump. Be sure it will move freely on the end of the shaft.

4. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to FINDING TOP CENTER COMPRESSION POSITION FOR NO. 1 PISTON.

5. On earlier engines, tighten the bolt (2) first to 15 lb. ft. (20 N•m). Remove timing pin (1) and tighten bolt (2) to a last torque of 110 $\pm$ 10 lb. ft. (149 $\pm$ 14 N•m). On later engines, tighten the four bolts (2) evenly to 25 lb. ft. (35 N•m). Remove timing pin (1), and tighten four bolts (2) evenly to 50 lb. ft. (70 N•m). Tighten bolts (2) to a last torque of 100 ± 5 lb. ft. (135 $\pm$ 7 N•m).

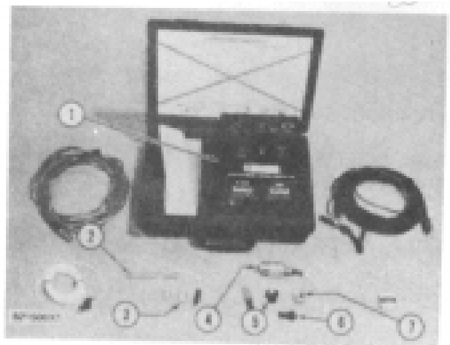
6. Remove the timing bolt from the flywheel.

7. Turn the crankshaft two complete revolutions and check the timing again to see that timing is correct.

8. If timing is not correct, do the above procedure again.

Checking Engine Timing and Timing Advance with 6V3100 Diesel Engine Timing Indicator Group (Dynamic Check)

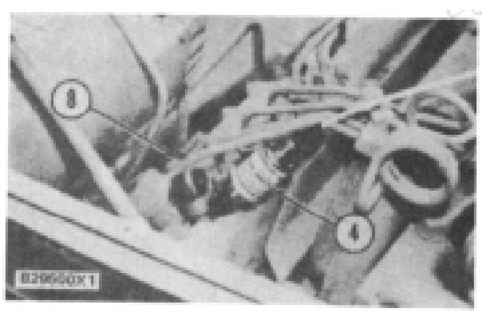
Tools Needed:
6V3100 Diesel Engine Timing Indicator Group.



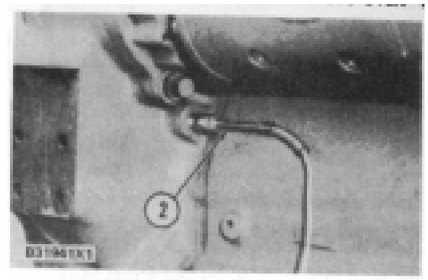
6V3100 DIESEL ENGINE TIMING INDICATOR GROUP
1. Engine timing indicator. 2. TDC magnetic transducer. 3. Pipe adapter. 4. Injection transducer. 5. 5P7437 Adapter. 6. 5P7435 Tee Adapter. 7. 5P7436 Adapter.

CAUTION
The engine must be stopped while the timing indicator is being connected.

1. Make reference to Operation Instructions inside the lid of the 6V3100 Diesel Engine Timing Indicator Group for complete instructions and calibration.



TRANSDUCER IN POSITION (TYPICAL EXAMPLE)
4. Injection transducer. 8. Fuel injection line for No. 1 cylinder.



TRANSDUCER IN POSITION (TYPICAL EXAMPLE)
2. TDC magnetic transducer.

2. Loosen all fuel line clamps that hold No. 1 fuel injection line and disconnect the fuel injection line for the No. 1 cylinder at the fuel injection pump. Slide the nut up and out of the way. Put 5P7436 Adapter (7) in its place and turn adapter (7) onto the fuel pump bonnet until the top of the bonnet threads are approximately even with the bottom of the "window" in the adapter.

3. Put the 5P7435 Tee Adapter (6) on the Injection transducer (4) and put the end of the 5P7435 Tee Adapter (6) in the "window" of the 5P7436 Adapter (7).

4. Put fuel injection line (8) on top of 5P7435 Tee Adapter (6). Install 5P7437 Adapter (5) and tighten to 30 lb. ft. (40 N•m).

5. Remove the plug from the flywheel housing. Install pipe adapter (3) into the hole the plug was removed from. Tighten only a small amount.

6. Push the TDC magnetic transducer (2) into the pipe adapter (3) until it makes contact with the flywheel. Pull it back out .06 in. (1.6 mm) and lightly tighten the knurled locknut.

7. Connect the cables from the transducers to the Engine Timing Indicator. Make a calibration check of the indicator.

8. Start the engine and let it reach operating temperature. Then run the engine at approximately one-half throttle for eight to ten minutes before measuring timing.

9. Make reference to FUEL SETTING INFORMATION for static timing, timing advance settings and tolerances.

FUEL SETTING INFORMATION

3406 ENGINE, DI-T, SCROLL FUEL INJECTION SYSTEM
330 KW (BHP) @ 1900 RPM

DATA	TYPE	VALUES		
		SPEC.	MIN	MAX
FULL LOAD RATING	BHP	330	320	340
	kw	246	239	253
ENGINE SPEEDS				
FULL LOAD	rpm	1895	1890	1910
HIGH IDLE		2309	2259	2359
LOW IDLE		775	745	805
STABILIZED		2011	2008	2018
TORQUE CHECK		1200	1190	1210
SET POINT		1915	1910	1930
TORQUE VALUES				
STABILIZED ENGINE RPM	lb ft	869	860	879
	nm	1175	1162	1188
TORQUE CHECK RPM				
TORQUE RISE		8.4	16.8	
INLET MANIFOLD PRESSURE	in/Hg	35.6	30.2	40.9
@ FULL LOAD	kPa	120	102	138
LUBE OIL PRESSURE				
@ LOW IDLE	psi		27	87
	kPa		185	600
@ FULL LOAD	psi		40	87
	kPa		275	600
FUEL TIMING				
STATIC @ ZERO RPM	Degrees	26.5	25.5	27.5
@ LOW IDLE	Degrees	27.3	26.1	28.5
	rpm	890	860	920
@ FULL LOAD STOP	Degrees	33.0	31.8	34.2
	rpm	2050		

DATA	TYPE	VALUES		
		SPEC.	MIN	MAX
PISTON TRAVEL	in	0.444	0.443	0.445
	mm	11.28	11.25	11.30
STATIC FUEL SETTINGS				
FULL LOAD	in	0.160	0.150	0.170
	mm	4.06	3.81	4.31
TORQUE RISE	in	0.160	0.150	0.170
	mm	4.06	3.81	4.31
DYNAMIC FUEL SETTINGS				
FULL LOAD	in	0.180	0.170	0.189
	mm	4.56	4.31	4,81
TORQUE RISE	in	0.180	0.170	0.189
	mm	4.56	4.31	4.81
FUEL CONSUMPTION RATES @ FULL LOAD	lbs/min gal/hr gm/min l/hr	2.073 17.1 940 66	1.969 16.7 893 63	2.177 18.4 987 70
BRAKE SPECIFIC				
@ FULL LOAD	.lbs/hphr	0.377	0.358	0.396
	gm/kwhr	229	218	241

ALTITUDE DERATING DATA

MAXIMUM ALTITUDE		HIGH IDLE RPM	ENGINE RATING		FUEL SETTINGS				FUEL RATES		MANIFOLD PRESS. @FULL LOAD	
					STATIC		TORQUE RISE		gals	liters		
FEET	METERS		bhp	kw	in	mm	in	mm	per hr	per hr	kPa	In/Hg
7400	2250	2309	330	246	0.160	4.06	0.160	4.06	17.50	66	113	33.5
9800	3000	2244	310	231	0.140	3.55	0.140	3.55	16.35	62	100	29.5
12500	3750	2204	285	213	0.115	2.92	0.115	2.92	15.13	57	95	28.0
14800	4500	2154	260	194	0.0O5	2.15	0.085	2.15	13.78	52	85	25.0

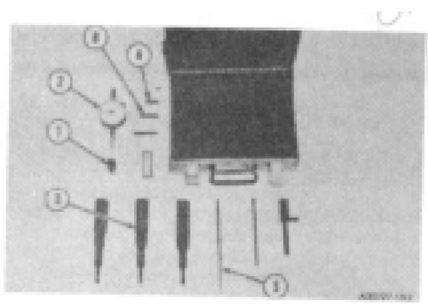
10. Calculate (find) the correct dynamic setting ranges for the engine.

11 Run the engine at the speeds required to check low idle, timing, timing advance and high idle. Record the engine timing indicator readings. If the engine timing is not correct, make reference to CHECKING ENGINE TIMING BY TIMING PIN METHOD.

12 If the automatic timing advance is not correct, repair or replace the automatic timing advance unit.

Flow Checking Fuel Injection Pump Timing
Tools Needed:

1P540 Flow Checking Tool Group.
5P6524 Engine Timing Indicator Group.
5P72M8 Adapter.
98215 Dial Indicator.
3P1585 Collet.
5P2393 Contact Point (DI Engines).
8S2296 Rod (DI Engines).
5P3564 Flow Check Assembly (DI Engines).
882291 Timing Pin.



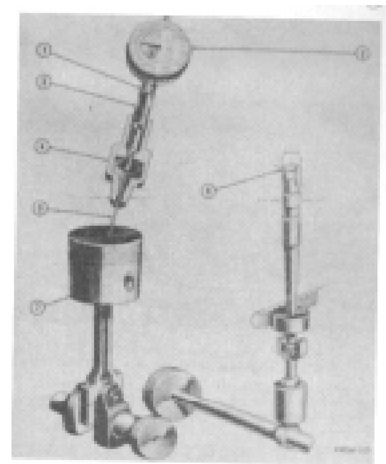
5P524 ENGINE TIMING INDICATOR GROUP

1. 3P1565 Collet Clamp. 2. 9S215 Dial Indicator. 3. 5P7268 Adapter. 5. 8S2296 Rod, 5.25 in. (133.4 mm) long or 3832,4 Rod, 7.12 in. (180.9 mm) long. A. 3S3268 Contact Point, .25 in. (6.4 mm) long. B. 5P2393 Contact Point, 1.50 in. (38.1 mm) long.

To find the travel (movement) of piston (7), from point of closing inlet port (6) to top center, use the procedure that follows:

1. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to FINDING TESTING AND TOP CENTER COMPRESSION POSITION FOR NO. 1 PISTON.

2. Remove the timing bolt from the flywheel.



MEASURING PISTON TRAVEL (PC TYPE ENGINE SHOWN)

1. 3P1565 Collet. 2. 9S215 Dial Indicator and Contact Point. 3. 5P7268 Adapter. 4. Precombustion chamber or Direct Injection Adopter. 5. Rod. 6. Inlet port. 7. Piston.

3. Remove the fuel nozzle from the precombustion chamber or direct injection adapter for No. 1 cylinder.

4. Put the correct rod (5) in 5P7268 Adapter (3). Put the 5P7268 Adapter in the precombustion chamber or direct injection adapter and tighten the 5P7268 Adapter finger tight.

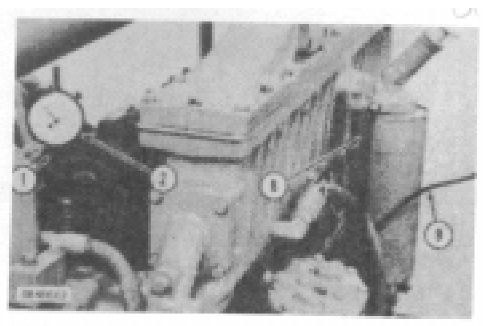
CAUTION

Do not use a wrench to tighten the adapter. There will be damage to the nozzle seat if the adapter is too tight.

5. Put the 9S215 Dial Indicator with the correct contact point in adapter (3). Make an adjustment to the dial indicator so both pointers are on "0" (zero).

6. Turn the crankshaft a minimum of 45° in the CLOCKWISE direction (when seen from the flywheel end of the engine).

7. Turn the crankshaft in the COUNTERCLOCKWISE direction (when seen from the flywheel end of the engine) until the dial indicator gives an indication of maximum piston travel. Make an adjustment to the dial indicator if necessary, to put both pointers of the dial indicator at "0" (zero).



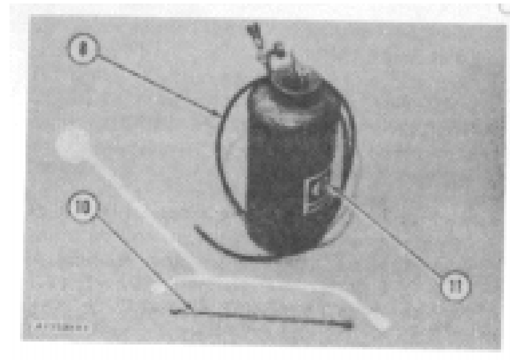
TOOL INSTALLED
(Typical Illustration)
1. 3P1565 Collet and SP7268 Adapter. 2 9S215 Dial Indicator. 8. 5J5634 Hose Assembly. 9. 5P3564 Flow Check Assembly (DI Engines).

8. Disconnect the fuel line for No. 1 injection pump at the injection pump housing. Put the end with the longest pin of a 5P3564 Flow Check Assembly (10) on No. 1 injection pump and tighten the nut. The free end of tube (10) must be in a position a little above horizontal and higher than the end of the injection pump.

9. Disconnect fuel line to the fuel filter. Use an adapter to connect the 5J4634 Hose Assembly (8) to the fuel filter. Disconnect the fuel return line from the outlet elbow on the top of the fuel injection pump. Install a cap plug on the outlet elbow.

10. Turn the crankshaft approximately 45° in a CLOCKWISE direction (when seen from the flywheel end of the engine).

11. With 1 U.S. gal. (4 liters) of clean fuel in tank assembly (11), move the governor lever to full FUEL-ON position. Put 15 psi (105 kPa) of air pressure in the tank by using the hand pump or shop air.



1P540 FLOW CHECKING TOOL GROUP
8. 5J434 Hose Assembly. 10. 5P3564 Flow Check Assembly (not included in 1P540 Tool Group). 11. Tank Assembly.

WARNING

If shop air is used, set the tank regulator to the minimum psi (kPa) setting. If air pressure is too high, fittings and hoses can be blown off or the -tank can explode causing personal injury. Do not exceed 60 psi (415 kPa) air pressure in the tank.

12. Hold a pan under the free end of the tube (10) for the fuel that comes out.

13. Turn the crankshaft slowly in direction of normal rotation (counterclockwise when seen from the flywheel end of the engine). Do this until the flow of fuel coming from the end of the tube (10) is 6 to 12 drops per minute [point of closing inlet port (6)].

14. Stop rotation of the crankshaft when the flow of fuel is 6 to 12 drops. Take a reading of the measurement on the dial indicator.

15. To check for correct timing of the fuel system, make a comparison of the measurement on the dial indicator with the measurements in the chart that follows.

NOTE: The fuel system has a tolerance of ± 1° .

TIMING ANGLE ± 1° INDICATOR READING		
8°	.042 in.	1.07 mm
9°	.053 in.	1.356 mm
11°	.078 in.	1.98 mm
12°	.093 in.	2.36 mm
250	.396 in.	10.06 mm
26°	.428 in.	10.87 mm
"26.5°	.445 in.	11.30 mm
27°	.460 in.	11.68 mm
29°	.529 in.	13.44 mm
30°	.564 in.	14.33 mm

***Correct Timing Angle for DI Engines with Fuel Injection Pump Group P/N 8N5533.*

16. If the injection pump timing is wrong, several other cylinders can be checked.

NOTE: On all cylinders other than No. 1, top center (TC) of each piston will have to be found by use of the dial indicator. Only No. I cylinder can be found by installation of bolt in flywheel.

17. If they show different readings, remove the injection pump housing to check all lifter settings and plunger lengths, and adjust as needed. See SETTING THE INJECTION PUMP TIMING DIMENSION: OFF ENGINE, and CHECKING THE PLUNGER AND LIFTER WASHER OF AN INJECTION PUMP.

Measuring Fuel Injection Pump Timing Dimension

Tools Needed:

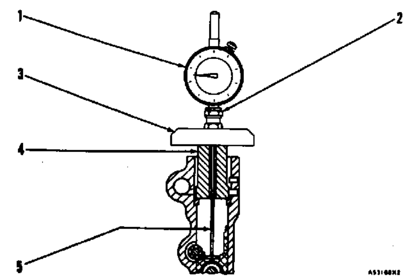
5P4165 Indicator Group.
- **8S3158 Indicator.**
- **3P1565 Collet Clamp.**
- **5P4165 Bee.**
- **5P4163 Contact Point, 4.7 in. (10.7 mm) long**
- **5P4158 Gauge, 2.00 in. (50.8 mm) long.**

8S2291 Timing Pin.
8S4613 Wrench.
8S2244 Extractor.

1. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to FINDING TOP CENTER COMPRESSION POSITION FOR NO. 1 PISTON.

2. Remove No. 1 fuel injection pump with 8S4613 Wrench and 8S2244 Extractor. Make reference to REMOVAL AND INSTALLATION OF INJECTION PUMPS (ON ENGINE).

3. Put 5P4158 Gauge (4) into the bore in the fuel pump housing.



CHECKING TIMING DIMENSION

1. 8S3158 Indicator. 2. 3P1565 Collet Clamp. 3. 5P4156 Base. 4. 5P4158 Gauge - 2.00 in. (50.8 mm) long. 5. 5P4163 Contact Point.

4. Put 3P1565 Collet Clamp (2) and 5P4156 Base (3) on 8S3158 Indicator (1). Put 5P4163 Contact Point (5) on the indicator. Install the indicator assembly through 5P4158 Gauge (4).

NOTE: The timing dimension can also be checked with the 8S7167 Gauge, 6F6922 Depth Micrometer and 4 to 5 in. (101.6 to 127.0 mm) rod.

5. The correct timing dimension (on engine) for the fuel injection pump is shown in the chart that follows:

TIMING DIMENSION (ON ENGINE)
DI Engines
(26.50) Fuel Injection Pump Group P/N 8N55633
4.183 ± .002 in. (106.25 ± 0.05 mm)

NOTE: If the timing of the fuel system is different than the correct timing dimension given in the chart, make reference to CAMSHAFT TIMING FOR THE FUEL INJECTION PUMP.

NOTE: If the timing of the fuel system is different than the correct timing dimension given in the chart and the camshaft timing for the fuel injection pump is correct, make reference to FUEL SYSTEM ADJUSTMENTS: OFF ENGINE.

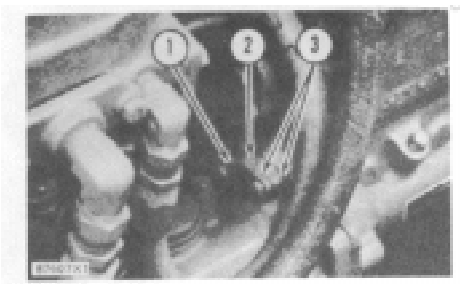
Fuel Rack Setting

Tools Needed:

9S240 Rack Position Tool Group.
- **8S4627 Circuit Tester.**
- **9S215 Dial Indicator.**
- **9S8903 Contact Point (Flat Face with Bevel).**
- **3P1565 Collet Clamp.**
- **9S7350 Bracket Group.**

1. Remove stop (1), spacer (2) and both gaskets (3) from the drive housing for the fuel injection pump.

2. Disconnect the governor control linkage to let the governor control lever move freely through its full travel.

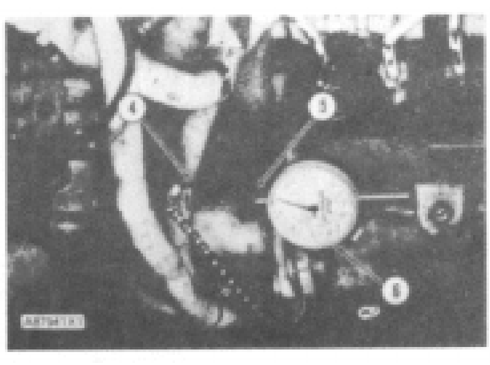


RACK STOP
1. Stop. 2. Spacer. 3. Gaskets.

3. Install the 9S7350 Bracket Group (5) and the 9S215 Dial Indicator (6) on the drive housing for the fuel injection pump.

4. With the governor control lever in the "shutoff' position, put the spacer (4) of the bracket group (the spacer is on the rod connected to the chain) over the rod that makes contact with the rack. Put force on the end of the rod that makes contact with the rack, to hold spacer in position while dial indicator setting is made.

5. Put the dial indicator on zero. Take the spacer away from the rod that makes contact with the rack.



PUTTING FUEL RACK AT CENTER POSITION
4. Spacer. 5. 9S7350 Bracket Group. 6. 9S215 Dial Indictor.

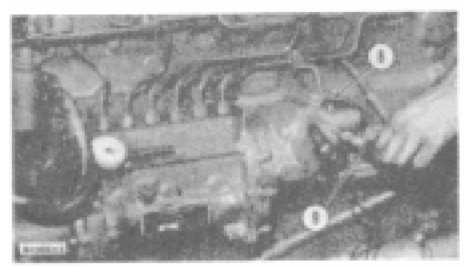
6. Connect the clip end of the 8S4627 Circuit Tester (9) to the brass terminal (8) on the governor housing. Put the other end of the tester to a good ground.

7. Turn the governor lever in the "fuel-on" direction until the light in the tester comes on. Now move the governor lever toward the "shut-off" position until the test light goes out. Now slowly, turn the governor lever toward "fuel-on" until the test light has a minimum light output. In this position, rack stop collar (11) is just making contact with the torque spring or stop bar.

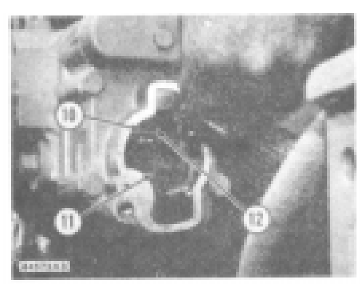
8. Read the measurement on the dial indicator. Look in the FUEL SETTING INFORMATION to find the correct measurement for rack setting.

9. If an adjustment is necessary, remove the cover, or air-fuel ratio control (if so equipped), from the rear of the governor.

10. To make an adjustment to the fuel rack, loosen locknut (10). Turn adjustment screw (12) to change the fuel rack setting.



MEASURING FUEL RACK SETTING
8. Brass terminal. 9. 8S4627 Circuit Tester.



MAKING AN ADJUSTMENT TO THE RACK SETTING
10. Locknut. 11. Stop collar. 12. Adjustment screw.

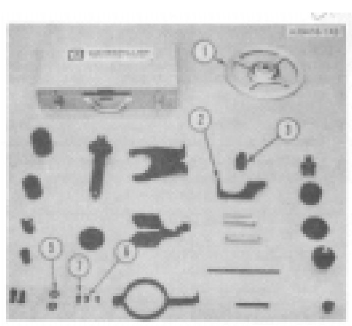
11. After the adjustment procedure is done, tighten locknut (10) to 9 ± 3 lb. ft. (12 ± 4 N•m).

12. Install the cover, or air-fuel ratio control (if so equipped). Make reference to ADJUSTMENT OF HYDRAULIC AIR-FUEL RATIO CONTROL.

FUEL SYSTEM ADJUSTMENTS:
OFF ENGINE

Setting Fuel Injection Pump Dimension

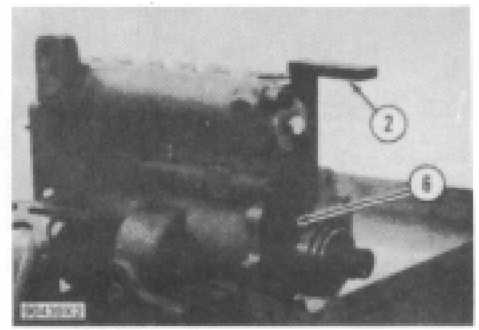
Tools Needed:
- **5P6600 Off Engine Lifter Setting Tool Group.**
- **5P4165 Indicator Group.**
  - **8S3158 Indicator.**
  - **3P1505 Collet Clamp.**
  - **5P4165 Base.**
  - **5P4163 Contact Point, 4.75 in. (120.7 mm) long.**
  - **5P4158 Gauge, 2.00 in. (50.8 mm) long.**
- **8S4613 Wrench.**
- **8S2244 Extractor.**
- **8S2291 Timing Pin.**



5P6600 OFF ENGINE LIFTER SETTING TOOL GROUP
1. 1P7410 Timing Plate. 2. 5P1768 Pointer Assembly. 3 SP1761 Shaft. 5. 2S6160 Washer. 6. S509 Bolt. 7. S1594 Bolt.

The off engine setting makes an adjustment for wear of components in the injection pump housing. Adjustment of the accessory drive shaft is a compensation for wear in the timing gears, accessory drive shaft and the camshaft of the injection pumps.

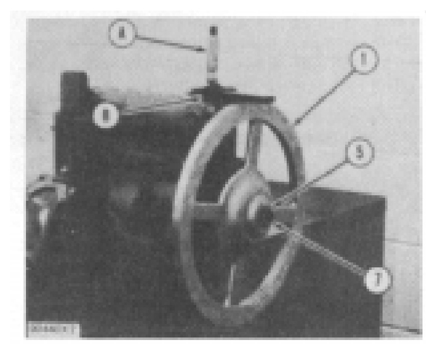
1. Fasten the 5P1768 Pointer Assembly (2) to the pump housing using S509 Bolt (6).



INSTALLATION OF THE 5P1768 POINTER ASSEMBLY
2. 5P1768 Pointer Assembly. 6. S509 Bolt

2. Install 5P1761 Shaft (3) in the IP7410 Plate (1). Put the plate with shaft on the drive end of the camshaft of the injection pump.

3. Install the 8S2291 Timing Pin through the hole in the pump housing and into the notch in the camshaft.



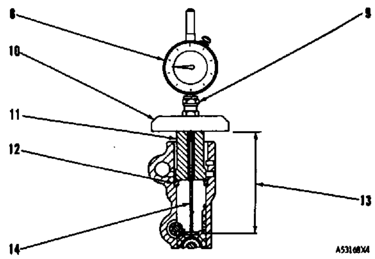
INSTALLATION OF THE 1P7410 PLATE
1. 1P7410 Plate. 5. 2S6160 Washer. 7. S1594 Bolt. A. Depth Micrometer and 4 to 5 in. (101.6 to 127.0 mm) rod. B. 8S7167 Gauge.

4. Put the 0° mark on the 1P7410 Plate (4) in alignment with the pointer and tighten S1594 Bolt (7).

NOTE: Be sure IP7410 Plate (1) does not move from 0° mark while bolt is tightened.

5. Remove the timing pin.

6. The fuel rack must be in the center position before the injection pumps can be removed. Push and hold the fuel rack against Pointer Assembly (2) to center the fuel rack.



MEASURING TIMING DIMENSION

8. 8S3158 Indicator. 9. 3P1565 Collet Clamp. 10. 5P4156 Base. 11. 5P4158 Gauge — 2.00 in. (50.8 mm) long. 12. Spacer. 13. Timing dimension. 14. 5P4163 Contact Point — 4.75 in. (120.7 mm) long.

7. Use the 8S4613 Wrench and 8S2244 Extractor to remove the injection pumps.

NOTE: When injection pumps, spacers and lifters are removed from the injection pump housing, keep the parts of each pump together so they can be installed back in their original location.

8. To adjust (calibrate) the dial indicator for the lifter measurements, use the procedure that follows:

    a. Put the 5P4157 Gauge [4.00 in. (101.6 mm)] on the 5P4159 Gauge Stand.

    b. With contact point in gauge hole, put the dial indicator and base on top of 5P4157 Gauge.

    c. Loosen the screw that locks the dial face. Move the dial face until the large pointer is on zero and tighten the screw.

    d. Make a record of the position of the small pointer. The dial indicator is now adjusted (calibrated).

NOTE: When measurement of the pump timing dimension (13) is made, find the difference between the adjustment reading and the present reading on the dial face. A dimension of 4.00 in. (101.6 mm) must be added to the difference in indicator readings for the correct measurement.

NOTE: The timing dimension can also be checked with the 8S7167 Gauge, 6F6922 Depth Micrometer, and 4 to 5 in. (101.6 to 127.0 mm) rod as shown in picture.

9. Make reference to the lifter setting chart for the timing plate degrees for the lifter being checked. To use the timing plate, turn it counterclockwise until the degree setting for the lifter to be checked is in alignment with the pointer.

LIFTER SETTING CHART (OFF ENGINE)		
Lifter Number(shown beside each pump hole)		**Turn Timing Plate Counterclockwise to (degrees)**
		DI (26.5°)
1		346.75°
4		286.75°
2		226.75°
6		166.75°
3		106.75°
5		46.75°

10. The correct timing dimension for off engine adjustment of the lifter is shown in the chart that follows:

TIMING DIMENSION (OFF ENGINE)
DI Engine
26.5°
4.344 ± .002 in.
(110.34 ± 0.05 mm)

11. The spacer (12) of each injection pump must be changed to change the timing dimension of that injection pump. Make reference to the spacer chart for spacer thickness.

SPACER CHART	
ENGINES WITH DIRECT INJECTION	
4N9837	.195 in. (4.95 mm)
4N9838	.199 in. (5.05 mm)
4N9839	.203 in. (5.16 mm)
4N9840	.207 in. (5.26 mm)
4N9841	.211 in. (5.36 mm)
4N9842	.215 in. (5.46 mm)
4N9843	.219 in. (5.56 mm)
4N9844	.223 in. (5.66 mm)

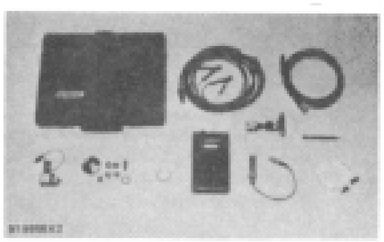
12. Make another check for all timing dimensions after all adjustments have been made.
13. Before the injection pumps are installed in the pump housing, the fuel rack MUST be in the center position. Push and hold the fuel rack against Pointer Assembly (2) when pumps are to be installed in housing bore. For correct alignment of pumps, make reference to INSTALLATION OF INJECTION PUMPS.
14. After the fuel injection pump housing is again installed on the engine, make reference to CAMSHAFT TIMING FOR THE FUEL INJECTION PUMP.

CHECKING LOW AND HIGH IDLE SPEED

Tools Needed:
6V3121 Multitach Group.

Engine rpm must be checked with an accurate tachometer.

The 6V3121 Multitach Group can measure engine speed by the use of either the photo pickup and reflective tape, or a magnetic pickup or tachometer generator.



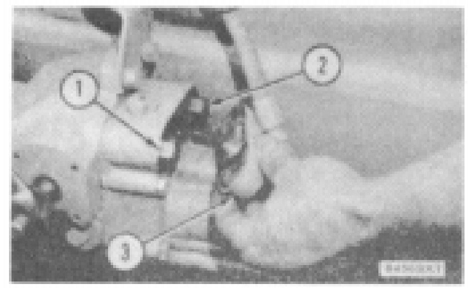
6V3121 MULTITACH GROUP

CAUTION
A mechanic with training in governor adjustments is the only one to make the adjustment to the low idle and high idle rpm. The correct low idle and high idle rpm, and the measurement for adjustment of the fuel rack are in the FUEL SETTING INFORMATION.

NOTE: The correct low idle and high idle rpm are in the FUEL SETTING INFORMATION.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.



IDLE ADJUSTMENT
1. Low idle screw. 2. High idle screw. 3. Cover.

Start the engine and run until the temperature of normal operation is reached. Check low and high idle rpm with no load on the engine. If an adjustment is necessary, use the procedure that follows:

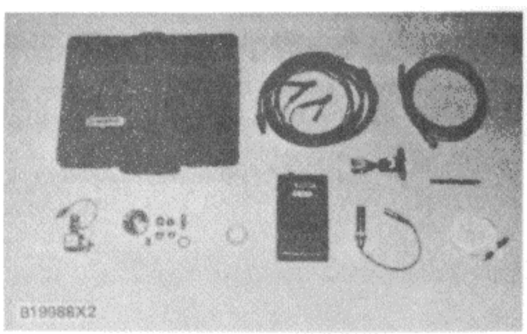
1. Remove cover (3) at the rear of the governor.
2. To adjust the LOW IDLE rpm, move the governor linkage to LOW IDLE position and turn screw (I). Increase the engine speed and then return linkage back to LOW IDLE position to check the setting again.
3. Move the governor linkage to HIGH IDLE position and turn screw (2) to adjust HIGH IDLE rpm. When the specific rpm setting is made, move the governor control to reduce engine speed, then move the linkage to HIGH IDLE and check the setting again. Repeat this procedure until rpm setting is correct.
4. When the governor adjustment is correct, install cover (3) on the rear of the governor.

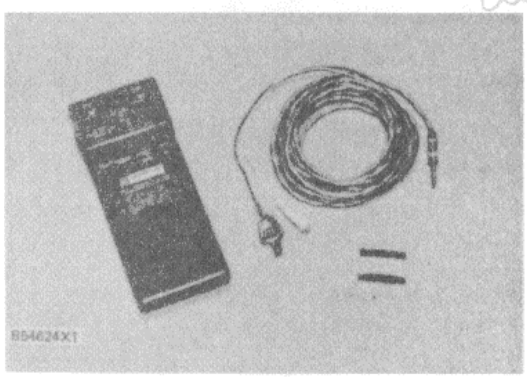
When the cover is installed on the governor, the idle adjustment screws fit into holes in the cover. The shape of the holes will not let the idle adjustment screw turn after the idle adjustment is done and the cover is installed.

5. Now install a new wire and seal to cover bolt.

SET POINT CHECK
Tools Needed:
6V3121 Multitach Group.
6V4060 Engine Set Point indicator Group.

Refer to SPECIAL INSTRUCTION FORM NO. SEHS7807 for instructions on the use of the 6V3121 Multitach Group. Refer to SPECIAL INSTRUCTION FORM NO. SEHS7931 for instructions on the use of the 6V4060 Engine Set Point Indicator Group.





6V4080 ENGINE SET POINT INDICATOR GROUP

Measurement of the set point of the engine is a way to find the actual full load rpm (speed) of the engine. The set point of an engine is:

a. Always 20 rpm more than the full load speed.
b. When the engine is just leaving the overrun (governed) condition, but has not yet reached the lug (non-governed) condition.
c. When the load stop pin starts touching the load stop (makes contact approximately 10% of the time).
d. Just before the rpm where the engine gets the maximum amount of fuel per stroke allowed by the governor.
e. Just before the rpm where an increase in load on the engine will put the engine into a lug (non-governed) condition.

NOTE : It is important, to the correct operation of the transmission, that the SET POINT is adjusted to the correct specifications.

NOTE : The rack setting must be correct before an adjustment is made to the SET POINT.

Use the procedure that follows to check the engine set point.

1. Install 6V3121 Multitach on 6V4060 Set Point Indicator. Connect the multitach speed sensor as per SPECIAL INSTRUCTION FORM NO. SEHS7807. Connect the set point indicator rack contact cable as per SPECIAL INSTRUCTION FORM NO. SEHS7931.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

2. Start the engine and let it run at low idle until normal operating temperature is reached. Be sure the multitach is correctly indicating the engine speed.
3. Run the engine to high idle with no load and make a record of the engines speed. The ENGINE 1 OVERRUN light on the set point indicator should be on.
4. Slowly and smoothly add load to the engine until the ENGINE 1 OVERRUN light just goes off. This is the engine set point. Make a record of the engines speed at set point.
5: . Repeat Steps 3 and 4 a minimum of five times. Make an average of the speeds recorded in Step 4. Subtract 20 rpm from the average set point to find the full load speed setting of the engine.
6. Stop engine. Make a comparison of the records from Steps 3 and 5 with information given in the FUEL SETTING INFORMATION.
7. If the full load speed is not correct, adjust the HIGH IDLE speed to make a change in the full load speed.

CAUTION

Do not adjust rpm above the range for HIGH IDLE given in FUEL SETTING INFORMATION. Damage to engine can result if setting Is too high.

8. If the high idle speed is out of tolerance and the full load speed is correct, look for a weak governor spring or the wrong governor spring. Both the full load speed and the high idle speed must be in the tolerance given in the FUEL SETTING INFORMATION.

ADJUSTMENT OF HYDRAULIC AIR-FUEL RATIO CONTROL

Tools Needed:

9S240 Rack Position Tool Group.
9S215 Dial Indicator.
9S8903 Contact Point (Flat Face with Bevel).
3P1565 Collet Clamp.
9S7350 Bracket Group.

1. The fuel rack setting must be correct before the adjustment for the hydraulic air-fuel ratio control can be checked or changed. Make reference to FUEL RACK SETTING.

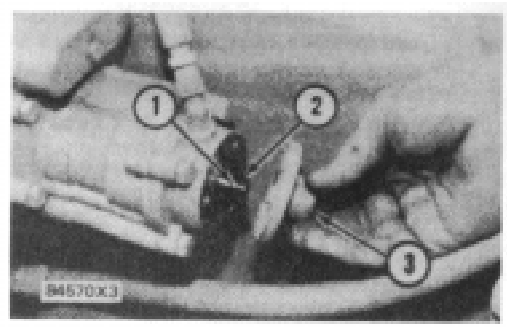
NOTE : Use the 9S215 Dial Indicator and 9S8903 Bracket Group from FUEL RACK SETTING to measure rack movement for air-fuel ratio control.

2. Remove cover (3) from the hydraulic air-fuel ratio control.
3. Start the engine.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

4. Push end of valve (1) in and hold it in for two or three seconds. This action will manually move the valve into position to operate with the engine.
5. Rapidly move the governor control lever in the fuel-on direction and read the measurement on the dial indicator. Read the indicator carefully because this reading will be a maximum for only a moment. See the FUEL SETTING INFORMATION to find the correct measurement.



HYDRAULIC AIR-FUEL RATIO CONTROL
1. Valve. 2 Pin. 3. Cover.

6. To make an adjustment to the hydraulic air-fuel ratio control, turn valve (1) in a clockwise direction to increase the amount of fuel possible (more rack travel) at the limited rack position. The counterclockwise direction will decrease the amount of fuel possible (less rack travel) at the limited rack position.
7. After each adjustment is made, the governor control lever must be moved rapidly from the low idle position in the fuel-on direction before an accurate reading can be made.
8. After the correct adjustment has been made, put cover (3) in alignment with pin (2) in the valve and turn the cover to put it in alignment with the nearest bolt holes. Install the bolts.
9. Stop the engine.
10. After the oil pressure has gone out of the hydraulic air-fuel ratio control, full rack travel must be available.
11. Now install the wire and seal on the control.

AIR INLET AND EXHAUST SYSTEM

RESTRICTION OF AIR INLET AND EXHAUST

There will be a reduction of horsepower and efficiency of the engine if there is a restriction in the air inlet or exhaust system.

Air flow through the air cleaner must not have a restriction of more than 30 in. (762 mm) of water difference in pressure.

Back pressure from the exhaust (pressure difference measurement between exhaust outlet elbow and atmosphere) must not be more than 34 in. (864 mm) for naturally aspirated and 27 in. (686 mm) for turbocharged engines.

MEASUREMENT OF PRESSURE IN INLET MANIFOLD

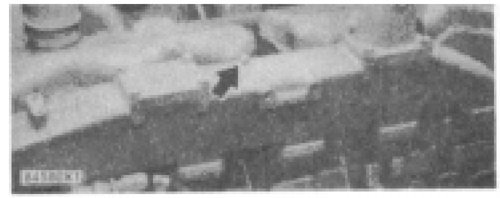
The efficiency of an engine can be checked by making a comparison of the pressure in the inlet manifold with the information given in the FUEL SETTING INFORMATION. This test is used when there is a decrease of horsepower from the engine, yet there is no real sign of a problem with the engine.

The correct pressure for the inlet manifold is given in the FUEL SETTING INFORMATION. Development of this information is done with these conditions:

a. 29.4 in. (747 mm) of mercury barometric pressure.
b. 85°F (29°C) outside air temperature.
c. 35 API rated fuel.

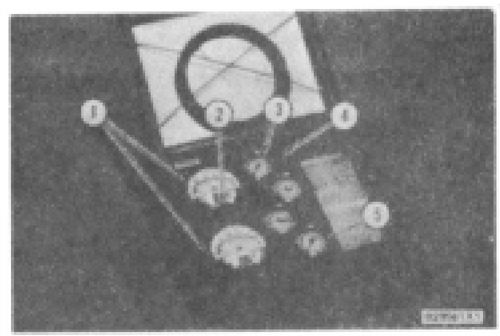
Any change from these conditions can change the pressure in the inlet manifold. Outside air that has higher temperature and lower barometric pressure than given above will cause a lower horsepower and a lower inlet manifold pressure measurement than given in the FUEL SETTING INFORMATION. Outside air that has a lower temperature and a higher barometric pressure will cause higher horsepower and a higher inlet manifold pressure measurement.

A difference in fuel rating will also change horsepower and the pressure in the inlet manifold. If the fuel is rated above 35 API, pressure in the inlet manifold can be less than given in the FUEL SETTING INFORMATION. If the fuel is rated below 35 API, the pressure in the inlet manifold can be more than given in the FUEL SETTING INFORMATION. BE SURE THAT THE AIR INLET AND EXHAUST DO NOT HAVE A RESTRICTION WREN MAKING A CHECK OF PRESSURE IN THE INLET MANIFOLD.



PLUG FOR PRESSURE TEST

Use the 6V3150 Engine Pressure Group to check the pressure in the inlet manifold.

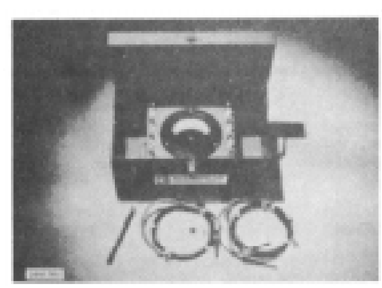


6V3150 ENGINE PRESSURE GROUP

1. Differential pressure gauges. 2. Zero adjustment screw. 3. Pressure gauge 0 to 160 psi (0 to 1100 kPa). 4. Pressure tap. 5. Pressure gauge 0 to 60 psi (0 to 415 kPa).

This tool group has a gauge to read pressure in the inlet manifold. Special Instruction Form No. SEHS7851 is with the tool group and gives instructions for the test procedure.

MEASUREMENT OF EXHAUST TEMPERATURE



1P3060 PYROMETER GROUP

Use the 1P3060 Pyrometer Group to check exhaust temperature. Special Instruction Form No. SMHS7179 is with the tool group and gives instructions for the test procedure.

CRANKCASE (CRANKSHAFT COMPARTMENT) PRESSURE

Pistons or piston rings that have damage can be the cause of too much pressure in the crankcase. This condition will cause the engine to run rough. There will also be more than the normal amount of fumes coming from the crankcase breather. This crankcase pressure can also cause the element for the crankcase breather to have a restriction in a very short time. It can also be the cause of oil leakage at gaskets and seals that would not normally have leakage.

COMPRESSION

An engine that runs rough can have a leak at the valves, or valves that need adjustment. Run the engine at the speed that gives rough running. To find a cylinder that has low compression or does not have good fuel ignition, loosen a fuel line nut at a fuel injection pump. This will stop the flow of fuel to that cylinder. Do this for each cylinder until a loosened fuel line is found that makes no difference in engine rough running. Be sure to tighten each fuel line nut after the test before the next fuel line nut is loosened. This test can also be an indication that the fuel injection is wrong, so more checking of the cylinder will be needed. This test is just a fast method of finding the cause of compression loss in a cylinder. Removal of the head and inspection of the valves and valve seats is necessary to find those small defects that do not normally cause a problem. Repair of these problems is normally done when reconditioning (overhaul) the engine.

CYLINDER HEAD

The cylinder head has valve seat inserts, valve guides, and bridge dowels that can be removed when they are worn or have damage. Replacement of these components can be made with the following tools.

Valves

Valve removal and installation is easier with use of 5S1330 Valve Spring Compressor Assembly and 5S1322 Valve Keeper Inserter.

Valve Seat Inserts

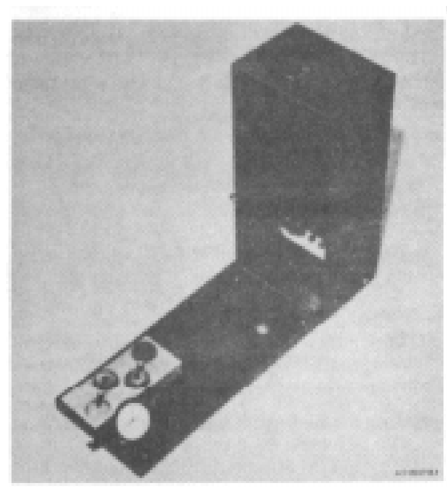
Tools needed to remove and install valve seat inserts are in the 9S3080 Valve Insert Puller Group. The insert can be more easily installed by lowering the temperature of the insert before installing it in the head.

Valve Guides

Tools needed to install valve guides are: 5P2396 Driver Bushing and 7S8859 Driver. The counterbore in the driver bushing installs the guide to the correct height. Use a 1P7450 Honing Arrangement to make a finished bore in the valve guide after installing the guide in the head. Grind the valves after installing new valve guides.

Checking Valve Guide Bore

Use the 5P3536 Valve Guide Gauge Group to check the bore of the valve guides. Special Instructions GMG02562 gives complete and detailed instructions for use of the 5P3536 Dial Bore Gauge Group.



5P3536 VALVE GUIDE GAUGE GROUP

Bridge Dowel

Use a 5P944 Dowel Puller Group with a 5P942 Extractor to remove the bridge dowels. Install a new bridge dowel with a 5P2406 Dowel Driver. This dowel driver installs the bridge dowel to the correct height.

BRIDGE ADJUSTMENT

When the head is disassembled, keep the bridges with their respective cylinders. Adjustment of the bridge will be necessary only after grinding the valves or other reconditioning of the cylinder head is done. Make an adjustment to the bridge using the following procedure.

NOTE: Valves must be fully closed.

BRIDGE ADJUSTMENT

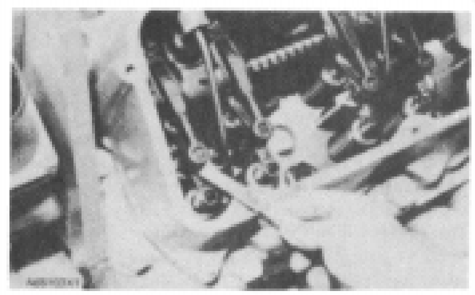
1. Put engine oil on the bridge dowel in the cylinder head and in the bore in the bridge.
2. Install the bridge with the adjustment screw toward the exhaust manifold.
3. Loosen the locknut for the adjustment screw and loosen the adjustment screw several turns.
4. Put a force on the bridge with a finger to keep the bridge in contact with the valve stem opposite the adjustment screw.
5. Turn the adjustment screw clockwise until it just makes contact with the valve stem. Then turn the adjustment screw 30° more in a clockwise direction to make the bridge straight on the dowel and to make compensation for the clearance in the threads of the adjustment screw.
6. Hold the adjustment screw in this position and tighten the locknut to 22 ± 3 lb. ft. (28 ± 4 N•m).
7. Put engine oil at the point where the rocker arm makes contact with the bridge.

VALVE CLEARANCE SETTING

NOTE: Valve clearance is measured between the rocker arm and the bridge for the valves.

VALVE CLEARANCE CHECK: ENGINE STOPPED
Exhaust .... 027 to .033 in. (0.69 to 0.84 mm)
Intake .... .012 to .018 in. (0.30 to 0.46 mm)

NOTE : When the valve lash (clearance) is checked, adjustment is NOT NECESSARY if the measurement is in the range given in the chart for VALVE CLEARANCE CHECK: ENGINE STOPPED. If the measurement is outside this range, adjustment is necessary. See the chart for VALVE CLEARANCE SETTING: ENGINE STOPPED, and make the setting to the nominal (desired) specifications in this chart.



TYPICAL VALVE CLEARANCE CHECK

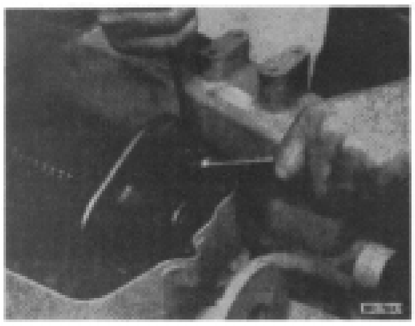
To make an adjustment to the valve clearance, turn the adjustment screw in the rocker arm. It is not necessary to change the bridge adjustment for normal valve clearance adjustments. Valve clearance adjustments can be made by using the procedure that follows:

VALVE CLEARANCE SETTING: ENGINE STOPPED
Exhaust ....030 in. (0.76 mm)
Intake ....016 in. (0.38 mm)

1. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to FINDING TOP CENTER COMPRESSION POSITION FOR NO. 1 PISTON.

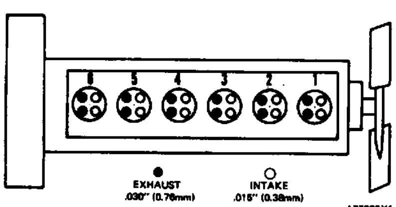
2. Make an adjustment to the valve clearance on the intake valves for cylinders 1, 2, and 4. Make an adjustment to the valve clearance on the exhaust valves for cylinders 1, 3, and 5.

3. After each valve adjustment, tighten the nut for valve adjustment screw to 22 ± 3 lb. ft. (28 ± 4 N•m) and check the adjustment again.



VALVE ADJUSTMENT

4. Remove the timing bolt and turn the flywheel 360° in the direction of engine rotation. This will put No. 6 piston at top center (TC) on the compression stroke. Install the timing bolt in the flywheel.
5. Make an adjustment to the valve clearance on the intake valves for cylinders 3, 5, and 6. Make an adjustment to the valve clearance on the exhaust valves for cylinders 2, 4, and 6.
6. Remove the timing bolt from the flywheel when all adjustments to the valve clearances have been made.



CYLINDER AND VALVE LOCATION

LUBRICATION SYSTEM

One of the problems in the list that follows will generally be an indication of a problem in the lubrication system for the engine.

TOO MUCH OIL CONSUMPTION
OIL PRESSURE IS LOW
OIL PRESSURE IS HIGH
TOO MUCH BEARING WEAR
INCREASED OIL TEMPERATURE

TOO MUCH OIL CONSUMPTION

Oil Leakage on Outside of Engine

Check for leakage at the seals at each end of the crankshaft. Look for leakage at the oil pan gasket and all lubrication system connections. Check to see if oil comes out of the crankcase breather. This can be caused by combustion gas leakage around the pistons. A dirty crankcase breather will cause high pressure in the crankcase, and this will cause gasket and seal leakage.

Oil Leakage Into Combustion Area of Cylinders

Oil leakage into the combustion area of the cylinders can be the cause of blue smoke. There are four possible ways for oil leakage into the combustion area of the cylinders:

1. Oil leakage between worn valve guides and valve stems.
2. Worn or damaged piston rings, or dirty oil return holes.
3. Compression ring and/or intermediate ring not installed correctly.
4. Oil leakage past the seal rings in the impeller end of the turbocharger shaft.

Too much oil consumption can also be the result if oil with the wrong viscosity is used. Oil with a thin viscosity can be caused by fuel leakage into the crankcase, or by increased engine temperature.

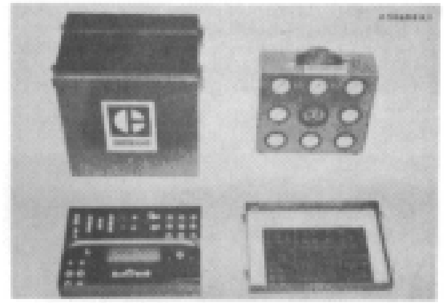
MEASURING ENGINE OIL PRESSURE

Tools Needed:

5P6225 Hydraulic Test Box.
9S9102 Thermistor Thermometer Group.

An oil pressure gauge that has a defect can give an indication of low oil pressure.

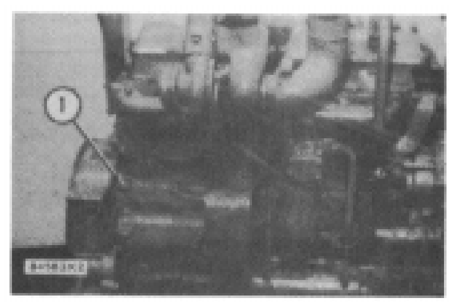
An 8M2744 Oil Pressure Gauge which is part of the 5P6225 Hydraulic Test Box can be used to check oil pressure in the system.



5P6225 HYDRAULIC TEST BOX

This procedure must be followed exactly for the pressure readings to have any value for comparison with Engine Oil Pressure Chart.

1. Be sure that the engine is filled to the correct level with SAE 30 oil. If any other viscosity of oil is used, the information in the Engine Oil Pressure Chart does not apply.
2. Find a location on the oil manifold to install a tee. The easiest method is to remove the sending unit for the present gauge and install a tee at this location. Install a probe from the 9S9102 Thermistor Thermometer Group in one side of the tee. Connect an 8M2744 Gauge from the 5P6225 Hydraulic Test Box to the other side of the tee.



OIL MANIFOLD
1. Pressure test location.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

3. Run the engine to get the oil temperature at 200 ± 10°F (93 ± 6°C).
4. Keep the oil temperature constant with the engine at the rated rpm from the chart, and read the pressure gauge.

ENGINE OIL PRESSURE				
	SAE 30 OIL			
	Temperature		Pressure	
Engine rpm Rating	°F	°C	psi	kPa
2100	200 ± 10	93± 6	60 ± 7	415 ± 50
Low Idle	200 ± 10	93 ± 6	30 ± 5	205 ± 35

If the results do not fall within the pressure range given in the chart, find the cause and correct it. Engine failure or a reduction in engine life can be the result if engine operation is continued with oil manifold pressure outside this range.

OIL PRESSURE IS LOW

Crankcase Oil Level

Check the level of the oil in the crankcase. Add oil if needed. It is possible for the oil level to be too far below the oil pump supply tube. This will cause the oil pump to not have the ability to supply enough lubrication to the engine components.

Oil Pump Does Not Work Correctly

The inlet screen of the supply tube for the oil pump can have a restriction. This will cause cavitation (low pressure bubbles suddenly made in liquids by mechanical forces) and a loss of oil pressure. Air leakage in the supply side of the oil pump will also cause cavitation and loss of oil pressure. If the bypass valve for the oil pump is held in the open (unseated) position, the lubrication system can not get to maximum pressure. Oil pump gears that have too much wear will cause a reduction in oil pressure.

Oil Filter Bypass Valves

If the bypass valve for the oil filter is held in the open position (unseated) because the oil filter has a restriction, a reduction in oil pressure can result. To correct this problem, remove and clean the bypass valve and bypass valve bore. Install a new Caterpillar oil filter to be sure that no more debris makes the bypass valve stay open.

Too Much Clearance at Engine Bearings or Open Lubrication System (Broken or Disconnected Oil Line or Passage)

Components that are worn and have too much bearing clearance can cause oil pressure to be low. Low oil pressure can also be caused by an oil line or oil passage that is open, broken or disconnected.

Piston Cooling Tubes (Jets)

When engine is operated, cooling jets direct oil toward the bottom of the piston to lower piston and ring temperatures. If there is a failure of one of the jets, or it is bent in the wrong direction, seizure of the piston will be caused in a very short time.

Use the 5P8709 Piston Tool Group to check and adjust the alignment of piston cooling jets.

OIL PRESSURE IS HIGH

Oil-pressure will be high if the bypass valve for the oil pump can not move from the closed position.

TOO MUCH BEARING WEAR

When some components of the engine show bearing wear in a short time, the cause can be a restriction in an oil passage. A broken oil passage can also be the cause.

If the gauge for oil pressure shows enough oil pressure, but a component is worn because it can not get enough lubrication, look at the passage for oil supply to the component. A restriction in a supply passage will not let enough lubrication get to a component, and this will cause early wear.

INCREASED OIL TEMPERATURE

Look for a restriction in the oil passages of the oil cooler. If the oil cooler has a restriction, the oil temperature will be higher than normal when the engine is operated. The oil pressure of the engine will not get low just because the oil cooler has a restriction.

Also check the oil cooler bypass valve to see if it is held in the open position (unseated). This condition will let the oil through the valve instead of the oil cooler, and oil temperature will increase.

COOLING SYSTEM

This engine has a pressure type cooling system. A pressure type cooling system gives two advantages. The first advantage is that the cooling system can have safe operation at a temperature that is higher than the normal boiling (steam) point of water. The second advantage is that this type system prevents cavitation (the sudden making of low pressure bubbles in liquids by mechanical forces) in the water pump. With this type system, it is more difficult for an air or steam pocket to be made in the cooling system.

The cause for an engine getting too hot is generally because regular inspections of the cooling system were not made. Make a visual inspection of the cooling system before testing with testing equipment.

VISUAL INSPECTION OF THE COOLING SYSTEM

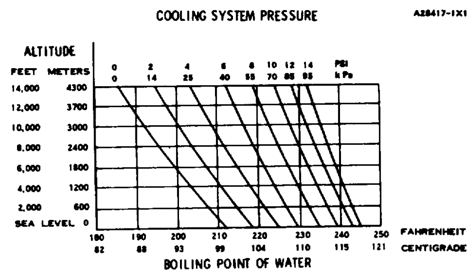
⚠ WARNING

DO NOT loosen the filler cap or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

1. After the engine is cool, loosen the filler cap (on radiator with a pressure cap turn it to the first stop) to let pressure out of the cooling system. Then remove filler or pressure cap.
2. Check coolant level in the cooling system.
3. Look for leaks in the system.
4. Look for bent radiator fins. Be sure that air flow through the radiator does not have a restriction.
5. Inspect the drive belts for the fan.
6. Check for damage to the fan blades.
7. Look for air or combustion gas in the cooling system.
8. Inspect the filler cap and the surface that seals the cap. This surface must be clean.

TESTING THE COOLING SYSTEM

Remember that temperature and pressure work together. When making a diagnosis of a cooling system problem, temperature and pressure must both be checked. Cooling system pressure will have an effect on cooling system temperatures. For an example, look at the chart to see the effect of pressure and height above sea level on the boiling (steam) point of water.



Checking Coolant Temperatures

Tools Needed: 989102 Thermistor Thermometer Group.

The 9S9102 Thermistor Thermometer Group is used in the diagnosis of overheating (engine running too hot) or overcooling (engine runs too cool) problems. This group can be used to check temperatures in several different parts of the cooling system.

9S9102 THERMISTOR THERMOMETER GROUP

The locations for making the temperature checks with probe are listed below:

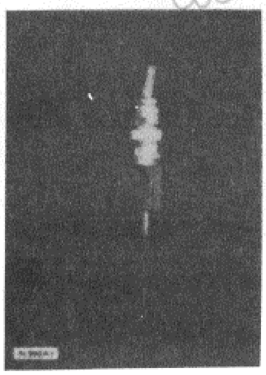


Fig. 1

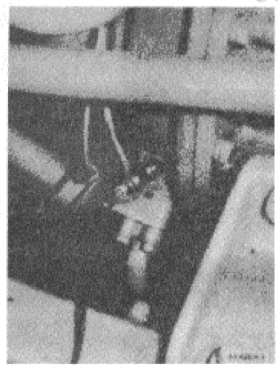


Fig. 2
(Typical Illustration)

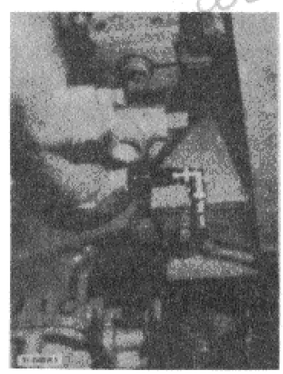


Fig. 3
(Typical Illustration)

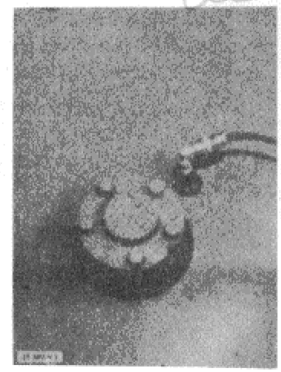


Fig. 4
(Typical Illustration)

Fig. 1. Ambient (air temperature away from the machine an not in direct sunlight).
Fig. 2. Top tank (in a pipe plug location in the top tank of the radiator and in the housing for the regulators or in the water manifold).
Fig. 3. Bottom tank (in the drain outlet for the radiator or the pipe plug location in the lower elbow of the radiator).
Fig. 4. Torque converter (in a pipe plug location of the oil outlet for the torque converter).

PROBE LOCATIONS	TEMPERATURES	PROBLEM	CHECK FOR
Top Tank (Fig. 2) and Ambient (Fig. 1)	Maximum 110° F (61° C) difference.	Overheating	Wrong Gear Selection. Radiator Core with Restriction to Air Flow. Bent Radiator Fins. Low Fan Speed. Damaged Fan Guard. Wrong Blade Position.
Top Tank (Fig. 2) and Bottom Tank (Fig. 3)	Maximum 15° F (90 C) difference.	Not enough Water Flow	Defect in Water Pump. Collapsed Hoses. Restriction in Radiator Core Tubes. Low Coolant Level.
Top Tank (Fig. 2) and Torque Converter Oil Outlet (Fig. 4)	Under normal conditions, temperature difference maximum 400 F (22° C). At stall conditions, normal temperature of torque converter oil 270° F (132° C) for any extended period of time.	Overheating	Wrong Gear Selection. Engine Operated with too Great a Load. Leakage Inside Torque Converter. Low Oil Flow From Torque Converter to Cooler.
Top Tank (Fig. 2) and Regulator Housing (Fig. 2)	Maximum 2° F (1° C) difference with regulators open.	Overcooling Overheating	Temperature Regulator will not Close. Regulator Seals Leaking. Coolant Flow Past the Regulator Flange. Low Ambient Temperature with Light Loads. Temperature Regulators will not Open.

Be sure the probe is installed in the liquid of the system being tested.

CAUTION

Do not tighten the probe to more than 30 lb. ft. (40 N-m) torque.

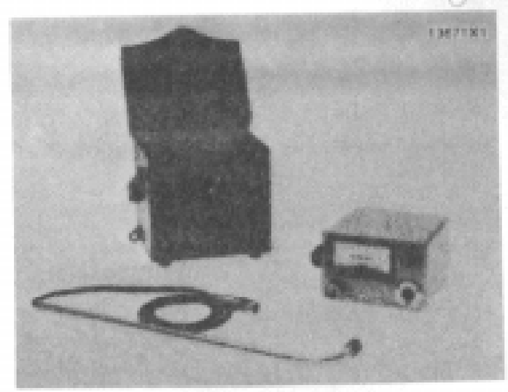
Check temperatures in the locations listed in the chart and make a comparison of these temperatures. Look at the chart to see if these comparisons are within the range in the chart. Make the needed checks if the temperatures are not within the ranges.

NOTE: To get the correct reading, make a measurement of the temperatures during working conditions.

Checking Radiator Air Flow

Tools Needed: 987373 Air Meter Group.

The 9S7373 Air Meter Group is used to check the air flow through the radiator core. Overheating can be caused by installing the wrong fan guard, low fan speed, or a restriction in the radiator core (clogging). The meter will give aid in finding a restriction in the core.



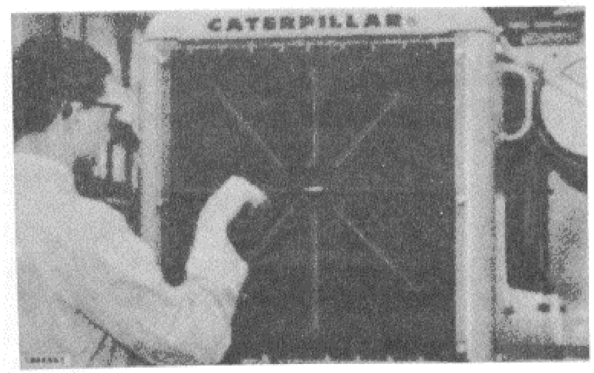
987373 AIR METER GROUP

⚠ WARNING

The machine can move suddenly. Damage or Injury to personnel is possible. When checks are made, put the transmission in NEUTRAL. Put the parking brake on. Lower all implements.

⚠ WARNING

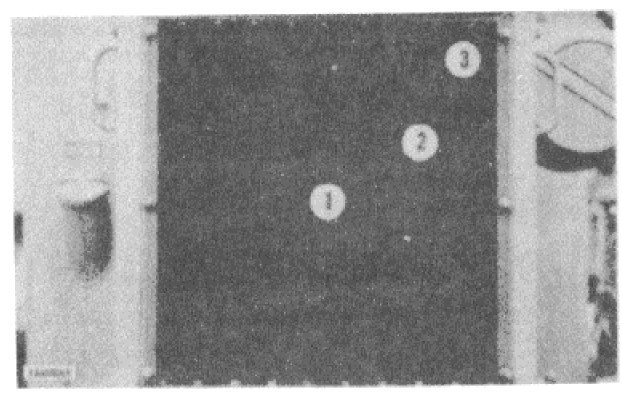
The radiator air flow can cause foreign material or dirt to move very fast. Injury to personnel is possible. Always wear eye protection.



CHECKING AIR FLOW IN CROSS AND DIAGONAL LINES
(Typical Illustration)

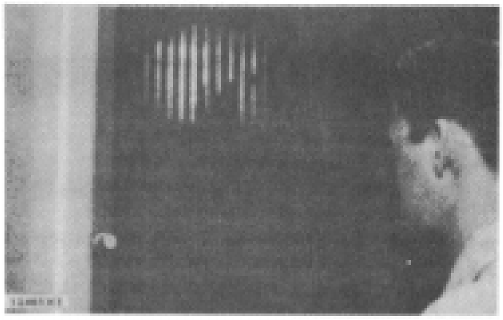
Take readings in a cross and diagonal pattern. Make a comparison of the readings in each line the same distance from the center of the fan. Permit differences for restrictions such as guards, braces and engine components which will cause a change in the rate of air flow.

NOTE: All readings are taken at engine LOW IDLE.



AIR FLOW
(Typical Illustration)

1. Fan Hub area. 2. Fan blade area. 3. Area outside



INSPECTING RADIATOR CORE FOR RESTRICTION (Typical Illustration)

Checking Fan Speed

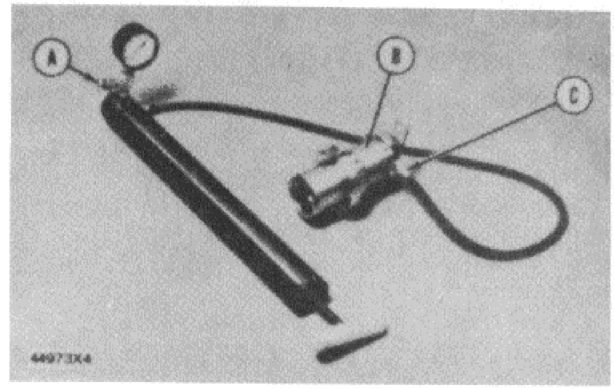
Tools Needed: 1P5500 Portable Phototach Group.

If the radiator core does not have a restriction, check the fan speed with the 1 P5500 Portable Phototach Group.

1P5500 PORTABLE PHOTOTACH GROUP

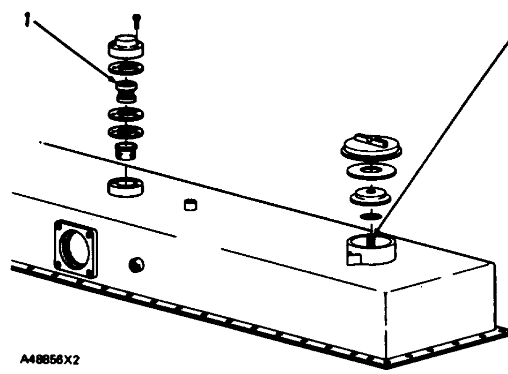
Filler Cap and Pressure Relief Valve

The 9S8140 Cooling System Pressurizing Pump Group is used to test pressure relief valves and to pressure check the cooling system for leaks.



9S8140 COOLING SYSTEM PRESSURIZING PUMP GROUP
A. Release valve. B. Adapter. C. Hose.

One cause for a pressure loss in the cooling system can be a bad seal on the radiator filler cap.



TYPICAL PRESSURE RELIEF VALVE SYSTEM
1. Pressure relief valve. 2. Stud for filler cap.

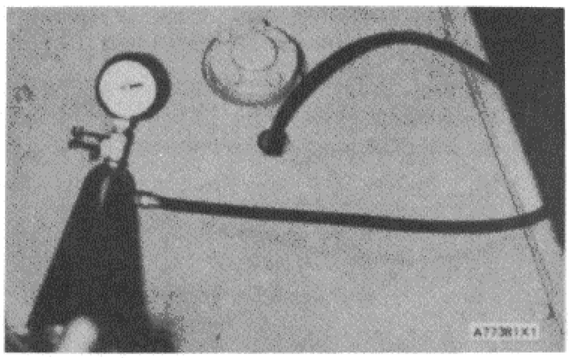
WARNING

DO NOT loosen the filler cap or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

Inspect the filler cap carefully. Look for damage to the seal or to the surface that seals. Any foreign material or deposits on the cap, seal or surface that seals, must be removed.

Use the procedure that follows to pressure check the cooling system:

1. Make sure the coolant level is above the top of the radiator core.
2. Install and tighten the filler cap.
3. Remove hose (C) from adapter (B).
4. Remove the pressure test plug from the radiator top tank.
5. Install the end of hose (C) in the hole for the pressure test plug as shown.



9S8140 PUMP GROUP INSTALLED

6. Operate the pump until the pointer on the pressure gauge no longer increases. The highest pressure indication on the gauge is the point that the relief valve opens. The correct pressure that makes the relief valve open is 15 to 18 psi (105 to 125 kPa).
7. If the relief valve does not open within pressure specification, replacement of the relief valve is necessary.
8. If the relief valve is within specifications, check the radiator for outside leakage.
9. Check all connections and hoses for the cooling system for outside leakage.
10. If you do not see any outside leakage and the pressure reading on the gauge is still the same after 5 minutes, the radiator and cooling system does not have leakage. If the reading on the gauge goes down and you do not see any outside leakage, there is leakage on the inside of the cooling system. Make repairs as necessary.

⚠ WARNING

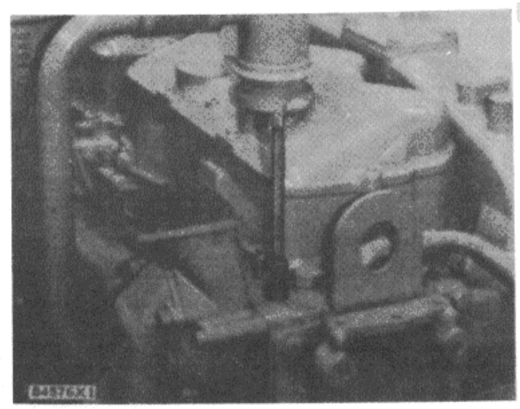
If a pressure indication is shown on the gauge, to avoid personal injury push release valve (A) to release all pressure in the system before removal of hose (C) from the radiator.

11. Remove hose (C) from radiator test pressure location.
12. Install plug in pressure test location.

Gauge for Water Temperature

Tools Needed: 9S9102 Thermistor Thermometer Group.
or
2F7112 Thermometer and 685072 Bushing.

If the engine gets too hot and a loss of coolant is a problem, a pressure loss in the cooling system could be the cause. If the gauge for water temperature shows that the engine is getting too hot, look for coolant leakage. If a place can not be found where there is coolant leakage, check the accuracy of the gauge for water temperature. Use the 9S9102 Thermistor Thermometer Group or the 2F7112 Thermometer and 6B5072 Bushing.



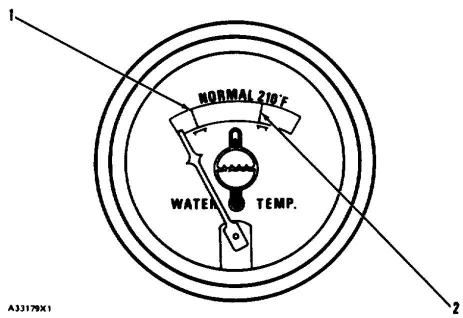
2F7112 THERMOMETER INSTALLED

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

Start the engine and run it until the temperature reaches the desired range according to the test thermometer. If necessary, put a cover over part of the radiator or cause a restriction of the coolant flow. The reading on the gauge for water temperature should agree with test thermometer within the tolerance range in the chart.

POINTER POSITION	TEST THERMOMETER	
	F°	C°
1	150 to 170	65 to 77
2	210 to 218	99 to 103



WATER TEMPERATURE GAUGE

Temperature Regulator

Test procedure for water temperature regulators:

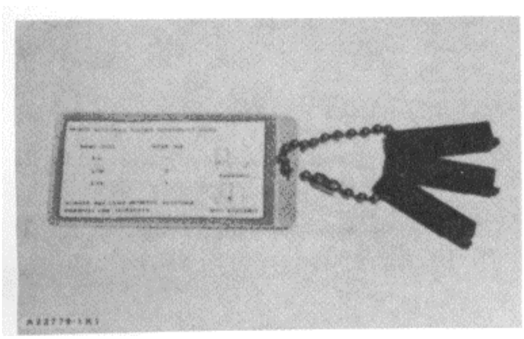
1. Remove the regulator from the engine.
2. Put heat to a pan of water. Get the temperature of the water to 1970F (920C).
3. Hang the regulator in the pan of hot water. Put the regulator completely under the water. Do not let the regulator make contact with the pan.
4. Keep the temperature of the water at 197°F (920C) for ten minutes. Make the water move around. This keeps all of the water at the same temperature.
5. After ten minutes, remove the regulator and immediately measure the distance the regulator is opened. The distance must be a minimum of 375 in. (9.53 mm).
6. If the distance is less than .375 in. (9.53 mm), make a replacement of the regulator.

V-BELT TENSION CHART										
BELT SIZE	WIDTH BELT TOP		WIDTH TOP OF PULLEY GROOVE		BELT TENSION "INITIAL"* GAUGE READING		BELT TENSION USED"** GAUGE READING		BORROUGHS GAUGE NUMBERS	
	In.	mm	In.	mm	lb.	N	lb.	N	OLD GAUGE NO.	NEW GAUGE NO.
3/8	.422	10.72	.380	9.65	100 ± 5	.445 ± 22	90 ± 5	400 ± 22	BT-33-73F	BT-33-95
1/2	.547	13.89	.500	12.70	120 ± 5	534 ± 22	90 ± 10	400 ± 44	BT-33-94-16	BT-33-95
5V	.625	15.88	.600	15.24	120 ± 5	534 ± 22	90 ± 10	400 ± 44	BT-33-72-4-15	BT-33-72C
11/16	.688	17.48	.625	15.88	120 ± 5	534 ± 22	90 ± 10	400 ± 44	BT-33-72-4-15	BT-33-72C
3/4	.750	19.05	.690	17.53	120 ± 5	534 + 22	90 ± 10	400 ± 44	BT-33-72-4-15	BT-33-72C
15/16	.938	23.83	.878	22.30	120 ± 5	534 ± 22	90 ± 10	400 ± 44	BT-33-72-4-15	BT-33-72C
MEASURE TENSION OF BELT FARTHEST FROM THE ENGINE										
*"INITIAL" BELT TENSION is for a new belt. **"USED" BELT TENSION is for a belt which has more than 30 minutes of operation at rated of engine. A10232X5										

BASIC BLOCK

PISTON RINGS

This engine has piston grooves and rings of the KEYSTONE (taper) design. A special 5P4812 Piston Ring Groove Gauge is available for checking the top two ring grooves in the piston.



5P4812 PISTON RING GROOVE GAUGE

CONNECTING RODS AND PISTONS

Use the 7M3978 Piston Ring Expander to remove or install piston rings.

Use the 5P3526 or 7M3977 Piston Ring Compressor to install pistons into cylinder block.

Tighten the connecting rod bolts in the following step sequence:

1. Put 2P2506 Thread Lubricant on bolt threads and contact surfaces of nut and cap.
2. Tighten all bolts to 60 ± 4 lb. ft. (80 ± 5 N-m).
3. Put a mark on each nut and end of bolt.
4. Tighten each nut 1200 from the mark.

The connecting rod bearings should fit tightly in the bore in the rod. If bearing joints or backs are worn (fretted), check for bore size as this is an indication of wear because of looseness.

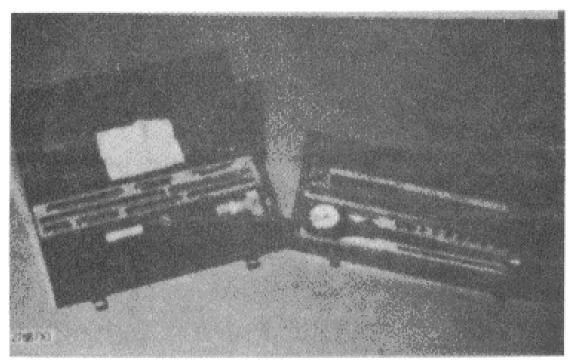
CONNECTING ROD AND MAIN BEARINGS

Bearings are available with .025 in. (0.64 mm) and .050 in. (1.27 mm) smaller inside diameter than the original size bearings. These bearings are for crank-shafts that have been "ground" (made smaller than the original size).

Main bearings are available with a larger outside diameter than the original size bearings. These bearings are for cylinder blocks that have had the bore for the main bearings "bored" (made larger than the original size.) The size available is .025 in. (0.64 mm) larger outside diameter than the original size bearings.

CYLINDER BLOCK

The bore in the block for main bearings can be checked with the main bearing caps installed without bearings. Tighten the nuts holding the caps to the torque shown in the SPECIFICATIONS. Alignment error in the bores must not be more than .003 in. (0.08 mm). 1P3537 Dial Bore Gauge Group can be used to check the size of the bores. Special Instruction Form No. GMG00981 is with the group.



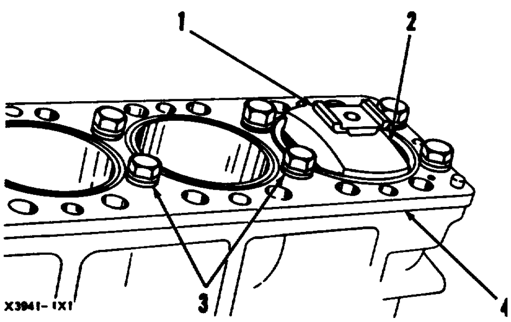
1P3537 DIAL BORE GAUGE GROUP

PROJECTION OF CYLINDER LINER

Tools Needed: 1P2396 Puller Plate.
887548 Push Puller Crossbar and three
3H465 Plates.
Four 3/4 in. 16NF Bolts, 3 in. (76.2 mm) long.
Two 3/4 in. 16NF Bolts, 7 in. (177.8 mm) long.
Eight 2F126 Seals (Copper Washers).
1P5510 Liner Projection Tool Group.
853140 Cylinder Block Counterboring Tool Arrangement.

Check liner projection above top plate as follows:

1. Make certain that top plate (4) and the cylinder liner flange are clean. Do not install liner seals during this check.

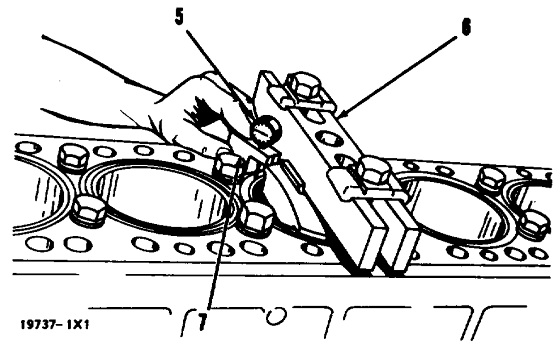


HOLDING TOP PLATE TO CYLINDER BLOCK
(Typical Example)
1. 3H465 Plate 2. 1P2396 Puller Plate. 3. 2F126 Seals (copper washers). 4. Top plate.

2. Use 3/4 in. NF bolts, 3 in. (76.2 mm) long, with two 2F126 Seals (3) on each bolt to hold the top plate (4) to the cylinder block. Install two bolts with seals (3) on each side of the cylinder liner. Tighten the bolts evenly, in four steps; 10 lb. ft. (14 N-m), 25 lb. ft. (35 N-m), 50 lb. ft. (70 N-m) and then to 70 lb. ft. (95 N-m).

NOTE: To keep from moving bolts and washers as each liner is checked, install two bolts with washers on each side of each cylinder liner, along the complete length of the top plate.

3. Use a 1P2396 Puller Plate (2), three 3H465 Plates (1), the crossbar (6) from the 8B7548 Push Puller, and two 3/4 in. 16NF bolts 7 in. (177.8 mm) long to hold the liner down.
4. Tighten the bolts evenly, in four steps; 5 lb. ft. (7 N-m), 15 lb. ft. (20 N-m), 25 lb. ft. (35 N-m), and then to 50 lb. ft. (70 N-m). Distance from bottom edge of crossbar to top plate must be the same on both sides of cylinder liner.
5. Use a 1P5510 Liner Projection Tool Group (5) to measure liner projection. Special Instruction, Form No. SMHS7727 is included with the tool.



MEASURING LINER HEIGHT PROJECTION
(Typical Example)
5. Dial indicator. 6. Crossbar. 7. 1P2402 Block.

6. Zero dial indicator (5) by using the back of 1P5507 Gauge with dial indicator (5) mounted in 1P2402 Block (7).
7. Liner projection must be .001 to .006 in. (0.03 to 0.15 mm). (Make the measurement to the flange of the liner, not the inner ring.) The maximum difference between high and low measurements made at four places around each liner is .002 in. (0.05 mm). The average projection of liners next to each other must not be more than .002 in. (0.05 mm). The maximum difference in the average projection for all cylinder liners must not be more than .004 in. (0.10 mm).

NOTE: If liner projection changes from point to point around the liner, turn the liner to a new position within the bore. If still not within specifications, move liner to a different bore.

NOTE: When liner projection is correct, put a temporary mark on the liner and top plate so when seals and band are installed, the liner can be installed in the correct position.

NOTE: Measure and check the following dimensions when installing new parts. With all dimensions correct, proceed with the above listed Steps.

a. Top plate thickness: .338 ± .001 in. (8.59 ± 0.03 mm).
b. Top plate gasket thickness: .008 ± .001 in. (0.20 ± 0.03 mm). (All surfaces must be clean and dry when installing gasket.)
c. Cylinder liner flange thickness: .3500 ± .0008 in. (8.890 ± 0.020 mm).

Liner projection can be adjusted by machining the contact face of the cylinder block with use of the 8S3140 Cylinder Block Counterboring Tool Arrangement. Form FM055228 is part of the cylinder block counterboring tool arrangement and gives tool arrangement and tool usage information.

The counterboring depth ranges from a minimum of.030 in. (0.76 mm) to a maximum of .045 in. (1.14 mm). Put a .030 in. (0.76 mm) shim directly beneath the liner flange and coat the top and bottom of the shim with 7M7260 Liquid Gasket. If more than one shim is installed put the other shims under the .030 in. (0.76 mm) shim and coat only top face of the top shim and the bottom face of the bottom shim with the 7M7260 Liquid Gasket.

The following shims are available for the adjustment of the liner projection:

ADJUSTMENT SHIMS FOR LINER PROJECTION				
SHIM THICKNESS, COLOR CODE, AND PART NUMBER				
.007 in. (0.18 mm)	.008 in. (0.20 mm)	.009 in. (0.23mm)	.015 in. (0.38mm)	.030 in. (0.76 mm)
BLACK	RED	GREEN	BROWN	BLUE
5S8138	5S8139	5SB140	5S8141	5S8142

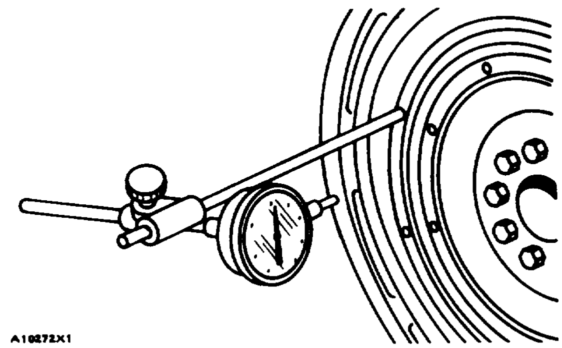
FLYWHEEL AND FLYWHEEL HOUSING

Tools Needed: 8S2328 Dial Indicator Group.

Heat the ring gear to install it. Do not heat to more than 600°F (315°C). Install the ring gear so the chamfer on the gear teeth are next to the starter pinion when the flywheel is installed.

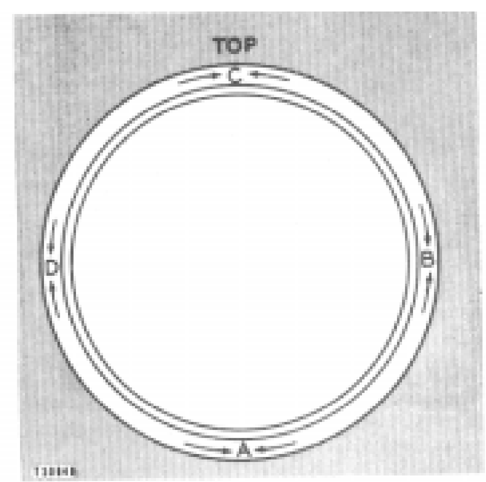
Face Run Out (axial eccentricity) of the Flywheel Housing

If any method other than given here is used, always remember bearing clearances must be removed to get correct measurements.



8S2328 DIAL INDICATOR GROUP INSTALLED

1. Fasten a dial indicator to the crankshaft flange so the anvil of the indicator will touch the face of the flywheel housing.



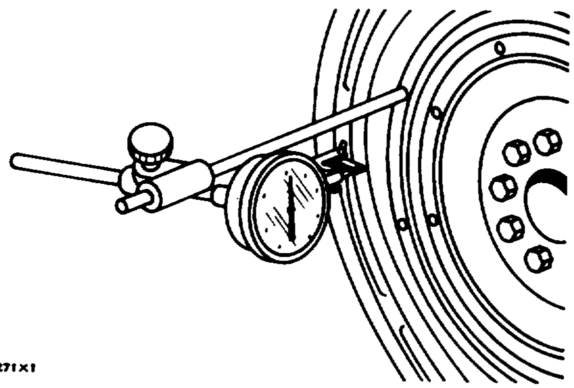
CHECKING FACE RUNOUT OF THE FLYWHEEL HOUSING
A. Bottom. B. Right side. C. Top. D. Left side.

2. Put a force on the crankshaft toward the rear before reading the indication at each point.
3. With dial indicator set at .000 in. (0.0 mm) at location (A), turn the crankshaft and read the indicator at locations (B), (C) and (D).

4. The difference between lower and higher measurements taken at all four points must not be more than .012 in. (0.30 mm), which is the maximum permissible face run out (axial eccentricity) of the flywheel housing.

Bore Runout (radial eccentricity) of the Flywheel Housing

1. Fasten the dial indicator as shown so the anvil of the indicator will touch the bore of the flywheel housing.

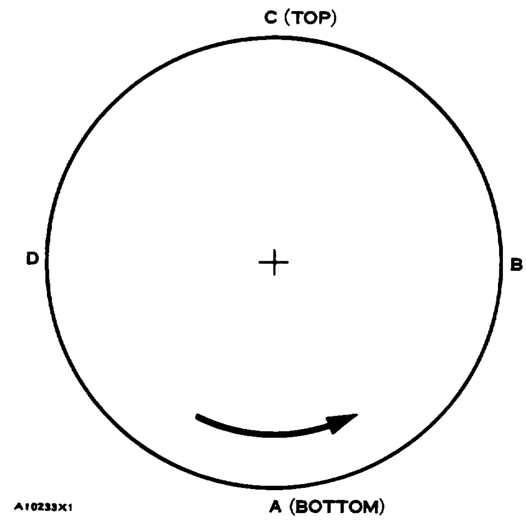


8S2328 DIAL INDICATOR GROUP INSTALLED

2. With the dial indicator in position at (C), adjust the dial indicator to "0" (zero). Push the crank-shaft up against the top of the bearing. Write the measurement for bearing clearance on line 1 in column (C).

NOTE: Write the dial indicator measurements with their positive (+) and negative (-) notation (signs). This notation is necessary for making the calculations in the chart correctly.

3. Divide the measurement from Step 2 by 2. Write this number on line I in columns (B) & (D).
4. Turn the crankshaft to put the dial indicator at (A). Adjust the dial indicator to "0" (zero).
5. Turn the crankshaft counterclockwise to put the dial indicator at (B). Write the measurement in the chart.



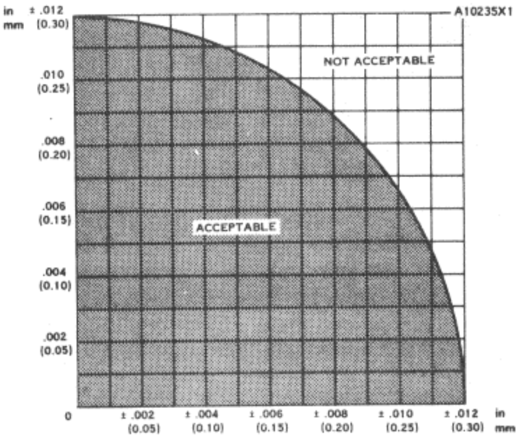
CHECKING BORE RUNOUT OF THE FLYWHEEL HOUSING.

6. Turn the crankshaft counterclockwise to put the dial indicator at (C). Write the measurement in the chart.
7. Turn the crankshaft counterclockwise to put the dial indicator at (D). Write the measurement in the chart.
8. Add lines I & II by columns.

CHART FOR DIAL INDICATOR MEASUREMENTS					
	Position of dial Indicator				
	Line No.	A	B	C	D
Correction for bearing clearance	I	0			
Dial Indicator Reading	II	0			
Total of Line 1& 2	III	0	**	*	**

*Total Vertical eccentricity (out of round).
**Subtract the smaller No. from the larger No. The difference is the total horizontal eccentricity. A10234X1

9. Subtract the smaller number from the larger number in line III in columns (B) & (D). The result is the horizontal "eccentricity" (out of round). Line III, column (C) is the vertical eccentricity.
10. On the graph for total eccentricity find the point of intersection of the lines for vertical eccentricity and horizontal eccentricity.

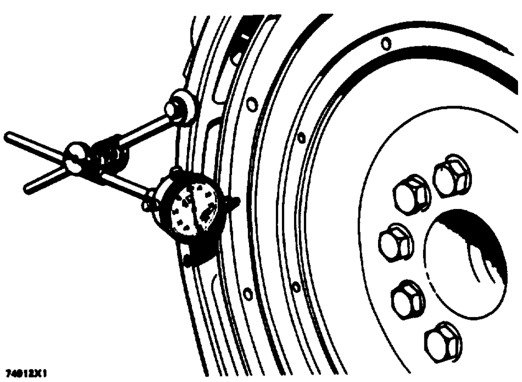


GRAPH FOR TOTAL ECCENTRICITY

11. If the point of intersection is in the range marked "Acceptable" the bore is in alignment. If the point of intersection is in the range marked "Not Acceptable", the flywheel housing must be changed.

Face Runout (axial eccentricity) of the Flywheel

1. Install the dial indicator as shown. Always put a force on the crankshaft in the same direction before the indicator is read so the crankshaft end clearance (movement) is always removed.



CHECKING FACE RUNOUT OF THE FLYWHEEL

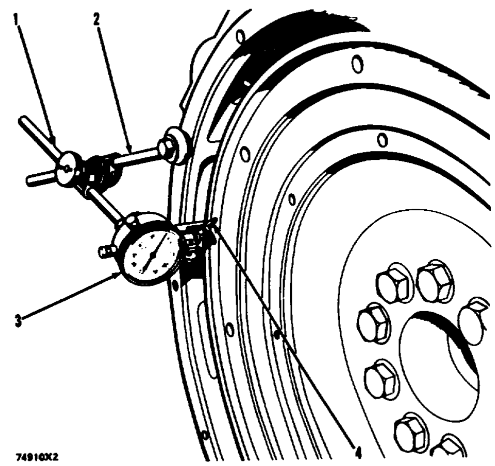
2. Set the dial indicator to read .000 in. (0.0 mm).

3. Turn the flywheel and read the indicator every 90°.

4. The difference between the lower and higher measurements taken at all four points must not be more than .006 in. (0.15 mm), which is the maximum permissible face runout (axial eccentricity) of the flywheel.

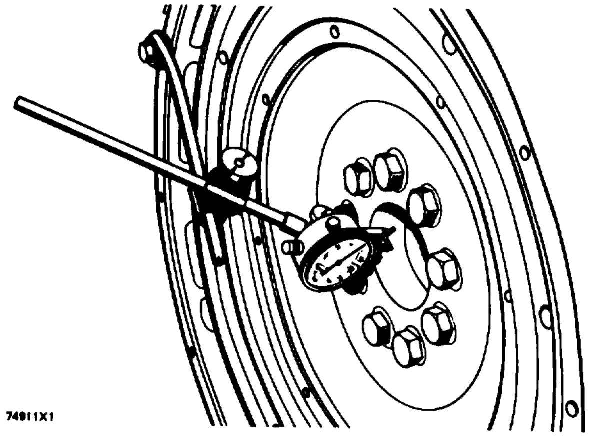
Bore Runout (radial eccentricity) of the Flywheel

1. Install the dial indicator (3) and make an adjustment of the universal attachment (4) so it makes contact as shown.



CHECKING BORE RUNOUT OF THE FLYWHEEL
1. 7H1945 Holding Rod. 2. 7H1645 Holding Rod. 3. 7H1942 Indicator. 4. 7H1940 Universal Attachment.

2. Set the dial indicator to read .000 in. (0.0 mm).
3. Turn the flywheel and read the indicator every 90°.
4. The difference between the lower and higher measurements taken at all four points must not be more than .006 in. (0.15 mm), which is the maximum permissible bore runout (radial eccentricity) of the flywheel.
5. Runout (eccentricity) of the bore for the pilot bearing for the flywheel clutch, must not exceed .005 in. (0.13 mm).

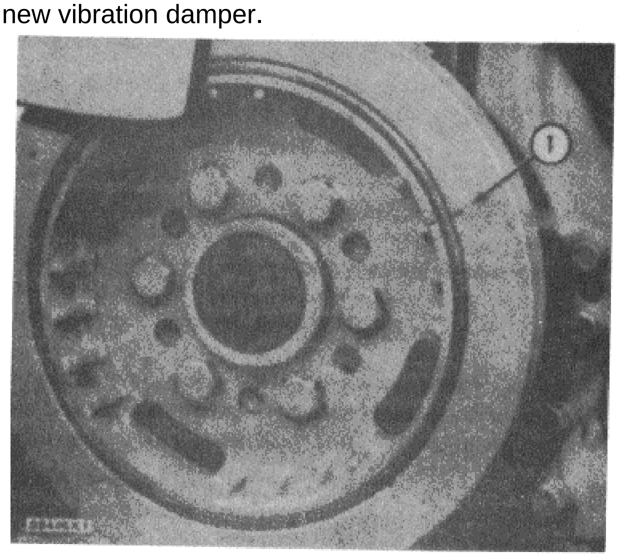


CHECKING FLYWHEEL CLUTCH PILOT BEARING BORE

VIBRATION DAMPER

Damage to or failure of the damper will increase vibrations and result in damage to the crankshaft. It will cause more gear train noise at variable points in the speed range.

The vibration damper has marks (1) on the hub and the ring. These marks give an indication of the condition of the vibration damper. If the marks are not in alignment, the rubber part (between the ring and the hub) of the vibration damper has had a separation from the ring and/or hub. If the marks are not in alignment, install a new vibration damper.



VIBRATION DAMPER

1. Alignment marks.

A used vibration damper can have a visual wobble (movement to the front and then to the rear when in rotation) on the outer ring and still not need replacement, because some wobble of the outer ring is normal. To see if the amount of wobble is acceptable, or replacement is necessary, check the damper with the procedure that follows:

1. Install a dial indicator, contact point and other parts as necessary to hold the dial indicator stationary. The contact point must be perpendicular (at 900 angle) to the face of the outer ring of the damper, and must make contact approximately at the center of the outer ring.

2. Push on the front end of the crankshaft so the end play (free movement on the centerline) is removed. Keep the crankshaft pushed back until the measurements are done.

3. Adjust the dial indicator to zero.

4. Turn the crankshaft 3600 and watch the dial indicator. A total indicator reading of .000 to .080 in. (0.00 to 2.03 mm) is acceptable.

ELECTRICAL SYSTEM

Most of the tests of the electrical system can be done on the engine. The wiring insulation must be in good condition, the wire and cable connections must be clean and tight, and the battery must be fully charged. If on the engine test shows a defect in a component, remove the component for more testing.

BATTERY

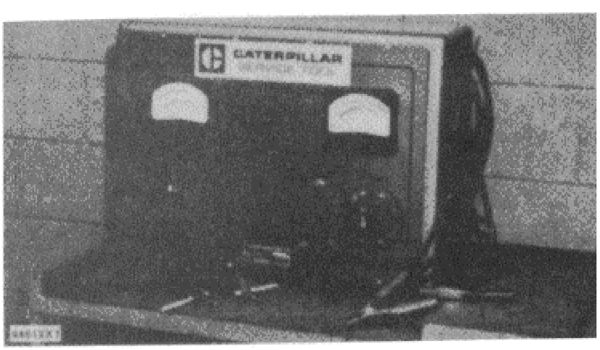
Tools needed: 5P300 Electrical Tester.
981990 or 1P7400 Battery Charger Tester.
SP957 or SP3514 Coolant and Battery Tester.

NOTE: Make reference to the instructions inside of the cover of the tester, when testing with the 5P300 Electrical Tester.

The battery circuit is an electrical load on the charging unit. The load is variable because of the condition of the charge in the battery. Damage to the charging unit will result, if the connections, (either positive or negative) between the battery and charging unit are broken while the charging unit is charging. This is because the battery load is lost and there is an increase in charging voltage. High voltage will damage, not only the charging unit but also the regulator and other electrical components.

⚠ WARNING

Never disconnect any charging unit circuit or battery circuit cable from battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.



9S1990 BATTERY CHARGER TESTER

Load test a battery that does not hold a charge when in use. To do this, put a resistance across the main connections (terminals) of the battery. For a 6, 8 or 12V battery, use a test load of three times the ampere/hour rating (the maximum test load on any battery is 500 amperes). Let the test load remove the charge (discharge) of the battery for 15 seconds and, with the test load still applied, test the battery voltage. A 6V battery in good condition will show 4.5V; an 8V battery will show 6V; a 12V battery will show 9V. Each cell of a battery in good condition must show 1.6V on either a 6, 8 or 12V battery.

CHARGING SYSTEM

Tools needed: 5P00 Electrical Tester.

NOTE: Make reference to the instructions inside of the cover of the tester, when testing with the 5P300 Electrical Tester.

The condition of charge in the battery at each regular inspection will show if the charging system is operating correctly. An adjustment is necessary when the battery is constantly in a low condition of charge or a large amount of water is needed (more than one ounce of water per cell per week or per every 50 service hours).

Make a test of the charging unit and voltage regulator on the engine, when possible, using wiring and components that are a permanent part of the system.
Off the engine (bench) testing will give a test of the charging unit and voltage regulator operation. This testing will give an indication of needed repair. After repairs are made, again make a test to give proof that the units are repaired to their original operating condition.

Before starting the on engine testing, the charging system and battery must be checked as given in the Steps below.

1. Battery must be at least 75% (1.240 Sp. Gr.) full charged and held tightly in place. The battery holder must not put too much stress on the battery.

2. Cables between the battery, starter and engine ground must be the correct size. Wires and cables must be free of corrosion and have cable support clamps to prevent stress on battery connections (terminals).

3. Leads, junctions, switches and panel instruments that have direct relation to the charging circuit must give correct circuit control.
4. Inspect the drive components for the charging unit to be sure they are free of grease and oil and have the ability to operate the charging unit.

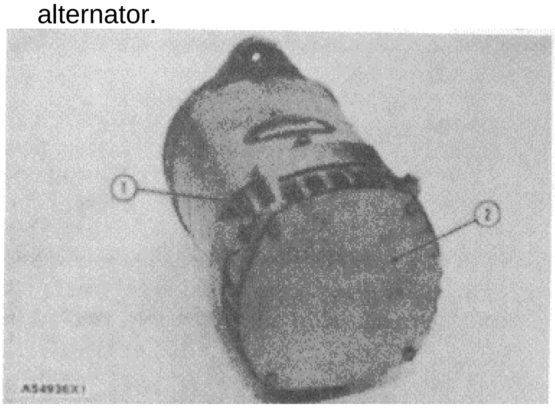
Alternator Regulator

Delco-Remy (3T188 Alternator)

When the alternator is charging the battery too much or not enough, an adjustment can be made to the alternator regulator. The voltage adjustment screw for the alternator is located under the end plate.

To adjust the voltage setting, use the procedure that follows:

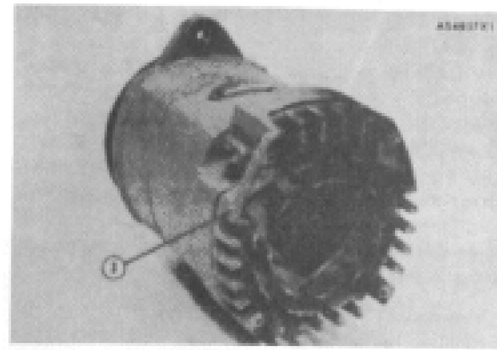
1. Remove end plate (2) and cover (3) from the alternator.



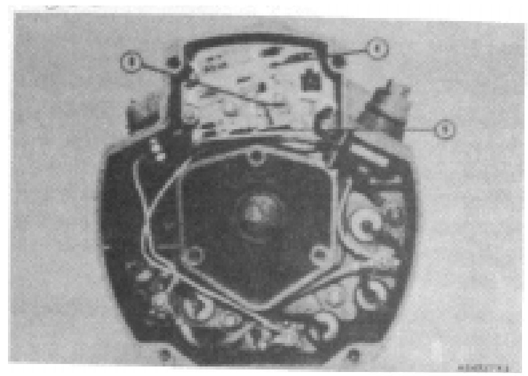
3T1888 ALTERNATOR
1. Adjustment screw under plug (earlier regulator).
2. End plate.

2. Remove the rubber sealant from the adjustment screw (4).
3. Use a voltmeter to measure alternator voltage output.
4. Turn Adjustment screw (4) counterclockwise to lower the voltage setting. Turn adjustment screw (4) clockwise to raise the voltage setting.
5. Put 3S6252 Rubber Sealant on adjustment screw (4) and install cover (3) and end plate (2).

CAUTION
Make certain that the field wire (5) is not located over the transistor pins (6). The pins can make a hole in the insulation of the wire.



LOCATION OF COVER
3. COVER



ALTERNATOR REGULATOR
4. VOLTAGE ADJUSTMENT SCREW.
5. FIELD WIRE. 6. TRANSISTOR PINS

STARTING SYSTEM

Tools Needed: SP300 Electrical Tester.

NOTE: Make reference to the instructions inside the cover of the tester, when testing with the 5P300 Electrical Tester.

Use a D.C. Voltmeter to find starting system components which do not function.

Move the starting control switch to activate the starter solenoid. Starter solenoid operation can be heard as the pinion of the starter motor is engaged with the ring gear on the engine flywheel.

If the solenoid for the starter motor will not operate, it is possible that the current from the battery is not getting to the solenoid. Fasten one lead of the voltmeter to the connection (terminal) for the battery cable on the solenoid. Put the other lead to a good ground. No voltmeter reading shows there is a broken circuit from the battery. More testing is necessary when there is a reading on the voltmeter.

The solenoid operation also closes the electric circuit to the motor. Connect one lead of the voltmeter to the solenoid connection (terminal) that is fastened to the motor. Put the other lead to a good ground. Activate the starter solenoid and look at the voltmeter. A reading of battery voltage shows the problem is in the motor. The motor must be removed for further testing. No reading on the voltmeter shows that the solenoid contacts do not close. This is an indication of the need for repair to the solenoid or an adjustment to be made to the starter pinion clearance.

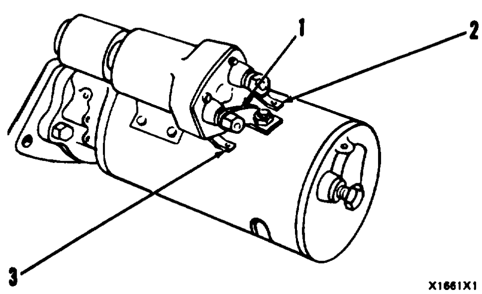
Make a test by fastening one voltmeter lead to the connection (terminal) for the small wire at the solenoid and the other lead to the ground. Look at the voltmeter and activate the starter solenoid. A voltmeter reading shows that the problem is in the solenoid. No voltmeter reading shows that the problem is in the heat-start switch or wiring.

Fasten one voltmeter lead to the heat-start switch at the connection (terminal) for the wire from the battery. Fasten the other lead to a good ground. No voltmeter reading indicates a broken circuit from the battery. Make a check of the circuit breaker and wiring. If there is voltmeter reading, the malfunction is in the heat-start switch or in the wiring.

Fasten one lead of the voltmeter to the battery wire connection of the starter switch and put the other lead to a good ground. A voltmeter reading indicates a failure in the switch.

A starter motor that operates too slow can have an overload because of too much friction in the engine being started. Slow operation of the starter motor can also be caused by shorts, loose connections, and/or dirt in the motor.

Pinion Clearance Adjustment (Delco-Remy)



CONNECTION FOR CHECKING PINION CLEARANCE

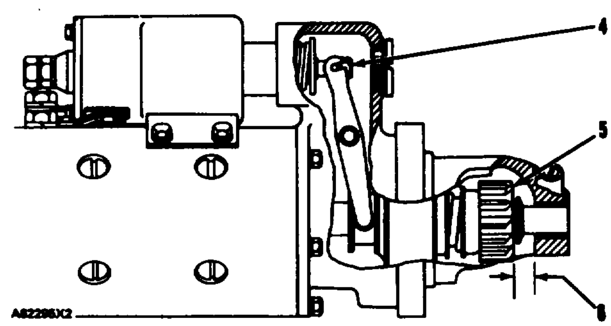
1. Connector from MOTOR terminal on solenoid to motor. 2. SW terminal. 3. Ground terminal.

Whenever the solenoid is installed, make an adjustment of the pinion clearance. The adjustment can be made with the starter motor removed.

1. Install the solenoid without connector (1) from the MOTOR connection (terminal) on solenoid to the motor.

2. Connect a battery, of the same voltage as the solenoid, to the terminal (2), marked SW.

3. Connect the other side of battery to ground terminal (3).



PINION CLEARANCE ADJUSTMENT
4. SHAFT NUT. 5. PINION. 6. PINION CLEARANCE

4. Connect for a moment, a wire from the solenoid connection (terminal) marked MOTOR to the ground connection (terminal). The pinion will shift to crank position and will stay there until the battery is disconnected.

5. Push the pinion toward commutator end to remove free movement.

6. Pinion clearance (6) is .36 + .03 in. (9.1 + 0.8 mm).

7. Pinion clearance adjustment is made by removing plug and turning nut (4).

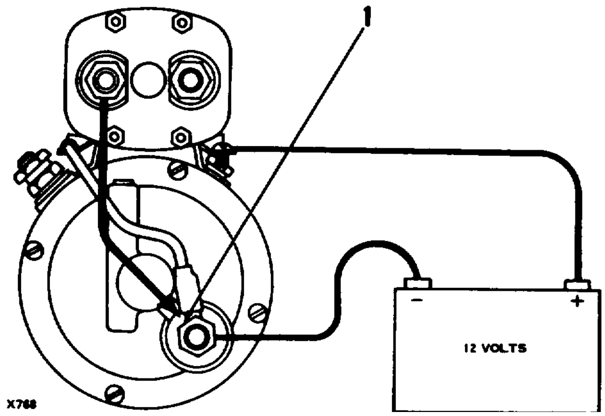
Pinion Clearance Adjustment (Prestolite)

There are two adjustments on this type motor. They are end play for the armature and pinion clearance.

End Play For The Armature

The correct end play for the armature is .005 to .030 in. (0.13 to 0.76 mm). The adjustment is made by adding or removing thrust washers on the commutator end of the armature shaft.

Pinion Clearance Adjustment

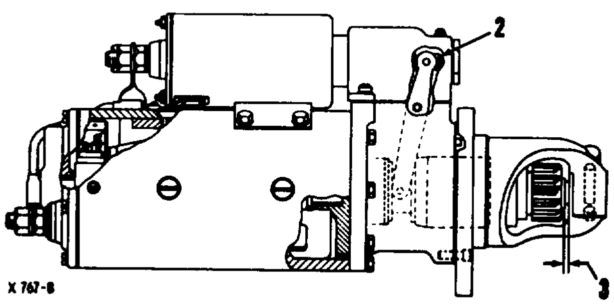


CONNECTIONS FOR ADJUSTMENT OF THE PINION CLEARANCE
1. Stud.

1. To adjust the pinion distance, connect the solenoid to a 12 volt battery as shown. For a short moment, connect a wire from the "motor" stud of the solenoid to the stud at (1) in the commutator end. This moves the solenoid and drive into the cranking position.

Disconnect the wire.

NOTE: The drive is in the cranking position until the battery is disconnected.



PINION CLEARANCE ADJUSTMENT
2. ADJUSTING NUT. 3. DISTANCE.

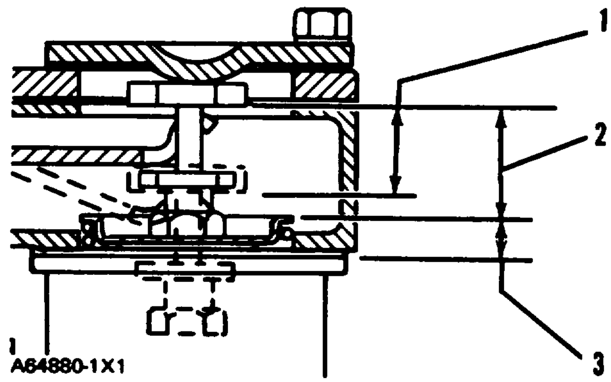
2. Push the drive toward the commutator end of the motor to eliminate any slack movement in the linkage and measure the distance between the outside edge of the drive sleeve and the thrust washer. The distance (3) must be .020 to .050 in. (0.51 to 1.27 mm).

3. Remove the plug. Turn the adjusting nut (2) in or out as necessary to get this distance.

4. Install the plug.

RACK SHUT-OFF SOLENOID
Tools Needed
9S240 Rack Position Tool Group.
9S215 Dial Indicator.
3S3268 Contact Point, .25 in. (4 mm) long.
3P1565 Collet Clamp.

Adjust, if necessary, the distance (2) between the shaft and the plate to .96 in. (24.4 mm) at the start of the test.



RACK SOLENOID
1. Travel .62 in. (15.7 mm)). 2. Distance between shaft and plate .96 in. (24.4 mm). 3. Start position of plunger plate from mounting flange is .44 in (11.2 mm) to measure travel of plunger.

Two checks must be made on the engine to give proof that the solenoid adjustment is correct.

1. The adjustment must give the plunger enough travel to move the rack to the fuel shut-off position. Use the 9S240 Rack Position Tool Group to make sure the rack goes to the fuel shut-off position.

2. The adjustment must give the plunger enough travel to cause only the "hold-in" windings of the solenoid to be activated when the rack is held in the fuel shut-off position. Use a thirty ampere ammeter to make sure the plunger is in the "hold-in" position. Current needed must be less than two amperes.

ALPHABETICAL AND SERVICE INDEX
CHAPTER 2
ENGINE
DISASSEMBLY AND ASSEMBLY

ALPHABETICAL AND SERVICE INDEX

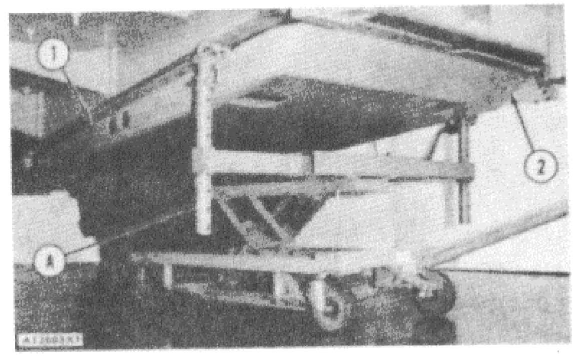
DISCONNECT BATTERIES BEFORE PERFORMANCE OF ANY SERVICE WORK

CRANKCASE GUARDS, STARTER

REMOVE CRANKCASE GUARDS

	Tools Needed	A
5P3050	Crankcase Guard and Transmission Jack	1

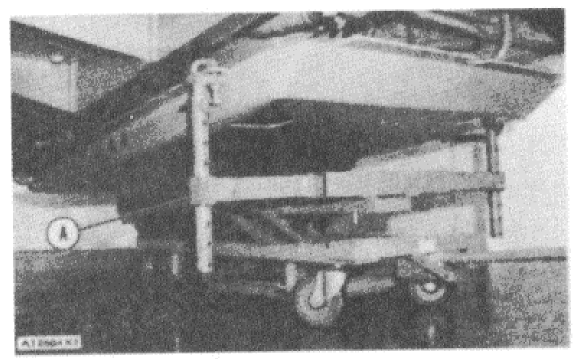
1. Put tool (A) in position under front crankcase guard (2). Remove all but two of the twenty-two bolts (I) that hold the crankcase guard. Install tool (A) into the crankcase guard and remove the other two bolts (I). Remove the guards. Weight of the front guard is 274 lb. (124 kg). Weight of the rear guard is 91 lb. (41 kg).



INSTALL CRANKCASE GUARDS

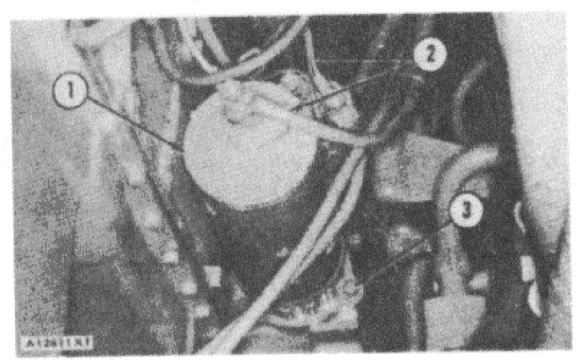
	Tools Needed	A
5P3050	Crankcase Guard and Transmission Jack	1

1. Put the crankcase guards in position on the frame with tool (A) and install the bolts that hold them.



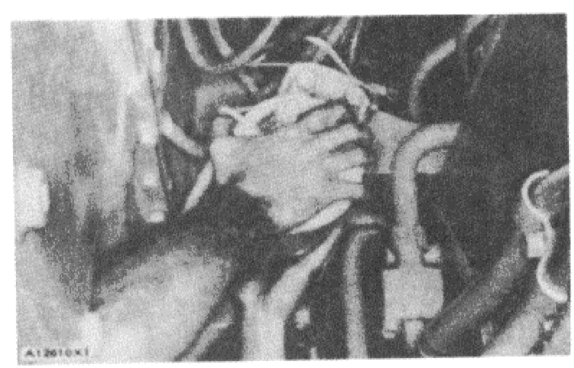
REMOVE STARTER

start by:
 a) remove crankcase guards
1. Remove doors from left side of the engine.
2. Disconnect wires (2) from the starter and put identification on them.
3. Remove three bolts (3) that hold the starter to the engine. Remove starter (1). Weight of the starter is 77 lb. (35 kg).



INSTALL STARTER

1. Put starter in position on the engine and install the bolts that hold it.
2. Connect the wires to the starter.
3. Install doors on the left side of the engine.
 end by:
 a) install crankcase guards

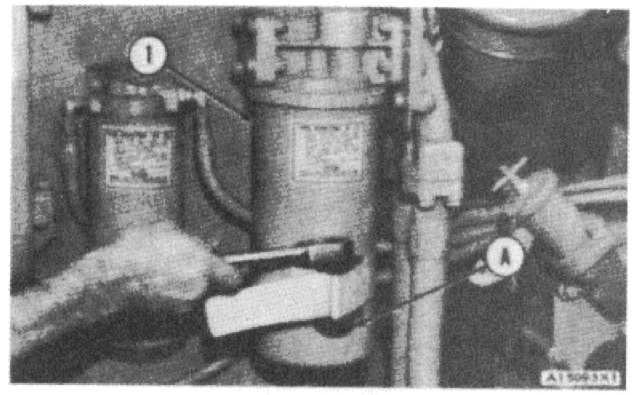


OIL AND FUEL FILTERS

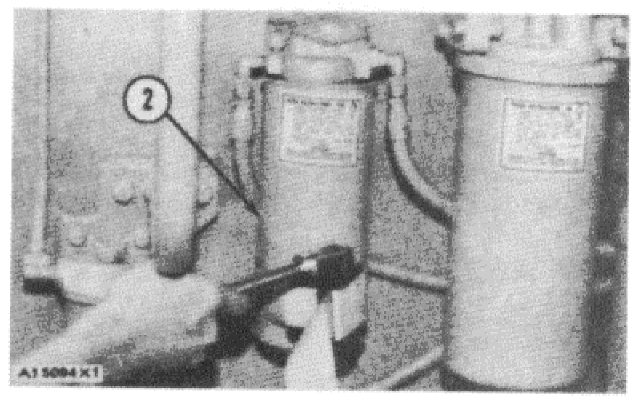
REMOVE AND INSTALL OIL AND FUEL FILTERS

	Tools Needed	A
2P8250	Strap Wrench	1

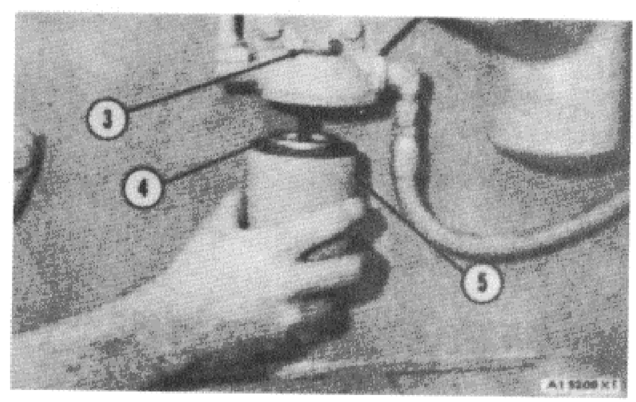
1. Remove oil filter housing (1) and element with tool (A). Read instructions on filter housings. Install filter housing and element.



2. Remove secondary fuel filter (2) and element with tool (A). Read instructions on filter housing. Install filter housing and element.



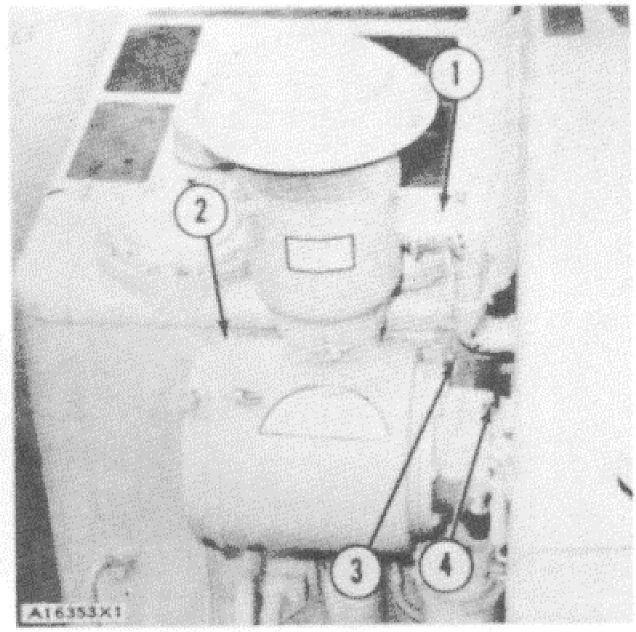
3. Loosen bolt (3) and remove primary fuel filter housing (5) and filter element (4). Inspect element, replace if necessary. Install filter housing and element. Tighten bolt.



AIR CLEANER

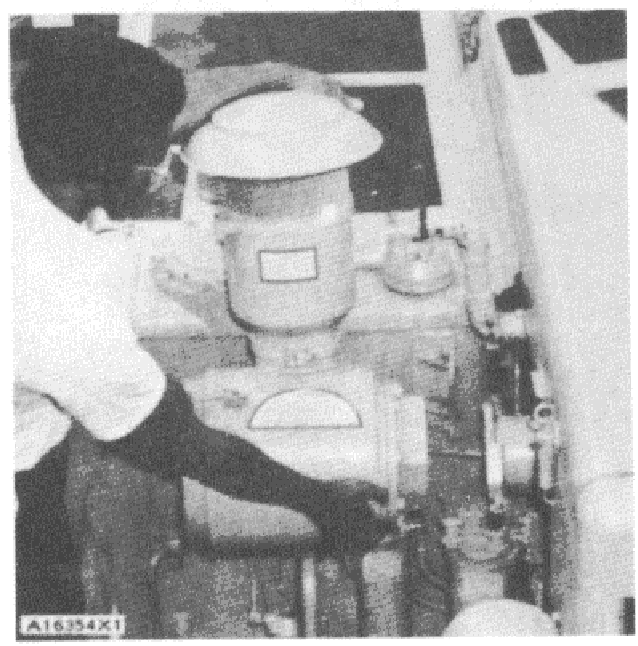
REMOVE AIR CLEANER

1. Loosen clamp and disconnect hose (1).
2. Remove bolts (4) from elbow.
3. Remove three bolts (3) that hold air cleaner to bracket. Remove air cleaner (2).



INSTALL AIR CLEANER

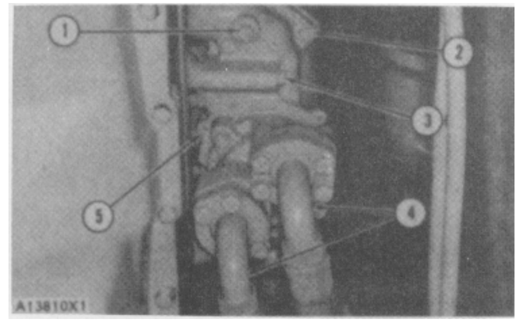
1. Put air cleaner in position on bracket and install the three bolts that hold it.
2. Install the bolts that hold air cleaner to the elbow.
3. Connect hose and tighten clamp.



OIL FILTER BASE

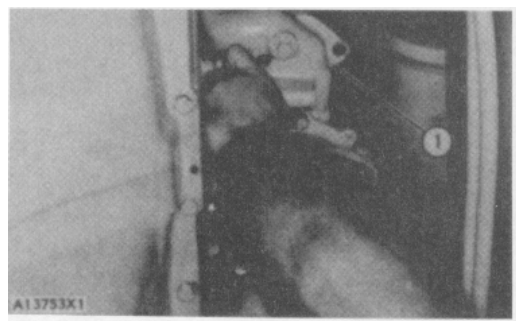
REMOVE OIL FILTER BASE

1. Remove plug (I) and remove oil from oil filter base.
2. Remove the two oil filter base hoses (4).
3. Remove four bolts (2) that hold oil filter base to oil cooler and the six bolts (3) that hold the oil filter base to the cylinder block.
4. Disconnect turbocharger oil line from the top of the oil filter base.
5. Remove oil filter base (5).



INSTALL OIL FILTER BASE

1. Put oil filter base (I) in position on the oil cooler and cylinder block.
2. Install six bolts that hold oil filter base to cylinder block.
3. Install four bolts that hold oil filter base to cylinder block.
4. Install four bolts that hold oil filter base to oil cooler.
5. Connect the turbocharger oil line.
6. Install the two oil filter hoses.

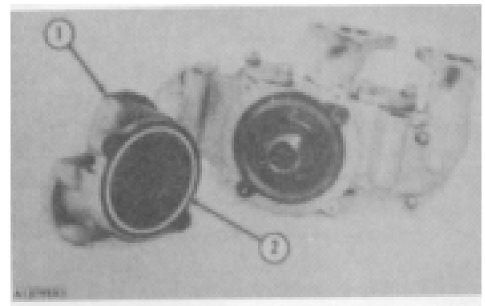


OIL FILTER BASE

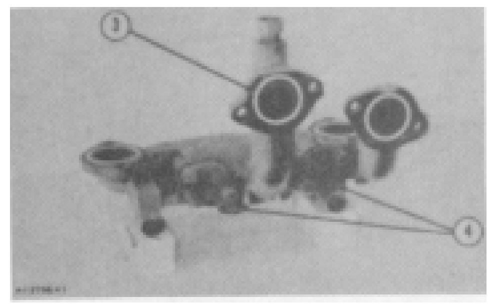
DISASSEMBLE OIL FILTER BASE

start by:

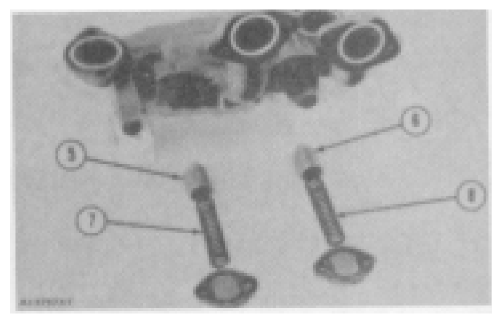
a) remove oil filter base



1. Remove hose adapter (l). Inspect O-ring seal (2) and make a replacement if necessary.



2. Put the oil filter base on blocks. Inspect O-ring seals (3) and make replacements if necessary. Remove covers (4).



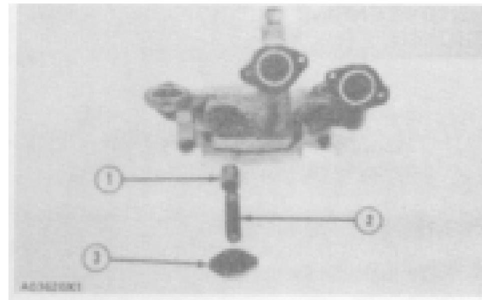
3. Remove the spring (7) and bypass valve (5) for the oil cooler.

4. Remove the spring (8) and valve (6) for the oil filter.

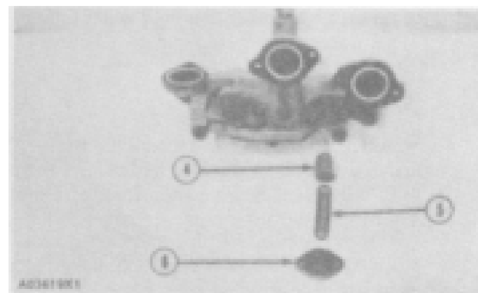
OIL FILTER BASE

ASSEMBLE OIL FILTER BASE

1. Install the bypass valve (I) and spring (2) for the oil cooler.

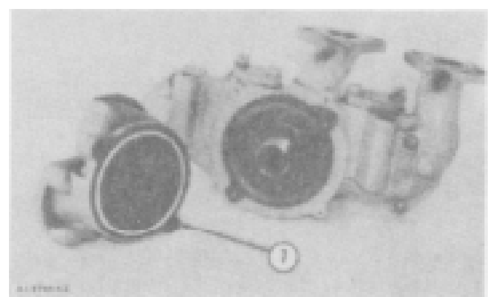


2. Install the cover (3).



3. Install the bypass valve (4) and spring (5) for the oil filter.

4. Install the cover (6).



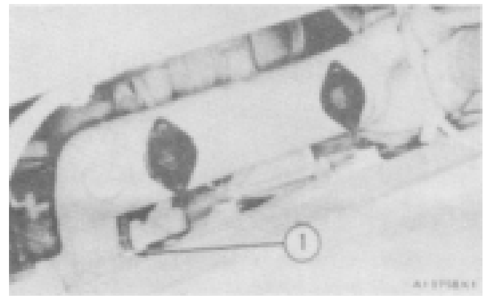
5. Install the hose adapter (7). end by:

   a) install oil filter base

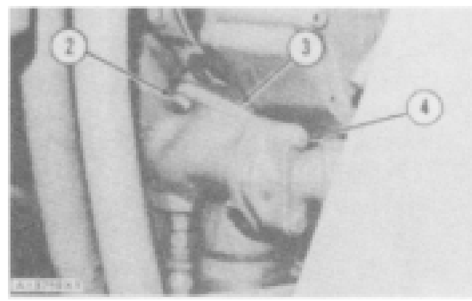
ENGINE OIL COOLER

REMOVE ENGINE OIL COOLER

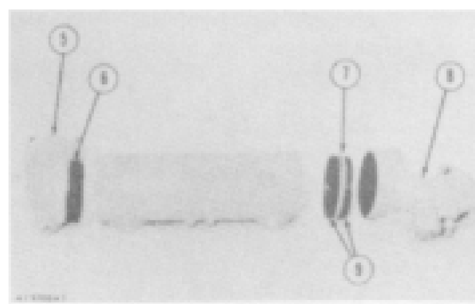
start by:
a) remove oil filter base



1. Remove oil from the engine oil cooler. Remove coolant from the engine.
2. Remove four bolts (1) that hold engine oil cooler to the cylinder block.
3. Remove two bolts (2) that hold water inlet pipe (3) to water pump. Remove two bolts (4) to disconnect water inlet hose.



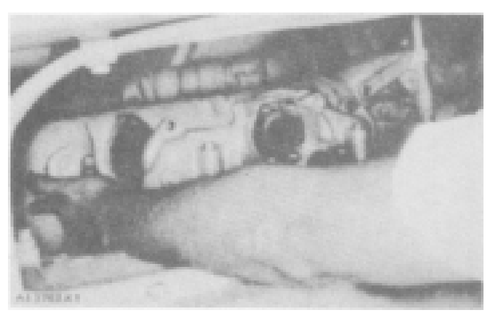
4. Remove engine oil cooler from the engine. Remove water outlet pipe (5) and water inlet pipe (8) from the engine oil cooler. Remove coupling (7) from water inlet pipe. Remove O-ring seal (6) from water outlet pipe and O-ring seals (9) from coupling. Inspect seals and make replacements if necessary.



INSTALL ENGINE OIL COOLER

1. Put clean engine oil on O-ring seal. Install seal on water outlet pipe and install the pipe into the engine oil cooler.
2. Put clean engine oil on O-ring seals for the coupling. Put O-ring seals on coupling and install coupling into water inlet pipe. Install pipe into engine oil cooler.
3. Put engine oil cooler in position on engine. Install the four bolts that hold it to the cylinder block. Install two bolts that hold it to the water pump. Connect water inlet hose to the water inlet pipe and install the two bolts. end by:

   a) install oil filter base

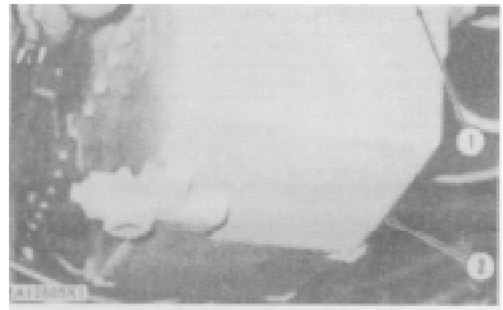


OIL PAN, OIL PUMP

REMOVE OIL PAN

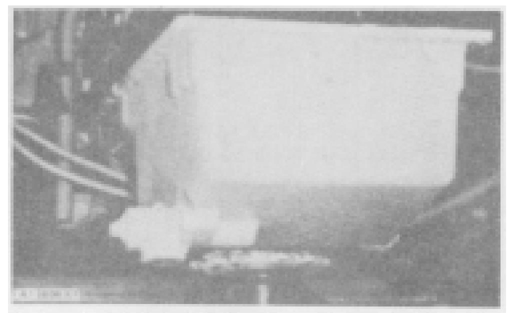
start by:

a) remove crankcase guards



1. Remove oil from engine.
2. Remove forty bolts (I) that hold the oil pan (2) to the engine. Remove the oil pan with a floor jack.

INSTALL OIL PAN



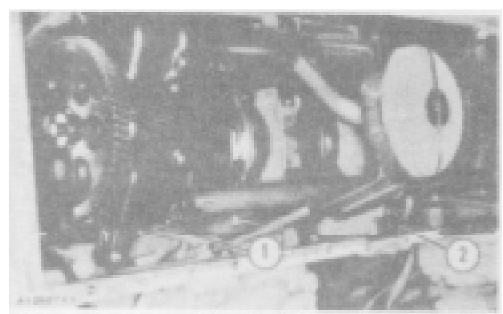
1. Put the oil pan in position on the engine and install the bolts that hold it.
2. Fill the engine with oil to the correct level. end by:

a) install crankcase guards

REMOVE OIL PUMP

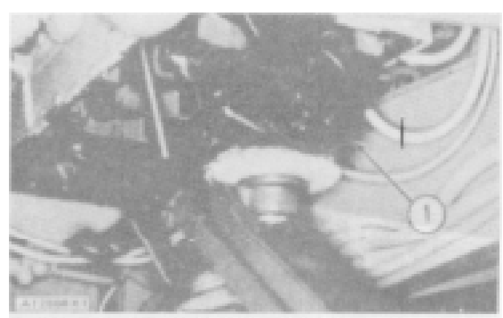
start by:

a) remove oil pan



1. Put a floor jack under the oil pump as a support.
2. Remove the bolts (2) that hold the oil pump and suction pipe to the cylinder block.
3. Remove the oil pump (1). Weight of the oil pump is 70 lb. (32 kg).

INSTALL OIL PUMP



1. Put the oil pump in position with a floor jack. Make sure that the teeth of the drive gear and idler gear (I) are engaged correctly.
2. Install the bolts that hold the pump. end by:

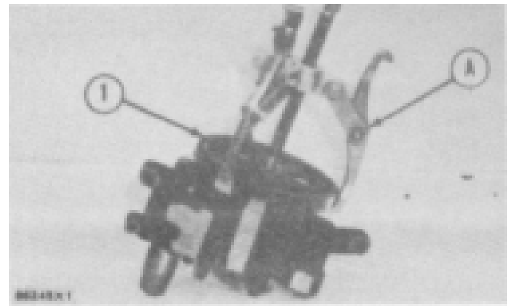
a) install oil pan

OIL PUMP

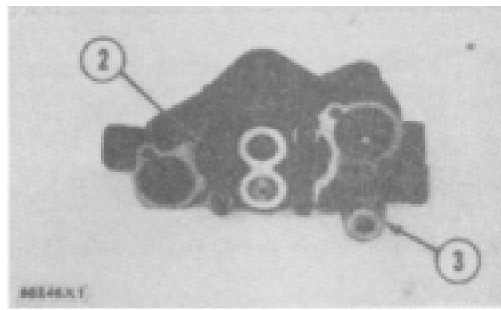
DISASSEMBLE OIL PUMP

Tools Needed		A	B
1P2321	Puller Assembly	1	
1P458	Step Plate	1	
1P529	Handle		1
1P461	Drive Plat		1
1P463	Drive Plate		1

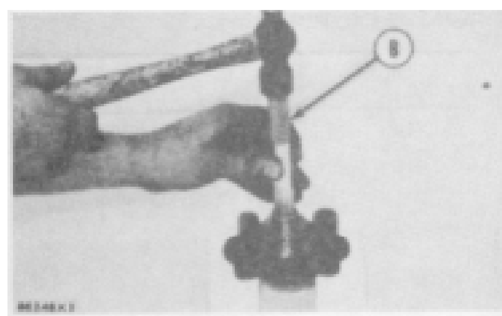
start by:
a) remove oil pump



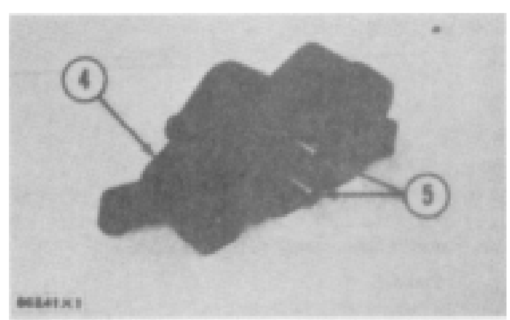
1. Remove bolt and washer that hold gear on the shaft.
2. Use tooling (A) to remove drive gear (1) from shaft. Remove the key from shaft.



3. Remove retainer (3) for bypass valve.
4. Remove spring and bypass valve.



5. Remove the cover (2) from pump body.
6. Use tooling (B) to remove bearings from the cover.

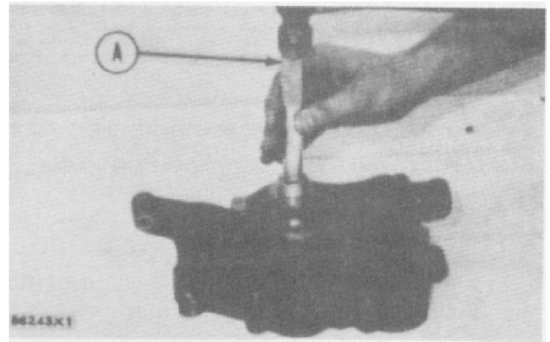


7. Remove gears (5) from pump body (4).
8. Use tooling (B) to remove bearings from pump body.

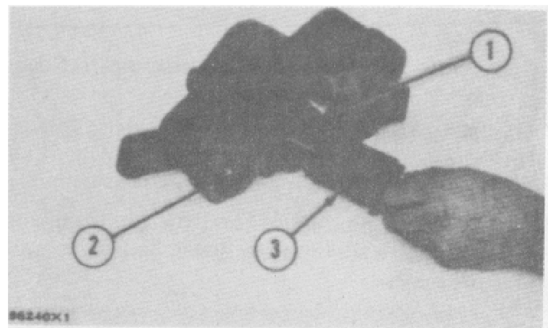
OIL PUMP

ASSEMBLE OIL PUMP

	Tools Needed	A
1P529	Handle	1
1P461	Drive Plate	1
1P465	Drive Plate	1

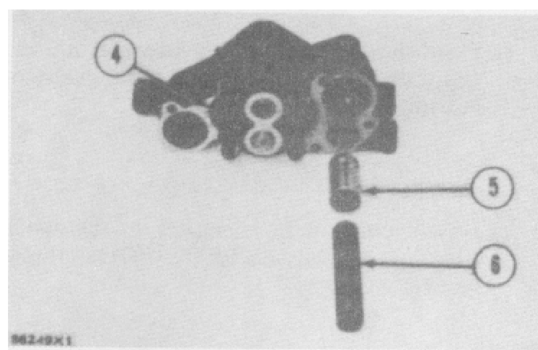


1. Use tooling (A) to install bearings in pump body. Install bearings so split in bearings is 30° $\pm$ 15° from center line of oil pump outlet passage (2).



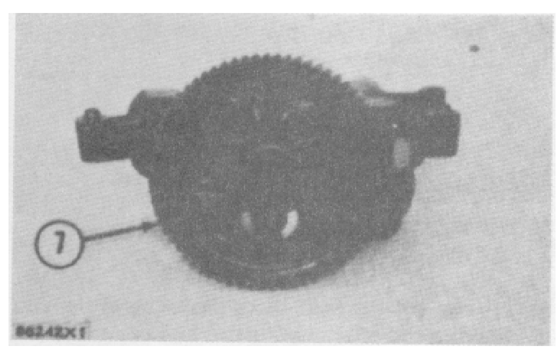
2. Install idler gear (I) and drive gear (3) in oil pump body. Put clean engine oil on bearings and on gears.

3. Use tooling (A) to install bearings in cover (4). Install bearings so split in bearings is 30° $\pm$ 15° from center line of bearing bores toward oil pump outlet passage (2).



4. Install bypass valve (5), spring (6) and the retainer.

5. Install key on the shaft.



6. Install gear (7) on shaft. Install washer and bolt that hold gear on the shaft. Be sure pump turns freely after assembly. end by:

   a) install oil pump

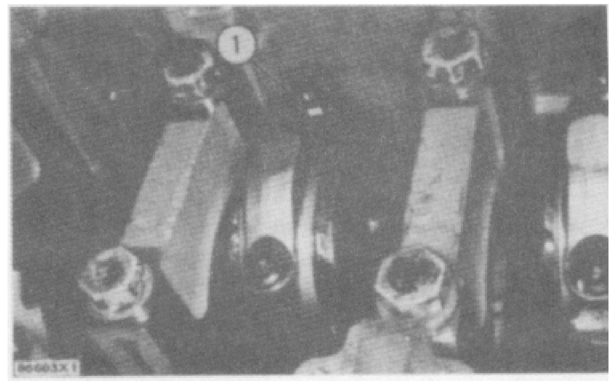
CONNECTING ROD BEARINGS

REMOVE AND INSTALL CONNECTING ROD BEARINGS

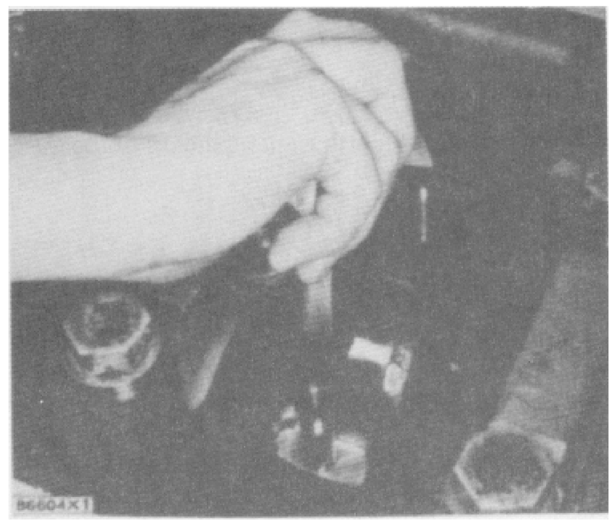
	Tools Needed	A
5B1161	Wire	*

start by:

a) remove oil pump



1. Check the connecting rods and caps for their identification and location.



2. Turn crankshaft until connecting rod caps are in position shown.

3. Remove the nuts (1) and the cap from connecting rod. Remove lower half of bearing from cap.

4. Push the connecting rod away from the crankshaft. Remove the upper half of bearing from connecting rod.

5. Install upper half of bearing in connecting rod. Put clean engine oil on bearing and on crankshaft journal.

6. Pull the connecting rod slowly on to the crankshaft.

7. Install lower half of bearing in cap.

   NOTE: Be sure the tabs in back of bearings are in the tab grooves of connecting rod and cap.

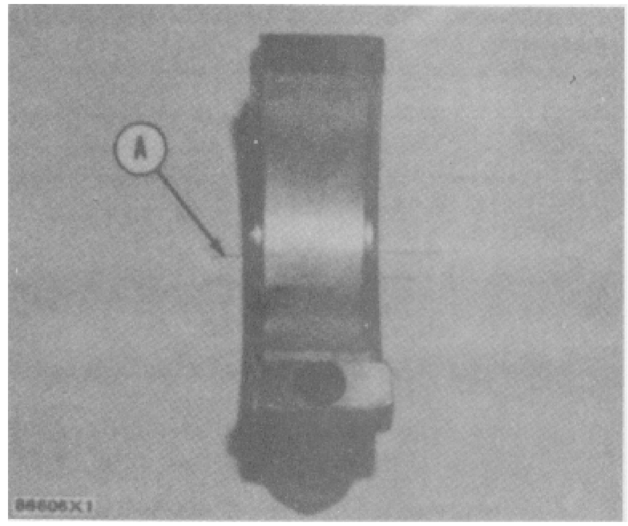
CONNECTING ROD BEARINGS

8. Use wire (A) to check bearing clearance.

9. Put wire (A) on the bearing.

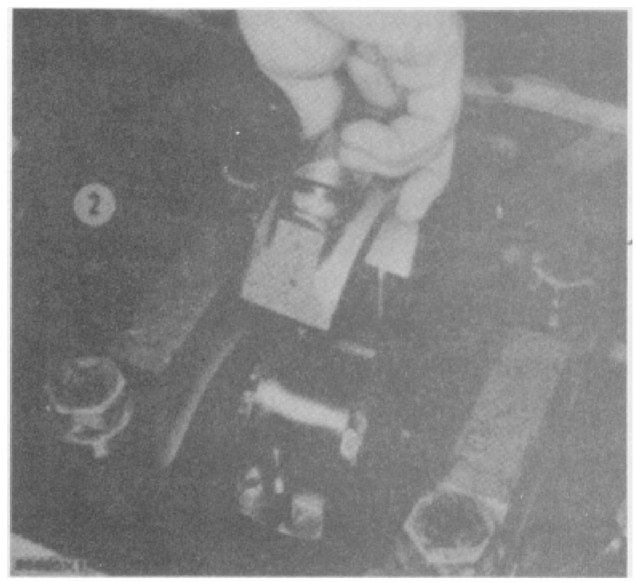
10. Put clean engine oil on threads of rod bolts and seat surfaces of nuts.

    NOTE: Be sure the cylinder numbers on the rod cap and rod are the same, and are on the same side of the connecting rod. Numbers are on the same side of rod and cap as are the grooves for the bearing tabs. If new rods are installed, put the cylinder number on the rod and cap.



11. Install the rod caps (2). Install the nuts. Tighten each nut to a torque of 60 ± 4 lb.ft. (8.3 ± 0.6 mkg). Put a mark on the nuts and cap and tighten nuts an extra 1200° $^{5^\circ}$ from the mark. Remove the rod cap. Remove wire (A) and check the bearing clearance. The bearing clearance must be .0041 to .0073 in. (0.014 to 0.185 mm) for new bearings.

12. Put clean engine oil on lower half of bearing. Install rod cap again. Tighten each nut to 60 ± 4 lb.ft. (8.3 ± 0.6 mkg). Put a mark on nuts and cap and tighten nuts an extra 120° ± 5° from mark.



13. Do Steps 1 through 12 for remainder of connecting rod bearings.

end by:
   a) install oil pump

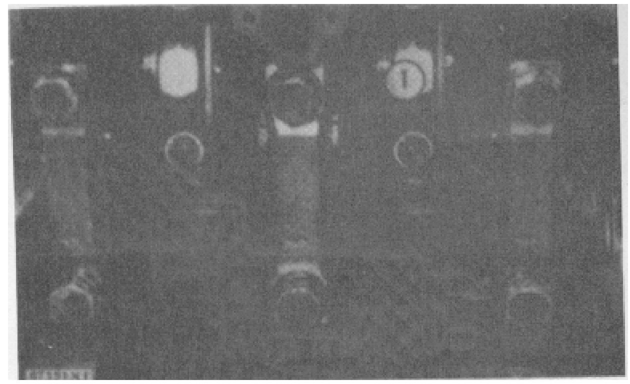
CRANKSHAFT MAIN BEARINGS

REMOVE AND INSTALL CRANKSHAFT MAIN BEARINGS

Tools Needed		A	B	C
2P5518	Main Bearing Remove & Install Tool	1		
5B1161	Wire		*	
8S2328	Dial Test Indicator Group			1

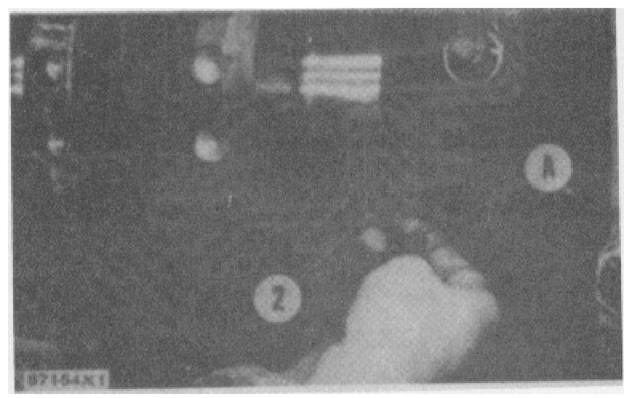
start by:

a) remove oil pump



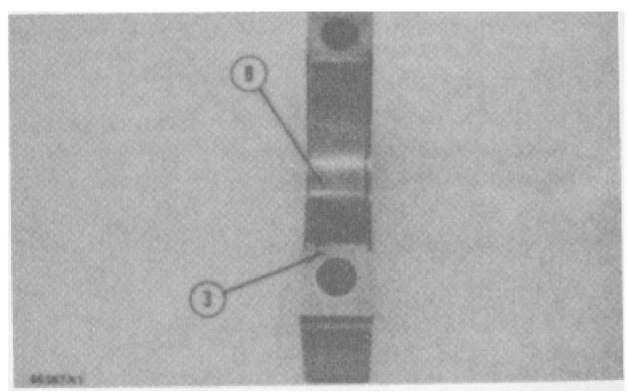
1. Check the main bearing caps for identification for their location and direction in the block. The caps must be installed in the same location and direction from which they were removed.

2. Remove No. 2 through No. 6 bearing caps (1). Remove thrust bearings from No. 4 main bearing cap.



3. Remove the upper halves of main bearings by putting tool (A) in oil hole (2) in the crankshaft. Turn the crankshaft in the direction which will push the end of the bearing with a tab out first.

   CAUTION: If the crankshaft is turned in the wrong direction, the tab of the bearing will be pushed between the crankshaft and cylinder block. This can cause damage to either or both.



4. Remove the lower halves of the bearings from the caps.

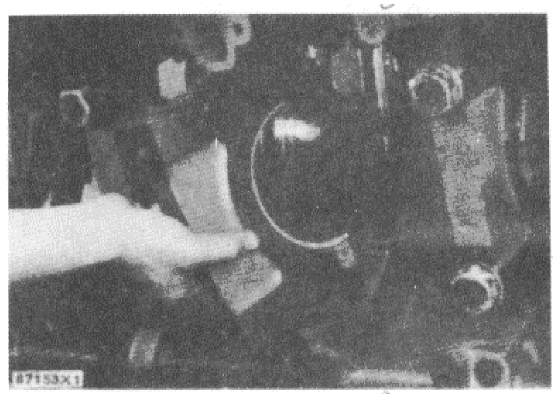
5. Install new bearings in the caps. Put clean engine oil on the bearings.

6. Put clean engine oil on the upper halves of the bearings. Install the upper halves of the bearings in the cylinder block with tool (A).
   NOTE: Be sure tabs (3) on the back of the bearings fit in the grooves of the caps and cylinder block.

7. Check the bearing clearance with wire (B). Put wire (B) on the bearings.

CRANKSHAFT MAIN BEARINGS

NOTE: Be sure the main bearing caps are installed so the numbers on the side of the cylinder block are the same as the numbers on the bearing caps, and the arrows (4) on the bearing caps are toward the front of the cylinder block.



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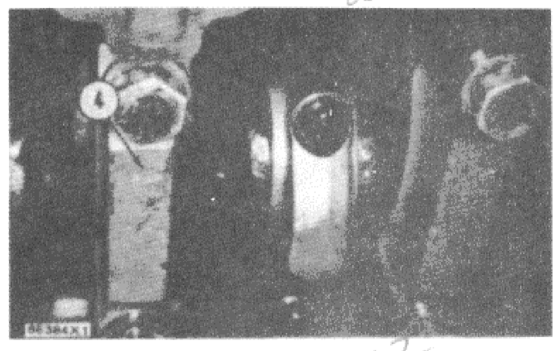

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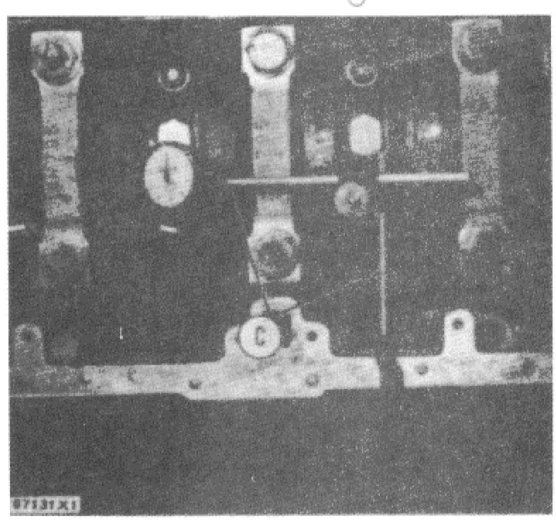


8. Install the bearing caps for No. 2 through No. 6. Put clean engine oil on the bolts. Install the bolts and tighten bolts, at end, with tab first, to a torque of 190±10 lb.ft. (26.2 ± 1.4 mkg). Turn the bolts an extra 120° ± 5° first at the end opposite of the tab. Remove the bearing caps for No. 2 through No. 6. Remove wire (B) from the caps. Check the thickness of wire (B) to find the bearing clearance. The bearing clearance must be .0037 to .0068 in. (0.093 to 0.172 mm) with new bearings. Maximum clearance with used bearings is .010 in. (0.35 mm).

9. Put clean engine oil on the threads of the bolts. Install the bearing caps for No. 2 through No. 6. Install the bolts and tighten the bolts, at the end with the tab first, to a torque of 190 ± 10 lb.ft. (26.2 ±1.4 mkg). Put a mark on the bolts and caps. Turn the bolts at opposite end of tab first an extra 120° ± 5° from the mark.

10. Remove the No. 1 and No. 7 main bearing caps. Do Steps 3 through 9 for the No. 1 and No. 7 caps.

11. Install the thrust bearings for No. 4 main bearing.

NOTE: Install the thrust bearings with the side marked "BLOCK SIDE" toward the cylinder block.

12. Check the end play of the crankshaft with tool group (C). Be sure the dial indicator is against a machined surface. The end play is controlled by the thrust bearings of No. 4 (center) main. The end play with new bearings must be .006 to .020 in. (0.152 to 0.508 mm). The maximum permissible end play with used bearings is .035 in. (0.89 mm).
    end by:
    a) install oil pump

HOOD, AIR COMPRESSOR GOVERNOR

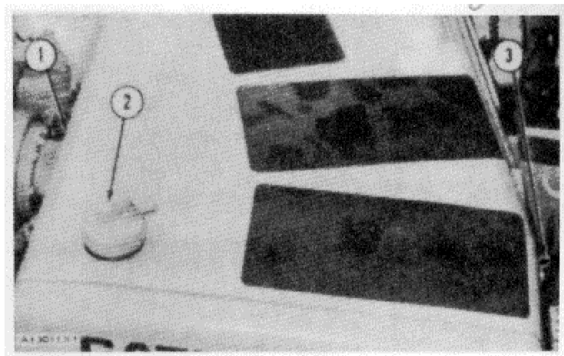
REMOVE HOOD

1. Loosen side plates.

2. Remove radiator cap (2).

3. Release four fasteners (3) that hold hood (1).

4. Remove the hood with a hoist. Weight is 215 lb. (97.5 kg).

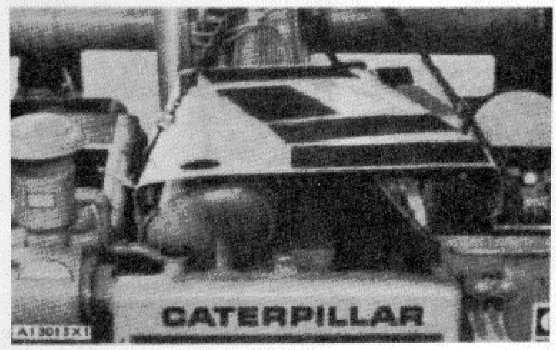


INSTALL HOOD

1. Put the hood into position with a hoist.

2. Connect fasteners and tighten side guards.

3. Install radiator cap.



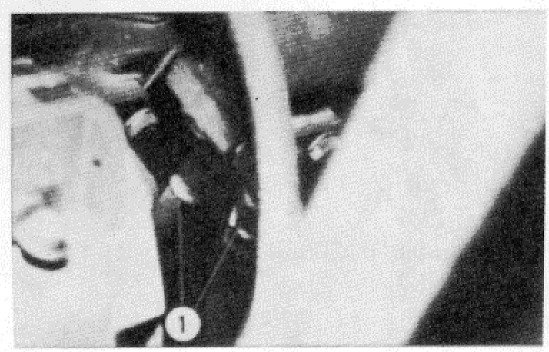
REMOVE AIR COMPRESSOR GOVERNOR

1. Remove side guards.

2. Release the air pressure in the air tank by loosening the bleed valves.

WARNING: Do not disconnect the air lines from the air compressor governor until the air pressure is zero.

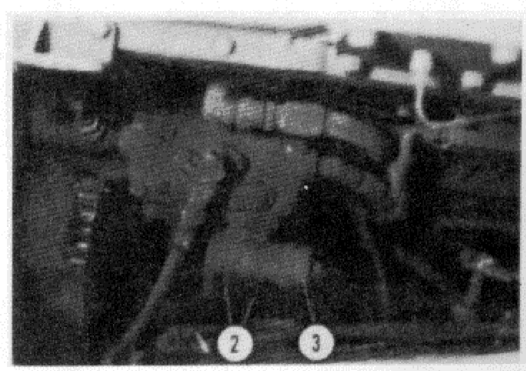
3. Disconnect two air lines (1). Remove bolts (2). Remove air compressor governor (3).



INSTALL AIR COMPRESSOR GOVERNOR

1. Put air compressor governor (3) in position on the air compressor. Install the bolts that hold it.

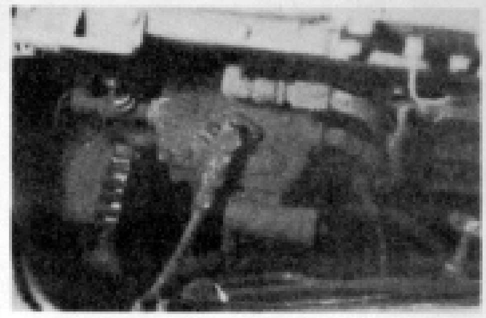
2. Connect both air lines.



AIR COMPRESSOR, ACCESSORY DRIVE

REMOVE AIR COMPRESSOR

start by:
a) remove hood



1. Remove the coolant from the engine. Release the air pressure in the air tank by loosening the bleed valves.

WARNING: Do not disconnect any air lines until the air pressure is zero.

2. Remove compressor governor.

3. Disconnect air lines and water lines. Disconnect oil line from air compressor.

4. Remove nuts, then remove air compressor.

INSTALL AIR COMPRESSOR

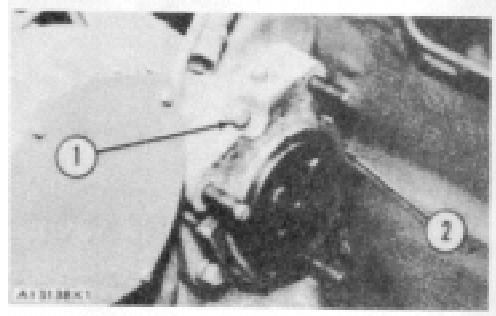
1. Put oil in the bore of the accessory drive. Put air compressor in position on the accessory drive. Install the nuts that hold it.

2. Connect the air lines, water lines and the oil line to the air compressor.

3. Install compressor governor.

4. Fill the engine with coolant to the correct level. end by:
a) install hood

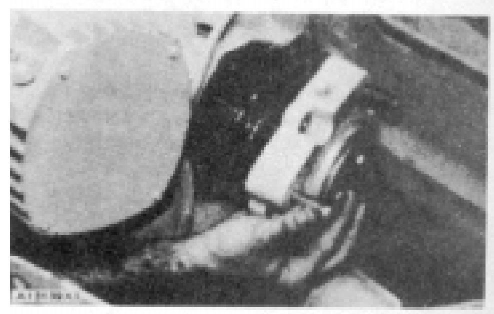
REMOVE ACCESSORY DRIVE



start by:
a) remove air compressor

1. Remove four bolts (1) that hold the accessory drive to the timing gear cover.

2. Remove accessory drive (2).



INSTALL ACCESSORY DRIVE

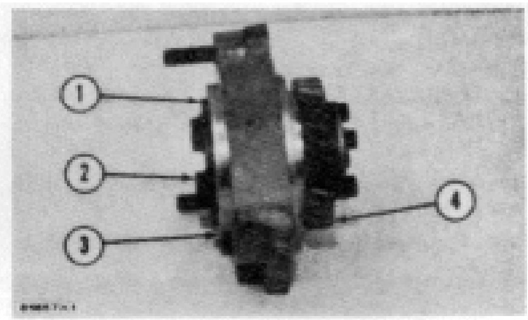
1. Put accessory drive in position in timing gear cover so accessory drive gear is in alignment with the camshaft gear.

2. Install the four bolts.
end by:
a) remove air compressor

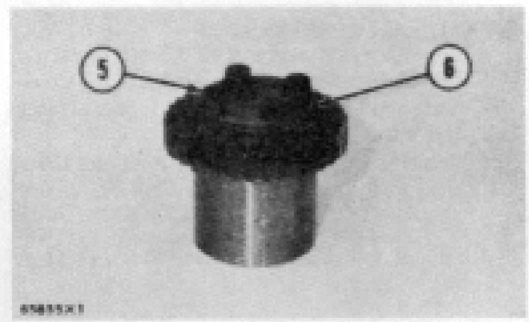
ACCESSORY DRIVE

DISASSEMBLE ACCESSORY DRIVE

start by:
a) remove accessory drive



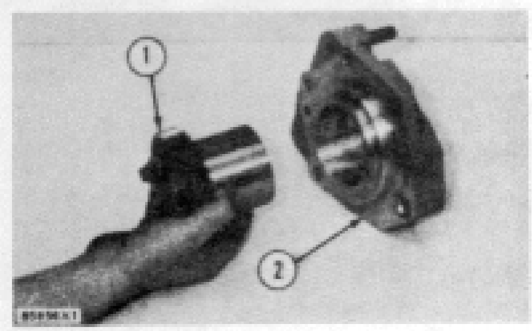
1. Remove four bolts (2) and the plate (1) that hold gear assembly in bearing assembly (3).



2. Remove gear assembly (4) from the bearing assembly (3).

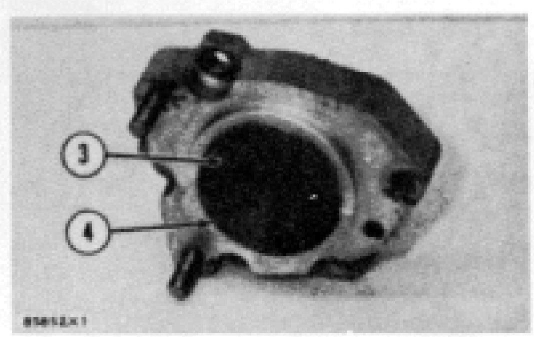
3. Remove four bolts (5) and cover (6) from gear.

ASSEMBLE ACCESSORY DRIVE



1. Install cover and four bolts on gear.

2. Install gear assembly (1) in the bearing assembly (2).



3. Install plate (4) and four bolts (3) that hold gear assembly in the bearing assembly.

end by:
a) install accessory drive

TACHOMETER DRIVE

REMOVE TACHOMETER DRIVE

start by:
a) remove air compressor

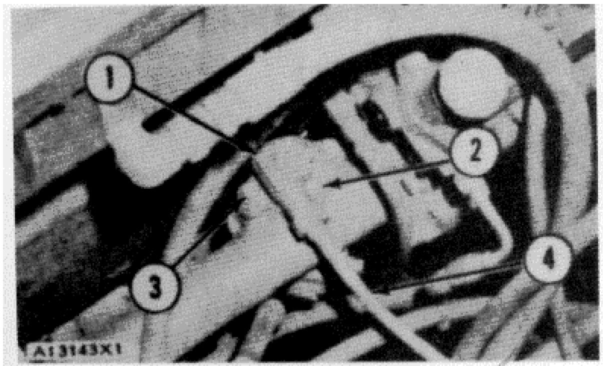
1. Disconnect cable (4) from adapter assembly (1). Remove adapter (1). Remove two bolts (3) and clamps. Remove housing (2).

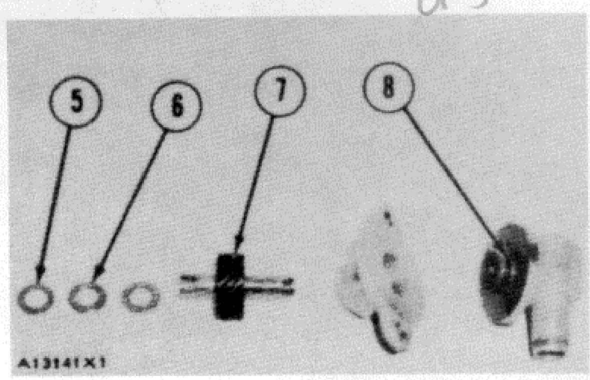
2. Remove O-ring seal (8) from adapter.

3. Remove tachometer drive gear (7) from governor drive housing.

4. Remove two washers (5) and bearing (6) from governor drive housing.

CAUTION: Do not let washers or bearing fall into governor drive housing when drive gear is removed.





INSTALL TACHOMETER DRIVE

1. Put clean engine oil on O-ring seal and install O-ring seal on the adapter. Install adapter in housing.

2. Install washer, bearing and washer in governor drive housing.

3. Install tachometer drive gear in governor drive housing with large groove in shaft in housing.

4. Install adapter assembly on the drive gear so groove of gear is in alignment with groove in adapter.

5. Install clamps and bolts. Tighten bolts to 96 ± 24 lb.in. (110.7 ± 27.7 cm.kg).

6. Connect cable to adapter assembly.

end by:
a) install air compressor

AUTOMATIC TIMING ADVANCE

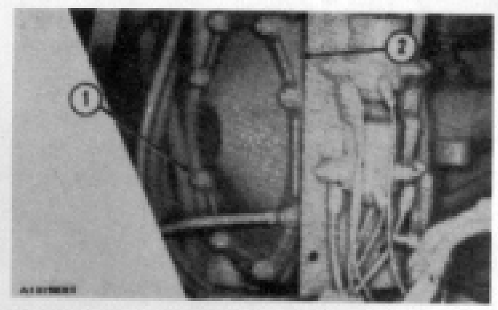
REMOVE AUTOMATIC TIMING ADVANCE

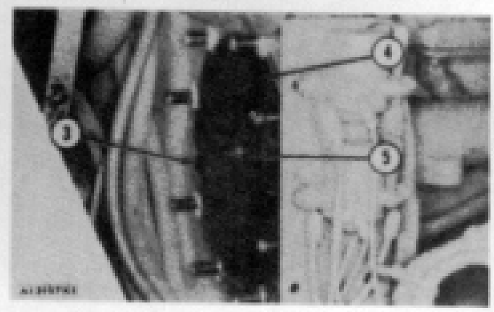
	Tools Needed	A	B
9S9082	Engine Turing Pin	1	
8S2291	Pin		1

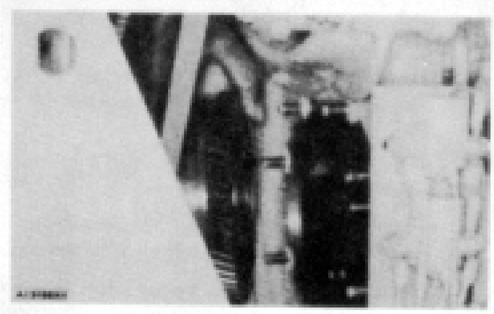
1. Make a setting of the fuel injection pump timing. See REMOVE FUEL INJECTION PUMP HOUSING AND GOVERNOR for timing procedure. Tools (A) and (B) will be needed to make a setting of the timing.

2. Remove nuts (1) and cover (2) from the timing gear cover.

3. Remove four bolts (3), washer (5) and automatic timing advance (4).







INSTALL AUTOMATIC TIMING ADVANCE

	Tools Needed	A
8S2291	Pin	1

1. Put automatic timing advance in position on the drive shaft for the fuel injection pump.

NOTE: Make sure the gear is engaged with the camshaft gear.

2. Install the washer and four bolts. Tighten the bolts in the following sequence:

   Step 1: Tighten bolts to a torque of 25 lb.ft. (3.5 mkg).

   Step 2: Remove tool (A) from fuel injection housing.

   Step 3: Tighten bolts to a torque of 50 lb.ft. (6.9 mkg).

   Step 4: Tighten bolts to a final torque of 75 lb.ft. (10.4 mkg).

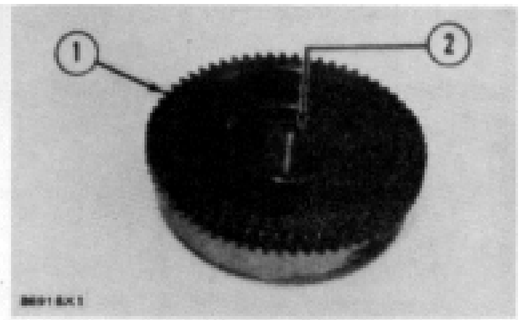
3. Install the cover on the timing.

AUTOMATIC TIMING ADVANCE

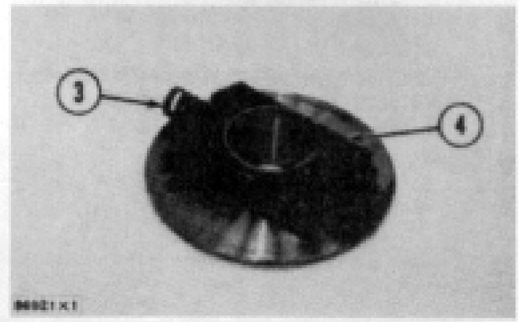
DISASSEMBLE AUTOMATIC TIMING ADVANCE

start by:
a) remove automatic timing advance

1. Remove ring (2) and gear (1) from flange.



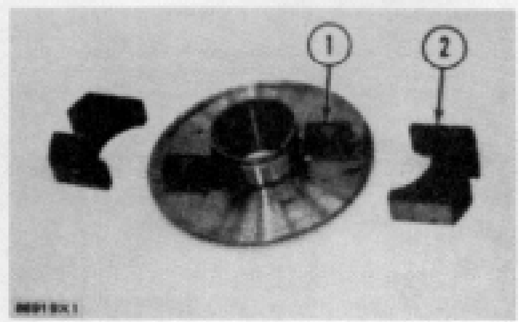
2. Remove springs (3) and counterweights (4) from flange.



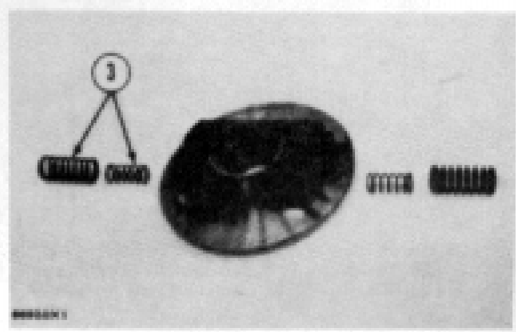
3. Remove slides from dowels on the flange.

ASSEMBLE AUTOMATIC TIMING ADVANCE

1. Install slides (1) on to dowels.
2. Install the counterweights (2) on the flange.



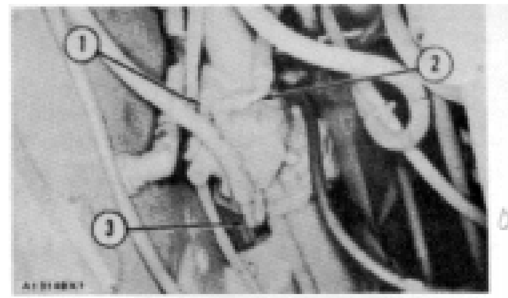
3. Install the springs (3).
4. Install the gear on flange.
5. Install the ring that holds gear and flange together.



end by:
a) install automatic timing advance

FUEL TRANSFER PUMP

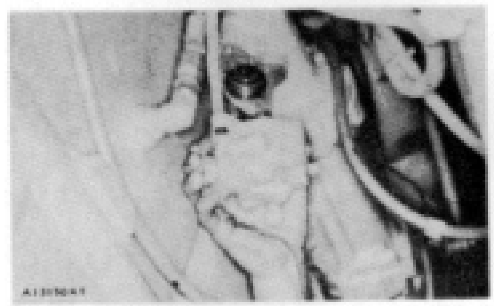
REMOVE FUEL TRANSFER PUMP



1. Disconnect fuel outlet line (2) and fuel inlet line (3).

2. Remove two bolts (I) that hold pump to drive housing. Remove fuel transfer pump.

INSTALL FUEL TRANSFER PUMP



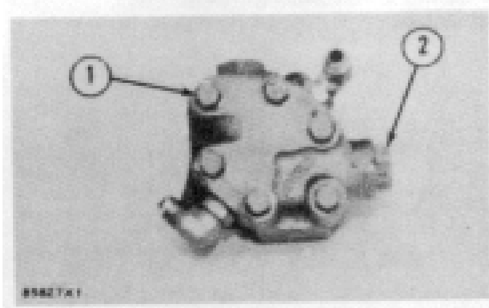
1. Put the fuel transfer pump in position so the shaft is in alignment with groove in drive housing.

2. Install the bolts and connect fuel inlet and outlet lines.

DISASSEMBLE FUEL TRANSFER PUMP

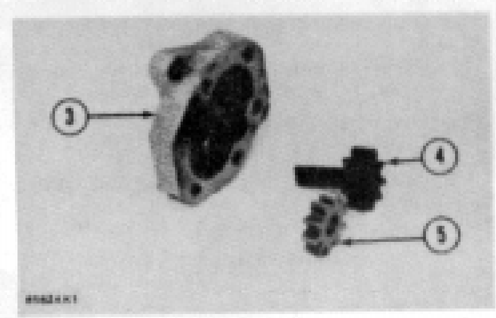
	Tools Needed	A
1P529	Handle	1
1P528	Extension Tube	1
1P454	Drive Plate	1
1P457	Drive Plate	1

start by:
a) remove fuel transfer pump



1. Remove six bolts (1) that hold the transfer pump cover to transfer pump body. Remove the cover.

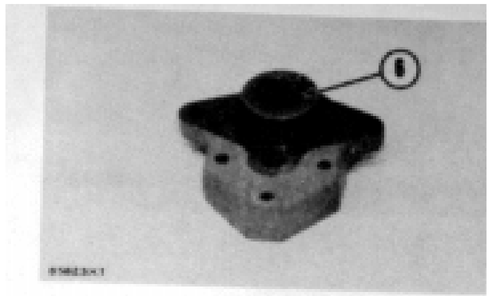
2. Remove the plug (2), seat, spring and fuel bypass valve from cover.



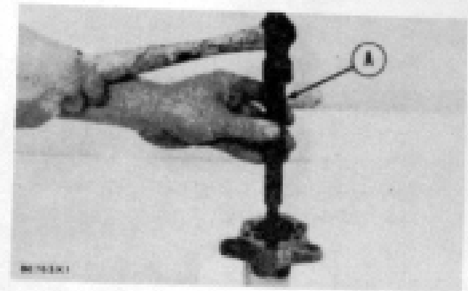
3. Remove the gear (5) and shaft assembly (4) from the body (3).

FUEL TRANSFER PUMP

4. Remove the seals (6) from the body.

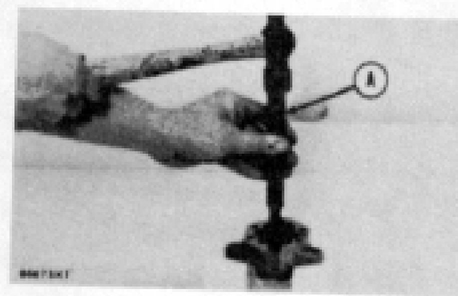


5. Use tooling (A) to remove the bearing from the body.



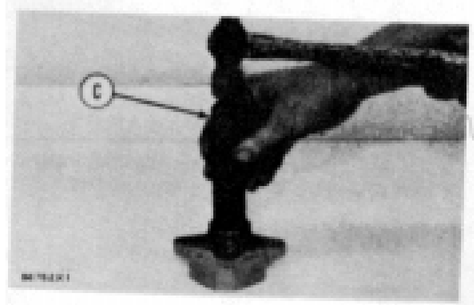
ASSEMBLE FUEL TRANSFER PUMP

Tools Needed		A	B	C	D
1P529	Handle	1			
1P528	Extension Tube	1			
1P454	Drive Plate	1			
1P459	Drive Plate	1			
5P2391	Seal Installation Tool		1		
5P2392	Seal Installation Tool			1	
5P2394	Seal Pilot Tool				1



1. Use tooling (A) to install bearing into body.

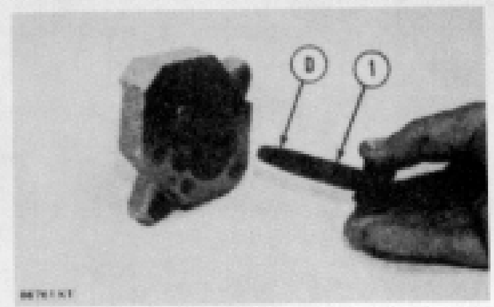
2. Use tool (B) to install inner seal in body. Install seal with lip of seal toward the outside.



3. Use tool (C) to install outer seal in the body. Install seal with lip of seal toward the outside.

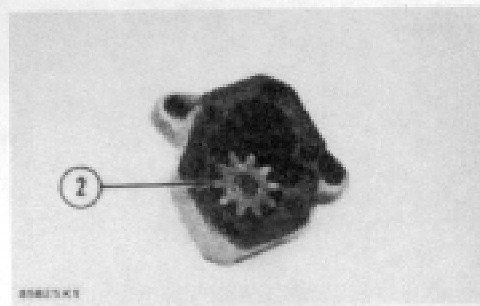
FUEL TRANSFER PUMP

4. Install tool (D) on the shaft assembly (1) and install shaft assembly into body.

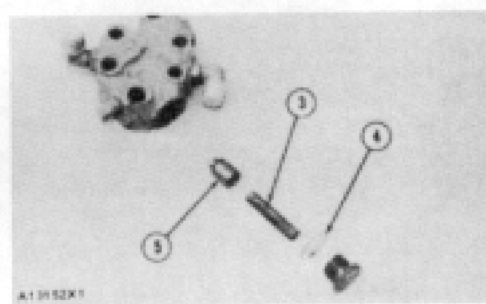


CAUTION: Tool (D) must be used to install shaft assembly. The shaft will cause damage to seals if it is not used.

5. Install idler gear (2) in the body.



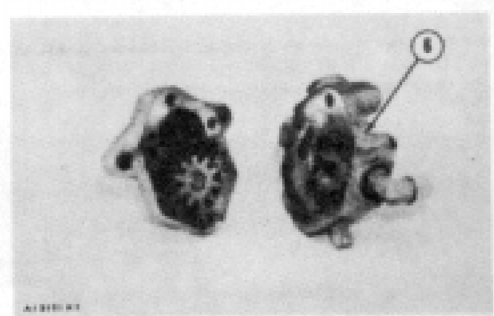
6. Install fuel bypass valve (5), spring (3), washer (4) and plug into cover.



7. Put a thin amount of 8S6747 Aviation Type Permatex on face of body.

CAUTION: Do not let Permatex get into the pump body.

8. Put the cover (6) in position on the body and install the six bolts.



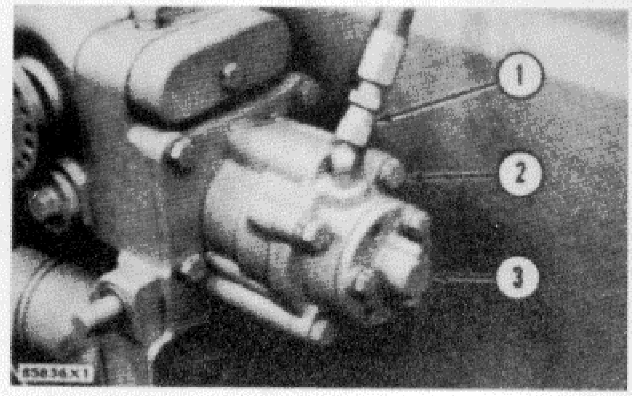
NOTE: After tightening bolts which hold cover to body, the gear and shaft assembly must turn freely.

end by:
a) install fuel transfer pump

FUEL RATIO CONTROL

REMOVE FUEL RATIO CONTROL

1. Disconnect line (1) from fuel ratio control.
2. Remove the wire seal from the bolts.
3. Remove the two bolts (2). Remove fuel ratio control (3) by pulling down and out from collar.



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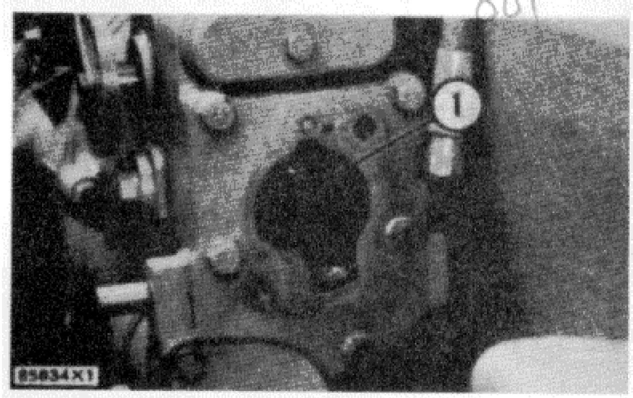
INSTALL FUEL RATIO CONTROL

1. Put fuel ratio control on the governor.



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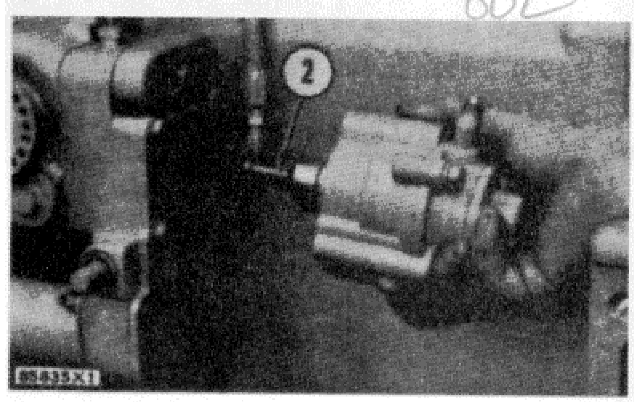
2. Be sure the bolt (2) of fuel ratio control is connected in groove of collar (1).
3. Install the two bolts that hold fuel ratio control on governor.



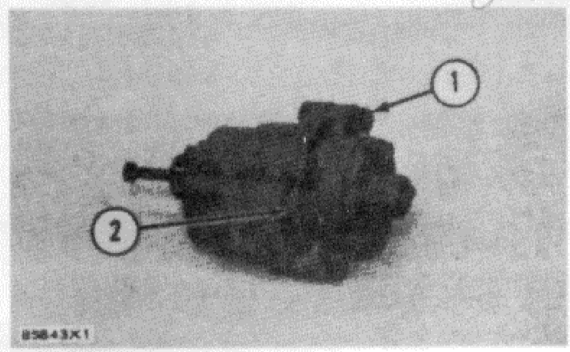
4. Connect the line to fuel ratio control.
5. Install a wire seal on the bolts.

FUEL RATIO CONTROL

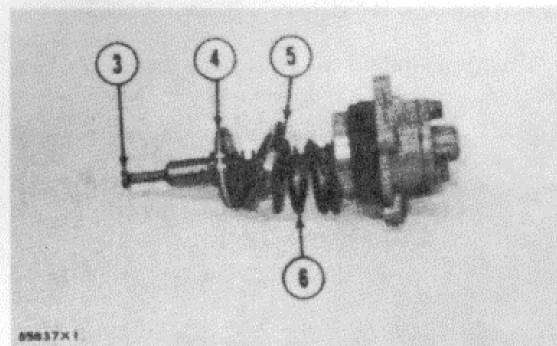
DISASSEMBLE FUEL RATIO CONTROL

start by:
a) remove fuel ratio control

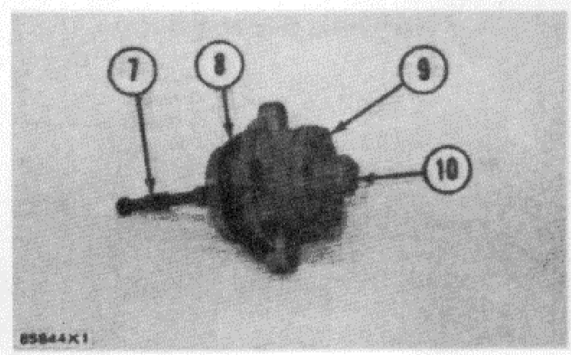
1. Remove two bolts (1) and the housing (2).



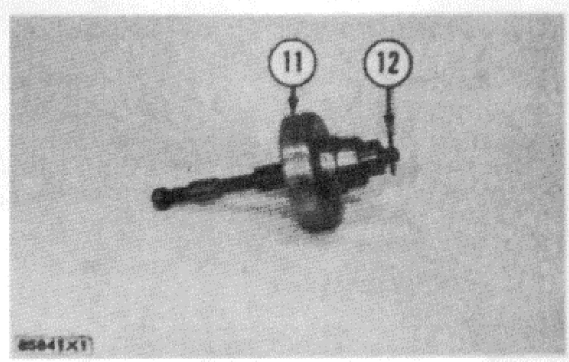
2. Remove valve assembly (3).
3. Remove seal (4) and O-ring seal from valve.
4. Remove the retainer (5) and two springs (6).



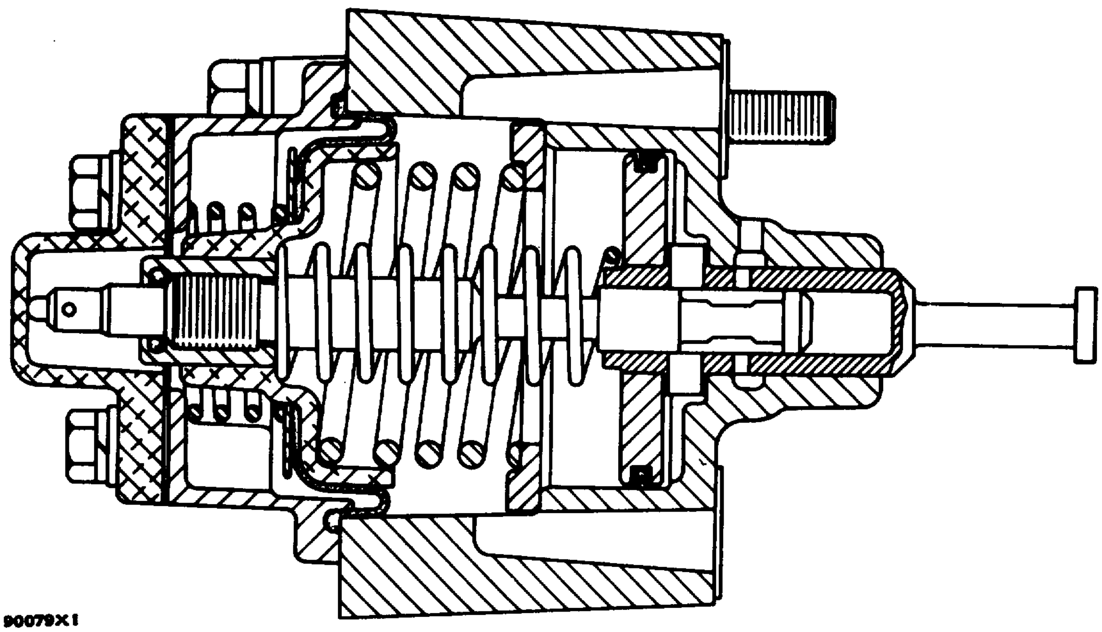
5. Remove three bolts (9) and cover (10).
6. Remove valve (7), diaphragm (8), retainer and spring.



7. Remove pin (12) from valve (7).
8. Remove cover (I 11) from the valve.
9. Remove the seal from the cover (11).



FUEL RATIO CONTROL



FUEL RATIO CONTROL

ASSEMBLE FUEL RATIO CONTROL

1. Put clean engine oil on lip of seal. Install the seal (1) in cover (2). Install seal so lip of seal is toward the inside of the cover.

2. Install the valve (3) into cover (2).

3. Install the pin that holds cover on valve.

4. Install spring (7) and the retainer (6) in cover (8).

5. Install diaphragm (5) on the valve assembly (4) and in the cover.

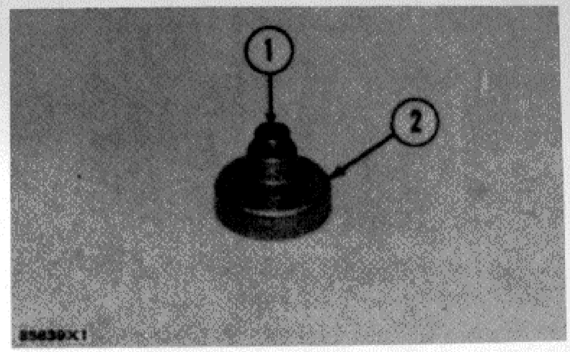
6. Install cover and three bolts (II) that hold covers together.

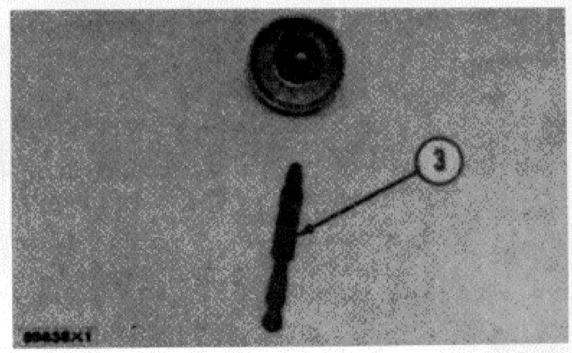
7. Put clean engine oil on seal and ring seal. Install the seals (10) on valve.

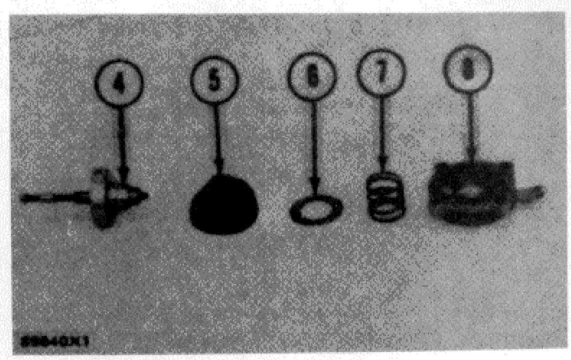
8. Install the two springs (13), retainer, and valve assembly (12).

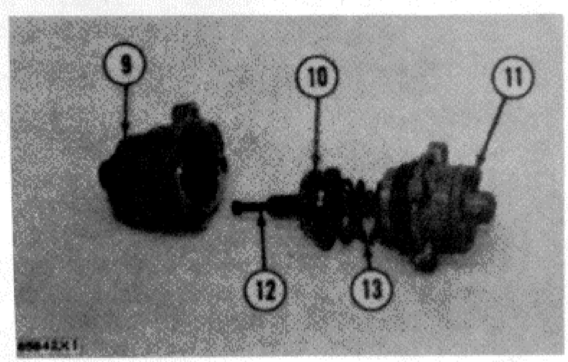
9. Install housing (9) and two bolts.

end by:
a) install fuel ratio control

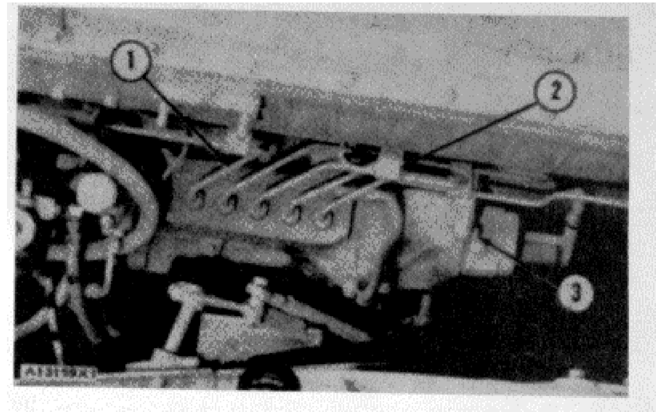








FUEL INJECTION LINES



REMOVE FUEL INJECTION LINES

1. Disconnect the fuel injection lines (I) from the fuel injection pump housing and the cylinder head. Install protection covers on all fuel line connections to prevent dirt or dust from getting into the fuel system.

2. Remove the bolts that hold the brackets (2) for the fuel injection lines to the cylinder head.

3. Remove the two bolts (3) that hold the bracket for the fuel lines to the governor housing.

4. Remove the fuel injection lines from the engine.

INSTALL FUEL INJECTION LINES

	Tools Needed	A
5P326	Socket	1

1. Put the fuel lines in position on the engine and install the bolts that hold the brackets for the fuel lines to the cylinder head.

2. Install the two bolts that hold the bracket for the fuel lines to the governor housing.

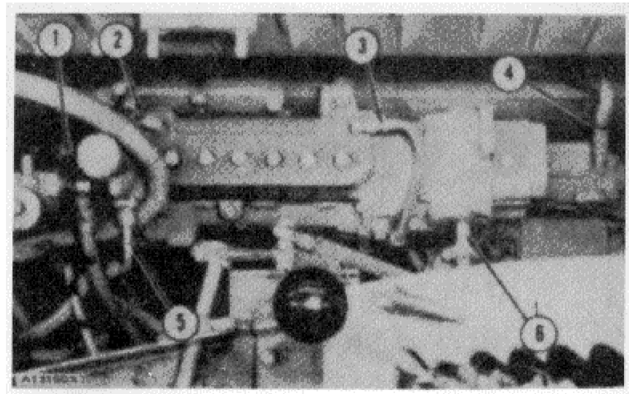
3. Remove the protection covers from the fuel line connections. Connect the fuel injection lines to the fuel injection pump housing and the cylinder head. Use tool (A) to tighten the fuel line nuts to a torque of 30 ± 5 lb. ft. (4.1 ± 0.7 mkg).

FUEL INJECTION PUMP HOUSING AND GOVERNOR

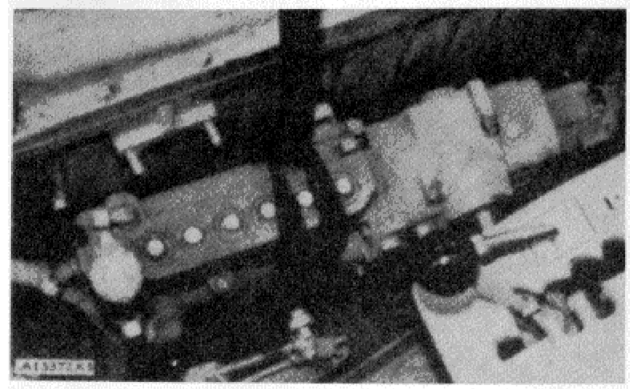
REMOVE FUEL INJECTION PUMP HOUSING AND GOVERNOR

start by:
a) remove fuel injection lines

1. Disconnect lines (1), (2), (3), (4) and (5) from fuel injection pump housing and fuel ratio control. Put identification on all lines. Install protective covers for protection from dirt or dust. Disconnect governor linkage (6).



2. Fasten a hoist to the fuel injection pump housing and governor. Remove the bolts that hold the pump housing to the cylinder block. Remove the bolts that hold the pump housing to the governor drive housing.



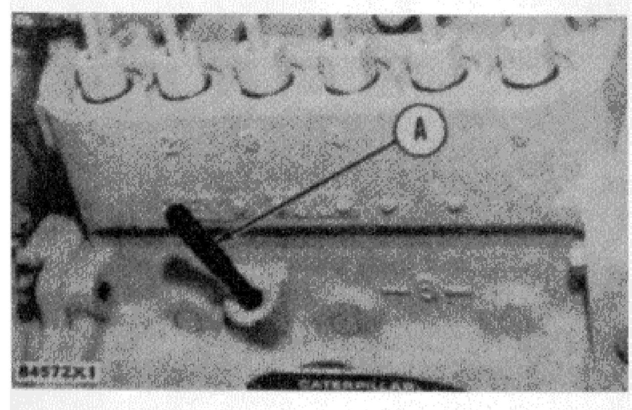
INSTALL FUEL INJECTION PUMP HOUSING AND GOVERNOR

	Tools Needed	A	B
8S2291	Timing Pin	1	
9S9082	Engine Turning Pinion		1

1. Install two new O-ring seals on the pump housing.
2. Fasten a hoist to the fuel injection pump housing and governor and put it in position on the governor drive housing.
3 Install the bolts that hold the fuel injection pump housing to the governor drive housing.
4. Install the bolts that hold the fuel injection pump housing to the cylinder block.
5. Remove the protective covers from all lines and openings. Install lines in their respective positions.
6. Set the fuel injection pump timing as follows:

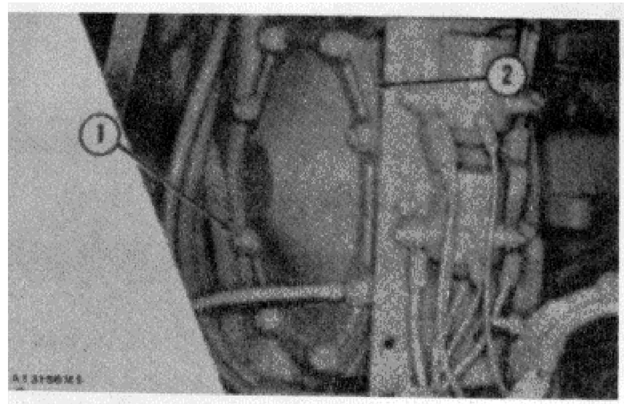
   a) Turn the engine with tool (B) to top center of the compression stroke for No. I piston. See FINDING TOP CENTER COMPRESSION POSITION FOR NO. I PISTON in 3406 VEHICLE ENGINE, TESTING AND ADJUSTING.

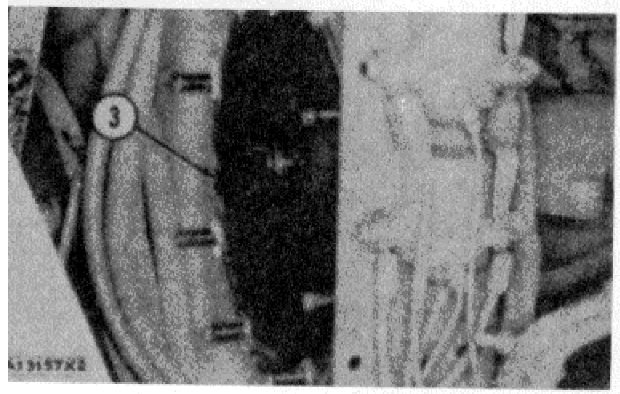
   b) Remove the plug from the side of the fuel injection pump housing. Install tool (A) through the hole in pump housing and into the notch in the fuel injection pump camshaft.



FUEL INJECTION PUMP HOUSING AND GOVERNOR

NOTE: If tool (A) can not be installed in the notch of the fuel injection pump camshaft the injection pump is not in time with the engine and the following procedure must be followed: a) Remove nuts (I) and cover (2) for the automatic timing advance.





b) Loosen four bolts (3) to loosen the automatic timing advance.

c) Put a screwdriver between the four bolts and turn the fuel injection pump drive shaft until tool (A) can be put into the notch in the fuel injection pump camshaft.

d) Remove the timing bolt from the flywheel. Turn the engine 60°counterclockwise [as seen from the front of the engine with tool (B)].

e) Tighten the four bolts that hold the automatic timing advance by hand. Turn the engine clockwise [as seen from the front of the engine with tool (B)] until the engine is at top center compression stroke of No. 1 piston.

(f) Tighten the four bolts (3) to a torque of 25 Ib. ft (3.5 mkg). Remove tool (A) from the fuel injection pump housing.

g) Tighten the bolts to a torque of 50 lb. ft. (6.9 mkg), and then to a final torque of 75 ± 10 lb. ft. (10.4 ±1.4 mkg).

h) Turn the crankshaft two complete revolutions and check the timing to see that timing is correct. If timing is not correct, do the above procedure again.

i) Install the cover for the automatic timing advance and the nuts that hold it.

end by:
a) install fuel injection lines

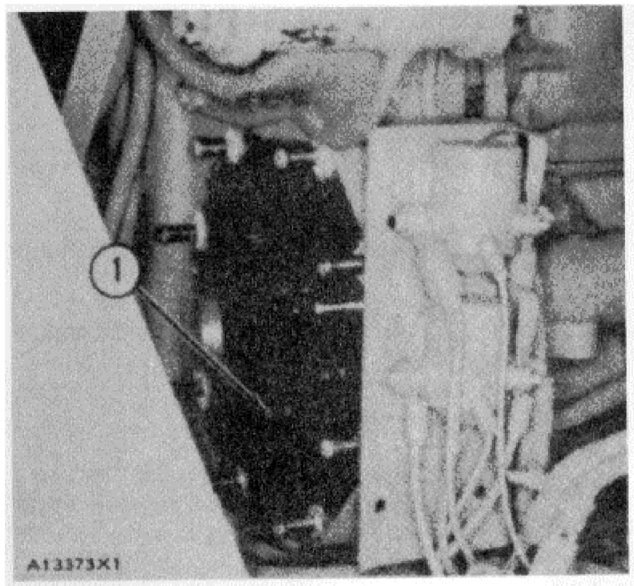
GOVERNOR AND FUEL PUMP DRIVE

REMOVE GOVERNOR AND FUEL PUMP DRIVE

start by:

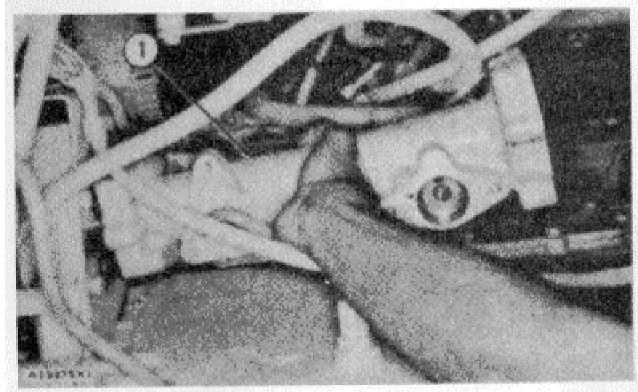
a) remove automatic timing advance
b) remove fuel injection pump housing and governor
c) remove fuel transfer pump
d) remove tachometer drive

1. Remove four bolts (I) that hold the governor and fuel pump drive to the timing gear plate.
2. Remove governor and fuel pump drive from the engine.



INSTALL GOVERNOR AND FUEL PUMP DRIVE

1. Put the governor and fuel pump drive (1) in position in the timing gear.
2. Install the four bolts that hold the governor and fuel pump drive to the timing gear plate.



end by:

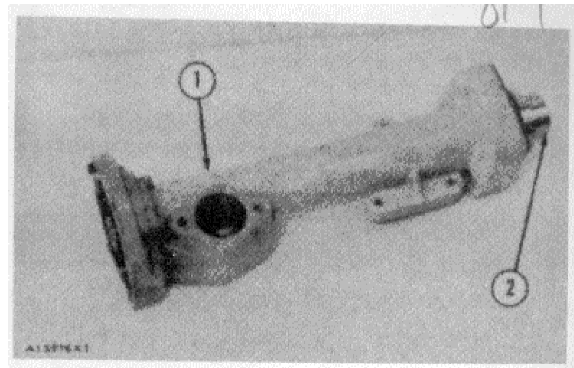
a) install tachometer drive
b) install fuel transfer pump
c) install fuel injection pump housing and governor
d) install automatic timing advance

GOVERNOR AND FUEL PUMP DRIVE

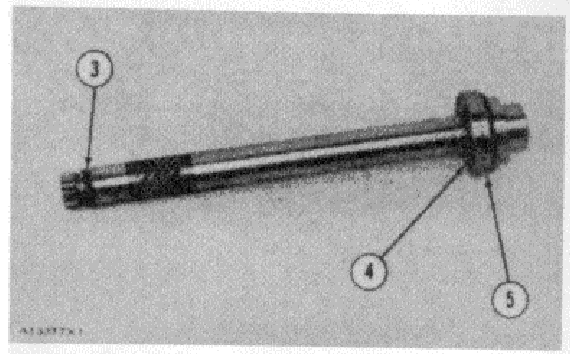
DISASSEMBLE GOVERNOR AND FUEL PUMP DRIVE

start by:
a) remove governor and fuel pump drive

1. Remove shaft (2) from housing (1).

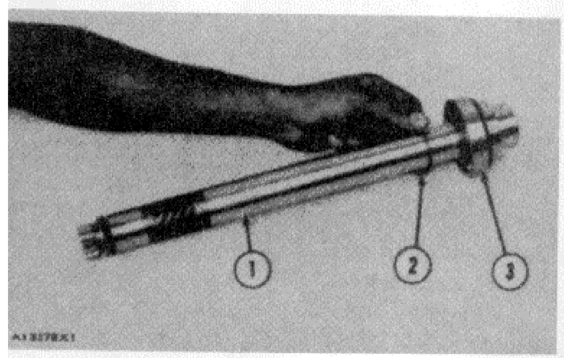


2. Remove O-ring seal (3), ring (4) and bearing (5) from shaft.



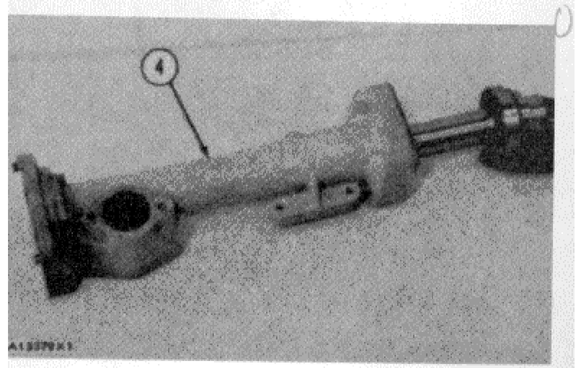
ASSEMBLE GOVERNOR AND FUEL PUMP DRIVE

1. Install bearing (3), ring (2) and O-ring seal on the shaft (1).



2. Install shaft (1) into housing (4).

end by:
a) install governor and fuel pump drive

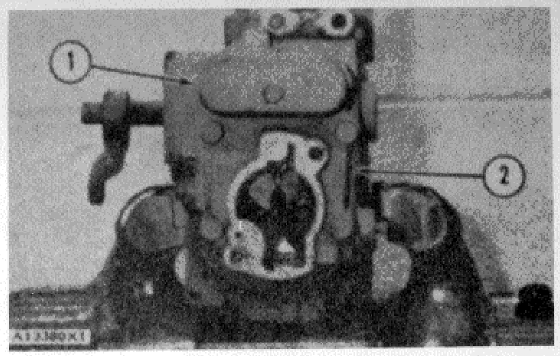


FUEL INJECTION PUMP HOUSING AND GOVERNOR

SEPARATION OF GOVERNOR FROM FUEL INJECTION PUMP HOUSING

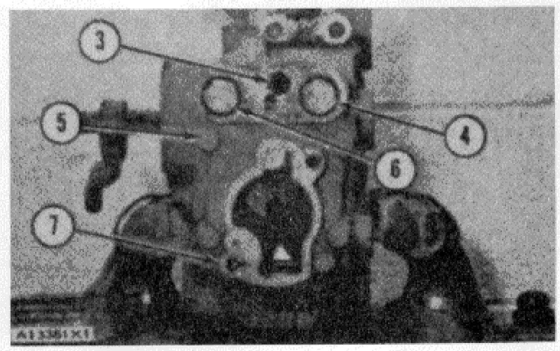
start by:

a) remove fuel injection pump housing and governor

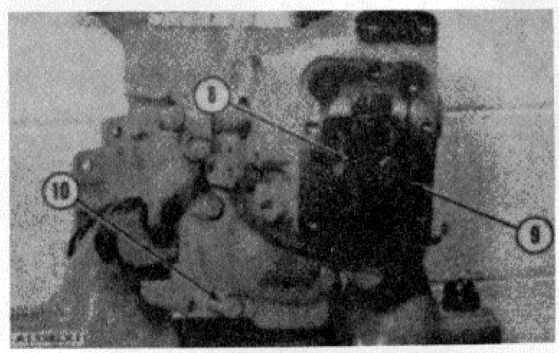


1. Remove plate (2) from the idle screw housing.

2. Remove cover (19 for idle screw.

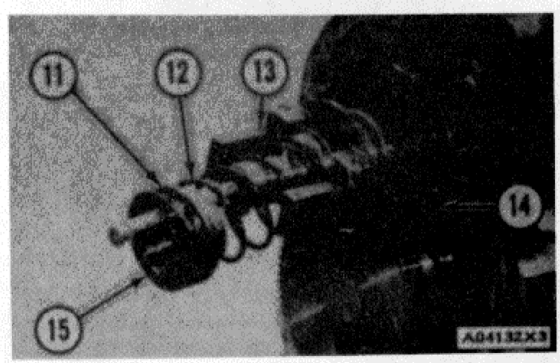


3. Remove low idle screw (6) and high idle screw (4). Remove bolt (3) and four bolts (5). Remove idle screw housing (7). Inspect strainer assembly in idle screw housing.



4. Remove the screw (9) that holds the rack stop collar (8) to the governor shaft.

5. Remove the rack stop collar (8) and spring.



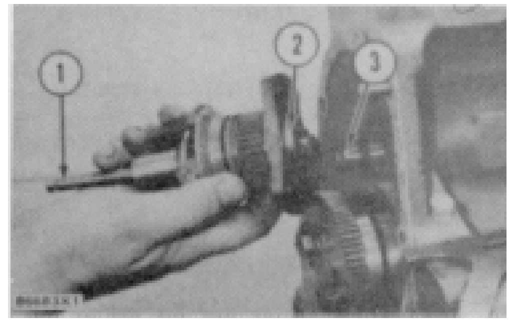
6. Remove the bolts (10) that hold governor housing to the fuel injection pump housing. Remove governor housing.

7. Remove seat (15), washer type springs (11), governor spring (12) and washer.

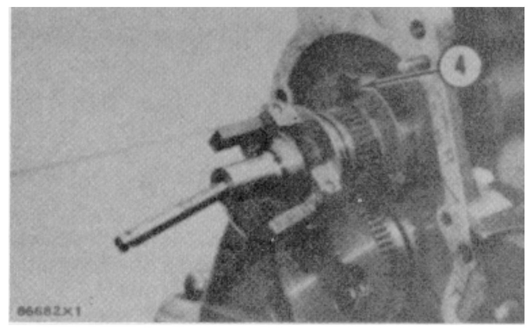
8. Remove three bolts (14) and lock that holds cylinder and weight assemblies (13) to pump housing. Remove the cylinder and weight assemblies from the rack.

FUEL INJECTION PUMP HOUSING AND GOVERNOR

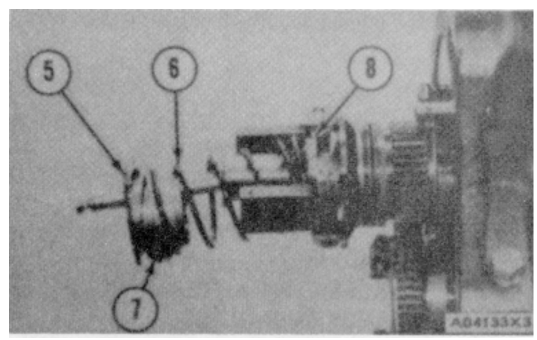
CONNECTION OF GOVERNOR TO FUEL INJECTION PUMP HOUSING



1. Put the cylinder and weight assemblies (1) on fuel injection pump housing. Be sure the groove (slot) in piston (2) is engaged in groove (slot) in the rack (3).



2. Install the lock and three bolts (4) that hold cylinder and weight assemblies on the pump housing.

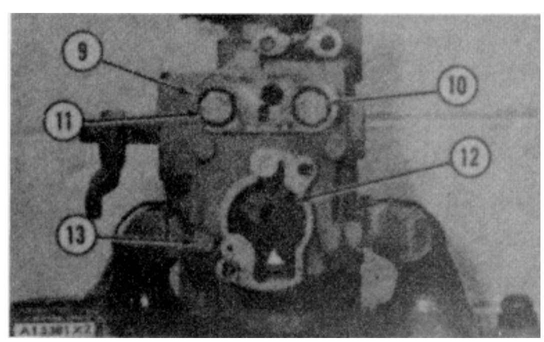


3. Install washer (8), governor spring (6), seat (5) and washer type springs (7) on the seat and bolt.

4. Put the governor housing on pump housing and install the bolts.

5. Install the spring and rack stop collar (12). Install the screw that holds the collar to the bolt.

6. Put strainer into position in idle screw housing with the screen side of the assembly toward the governor housing.



7. Install the idle screw housing (9) and the bolts (13) that hold it. Install high idle screw (10) and low idle screw (11).

8. Install the cover for the idle screws.

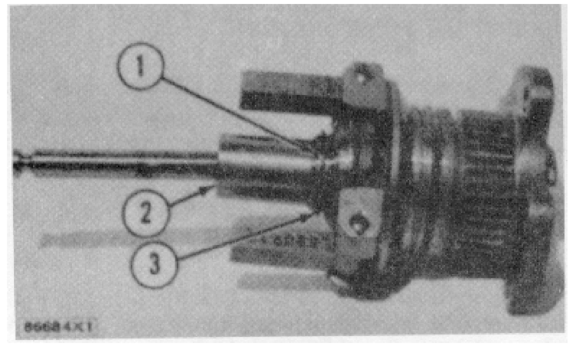
9. Install the plate for the idle screw housing.

end by:
   a) install fuel injection pump housing and governor

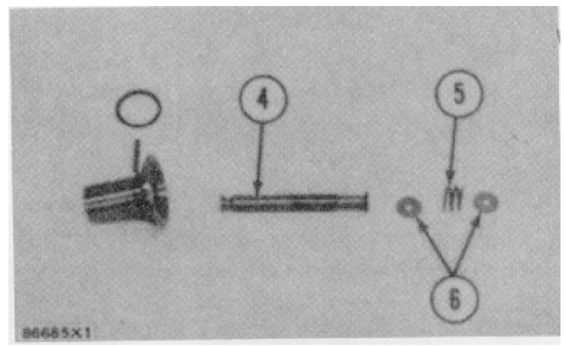
GOVERNOR

DISASSEMBLE GOVERNOR

start by:
a) separation of governor from fuel injection pump housing

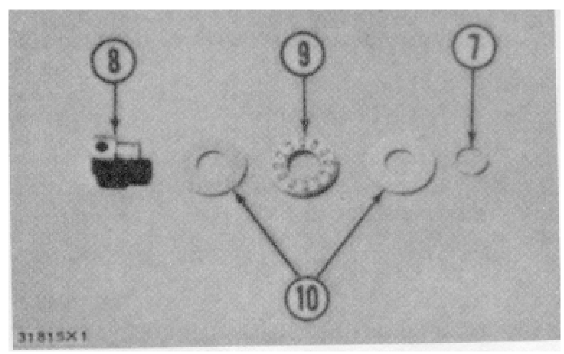


1. Remove the ring (3) and pin (1) that hold seat (2).

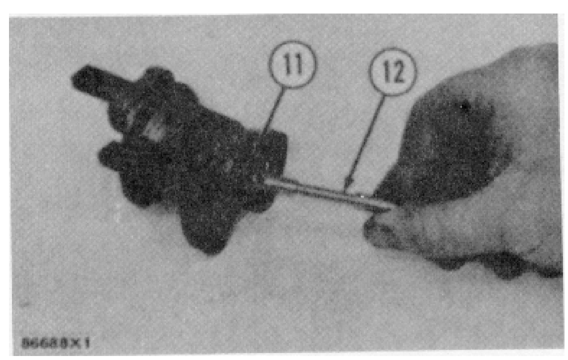


2. Remove seat (2), bolt (4), washers (6) and spring (5).

3. Remove the sleeve and bearing assembly from the cylinder and weight assemblies.



4. Remove ring (7) from sleeve (8).



5. Remove bearing (9) and washers (10) from sleeve (8).

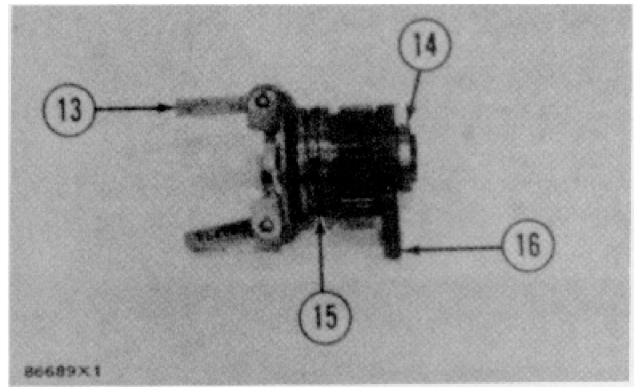
6. Remove valve (12) from piston (11).

GOVERNOR

7. Remove the ring (15) that holds weight assembly to cylinder (16).

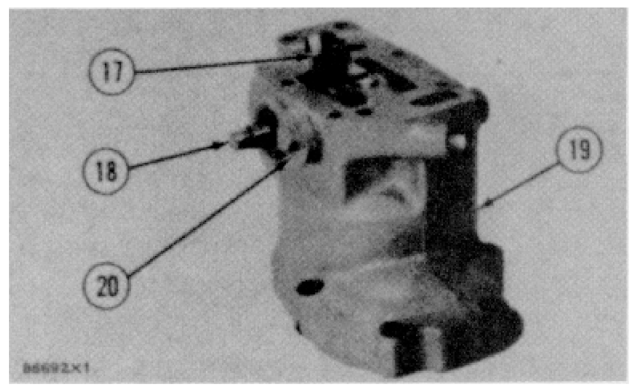
8. Remove weight assembly (13) from cylinder.

9. Remove piston (11) and sleeve (14) from cylinder. Remove O-ring seal from sleeve (14).



10. Remove speed limiter plug (20), spring and plunger from the governor housing (19).

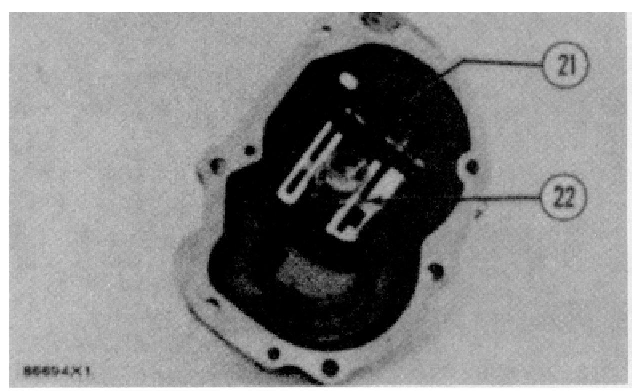
11. Remove torque spring assembly (17).



12. Remove bolt (21) and lock that hold lever (22) to shaft (18).

13. Remove lever (22) and shaft from housing.

14. Remove the seal from housing (19).

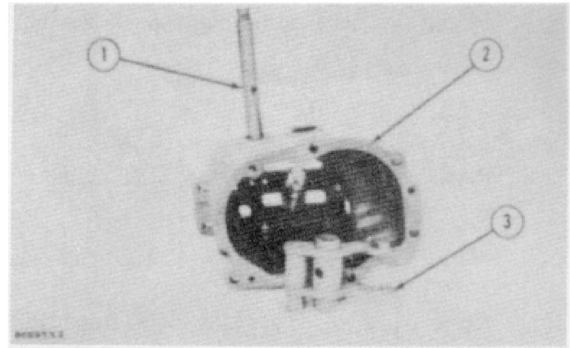


GOVERNOR

ASSEMBLE GOVERNOR

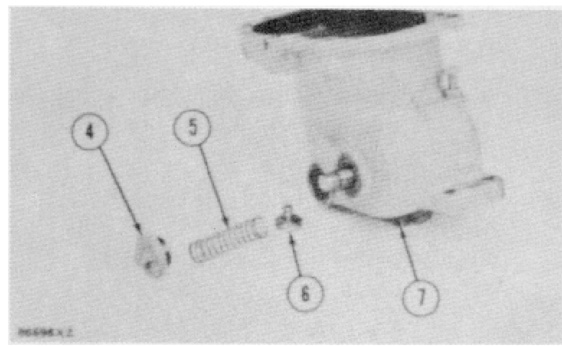
	Tools Needed	A
1P529	Handle	1
1P463	Drive Plate	1

1. Use tooling (A) to install seal in governor housing. Install seal so lip of seal is toward the outside.



2. Install the lever assembly (3) in governor housing (2). Install the shaft (1) through lever. Install the lock and bolt that hold lever to shaft.

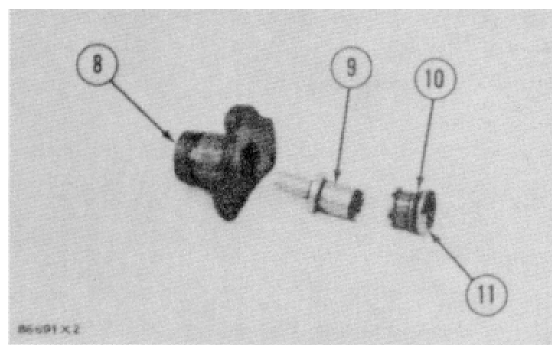
3. Install the torque spring assembly (7) on the housing. Install lock and two bolts.



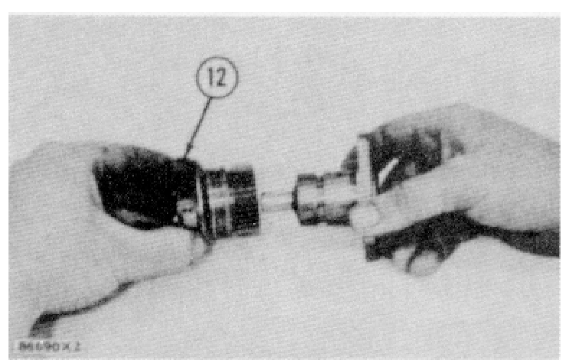
4. Install speed limiter plunger (6), spring (5) and plug (4).

5. Install the O-ring seal (10) on sleeve (11).

6. Install piston (9) and sleeve in the cylinder (8).



7. Put the weight assembly (12) on the cylinder (8). Install the ring that holds weight assembly on the cylinder.



GOVERNOR, FUEL INJECTION PUMP HOUSING

8. Install the valve (14) in the piston (9).

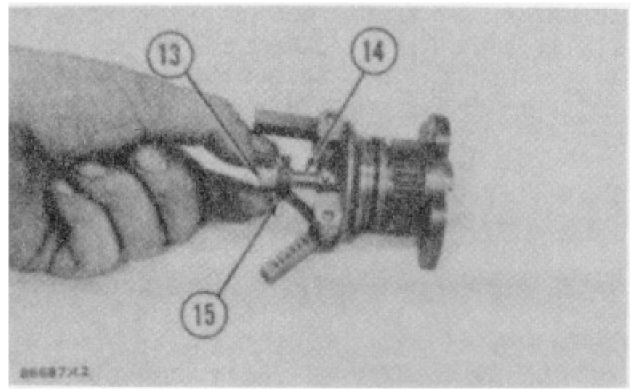
9. Install bearing and washers (15) on sleeve (13). Install the ring that holds washers and bearing on sleeve.

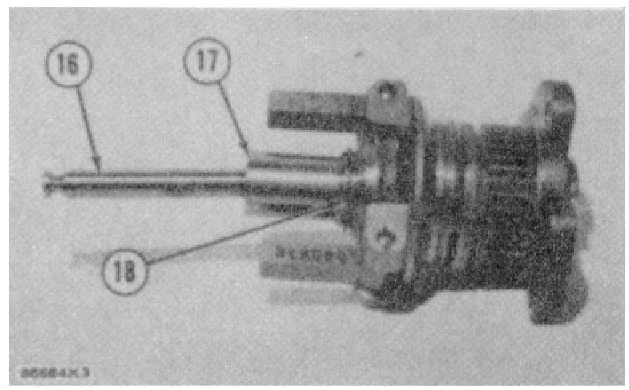
10. Install the sleeve assembly on valve (14).

11. Install the bolt (16) in the seat (17). Install the washers and spring in the seat.

12. Put the seat in position on the valve (14). Install the pin that holds the valve sleeve and seat together. Install the ring (18) that holds the pin in position.

end by:
a) connect governor to fuel injection pump housing





DISASSEMBLE FUEL INJECTION PUMP HOUSING

	Tools Needed	A	B	C
8S4613	Wrench	1		
8S2244	Extractor		1	
8S2241	Camshaft Bearing Removal			
	& Installation Tool Group			1

start by:
a) separation of governor from fuel injection pump housing

1. Remove protection caps and felt washers (1) from pumps.

2. Use wrench (A) to remove the bushings (2) that hold fuel injection pumps into housing. Remove the seals (3).

3. Use extractor (B) to remove pumps from the pump housing.

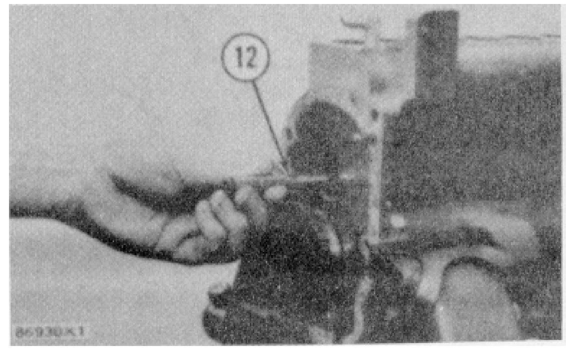
NOTE: Put identification on the injection pumps as to their location in the pump housing.

4. Remove the bonnet (4), ring (5), spring (6), and check valve (7) from barrel (8).

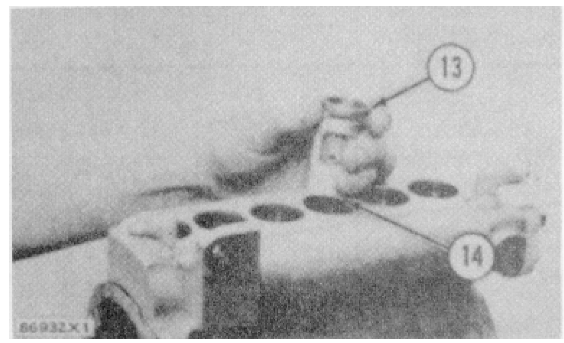
5. Remove the plunger assembly (11), washer (10), and spring (9) from barrel.

FUEL INJECTION PUMP HOUSING

CAUTION: Be careful not to cause damage to plunger assemblies. Keep same cylinder pump and plunger together, the plunger from one pump can not be installed in another pump.

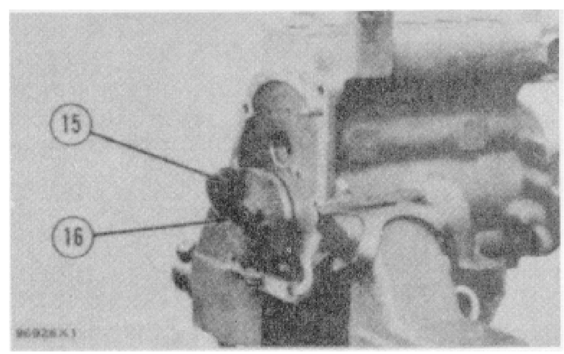


6. Remove the rack (12) from the housing.



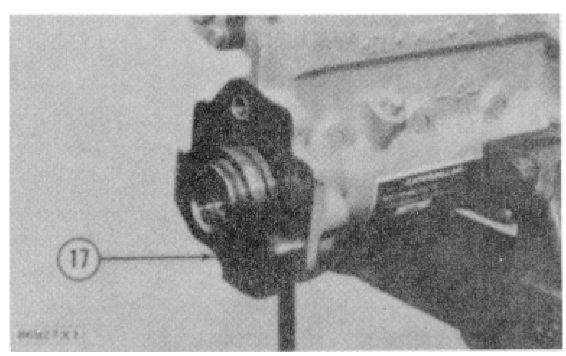
7. Remove the spacers (13) and the lifters (14) from the housing.

NOTE: Keep the spacers and lifters together with identification as to their location in the pump housing.



8. Remove two bolts (16), lock, and two sleeves from the gear assembly.

9. Remove the gear assembly (15) from camshaft.



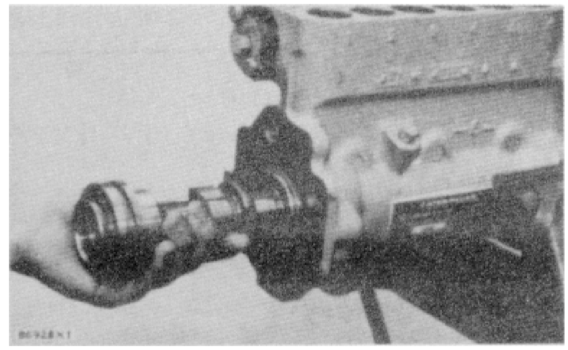
10. Remove two bolts, plate (17), and spacer that hold camshaft in position in pump housing.

FUEL INJECTION PUMP HOUSING

11. Remove the camshaft from the pump housing.

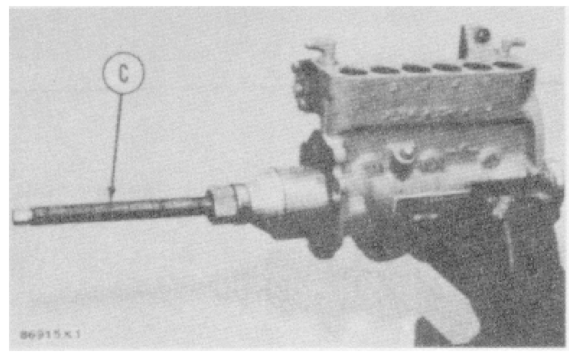
12. Use tool group (C) to remove the camshaft bearings from the pump housing.

13. Remove the bearings for fuel rack from the pump housing.

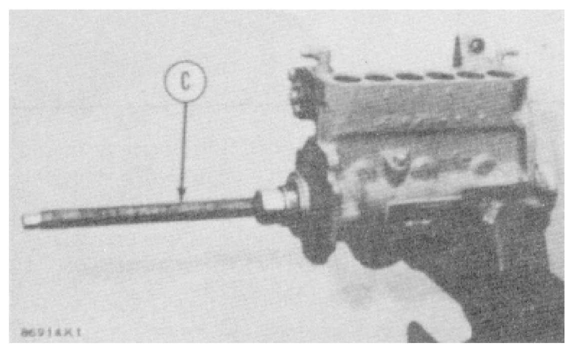


ASSEMBLE FUEL INJECTION PUMP HOUSING

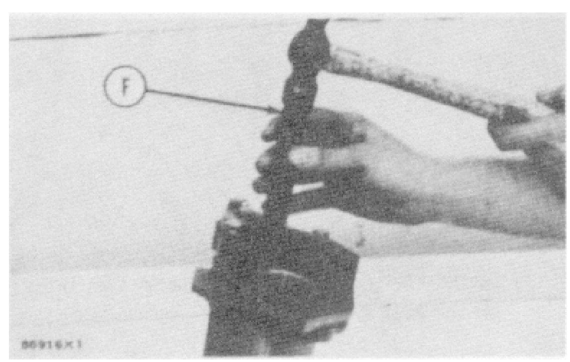
	Tools Needed	A	B	C	D	E	F
8S4613	Wrench	1					
8S2244	Extractor		1				
852241	Camshaft Bearing						
	Removal & Installation						
	Group			1			
5P1768	Pointer Group				1		
1P529	Handle					1	
1P455	Drive Plate					1	
5P1664	Adapter Plate						1
1P463	Drive Plate					1	
9S6329	Driver						1



1. Use tool group (C) to install the camshaft bearings in fuel injection pump housing. Install bearing in governor end of housing so oil hole in bearing is in alignment with oil hole in housing.



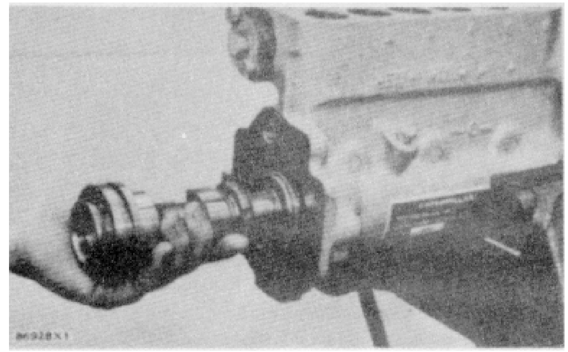
2. Use tooling (F) to install bearing with a groove for the rack.



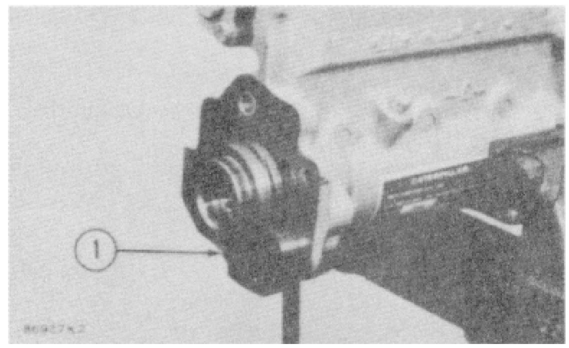
FUEL INJECTION PUMP HOUSING

3. Use tooling (E) to install the other bearing for the rack.

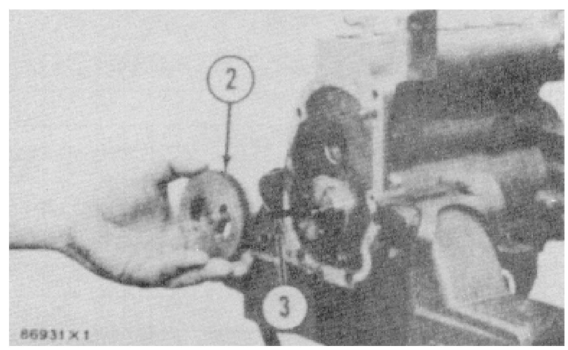
4. Put clean engine oil on the camshaft. Install the camshaft in the pump housing.



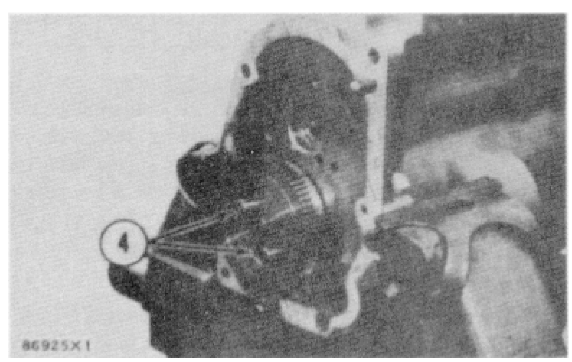
5. Install the spacer, plate (1), and two bolts that hold camshaft in place in pump housing.



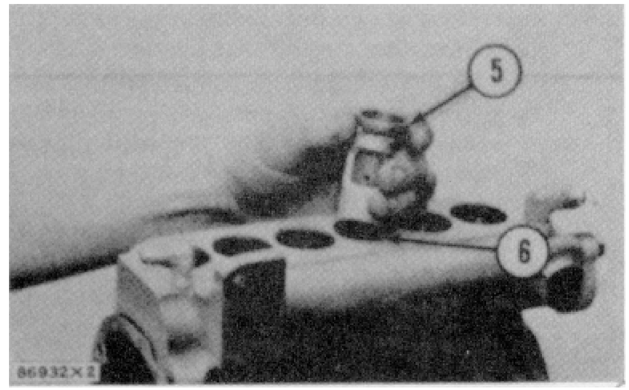
6. Put the gear assembly (2) in position on end of camshaft. Be sure the rod (3) is in the groove of camshaft.



7. Install the sleeves (4), lock, and two bolts on the gear assembly.

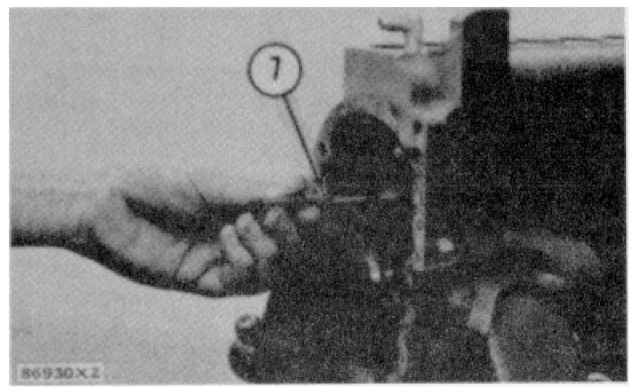


FUEL INJECTION PUMP HOUSING



8. Install the spacers (5) with their respective lifters (6) in pump housing. If new lifters and/or pumps are to be installed, make adjustment of fuel pump timing dimension. See TIMING DIMENSION ADJUSTMENT OF FUEL INJECTION PUMPS OFF ENGINE in TESTING AND ADJUSTING.

9. Install the rack (7) in the pump housing.



10. Assemble the fuel injection pumps as follows:

    a) Put clean fuel on all parts.

    b) Install spring, washers, and plunger in the barrel.

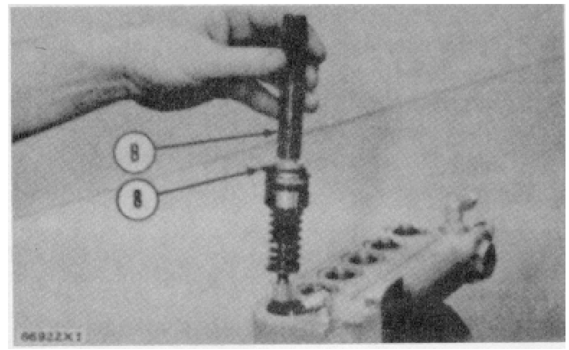
    c) Install the spring, check valve, bonnet, and ring on the barrel.

CAUTION: The plunger from one pump can not be installed in another pump. Do not install the pumps until rack (7) is in center position (centered).

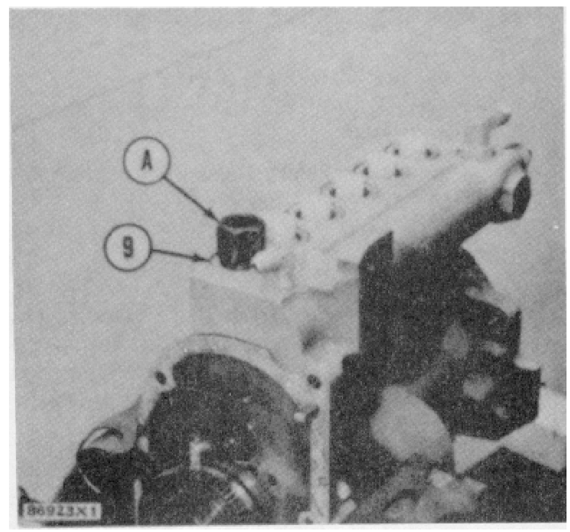
11. Use pointer group (D) to put rack (7) in center position. Push the rack into pointer (D) to get the center position.

NOTE: The rack will be extended .156 in. (3.963 mm) from the end of pump housing (opposite the governor) when rack is in center position.

FUEL INJECTION PUMP HOUSING



12. Install fuel injection pumps with extractor (B). Turn the camshaft until lobe of camshaft is down on pump to be installed. Look down the pump and make grooves in bonnet and barrel in alignment with groove (slot) in the pump gear. The groove (slot) of gear must be in line with center of these grooves. Put the pump so grooves are in alignment with guide pins in housing bores. Install the pump in its respective bore in housing.



13. Install seal (8) and bushing (9). Put pressure by hand to extractor (B). Tighten bushing by hand (finger tight only) until bushing is even with top of housing. If bushing can not be installed by hand, remove bushing and pump. Make grooves in alignment and install again.

CAUTION: Do not put force on bushings by installing with a wrench to make even with pump housing. Pump is not installed correctly if a force has to be used to install bushing.

14. Check the rack movement (travel) after each pump is installed. Total rack movement (travel) must be .620 in. (15.75 mm). See INSTALLATION OF INJECTION PUMPS in TESTING AND ADJUSTING.

15. Tighten the bushing with wrench (A) to 150 ± 10 lb.ft. (20.7 ± 1.4 mkg). Remove wrench (A) and install felt seals and protection caps.

end by:

a) connection of governor to fuel injection pump housing.

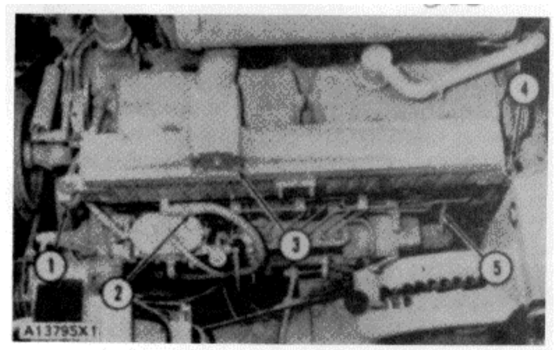
AFTERCOOLER HOUSING AND CORE

REMOVE AFTERCOOLER HOUSING AND CORE

start by:
a) remove hood

1. Remove the coolant from the engine.

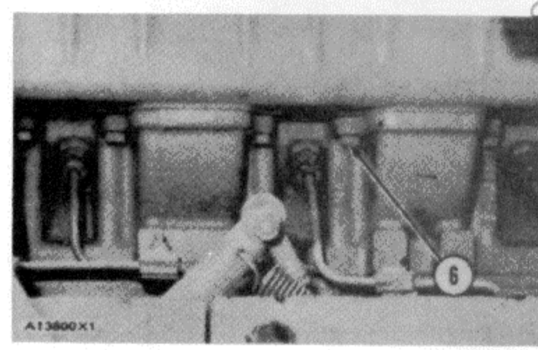
2. Disconnect air compressor line (2) and fuel ratio control line (5) from the aftercooler housing.



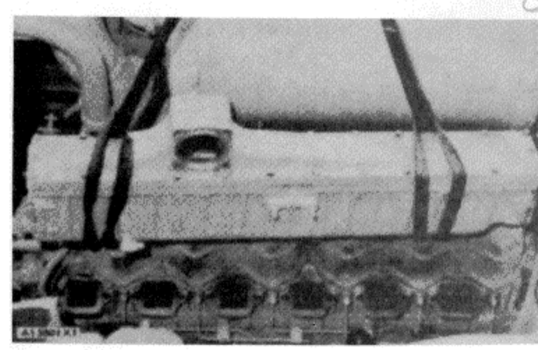
3. Remove the four bolts (3) and cover. Remove four nuts that connect inlet pipe to the aftercooler housing.

4. Remove elbows (I) and (4).

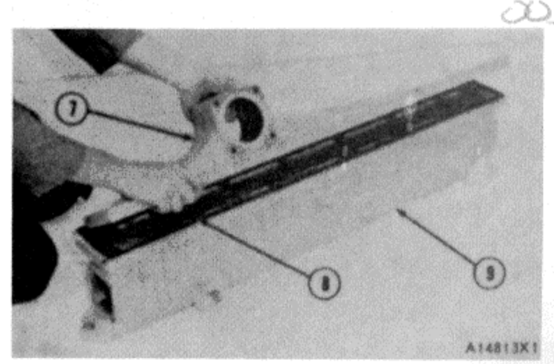
5. Remove the bolts (6) that hold the aftercooler housing to the cylinder head.



6. Fasten a hoist to the aftercooler housing and core assembly and remove from engine. Weight of the assembly is 95 lb. (43 kg).



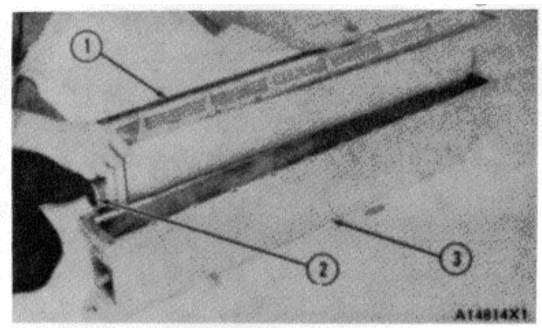
7. Remove bolts and remove cover (7) from aftercooler housing (9). Remove core (8) from housing. Remove O-ring seals from aftercooler core. Inspect and make a replacement of seals if necessary.



AFTERCOOLER HOUSING AND CORE, WATER TEMPERATURE REGULATORS

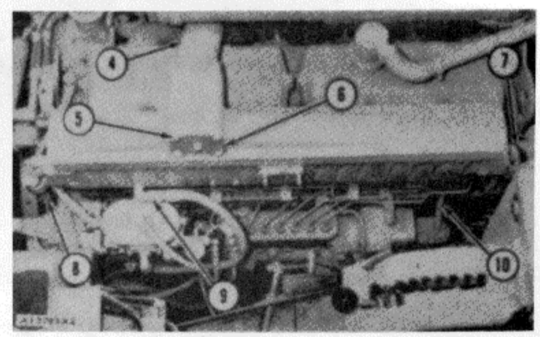
INSTALL AFTERCOOLER HOUSING AND CORE

1. Install new O-ring seals (2) on the aftercooler core (1). Install core (I) in aftercooler housing (3). Install cover on housing. Install bolts. Fasten a hoist to the aftercooler housing and core assembly and put it in position on the cylinder head.



2. Install the bolts that hold the aftercooler housing to the cylinder head. Install elbows (8) and (7). Connect air compressor line (9) and fuel ratio control line (10) to aftercooler housing.

3. Install cover (6) and four bolts (5). Connect the inlet pipe (4) and install the four nuts that hold it.



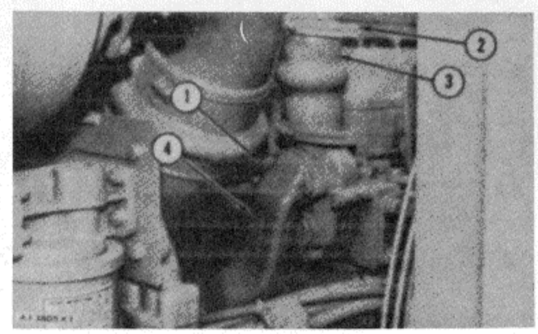
4. Fill engine w ith coolant to the correct level.
   end by:
   a) install hood

REMOVE WATER TEMPERATURE REGULATORS

1. Remove coolant from the engine to a level below the water temperature regulator.

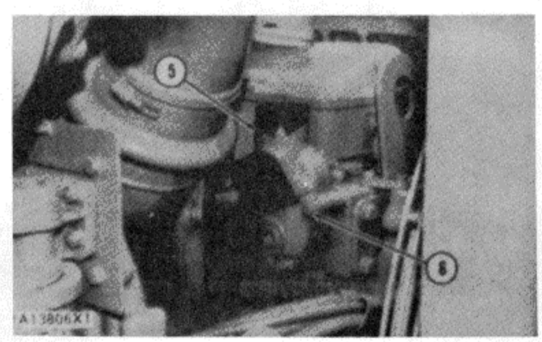
2. Disconnect radiator hose (3) from the regulator housing by loosening clamps (2).

3. Remove two bolts (I) and pipe (4).



4. Remove three bolts (6) and regulator housing (5).

5. Remove regulator and seal from the housing (5).



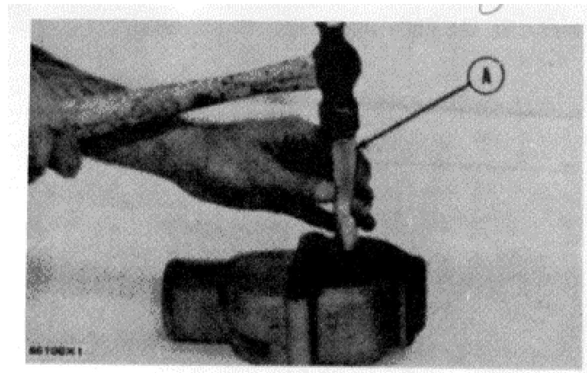
WATER TEMPERATURE REGULATORS

INSTALL WATER TEMPERATURE REGULATORS

	Tools Needed	A
1P52	Handle	1
1P488	Drive Plate	1
1P481	Drive Plate	1

1. Put clean engine oil on lip of seal.

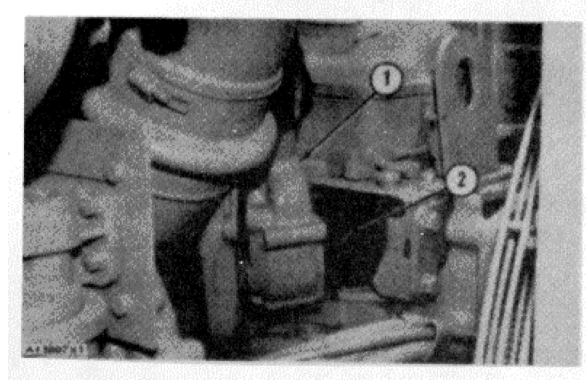
2. Use tooling (A) to install seal in housing with lip of seal away from regulator.



3. Install regulator (2) in housing. Put regulator housing (I) in position on cylinder head and 'install the three bolts that hold it.

4. Install pipe and two bolts. Connect radiator hose to regulator housing.

5. Fill the engine with coolant to the correct level.

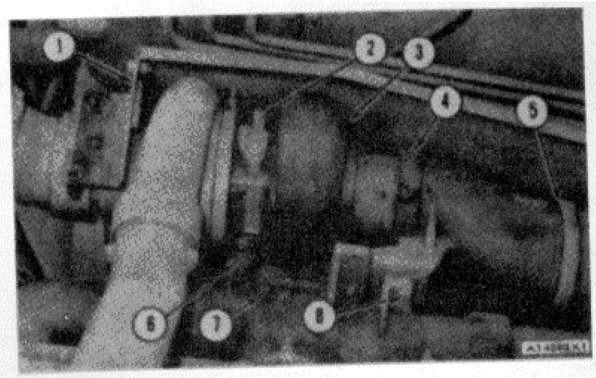


TURBOCHARGER

REMOVE TURBOCHARGER

start by:
a) remove hood

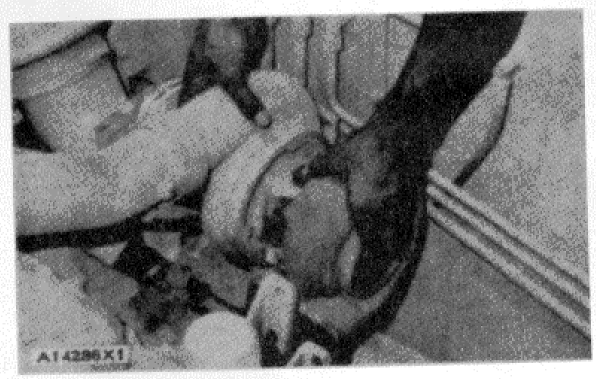
1. Remove muffler.
2. Remove guard (1). Disconnect oil drain line (6). Remove oil supply line (2).
3. Remove clamp (5). Remove bolts (8) and nuts and remove coupling (4).
4. Remove bolts (7) and nuts. Remove turbocharger (3).



INSTALL TURBOCHARGER

1. Put turbocharger in position on the exhaust manifold. Put 9M37 10 Anti-Seize Compound on the bolt threads. Install the bolts and nuts that hold turbocharger to exhaust manifold.
2. Put coupling in position on the turbocharger. Install clamp. Install bolts and nuts that hold coupling to manifold bracket.
3. Connect the oil drain line and oil supply line.
4. Install guard. Install muffler.

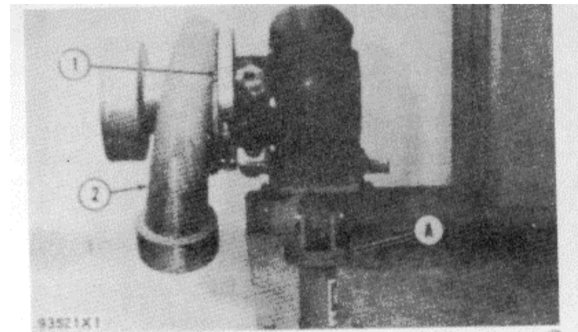
end by:
a) install hood



TURBOCHARGER

DISASSEMBLE TURBOCHARGER

	Tools Needed	A	B	C	D	E	F	G
9S6363	Holding & Positioning Fixture	1						
9S6343	Cartridge Fixture		1					
8S9944	Holder			1				
	Oil Cooker (Thermostat Controlled)				1			
FT808	Adapter					1		
FT165	Fixture						1	
FT174	Driver Tool							1



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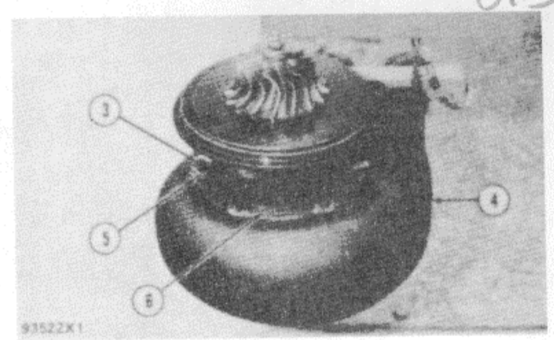
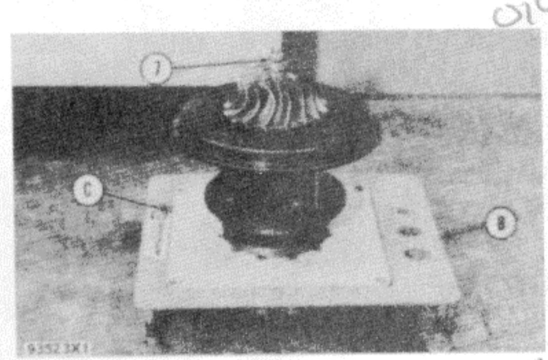
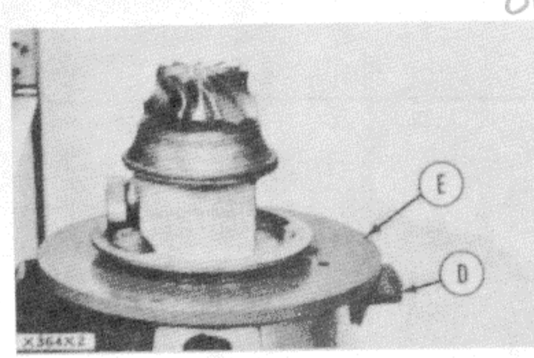


014



015



start by:
  a) remove turbocharger

1. Install the turbocharger on tool (A).

2. Put marks on the housings for correct installation at assembly.

3. Loosen clamp (1). Remove compressor housing (2). Remove the clamp.

4. Remove bolts (3), locks (6) and plates (5).

5. Remove the center section from turbine housing (4).

6. Install tool (C) in tool (B). Install the center section in tool (C) as shown.

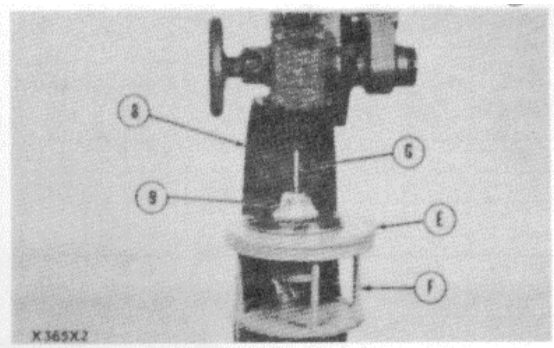
7. Remove nut (7) that holds the impeller to the shaft and wheel assembly.

8. Install tool (E) on tool (D). Heat tool (D) to 350°F (177°C). Install the impeller on tool (E).

CAUTION: Make sure only the impeller is in the hot oil.

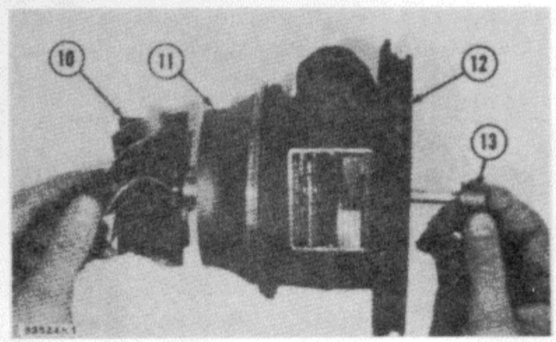
TURBOCHARGER

9. Install tool (E) with the center section on tool (F). Remove impeller (9) with an arbor press (8) and tool (G).

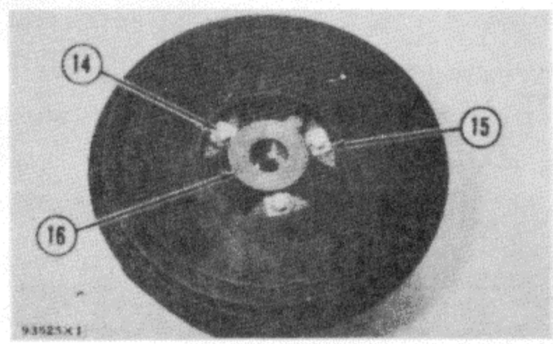


NOTE: Step 9 must be done before the impeller gets cold.

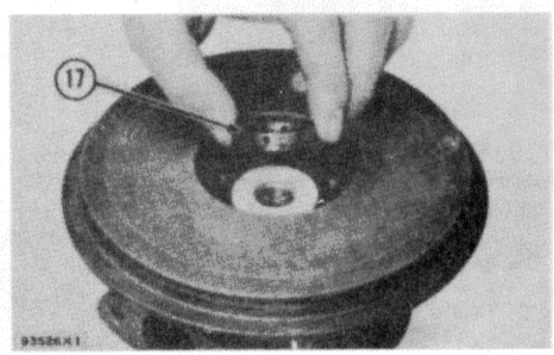
10. Remove shaft and wheel assembly (10), shroud (11) and spacer (13) from center housing (12).



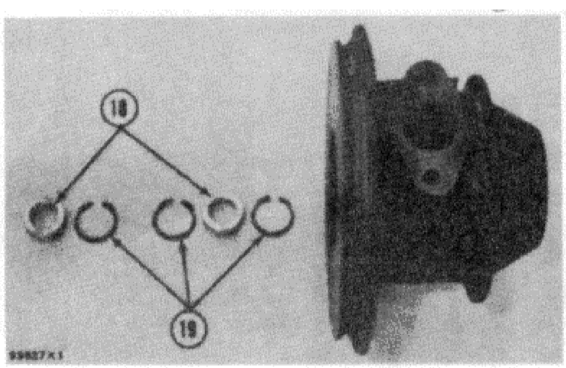
11. Remove bolts (14), locks (15) and plate (16) from the center housing.



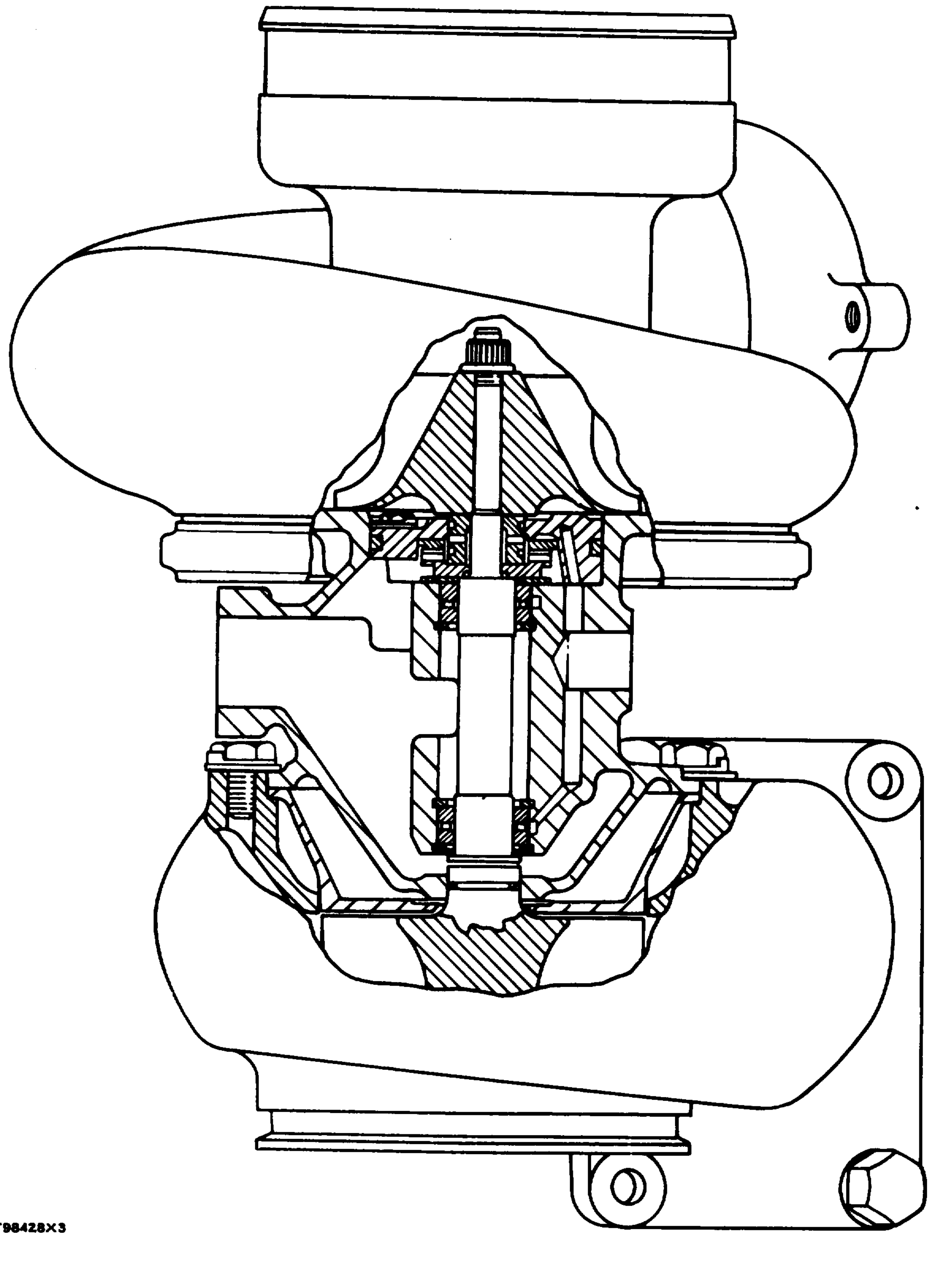
12. Remove collar (17).



13. Remove two bearings (18) and three snap rings (19) from the center housing.



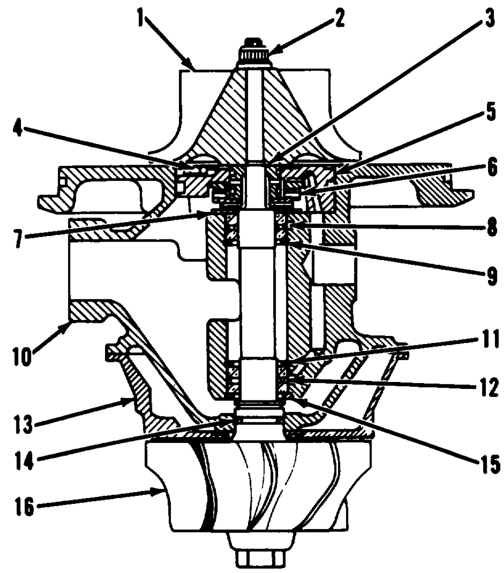
TURBOCHARGER



TURBOCHARGER

ASSEMBLE TURBOCHARGER

	Tools Needed	A	B	C	D	E
9S6363	Holding & Positioning Fixture	1				
9S6343	Cartridge Fixture		1			
8S9944	Holder			1		
FT165	Fixture				1	
FT174	Driver Tool					1



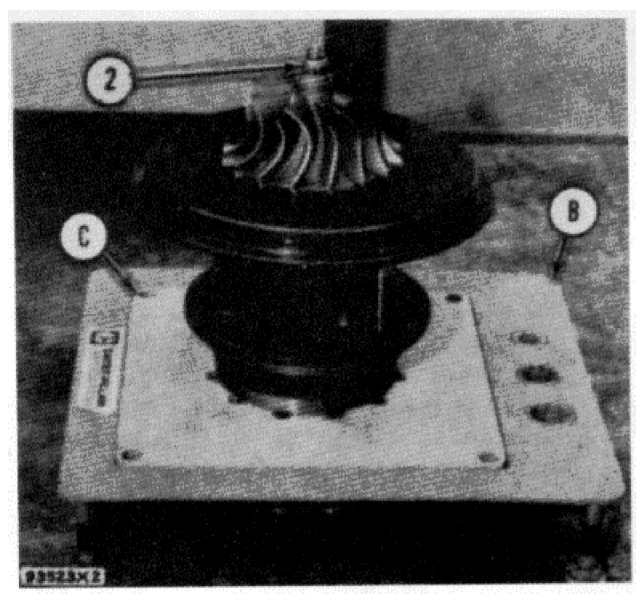
1. Clean all parts thoroughly before assembling.
2. Install snap ring (15), bearing (12) and snap ring (11) in center housing (10). Install snap ring (9) and bearing (8).
3. Install shroud (13) and shaft and wheel assembly (16) in the center housing.

CAUTION: Use caution not to cause damage to ring seal (14) when installing the shaft and wheel assembly.

4. Install spacer (7) and collar (6).
5. Put plate (5) in position on the center housing. Install bolts (4). Tighten the bolts to a torque of 35 ± 5 lb.in. (40.4 ± 5.8 cm.kg).
6. Install spacer (3). Make sure the small inside diameter of the spacer is toward the impeller end of the shaft and wheel assembly.

CAUTION: Install spacer (3) with its small inside diameter toward the center housing will cause a restriction of oil flow to the chamber and rings. This will cause a failure to the turbocharger.

7. Heat impeller (1) in oil to a maximum temperature of 350°F (177°C). Install the impeller on the shaft and wheel assembly.
8. Install tool (C) in tool (B). Install the center section in tool (C). Install nut (2). Tighten the nut to a torque of 120 lb.in. (138.4 cm.kg). Let the temperature of the impeller get below 150°F (65°C). Loosen the nut. Put a light amount of oil on the threads of the shaft and wheel assembly. Tighten the nut again to a torque of 30 lb.in. (34.6 cm.kg). Put a mark on the nut and impeller. Tighten the nut 120° past the mark.

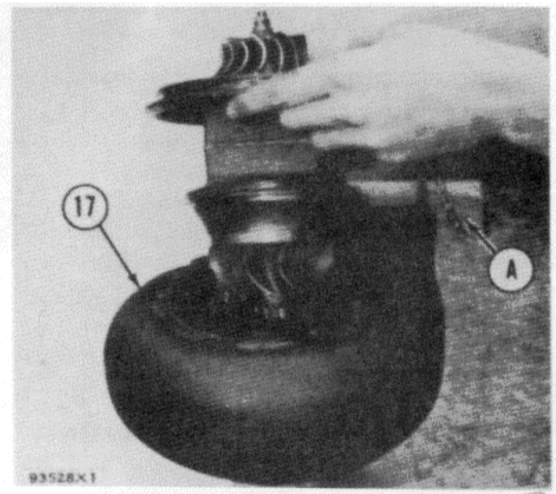


CAUTION: Do not put a bending force on the shaft and wheel assembly when tightening nut (2).

TURBOCHARGER

9. Install turbine housing (17) on tool (A). Install the center section in the turbine housing.

NOTE: Put the marks that were made at disassembly in alignment to make sure the housings are in their original position.



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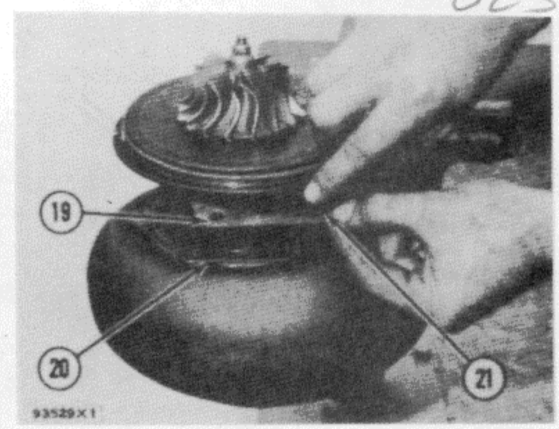
10. Put 9M3710 Anti-Seize Compound on the threads of bolts (21). Install plates (20), locks (19) and the bolts. Tighten the bolts to a torque of 175 ± 15 lb.in. (201.8 ± 17.3 cm.kg).



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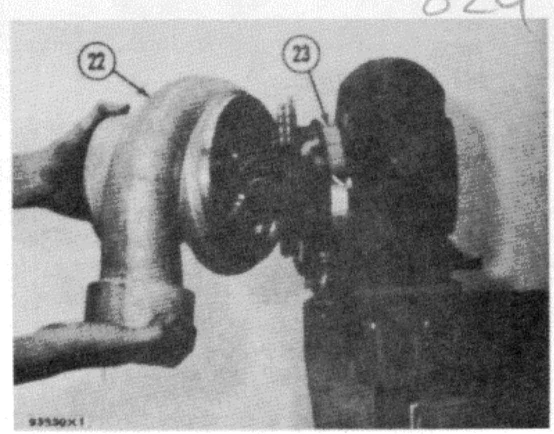
11. Put clamp (23) over the center section. Put compressor housing (22) in alignment with the marks made at disassembly. Put the clamp in position over the housing. Tighten the clamp to a torque of 120 ± 10 lb.in. (138.4 ± 11.5 cm.kg).

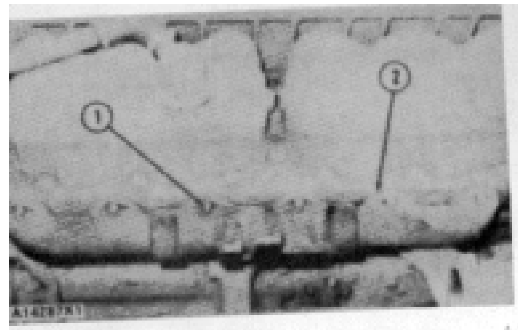


12. Put oil in the center section and turn the shaft and wheel assembly.
    end by:
    a) install turbocharger

EXHAUST MANIFOLD, ALTERNATOR

B

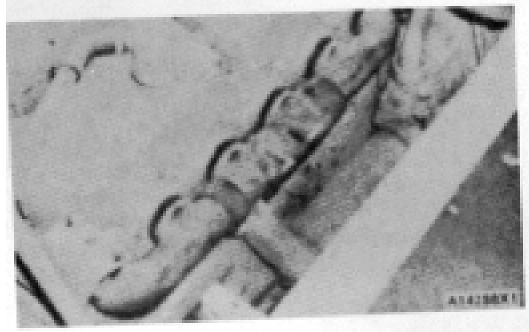
start by:
a) remove turbocharger



1. Remove the nuts (1) that hold exhaust manifold to the cylinder head.

2. Remove exhaust manifold (2) from the cylinder head.

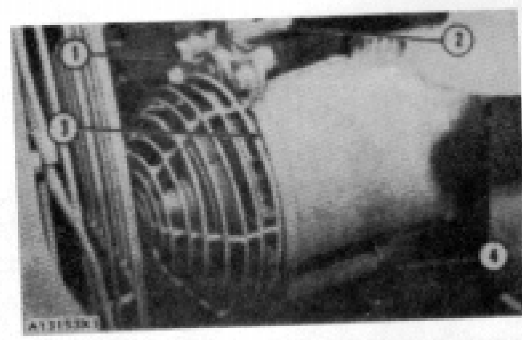
INSTALL EXHAUST MANIFOLD



1. Put 9M3710 Anti-Seize Compound on threads of the studs.

2. Put the exhaust manifold in position on the studs and install the nuts.
   end by:
   a) install turbocharger

REMOVE ALTERNATOR

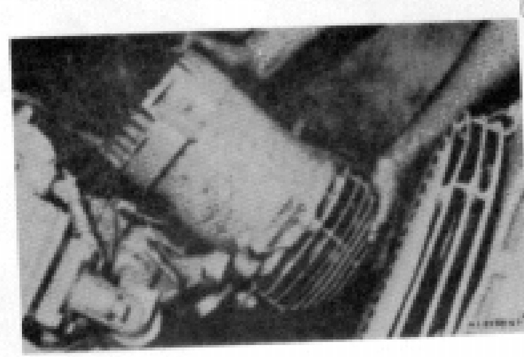


1. Loosen the nuts from the belt tightener (2). Remove the alternator belt.

2. Remove bolt (1).

3. Remove two bolts (4) and remove the alternator (3) from the engine.

INSTALL ALTERNATOR



1. Put alternator in position on bracket and install the two bolts that hold the alternator.

2. Install the alternator belts. Make an adjustment of belt deflection (movement) to 7/8 in. (22.2 mm) under 25 lb.ft. (11.3 kg) force, half way between pulleys.

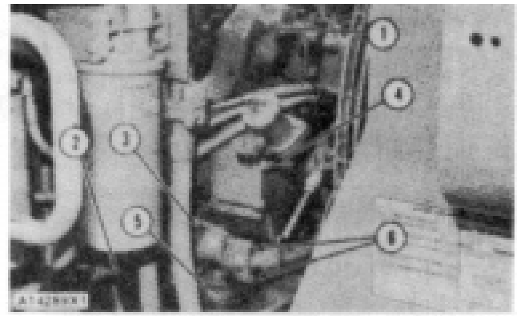
WATER PUMP

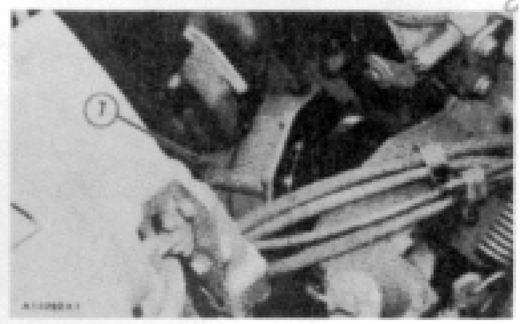
REMOVE WATER PUMP

start by:

a) remove engine oil cooler

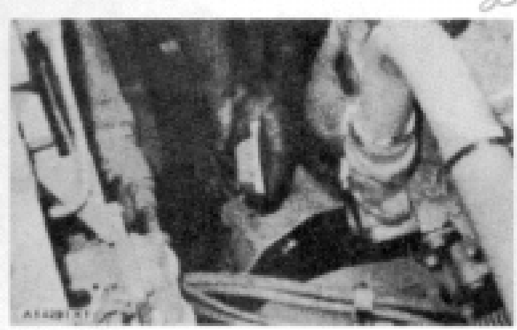
1. Remove oil level gauge tube (2).
2. Loosen clamp and disconnect hose (5).
3. Remove two bolts (6). Remove two bolts (3) and remove oil cooler elbow.
4. Remove two bolts (1) that hold pipe to water temperature regulator housing.
5. Remove seven bolts (4) that hold water pump to timing gear cover.
6. Remove water pump (7).





INSTALL WATER PUMP

1. Put water pump in position on timing gear cover. Be sure water pump gear is in alignment with the idler gear.
2. Install the bolts that hold the water pump to the timing gear cover.
3. Install the two bolts that hold pipe to the water temperature regulator housing.
4. Install oil cooler elbow and the bolts that hold it.
5. Connect hose to water pump and tighten clamp.
6. Install oil level gauge tube.



end by:

a) install engine oil cooler

WATER PUMP

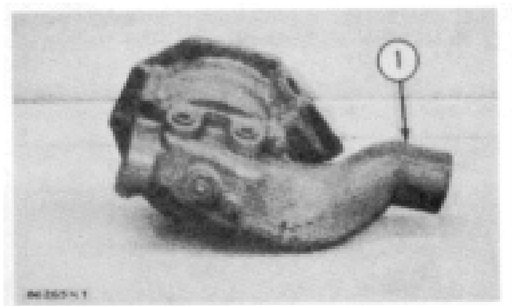
DISASSEMBLE WATER PUMP

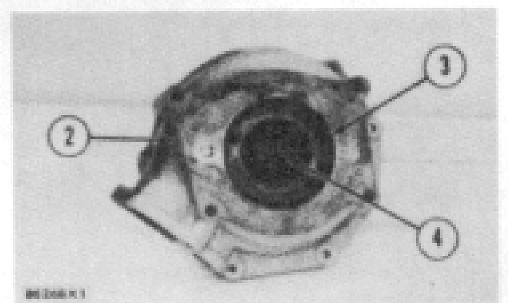
Tools Needed		A	B	C
8S2264	Puller Group	1		
1P456	Step Plate	1		
5/16"	NC bolt 4 in. long	2		
5/16"	I.D. Washer, Flat	2		
1P2321	Puller Assembly		1	
1P529	Handle			1
1P461	Drive Plate			1
1P459	Drive Plate			1

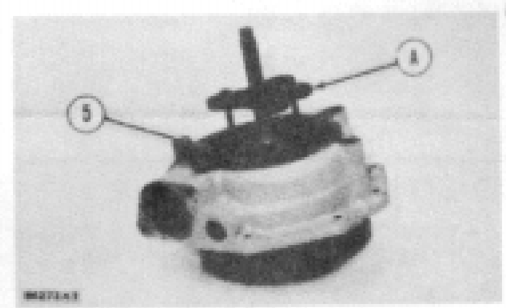
start by:

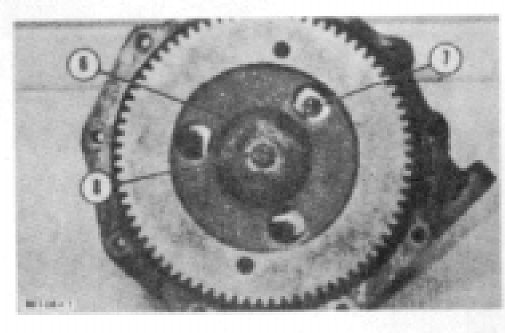
a) remove water pump

1. Remove cover ( ) from water pump.
2. Remove O-ring seal (3) from adapter (2).
3. Remove adapter (2) from the water pump.
4. Remove bolt (4) and washer that hold impeller on the shaft.
5. Use tooling (A) to remove impeller (5) from water pump shaft.
6. Remove the spring and seal from shaft.
7. Remove four bolts (7) that hold retainer and shaft assembly to pump housing.
8. Remove bolt (8) and washer (6).









WATER PUMP

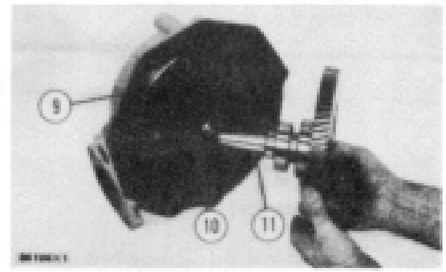
9. Remove shaft assembly (11) from housing. Remove the O-ring seal (9) from housing.

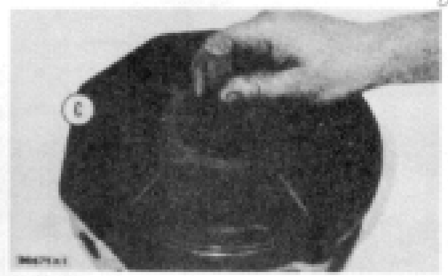
10. Remove the seal (10) from housing.

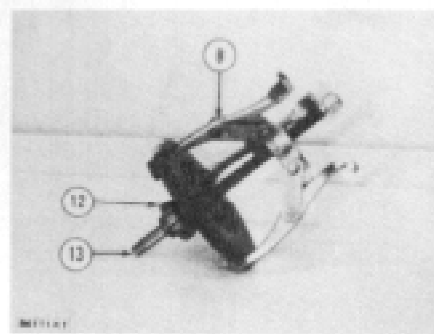
11. Use tooling (C) to remove ceramic seal from housing.

12. Use tooling (B) to remove gear from the shaft.

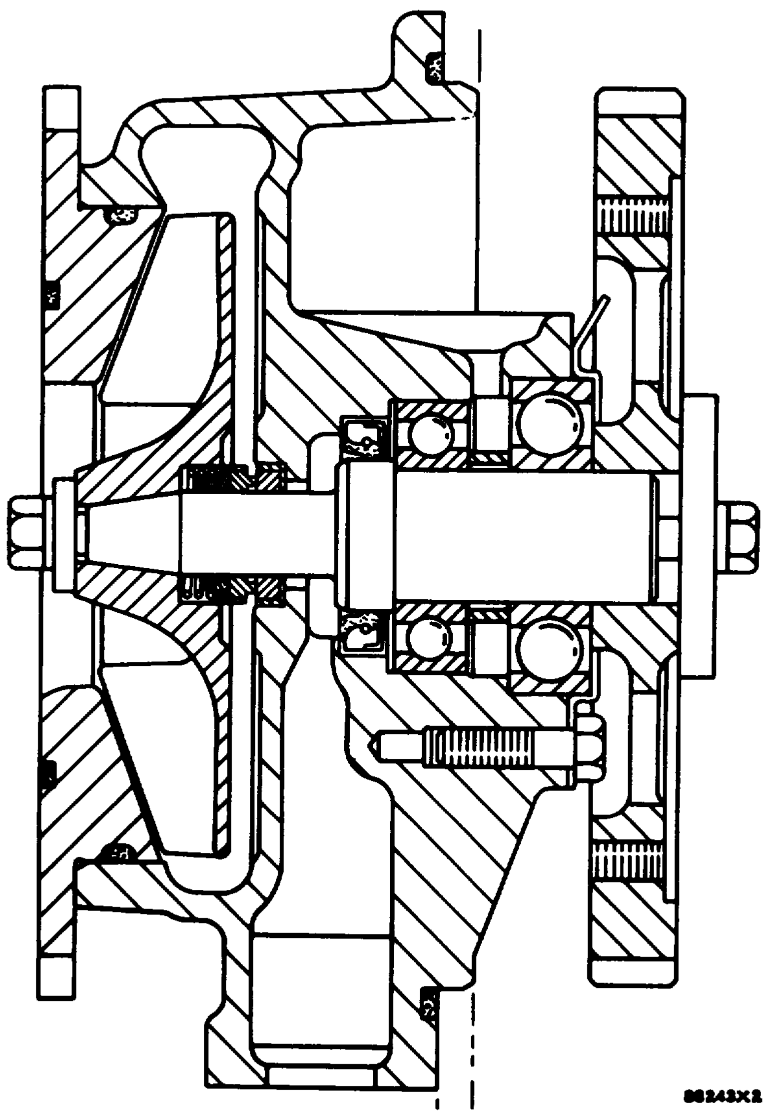
13. Remove the retainer, bearing, spacer and bearing (12) from the shaft (13).







WATER PUMP

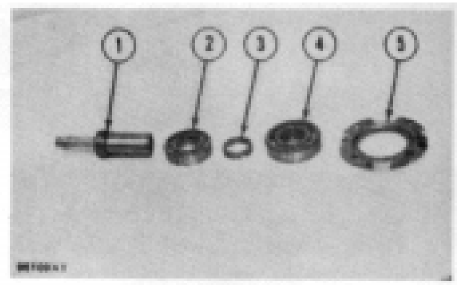


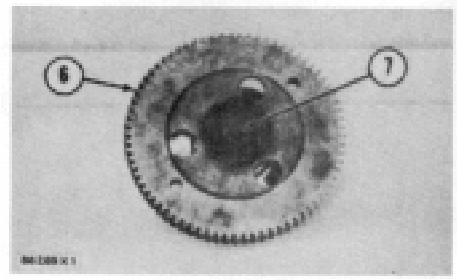
WATER PUMP

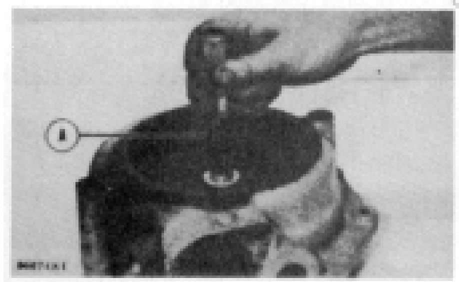
ASSEMBLE WATER PUMP

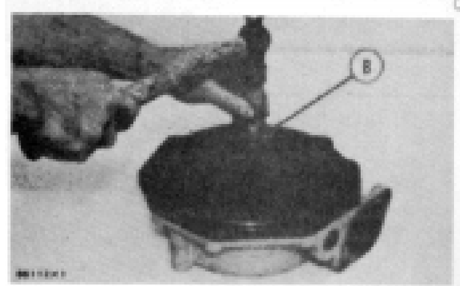
Tools Needed		A	B	C
1P529	Handle	1	1	
1P468	Drive Plate	1		
1P479	Drive Plate	1		
1P459	Drive Plate		1	
1P467	Drive Plate		1	
5P2686	Seal Installation Tool			1

1. Install bearing (2), spacer (3), bearing (4) and retainer (5) on the shaft (I).
2. Install the gear (6).
3. Install the bolt (7) and washer that hold gear to shaft.
4. Use tooling (A) and hand pressure to install ceramic seal into housing.
5. Use tooling (B) to install lip-type seal in housing, with lip of seal toward drive gear.
6. Put clean engine oil on lip of seal.







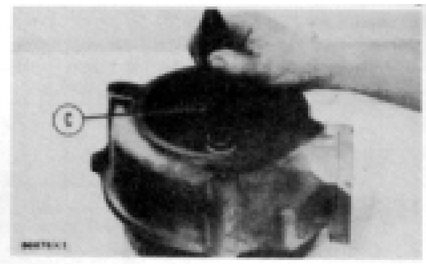


WATER PUMP

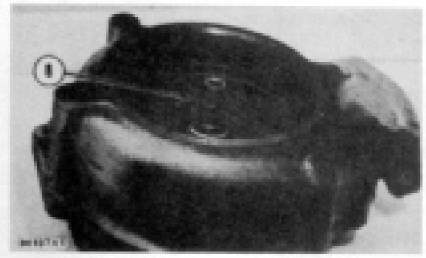
7. Install shaft assembly into water pump housing.

8. Install four bolts that hold shaft assembly to housing.

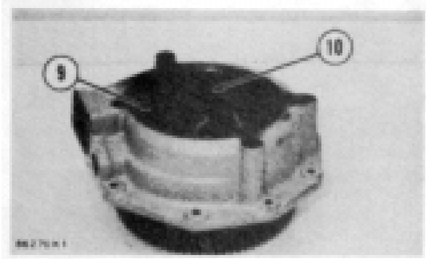
9. Use tool (C) and hand pressure to install seal on to shaft. Install seal so smooth face of seal is toward ceramic seal.



10. Install spring (8) on the shaft.

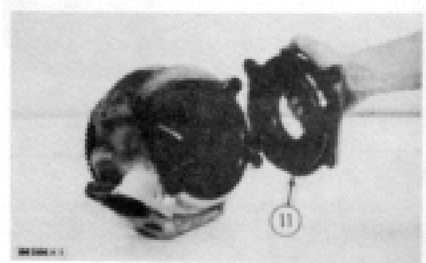


11. Install impeller (9), washer, and bolt (10) on to shaft. Tighten bolt (10) to 28 ± 5 lb.ft. (3.9 ± 0.7 mkg).



12. Install new O-ring seals on adapter (11).

13. Install the adapter (11) on the water pump.



14. Install the cover on the water pump.

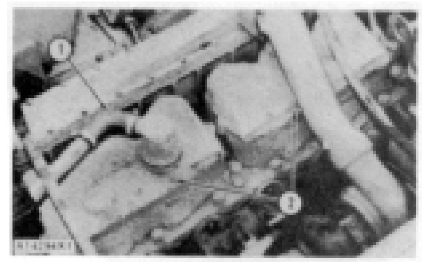
end by:

a) install water pump

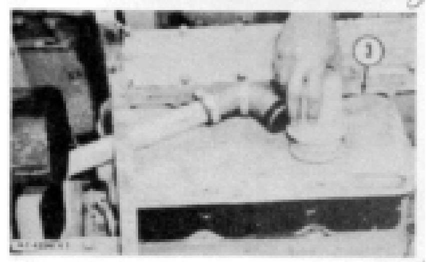
VALVE COVERS

REMOVE VALVE COVERS

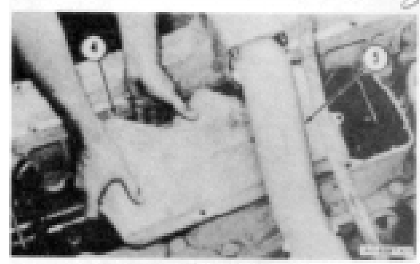
1. Loosen two clamps and slide hose (I) off breather element.
2. Remove bolts (2) that hold valve covers to the valve cover housings.



3. Remove rear valve cover (3).

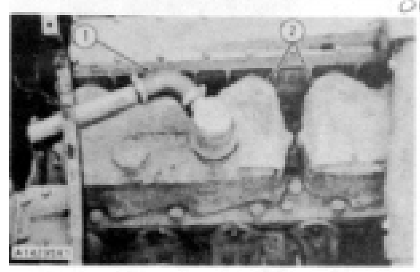


4. Remove front valve cover (4). For easier access to front valve cover, remove pipe (5) from the inlet manifold.



INSTALL VALVE COVERS

1. Put valve covers (2) in position on the valve cover housings. Install bolts.
2. Install inlet manifold pipe if it was removed to remove front valve cover.
3. Slide hose (I) on breather element and tighten the clamps.



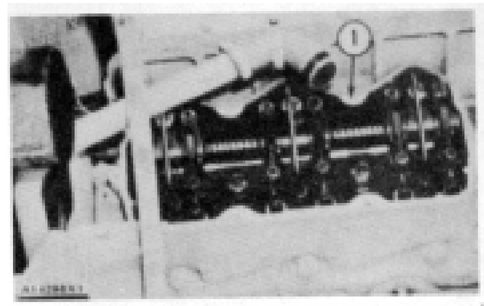
ROCKER SHAFTS AND PUSH RODS

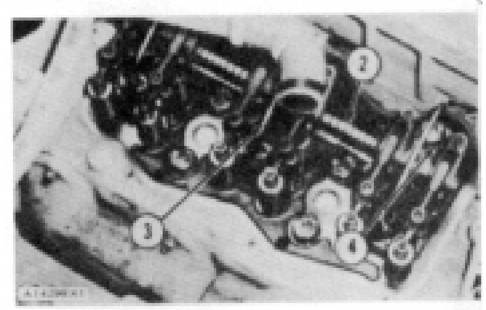
REMOVE ROCKER SHAFTS AND PUSH RODS

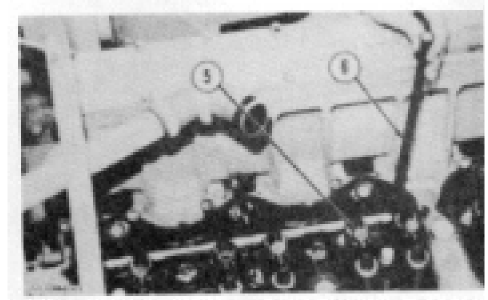
start by:

a) remove valve covers

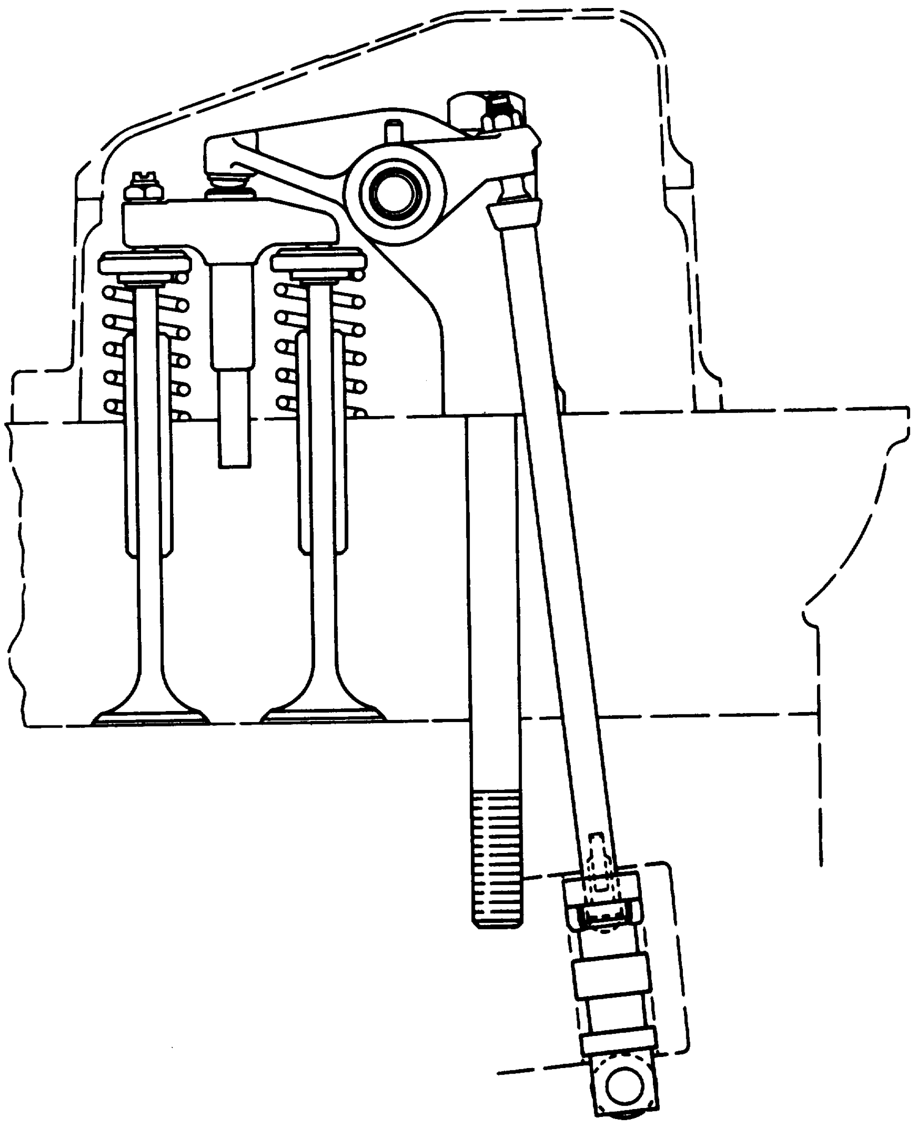
1. Remove valve cover housing (I).
2. Disconnect wire clips from fuel injection lines. Remove fuel injection lines (3). Install covers on all injection line openings.
3. Remove three bolts (4) that hold rocker shaft assembly to the cylinder head.
4. Remove rocker shaft assembly (2).
5. Remove push rods (6) from valve lifters.
6. Remove bridges (5) from dowels on cylinder head.







ROCKER SHAFTS AND PUSH RODS

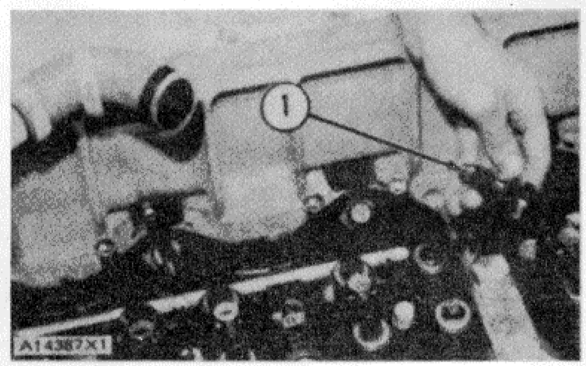


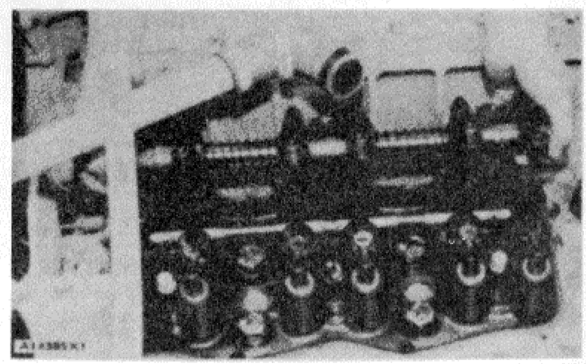
ROCKER SHAFTS AND PUSH RODS

INSTALL ROCKER SHAFTS AND PUSH RODS

1. Put clean engine oil on the bridges and dowels.

2. Install the bridges (1) on the dowels. Keep pressure by hand on the bridges and turn the adjustment screw clockwise until contact is made with the valve stem. Turn the screw and extra 20° to 30°. This will make dowel straight in guide and make compensation for gap (slack) in the threads. Hold adjustment screw in this position and tighten locknut to 22 + 3 lb.ft. (3.0 + 0.4 mkg).





3. Install the push rods.

4. Install rocker shaft assembly.

5. Put clean engine oil on threads of cylinder head bolts. Install the bolts that hold rocker shaft assembly. Tighten the three bolts first to 200 + 20 lb.ft. (27.7 ± 2.8 mkg) starting with bolt in center of rocker shaft. Tighten bolts again to 330 + 15 lb.ft. (45.6 + 2.1 mkg). Tighten bolts again by hand to 330 + 15 lb.ft. (45.6 + 2.1 mkg).
6. Install fuel injection lines. Tighten fuel line nuts to 30 + 5 lb.ft. (4.1 + 0.7 mkg). Connect wire clips to fuel lines.

CAUTION: Do not cause damage to the O-ring seals on the fuel lines.

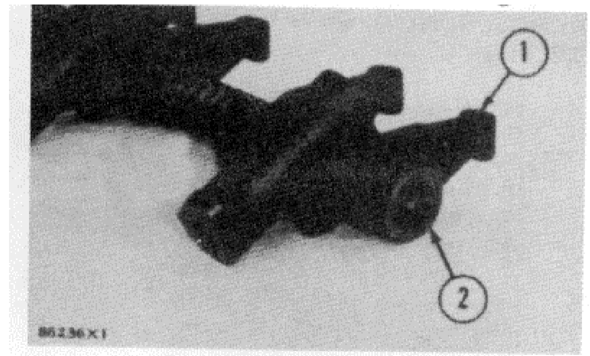
7. Install valve cover housing. Make adjustment of valves to have a clearance of-.015 + .003 in. (0.38 + 0.07 mm) for intake and .030 ± .003 in. (0.76 + 0.07 mm) for exhaust.

   end by:

   a) install valve covers

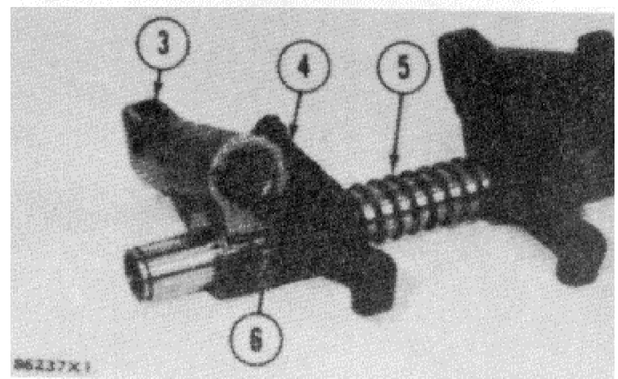
ROCKER SHAFTS

DISASSEMBLE ROCKER SHAFTS



start by:
a) remove rocker shafts and push rods

1. Remove retainer (2) from end of shafts.



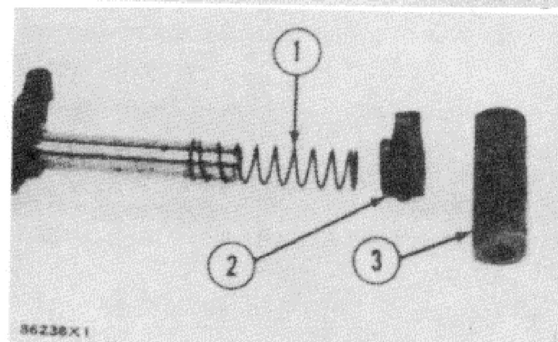
2. Remove washers and rocker arm (1).

3. Remove pins (6) that hold brackets to each end of shaft.

NOTE: The center bracket does not have a pin.

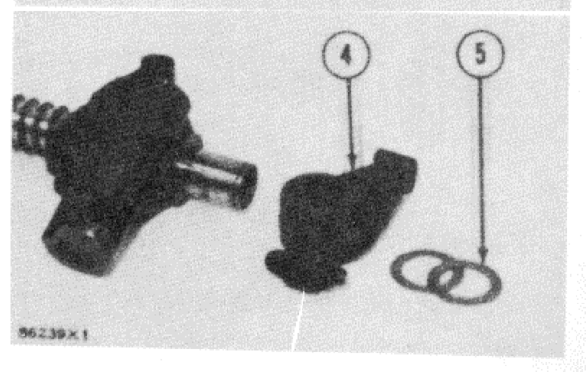
4. Remove bracket (3), rocker arm (4) and spring (5).

ASSEMBLE ROCKER SHAFTS



1. Put clean engine oil on the shaft.

2. Install bracket and rocker arms for the center bracket.



3. Install spring (I), rocker arm (2), and bracket (3). Install the pin that holds brackets on each end of rocker shaft. Install pin to have .34 in. (8.6 mm) extending from surface of bracket.

4. Install rocker arm (4), washers (5) and retainer on each end of shaft.
end by:
a) install rocker shaft and push rods

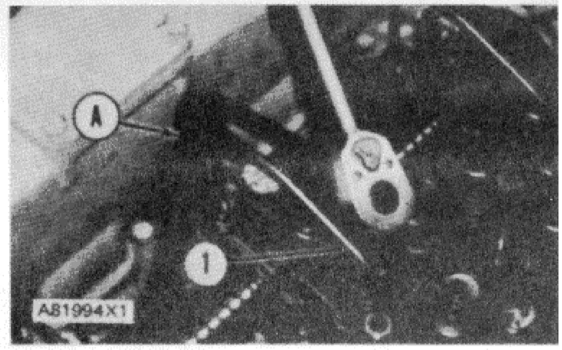
FUEL INJECTION VALVES

REMOVE FUEL INJECTION VALVES

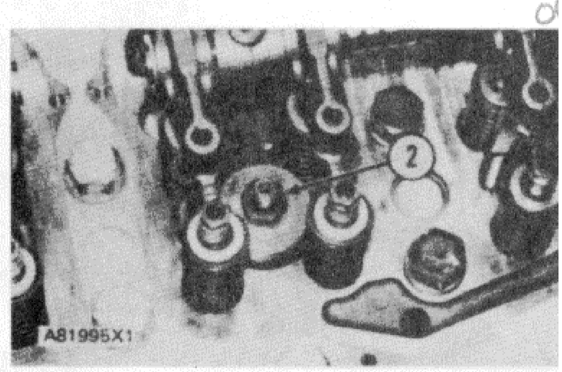
	Tools Needed	A	B	C
5P5195	Fuel Line Wrench	1		
5P6729	Extractor		1	
1P3075	Puller Group			1
1B4201	Nut (1/4"-28 NF)			1
4N5336	Line Assembly (Nut Only)			1

start by:
a) remove valve covers and bases

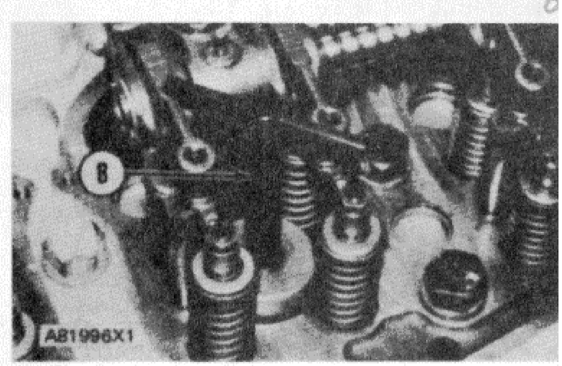
NOTE: Hoods and engine side panels and doors are removed for photo purposes only.



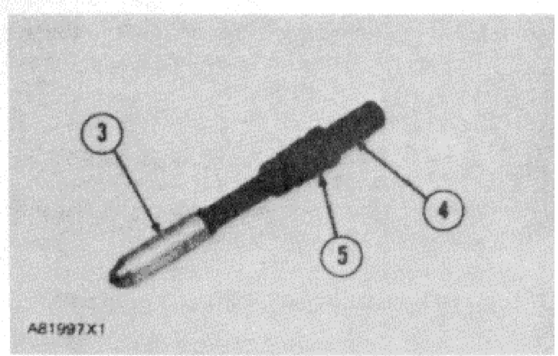
1. Use tool (A) to disconnect the fuel line assemblies from the cylinder head.



2. Disconnect fuel line assemblies (1) from the fuel injection valves and remove them from the engine. Install covers on all fuel line connections to keep dirt or foreign material out of the fuel system.
3. Remove nut (2) that holds the fuel injection valve to the adapter assembly.



4. Use tool (B) to remove the fuel injection valves.
5. If the fuel injection valves can not be removed with tool (B), use tooling (C).



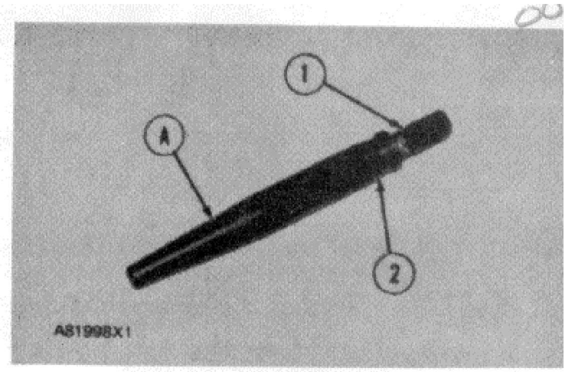
6. Remove nozzle assembly (3) from body (4).
7. Remove seal (5) from the body.

FUEL INJECTION VALVES

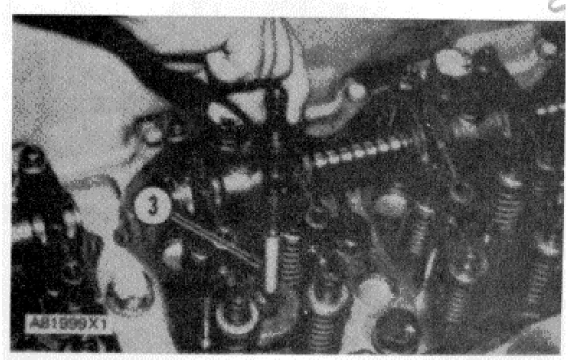
INSTALL FUEL INJECTION VALVES

	Tools Needed	A	B	C
5P4755	Seal Guide	1		
5PS196	Fuel Line Wrench		1	
SP144	Socket			1

1. Use tool (A) to install seal (2) on valve body (1).



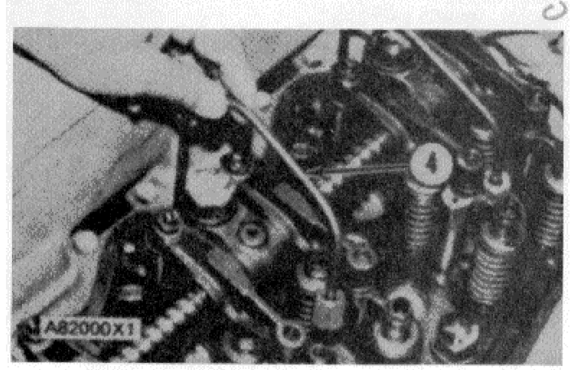
2. Install nozzle assembly (3) on the valve body. Tighten nozzle finger tight only.



3. Put a small amount of clean diesel fuel on the seal and install the fuel injection valves in the adapter assemblies.

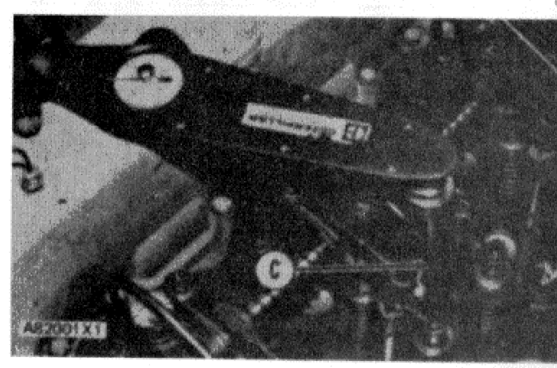
4. Install the nut that holds the fuel injection valves and tighten to a torque of 55 ± 5 lb. ft. (75 ± 7 N•m).

5. Remove the covers from the fuel line connections. Put fuel line assemblies (4) in position on the engine. Use tool (B) to tighten the fuel line nuts on the cylinder head adapter assembly.



6. Use tool (C) to tighten fuel line nuts to a torque of 30 ± 5 lb. ft. (40 ± 7 N•m).

   end by:
      a) install valve covers and bases



VALVE SEAT INSERTS, FUEL VALVE ADAPTERS

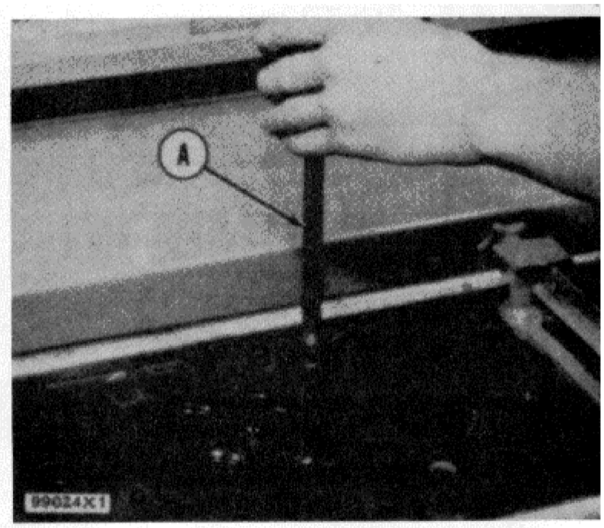
REMOVE VALVE SEAT INSERTS

	Tools Needed	A
93095	Handle Assembly	
9S3081	Extractor Intake	1
9S3086	Extractor Exhaust	1

start by

a) remove valves

1. Use tooling (A) to remove valve seat inserts.
2. Clean and remove burrs from valve seat bore.



INSTALL VALVE SEAT INSERTS

	Tools Needed	A
9S3095	Handle Assembly	1
9S3081	Extractor Intake	1
9S3086	Extractor Exhaust	1

1. Use tooling (A) to install valve seat inserts.

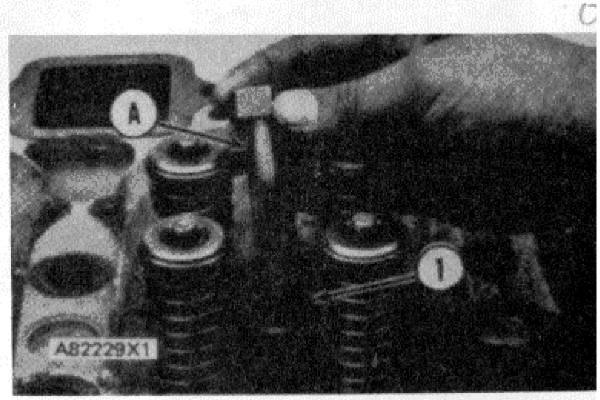
CAUTION

Do not increase diameter of extractor in valve seat inserts when insert is installed In cylinder head.

2. Grind valve seat insert according to specifications given in ENGINE SPECIFICATIONS for 3406 VEHICLE ENGINE.

end by:

a) install valves



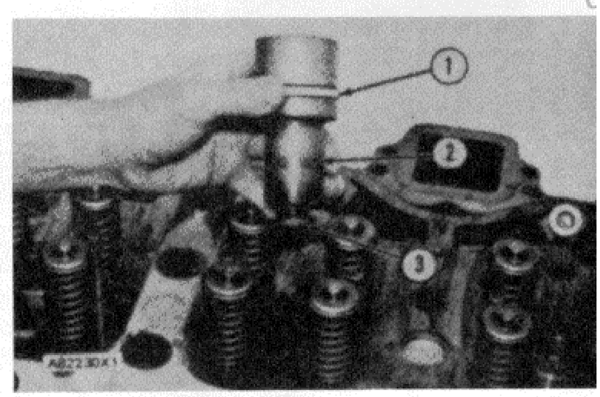
REMOVE FUEL VALVE ADAPTERS

	Tools Needed	A
5P961	Wrench	1

start by:

a) remove rocker shafts and push rods

1. Use tool (A) to remove fuel valve adapters (1) from the cylinder head.
2. Remove the gasket and O-ring seal from the adapter.



INSTALL FUEL VALVE ADAPTERS

	Tools Needed	A
5P961	Wench	1

1. Install a new O-ring seal (1) on the adapter. Put a small amount of liquid soap on the O-ring seal.

2. Put 5P3931 Anti-Seize Compound on the threads of the adapter. Put gasket (3) on the adapter. Install fuel valve adapter (2). Use tool (A) to tighten the adapter to a torque of 150 $\pm$ 10 lb. ft. (205 $\pm$ 14 N•m).

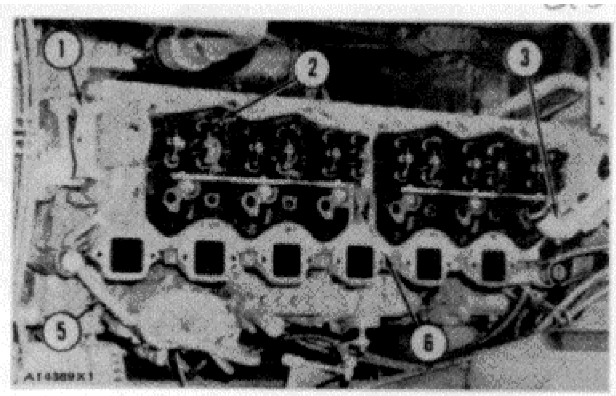
end by:

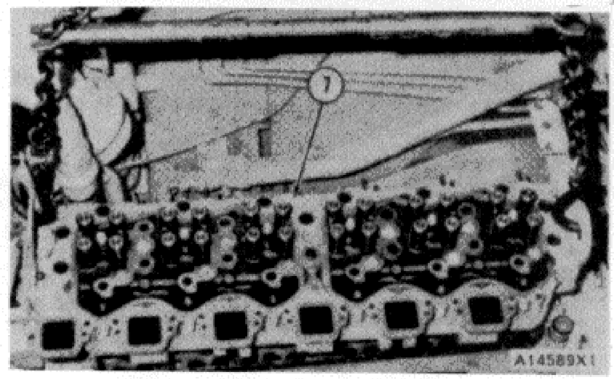
a) install rocker shafts and push rods

CYLINDER HEAD

REMOVE CYLINDER HEAD

start by:
- a) remove exhaust manifold
- b) remove fuel injection lines
- c) remove aftercooler housing and core
- d) remove water temperature regulator
- e) remove rocker shafts and push rods





1. Remove water line (5) for the air compressor and breather tube (3).

2. Remove the bracket (I) for the belt tightener.

4. Remove the bolts (2) that hold cylinder head to the cylinder block.

NOTE: Make sure the 3/8 inch bolts (6) are removed.

5. Fasten a hoist and remove the cylinder head (7) from the cylinder block. Weight is 300 lb. (136 kg).

CAUTION:

Do not put the cylinder head down on a flat surface. This can cause damage to the fuel injection valves.

NOTE: Always install a new gasket between spacer plate and cylinder block before cylinder head is installed. See REMOVE SPACER PLATE.

CYLINDER HEAD

INSTALL CYLINDER HEAD

1. Thoroughly clean the spacer plate and bottom surface of cylinder head. Install new head gasket and seals.

NOTE: Be sure a new gasket has been installed between spacer plate and cylinder block. See INSTALL SPACER PLATE.

2. Fasten a hoist and install cylinder head on engine.

3. Put clean engine oil on threads of cylinder head bolts. Install cylinder head bolts and washers. Tighten bolts in following sequence:

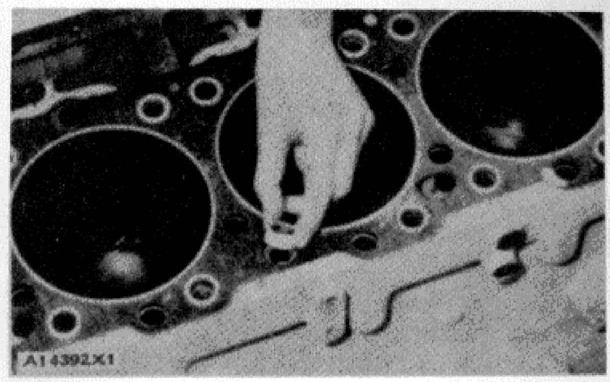
Step 1: Tighten bolts 1 through 20 in number sequence to 200 ± 20 lb. ft. (27.7 ± 2.8 mkg).
Step 2: Tighten bolts 1 through 20 in number sequence 330 ± 15 lb. ft. (45.6 ± 2.1 mkg).
Step 3: Tighten bolts 1 through 20 in number sequence to 330 ± 15 lb. ft. (45.6 ± 2. 1 mkg) by hand.
Step 4: Install rocker shafts and push rods (1).
Step 5: Tighten bolts 21 through 26 in number sequence to 200 ± 20 lb. ft. (27.7 ± 2.8 mkg).
Step 6: Tighten bolts 21 through 26 in number sequence to 330 ± 15 lb. ft. (45.6 ± 2.1 mkg).
Step 7: Tighten bolts 21 through 26 in number sequence to 330 ± 15 lb. ft. (45.6 ± 2.1 mkg) by hand.
Step 8: Tighten the 3/8 in, bolts (2) to 32 ± 5 lb. ft. (4.4 ± 0.7 mkg).

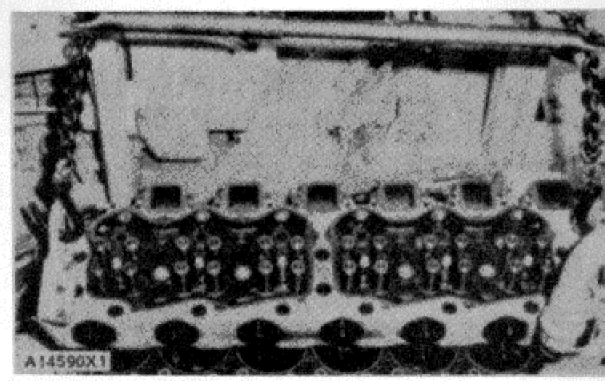
NOTE: If studs (3) were removed, install new studs and tighten to 20 -+ 5 lb. t. (2.8 + 0.7 mkg).

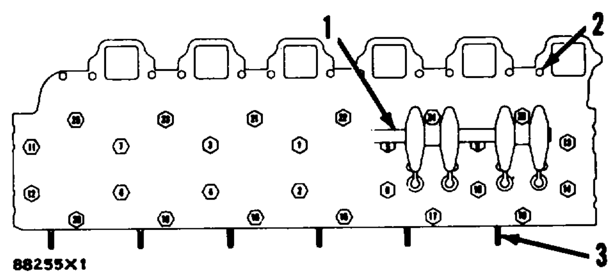
4. Make adjustment of valves to have a clearance of .015 ± .003 in. (0.38 ± 0.07 mm) for intake and .030 ± .003 in. (0.76 ± 0.07 mm) for exhaust. Install valve cover housing and inner fuel lines.

5. Install bracket for the belt tightener. Install water line for the air compressor and breather tube.

end by:
a) install exhaust manifold
b) install aftercooler
c) install fuel injection lines
d) install water temperature regulator







VALVE LIFTERS

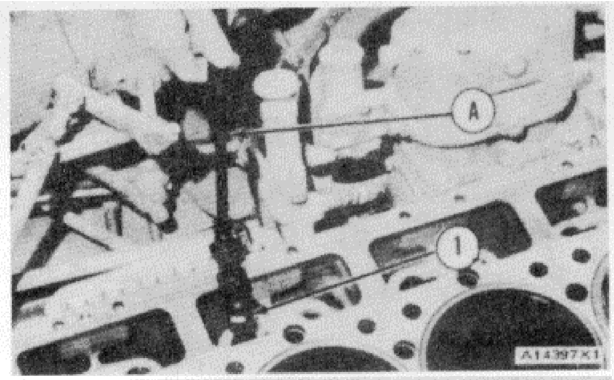
REMOVE VALVE LIFTERS

	Tools Needed	A
5P2401	Removal Tool	1

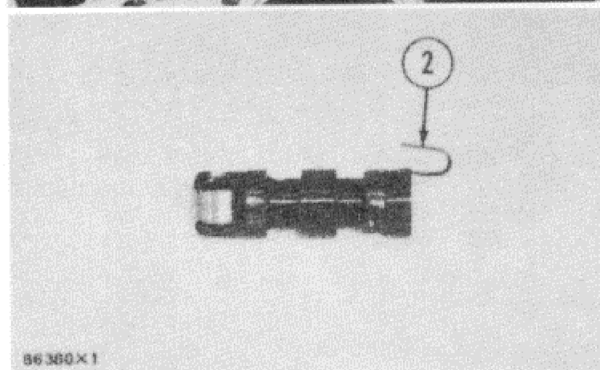
start by:

a) remove cylinder head (valve lifters can be removed without this operation)

1. Use tool (A) to remove valve lifters (I) from cylinder block.



2. Remove guide spring (2) from the lifter.



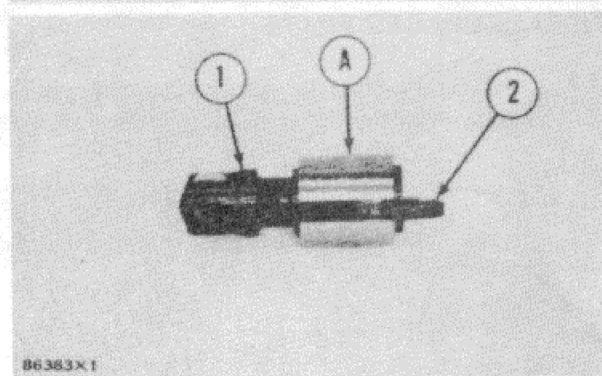
INSTALL VALVE LIFTERS

	Tools Needed	A	B
5P2405	Spring Compressor	1	
SP2408	Installation Tool		1

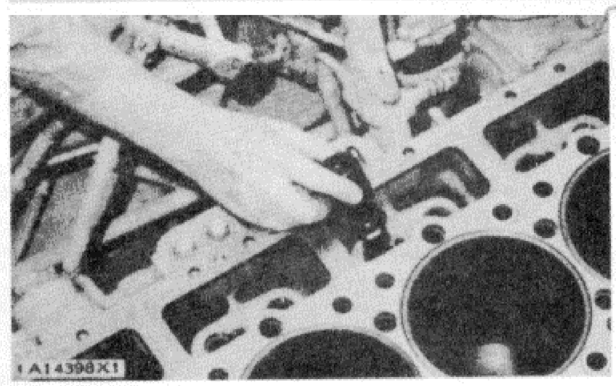
1. Install a new guide spring (2) on lifter (1). Put clean engine oil on lifter.

CAUTION: Always install a new guide spring on lifter when lifter is removed from engine.

2. Use tool (A) to compress guide spring on lifter.



3. Put lifter with tool (A) installed in its bore in cylinder block. Use tool (B) to push lifter into position in cylinder block.



end by:

a) install cylinder head

SPACER PLATE

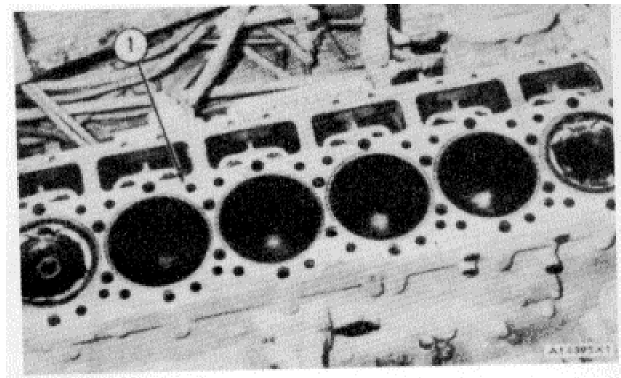
REMOVE SPACER PLATE

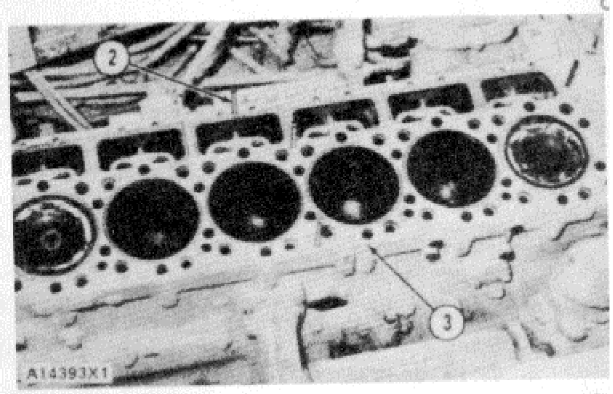
start by:
a) remove cylinder head

1. Remove the seals (I) from the spacer plate.

2. Install seven 3/8"-16NC forcing screws (2) and remove the spacer plate (3) from the cylinder block.

NOTE: Do not cause damage to the dowels.





INSTALL SPACER PLATE

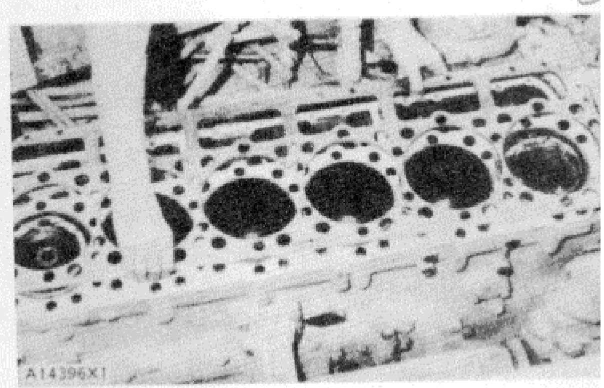
1. Thoroughly clean the spacer plate and cylinder block surface.
2. Install a new spacer plate gasket and install the spacer plate on the cylinder block.

CAUTION: Both surfaces of spacer plate, top of cylinder block and both sides of spacer plate gasket must be clean and dry. Use no gasket adhesives or other substances on these surfaces.

3. Install new seals.

4. Check cylinder liner projection. See INSTALL CYLINDER LINERS.

end by:
a) install cylinder head



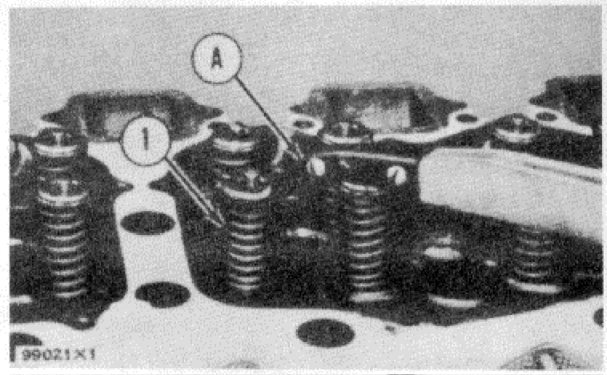
VALVES

REMOVE VALVES

	Tools Needed	A	B
5S1330	Valve Spring Compressor	1	
8S2283	Valve Spring Tester		1

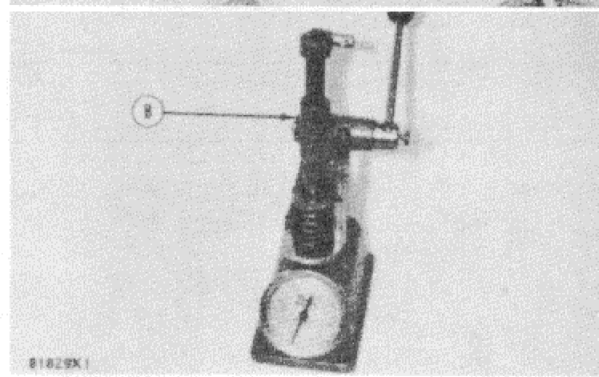
start by:
- a) remove cylinder head assembly
- b) remove fuel valve adapters

1. Use tool (A) to compress springs (1).
2. Remove locks.
3. Remove tool (A), valve, rotocoil and spring.



NOTE: If valve can be used again, put identification on valve for location at installation.

4. Use tool (B) to check spring force. Spring force should be 77.5 + 3.9 lb. (342 + 17.6 N) when length of spring under test force is 2.165 in. (54.99 mm).

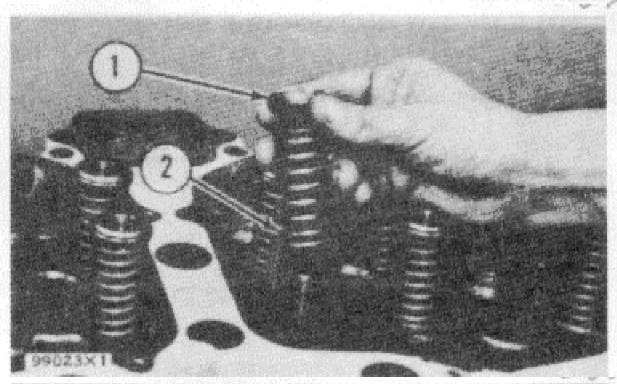


5. Do Steps I through 4 again for remainder of valves.

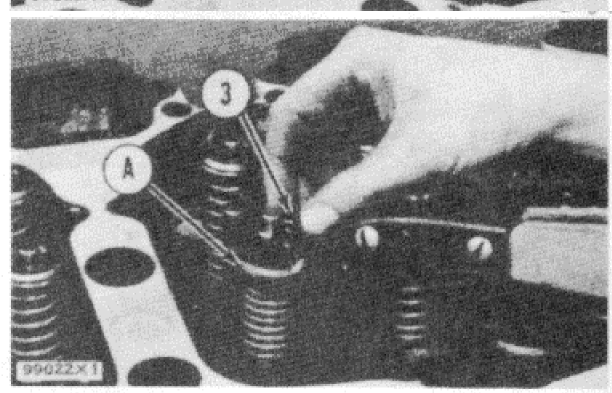
INSTALL VALVES

	Tools Needed	A
5S1330	Valve Spring Compressor	1

1. Put clean engine oil on valve stem. Install spring (2), rotocoil (1), and valve.



2. Use tool (A) to compress spring.
3. Install locks (3) with thick end up.



⚠ WARNING

Locks can be thrown from valve when compressor is released, if they are not In their correct position on valve stem.

4. Remove compressor and hit valve with a soft hammer to be sure locks are in their correct position on valve.

5. Do Steps I through 4 again for remainder of valves.

end by:
- a) install fuel valve adapters
- b) install cylinder head assembly

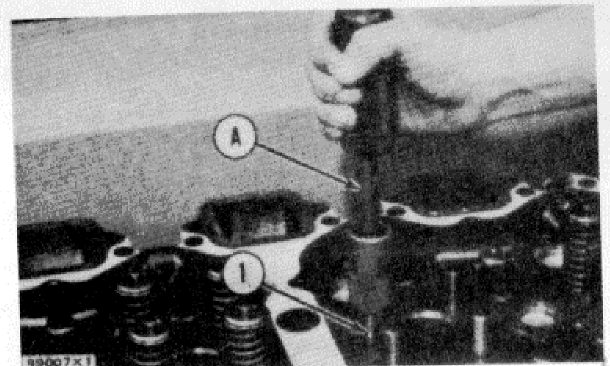
BRIDGE DOWELS, VALVE GUIDES

REMOVE BRIDGE DOWELS

	Tools Needed	A
5P944	Dowel Puller Group	1
5P942	Extractor	1

start by:
a) remove valves

1. Use tooling (A) to remove dowel (1).

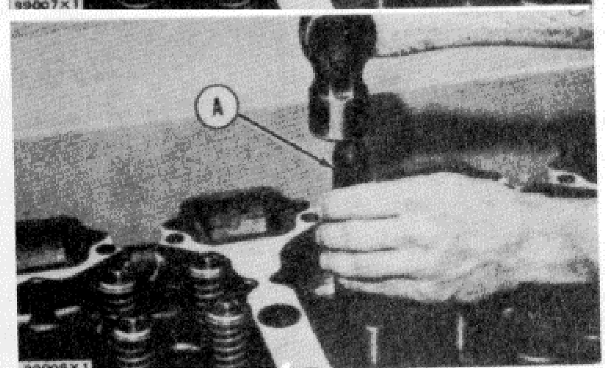


INSTALL BRIDGE DOWELS

	Tools Needed	A
5P2406	Dowel Driver	1

1. Use tool (A) to install dowel.

end by:
a) install valves

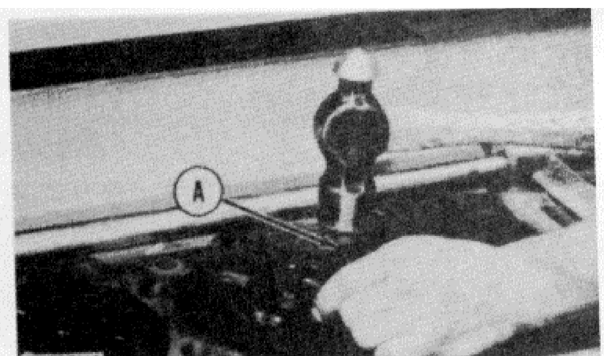


REMOVE VALVE GUIDES

	Tools Needed	A
7S8859	Driver	1

start by:
a) remove valves

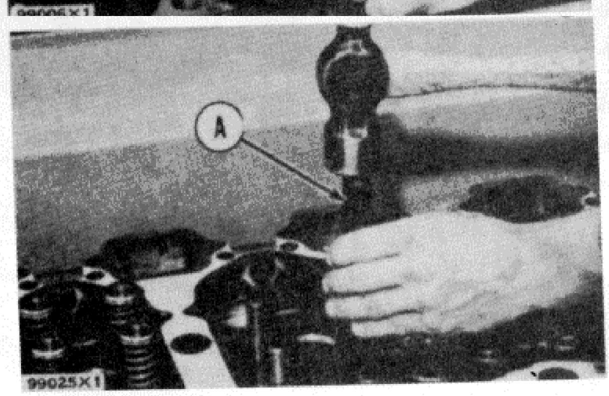
1. Use tool (A) to remove valve guides.



INSTALL VALVE GUIDES

	Tools Needed	A
728859	Driver	1
5P2396	Brushing	1

1. Put clean engine oil on outside of valve guide.
2. Use tooling (A) to install valve guides
3. After installation inside diameter of valve guide must be .3735 i .0010 in. (9.487 t 0.025 mm).
end by:
a) install valves



PISTONS

REMOVE PISTONS

start by:
a) remove cylinder head
b) remove oil pump

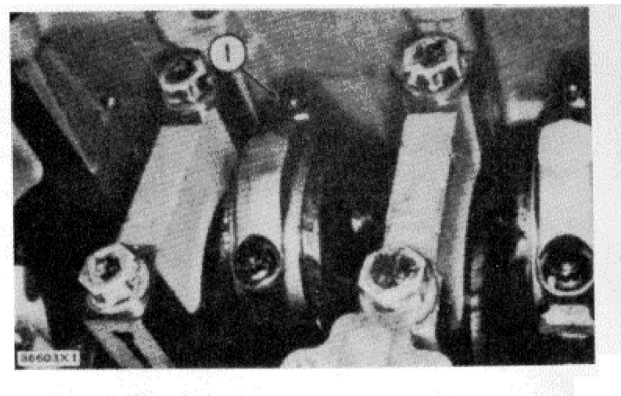
1. Remove the carbon ridge from top inside surface of cylinder liners.

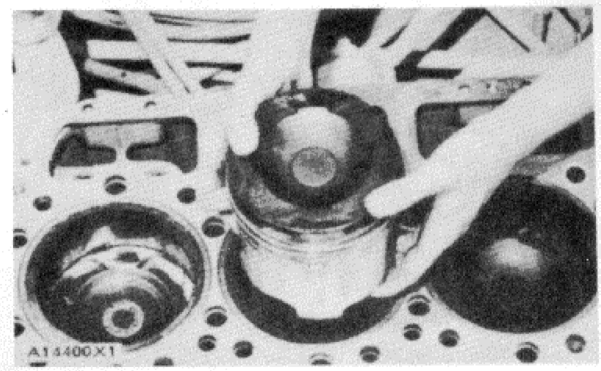
2. Turn the crankshaft until two pistons are at bottom center.

3. Remove the nuts (1) and the bearing caps. Push the rod and pistons up until rings are away from the liners.

4. Remove the two pistons from the cylinder liners.

5. Do Steps 1 through 4 for remainder of pistons.





INSTALL PISTONS

	Tools Needed	A
7M3977	Piston Ring Compressor	1

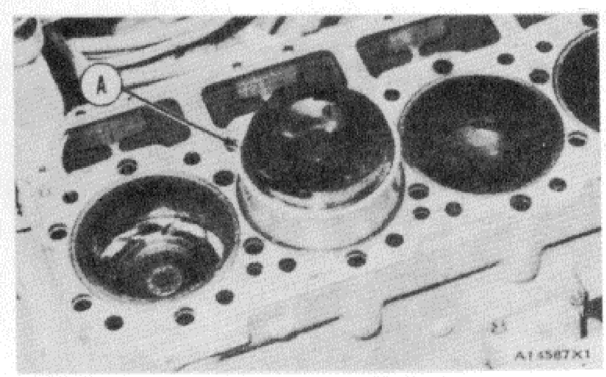
1. Put clean engine oil on piston rings, connecting rod bearings and cylinder liners.

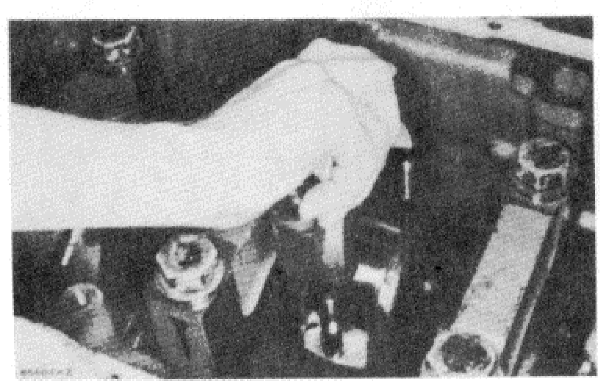
2. Use compressor (A) to install pistons in cylinder liners. Be sure the numbers on connecting rods are on the opposite side from the camshaft.

3. Install the bearing cups on connecting rods with number on side of bearing caps on the same side, and same number as on connecting rod.

4. Install the nuts and tighten to 60 ± 4 lb.ft. (8.3 ± 0.6 mkg). Put a mark on nuts and cap. Tighten an extra 120° ± 5° from the mark.

end by:
a) install oil pump
b) install cylinder head





PISTONS

DISASSEMBLE PISTONS

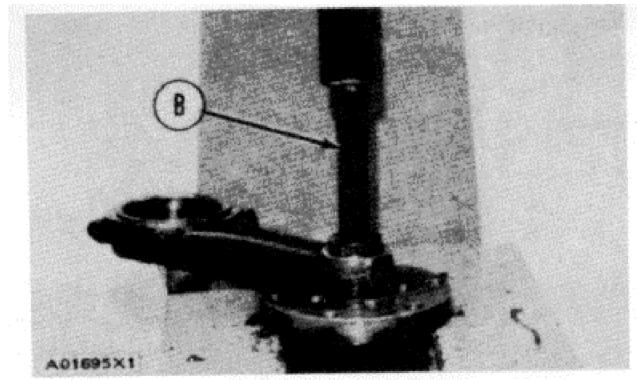
	Tools Needed	A	B
7M3978	Piton Rig Expander	1	
1P531	Handle		1
1P479	Drive Plate		1
1P481	Drive Plate		1

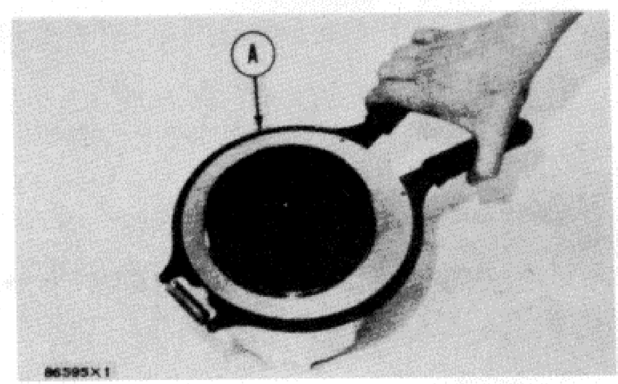
start by:
a) remove pistons

1. Remove snap ring from pistons. Remove piston pin and piston from connecting rod.

2. Use tooling (B) and a press to remove piston pin bearing from connecting rod.

3. Use expander (A) to remove piston rings from piston.

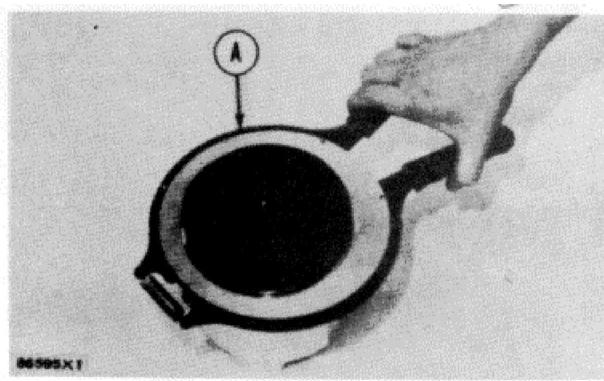




PISTONS

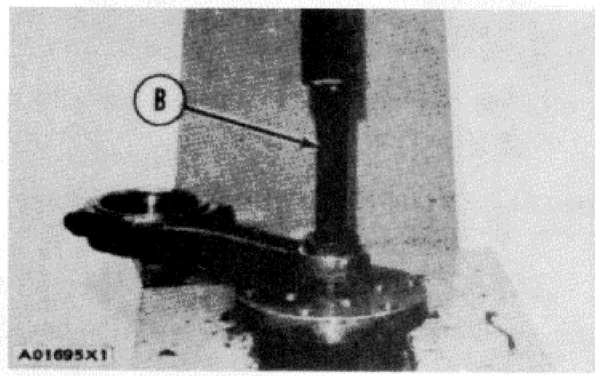
ASSEMBLE PISTONS

	Tools Needed	A	B
7M3978	Piston Ring Expander	1	
1P531	Handle		1
1P479	Drive Plate		1
1P481	Drive Plate		1



1. Clean ring grooves in the piston before rings are installed.

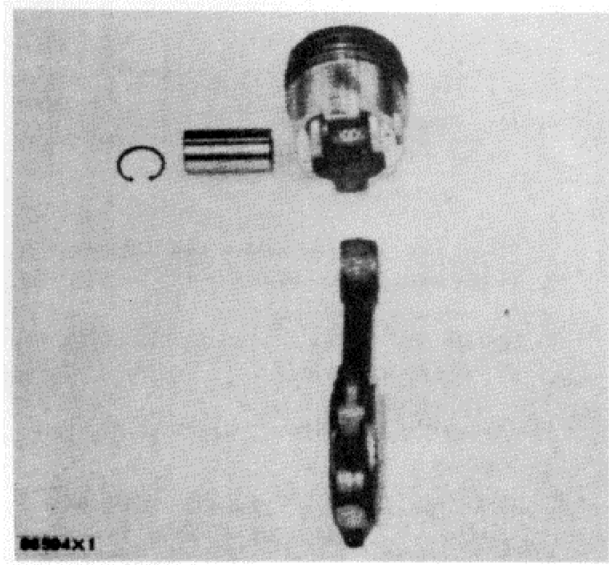
NOTE: The two compression rings have marks "UP-1" and "UP-2". The rings must be installed with these marks toward top of piston with "UP-1" being the top ring. After installation of three rings, put rings in position so gaps in rings are 120° apart.



2. Use expander (A) to install piston rings on piston.

3. Use tooling (B) and a press to install piston pin bearing in connecting rod. Be sure oil hole in bearing is in alignment with oil hole in connecting rod.

4. se a pin boring machine to make the piston pin bearing the correct size.



5. Put clean engine oil on piston pin. Put the piston in position on the connecting rod and install piston pin. Install snap rings. Make sure snap rings ary in grooves in piston.

end by:
   a) install pistons

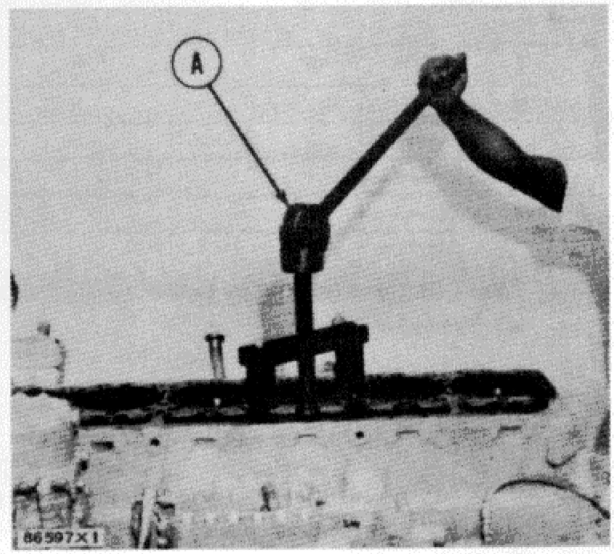
CYLINDER LINERS

REMOVE CYLINDER LINERS

	Tools Needed	A
1P2400	Cylinder Liner Puller Group	1
1P2396	Adapter Plate	1

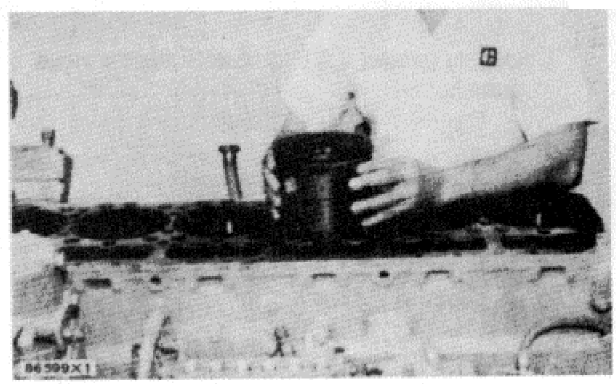
start by:
a) remove pistons

1. Remove coolant from cylinder block.
2. Put covers on journals of crankshaft for protection from dirt or water.
3. Use tooling (A) to remove the cylinder liners.



INSTALL CYLINDER LINERS 12-1216

	Tools Needed	A	B	C
2P8260	Cylinder Liner Installation Tool	1		
2H3750	Bolt (For Heed)	1	1	
5H1504	Washer (For Head)	1	1	
2F126	Washer (Copper)		6	
887548	Push Puller Crossbar		1	
3H465	Plate		3	
1P2396	Adapter Plate		1	
3/4"-16	NF Bolt 3 in. long		6	
1P5510	Liner Projection Tool Group			1



1. Clean the cylinder liners and the liner bores in the cylinder block.
2. Install the cylinder liners in the block without the O-ring seals.
3. Check the cylinder liner projection as follows:

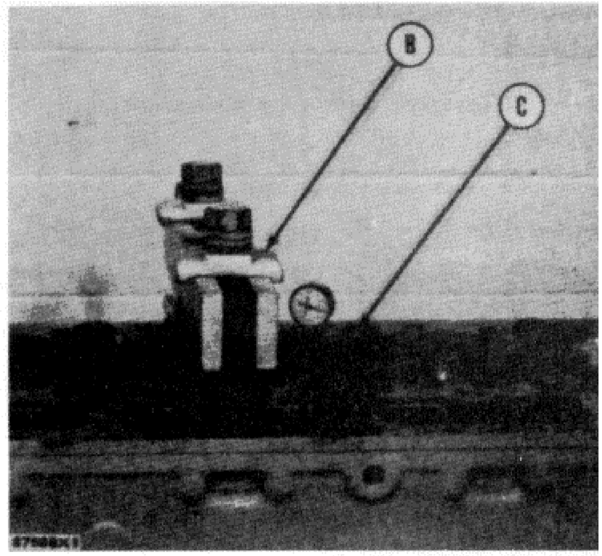
   a) Install the 3/4"-16 NF bolts and the 2F126 washers of tooling (B) on the cylinder block next to each liner. Tighten the bolts to a torque of 70 lb.ft. (9.7 mkg) to hold the spacer plate in position on the block.
   b) Put the adapter plate and one plate of tooling (B) on top of the liner and install the remainder of tooling (B). Be sure the bar is in position at the center of the liner. Tighten the bolts that hold tooling (B) evenly to a torque of 50 lb.ft. (6.9 mkg).

CYLINDER LINERS

c) Check to be sure the distance from the bottom edge of the bar to the top of the cylinder block is the same on both sides of the liner.

d) Check the cylinder liner projection with tool group (C) at four locations around the liner.

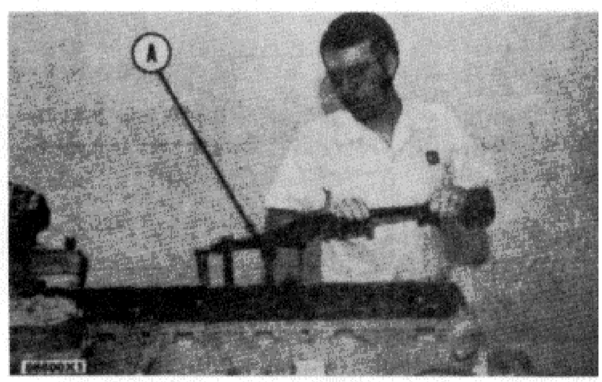
e) Liner projection must be .005 ± .003 in. (0.13 ± 0.08 mm). Measurements on the same liner must not be different by more than .001 in. (0.03 mm). Average measurements between liners next to each other must not be different by more than .001 in. (0.03 mm).



NOTE: Turning the liner in the bore can make a difference in the liner projection.

4. If the liner projection is not .005 ± .003 in. (0.13 ± 0.08 mm), check the thickness of the following parts: spacer plate, spacer plate gasket, and cylinder liner flange (1). The thickness of the spacer plate must be .338 ± .001 in. (8.59 + 0.03 mm). The thickness of the spacer plate gasket must be .008 ± .001 in. (0.20 ± 0.03 mm). The thickness of the cylinder liner flange must be .3500 ± .0008 in. (8.890 ± 0.020 mm).

NOTE : The cylinder liner projection can be chanced by malting a counterbore in the block to a minimum depth of .030 in. (0.76 mm) with a cylinder block counterboring tool. Shims are available for the adjustment of the liner projection. See PROTECTION OF CYLINDER LINER in 3406 VEHICLE ENGINE, TESTING AND ADJUSTING for the shim thickness and part number.



5. Put a mark on the liner and block so the liner can be installed in the same position as it was removed.
6. Remove tooling (B) and (C). Remove the liner. Install new O-ring seals on the liners. Put 7M7260 Liquid Gasket Material on the under side of the cylinder liner flange.

NOTE : Do not put 7M7260 Liquid Gasket Material on the cylinder block.

7. Put liquid soap on the O-ring seals and on the cylinder bores. Put the cylinder liners in position in the cylinder block bores. Push the liners down with tooling (A).

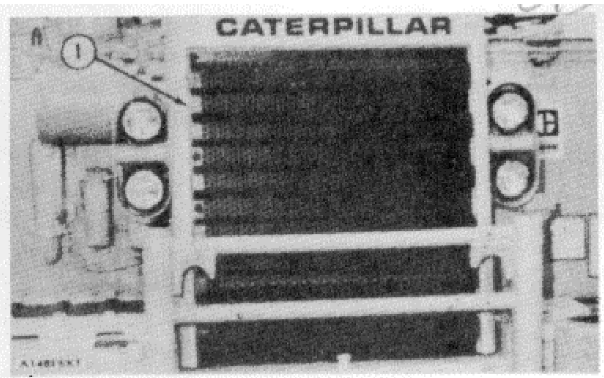
end by:

a) install pistons

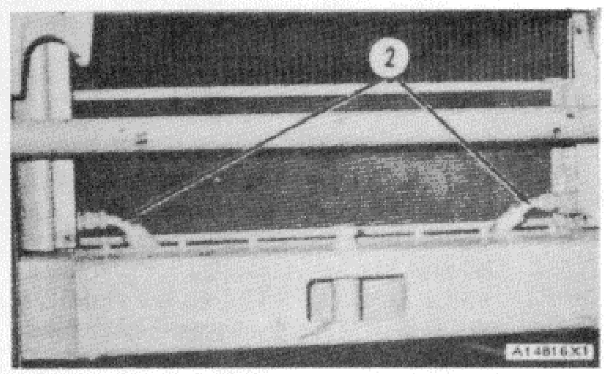
HYDRAULIC OIL COOLER

REMOVE HYDRAUUC OIL COOLER

1. Remove oil from the hydraulic tank.

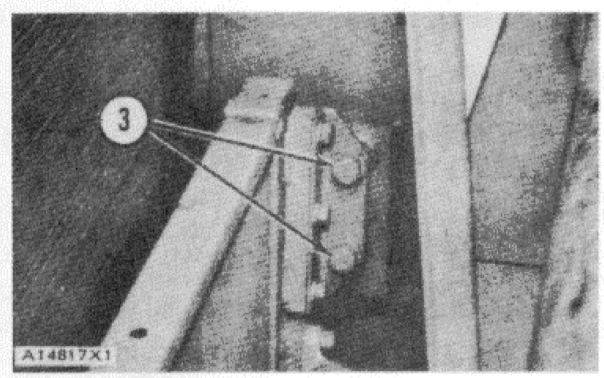


2. Remove radiator guard (1).



3. Disconnect two lines (2) from the hydraulic oil cooler.

4. Remove two bolts (3) from each side of the hydraulic oil cooler. Remove hydraulic oil cooler.

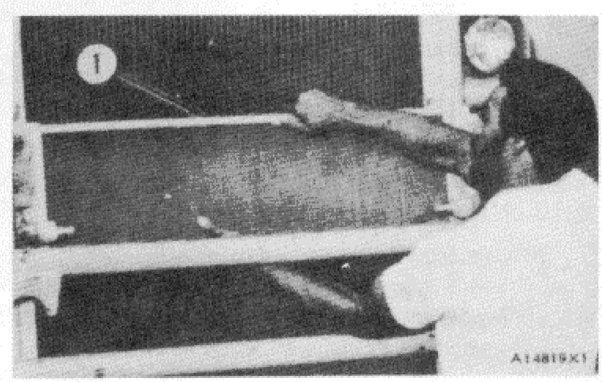


INSTALL HYDRAUUC OIL COOLER 12-1374

1. Put hydraulic oil cooler (1) in position and install the four bolts that hold it to the radiator.

2. Connect the two lines to hydraulic oil cooler.

3. Install radiator guard.



RADIATOR

REMOVE RADIATOR

start by:
a) remove hood

1. Let coolant out of the radiator.

2. Let oil out of the hydraulic tank.

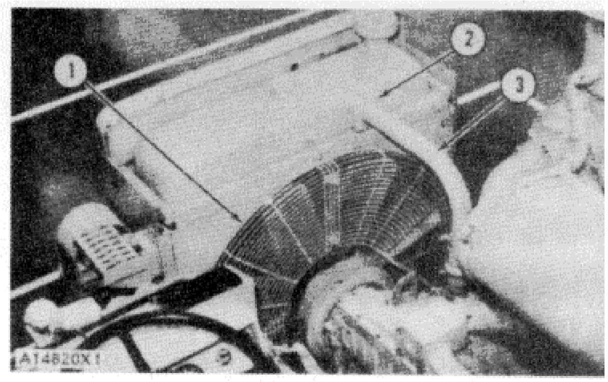
3. Remove four bolts (2) and remove water inlet pipe (3).

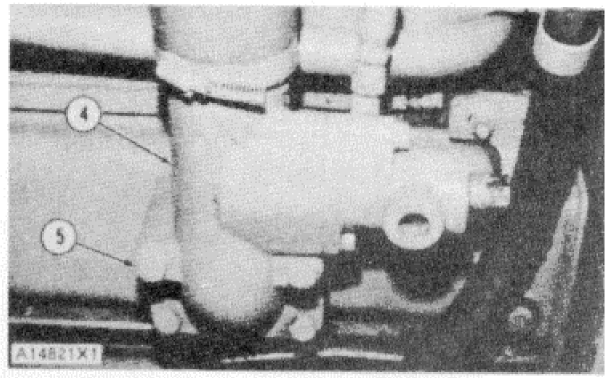
4. Remove fan guards (1).

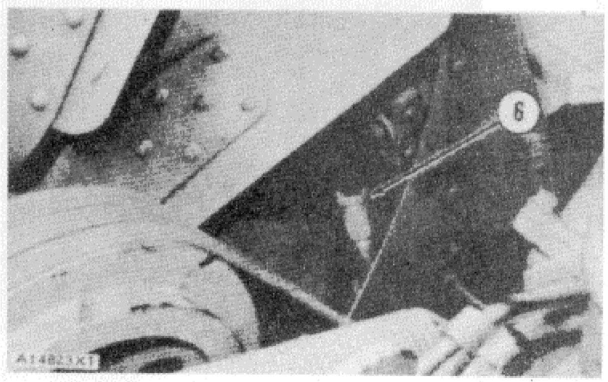
5. Remove bolts (5) and remove water outlet elbow (4).

6. Disconnect transmission oil cooler lines (6). Disconnect hydraulic oil cooler lines. Disconnect headlamp wires.

7. Fasten a hoist to the radiator. Remove four bolts on each side of the radiator and remove radiator. Weight of the radiator is 900 lb. (408 kg).

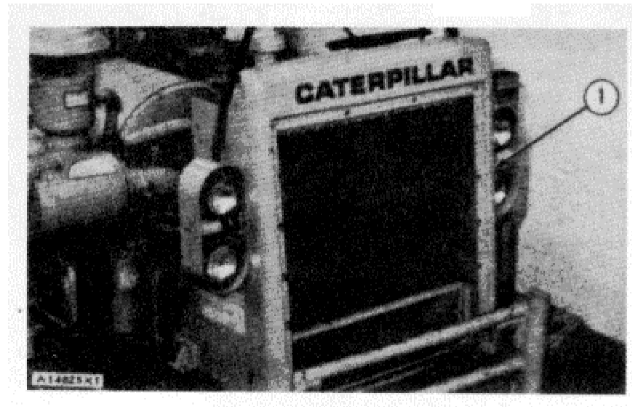






RADIATOR

INSTALL RADIATOR



1. Put radiator (1) in position on the frame and install the eight bolts that hold it.
2. Connect headlamp wires. Connect two hydraulic oil cooler lines and connect two transmission oil cooler lines.
3. Install water outlet elbow under radiator.
4. Install fan guards.
5. Install water inlet pipe.
6. Fill hydraulic tank with oil to the correct level.
7. Fill radiator with coolant to the correct level.

end by:
a) install hood
b) install crankcase guard

TRANSMISSION OIL COOLER

REMOVE TRANSMISSION OIL COOLER

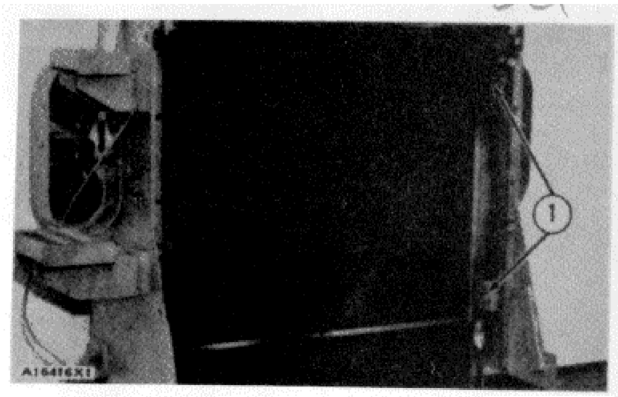
start by:

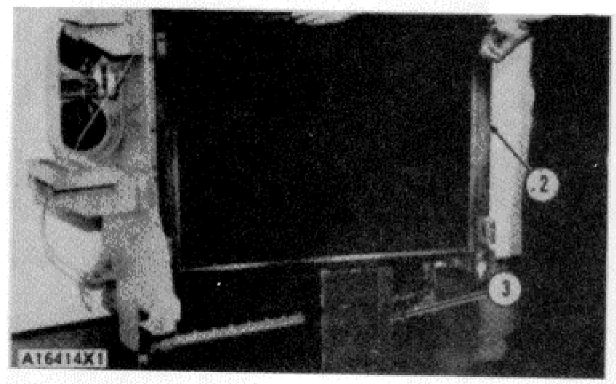
a) remove radiator

1. Let the oil out of the transmission oil cooler cores.

2. Remove two bolts (1) from each side of the oil cooler. Put a block (3) under oil cooler.

3. Remove transmission oil cooler (2). Weight of the cooler is 80 lb. (36 kg).





INSTALL TRANSMISSION OIL COOLER

1. Put transmission oil cooler in position on the radiator and install the bolts that hold it.

2. Fill the transmission oil cooler with oil to the correct level.

end by:

a) install radiator

FAN AND FAN DRIVE

REMOVE FAN AND FAN DRIVE

start by:
a) remove radiator

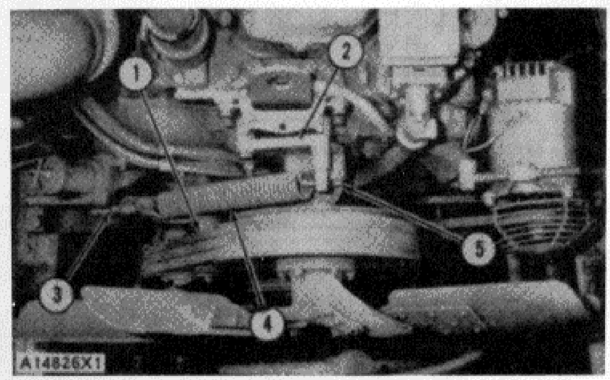
1. Remove tension on the three belts (1) by loosening the adjustment nut on the bolt (3) for the belt tightener.

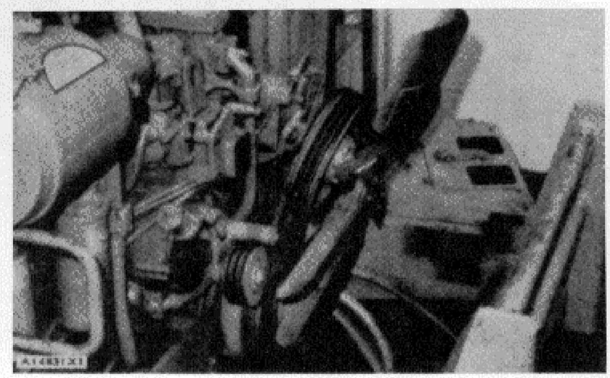
2. Remove the three belts.

3. Remove the spring (4) for the belt tightener.

4. Connect a hoist to the fan drive and remove the four bolts (5) that hold the fan drive to the adapter plate (2).

5. Remove the fan and fan drive. Weight of the fan and fan drive is 124 lb. (56 kg).





INSTALL FAN AND FAN DRIVE

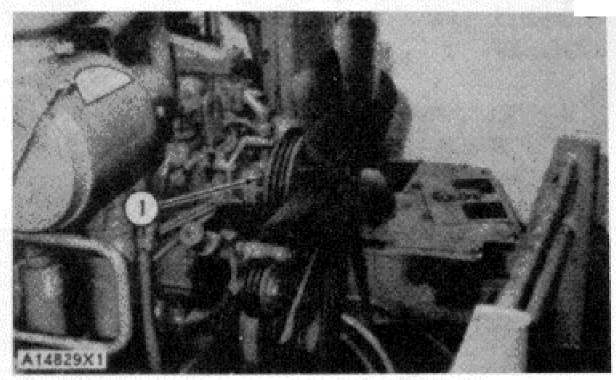
1. Put the fan and fan drive in position on the adapter plate and install the four bolts (1) that hold it.

2. Install the spring for the belt tightener.

3. Install the three belts.

4. Tighten the adjustment nut on the bolt for the belt tightener.

end by:
a) install radiator



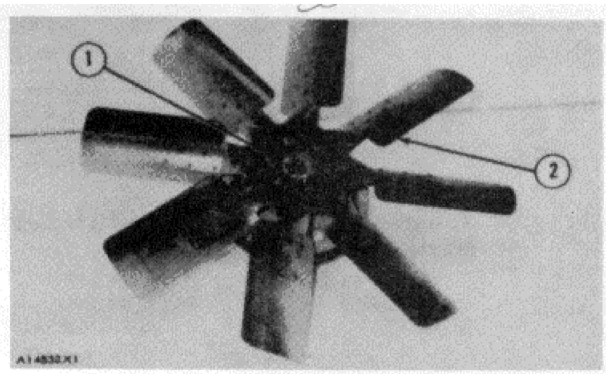
FAN AND FAN DRIVE

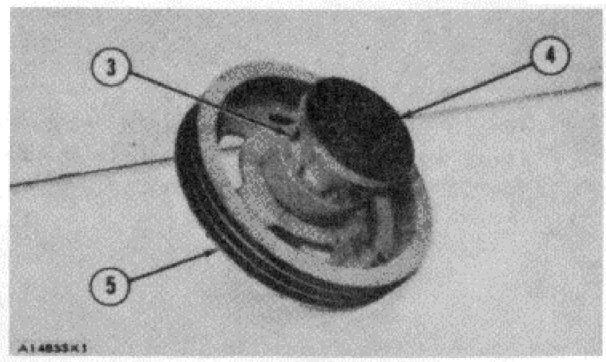
DISASSEMBLE FAN AND FAN DRIVE

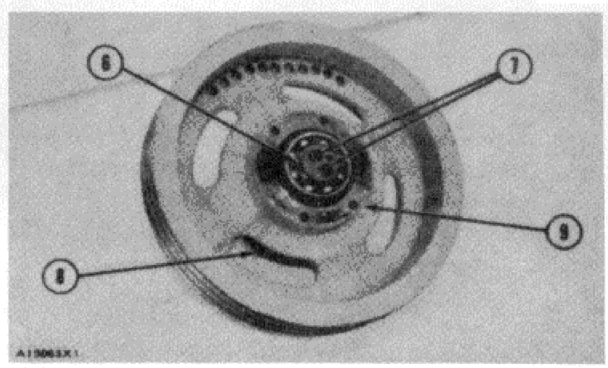
start by:

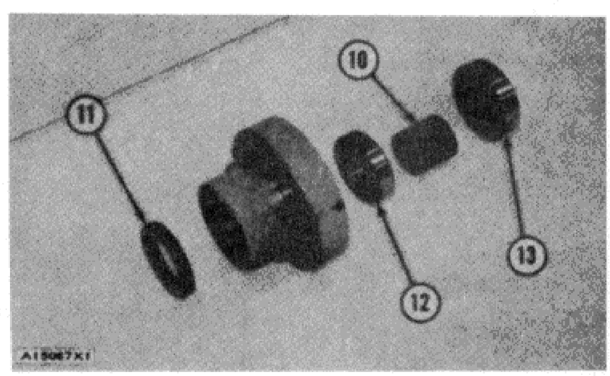
a) remove fan and fan drive

1. Remove bolts (I) and fan (2). Weight of fan is62 lb. (28 kg).
2. Remove six nuts (3) and adapter (4). Remove six bolts from other side of pulley (5).
3. Remove two bolts (7) and washer (6). Remove bracket assembly (8). Remove hub (9) from pulley.
4. Remove seal (II), bearing (12), bearing (13) and spacer (10) from hub.





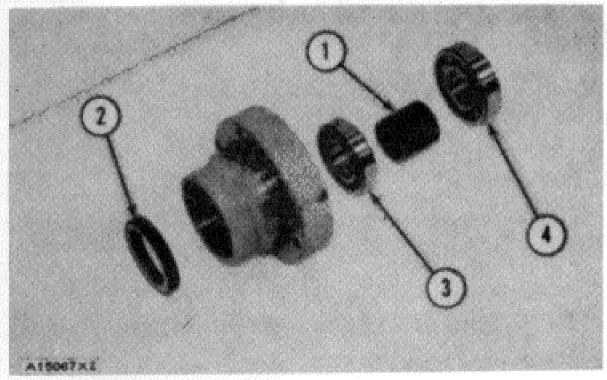




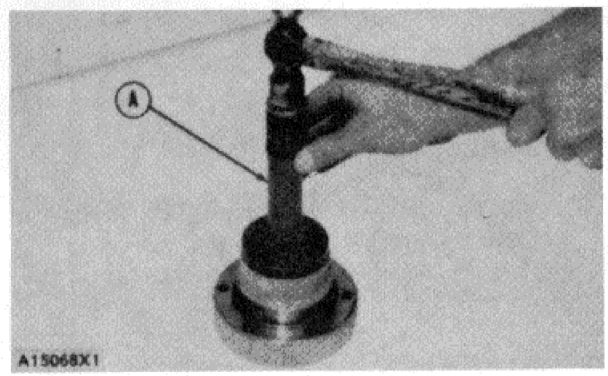
FAN AND FAN DRIVE

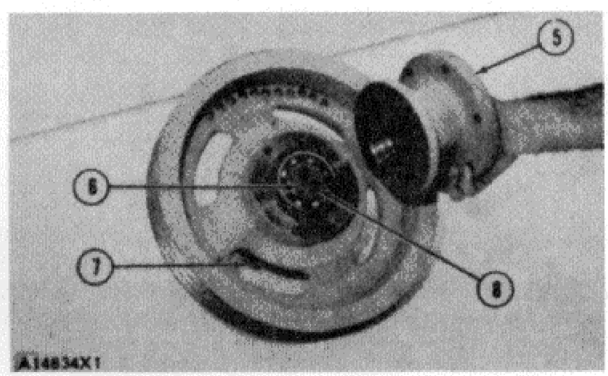
ASSEMBLE FAN AND FAN DRIVE

	Tools Needed	A
1P531	Handle	1
1P498	Drive Plate	1



1. Fill the hub with IP808 Grease. Install bearing (3), spacer (1) and bearing (4) in hub.
2. Install seal (2) in hub with tooling (A). Install the lip of the seal toward the outside of the hub. Install hub in pulley with six bolts.
3. Install bracket assembly (7). Install washer (6) and two bolts (8). Install adapter (5) on hub with six nuts.
4. Install fan with six bolts.





end by:

a) install fan and fan drive

CRANKSHAFT PULLEY AND VIBRATION DAMPER

REMOVE CRANKSHAFT PULLEY

start by:

a) remove fan and fan drive

1. Remove four bolts (2) that hold pulley (3) to the vibration damper (1).
2. Remove the pulley.

INSTALL CRANKSHAFT PULLEY

1. Put pulley in position on the vibration damper.
2. Install the four bolts that hold the pulley to the vibration damper. end by:

a) install fan and fan drive

REMOVE VIBRATION DAMPER

start by:

a) remove crankshaft pulley

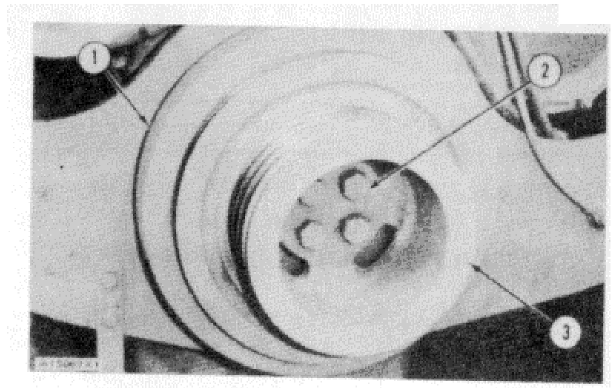
1. Remove bolts (I) that hold the vibration damper (2) to the crankshaft.
2. Remove the vibration damper.

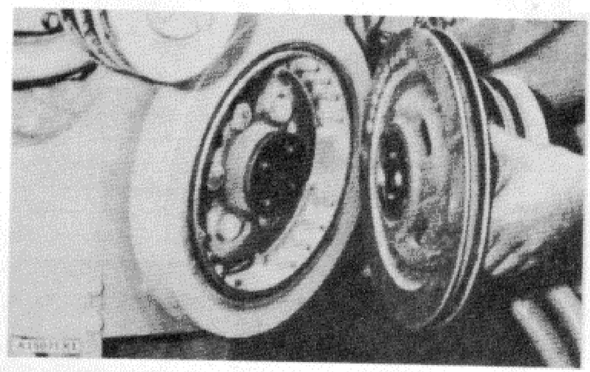
INSTALL VIBRATION DAMPER

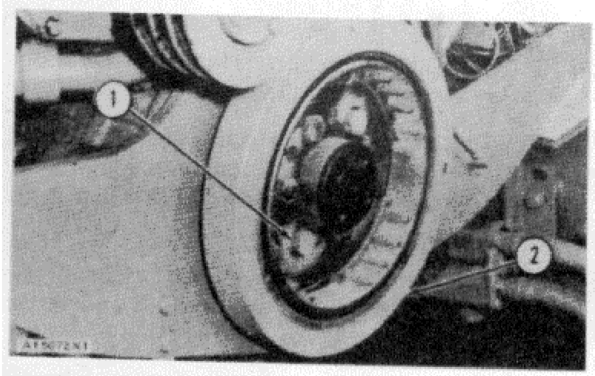
1. Put vibration damper in position on the crank-shaft.
2. Install the bolts that hold the vibration damper to the crankshaft.

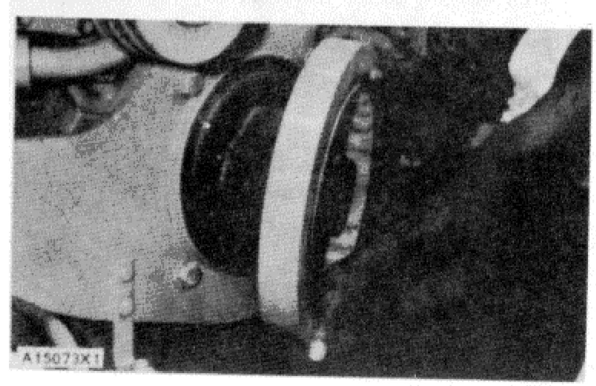
end by:

a) install crankshaft pulley









CRANKSHAFT FRONT SEAL

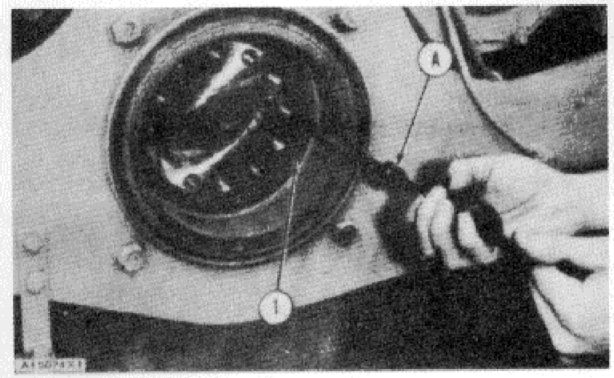
REMOVE CRANKSHAFT FRONT SEAL

	Tool Needed	A
1P3075	Puller Group	1

start by:

a) remove crankshaft pulley
b) remove vibration damper

1. Remove crankshaft front seal (1) with tool (A).

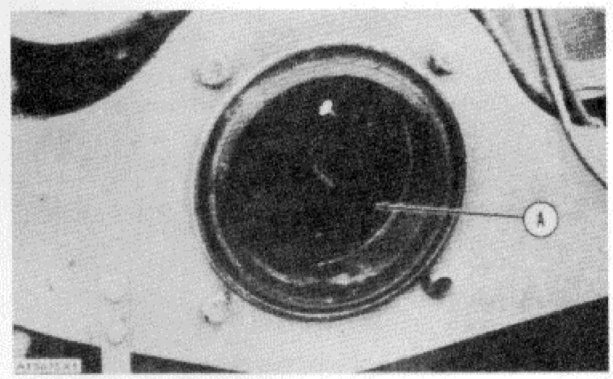


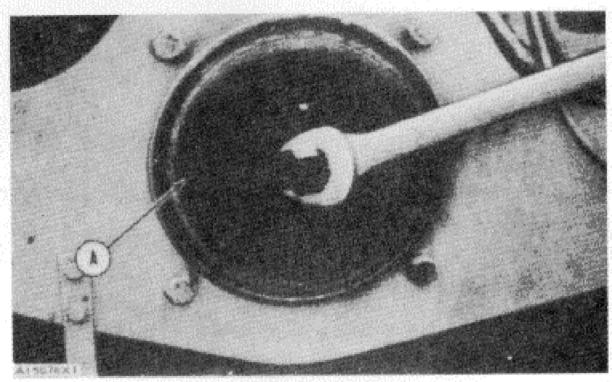
INSTALL CRANKSHAFT FRONT SEAL

	Tools Needed	A
5P1734	Seal Installer	1
5P1733	Locator Assembly	1
5P1737	Bolt	3
9S8858	Nut	1
FT1206	Pusher Plate	1
9S8550	Pilot	1

1. Install the crankshaft front with tooling (A) as follows:

   a) Install locator assembly and the bolts on the crankshaft.
   b) Put the pilot in the seal with the edge with a chamfer toward the crankshaft.
   c) Put clean engine oil on the lip of the seal and the wear sleeve. Put seal on the locator assembly with the lip toward the rear of the engine.
   d) Put the seal installer on the locator assembly. Slide pusher plate on the stud of the locator assembly.
   e) Install nut on the stud. Tighten the nut until the pusher plate is at bottom.
2. Remove tooling (A).





end by:
a) install vibration damper
b) install crankshaft pulley

CRANKSHAFT FRONT SEAL WEAR SLEEVE

REMOVE CRANKSHAFT FRONT SEAL WEAR SLEEVE

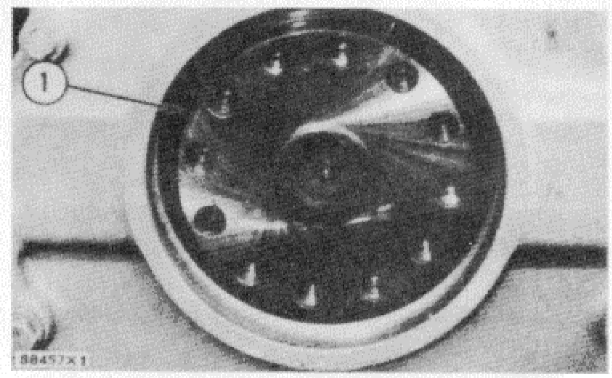
start by:

a) remove crankshaft front seal

1. Cut the old wear sleeve with a hammer and chisel. Remove crankshaft front seal wear sleeve (1).

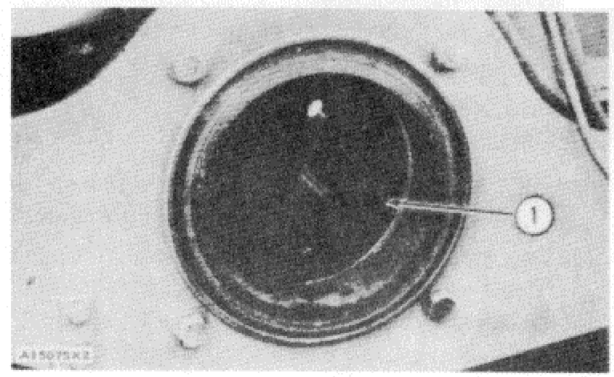
CAUTION: Do not cause damage to the surface of the crankshaft when hammer and chisel is being used.

2. Remove any cuts from the crankshaft that were caused when the wear sleeve was removed.



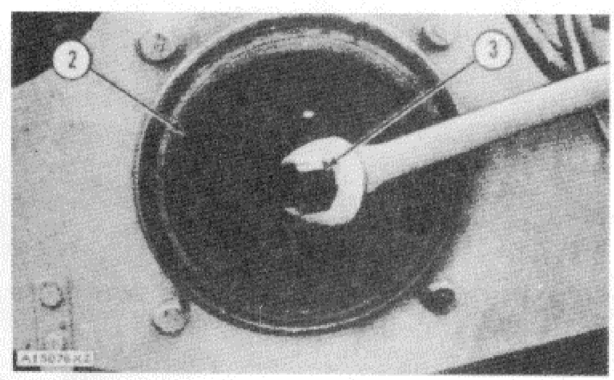
INSTALL CRANKSHAFT FRONT SEAL WEAR SLEEVE

	Tools Needed	A
9S8875	Locator Assembly	1
9S8890	Bolt	3
9S8858	Nut	1
FT1206	Pusher Plate	1
5P1735	Sleeve Installer	1



1. Install the crankshaft front seal wear sleeve with tooling (A) as follows:

    a) Install locator assembly (I) and the bolts on the crankshaft.
    b) Put the wear sleeve on the crankshaft with the outside diameter bevel toward the outside.
    c) Put the sleeve installer on the locator assembly. Slide pusher plate (2) on the stud of the locator assembly.
    d) Install nut (3) on the stud. Tighten the nut until the pusher plate is at bottom.



2. Remove tooling (A).

end by:

a) install crankshaft front seal

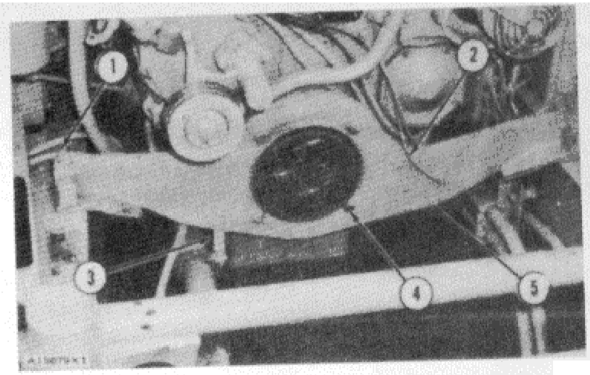
ENGINE FRONT SUPPORT, TRUNNION

REMOVE ENGINE FRONT SUPPORT

start by:

a) remove crankcase guards
b) remove crankshaft pulley
c) remove vibration damper

1. Disconnect wire (2) from front support. Remove water elbow clip (3).
2. Put a floor jack under the oil pan as a support and remove four bolts (4). Fasten a hoist to the front support.
3. Lift the front of the engine with the floor jack and remove four bolts (1) that hold front support to the frame. Remove front support (5). Weight of the support is 60 lb. (27 kg).

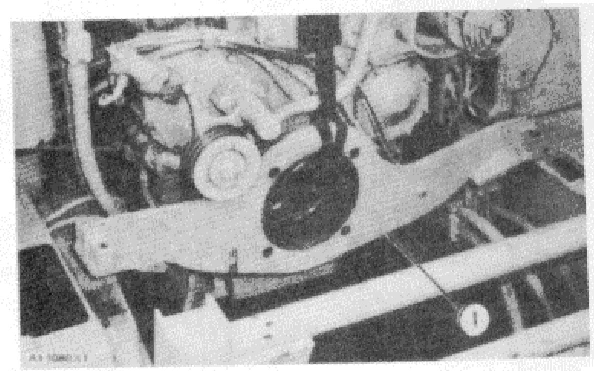


INSTALL ENGINE FRONT SUPPORT

1. Put front support (1) in position and install the four bolts that hold it to the front of the engine.
2. Lower the front of the engine so weight is on the front support. Install the four bolts that hold the support to the frame.
3. Connect wire and install the water elbow clip.

end by:

a) install vibration damper
b) install crankshaft pulley
c) install crankcase guards

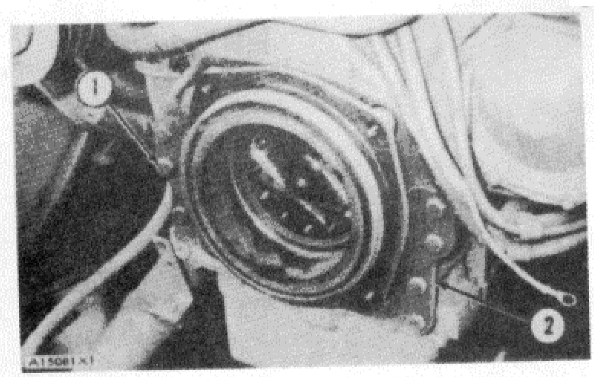


REMOVE TRUNNION

start by:

a) remove engine front support

1. Remove eight bolts (l) that hold trunnion to the timing gear cover.
2. Remove trunnion (2).

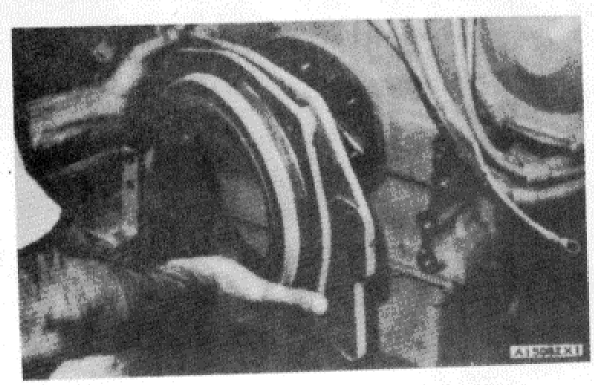


INSTALL TRUNNION

1. Put trunnion in position on the timing gear cover and install the eight bolts that hold it.

end by:

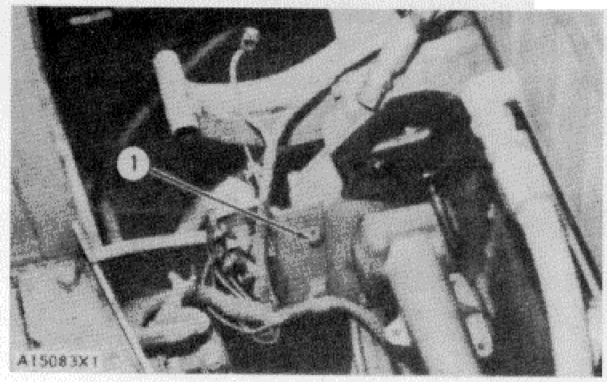
a) install engine front support



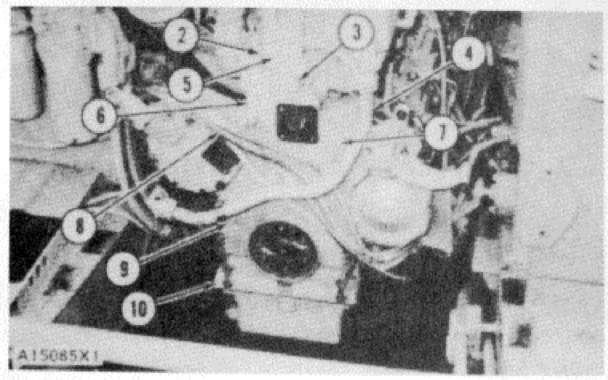
TIMING GEAR COVER

REMOVE TIMING GEAR COVER

start by:
- a) remove alternator
- b) remove accessory drive
- c) remove water pump
- d) remove fan and fan drive
- e) remove engine front support
- f) remove trunnion

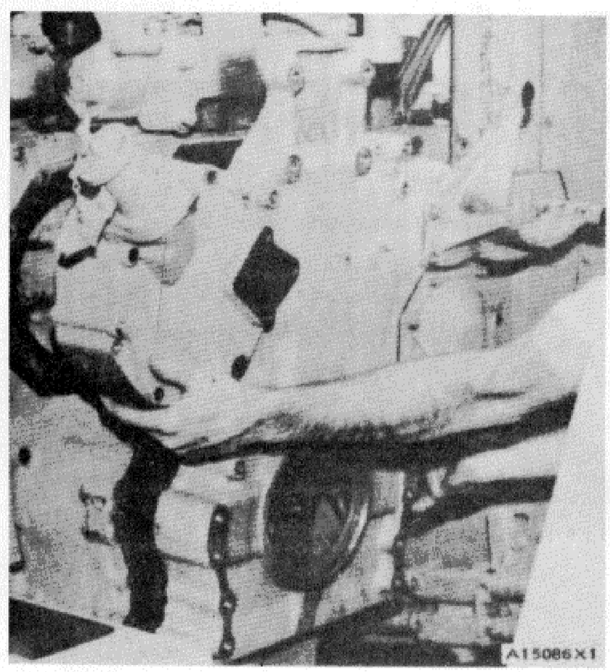


1. Loosen bolts that hold the oil pan to the engine. Install spacers between the oil pan plate and block.
2. Remove the belt tightener bracket.
3. Remove the bolts (I) that hold the timing gear cover to the timing gear plate.
4. Remove bolts (2) and plate (5) from top of timing gear cover.
5. Remove bolts (3) and fan drive bracket (6) from timing gear cover.
6. Remove bolt (7) and aftercooler pipe (4).
7. Disconnect all lines (8) from front of timing gear cover.
8. Remove bolts (9) that hold timing gear cover to cylinder block.
9. Remove timing gear cover (10).



INSTALL TIMING GEAR COVER

1. Install new gasket on timing gear cover and put it in position on the engine. Cut edges off gasket to make it even with cover.
2. Install the bolts that hold cover to engine. Remove spacers from between oil pan and block. Tighten bolts that fasten oil pan to block.
3. Connect all lines to front of timing gear cover.
4. Install aftercooler pipe and bolt that hold it to cover.
5. Install fan drive bracket and bolts that hold it to the cover.
6. Install the plate and bolts that fasten into top of timing gear cover.
7. Install bolts that hold timing gear cover to timing gear plate.
8. Install belt tightener bracket.



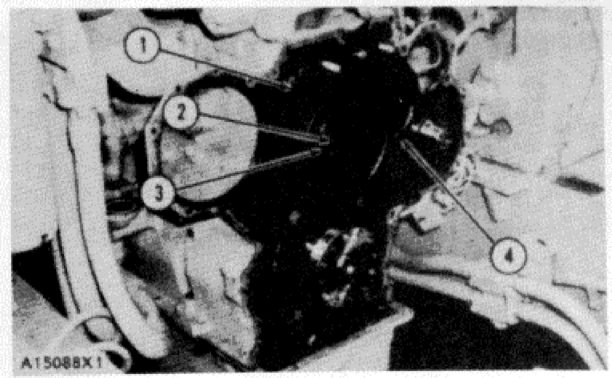
end by:
- a) install trunnion
- b) install engine front support
- c) install fan and fan drive
- d) install water pump
- e) install accessory drive
- f) install alternator

TIMING GEARS AND PLATE

REMOVE TIMING GEARS AND PLATE

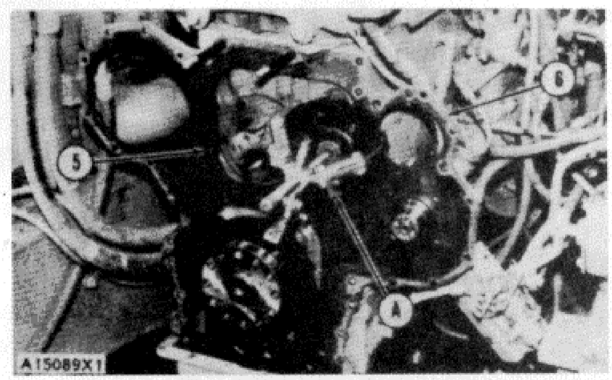
	Tool Needed	A	B
1P2321	Puller Assembly	1	
8B7561	Step Plate	1	
1P529	Handle		1
1P391	Drive Plate		1
1P387	Drive Plate		1

start by:
- a) remove accessory drive
- b) remove automatic timing advance
- c) remove timing gear cover



1. Remove four bolts (2), plate (3) and idler gear (1).

2. Use tooling (A) to remove camshaft gear (4).

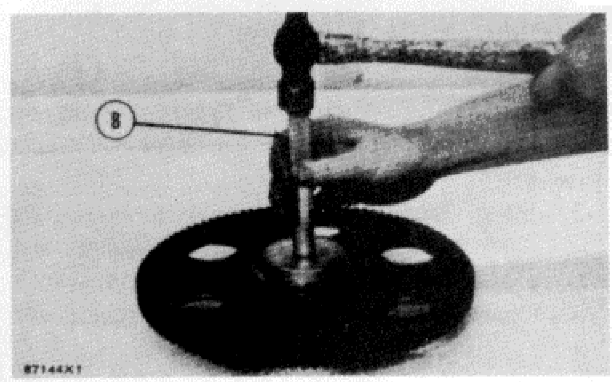


CAUTION : Do not turn the crankshaft with the camshaft gear removed. Damage can be caused to pistons or valves or both.

3. Remove bolts (5) that hold timing gear plate (6) to cylinder block.

4. Remove timing gear plate (6).

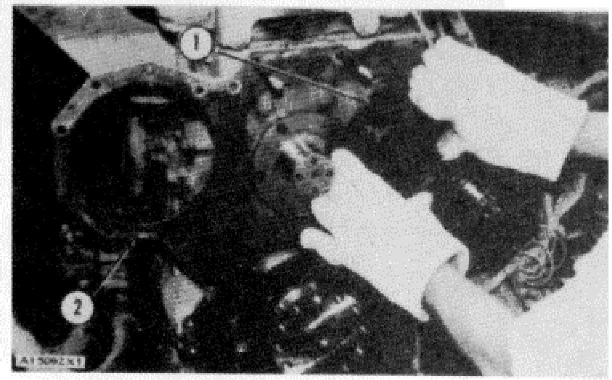
5. Use tooling (B) to remove bearing from the idler gear.



TIMING GEARS AND PLATE

INSTALL TIMING GEARS AND PLATE

	Tools Needed	A
1P529	Handle	1
1P491	Drive Plate	1
1P487	Drive Plate	1

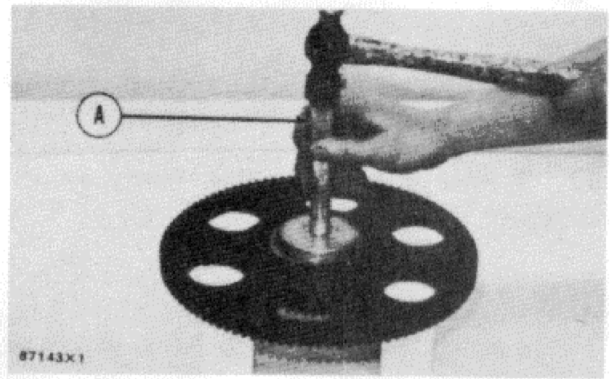


1. Install a new gasket on the timing gear plate.

2. Put timing gear plate (2) in position on cylinder block and install the bolts that hold the timing gear plate to the cylinder block.

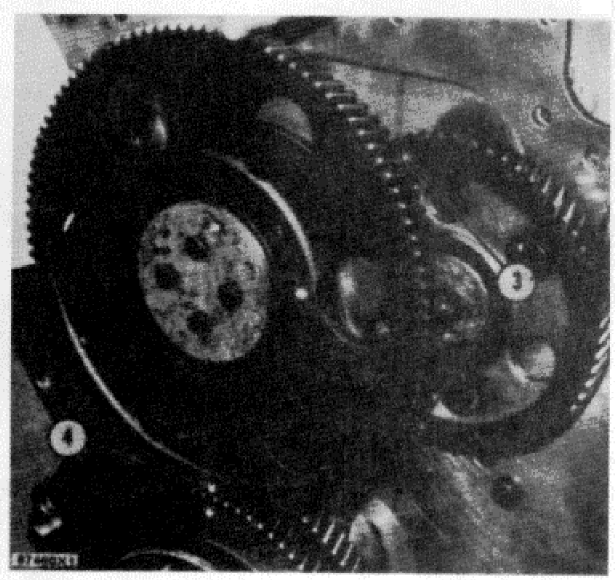
3. Cut timing plate gasket to make it even with the bottom of the cylinder block.

4. Heat camshaft gear (1) to a maximum of 500°F (260°C) and install it on the camshaft.



5. Use tooling (A) to install the bearing in the idler gear.

6. Install idler gear, plate and bolts.



NOTE : Be sure No. I cylinder is at top center on compression stroke. Install idler gear so the "V" mark (4) on the idler gear is in alignment with "V" mark on the crankshaft gear. The "K" marks (3) of the camshaft gear can be seen at the outer edges of the gear.

end by:

a) install timing gear cover
b) install automatic timing advance
c) install accessory drive

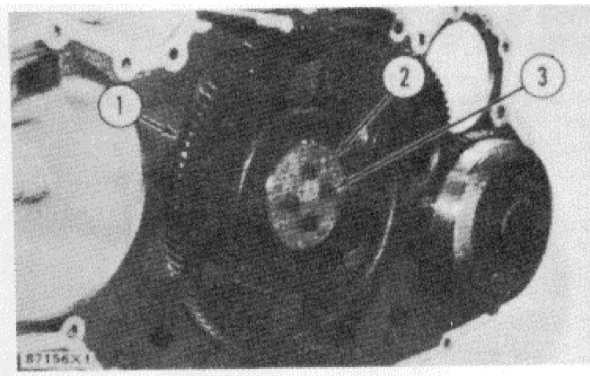
CAMSHAFT

REMOVE CAMSHAFT

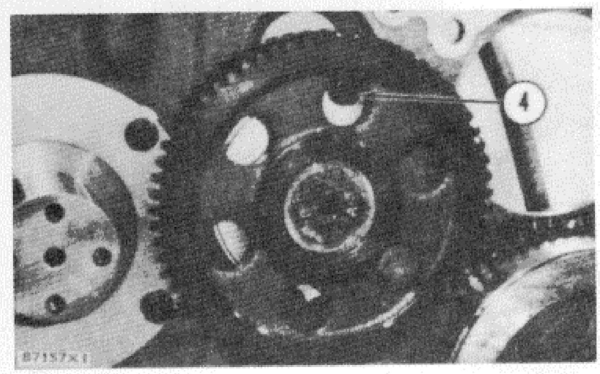
start by:
- a) remove timing gear cover
- b) remove valve lifters

1. Turn engine to top center compression stroke of No. 1 piston.

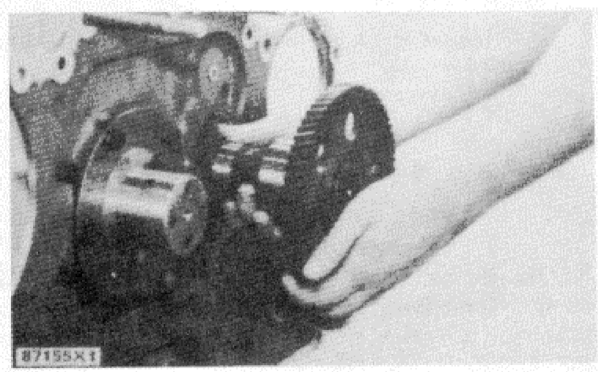
2. Remove four bolts (3), plate (2) and idler gear (1).



3. Remove two bolts (4) and the retainer that hold camshaft to the cylinder block.



4. Carefully remove the camshaft from the cylinder block.



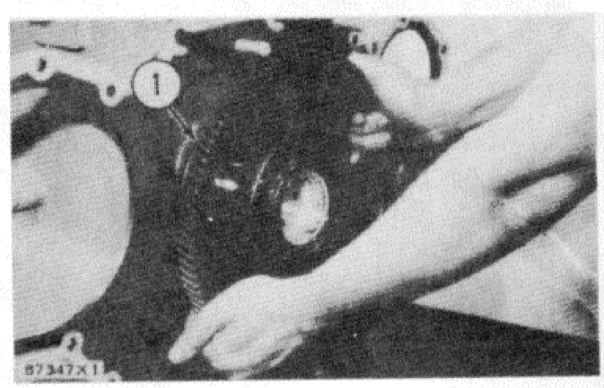
INSTALL CAMSHAFT

1. Put clean engine oil on the lobes and journals of the camshaft.

2. Carefully install the camshaft in cylinder block.

3. Install the retainer that holds the camshaft in the cylinder block.

4. Install idler gear (I) on its shaft. Be sure the "V" mark on idler gear (1) is in alignment with "V" mark on crankshaft gear. The "K" marks on camshaft gear can be seen at the edge of idler gear. Install the plate and bolts.



NOTE: It will be necessary to check the timing of automatic timing advance. See CAMSHAFT TIMING FOR FUEL INJECTION PUMP in TESTING AND ADJUSTING.

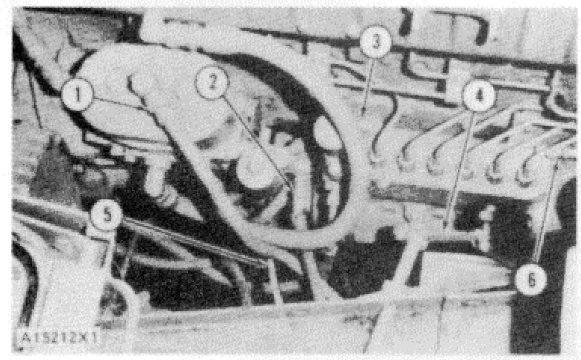
end by:
- a) install timing gear cover
- b) install valve lifters

ENGINE AND DRIVE SHAFT

REMOVE ENGINE AND DRIVE SHAFT AS A UNIT

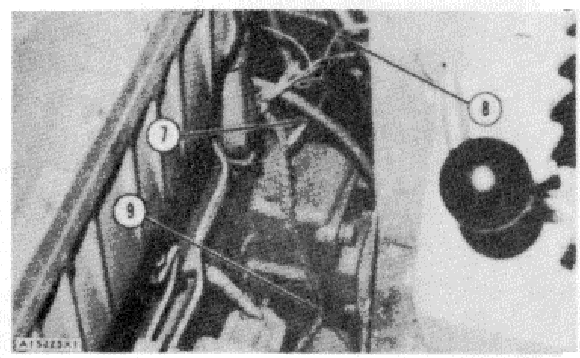
start by:
a) remove hood
b) remove crankcase guards
c) remove radiator

1. Remove engine oil and hydraulic oil.



2. Disconnect battery cables from the engine.

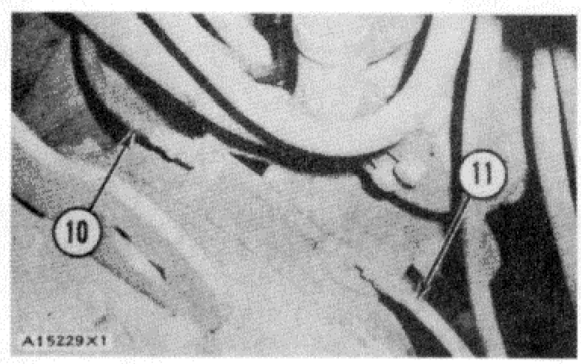
3. Disconnect lines (1), (2), (3) and (6). Disconnect tachometer drive cable (5).



NOTE: Put identification on all lines, cables, wires and tubes.

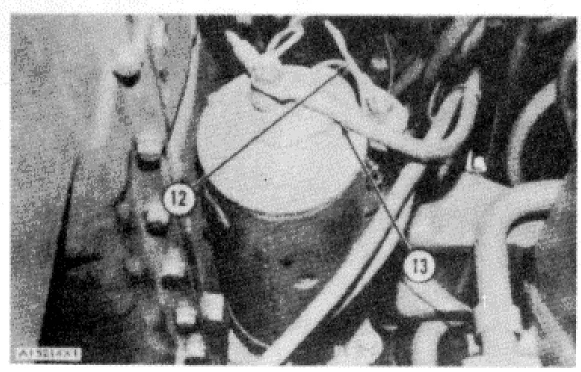
4. Disconnect governor linkage (4).

5. Disconnect lines (8) and (9). Disconnect tube (7).



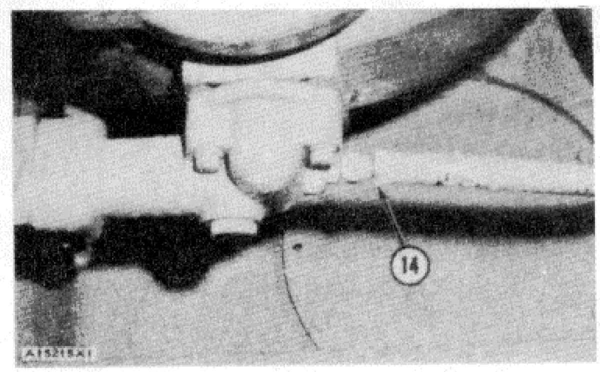
6. Remove lines (10) and (11) on top of drive shaft housing.

7. Disconnect all cables (13) and wires (12) from the starter.

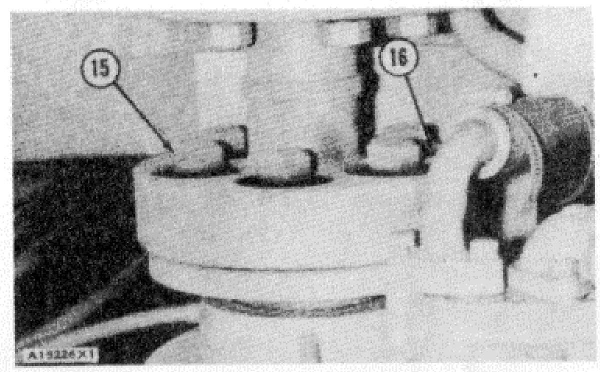


ENGINE AND DRIVE SHAFT

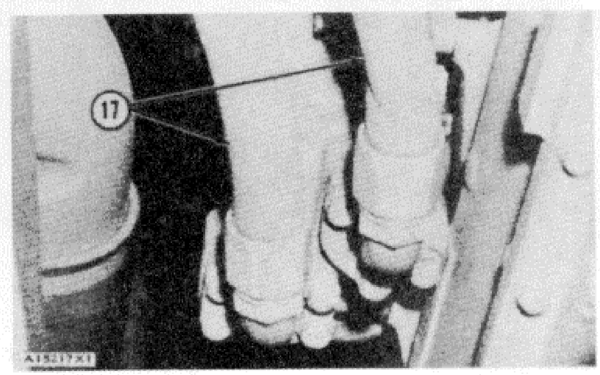
8. Remove hydraulic return line (14) for the seat.



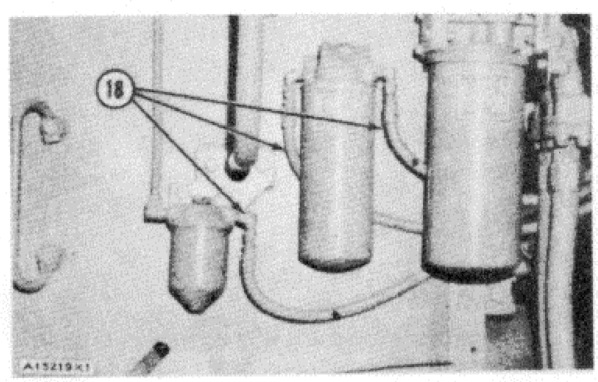
9. Remove hose (16) and bolts (15) from drive shaft coupling.



10. Disconnect hoses (17) from oil filter base.

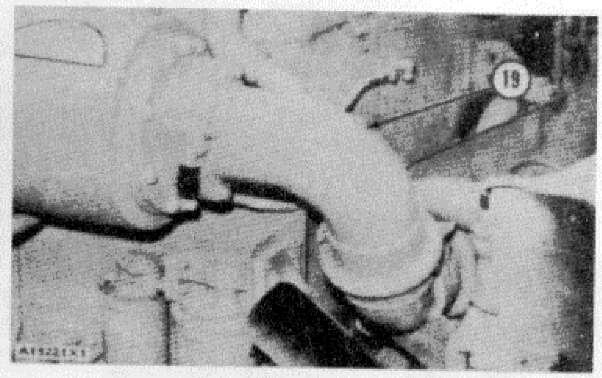


11. Disconnect lines (18) from the oil and fuel filters.

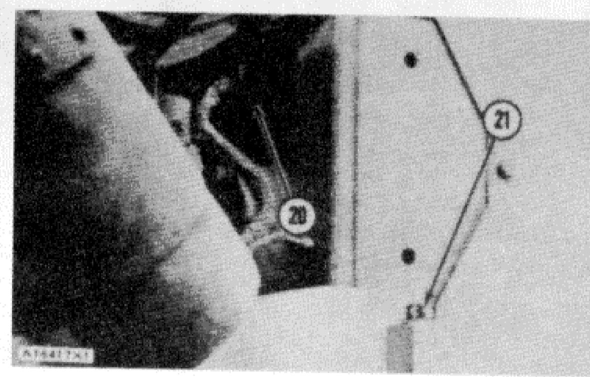


ENGINE AND DRIVE SHAFT

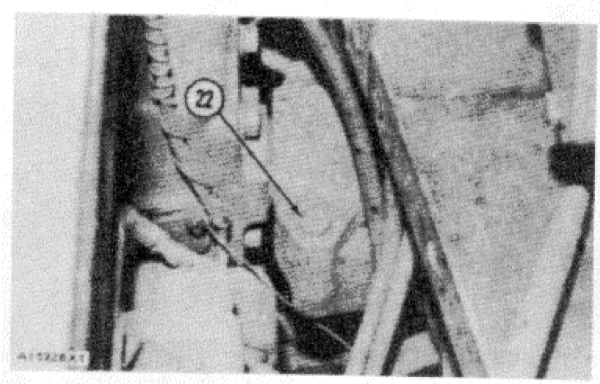
12. Remove the air inlet elbow (19) from turbocharger and air cleaner. Remove oil level gauge. Disconnect oil level gauge guide assembly.



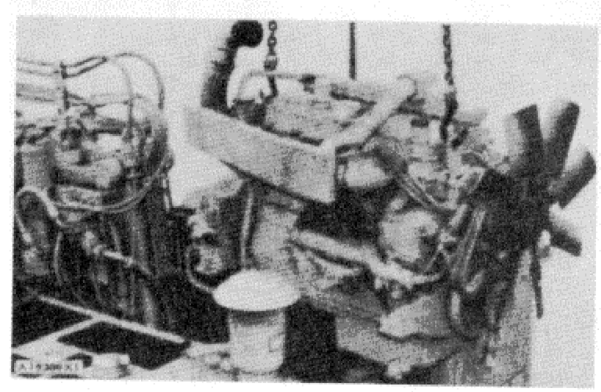
13. Remove wire cage (20) from the frame. Fasten a hoist to the engine. Remove bolts (21) from the front support.



14. Remove bolts (22) from the engine rear mounts.



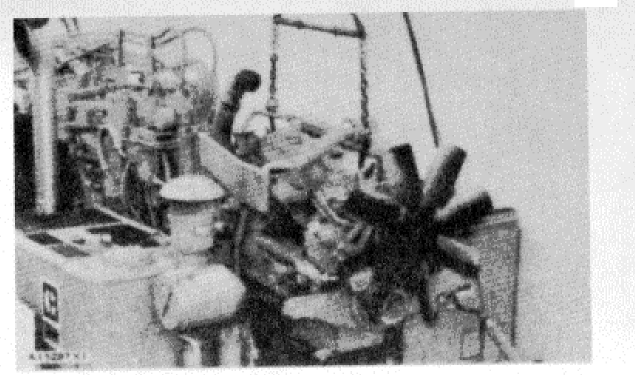
15. Remove engine and drive shaft as a unit. Weigh of the unit is 3150 lb. (1429 kg).



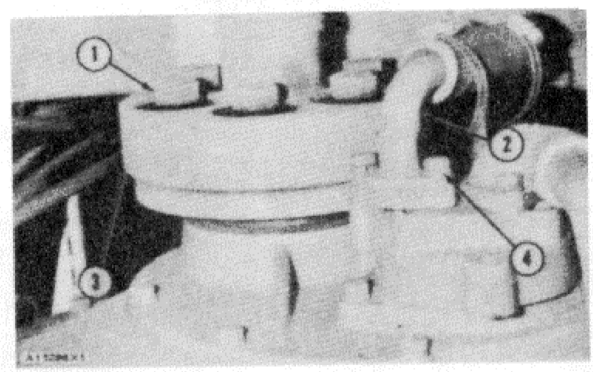
ENGINE AND DRIVE SHAFT

INSTALL ENGINE AND DRIVE SHAFT AS A UNIT

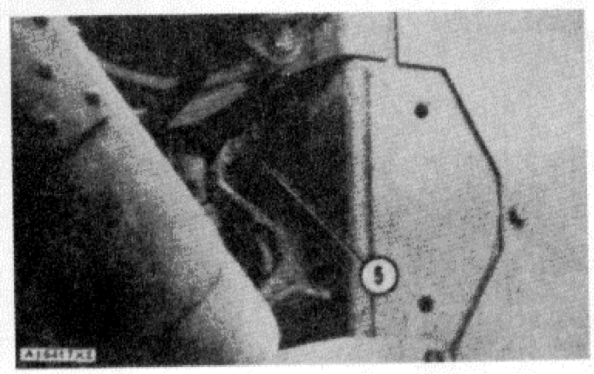
1. Put engine and drive shaft in position in the machine with a hoist.



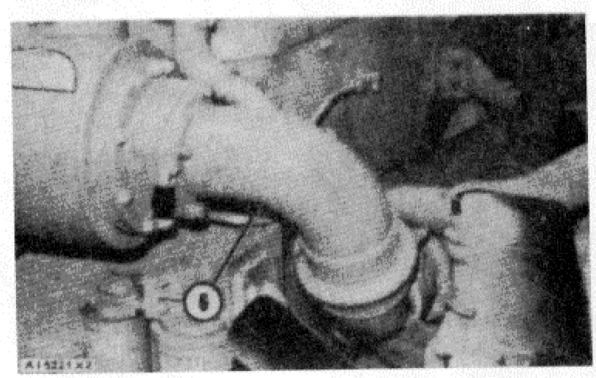
2. Install bolts for the rear mounts. Install bolts for the front support.



3. Connect coupling (3) to drive shaft and install bolts (1). Tighten the bolts to a torque of 320 ± 15 lb.ft. (44.3 ± 2.1 mkg). Install hose (2) and bolts (4).



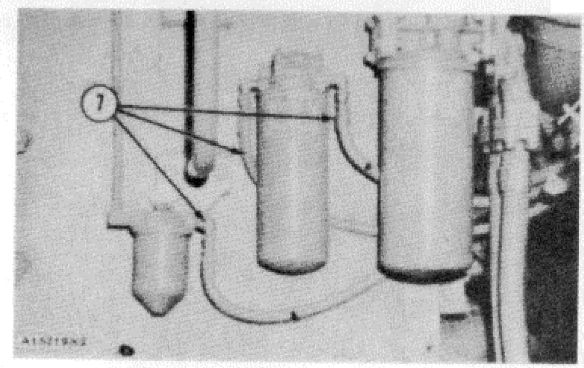
4. Install wire cage (5) on machine frame.



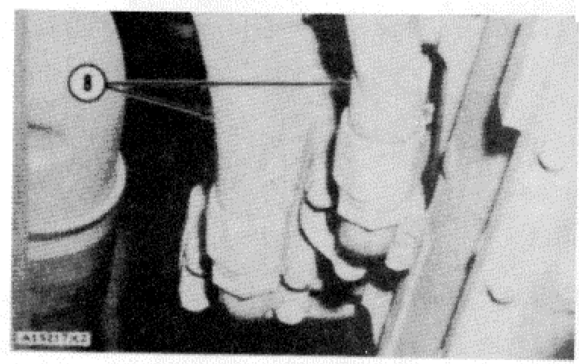
5. Install the air inlet elbow (6) to the turbocharger and air cleaner. Connect oil level gauge guide assembly and install oil level gauge.

ENGINE AND DRIVE SHAFT

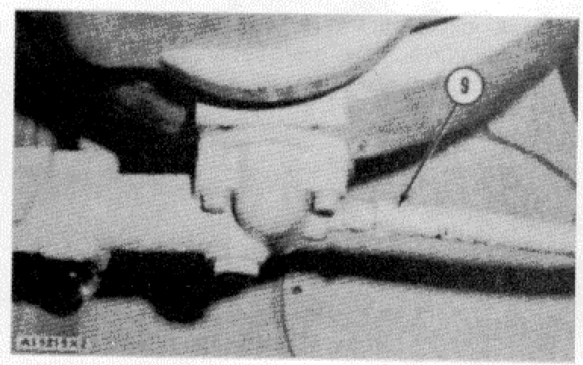
6. Connect lines (7) to the oil and fuel filters.



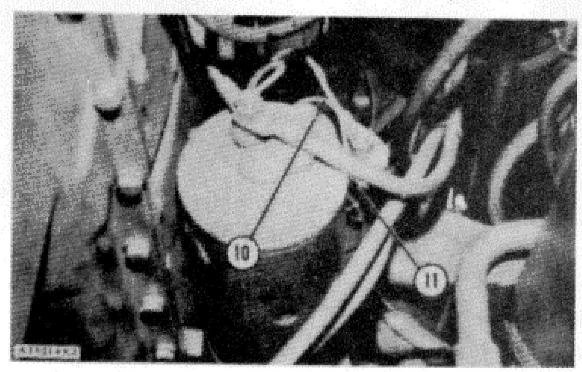
7. Connect hoses (8) to the oil filter base.



8. Install hydraulic return line (9) for the seat.

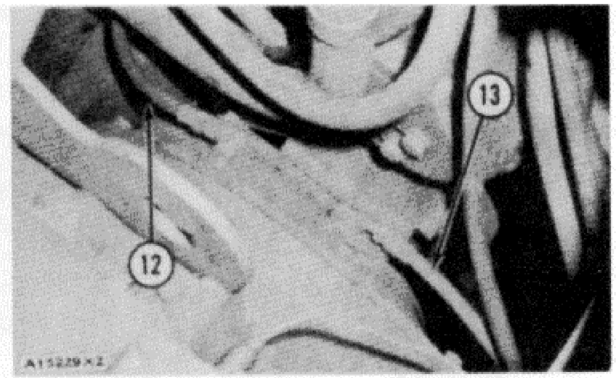


9. Connect all cables (11) and wires (10) to the starter.

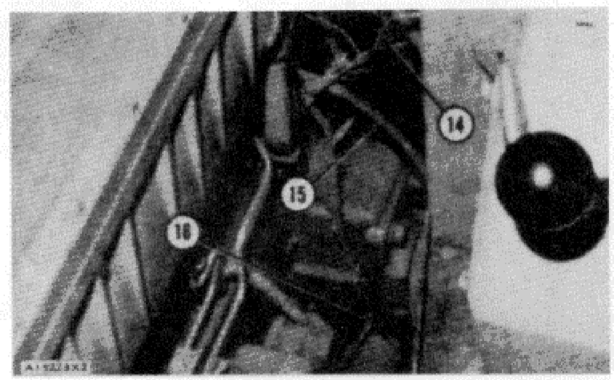


ENGINE AND DRIVE SHAFT

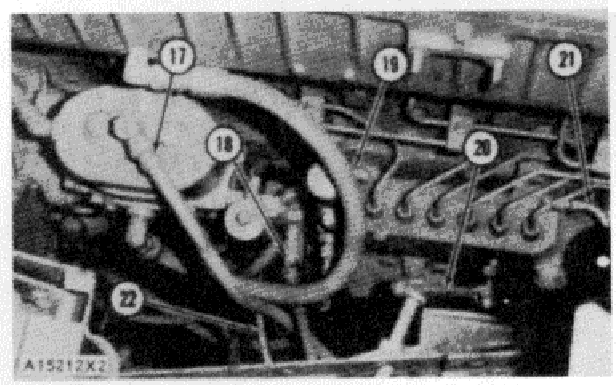
10. Install lines (12) and (13) on top of the drive shaft housing.



11. Connect lines (14) and (16). Connect tube (15).



12. Connect lines (17), (18), (19), and (21). Connect tachometer drive cable (22). Connect governor linkage (20).



13. Connect battery cables to the engine.

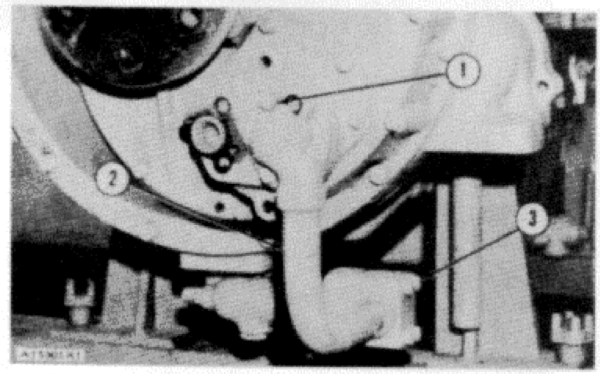
14. Fill engine with oil to correct level. Fill hydraulic system with fluid to correct level.
    end by:
    a) install radiator
    b) install crankcase guards
    c) install hood

SCAVENGE PUMP

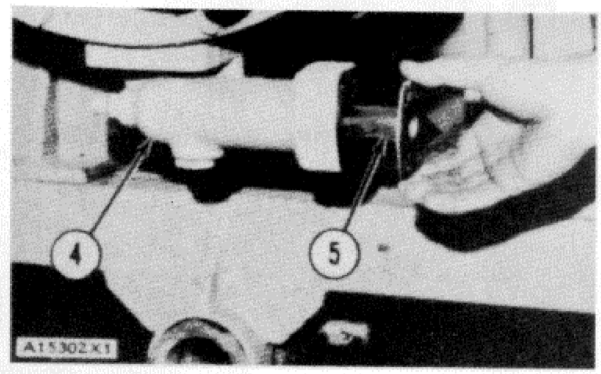
REMOVE SCAVENGE PUMP

start by:
a) remove engine and drive shaft

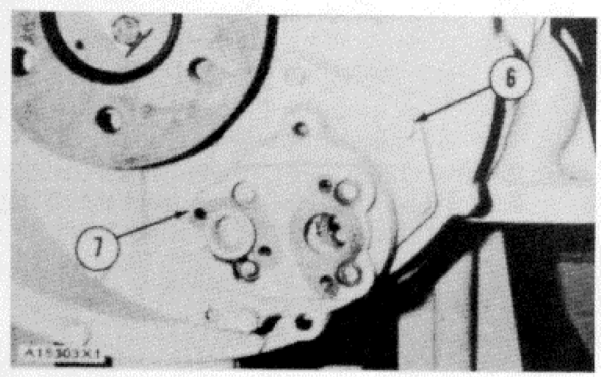
1. Remove bolts (1), bolts (3) and remove hydraulic tube (2).



2. Remove filter screen element (5) from filter housing (4). Inspect element and clean if necessary.

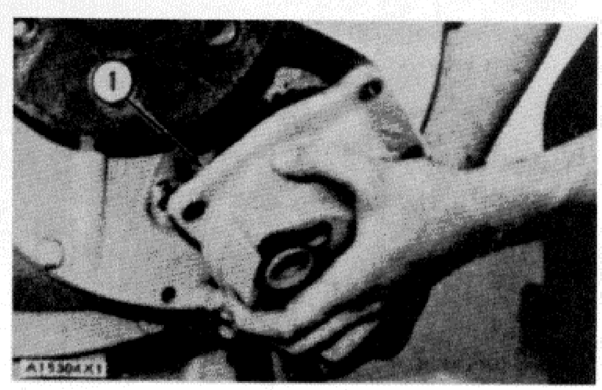


3. Remove bolts (6) and remove scavenge pump (7).



INSTALL SCAVENGE PUMP

1. Put scavenge pump (l) into position on the drive shaft housing and install the bolts that hold it.



2. Put filter screen element into filter housing.

3. Install the hydraulic tube and the bolts that hold it to the scavenge pump and filter housing.

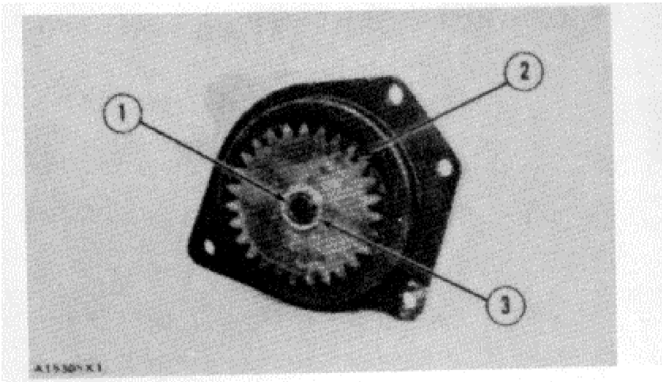
end by:
a) install engine and drive shaft

SCAVENGE PUMP

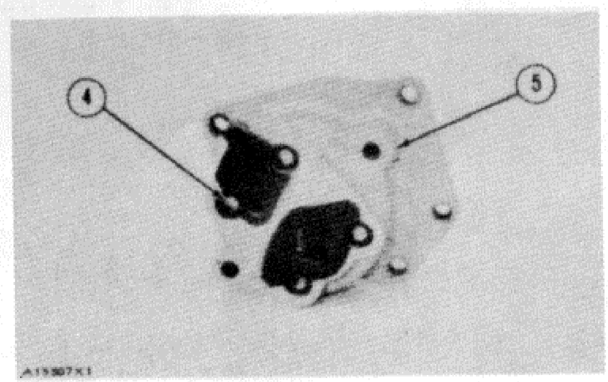
DISASSEMBLE SCAVENGE PUMP

start by:
a) remove scavenge pump

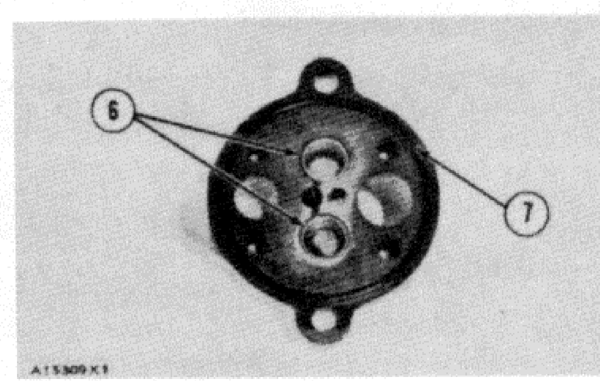
1. Remove snap ring (3), brass washer (1). Remove drive gear (2).



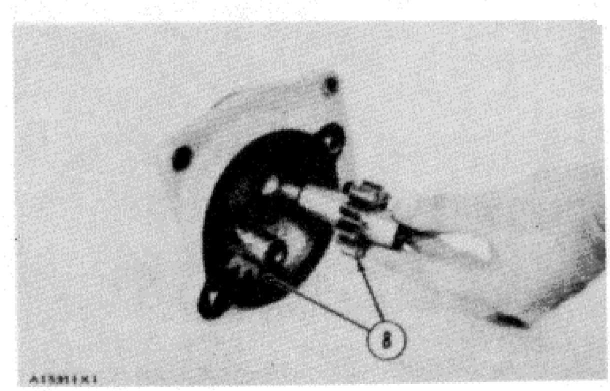
2. Remove four bolts (4) and cover assembly (5).



3. Remove O-ring seal (7) from cover assembly. Remove two bearings (6). Inspect the O-ring seal and make a replacement if necessary.

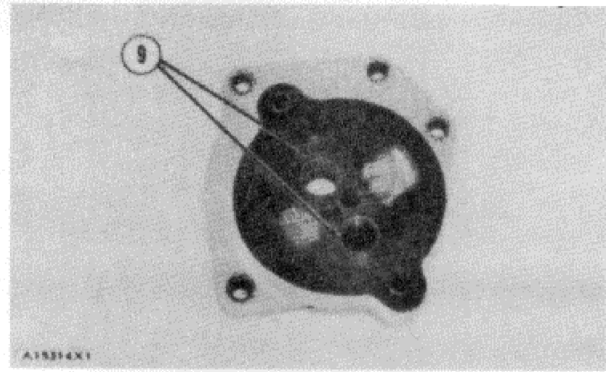


4. Remove gears (8) from manifold assembly.

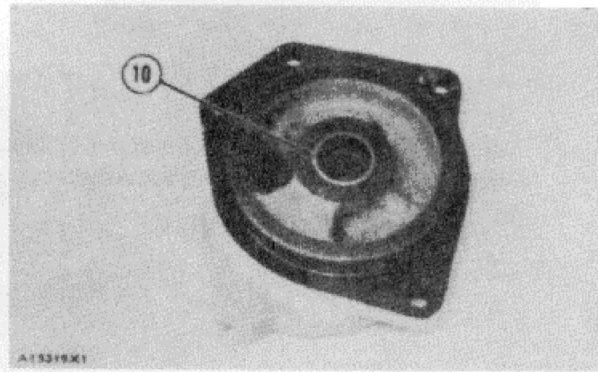


SCAVENGE PUMP

5. Remove bearing (9) from manifold assembly.



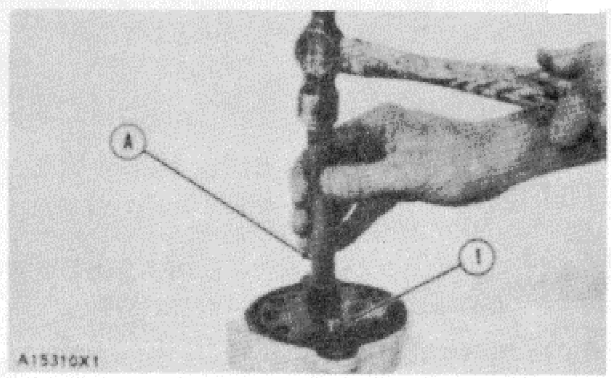
6. Remove seal (10) from manifold assembly.



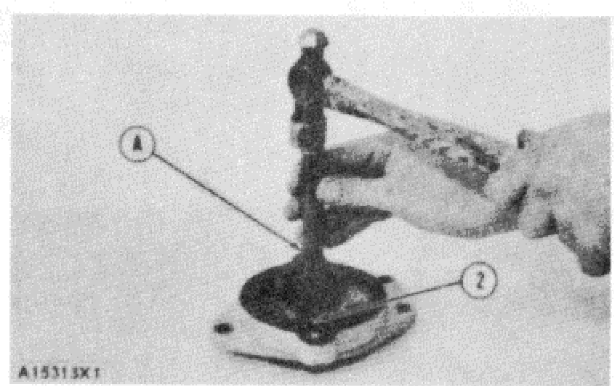
ASSEMBLE SCAVENGE PUMP

	Tool Needed	A	B
1P529	Handle	1	1
1P461	Drive Plate	1	
1P463	Drive Plate	1	
1P473	Drive Plate		1

1. Install bearings (1) into cover assembly with tooling (A). Bearings must be .062 in. (1.6 mm) below surface of the cover assembly.

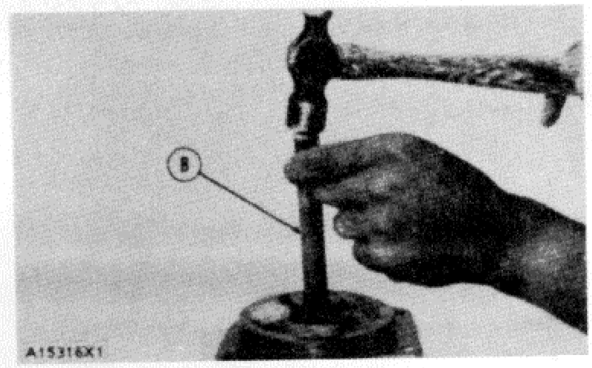


2. Install bearings (2) into manifold assembly, with tooling (A). Bearings must be installed .062 in. (1.6 mm) below inner surface of manifold assembly.

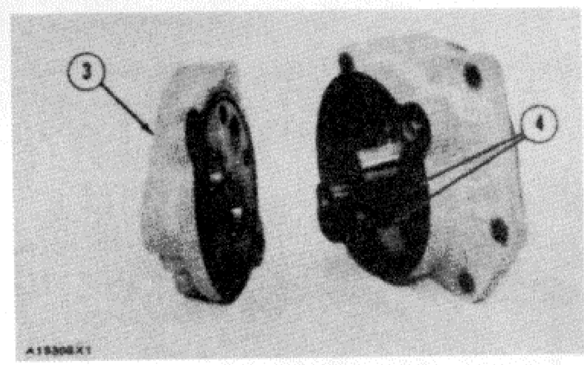


SCAVENGE PUMP

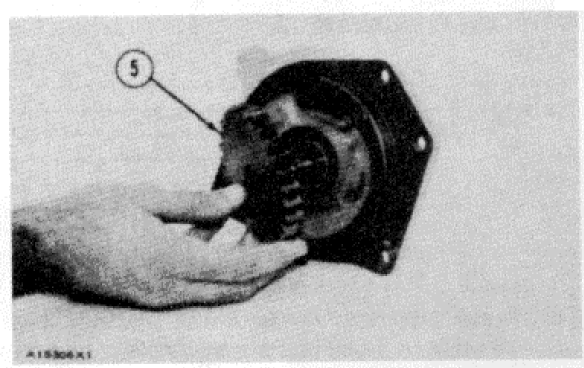
3. Install seal into manifold assembly with tooling (B).



4. Install gears (4) in manifold assembly. Install cover assembly (3) and install the bolts that hold it.



5. Install drive gear (5) on shaft. Install brass washer and snap ring on drive gear.
   end by:
   a) install scavenge pump

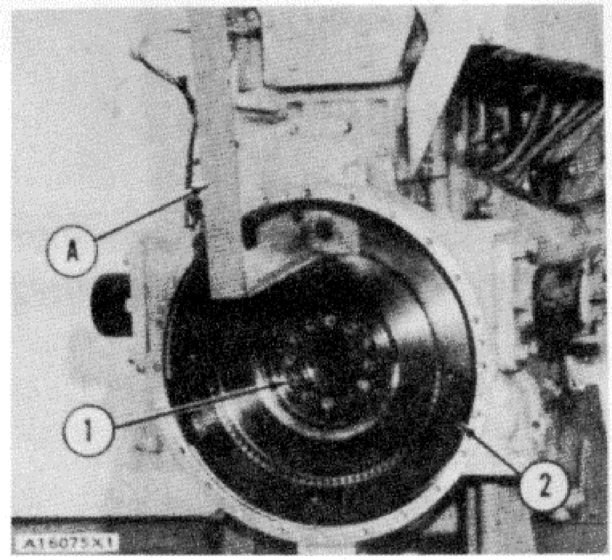


FLYWHEEL

REMOVE FLYWHEEL

	Tools Needed	A
FT121	Lifting Bracket	1

start by:
a) remove drive shaft

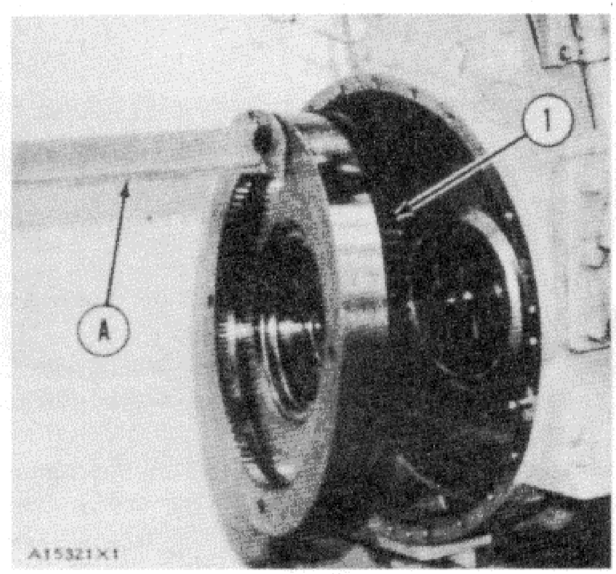


1. Fasten a hoist to tool (A). Put tool (A) in position on the flywheel. Install a 5/8"-11 NC x 1 in. Long bolt to hold tool (A).

2. Remove bolts (1). Remove flywheel (2). Weight of flywheel is 150 lb. (68 kg).

INSTALL FLYWHEEL

	Tools Needed	A
FT121	Lifting Bracket	1



1. Put flywheel (1) in position on the dowel of the crankshaft with tool (A) and a hoist.

2. Install the bolts that hold the flywheel to the crankshaft. Tighten the bolts to a torque of 210 ± 20 lb.ft. (29.0 ± 2.8 mkg).
end by:
a) install drive shaft

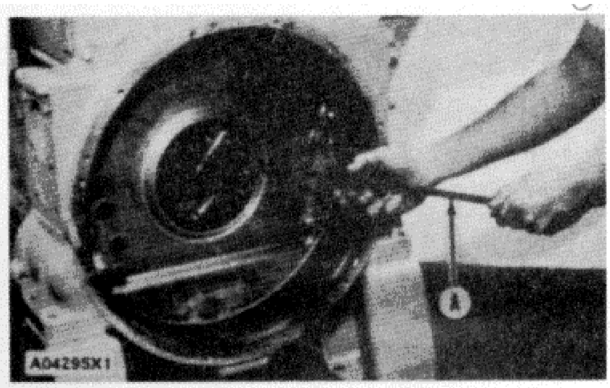
CRANKSHAFT REAR SEAL

REMOVE CRANKSHAFT REAR SEAL

	Tools Needed	A
1P3075	Puller Group	1

start by:
a) remove flywheel

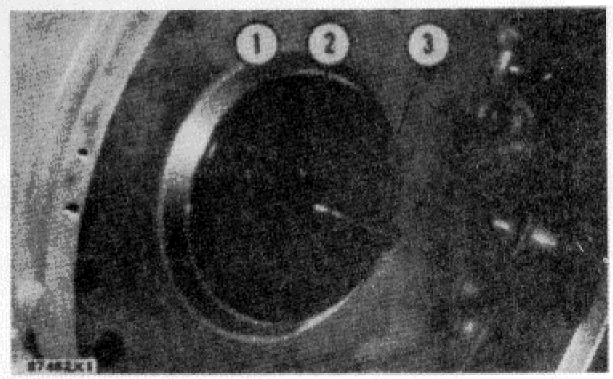
1. Use puller (A) to remove crankshaft rear seal.

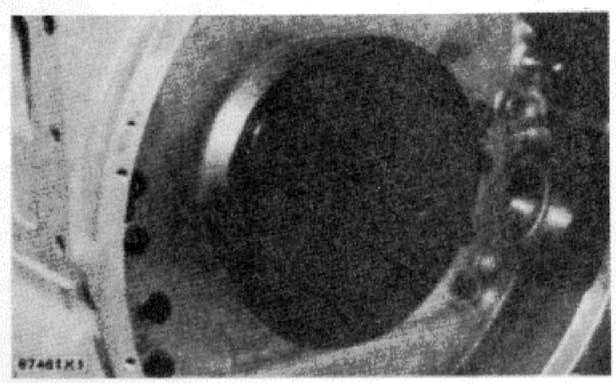


INSTALL CRANKSHAFT REAR SEAL

	Tools Needed	A
5P1733	Locator Assembly	1
5P1737	Bolt	3
9S8858	Nut	1
9S88S4	Pusher Plate	1
968S40	Seal Installer	1
9S8550	Pilot	1

1. Use tooling (A) to install the crankshaft rear seal as follows:
   a) Install the locator assembly (2) and bolts (3) on the crankshaft.
   b) Put clean engine oil on lip of seal and on wear sleeve.
   c) Put the seal (1) on wear sleeve with lip of seal toward front of engine. Put the seal installer on locator assembly (2).
   d) Slide the pusher plate on the stud of locator assembly (2).
   e) Install the nut on stud of locator assembly. Turn the nut until the pusher plate is at bottom.





2. Remove tooling (A).
   end by:
   a) install flywheel

CRANKSHAFT REAR SEAL WEAR SLEEVE

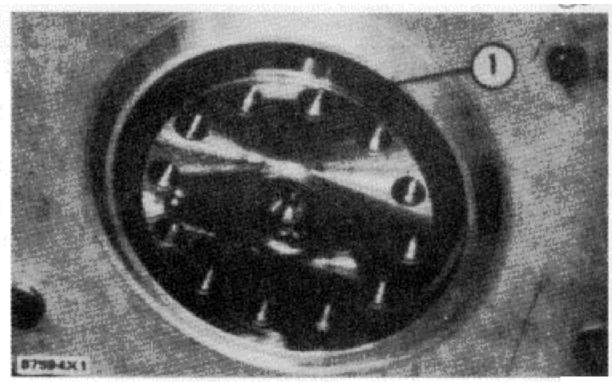
REMOVE CRANKSHAFT REAR SEAL WEAR SLEEVE

start by:
a) remove crankshaft rear seal

1. Use a chisel and hammer to cut the old wear sleeve (1). Remove the wear sleeve.

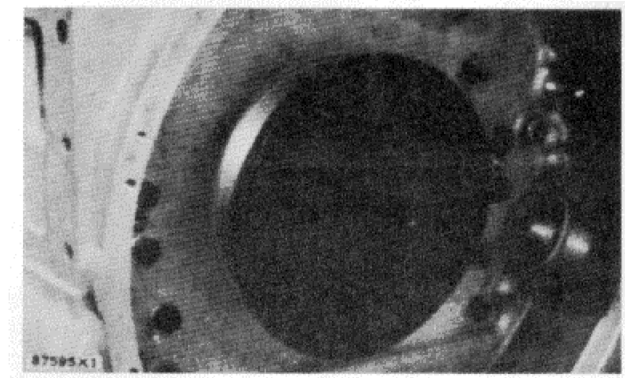
CAUTION: Do not cause damage to surface of crankshaft when chisel and hammer is being used.

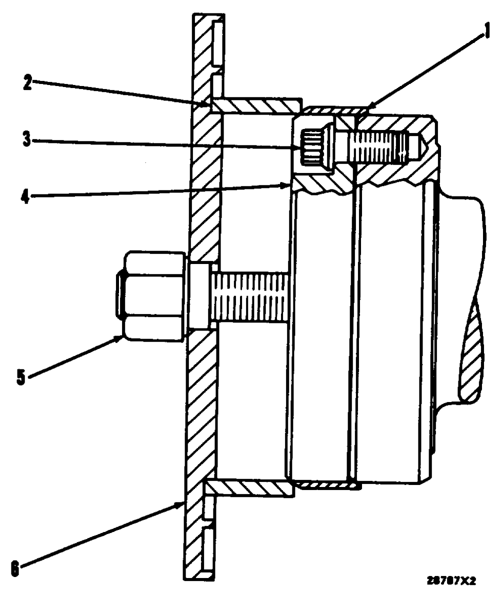
2. Remove any cuts from crankshaft that were caused when wear sleeve was removed.



INSTALL CRANKSHAFT REAR SEAL WEAR SLEEVE

	Tools Needed	A
5P1733	Locator Assembly	1
5P1737	Bolt	3
9S8858	Nut	1
9S8864	Push Plate	1
5P1736	Sleeve Installer	1





1. Use tooling (A) to install crankshaft rear seal wear sleeve as follows:

   a) Put the locator assembly (4) on the crankshaft and install bolts (3).

   b) Install wear sleeve (1) on locator assembly with bevel on sleeve toward outside.

   c) Put the installer ring (2) in pusher plate (6) and install plate on locator assembly (4). Install nut (5).

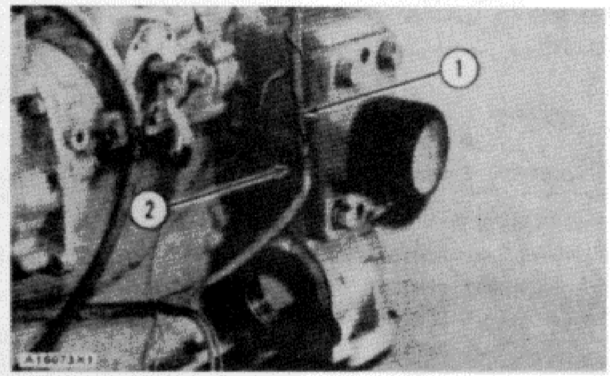
   d) Tighten nut until pusher plate is at bottom against locator assembly.

2. Remove tooling (A) from crankshaft.

end by:
a) install crankshaft rear seal

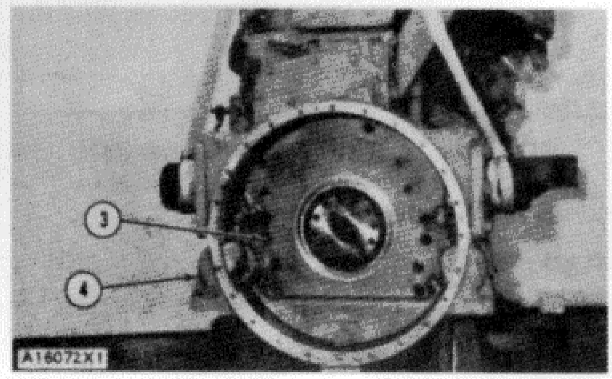
FLYWHEEL HOUSING

REMOVE FLYWHEEL HOUSING



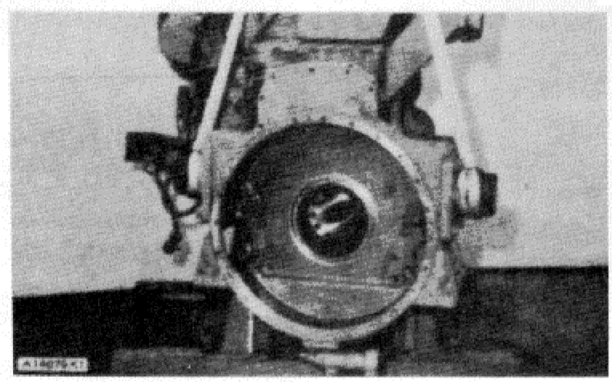
start by:
a) remove starter
b) remove oil pan
c) remove flywheel

1. Remove clamp (2) holding wires (1).
2. Fasten a hoist to the rear supports and remove bolts (3).



3. Remove flywheel housing (4). Weight of flywheel housing is 126 lb. (57 kg).

INSTALL FLYWHEEL HOUSING



1. Put flywheel housing in position on the cylinder block and install the bolts that hold it.

2. Install wires and clamp.

end by:
a) install flywheel
b) install oil pan
c) install starter

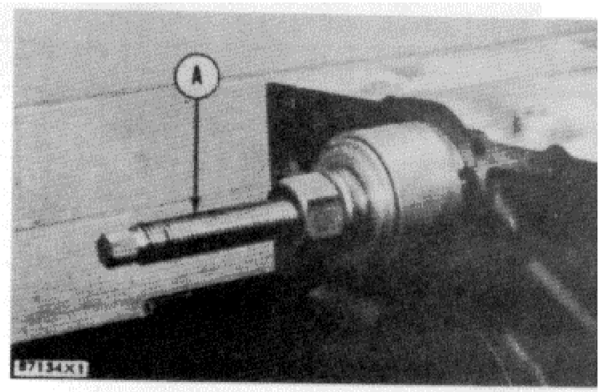
CAMSHAFT BEARINGS

REMOVE CAMSHAFT BEARINGS

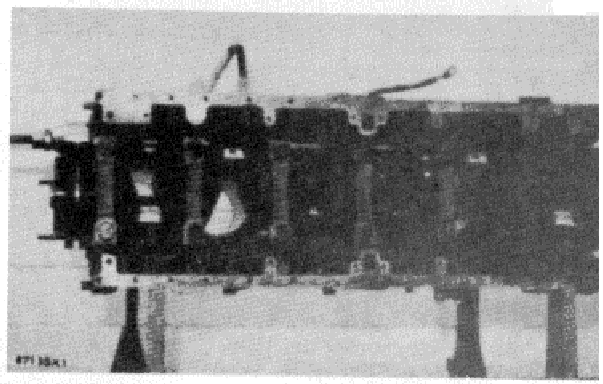
	Tools Needed	A
8S2241	Camshaft Bearing Installation & Removal Tool Group	1
8S8293	Extension	1

start by:

a) remove camshaft
b) remove flywheel housing
c) remove pistons
d) remove timing gears and plate

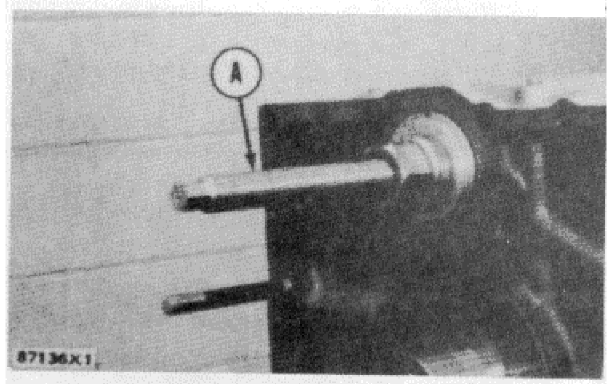


1. Use tool (A) to remove the camshaft bearings from cylinder block starting with the rear bearing.



INSTALL CAMSHAFT BEARINGS

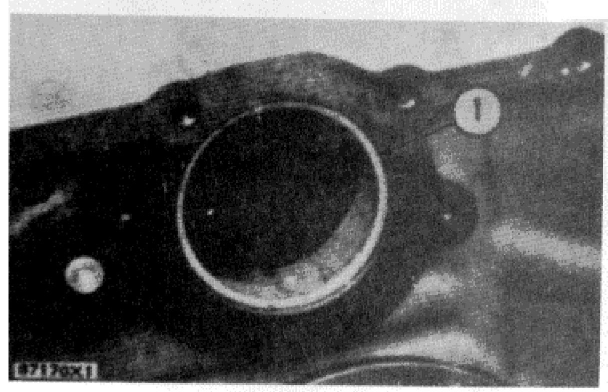
	Tools Needed	A
8S2241	Camshaft Bering Installation & Removal Tool Group	1
8S8293	Extension	1



1. Use tool group (A) to install the camshaft bearings in the cylinder block starting with the rear bearing.

2. Install all bearings with the oil hole in each bearing in alignment with oil hole in cylinder block. The front bearing has two oil holes.

3. Install the front bearing (I) so there is .11 in. (2.79 mm) from the machined surface of cylinder block.



end by:

a) install timing gears and plate
b) install camshaft
c) install pistons
d) install flywheel housing

CRANKSHAFT

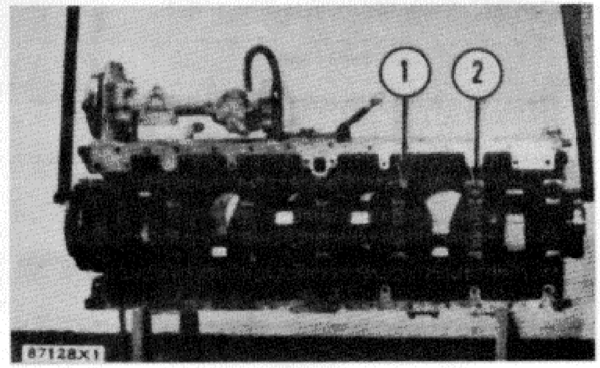
REMOVE CRANKSHAFT

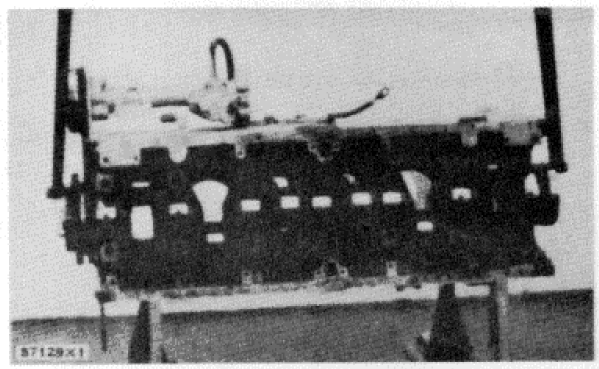
Tool Needed		A	B
1H3110	Bearing Puller Attachment	1	
8B7560	Step Plate	1	
9S5800	Hydraulic Pump	1	
1H3108	Leg	2	
1H3107	Puller Assembly	1	
3H468	Plate	5	
3H466	Nut	2	
7F9640	Puller Assembly	1	
1B4209	Nut	1	
5P944	Puller Group		1
5P939	Extractor		1

start by:

a) remove timing gear cover
b) remove flywheel housing
c) remove pistons
d) remove crankshaft rear seal wear sleeve
e) remove crankshaft front seal wear sleeve
f) remove fuel injection pump housing and governor

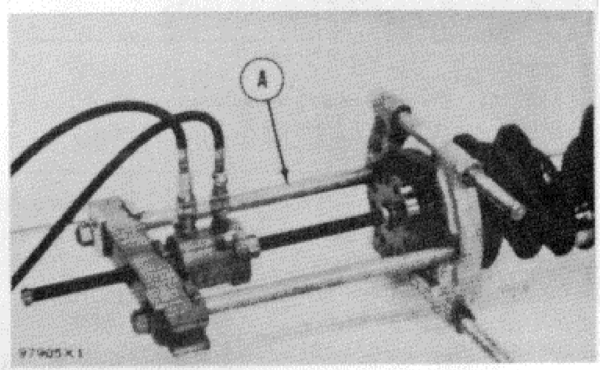
NOTE: Check the bearing caps for a number as to their location, if a number can not be seen, put a number on the left side of cylinder block and bearing cap.



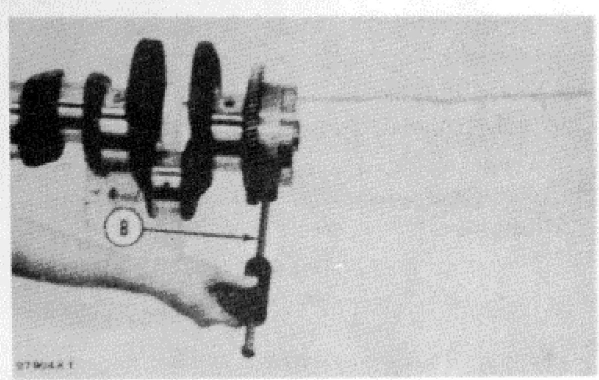


1. Loosen the bolts (2) that hold main bearing caps (1) to cylinder block.
2. Install one of the bolts for flywheel in each end of the crankshaft.
3. Fasten a hoist and remove the main bearing caps. Remove bearings from bearing caps.
4. Remove crankshaft from engine. Weight is 350 lb. (159 kg).
5. Remove crankshaft main bearings from cylinder block.

NOTE: If new main bearings are not to be installed, keep old bearings with identification as to their location in cylinder block.



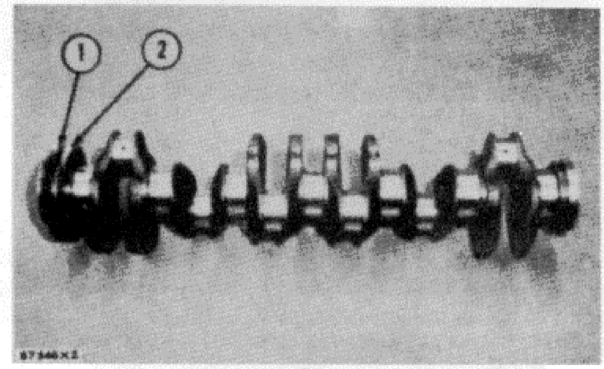
6. Use tooling (A) to remove crankshaft outer gear. Use a hammer and a chisel to remove spacer.
7. Use tooling (B) to remove dowel.
8. Use tooling (A) to remove crankshaft inner gear.



CRANKSHAFT

INSTALL CRANKSHAFT

Tools Needed		A	B
8S2328	Dial Test Indicator Group	1	
5B1161	Wire		*



1. Heat the crankshaft ears to maximum temperature of 400°F (204°C).

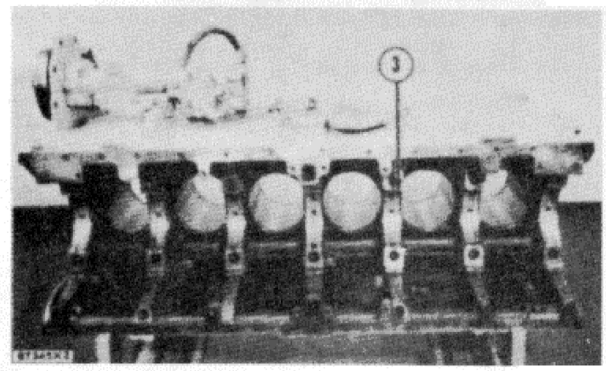
2. Install crankshaft inner gear (2) on crankshaft.

3. Install spacer on crankshaft.

4. Install the pin in end of crankshaft. The pin must be extended no more than .19 in. (4.82 mm) from surface of crankshaft.

5. Install the crankshaft outer gear (1) on crankshaft.

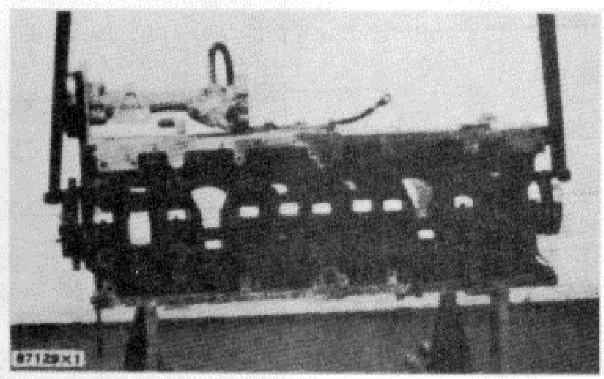
NOTE: The pin in crankshaft must be in alignment with notch in crankshaft gear (1).



6. Clean the cylinder block and main bearing caps thoroughly.

7. Install upper half of main bearings (3) in the block. Put clean engine oil on the bearings and journals of crankshaft.

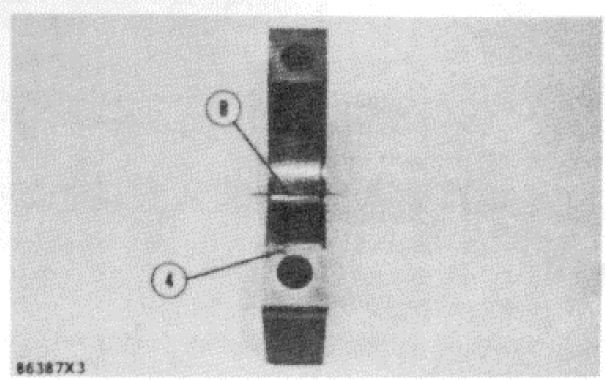
8. Install one bolt for flywheel on each end of crankshaft.



9. Fasten a hoist and put crankshaft in position in block. Be sure the "V" mark on camshaft gear is in alignment with "V" mark on crankshaft gear.

10. Install main bearing in bearing caps.

NOTE: Be sure the tabs (4) on back of bearings fit in the grooves of caps and cylinder block.

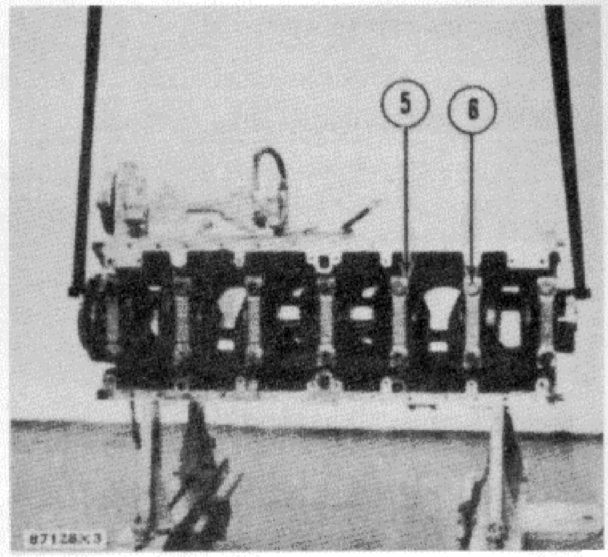


11. Use wire (B) to check bearing clearance.

12. Put wire (B) on the bearing.

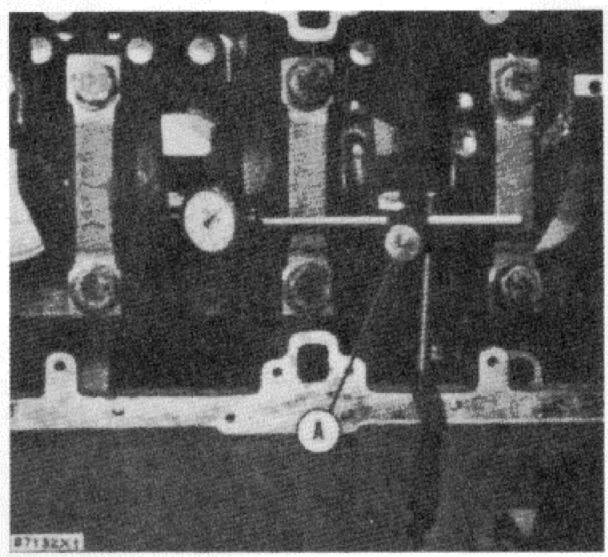
CRANKSHAFT

NOTE: Be sure main bearing caps (5) are installed so the numbers on the side of the cylinder block are the same as the numbers on the bearing caps, and the arrows on the caps are toward the front of the cylinder block.



13. Install the main bearing caps. Install the bolts (6) and tighten the bolts, at end with tab first, to a torque of 190 ± 10 lb.ft. (26.2 ± 1.4 mkg). Put a mark on the bolts and caps. Turn the bolts at opposite end of tab first an extra 120° ± 5° from the mark.
14. Remove the main bearing caps. Remove wire (B) from the caps. Check the thickness of wire (B) to find the bearing clearance. The bearing clearance must be .0037 to .0068 in. (0.093 to 0.172 mm) with new bearings. Maximum clearance with used bearings is .010 in. (0.35 mm).
15. Install the thrust bearings for No. 4 main bearing.

NOTE: Install the thrust bearings with the side marked "BLOCK SIDE" toward the cylinder block.



16. Put clean engine oil on the threads of the bolts. Install the main bearing caps. Install the bolts and the bolts, at the end with the tab first, to a torque of 190 ± 10 lb.ft. (26.2 ± 1.4 mkg). Put a mark on the bolts and caps. Turn the bolts, opposite end of tab first, an extra 120° ± 5° from the mark.
17. Check the end play of the crankshaft with tool group (A). Be sure the dial indicator is against a machined surface. The end play is controlled by the thrust bearings of No. 4 (center) main. The end play with new bearings must be .006 to .020 in. (0.152 to 0.508 mm). The maximum permissible end play with used bearings is .035 in. (0.89 mm).

end by:

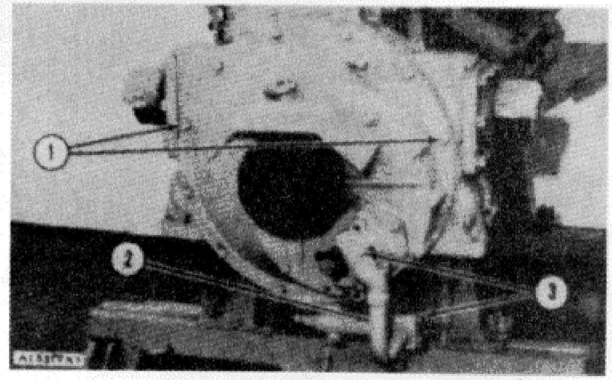
a) install pistons
b) install flywheel housing
c) install timing gear cover
d) install crankshaft front seal wear sleeve
e) install crankshaft rear seal wear sleeve
f) install fuel injection pump housing and governor

DRIVE SHAFT

REMOVE DRIVE SHAFT

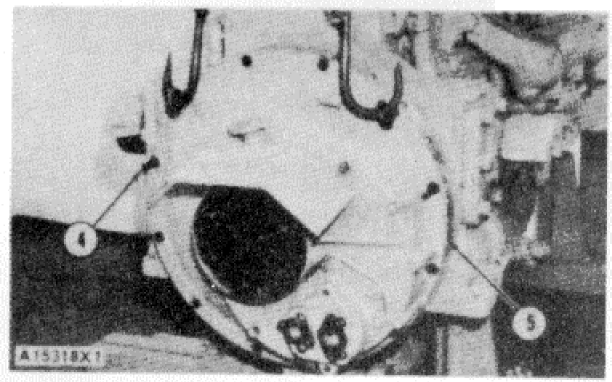
start by:
a) remove engine and drive shaft

NOTE: See TRACTOR POWER TRAIN DISASSEMBLY AND ASSEMBLY for disassembly and assembly of drive shaft.



1. Remove hydraulic tube (2) after removing bolts (3).

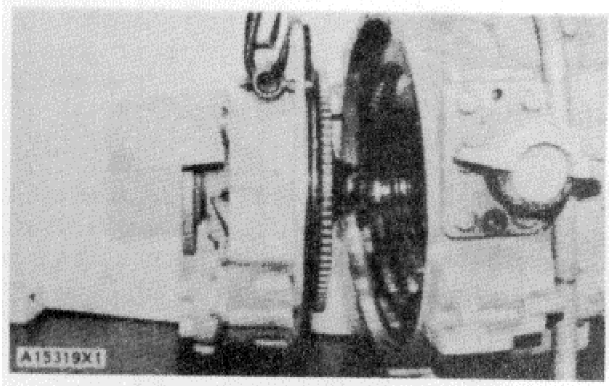
2. Remove two bolts (1).



3. Install two guide pins (4) and slide the drive shaft (5) far enough from the flywheel housing so two eyebolts can be installed. Remove the remainder of the bolts.

4. Fasten a hoist and remove the drive shaft. Weight of the drive shaft is 160 lb. (73 kg).

INSTALL DRIVE SHAFT



1. Put drive shaft in position on the guide pins. Slide drive shaft on to guide pins enough so the hoist and eyebolts can be removed.

2. Install all but two bolts. Remove the guide pins. Install the two bolts.

3. Install hydraulic tube and the bolts that hold it.

end by:
a) install engine and drive shaft

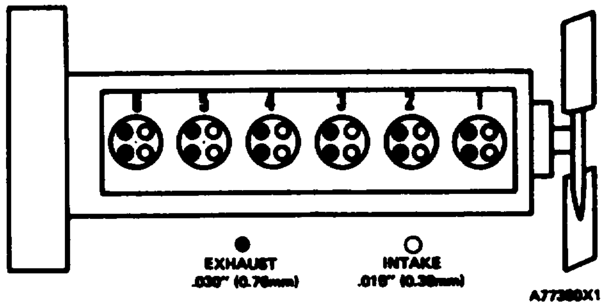
CHAPTER 3
ENGINE
SPECIFICATIONS

TOROQUE SPECIFICATION: You will find instances in this publication where the manufacturer has used "Meter-Kilograms" or "Centimeter-Kilograms" In place of "Newton Meters" for the metric torque. In these instances, use the following conversion factors to obtain the metric torque in "Newton-Meter."

lb.ft x 1.35819 = N-m
lb In x 0.1129848 = N-m

INDEX Page

ENGINE DESIGN



CYLINDER AND VALVE LOCATION

Bore .... 5.40 in. (137.2mm)

Stroke .... 6.50 in. (165.1mm)

Number and Arrangement of Cylinders .... 6,in Line

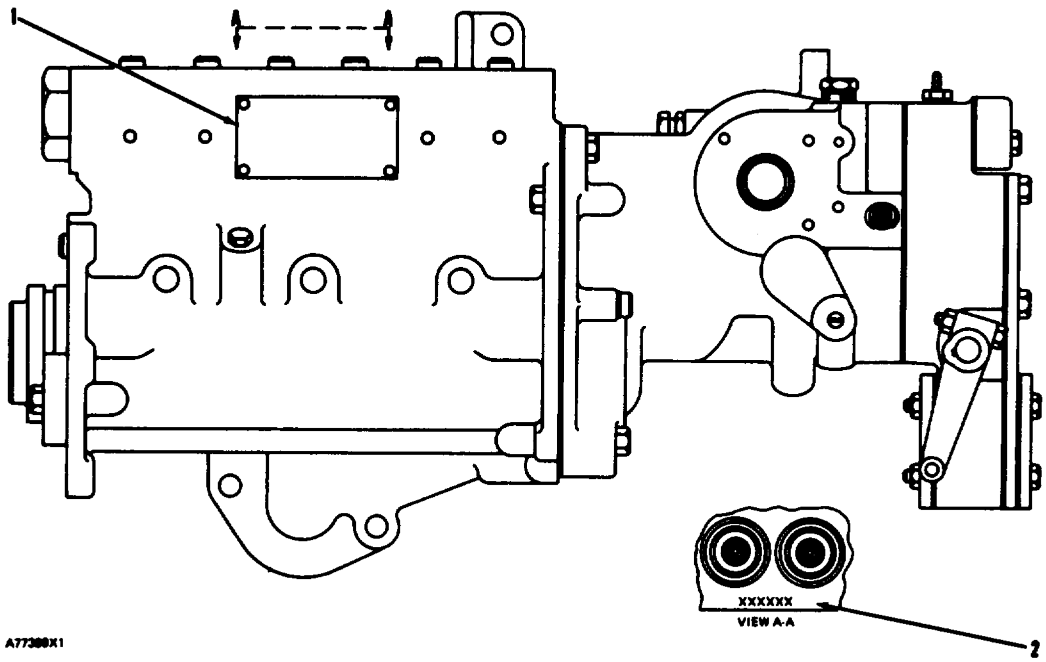
Firing Order (Injection Sequence) 1, 5, 3, 6, 2, 4

No. 1 Cylinder Location .... Front

Rotation of Crankshaft
(when seen from flywheel end) .... counterclockwise

Rotation of Fuel Pump Camshaft
(when seen from pump drive end) .... counterclockwise

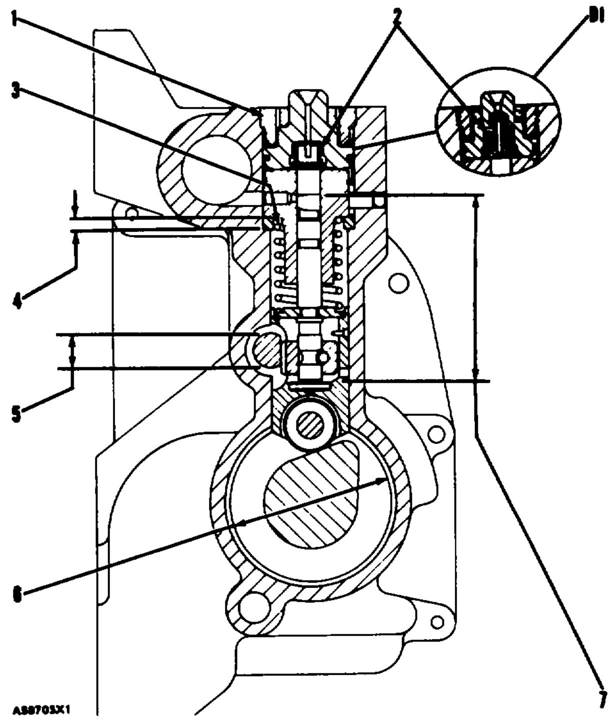
FUEL SYSTEM IDENTIFICATION



(1) Identification plate on side of injection pump housing

(2) Location of stamped part number for later Fuel Injection Pump and Governor Groups

FUEL INJECTION



Camshaft rotation counterclockwise in view shown.

Firing order (injection sequence) 1, 5, 3, 6, 2, 4

Injection timing before TC (top center):

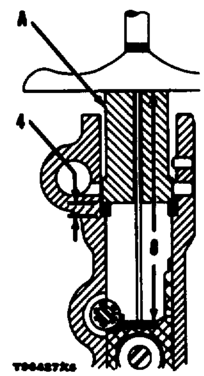
Direct injection (DI) with 8N5533 Fuel
Injection Pump Group.. 26.5 ±1°

(1) Torque for bushing .... 150 ± 10 lb. ft. (205 ± 14 N•m)

PUMP ASSEMBLY SPRINGS		
(2) Check Valve Spring		(3)Lifter Spring
Type	**DI**	**DI**
Part No.	6N24	7N1208
Length under test force	.375 In. (9.53 mm)	1.152 in. (29.26 mm)
Test force	12.5 ± .6 lb. (56 ± 3 N)	73 ± 3.6 lb. (325± 16 N)
Free length after test	.513 In. (13.03 mm)	1.891 In. (48.03 mm)
Outside diameter	.480 in. (11.88 mm)	.996 in. (25.30 mm)
Color code	none	one end yellow

Fuel Injection (Cont.)

(4) SPACER CHART	
SPACER PART NO.	**SPACER THICKNESS**
ENGINES WITH DIRECT INJECTION	
4N9837	.195 in. (4.95 mm)
4N9838	.199 in. (5.05 mm)
4N9839	.203 in. (5.16 mm)
4N9840	.207 in. (5.26 mm)
4N9841	.211 in. (5.36 mm)
4N9842	.215 in. (5.46 mm)
4N9843	.219 in. (5.56 mm)
4N9844	.223 in. (5.66 mm)



A—8S7167 GAUGE

(5) Bore for the rack and diameter of the rack:

Bearing at the rear
(after assembly)....5018±.0018 in.(12.746 ± 0.046 mm)

Bearing at the front
(after assembly)............5023±.0018 in. (12.758 ± 0.046 mm)

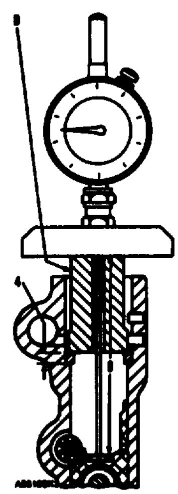
Diameter of fuel rack
(new) ....4985±.0002 in. (12.662 ± 0.005 mm)

Maximum permissible clearance between rack
and bearings (worn).............007 in. (0.18 mm)

(6) Bore In bearings for the camshaft
(after assembly)......2.1255± .0015 in. (53.988 ± 0.038 mm)

Diameter of bearing surfaces of the
camshaft (new).......2.1220±. 0005 in. (53.899± 0.013 mm)

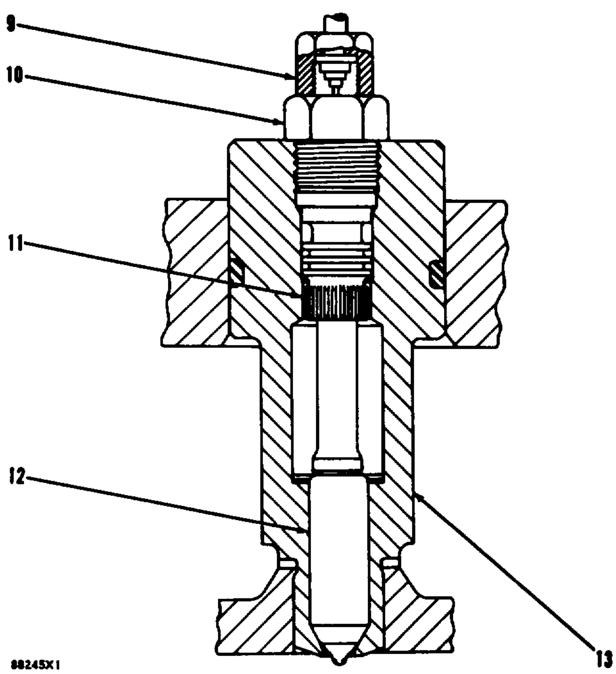
Maximum permissible clearance between the
bearings and the camshaft .... .010 in. (0.25 mm)



B—5P4158 GAUGE

Fuel Injection (Cont.)

Injection Pump & Timing Dimensions for						
			(7) Pump Plunger		(8) Timing ,dimensions for fuel injection pumps with pumps with 887187 Gauge (A) or 5P4158 Gauge (B)	
Engine Type	Fuel Injection Pump P/N	Timing (BTU)	Length (new)	Min. Permissible Length	On Engine	Off Engine
DI	8N5533	26.5	2.7212± .0015 in. (69.118 ± 0.038 mm	2.7197 in. (69.080 mm)	4.183 + .002 in. (106.25 + 0.05 mm)	4,344 ±.002 in. (110.34 ± 0.05 mm)



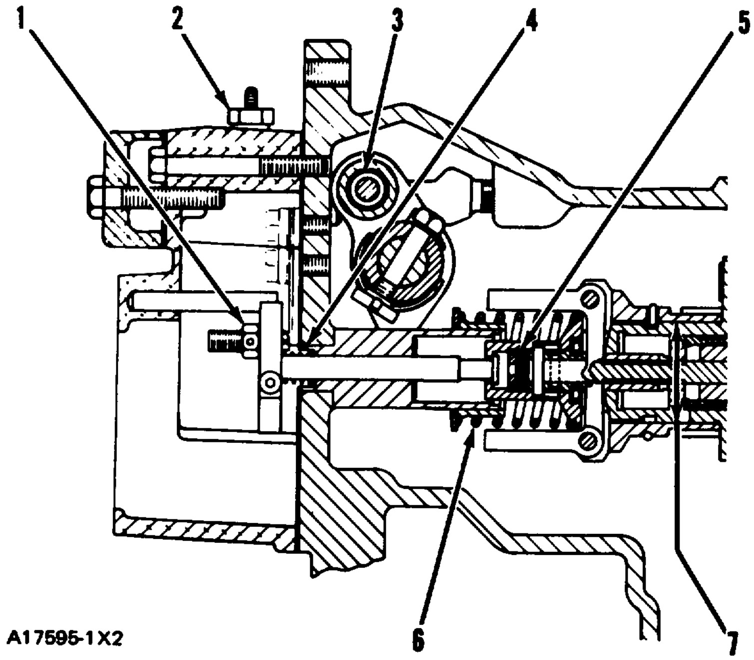
DIRECT INJECTION

(11) Body.

(12) Nozzle. Tighten nozzle finger tight on body (11).

(13) Put liquid soap (40% solid) in the bore in the cylinder head and on the O-ring seal. Put 5P3931 Anti-Seize Compound on the threads before installation. Torque for precombustion chamber or adapter .... 150 ± 10 lb. ft. (205 ± 14 N•m)

GOVERNOR



NOTE: Any adjustment to the governor must be made only by an approved person.

(1) Torque for nut .... 9 ± 3 lb. ft. (12 ± 4 N•m)

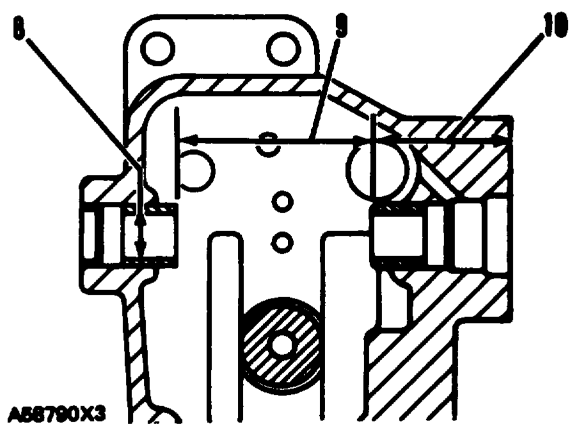
(2) Torque for insulator .... 40 ± 5 lb. in. (4.5 ± 0.6 N•m)

MISCELLANEOUS SPRING CHART			
Spring Type	**(3) Detent**	**(4) Rack Stop**	**(5) Low Idle Performance**
Part No.	5S9635	9N3096	9M6303
Length under test force	1.84 in. (46.74 mm)	.560 in. (14.22 mm)	1.80 in. (4.57 mm)
Test force	72 ±4 lb. (320 ± 18 N	.28 ± .03 lb. (1.25 ± 0.13 N	10± .5 lb. (45 ± 2N)
Free length after test	2.375 in. (60.32 mm)	.680 ± .30 in. (17.27 ± 0.76 mm)	.344 in. (8.74 mm)
Outside diameter	.454 in. (11.53 mm)	.382 in. (9.70 mm)	.480 in. (12.19 mm)
Color Code (stripes)	one yellow	none	none
Used with these Governors:	8N5534	8N5534	8N5534

Governor (Cont.)

(6) Governor Springs

GOVERNOR SPRING CHART	
Type of Fuel Injection	**DI**
Spring Part No.	9L6448
Color Code (stripes)	one green one yellow
Put a force on spring of.	4.0 lb (18 N)
Then add more force to make spring shorter by	.90 in. (22.9 mm)
Total test force	16.6 ±.3 lb. (74 ± 1 N)
Free length after test	2.24 + .03 in. (56.9 + 0.8 mm)
Outside diameter.	1.39 in (35.3 mm)
Used with these Governors and Fuel Pump Groups	7N2399 7N3704 8N5535



(7) Diameter of the outer surface of the cylinder (new).........1.2172 ± .0005 in. (30.917 ± 0.013 mm)

Bore in the gear (new) ....1.2192 ± .0005 in. (30.968 ±0.013 mm)

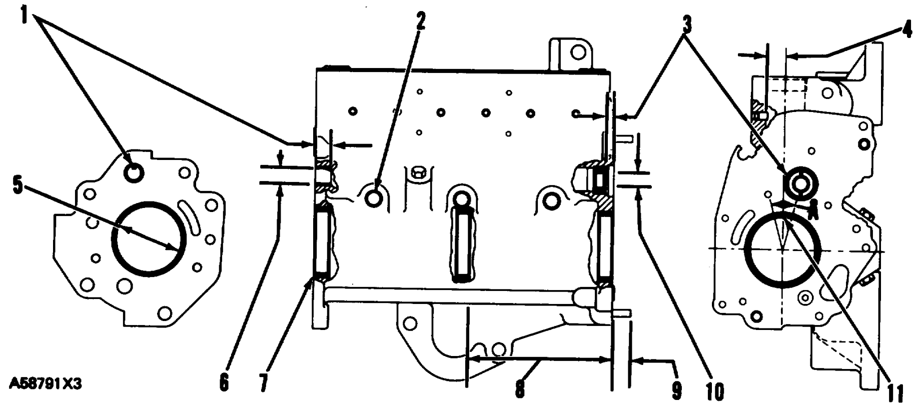
(8) Bore in the governor control shaft bearings (after assembly)......6205 ± .0015 in. (15.761 ± 0.038 mm)

Diameter of the governor control shaft (new) ....6189 ± .0003 in. (15.720 ± 0.008 mm)

(9) Distance between the bearings for the governor control shaft.....2.385 ± .005 in. (60.58 ± 0.13 mm)

(10) Distance from the face of the housing to the end of the bearing for the governor control shaft................1.708 ± .008 in. (43.38 ± 0.15 mm)

FUEL INJECTION PUMP HOUSING



(1) Rack bearing alignment the center of the rack bearing tab must be within .002 in. (0.05 mm) of a vertical line that:

(a) goes through the center of the rack bearing

(b) is parallel to the vertical centerline thru the injection pump bores and camshaft bearing bores.

NOTE : The following tools are available to position the rack bearings correctly: 5P1744 Plate and 9S6329 Driver.

The correct bearing depth is controlled when driver is stopped by plate.

(2) Install center pin until it is even with the surface of the housing. Install outer pins until they make contact with the bottom of the housing.

(3) Install rear rack bearing to
a depth of ....282 ±.005 in. (7.16 ±0..13 mm)

NOTE: Small holes in bearing must be positioned as shown (parallel to the vertical centerline thru the pump).

(4) Install dowel to get a dimension from centerline of fuel injection pump bore to dowel (seal dowel hole with aluminum ball)...584 ± .002 in. (14.83 ± 0.05 mm)

(5) Bore In bearings for the camshaft
(after assembly)......2.1255+ .0015 in. (53.988 ± 0.038 mm)

Diameter of bearing surfaces of the
camshaft (new).......2.1220 ± .0005 in. (53.899 ± 0.013 mm)

Maximum permissible clearance between the bearings and the camshaft ....010 in. (0.25 mm)

(6) Bore in bearing for rack
(after assembly).......5023 ± .0018 in. (12.758 ± 0.046 mm)

Diameter of rack
(new) ....4985 ± .0002 in. (12.662 ± 0.005 mm)

(7) Install front and rear camshaft bearing even with end of housing.

(8) Distance from rear face of housing to installed
center camshaft bearing ....4.81 ±.02 in. (122.2 ± 0.5 mm)

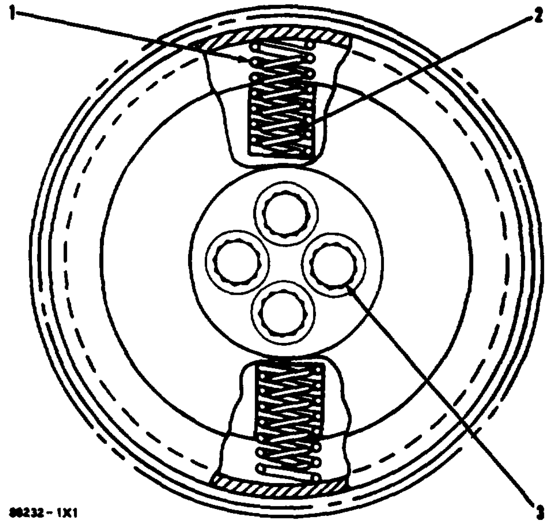
(9) Distance from rear of housing to end
of dowel...........62 ± .02 in. (15.7 ± 0.5 mm)

(10) Bore In bearing for rack
(after assembly)........5018 ± .0018 in. (12.746 ± 0.046 mm)

Diameter of rack
(new) ....4985:± .0002 in. (12.662 ± 0.005 mm)

(11) Position of camshaft bearing joints must be within area A (from vertical centerline) .... ±15°

AUTOMATIC TIMING ADVANCE UNIT



The DI unit moves the fuel system timing forward 21/4° between approximately low idle and 1100 rpm.

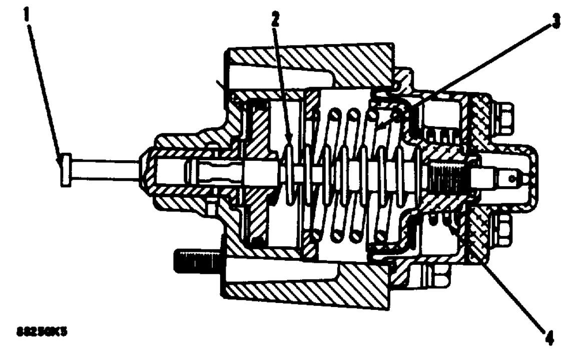
SPRINGS FOR AUTOMATIC TIMING ADVANCE UNIT		
	Outer	**Inner**
	DI	**DI**
Part No.	(1) 7N5577	(2) 6N5143
Length under test force	1.610 in. (40.89 mm)	none
Test force	14.90 + .75 lb. (66.28 + 3.34 N)	none
Free length after test	2.030 in. (51.56 mm)	1.29 + .03 in. (32.8 + 0.8 mm)
Outside diameter	.825 in. (20.91 mm)	.604 in. (15.34 mm)
Color code(stripes)	one white one brown	one green

(3) Torque for the four bolts ....100 t 5 lb. ft. (135 ± 7 N•m)

NOTE: Torque for bolt on earlier units with only one bolt.....................110 10 lb. ft. (149 14 N•m)

AIR-FUEL RATIO CONTROL

(1) On Direct Injection Engines, the valve has "Dl" on this surface.



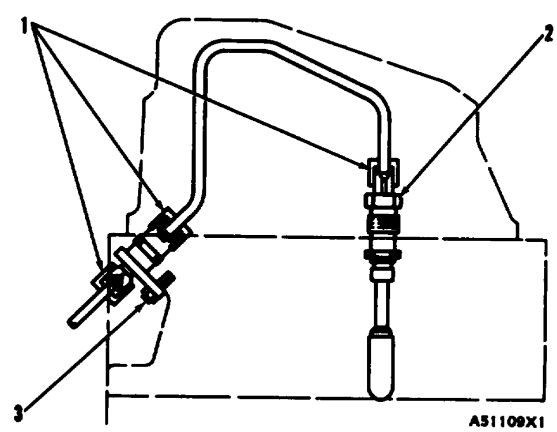
SPRING CHART			
Part No.	(2) 6N515	(3) 7N209	(4) 6N513
Length under test force	1.81 in. (46.0 mm)	1.27 in. (32.3 mm)	.55 in. (14.0 mm)
Test force.	6.8± .4 lb. (30 ± 2 N)	19.8±t 2.0 lb. (90 ± 9 N)	26.9 ± 2.0 lb (120 ± 9 N)
Free length after test	2.95 in. (74.9 mm)	1.49 in. (37.8 m)	1.22 in. (31.0 mm)
Outside diameter.	.810 in. (20.57 mm)	1.788 in. (45.42 mm)	1.281 in. (32.54 mm)
Color code (stripes)	one yellow	two yellow	one yellow

FUEL INJECTION LINES

(1) Torque for all nuts that hold the fuel injection lines...............30 ± 5 lb. ft. (40 ± 7 N•m)

(2) Torque for the nuts that hold the nozzles ....55 ± 5 lb. ft. (75 ± 7 N•m)

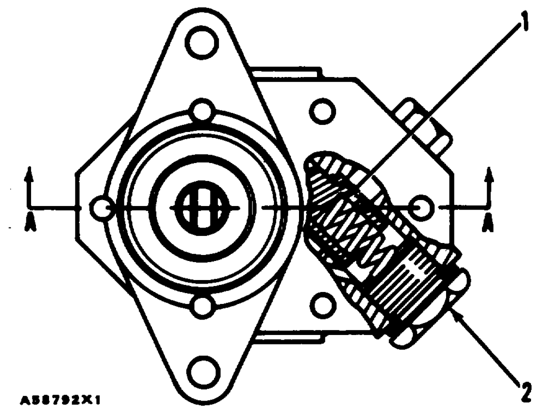
(3) Torque for the nuts that hold the adapter locks......................10 ± 2 lb. ft. (14 ± 3 N•m)



FUEL TRANSFER PUMP

Pressure of fuel to open the bypass valve........... 33 psi (225 kPa)

(1) BYPASS SPRING	
Part No.	2P4252
Length under test force	1.75 in. 144.5 mm)
Test force.	2.03 ± .12 lb. (9.04 ± 0.54 N)
Free length after test	1.97 in. (50.0 mm)
Outside diameter	.406 in. (10.31 mm)
Color Code (stripes)	one white



(2) Torque for bolt................27 ± 3 lb. ft. (38 + 4 N•m)

(3) Bore in bearing
(new).......4953 ± .0005 in. (12.581 ± 0.013 mm)

Diameter of shaft
(new).......4937 + .0001 in. (12.540 ± 0.003 mm)

(4) Install inner seal as shown
to a depth of......... 406 ±.010 in. (10.31 ± 0.25 mm)
Install outer seal a shown even with top surface.

NOTE: Put 8H5137 Sealer on outside diameter of seals before installation. Remove any extra sealer after installation.

CAUTION

Use 5P2394 Seal Pilot Tool when installing shaft in seals to prevent damage of seal lips.

(5) Plug must be pressed flush with outside surface.

(6) Install check valve as shown to
a depth of .... .57 ± .02 in. (14.5 ± 0.5 mm)

(7) Depth of bore for gears
(new)...........3750 ± .0003 in. (9.525 ± 0.008 mm)

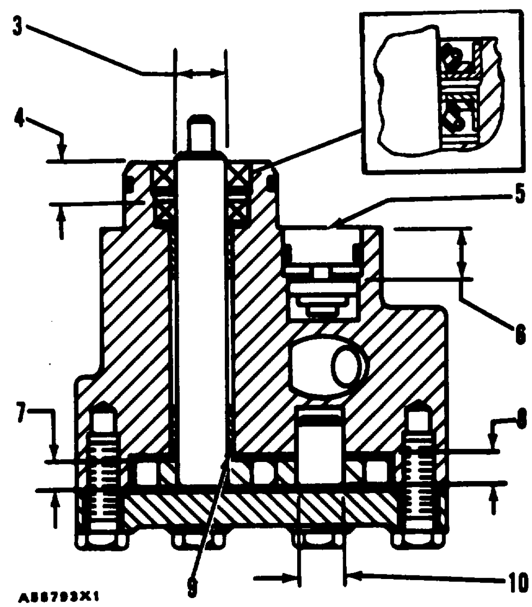
Width of gears (new) .3730 ± .0003 in. (9.474 ± 0.008 mm)

(8) Height of shaft................371 ± .003 in. (9.42 ± 0.08 mm)

(9) Bearing must not extend beyond this surface.

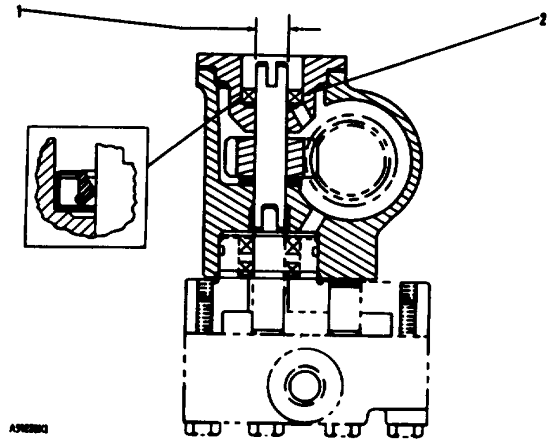
(10) Bore In gear (new).......492 ± .0003 in. (12.512 ± 0.008 mm)

Diameter of shaft
(new)...................4914 ± .0003 in. (12.481 ± 0.008 mm)



SECTION A-A

DRIVE FOR FUEL TRANSFER PUMP AND TACHOMETER



(1) Diameter of shaft (new). .4935± .0003 in. (12.535 ± 0.008 mm)

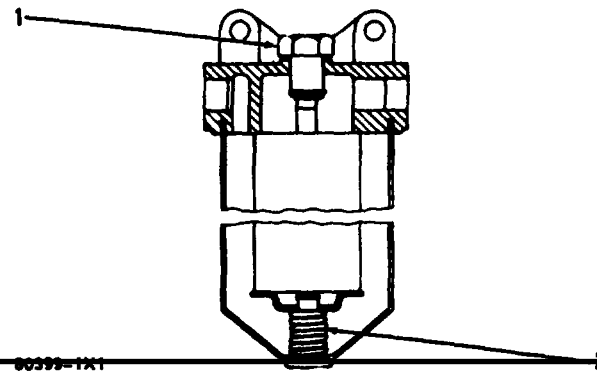
bore in adapter and housing
for shaft (new...............4952 ± .0005 in. (12.578 ± 0.013 mm)

(2) Install sea as shown to bottom of bore.

CAUTION

Use 5P2394 Seal Pilot Tool when installing seal over shaft to prevent damage of seal lips.

PRIMARY FUEL FILTER



(1) Torque for nut...................18 ± 3 lb.ft. (24± 4 N•m)

(2) 7S9323 Spring:

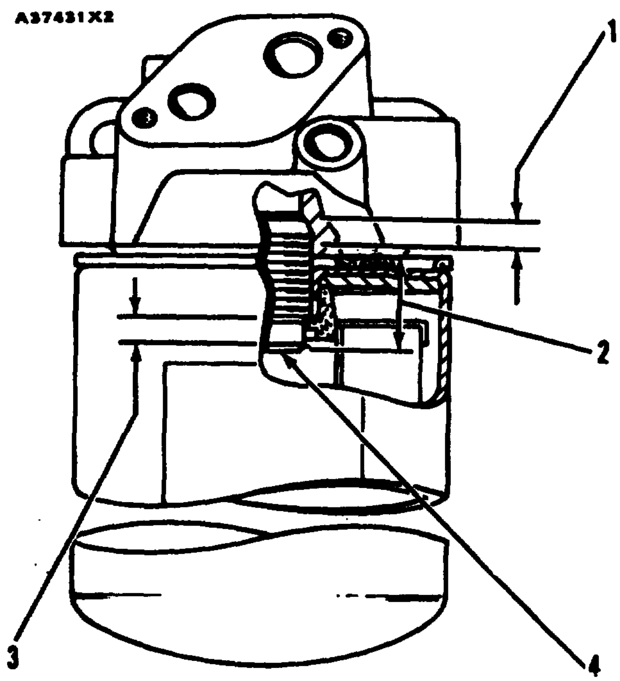
Length under test force ....1.10 in. (27.9 mm)

Test force............... 27.7 to 32.3 lb. (123 to 144 N)

Free length after test ....1.68 in. (42.7 mm)

Outside diameter..............................68 in. (17.3 mm)

FUEL FILTER BASE



(1) Put 9S3206 Retaining Compound on the tapered end of stud to a distance of .... 30 in. (7.6 mm)

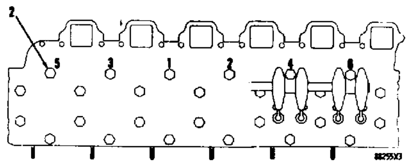
(2) Distance from sealing surface of base to end of stud................97± .05 in. (24.6 ±1.3 mm)

(3) Sealing surface of stud.

NOTE: Do not damage this warts.

(4) Torque for stud..................... 50 ± 10 lb ft. (70 ± 14 N•m)

VALVE ROCKER ARMS, LIFTERS, BRIDGES AND COVER



(1) Bore in rocker arm
for shaft (new) ....9765 ± .0005 in. (24.803 ± 0.013 mm)
Diameter of rocker arm
shaft.9745 ± .... .0005 in. (24.752 ± 0.013 mm)

(2) Put 2P2506 Thread Lubricant on all the threads of bolts that hold rocker arms shaft and tighten the bolts in the following step sequence:

Step 1. Tighten bolts from 1 to 6 in number
sequence to..........200 ± 20 lb. ft. (270 ± 25 N•m)
Step 2. Tighten bolts from 1 to 6 in number
sequence to............330 ± 15 lb. ft. (450 ± 20 N•m)
Step 3. Tighten bolts from 1 to 6 in number
sequence again to ......330 ± 15 lb. ft. (450 ± 20 N•m)

(3) Torque for locknut for valve
adjustment screw ....22 ± 3 lb. ft. (28 ± 4 N•m)

(4) Torque for locknut for bridge
adjustment screw ....22 ± 3 lb. ft. (28 + 4 N•m)

(5) Clearance for valves:
Intake valves ....015 in. (0.38 mm)
Exhaust valves ....030 in. (0.76 mm)

(6) Height to top of dowel.....................2.10 ± .02 in. (53.3 ± 0.5 mm)

(7) Diameter of dowel ....4334 ± .0001 in. (11.008 ± 0.003 mm)
Bore in bridge for
dowel................438 ± .002 in. (11.13 + 0.05 mm)
Bore in head for
dowel..............................4318 ± .0008 in. (10.968 ± 0.020 mm)

(8) Diameter of valve
lifter ....1.09825±.00050 in. (27.8960 ± 0.0127 mm)
Bore in block for valve
lifter ....1.1005 ± .0008 in. (27.953 ± 0.019 mm)

(9) Guide springs must not be used again. Always install new guide springs.

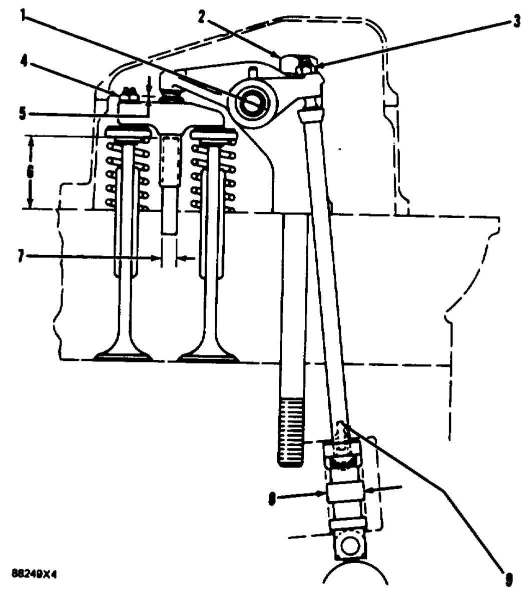
(10) 2N7229 Spring:
Length under test force...................2.92 in. (74.2 mm)
Test force .... 10 to 12 lb. (45 to 53 N)
Free length after test ....4.50 in. (114.3 mm)
Outside diameter................1. 17 in. (29.7 mm)

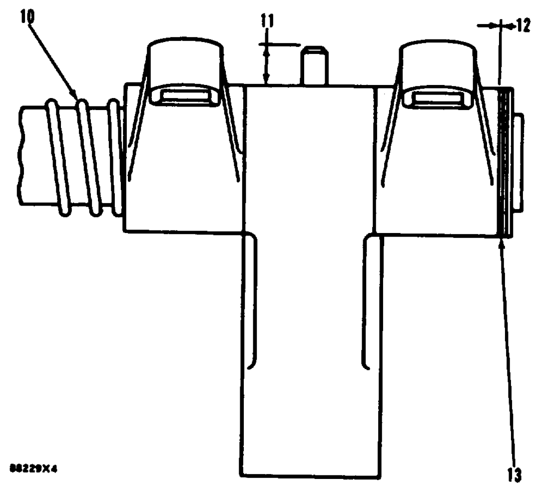
(11) Dowel length above top surface of rocker shaft support to be
.50 ± .04 in. (12.7± 1.0 mm)

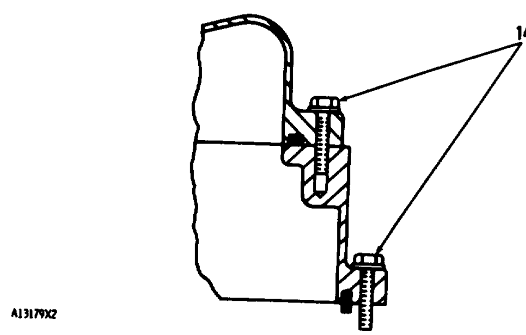
(12) Clearance for rocker arms
(both ends)...............012 to .055 in. (0.30 to 1.40 mm)

(13) Use 2N7228 Washer as needed to get clearance (12).

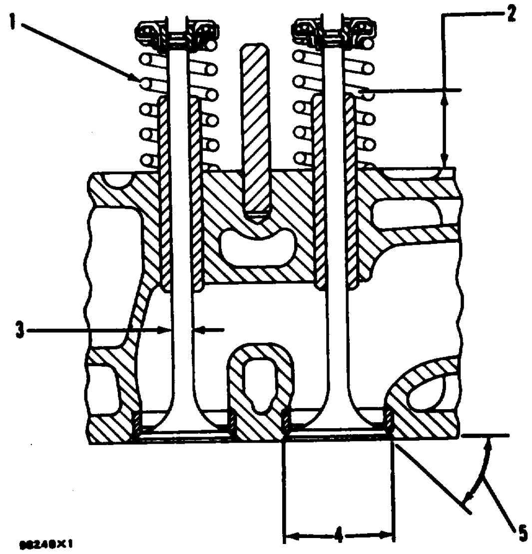
(14) Torque for 26 bolts ....120 ± 24 lb. in. (13.6 ± 2.8 N•m)







VALVES



(1) 4N5906 Spring for valves (new):

Length under test force..................2.165 in. (54.9 mm)
Test force .... 77.5 ± 3.9 lb. (344.7 ± 17.3 N)
Use again minimum load at length
under test force ....71 lb. (315.8 N)
Length of spring at valve
open position..................1.665 in. (42.3 mm)
Use again minimum load at valve
open position...... 191 lb. (849.6 N)
Free length after test ......2.47 in. (62.7 mm)
Outside diameter............1.250 in. (31.8 mm)
Spring must not be bent
more than........... 086 in. (2.2 mm)

(2) Height to top of valve
guide .... 1.27 ± .03 in. (32.3 ± 0.8 mm)

(3) Diameter of valve
stem (new) .... 3717 ± .0003 in. (9.441 ± 0.008 mm)
Use again minimum ....3704 in. (9.408 mm)
Bore in valve guide with guide installed in
the head (new) ....3735 ± .0010 in. (9.487 ± 0.025 mm)
Use again diameter for valve guide
bore .... 3755 in. (9.538 mm)
Maximum permissible diameter for valve
guide bore .... 3758 in. (9.545 mm)

(4) Diameter of valve head:
Exhaust valve..... 1.646 ± .005 in. (41.81 ± 0.13 mm)
Intake valve........ 1.771 ± .005 in. (44.98 ± 0.13 mm)

(5) Angle of intake valve face..............291/4°±1/4°
Angle of exhaust valve face...........441/4° ± 1/4°

(6) Depth of bore in head for valve
seat insert .... 512 ± .015 in. (13.00 ± 0.38 mm)

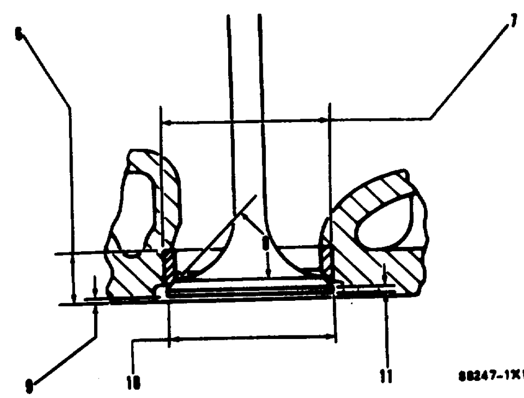
(7) Diameter of valve sea; insert for exhaust
valve................... 1.6870 ± .0005 in. (42.850 ± 0.013 mm)
Bore in head for valve seat Insert for exhaust
valve................... 1.684 ± .001 in. (42.77 ± 0.03 mm)
Diameter of valve seat Insert for
intake valve .... 1.8120 ± .0005 in. (40.025 ± 0.013 mm)
Bore in head for valve seat Insert for
Intake valve........ 1.809 ± .001 in. (45.95 ± 0.03 mm)

(8) Angle of face of intake valve seat insert .... 301/4° ±1/2°
Angle of face of exhaust valve seat insert .... 451/4°1/2°

(9) Dimension from end of closed valve to machined face of head:

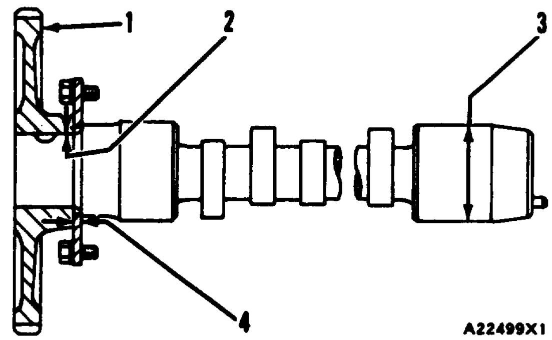
Maximum permissible dimension:
Below (recessed from) machined face
of head .... 048 in. (1.22 mm)
Above (extended from) machined face
of head .... 008 in. (0.20 mm)

(10) Outside diameter of the face of the valve seat Insert:
Exhaust seat ...... 1.591 ± 005 in. (40.41 ± 0.13 mm)
Intake seat .... 1.734± .005 in. (44.04 ± 0.13 mm)



(11) "Use again" thickness of valve lip:
Exhaust valve.....................080 in. (2.03 mm)
Intake valve..........................099 in. (2.51 mm)

CAMSHAFT



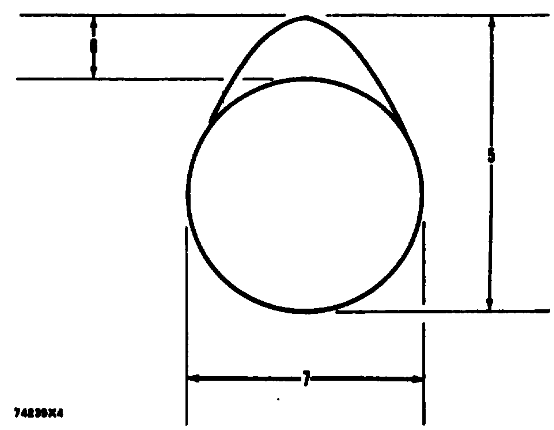
(1) Maximum permissible temperature of the gear for Installation on the camshaft (do not use a torch) ....600°F (315° C)

(2) Tight fit between the gear and camshaft......................0015 to .0048 in. (0.038 to 0.122 mm)

(3) Diameter of the surfaces (journals) for the camshaft bearings (new)......................2.7500 ± .0005 in. (69.850 ± 0.013 mm)

Bore in front bearing for the camshaft (new)...............2.7547± .0019 in. (68.969 ± 0.048 mm)

Bore in the other six bearings for the camshaft (new)...............2.7552 ± .0024 in. (69.982 ± 0.061 mm)



(4) Thickness of thrust plate (new).............183 ± .001 in. (4.65 ± 0.03 mm)

End play of the camshaft........004 to .010 in. (0.10 to 0.25 mm)

(5) Height of camshaft lobes.

To find lobe height, use the following procedure:

A. Measure camshaft lobe height (5).

B. Measure base circle (7).

C. Subtract brae circle (STEP B) from lobe height (STEP A). The difference is actual lobe lift (6).

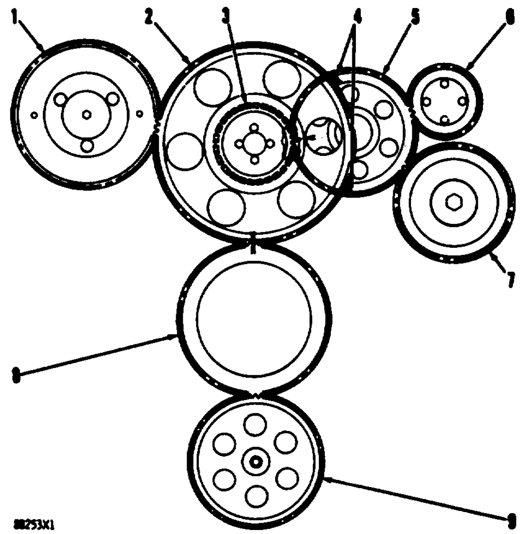
D. Specified camshaft lobe lift (6) is:

a. Exhaust lobe...........3468 in. (8.783 mm)

b. Intake lobe.......3189 in. (8.100 mm)

Minimum permissible difference between actual lobe lift (STEP C) and specified lobe lift (STEP D) is .005 in. (0.13 mm).

TIMING GEARS



(1) Drive gear for water pump.

(2) Idler gear for water pump.

(3) Idler gear for camshaft.

(4) "K" marks must be seen from front of engine when gears are in alignment as shown.

(5) Camshaft gear.

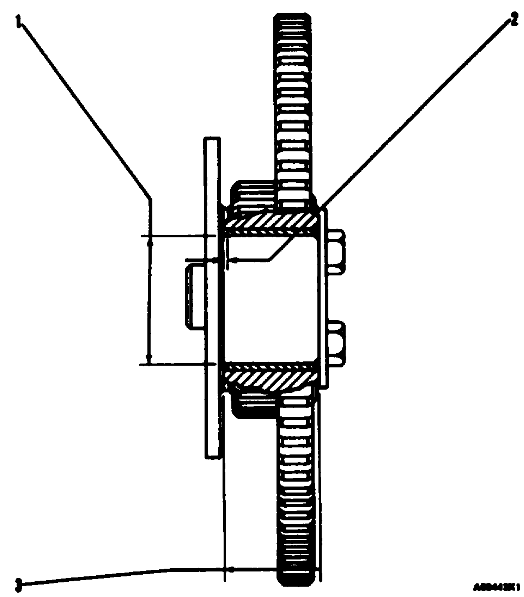
(6) Drive gear for air compressor.

(7) Drive gear for fuel pump.

(8) Crankshaft gears/

(9) Drove gear for oil pump.

IDLER GEAR ASSEMBLY



(1) Bore in bearing of gear
(assembly)................2.5040 ± .0015 in. (63.002 t 0.036 mm)

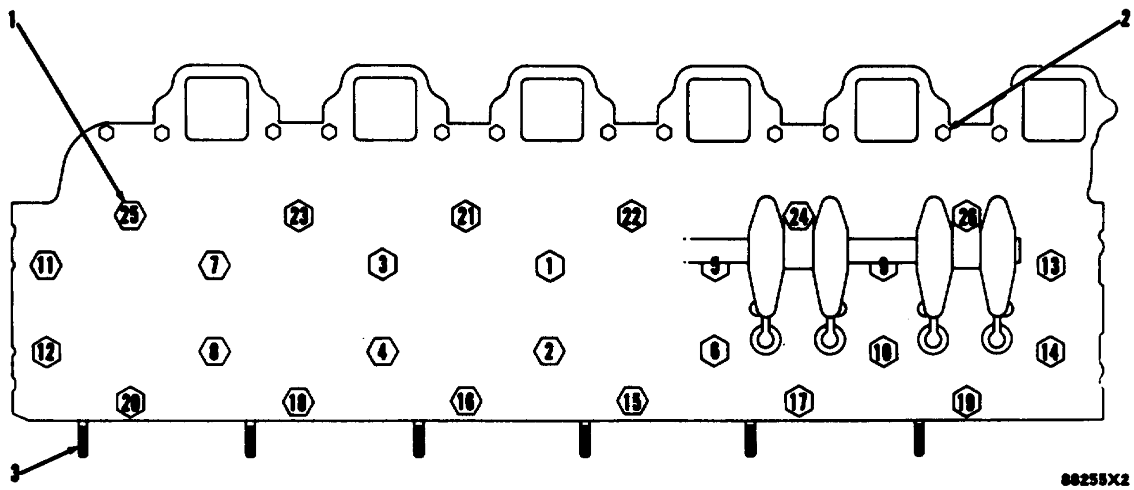
Diameter of bearing surface of the
shaft (new)............2.5000 ± .0005 in. (63.500 ± 0.013 mm)

(2) Install bearing from rear face of gear
assembly to a depth of ....06 ± .02 in. (1.5 ± 0.5 mm)

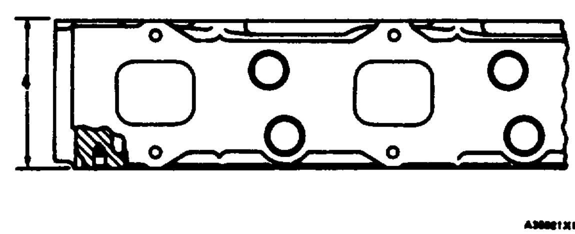
(3) Length of gear (new).....1.874 ± .002 in. (47.60 ± 0.05 mm)

Length of the bearing surface
of the shaft (new)............1.884 ± .002 in. (47.85 ± 0.05 mm)

CYLINDER HEAD



Large bolts (3/4 inch). Put 2P2506 Thread Lubricant on all bolt threads and tighten the bolts in the step sequence that follows:



Step 1. Tighten bolts from 1 to 20 in number sequence to.......... 200 ± 20 lb. ft. (270 ± 25 N•m)

Step 2. Tighten bolts from 1 to 20 in number sequence to.......... 330 ± 15 lb. ft. (450 ± 20 N•m)

Step 3 Tighten bolts from 1 to 20 in number sequence to.......... 330 ± 15 lb. ft. (450 ± 20 N•m)

Step 4. Install the rocker arm shafts (1) for the engine valves.

Step 5 Tighten bolts from 21 to 28 in number sequence to................200 ± 20 lb. ft. (270 ± 25 N•m)

Step 6. Tighten bolts from 21 to 28 in number sequence to................330 ± 15 lb. ft. (450 ± 20 N•m)

Step 7. Tighten bolts from 21 to 26 in number sequence again to......330 ± 15 lb. ft. (450 ± 20 N•m)

Step 8. Tighten the twelve small bolts (2) to ....32 ± 5 lb. ft. (43 ± 7 N•m)

(2) Small bolts (3/8 inch). See Step 8, above.

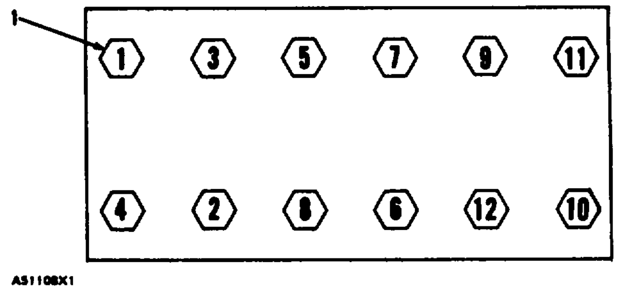
(3) Torque for twelve studs in cylinder head........ 20 ± 3 lb. ft. (25 ± 4 N•m)

(4) Height of cylinder head (new) .... 4.440 ± .010 in. (112.78 ± 0.25 mm)

EXHAUST MANIFOLD

Put 5P3931 Anti-Seize Compound on threads of studs.

(1) Tighten nuts in number sequence shown
to a torque of ....38 ± 5 lb. ft. (49 ± 7 N•m)

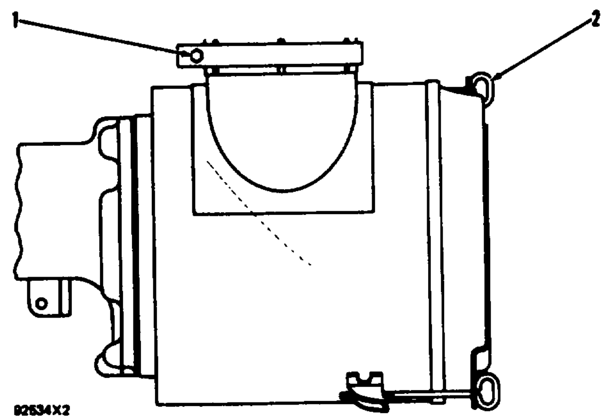


BOLT TIGHTENING SEQUENCE

AIR CLEANER

(1) Torque for damp bolt ....18 ± 5 lb. ft. (24 ± 7 N•m)

(2) Torque for wing bolts..............35 ± 5 lb. in. (4.0 ± 0.6 N•m)



TURBOCHARGER IMPELLER INSTALLATION (AiResearch ONLY)

TEST FOR TYPE OF IMPELLER INSTALLATION

1. Install the proper thrust collar and seal carrier spacer on the shaft-wheel assembly to be used.
2. Install impeller on shaft by hand.
3. Measure the distance between impeller and seal carrier at the point where impeller no longer moves freely on shaft.
4. If the distance is:

   (a) more than .31 in. (7.9 mm), use hat for installation.*

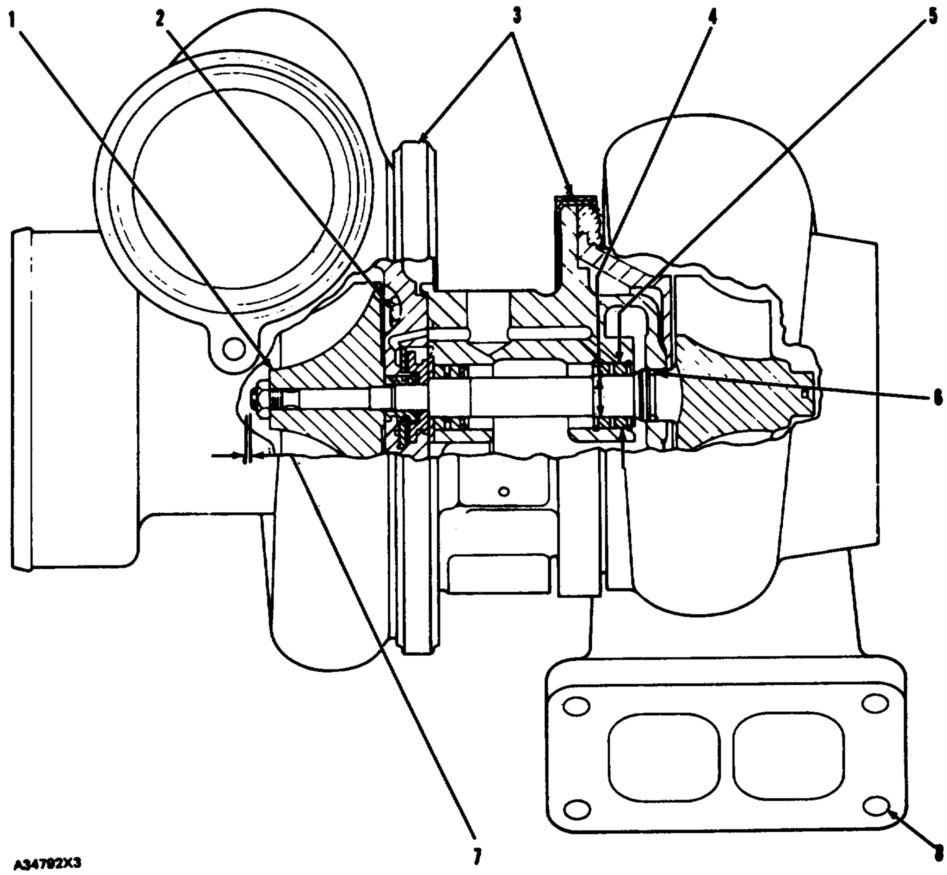
   (b) .31 in. (7.9 mm) or less, use room temperature installation.**

INSTALLATION PROCEDURE CHART

Type of Installation	**Step by Step Procedure**	**Turbochargers TV61**
*Impeller Heated	A. Heat impeller to (for 10 minutes max):	350 ± 25° F (177 ± 14° C)
	B. Install impeller on shaft.	
	C. Tighten nut to:	120 lb. in. (14 N•m)
	D. Let impeller become cool to below:	150° F (70° C)
	E. Loosen nut and put oil on shaft threads and nut face.	
	F. Tighten nut again to:	30 lb. in. (3 N•m)
	G. Tighten nut more: 120°	
**Impeller at Room Temperature	A. Put impeller on shaft.	
	B. Tighten nut to: 120 lb. in. (14 N•m)	
	C. Loosen the nut and put oil on nut seat face and threads.	
	D. Tighten the nut again to:	30 lb. in. (3 N•m)
	E. Tighten the nut more: 120°	

NOTE: Do not bend or add stress to the shaft when nut is tightened.

TURBOCHARGER
(AiRsearch TV61)



(1) See TURBOCHARGER IMPELLER INSTALLATION.

(2) Torque for the two bolts that hold the backplate..................90 ± 10 lb. in. (10.2 ± 1.1 N•m)

(3) Torque for the clamp bolts........... 120 ±10 lb. in. (13.6 ± 1.1 N•m)

(4) Bore in the bearings ....6268 to .6272 in. (15.921 to 15.931 mm)

Diameter for the surfaces (journals) on the shaft for the bearings .... 6250 to .6254 in. (15.875 to 15.885 mm)

(5) Bore in the housing .... 9827 to .9832 in. (24.961 to 24.973 mm)

Outside diameter of the bearings .... .9782 to .9787 in. (24.846 to 24.859 mm)

(6) Clearance between the ends of the oil seal ring........... .008 to .015 in. (0.20 to 0.38 mm)

(7) End play for the shaft .... 003 to .010 in. (0.08 to 0.25 mm)

(8) Torque for support nuts (put 5P3931 Anti-Seize Compound on the stud threads)................ 40 + 4 lb. ft. (55 + 5 N•m)

OIL PUMP

Rotation (seen from the drive end) ....counterclockwise

Test on test stand, with SAE 10W oil at 120° F (49° C)

Output ....72 U.S. gpm (272 liter/min)

at a pressure of ....45 psi (310 kPa)

with pump at.....................2550 rpm

Output .... 38 U.S. gpm (144 liter/min)

at a pressure of ....81 psi (580 kPa)

with pump at.................2550 rpm

(1) Diameter of drive shaft
(new) ....8747 .0002 in. (22.217 ± 0.005 mm)

Bore in bearings for drive shaft
(new) ....8763 ± .0003 in. (22.258 ± 0.008 mm)

Diameter of idler shaft
(new) ....8747 ± .0002 in. (22.217 ± 0.005 mm)

Bore in bearings for drive
shaft (new)............ 8763 ± .0003 in. (22.258 ± 0.008 mm)

(2) Length of gears
(new .... 3.1250 ± .0010 in. (79.375 ± 0.0025 mm)

Depth of bores of
gears (new) .... 3.1300 ± .0008 in. (79.502 ± 0.020 mm)

(3) 2S2760 Spring (oil pressure relief):

Length under test force............. 4.64 in. (117.9 mm)

Test force .... 110 ± 6 lb. (490 ± 27N)

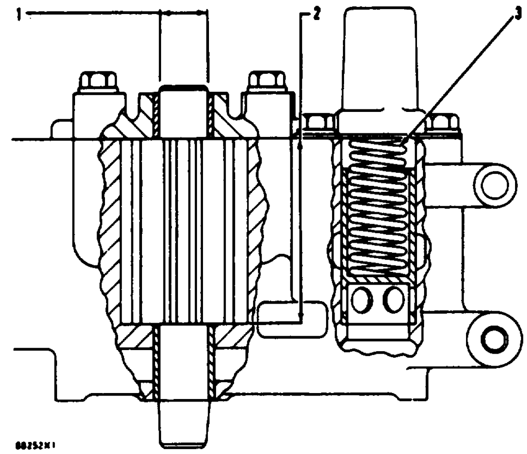
Free length after test 6.02 in. (152.9) mm)

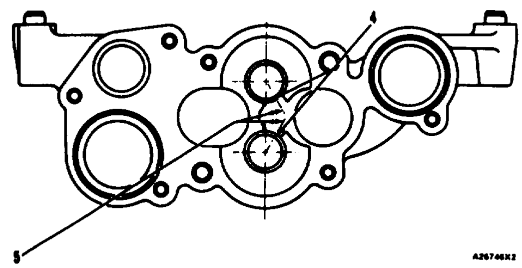
Outside diameter................1.063 in. (27.00 mm)

(4) Bearing junction.

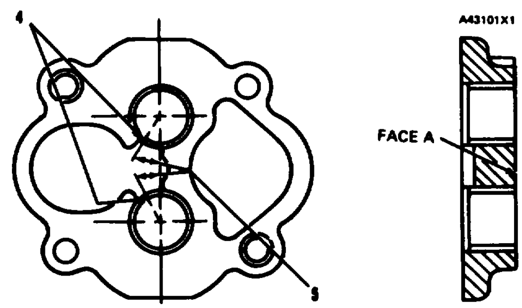
(5) Position of bearing junction from the centerline
through bearing bores................ 30° ± 15°

Install bearing so they are even with outside of pump body and even with FACE A of pump cover.





PUMP BODY



PUMP COVER

OIL FILTER

(1) 4N8150 Spring for bypass valves for oil cooler and oil filter:

Length under test force.....2.175 in. (55.25 mm)

Test force ....17.0± 1.3 lb. (76 ± 5N)

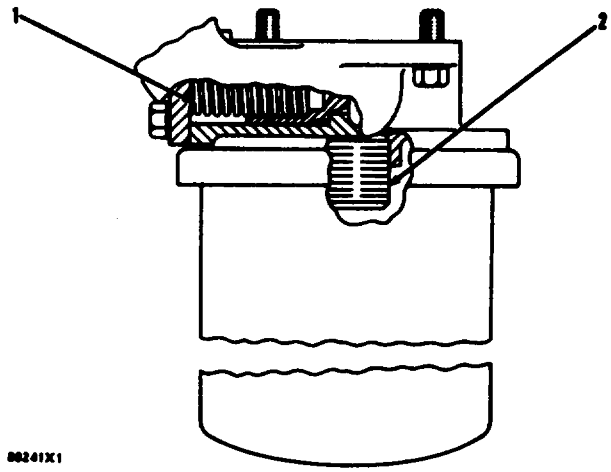
Free length after test .... 3.69 in. (93.7 mm)

Outside diameter ....81 in. (20.6 mm)

Filter and cooler bypass valves to open with
a pressure difference of..........37± 3 psi (255 ± 20 kPa)

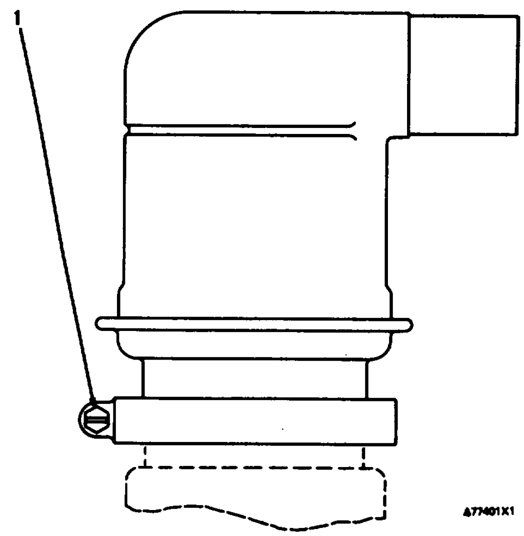
(2) Torque for stud:

Put 9S3263 Thread Lock Compound
on threads of the stud and tighten
the stud to ....60± 10 lb. ft. (80 ± 14 N•m)



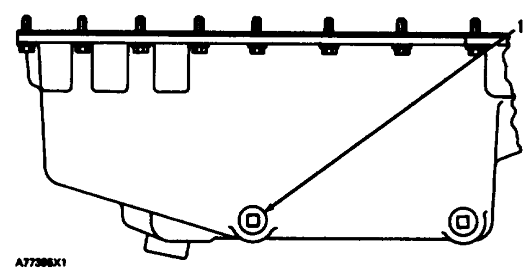
BREATHER CAP

(1) Tighten clamp to a
torque of............... 40 ± 5 lb. In. (4.56 + 0.6 N•m)



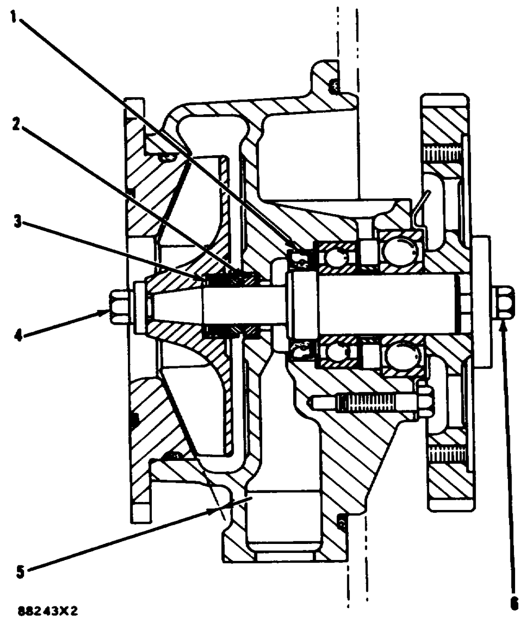
OIL PAN

(1) Put 9S3264 Pipe Sealant on threads and
tighten plugs to...........60 ± 8 lb. ft. (80 ± 11 N•m)



7

WATER PUMP



(1) Oil seal. Put engine oil on the seal lip. Assemble with the lip toward the bearings.

(2) Water seal and ring:

a. Put water on the real.

b. Install the seal and ring together in the housing bore, with the shiny face of the ring outside.

(3) Seal assembly:

a. Remove the spring from the seal.

b. Put water inside the seal assembly.

c. Install the seal assembly around the shaft with the 7N7843 Installation Tool, (the tool is with the seal group) until the carbon face makes contact with the shiny face of the ring (2).

d. Install the spring.

(4) Torque for bolt holding the impeller................. 28 ± 2 lb. ft. (39 ± 3 N•m)

(5) Clearance between the impeller and the housing...............022 to .059 in. (0.56 to 1.50 mm)

(6) Torque for bolt that holds the gear:

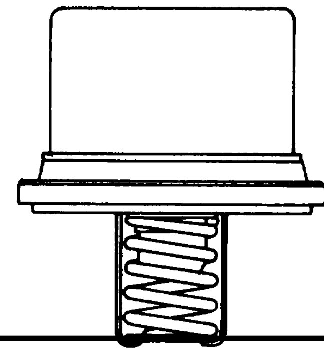
2P3205 3/8-16 NC Bolt...........42 ± 5 lb. ft. (58 ± 7 N•m)

1A1135 5/8-11 NC Bolt...........150 ± 20 lb. ft. (205 ± 25 N•m)

V-BELT TENSION CHART										
BELT SIZE	**WIDTH BELT TOP**		**WIDTH TOP OF PULLEY GROOVE**		**BELT TENSION "INITIAL:**		**BELT TENSION**		**BORROUGHS GAUGE NUMBERS**	
					GAUGE READING		**GAUGE READING**			
	in.	**mm**	**in.**	**mm**	**lb.**	**N**	**lb.**	**N**	**OLD GAUGE NO.**	**NEW GAUGE NO.**
3/8	.422	10.72	.380	9.65	100 ± 5	445 ± 22	90 ± 5	400 ± 22	BT-33-73F	BT-33-95
1/2	.547	13.89	.500	12.70	120 ± 5	534 ± 22	90 ± 10	400 ± 44	BT-33-95-4-16	BT-33-95
5V	.625	15.88	.000	15.24	120 ± 5	534 + 22	90 ± 10	400 ± 44	BT-33-72-415	BT-72C
11/16	.688	17.48	.625	15.86	120 ±5	534 ± 22	90 ± 10	400 ± 44	BT-33-724-15	BT-372C
3/4	.750	19.05	.890	17.53	120 ± 5	534 ± 22	90 ± 10	400 ± 44	BT-33-72-415	BT 33-72C
15/16	.938	23.83	.871	22.30	120 ± 5	534 ± 22	90 ± 10	400 ± 44	BT-33-72415	BT-33-72C
MEASURE TENSION OF BELT FARTHEST FROM THE ENGINE										
*"INITIAL" BELT TENSION Is for a new bit.										
**"USED" BELT TENSION is for a belt which has more than 30 minutes of operation at rated speed of engine. A10232X5										

WATER TEMPERATURE REGULATOR

Temperature when completely open...................... 197°F (92°C)
Minimum opening distance............................ 375 in. 19.53 mm)



RADIATOR

(1) Torque for bolts ....40 ± 5 lb. ft. (55 ± 7 N•m)

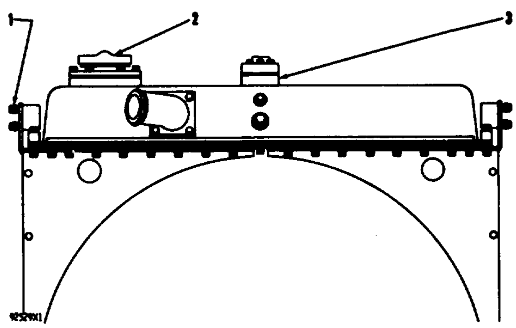
(2) Torque for stud for the filler cap.................... 40± 5 lb. ft. (55 ± 7 N•m)

(3) 5S1218 Pressure Relief Valve:

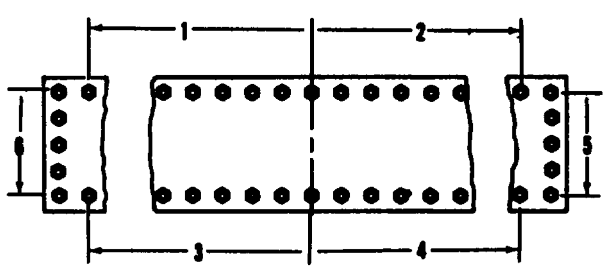
Pressure relief valve to open at .... 15 to 18 psi (105 to 125 kPa)

A vacuum condition in the cooling system must not result. The vacuum relief valve must open at a pressure of.......................... 0 to 1 psi (0 to 7 kPa)

NOTE: Use the tightening procedure shown to install top and bottom tanks to radiator core.

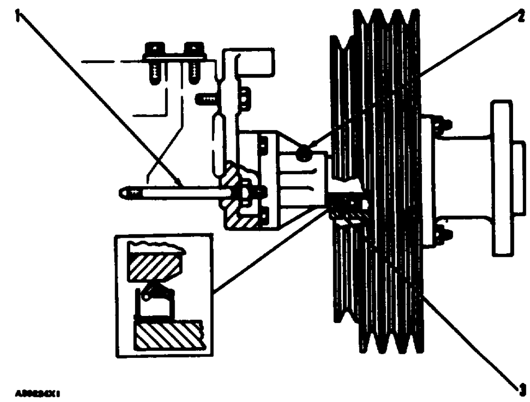


TYPICAL RADIATOR



TIGHTENING PROCEDURE FOR
TYPICAL TWO-ROW TANK

FAN DRIVE

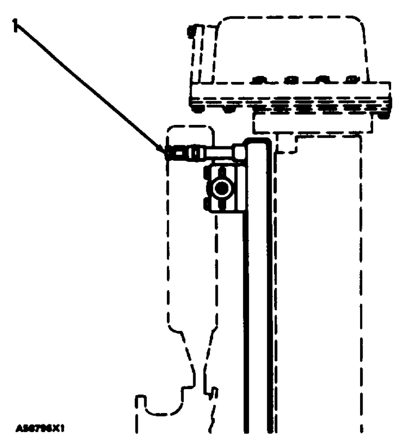


(1) Torque for studs ....40± 5 lb. ft. 55 ± 7 N•m)

(2) Fill with multipurpose grease at assembly.

(3) Position seal as shown and install even of pulley.

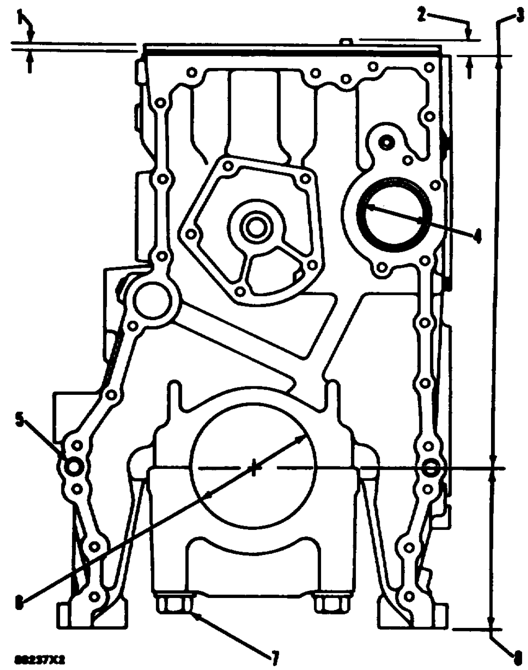
OIL COOLER
(Torque Converter Oil)



TYPICAL EXAMPLE

(1) Tighten valve to..............8 ± 2 lb. ft. (11 ± 3 N•m)

CYLINDER BLOCK



(1) Thickness of top plate ....338 ± .001 in. (8.59 ± 0.03 mm)
Thickness of gasket that is placed between top plate and cylinder block ....008 ± .001 in. (0.20 ± 0.03 mm)
Height of liner over top plate, under installation pressure........005 ± .003 in. (0.13 ± 0.08 mm)

(2) Height of four dowels above top surface of cylinder block:
End dowels...............................73 in. (18.5 mm)
Middle dowels...........................83 In. (16.0 mm)

(3) Dimension (new) from centerline of crankshaft bearing bore to top of block (top deck) ......16.750 + .006 in. (425.45 ± 0.15 mm)

(4) Bore in block for camshaft bearings ....3.0250 ± .0007 in. (76.835 + 0.018 mm)

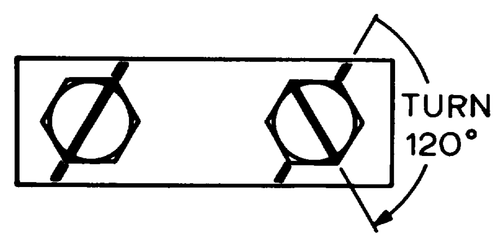
(5) Distance from front or rear face of cylinder block to end of dowels ....75 in. (19.1 mm)

(6) Bore in the block for the main bearings:
standard, original size (new) ....5.1138 ± .0005 in. (129.891 ± 0.013 mm)
.025 in. (0.64 mm) larger than original size ....5.1388 ±.0005 in. (130.526 ± 0.013 mm)

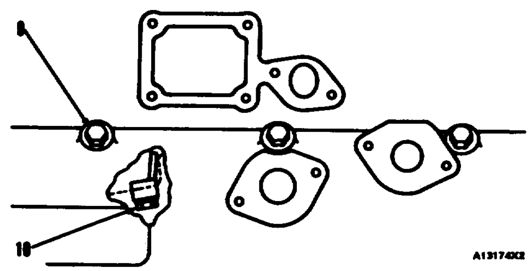
(7) Torque for the bolts that hold the caps for the main bearings:

Install the main bearing caps with the marks (arrow) toward the front of the engine. Install each cap in the correct position by putting the number stamped on the bottom of the cap toward the corresponding number on the cylinder block.

a. Put 2P2506 Thread Lubricant on the threads of the bolts.
b. Tighten the bolts first on the tab side of the cap to ....190 ± 10 lb. ft. (260 ± 14 N±m)
c. Tighten the bolts on the opposite side to..............190 ± 10 lb. ft. (280 ± 14 N•m)
d. Put a mark on each bolt and cap as shown.
e. Tighten the bolts on the opposite side, from the mark.................120°
f. Tighten the bolts on the tab side of the cap, from the mark .... 120°



TIGHTENING PROCEDURE FOR MAIN BEARINGS

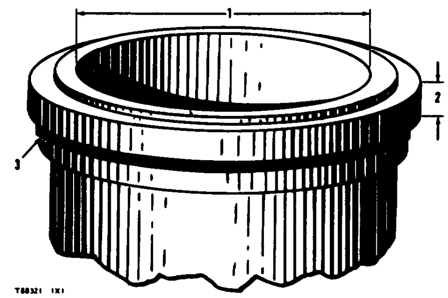


(8) Dimension (new) from centerline of crankshaft bearing bore to bottom of block (pan rails) ....6.500 .004 in. (165.10 ± 0.10 mm)

(9) Put 5P3414 Pipe Sealant on threads of 14 plugs before installation In the cylinder block.

(10) Torque for bolts holding oil jet cooling tubes ....18 ± 5 lb. ft (24 ± 7 N•m)

CYLINDER LINER



(1) Bore in liner (new) ....5.401 + .001 in. (137.19 ±

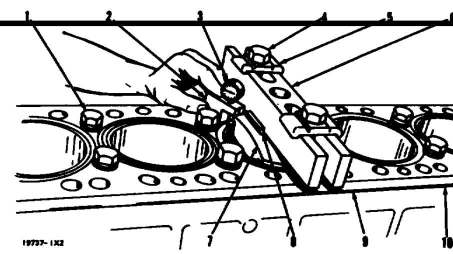
Maximum permissible bore when measured near upper end of the wear surface of the cylinder liner (worn) .... 5.408 in. (137.36 mm)

"Use again" maximum bore (when measured near upper end of the wear surface of the cylinder liner) .... 5.405 in. (137.29 mm)

(2) Thickness of flange on liner ....3500 + .0008 in. (8.890± 0.020 mm)

(3) Filler Band.
Installation procedure:
Put liquid soap on seals, liner grooves and bore in cylinder block. Install seals on bottom of liner. Put filler band in SAE 30 oil for a moment, then install it on the liner. Install the liner in the cylinder block immediately after the band is installed on the liner (before expansion of the band).

CYLINDER LINER PROJECTION



Make reference to CYLINDER LINER PROJECTION in Testing and Adjusting for the complete procedure.

1. Install gasket (10) and spacer plate (9) with bolts (1). Tighten bolts (1) evenly in four steps:
1st step .... 10 lb. ft. (14 N•m)
2nd step .... 25 lb. ft. (35 N•m)
3rd step .... 50 lb. ft. (70 N•m)
4th step .... 70 lb. ft. (95 N•m)

2. Install tooling as shown. Tighten bolts 14) evenly in four steps:
1st step .... 5 lb. ft. (7 N•m)
2nd step .... 15 lb. ft. (20 N•m)
3rd step .... 25 lb. ft. (35 N•m)
4th step .... 50 lb. ft. (70 N•m)

3. Measure cylinder liner projection with dial indicator (3) in 1P2402 Block (2) as shown. Measure at four places around each cylinder liner near the clamped are.

Average of four projection measurements from any cylinder liner must be...................001 to .008 in. (0.30 to 0.15 mm)

Maximum permissible difference between all four measurements ....002 in. (0.05 mm)

Maximum permissible difference between average projection of any two cylinder liners next to each other 002 in. (0.05 mm)

4. Minimum permissible depth to machine counterbore to adjust cylinder liner projection............ 030 in. (0.76 mm)

Maximum permissible depth to machine counterbore to adjust cylinder liner projection............ 045 in. (1.14 mm)

Install a .030 in. (0.76 mm) shim plus any added shims necessary to get the correct cylinder liner projection.

SHIM THICKNESS, COLOR CODE, AND PART NUMBER				
.007 in. (0.18 mm)	.008 in. (0.20 mm)	.001 in. (023 mm)	.015 in. 10.38 m)	.030 in. (0.76 mm)
BLACK	**RED**	**GREEN**	**BROWN**	**BLUE**
5S8138	5S8139	5S8140	6S8141	5S8142

NOTE: Be sure that the .030 in. (0.76 mm) shim is directly under the cylinder liner flange.

Put 7M7260 Liquid Gasket on the top of the top shim and on the bottom of the bottom shim before installing.

(5) 3H465 Plate.

(6) 8B7548 Push-puller Crowbar.

(7) 1P2396 Adapter Plate.

(8) 3H465 Plate (installed upside down).

PISTONS AND RINGS

(1) Top ring.

(2) Intermediate ring.

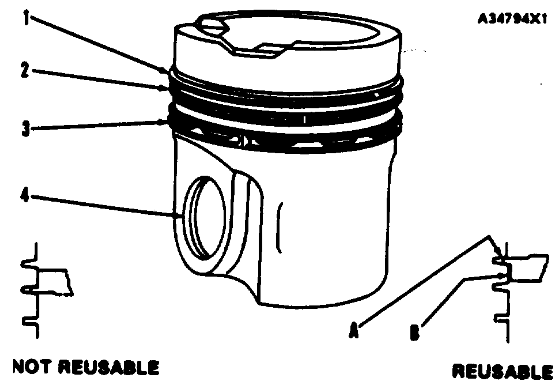
(3) Oil control ring.

(4) Bore in piston
for pin..................2.0006 ± .0003 in. (50.815 + 0.008 mm)

Clearance between pin and bore
in piston...............0003 to .0011 in. (0.008 to 0.028 mm)

Maximum permissible clearance (worn)....... .002 in. (0.05 mm)

Pin diameter.........1.9998 ± .0002 in. (50.795 ± 0.005 mm)



PISTONS AND PISTON RINGS			
	(1) TOP RING	(2) INTERMEDIATE RING	(3) OIL CONTROL RING-*
Width of groove in piston for piston ring (new).	***	***	1255 ± .0005 in. (3.188 ± 0.013 mm)
Thickness of piston ring (new).	***	***	1235 ± .0005 in. (3.137 ± 0.013 mm)
Clearance between groove and piston ring (new)	***	***	.0020 - .0010 in. (0.051 + 0.025 mm)
Maximum permissible clearance (worn).	***	***	.006 in. (0.15 mm)
Clearance between ends of piston ring (new) when installed in a cylinder liner with a bore size of 5.400 in. (137.16 mm).	.0285 ± .0075 in. (0.724 ± 0.191 mm)	.0425 ± .0075 in. (1.080 ± 0.191 mm).	.0225 ± .0075 in. (0.572 ± 0.191 mm)
Increase in clearance between ends of piston rings for each .001 in. (0.03 mm) increase in cylinder liner bore size.	.003 in. (0.08 mm)		

*Install piston rings with "UP" side toward top of piston.
NOTE: Top Ring (1) has the mark "UP-1." Intermediate Ring (2) has the mark "UP-2."
**Install Oil Control Ring (3) with the gap in the spring 180° away from the gap In the ring.
***"Keystone" style piston rings and grooves in pistons. The 5P4812 KEYSTONE PISTON RING GROOVE GAUGE is necessary for measuring these grooves. Put the pin end (A) of gauge "1" in the groove at four places around the circumference. Do this to both grooves. The flat edge (B) of the gauge must be between grooves (1) and (2). If there is clearance between the flat edge (B) of the gauge and the piston at all test locations, for both grooves. the piston is reusable. If the flat edge (B) is in contact with the piston, at any of the test locations. the piston is not reusable. Install a new piston.

CONNECTING ROD

(1) Bore in connecting rod for piston
pin bearing.......... 2.1825 ± .0005 in. (55.436 ± 0.013 mm)

Tight fit between connecting rod eye and
piston pin bearing ....002 to .004 in. (0.05 to 0.10 mm)

NOTE: Connecting rod must be heated for installation of piston pin bearing. Do not use a torch.

Heat connecting rod to
temperature of ....350 to 500° F (177 to 260° C)
Position of pin bearing:

Bearing junction and locating hole are 180° apart (directly across from each other). Bearing junction and locating hole must be assembled within either area A" (90 ± 10° from center-line through the connecting rod bores) as shown.

Make reference to Special Instruction Form No. SMHS7295 for use of pin bearing removal and installation tools and procedures.

(2) Bore in connecting rod for bearing
with nuts tight to specifications
(6) ....4.0748 ± .0005 in. (103.500 ± 0.013 mm)

(3) Distance between center of
bearings........................10.300 ± .002 in. (261.62 ± 0.05 mm)

(4) Bore in bearing for piston
pin (new).......................2.0012 ± .0003 in. (50.830 ± 0.006 mm)

Diameter of piston pin (new) 1.990 ± .0002 in.
(50.795 ± 0.005 mm)

Maximum permissible clearance between
bearing and piston pin (worn)..................003 in. (0.08 mm)

(5) Bore in bearing for
crankshaft.........3.8236 to 3.8258 in. (97.119 to 97.175 mm)

Clearance between bearing and
crankshaft (new) ....0028 to .0066 in. (0.071 to 0.168 mm)

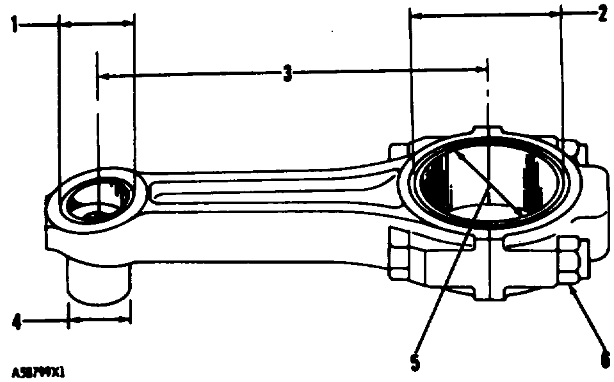
Maximum permissible clearance between bearing
and crankshaft (worn)...................010 in. (0.25 mm)

NOTE: Bearings are available in .025 in. 10.64 mm) and .050 in. (1.27 mm) smaller than original size.

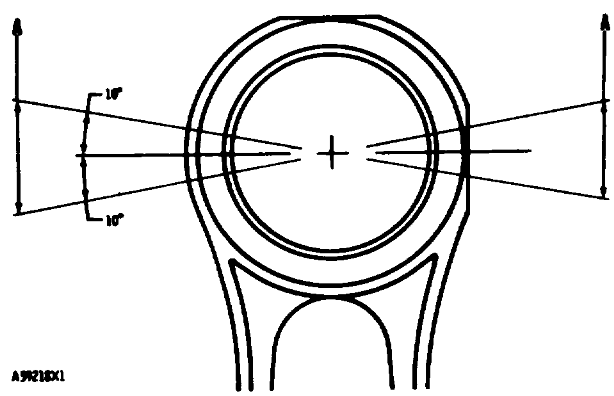
(6) Tighten procedure for connecting rod bolts:
a. Put 2P2506 Thread Lubricant on bolt threads and contact surfaces of nut and cap.
b. Tighten both nuts to................60 ± 6 lb. ft. (80 + 8 N•m)
c. Put a mark on each nut end of bolt as shown.
d. Tighten each nut from mark....... 120 ± 50°

NOTE: The connecting rod must be installed so the chamfer on the edge of bore (5) is near the corner on the crankshaft. The side opposite the chamfered edge must be against the other connecting rod on the same crankshaft pin.

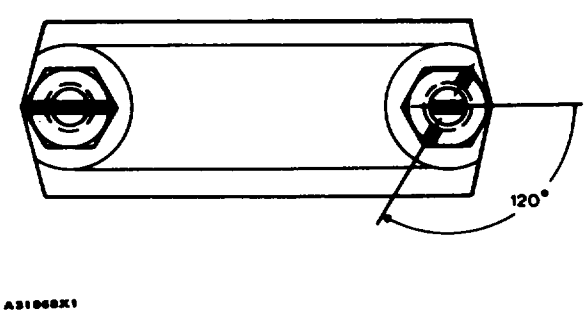
Side clearance between two connecting rods on same crankshaft pin
(new) ....011 to .033 in. (0.28 to 0.84 mm)



7N3231 CONNECTING ROD WITH TAPERED PIN END SHOWN



POSITIONING PIN BEARING

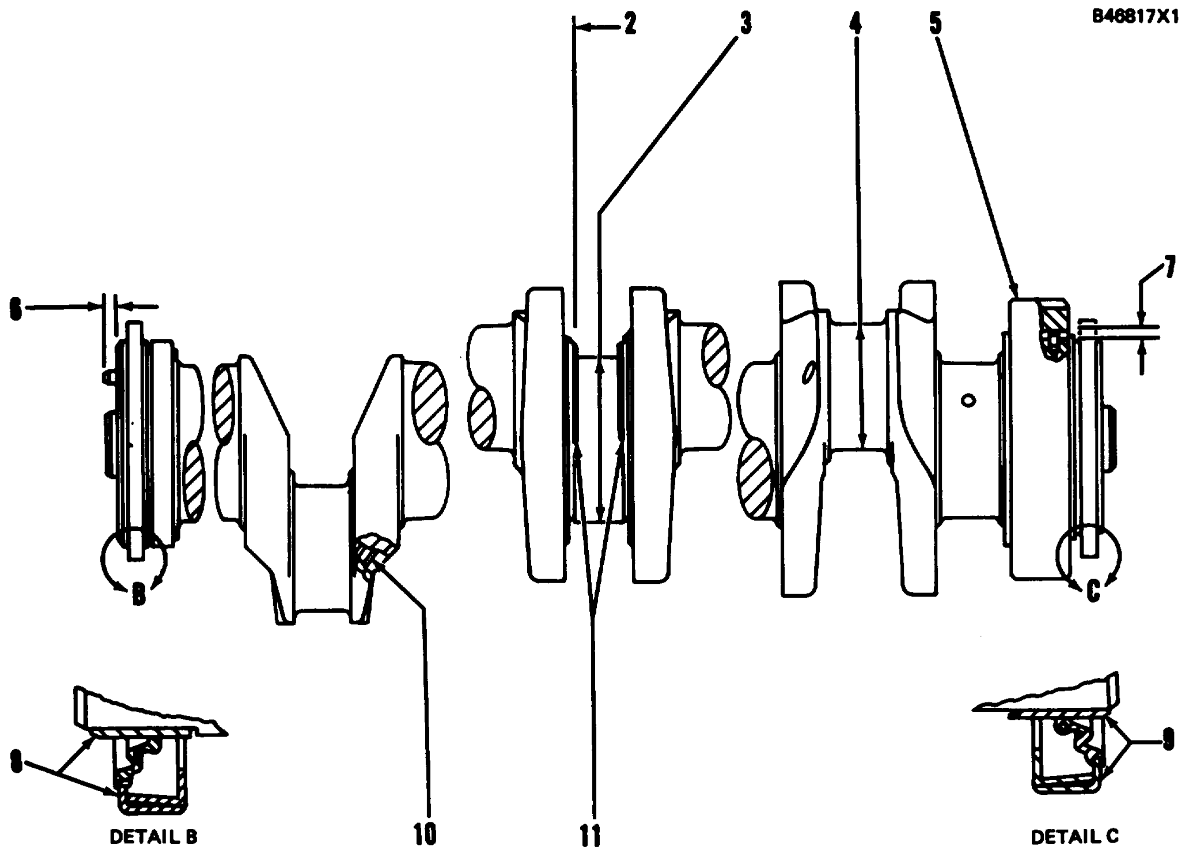


MARKS FOR TIGHTENING CONNECTING ROD BOLTS

BEARINGS FOR CONNECTING RODS AND MAINS

CONNECTING ROD BEARINGS			
	ORIGINAL SIZE JOURNAL	.025 in. (0.64 mm) UNDERSIZE (SMALLER) JOURNAL	.050 in. (1.27 mm) UNDERSIZE (SMALLER) JOURNAL
Diameter of crankshaft journal (bearing surface) for connecting rod	3.8200 ± .0008 in. (97.028 ± 0.020 mm)	3.7950 ± .0008 in. (96.393 ± 0.020 mm)	3.7700 ± .0008 in. (95.758 ± 0.020 mm)
Clearance between bearing and journal (new).	.0028 to .0066 in. (0.071 to 0.168 mm)		
Maximum permissible clearance between bearing and journal	.010 in. (0.25 mm)		

MAIN BEARINGS			
	ORIGINAL SIZE JOURNAL	.025 in. (0.64 mm) UNDERSIZE (SMALLER) JOURNAL	.050 in. (1.27 mm) UNDERSIZE (SMALLER) JOURNAL
Diameter of crankshaft journal (bearing surface) for main bearings.	4.7500 ± .0008 in. (120.650 ± 0.020 mm)	4.7250 ± .0008 in. (120.015 ± 0.020 mm)	4.7000 ± .0008 in. (119.380 ± 0.020 mm)
Clearance between bearing and journal (new).	.0036 to .0073 in. (0.091 to 0.186 Mm)		
Maximum permissible clearance between bearing and journal	.010 in. (0.25 mm)		



(2) End play for the crankshaft (new)...........................006 to .020 in. (0.15 to 0.50 mm)

(3) Make reference to MAIN BEARINGS.

(4) Make reference to CONNECTING ROD BEARINGS.

(5) Maximum permissible temperature of the gears for installation on the crankshaft .... 450° F (232° C)

Centerline of inside gear key way to be in alignment with centerline of dowel within.............. .020 in. (0.50 mm)

(6) Maximum length of pin out of crankshaft face .... .25 in. (6.4 mm)

(7) Length of dowel out of the crankshaft .... 16 ± .02 in. (4.1 ± 0.5 mm)

NOTE: Install gear with "V" mark to the outside.

(8) Rear wear sleeve and seal. For removal and installation procedure, see, (9).

(9) Front wear sleeve and seal:

Removal wear sleeves with 5P7318 Distorter Group.

Install front and rear wear sleeves and seals as follows:

a. Clean the inner surface of the sleeve and the outer surface of the crankshaft with 8M8060 Quick Cure Primer.
b. Put 9S3265 Retaining Compound on the cleaned with surfaces.
c. Install the sleeve and seal at the same time on the crankshaft as shown.

(10) Minimum distance below first thread for head of plug to be installed................. 100 in. (2.54 mm)

Minimum torque for six plugs........17 lb. ft. (23 N•m)

"Stake" (make a mark with a punch) the crankshaft to hold the plug tight.

(11) Thrust plates, at center main bearing.

FLYWHEEL HOUSING BORE

NOTE: Write the dial indicator measurements with their positive (+) and negative (-) notation (signs). This notation is necessary for making the calculations In the chart correctly.

1. With the dial indicator in position at (C), adjust the dial indicator to "O" (zero). Push the crankshaft up against the top bearing. Write the measurement for bearing clearance on line 1 in column (C)
2. Divide the measurement from Step 1 by 2. Write this number on line 1 in columns (B) & (D).
3. Turn the crankshaft to put the dial indicator at (A). Adjust the dial indicator to "O" (zero).
4. Turn the crankshaft counterclockwise to put the dial indicator at (B). Write the measurement in the chart.
5. Turn the crankshaft counterclockwise to put the dial indicator at (C). Write the measurement in the chart
6. Turn the crankshaft counterclockwise to put the dial indicator at (D). Write the measurement in the chart.
7. Add lines I & 11 by columns.
8. Subtract the smaller number from the larger number in line III in columns (B) & (D). The result is the horizontal "eccentricity" (out of round). Line III, column (C) is the vertical eccentricity.

CHART FOR DIAL INDICATOR MEASUREMENTS					
	Position of dial indicator				
	Line No.	A	B	C	D
Correction for bearing clearance	I	0			
Dial Indicator Reading	II	0			
Total of Line 1 & 2	III	0	**	**	**

*Total Vertical eccentricity (out of round).
**"Subtract the smaller No. from the larger No. The difference is the total horizontal eccentricity.

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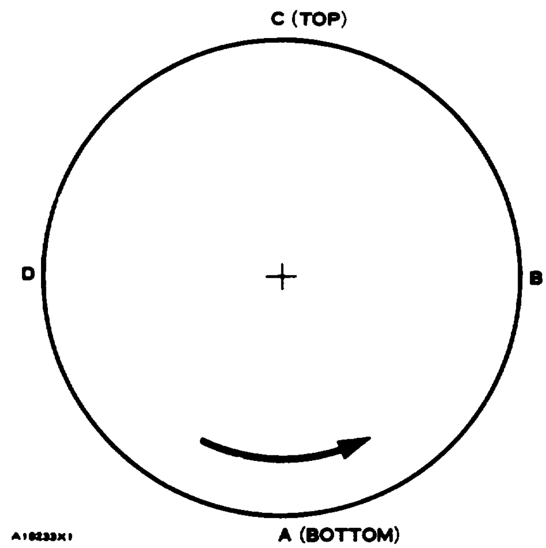
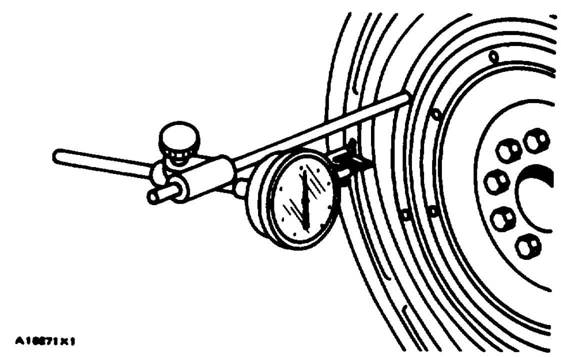
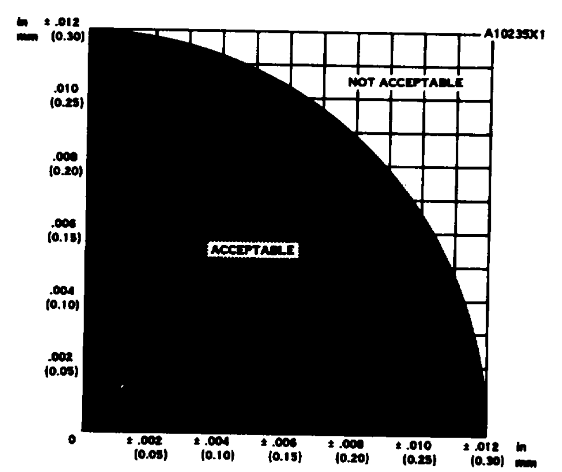
9. On the graph for total eccentricity find the point of intersection of the lines for vertical eccentricity and horizontal eccentricity.
10. If the point of intersection is in the range marked "Acceptable", the bore is in alignment, If the point of intersection is in the range marked "Not Acceptable", the flywheel housing must be changed.







FLYWHEEL HOUSING RUNOUT

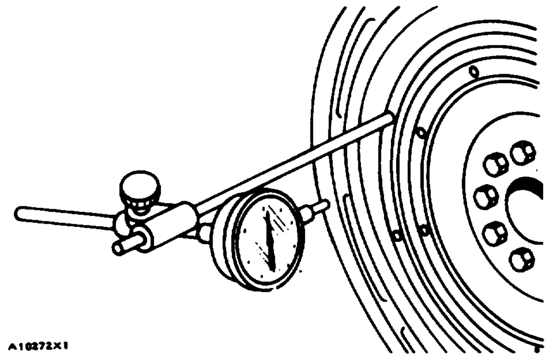
Face Runout (axial eccentricity) of the Flywheel Housing:

1. Fasten a dial indicator to the crankshaft flange so the anvil of the indicator will touch the face of the flywheel housing.

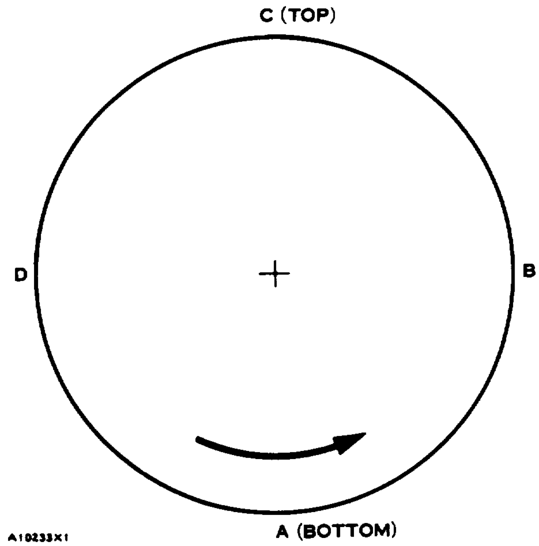
2. Put a force on the crankshaft toward the rear before reading the indicator at each point.

3. With dial indicator set at .000 in. (0.00 mm) at location (A), turn the crankshaft and read the indicator at locations (B), (C) and (D).

4. The difference between lower and higher measurements taken at all four points must not be more than .012 in. (0.30 mm), which is the maximum permissible face run out (axial eccentricity) of the flywheel housing.



8S2328 DIAL INDICATOR GROUP INSTALLED



FLYWHEEL RUNOUT

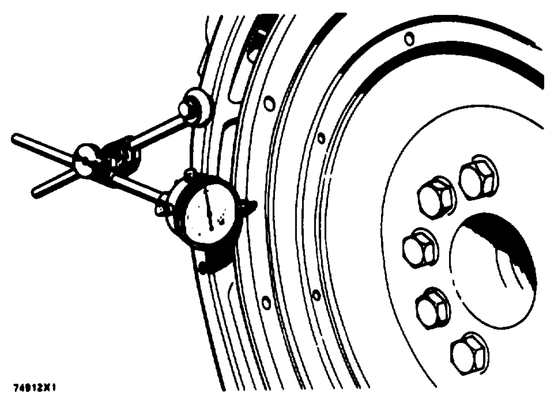
Face Runout (axial eccentricity) of the Flywheel:

1. Install the dial Indicator as shown. Put a force on the flywheel toward the rear.

2. Set the dial Indicator to read .000 in. (0.00 mm).

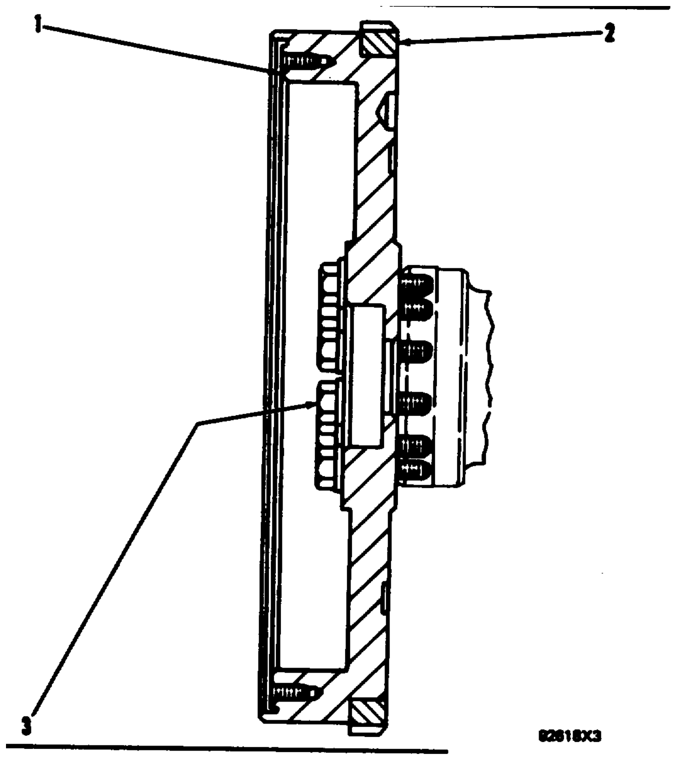
3. Turn the flywheel and read the Indicator every 90°. Put a force on the flywheel to the rear before each reading.

4. The difference between the lower and higher measurements taken at all four points must not be more then .006 in. (0.15 mm), which is the maximum permissible face runout (axial eccentricity) of the flywheel.



CHECKING FACE RUNOUT OF THE FLYWHEEL

FLYWHEEL



(1) Maximum permissible change from an exact vertical face (run out) during one rotation (total indicator reading)................ .006 in. (0.15 mm)

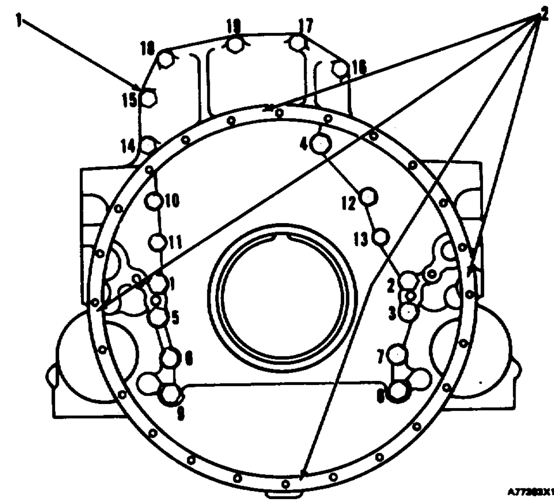
(2) Gear. Maximum temperature for installation (do not heat with a torch)................. 600° F (316° C)

NOTE: Install gear with chamfer on teeth in direction shown.

(3) Torque for the bolts that hold the flywheel to the crankshaft............200 ± 20 lb. ft. (270 ± 25 N•m)

NOTE: Put 5P2506 Thread Lubricant on threads before assembly.

FLYWHEEL HOUSING



(1) Tighten flywheel housing bolts with the procedure that follows:

a. Tighten bolts 1 thru 9 in number sequence to a torque of...........100 ± 10 lb. ft. (135 ± 14 N•m)

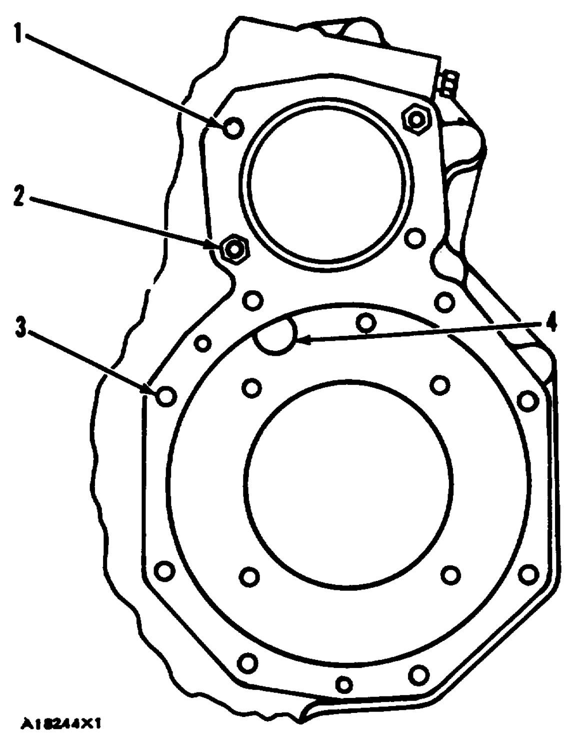
b. Tighten bolts 10 thru 19 in number sequence to a torque of..............40 ± 5 lb. ft. (55 ± 7 N•m)

c. Tighten bolts 1 thru 9 again In number sequence to a torque of..........100 ± 10 lb. ft. (135 ± 14 N•m)

d. Tighten bolts 10 thru 19 again in number sequence to a torque of...............40 ± 5 lb. ft. (55 ± 7 N•m)

(2) Maximum permissible change from an exact vertical face (face run out) at 4 points (total indicator reading)..........012 in. (0.30 mm)

TIMING GEAR HOUSING



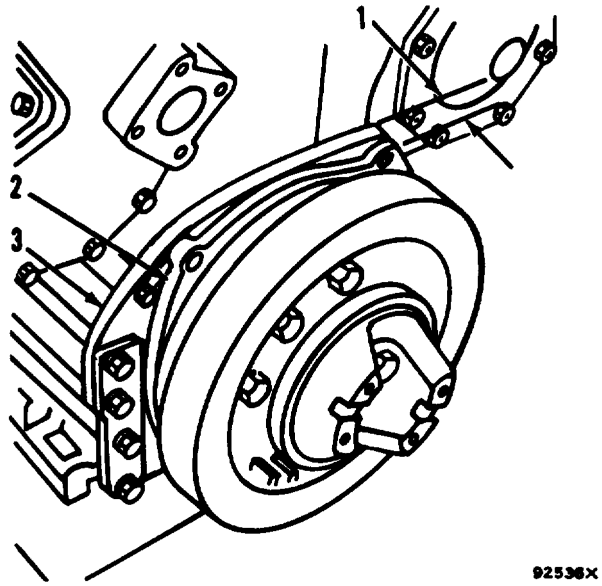
(1) Put 8H5137 Sealer on the two studs before Installing in the housing.

(2) Put 8H5137 Sealer on the two screws before installing in the housing.

(3) Put 8H5137 Sealer on the sight studs before installing In the housing.

(4) Put 9S3265 Retaining Compound on the stud serrations and each side of the gasket before installing in the housing. Head of stud must not be more then .18 in. (4.6 mm beyond the plate after it is installed. Put 8H5137 Sealer on the stud threads.

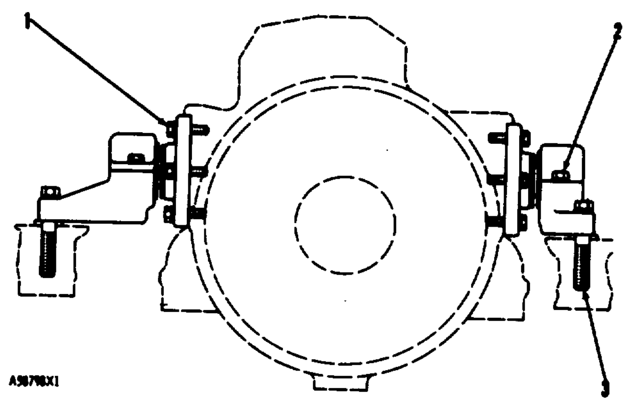
TRUNNION GROUP



TYPICAL EXAMPLE

(1) Distance from front face of bushing (2) to rear face of adapter (3).............1.060 ± .020 in. (26.92 ± 0.51 mm)

ENGINE SUPPORT

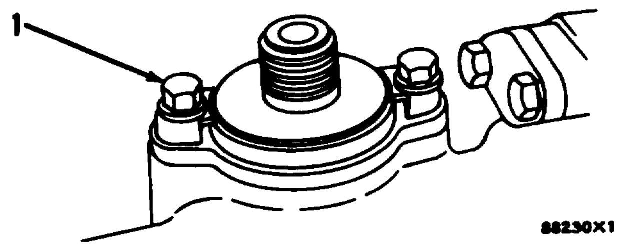


(1) Install supports to flywheel housing by putting three of the four mounting bolts next to the rear face of the flywheel housing. Tighten bolts to standard torque.

(2) Tighten the four cap bolts to a torque of ....185 ± 10 lb. ft. (254 ± 14 N•m)

(3) Tighten bolts to a torque of..................350 ± 35 lb. ft. (470 ± 46 N•m)

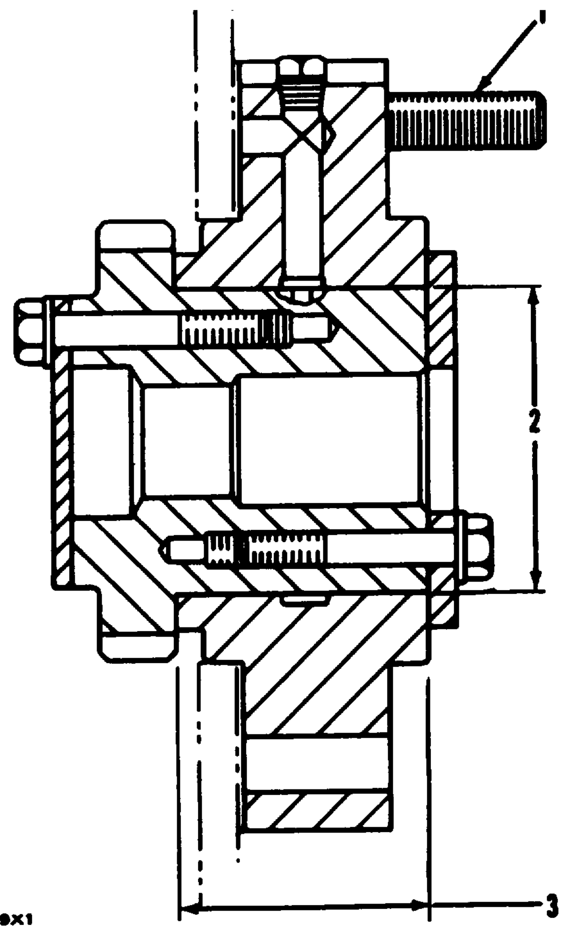
TACHOMETER DRIVE



TYPICAL EXAMPLE

(1) Tighten mounting bolts to
a torque of....................10 ± 2 lb. ft. 14 ± 3 N•m)

AIR COMPRESSOR DRIVE



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(1) Tighten mounting studs for air compressor
to a torque of.................40 ± 5 lb. ft. (55 ± 7 N•m)

(2) Bore in bearing for
gear (new)..........2.7545 ± .0015 in. (69.964 ± 0.038 mm)

Diameter of bearing surface
of gear (new)........2.7500 ±.0005 in. (69.850 ± 0.013 mm)

(3) Length of bearing (new).....2.278 ± .002 in. (57.86±0.05 mm)

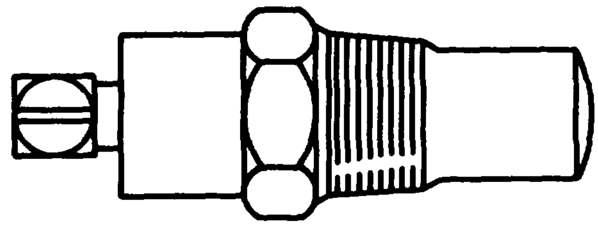
Length of bearing surface of
gear (new).......2.286 ± .002 in. (58.06 ± 0.05 mm)

TEMPERATURE SWITCH

6N5899 Switch

Switch activated at .... 100 ± 5° F (38 ± 3° C)

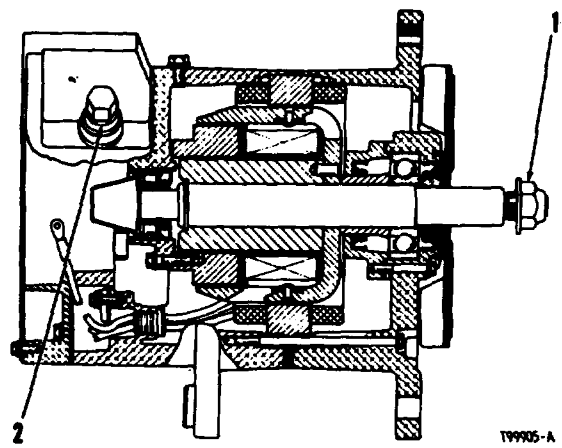
Type of switch .... normally closed



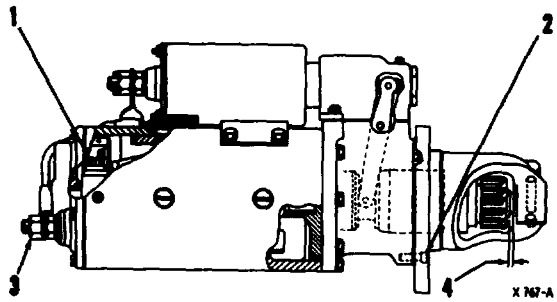
A77385X1

Alternators

ALTERNATOR (DELCO-REMY)		
Voltage Rating	24 V	
Caterpillar Number	5S9088	3T1888
Deco-Remy Number	1117226 1117236	1117248
Polarity	Negative ground	
Rotation	Either direction	
Speed for testing	5000 rpm	
Output (cold)	54A	
Rated output (hot)		
at max. Speed	50A	
Field current at rated		
voltage and 80° F (27° C)	2.5 to 2.9A	
(1) Torque for nut	70 to 80 lb. ft.	
	(95 to 109 N•m)	
(2) Torque for output	9 to 11 lb. ft.	
terminal	(12 to 15 N•m)	
Regulator (Inside Alternator)		
Regulator	7N129	
Voltage setting range	26 to 30 V	
Adjust voltage setting to:	28 V	
Then Increase speed		
to get max output of:	50A	



STARTER MOTOR



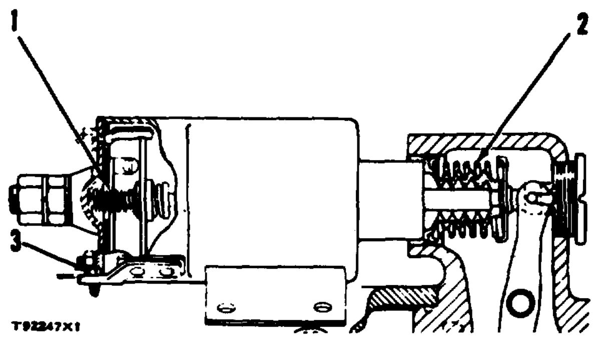
TESTING SPECIFICATIONS AT 20V WITH NO LOAD APPLIED				
Supplier		**Delco Remy**		
Part No.	C. T. Co. Supplier		3T2649 1114984	
Speed (rpm)	min. max.		5500 9000	
Current consumption (draw)	min. max.		70A 110A	
Used with solenoid			3T3421	
(1) Tension of brush spring			56 oz. (15.6 N)	
(2) Torque for screws holding nose housing to lever housing		13 to 17 lb. ft. (18 to 23 N•m)		
(3) Torque for all terminal nuts		20 to 25 lb. t. (25 to 35 N•m)		
(4) Clearance between pinion and housing (pinion clearance)		.36 ± .03 In. (9.1 ± 0.8 mm)		

STARTER SOLENOIDS

(1) 4M1815 Spring (contact release):

(2) 9M7609 Spring (to return the clutch lever):

(3) Torque for terminal screws .... 16 to 30 lb. in. (2 to 3 N•m)

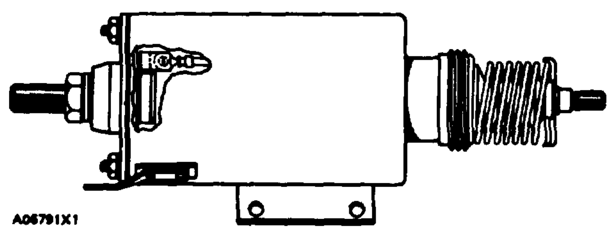


SPRING CHART		
	(1)	**(2)**
Part No.	4M1815	9M7609
Length under test	.42 in.	1.56 in.
force	(10.7 mm)	(39.6 mm)
Test force	9 ± .5 lb.	14 + .5 lb.
	(40 ± 2 N)	60 ± 2 N)
Free length after	.83 ±.02 in.	2.79 in.
test	(21.1 ± 0.5 mm)	(70.9 mm)
Outside diameter	.375 ± .010 in.	1.393 ± .015 in.
	(9.53 ± 0.25 mm)	(35.38 ± 0.35 mm)

CURRENT CONSUMPTION (DRAW)					
C.T. Co.		**Delco-Remy.**		**Current**	
Part No.		**Part No.**	**Voltage Rating**	**Pull -In windings**	**Hold-in windings**
24 V	3T4704	1115557	24V	9 to 1.5A at 5V	at 20 V

Current consumption (draw) at 70° F (21° C).

Pull-in windings at 20 to 24 V............... 38.6 to 52.4 A
Hold-in windings at 20 to 24 V .... 6.8 to 9.6 A



CHAPTER 1
POWER TRAIN
SERVICE MANUAL

TORQUE SPECIFICATIONS: You will find Instances in this publication where the manufacturer has used "Meter-Kilograms" or "Centimeter-Kilograms" in place of "Newton-Meters" for the metric torque. In these instances, use the following conversion factors to obtain the metric torque in "Newton-Meters."

lb ft x 1.355819 - N•m
lb. in. x 0.1129848 - N•m

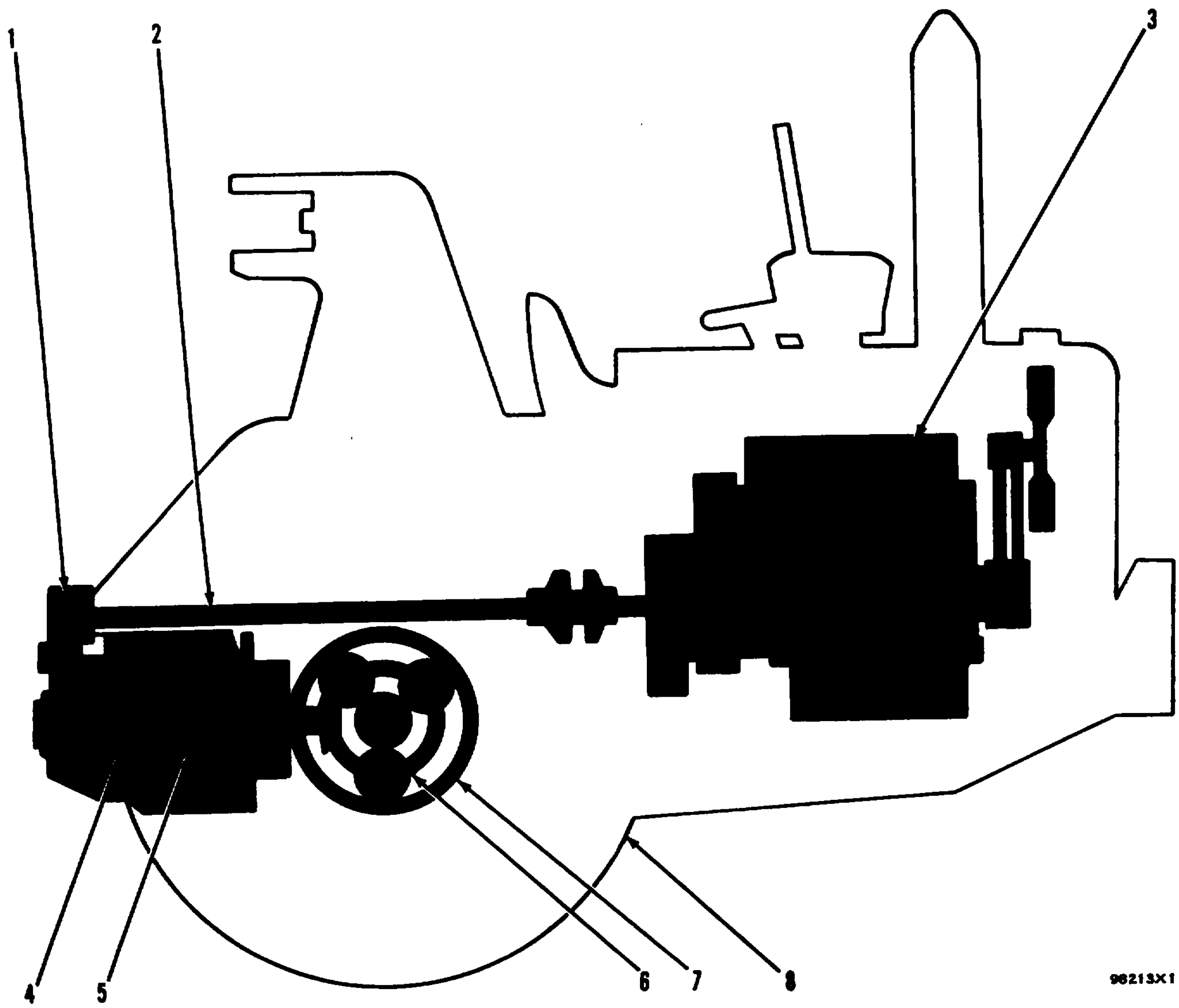
INDEX Page

SYSTEMS OPERATION

TESTING AND ADJUSTING

NOTE: See Chapter 4 for Specifications with illustrations.

GENERAL INFORMATION



LOCATION OF COMPONENTS

1. Transfer gears for the transmission. 2. Drive shaft. 3. Diesel engine. 4. Torque converter. 5 Transmission. 6. Differential. 7. Final Drive. 8. Wheels

The machine has eight forward speeds and one reverse speed. The flow of power from the engine to the flow of power from the engine to the wheels is:

From diesel engine (3) to drive shaft (2).

From drive shaft (2) to transfer gears (1).

In REVERSE and FIRST and SECOND FORWARD, the flow of power is from transfer gears (1) through torque converter (4) to transmission (5).

In THIRD through EIGHTH speeds FORWARD, the flow of power is from transfer gears (1) to transmission (5).

From differential (5) to differential (6).

From differential (6) to final drive (7).

From final drive to wheels (8).

TRANSMISSION LUBRICATION SYSTEM

Inlet oil to transmission oil pump (16) comes from reservoir (18) in the differential and bevel gear case through magnetic screen (15). The transmission oil pump sends the oil through oil filter (19) for the transmission. The oil then goes to priority valve (21) in semiautomatic controls (20).

The priority valve prevents the oil from going to the remainder of the system until the oil pressure in semiautomatic controls (20) is 120 psi (8.4 kg/cm^2). At 120 psi (8.4 kg/cm^2), the priority valve opens. The oil then goes to flow control valve (12) in valve group for pressure control (22). The flow control valve sends oil to inlet relief valve (11) for torque converter (10). The flow control valve also provides the oil for the clutches and some of the oil for planetary lubrication.

Inlet relief valve (11) for the torque converter prevents the oil pressure in the torque converter from going over 132 psi (9.3 kg/cm^2). If the pressure in the torque converter goes over 132 psi (9.3 kg/cm^2), the relief valve opens. The extra oil goes to planetary (9) for lubrication.

After the oil goes through the torque converter, it goes to oil cooler (2) for the transmission. The oil is then sent to planetary transmission (9) for the lubrication of the planetary and transfer gears.

On a machine with a retarder, the oil goes from torque converter (10) to temperature control valve (1). The temperature control valve lets some of the oil go to oil cooler (2) for the transmission and some of the oil go to retarder control valve (3).

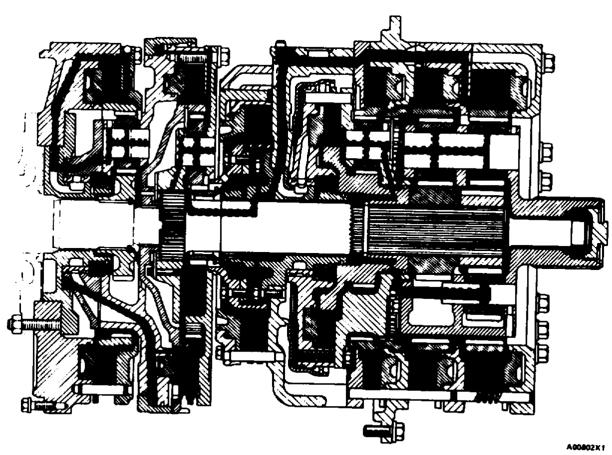
When the temperature of the oil is 135°F (57° C) temperature control valve (1) lets more of the oil go through oil cooler (2), then to retarder valve (3). When the temperature of the oil is 170°F (77 C), temperature control valve (1) lets all the oil from the torque converter go through oil cooler (2), then to retarder valve (3).

The oil to retarder valve (3) goes through the retarder valve to retarder (5). After going through the retarder, the oil goes back to retarder valve (3). The oil then goes to oil cooler (4). The oil from cooler (4) goes back through retarder valve (3) to planetary (9) for lubrication of the planetary and transfer gears.

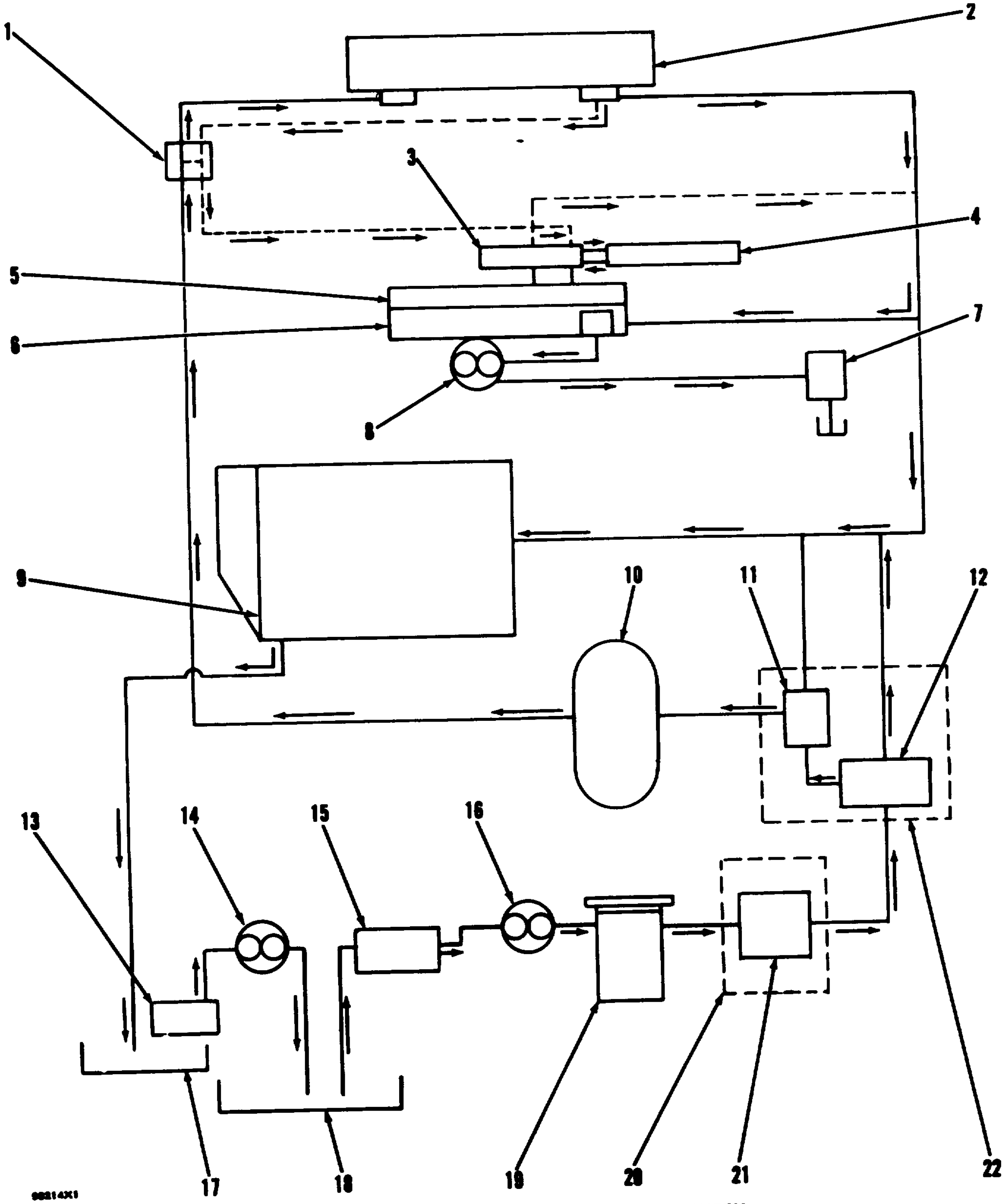
Some of the oil from the outlet side of oil cooler (2) goes through a tube to flywheel housing (6). This oil is for the lubrication of the gears in the housing. Pump (8), on the housing, takes the oil from the housing. The oil is sent through the tube for the drive shaft to bearings (7). The oil then goes through a tube to reservoir (18) in the differential and bevel gear case.

The oil from transmission oil cooler (2) goes into a passage in the No. 4 clutch housing to the center shaft of planetary transmission (9). The oil goes along the center shaft to passages in the clutch housings for the lubrication of the components inside the planetary. The transfer gears get oil from a passage in the planetary. The oil pressure to the planetary is controlled by the components in the lubrication system.

Oil leakage from the planetary is removed from reservoir (17) in the transmission case by pump (14). Pump (14) sends the oil through a tube to reservoir (18) in the differential and bevel gear case.



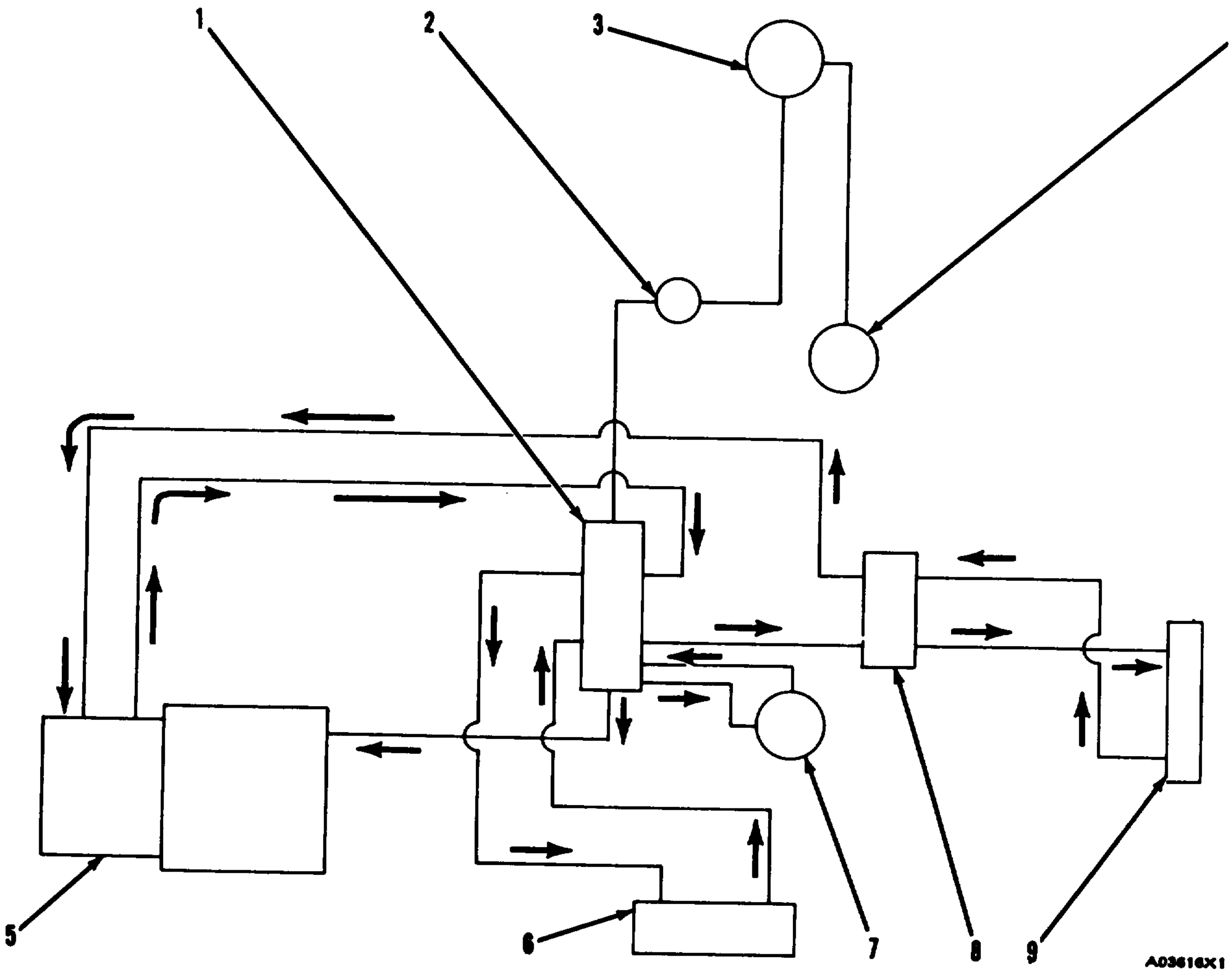
PLANETARY LUBRICATION



SCHEMATIC OF THE TRANSMISSION LUBRICATION SYSTEM

1. Temperature control valve. 2. Oil cooler for the transmission. 3. Control valve for the retarder. 4. Oil cooler for the retarder. 5. Retarder. 6. Flywheel housing. 7. Bearings for the drive shaft. 8. Oil pump for flywheel housing. 9. Planetary transmission. 10. Torque converter. 11. Inlet relief valve for the torque converter. 12. Flow control valve. 13. Screen. 14. Oil pump for transfer gears. 15. Magnetic screen. 16. Oil pump for the transmission. 17. Reservoir in transmission case. 18. Reservoir in differential and bevel gear case. 19. Oil filter for the transmission. 20. Semi-automatic controls. 21. Priority valve. 22. Valve group for pressure control.

RETARDER



RETARDER SYSTEM

1. Retarder control valve. 2. Air pressure regulator. 3. Hand air valve. 4. Brake control valve. 5. Torque converter and planetary. 6. Oil cooler for the retarder. 7. Retarder. 8. Temperature control valve. 9. Oil cooler for the transmission.

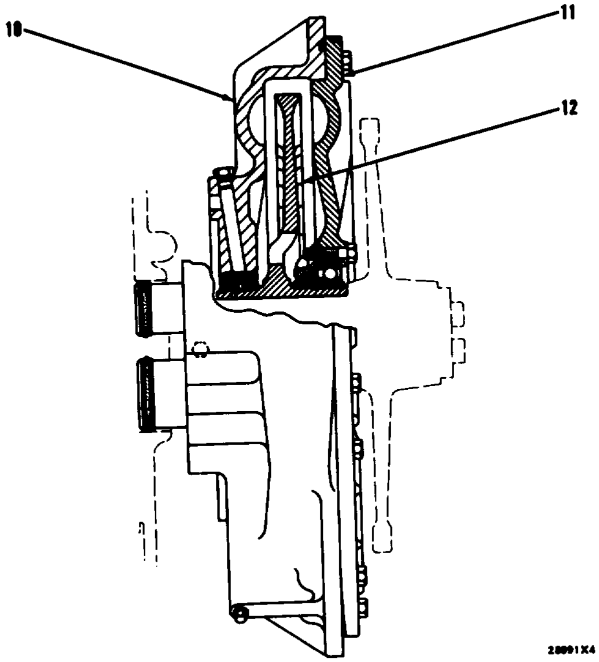
The hydraulic retarder (7), in addition to the service brakes, gives assistance to make the machine go slower. The retarder housing and retarder control valve (1) are fastened to the flywheel housing of the engine. Pressure air from hand air valve (3) activates retarder control valve (1).

When hand air valve (3) is moved toward the operator, pressure air goes from valve (3) through regulator (2) to retarder control valve (1). The pressure air moves spool (21) to the right. The movement of the spool lets the oil from temperature control valve (8) go to retarder (7).

The operation of the retarder is similar to that of a torque converter. Rotor (12) is fastened through a drive gear to the engine flywheel. Stator (11) is fastened to retarder housing (10). The rotor turns inside the retarder housing. The rotor throws oil against the stationary vanes of the stator which causes a resistance to oil flow. This action causes a resistance to the drive shaft and makes the machine go slower.

After going through retarder (7), the oil goes through retarder control valve (1) to oil cooler (6) for the retarder. The oil then goes back through retarder control valve (1) to the planetary transmission for lubrication.

When the retarder is not being used, the oil from temperature control valve (8) divides when it enters retarder control valve (1). Some of the oil moves plunger (15),to the left and goes around spool (21). This oil is for the lubrication of the inside components of the retarder.

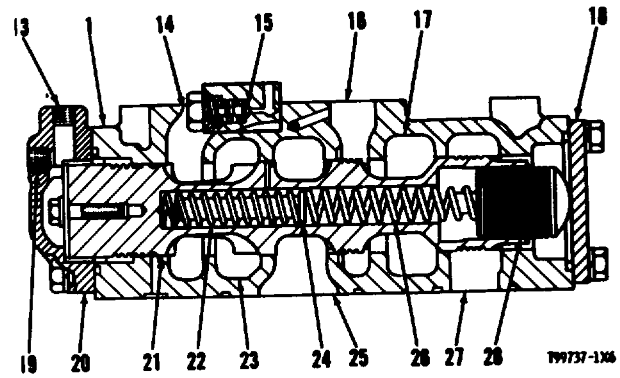


HYDRAULIC RETARDER

10. Retarder housing. 11. Stator. 12. Rotor.

The remainder of the oil goes through chamber (17) to oil cooler (6) for the retarder. From oil cooler (6), the oil goes through chamber (23) to opening (14). From opening (14) the oil goes to the planetary transmission for lubrication.

A hose is connected to cover (18) of the retarder control valve. When hand air valve (3) is pushed away from the operator, the oil in the retarder is sent through chamber (17) into the slug cavity and then to the hose. The oil then goes to the reservoir in the differential and bevel gear case.



RETARDER CONTROL VALVE

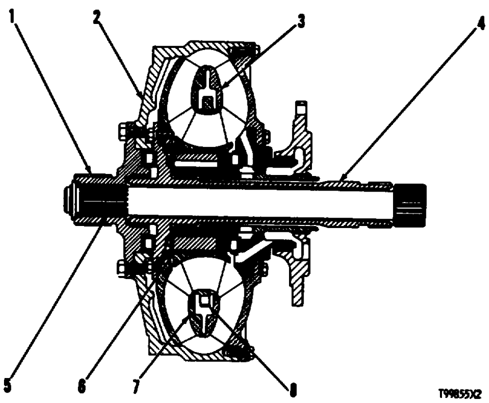
1. Retarder control valve. 13. Air inlet from hand air valve. 14. Opening. to planetary. 15. Plunger. 16. Opening from temperature control valve. 17. Chamber, to retarder oil cooler. 18. Cover. 19. Plug. 20. Cover. 21. Spool. 22. Spring. 23. Chamber, from retarder oil cooler. 24. Stop. 25. Opening to retarder. 26. Spring. 27. Opening, from retarder. 28. Slug.

The position of control valve (3), controls the amount of pressure air to control valve (1). An increase of pressure air to control valve (1) causes more oil to go into the retarder and cause an increase in braking force.

CAUTION: If the temperature of the retarder oil goes higher than 275°F (135°C), the speed of the machine must be made slower by either activating the service brakes or putting the transmission in a lower speed. Operation of the machine while the oil temperature is higher than 275°F (135°C) can cause damage to the retarder and engine.

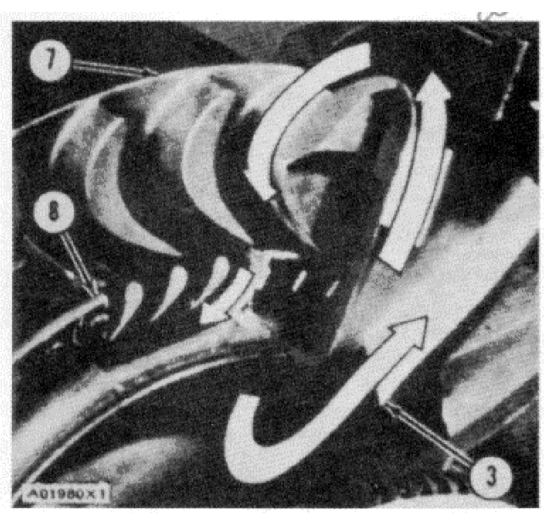
TORQUE CONVERTER

The machine has a single-stage torque converter with a one-way clutch (6). This clutch holds the stator when the torque converter is used and lets the stator turn freely when the torque converter is not used. The torque converter is not used in 3rd through 8th speeds.



TORQUE CONVERTER

1. Input flange. 2. Housing. 3. Impeller. 4. Output hub. 5. Input shaft of transmission. 6. One-way clutch. 7. turbine. 8. Stator.



FLOW OF OIL INSIDE OF TORQUE CONVERTER

3. Impeller. 7. Turbine. 8. Stator.

Splines connect input flange (1) to the output gear of the transfer gears. Splines connect input shaft (5) of the transmission to the input flange (1). Housing (2) is fastened to the input flange. Turbine (7) is fastened to output hub (4) of the torque converter. Stator (8) and one-way clutch (6) are on the carrier for the stator. Output hub (4) is connected to the sun gear of the No. 1. clutch.

Oil, from the inlet relief valve for torque converter goes into the torque converter through an inlet passage in the carrier for the stator. The oil is then sent to the impeller.

The flow of oil inside the torque converter is:
... From impeller (3) to turbine (7).
... From turbine (7) to stator (8).
... From stator (8) to impeller (3) and to the carrier for the stator.

An outlet passage in the carrier for the stator lets part of the oil out of the torque converter.

OPERATION

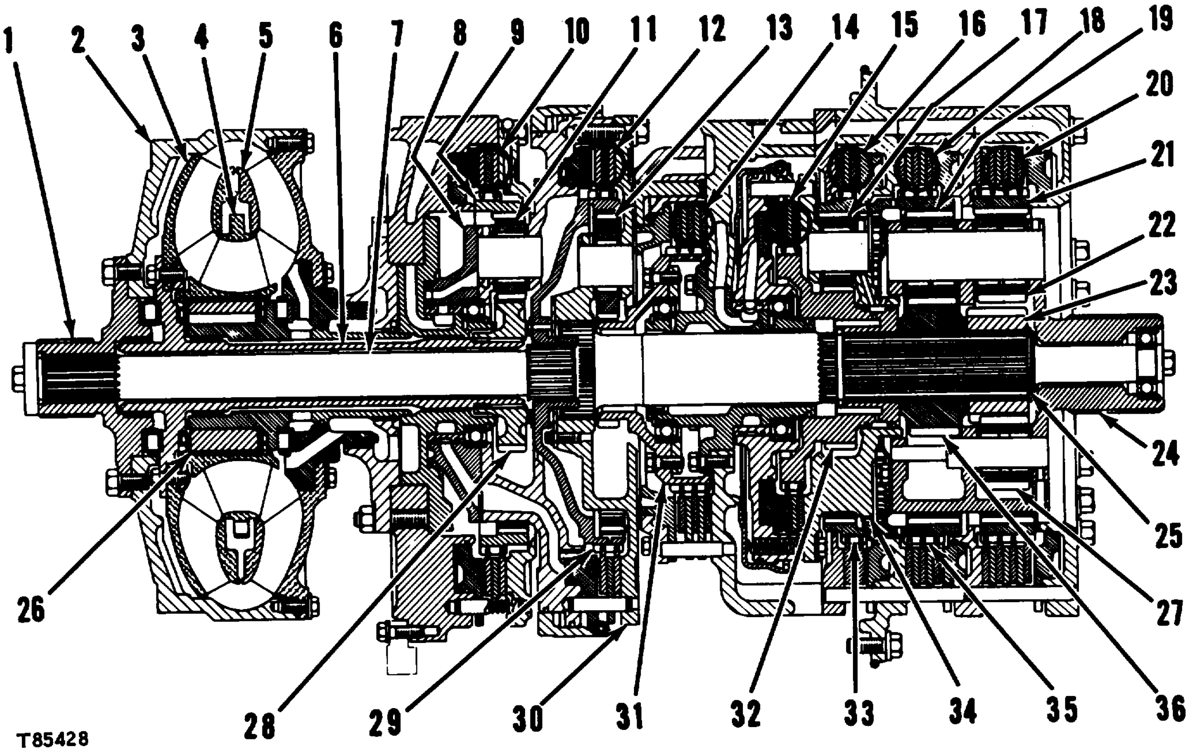
Reverse, First, and Second Speeds Forward

The output gear of the transfer gears turns input flange (1). The input flange turns housing (2) and impeller (3). The impeller directs the oil to the turbine blades. The oil from the impeller turns turbine (7). The turbine turns output hub (4). The turbine blades direct the oil to stator (8). The oil hitting the stator causes the stator to turn in the opposite direction of the turbine. The movement of the stator causes the balls of the one-way clutch to move between the stator and carrier for the stator. This action prevents the stator from turning. Since the stator is held by the one-way clutch, the stator directs some of the oil back to the impeller. The remainder of the oil goes out of the torque converter. The oil from the stator hits the impeller in the same direction the impeller is turning.

Third through Eighth Speeds

The output gear of the transfer gears turns input flange (1). The input flange turns housing (2) and impeller (3). The impeller directs the oil to the turbine blades. The oil from the impeller turns turbine (7). Since the ground speed of the machine is faster, the impeller is turning at a higher speed. The oil from the impeller causes the turbine to turn at a higher speed. As the speed of the turbine becomes faster, the oil from the turbine hits the back side of the stator blades. This action causes the stator to start to turn in the same direction as the turbine and impeller. As the stator starts to turn, the balls of the one-way clutch move from between the carrier for the stator and the stator. Since the stator is not held by the one-way clutch, the stator turns freely. The oil from the turbine is not directed back to the impeller. The torque converter is now a fluid coupling and no torque is sent through output hub (4). The input flange (1) turns transmission input shaft (5).

TRANSMISSION



TORQUE CONVERTER AND TRANSMISSION

1. Input flange of torque converter.
2. Turning housing.
3. Turbine.
4. Stator.
5. Impeller.
6. Output hub of torque converter.
7. Input shaft
8. No.1 carrier.
9. Ring gear for No.1 clutch.
10. No.1 clutch.
11. No.1 planetary gears.
12. No.2 clutch
13. No.2 planetary gears.
14. No.3 clutch.
15. No.4 clutch.
16. No.5 clutch.
17. No.5 planetary gears.
18. No.6 clutch.
19. No.6 planetary gears.
20. No.7 clutch.
21. Ring gear for No.7 clutch.
22. No.7 outer planetary gears.
23. No.7 sun gear.
24. No.6 and No.7 carrier and output shaft.
25. Shaft.
26. One-way clutch of stator.
27. No.7 inner planetary gears.
28. No.1 sun gear.
29. Ring gear for No.2 clutch.
30. No.2 carrier.
31. No.2 sun gear and No.3 ring gear.
32. No.4 ring gear and No.5 sun gear.
33. Ring gear for No.5 clutch.
34. No.5 carrier.
35. Ring gear for No.6 clutch.
36. No.6 sun gear.

The machine has a planetary transmission, which has eight forward speeds and one reverse speed. The selection of speed and direction is done manually. Control of the transmission is semiautomatic by hydraulic controls in third through eighth speeds FORWARD. Control of the transmission is manual by hydraulic controls in REVERSE, FIRST and SECOND speeds FORWARD. The transmission has seven clutches which are hydraulically activated. The transmission has two general sections.

...The front (planetary) section of the transmission has the No. 1, 2, and 3 clutches and No. 1 and 2 planetary carriers. The No. 1 clutch gives "converter speed." The No. 2 and No. 3 clutches give "direct drive" high and low speeds respectively. The No. 1 carrier, No. 2 clutch housing and No. 2 carrier are fastened together and turn as a unit.

The rear (planetary) section or the transmission has the No. 4, 5, 6 and 7 clutches and two planetary carriers. The No. 4, 5 and 6 are speed clutches. The No. 7 clutch gives reverse direction and has two sets of planetary gears. The No. 5 clutch has one carrier.

The No. 4 ring gear and No. 5 sun gear turns as a unit. The No. 5 carrier, No. 4 clutch housing and ring gear for No. 6 clutch are fastened together and turn as a unit.

The No. 6 and No. 7 planetary carrier is a single unit. The carrier is also the output of the transmission. Splines make the connection between the carrier and the differential. The No. 2 and No. 4 clutches and clutch housings turn.

The hydraulic system has control valves, filter and pumps. All these components are inside either the transmission case or the case of the transfer gear.

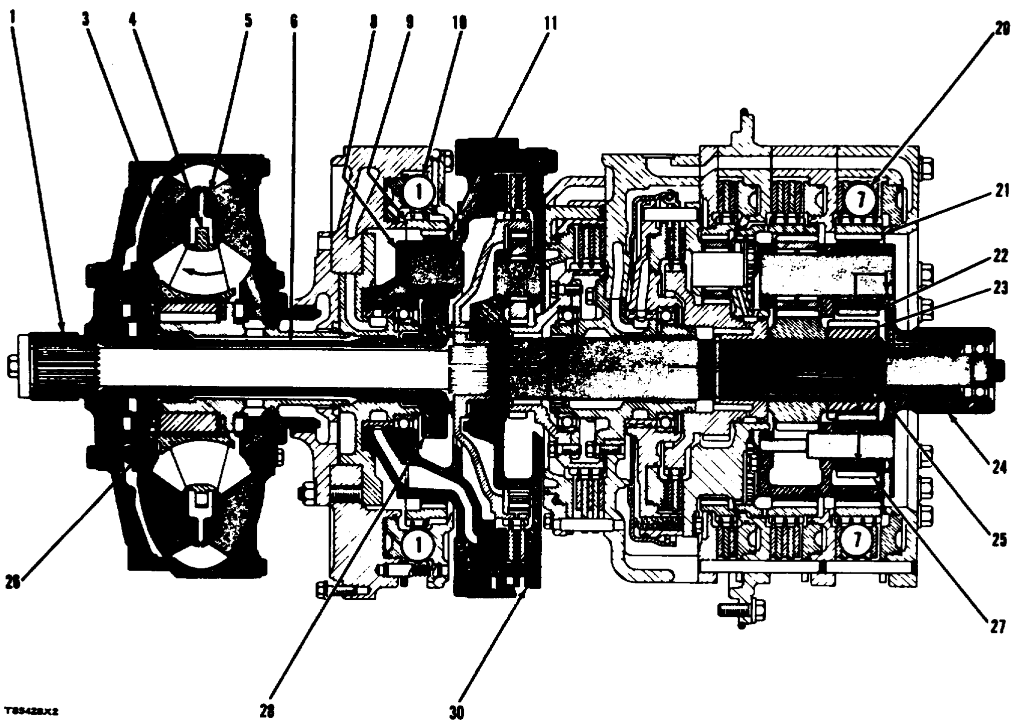
Oil lines outside the transmission are used for supply and return oil for the oil cooler for the transmission.

One clutch must be engaged in each planetary section for any speed before power will go through transmission.

Power from the diesel engine goes to the transmission through transfer gears. In "converter drive" (reverse, 1st, and 2nd speeds), the flow of power is through the torque converter to the front (planetary) section of the transmission. In "direct drive" (3rd through 8th speeds), the flow of power is through input shaft (7) to the front (planetary) section of the transmission.

The shaft (25) sends power to the rear (planetary) section of the transmission. The No. 6 and No. 7 carrier (24), which is also output shaft, sends power directly into the differential.

NOTE: In each of the illustrations that follow only the components which are turning and sending power have darker color. Circles are used to show the engaged clutch or clutches.



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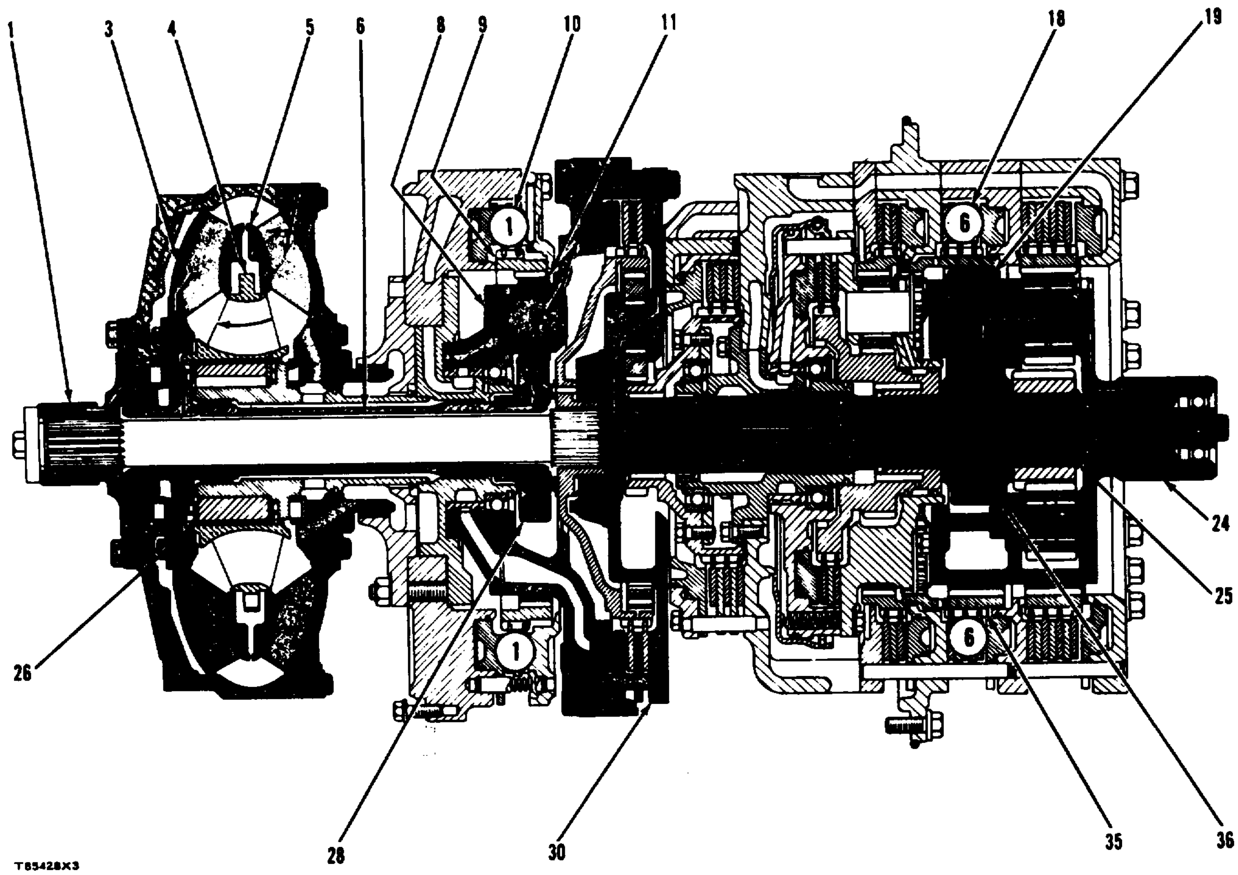
POWER FLOW IN REVERSE SPEED; No.1 and No.7 CLUTCHES ENGAGED

1. Input flange of torque converter. 3. Turbine. 4. Stator. 5. Impeller. 6. Output hub of torque converter. 8. No.1 carrier. 9. Ring gear for No.1 clutch. 10. No.1 clutch. 20. No.7 clutch. 21. Ring gear for No.7 clutch. 22. No.7 outer planetary gears. 23. No.7 sun gear. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 26. One way clutch of stator. 27. No.7 inner planetary gears. 28. No.1 sun gear. 30. No.2 carrier.

Power comes through torque converter flange (1) which causes impeller (5) to turn. Stator (4) does not turn because one-way clutch (26) is engaged. The oil from the impeller and stator turns turbine (3). Output hub (6) for torque converter turns because it is fastened to turbine (3). Splines connect output hub (6) to No. 1 sun gear (28). The output hub turns the No. 1 sun gear. The No. 1 sun gear turns planetary gears (11) for No. 1 carrier. Since the ring gear (9) for No. 1 clutch is held by the No. 1 clutch (10), the planetary gears (11) move around the inside of the ring gear. The movement of planetary gears causes No. 1 carrier (8), No. 2 clutch housing and No. 2 carrier (30) to turn. Splines connect No. 2 carrier (30) to shaft (25). The No. 2 carrier turns the shaft.

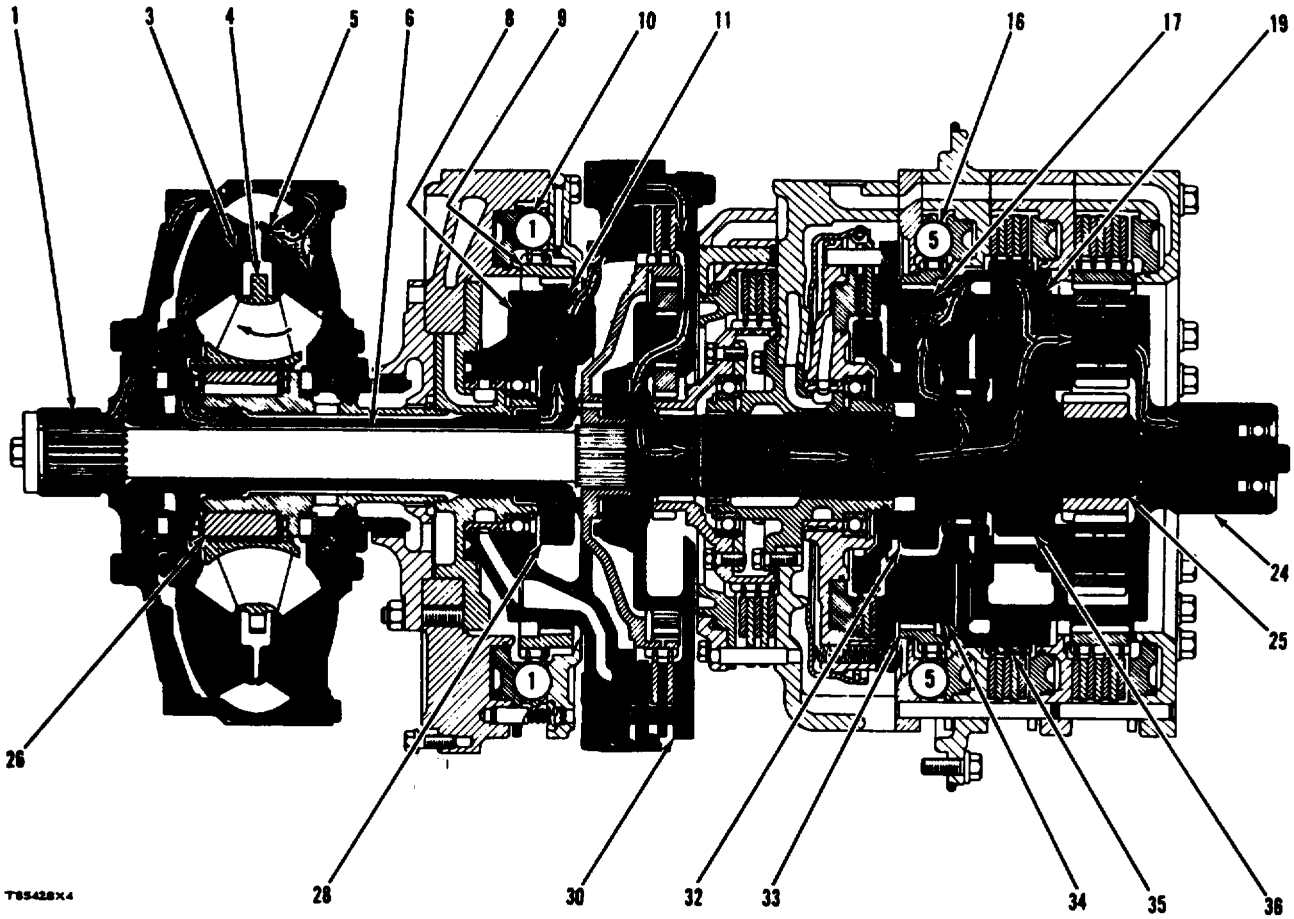
Splines connect shaft (25) to No. 7 sun gear (23). The shaft turns No. 7 sun gear. The No. 7 sun gear turns No. 7 planetary gears (22) and (27). Since ring gear (21) for No. 7. clutch is held by the No. 7 clutch, the planetary gears move around the inside of ring gear (21). The movement of No. 7 planetary gears (22) and (27) causes No. 6 and No. 7 carrier (24) to turn in the opposite direction of shaft (25). The No. 6 and No. 7 carrier is also the output shaft so the power goes to the differential.



POWER FLOW IN FIRST SPEED; No.1 and No.6 CLUTCHES ENGAGED

1. Input flange of torque converter. 3. Turbine. 4. Stator. 5. Impeller. 6. Output hub of torque converter. 8. No.1 carrier. 9. Ring gear for No.1 clutch. 10. No.1 clutch. 11. No.1 planetary gears. 18. No.6 clutch. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 26. One-way clutch of stator. 28. No.1 sun gear. 30. No.2 carrier. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

Power comes through torque converter flange (1) which causes impeller (5) to turn. Stator (4) does not turn because one-way clutch (26) is engaged. The oil from the impeller and stator turns turbine (3). Output hub (6) turns because it is fastened to turbine (3). Splines connect output hub (6) to No. 1 sun gear (28). The output hub turns the No. 1 sun gear. The No. 1 sun gear turns No. 1 planetary gears (11). Since ring gear (9) for the No. 1 clutch is held by the No. 1 clutch (10), planetary gears (11) move around the inside of the ring gear. The movement of the planetary gears causes No. 1 carrier (8), No. 2 carrier (30) and No. 2 clutch housing to turn. Splines connect shaft (25) to No. 2 carrier (30). The No. 2 carrier turns the shaft. Splines connect shaft (25) to No. 6 sun gear (36). The No. 6 sun gear turns No. 6 planetary gears (1-9). Since ring gear (35) for No. 6 clutch is held by the No. 6 clutch (18), planetary gears (19) move around the inside of the ring gear. The movement of the planetary gears causes No. 6 and No. 7 carrier (24) to turn. The No. 6 and No. 7 carrier is also the output shaft, so the power goes to the differential.

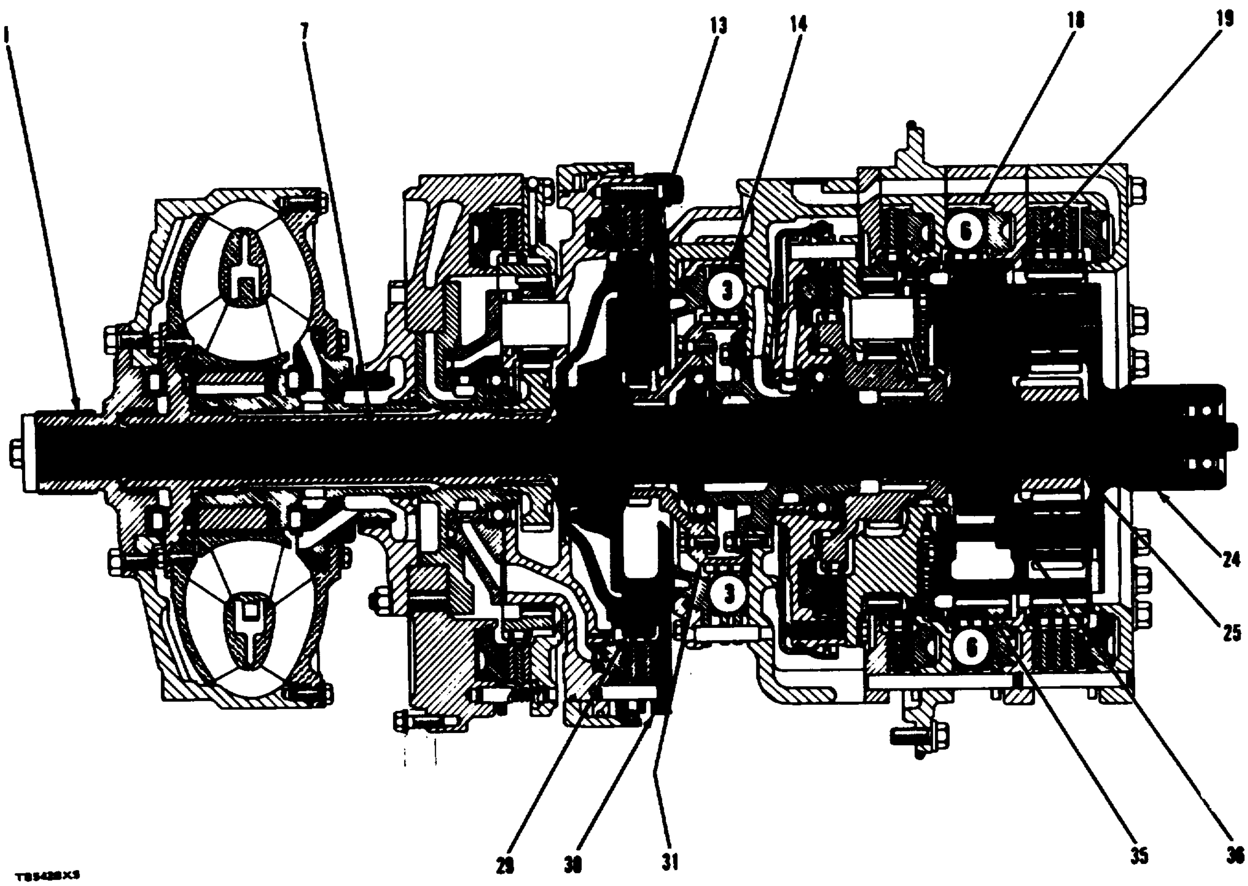


POWER FLOW IN SECOND SPEED; No.1 and No.5 CLUTCHES ENGAGED

1. Input flange of torque converter. 3. Turbine. , 4. Stator. 5. Impeller. 6. Output flange of torque converter. 8. No.1 carrier. 9. Ring gear for No.1 clutch. 10. No.1 clutch. 11. No.1 planetary gears. 16. No.5 clutch. 17. No.5 planetary gears. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 26. One-way clutch of stator. 28. No.1 sun gear. 30. No.2 carrier. 32. No.4 ring and No.5 sun gear. 33. Ring gear for No.5 clutch. 34. No.5 carrier. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

Power comes through torque converter flange (1) which causes impeller to turn. Stator (4) does not turn because one-way clutch (26) is engaged. The oil from the impeller and stator turns turbine (3). Output hub (6) turns because it is fastened to turbine (3). Splines connect output hub (6) to No. 1 sun gear (28). The output hub turns the No. 1 sun gear. The No. 1 sun gear turns No. 1 planetary gears (11). Since ring gear (9) for the No. 1 clutch is held by No. 1 clutch (10), planetary gears (11) move around the inside of the ring gear. The movement of the planetary gears causes No. 1 carrier (8), No. 2 clutch housing and No. 2 carrier (30) to turn. Splines connect shaft (25) to No. 2 carrier (30). The No. 2 carrier turns the shaft. Splines connect shaft (25) to No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). Shaft (25) turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). The torque is divided as No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36) turn. Since the ring gear (33) for No. 5 clutch is held by the No. 5 clutch (16), the No. 4 ring and No. 5 sun gear drives No. 5 planetary gears (17) and No. 5 carrier (34). Splines connect the No. 5 carrier to ring gear (35) for No. 6 clutch. The No. 5 carrier turns the ring gear for No. 6 clutch. No. 6 sun gear (36) turns No. 6 planetary gears (19). Since the ring gear (35) for No. 6 clutch is turning and No. 6 planetary gears (19) are turning, the No. 6 and No. 7 carrier (24) turns. The No. 6 and No. 7 carrier is also the output shaft, so the power goes to the differential.

THIRD SPEED

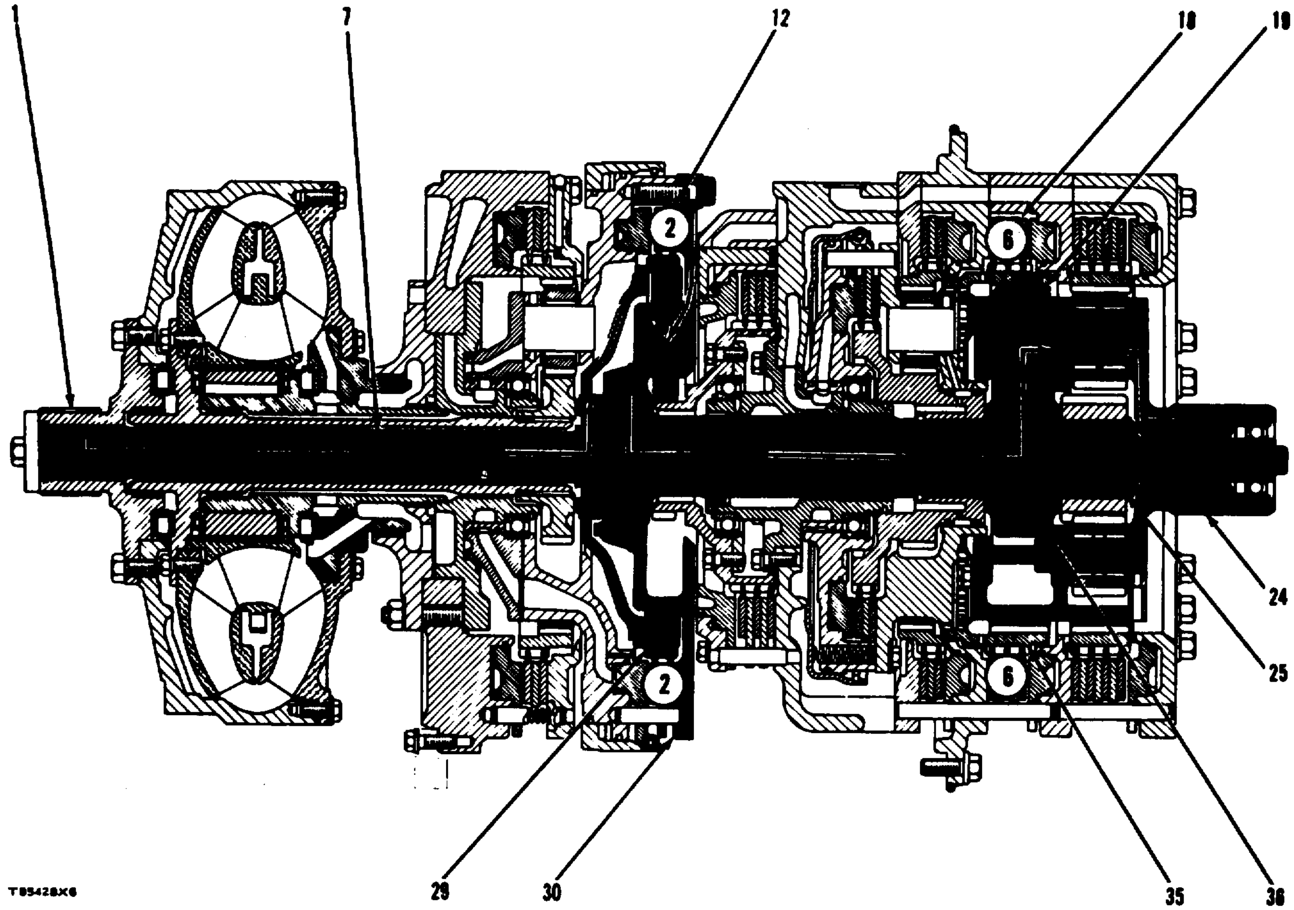


POWER FLOW IN THIRD SPEED; No.3 and No.6 CLUTCHES ENGAGED

1. Input flange of torque converter. 7. Input shaft. 13. No.2 planetary gears. 14. No.3 clutch. 18. No.6 clutch. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 29. Ring gear for No.2 clutch. 30. No.2 carrier. 31. No.2 sun and No.3 ring gear. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

Power comes into torque converter flange (1). Splines connect input shaft (7) to the torque converter flange. The flange turn the input shaft. The torque converter does not operate because the one-way clutch is not engaged. Splines connect input shaft to ring gear (29) for No. 2 clutch. The input shaft turns the ring gear for Nod clutch. Nod sun and No. 3 ring gear (31) does not turn because No. 3 clutch (14) is engaged. Since No. 2 sun and No. 3 ring gear (31) does not turn, ring gear (29) for No. 2 clutch turns No. 2 planetary gears (13). The movement of planetary gears (13) causes No. 2 carrier (30) to move around No. 2 sun and No. 3 ring gear (31). Splines connect shaft (25) to No. 2 carrier (30). The No. 2 carrier turns shaft (25). Splines connect No. 6 sun gear (36) to shaft (25). The shaft turns the No. 6 sun gear (36). The No. 6 sun gear turns No. 6 planetary gears (19). Since ring gear (35) for No. 6 clutch is held by No. 6 clutch (18), planetary gears (19) move around the inside of the ring gear (35) for No. 6 clutch. The movement of the planetary gears (19) causes No. 6 and No. 7 carrier (24) to turn. Since the No. 6 and No. 7 carrier is also the output shaft, the power goes to the differential.

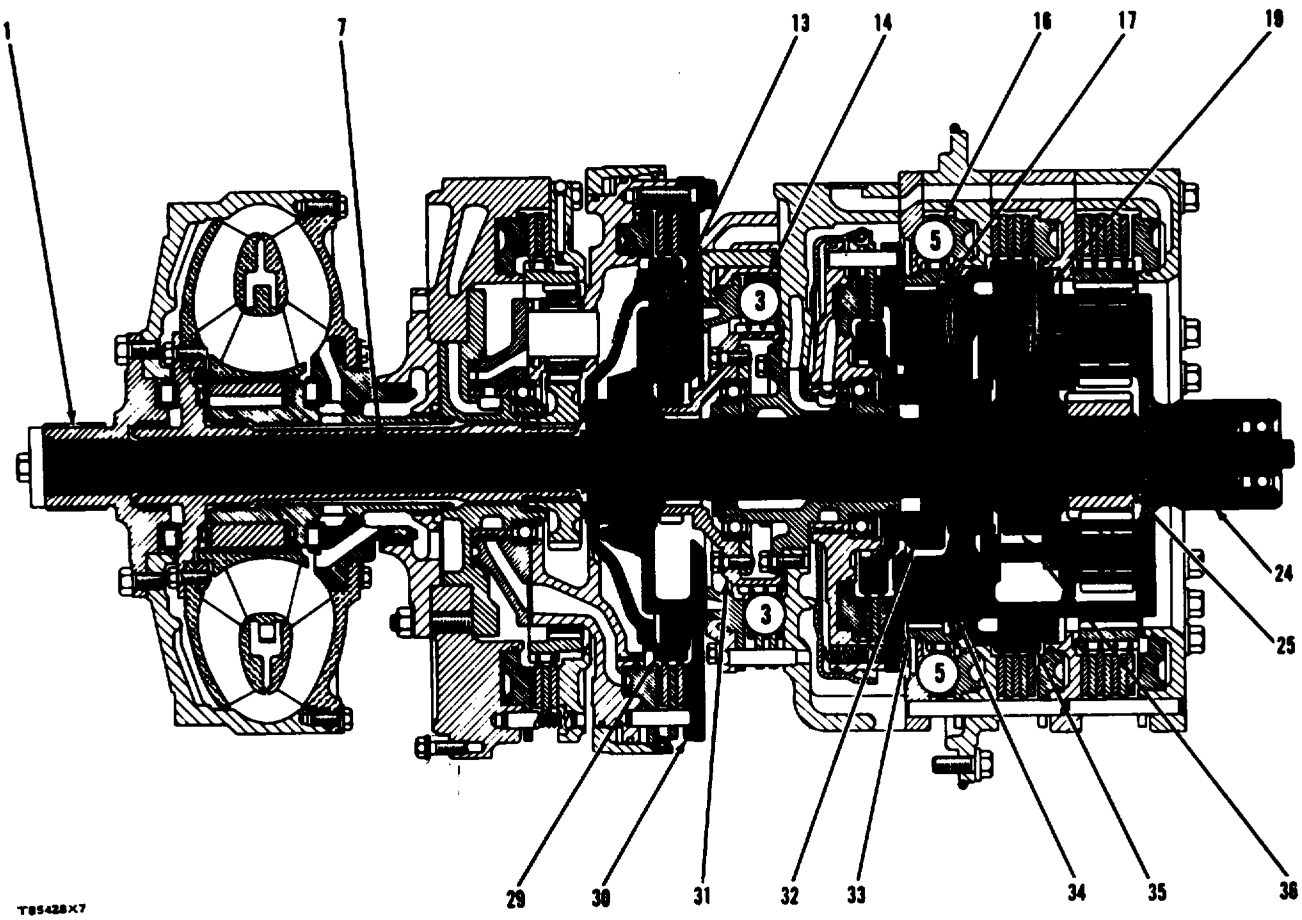
FOURTH SPEED



POWER FLOW IN FOURTH SPEED; No.2 and No.6 CLUTCHES ENGAGED

1. Input flange of torque converter. 7. Input shaft. 12. No.2 clutch. 18. No.6 clutch. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 29. Ring gear for No.2 clutch. 30. No.2 carrier. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

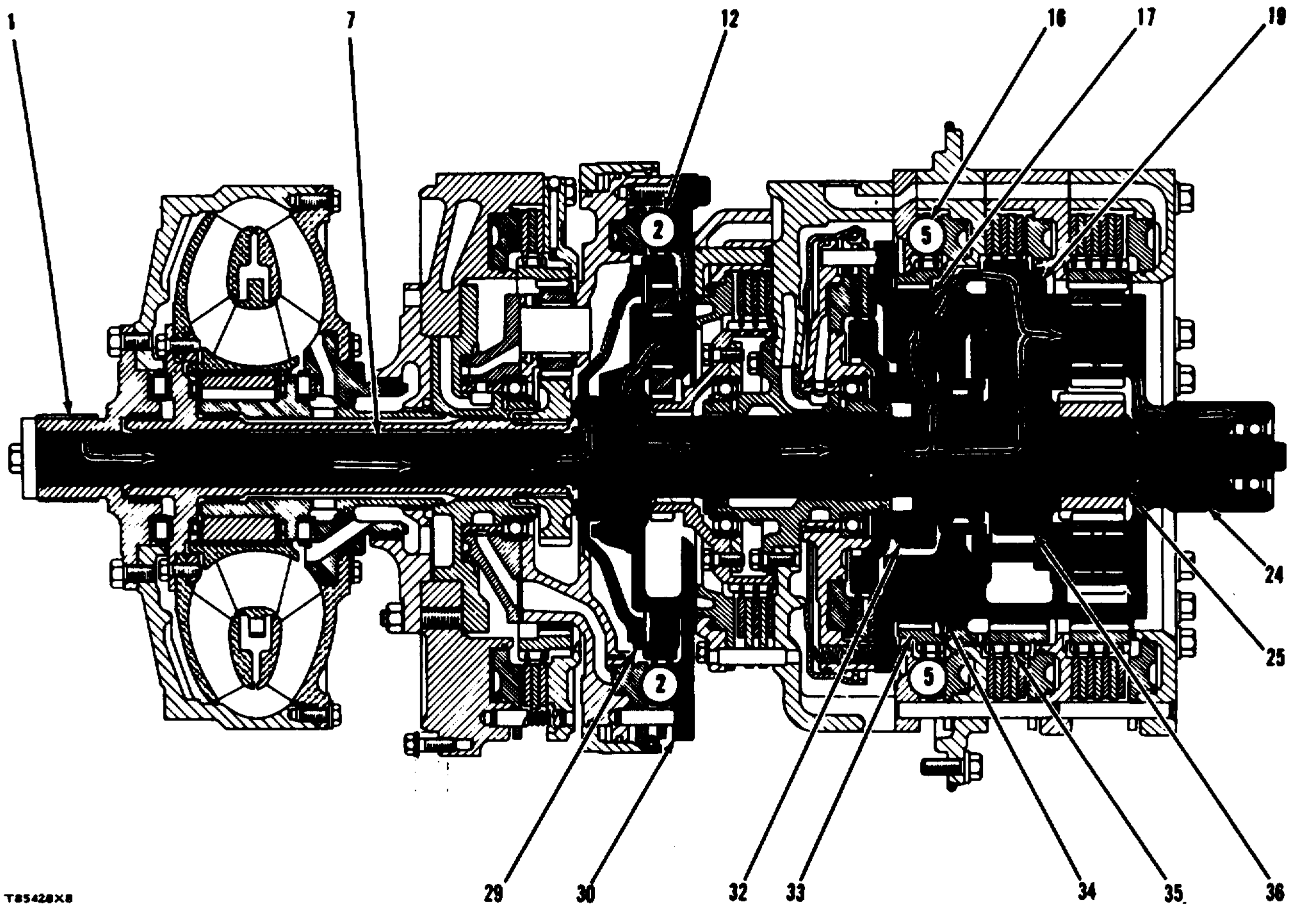
Power comes into torque converter flange (1). Splines connect input shaft (7) to the torque converter flange. The flange (1) turns the input shaft. The torque converter does not operate because the one-way clutch is not engaged. Splines connect input shaft to ring gear (29) for No. 2 clutch. The input shaft turns the ring gear. Because the ring gear is held by the No. 2 clutch, ring gear turns No. 2 clutch housing. The No. 2 clutch housing is connected to No. 2 carrier (30). Splines connect shaft (25) to the No. 2 carrier. The No. 2 carrier turns the shaft. Splines connect No. 6 sun gear (36) to shaft (25). The shaft turns the No. 6 sun gear (36). The No. 6 sun gear turns No. 6 planetary gears (19). Because ring gear (35) for No. 6 clutch is held by the No. 6 clutch (18), planetary gears (19) move around the inside of ring gear (35) for No. 6 clutch. The movement of planetary gears (19) causes No. 6 and No. 7 carrier (24) to turn. The No. 6 and No. 7 carrier is also the output shaft, so the power goes to the differential.



POWER FLOW IN FIFTH SPEED; No.3 and No.5 CLUTCHES ENGAGED

1. Input flange of torque converter. 7. Input shaft. 13. No.2 planetary gears. 14. No.3 clutch. 16. No.5 clutch. 17. No.5 planetary gears. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 29. Ring gear for No.2 clutch. 30. No.2 carrier. 31. No.2 sun and No.3 ring gear. 32. No.4 ring and No.5 sun gear. 33. Ring gear for No.5 clutch. 34. No.5 carrier. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

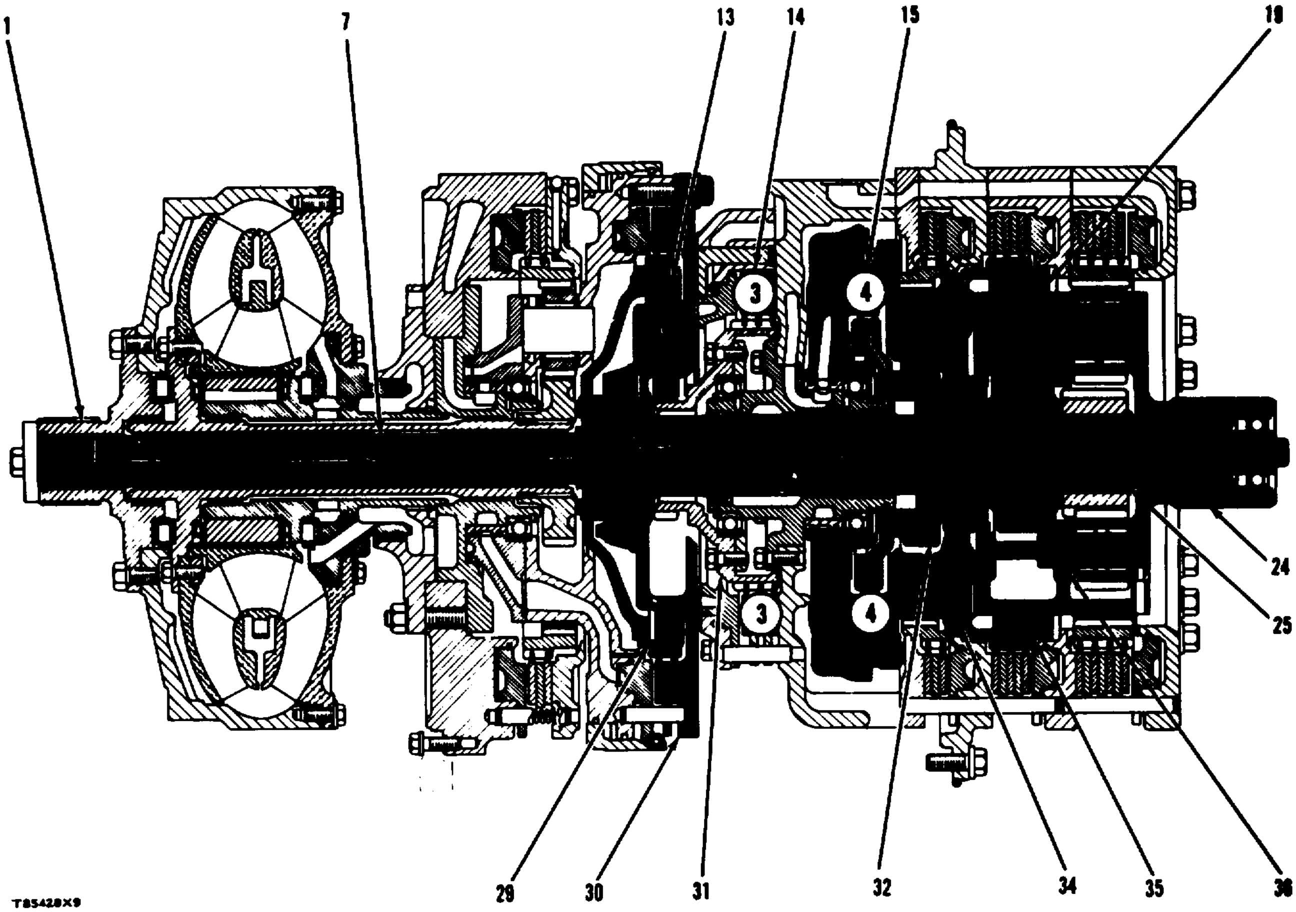
Power comes into torque converter flange (1). Splines connect input shaft (7) to the torque converter flange. The flange (1) turns the input shaft. The torque converter does not operate because the one-way clutch is not engaged. Splines connect input shaft to ring gear (29) for the No. 2 clutch. The input shaft turns the ring gear for the No. 2 clutch. No. 2 sun and No. 3 ring gear (13) does not turn because the No. 3 clutch is engaged. Since No. 2 sun and No. 3 ring gear does not turn, ring gear (29) for the No. 2 clutch turns No. 2 planetary gears (13). The movement of planetary gears (13) causes No. 2 carrier (30) to move around No. 2 sun and No. 3 ring gear (31). Splines connect shaft (25) to No. 2 carrier (30). The No. 2 carrier turns shaft (25). Splines connect shaft (25) to No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). Shaft (25) turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). The power flow is divided as No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear turn. Since ring gear (33) for No. 5 clutch is held by No. 5 clutch (16), the No. 4 ring and No. 5 sun gear turns No. 5 planetary gears (17) and No. 5 carrier (34). Splines connect the No. 5 carrier to ring gear (35) for the No. 6 clutch. The No. 5 carrier turns ring gear for the No. 6 clutch. No. 6 sun gear (36) turns No. 6 planetary gears (19). Since ring gear (35) for the No. 6 clutch is turning and No. 6 planetary gears (19) are turning, the No. 6 and No. 7 carrier turns. The No. 6 and No. 7 carrier is also the output shaft, so the power goes to the differential.



POWER FLOW IN SIXTH SPEED; No.2 and No.5 CLUTCHES ENGAGED

1. Input flange of torque converter. 7. Input shaft. 12. No.2 clutch. 16. No.5 clutch. 17. No.5 planetary gears. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 29. Ring gear for No.2 clutch. 30. No.2 carrier. 32. No.4 ring and No.5 sun gear. 33. Ring gear for No.5 clutch. 34. No.5 carrier. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

Power comes into torque converter flange (1).Splines connect input shaft (7) to the torque converter flange. The flange (1) turns the input shaft. The torque converter does not operate because the one-way clutch is not engaged. Splines connect input shaft to ring gear (29) for the No. 2 clutch. The input shaft turns the ring gear. Because ring gear (29) for the No. 2 clutch is held by No. 2 clutch (12), the ring gear turns the No. 2 clutch housing. The No. 2 clutch housing is connected to No. 2 carrier (30). The No. 2 clutch housing turns the No. 2 carrier. Splines connect shaft (25) to the No. 2 carrier. No. 2 carrier turns the shaft. Splines connect No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36) to shaft (25). The shaft turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). The power flow is divided as the shaft turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). No. 4 ring and No. 5 sun gear (32) turns No. 5 planetary gears (17). Since ring gear (33) for the No. 5 clutch is held by No. 5 clutch (16), No. 5 planetary gears (17) move around the inside of ring gear (33) for the No. 5 clutch. The movement of planetary gears (17) causes No. 5 carrier (34) to turn. No. 5 carrier (34) is connected to ring gear (35) for the No. 6 clutch. The No. 5 carrier turns the ring gear for the No. 6 clutch. No. 6 sun gear (36) turns No. 6 planetary gears (19). Since ring gear (35) for the No. 6 clutch is turning and No. 6 planetary gears (19) are turning, the No. 6 and No. 7 carrier (24) turns. Since the No. 6 and No. 7 carrier is also the output shaft, the power goes to the differential.

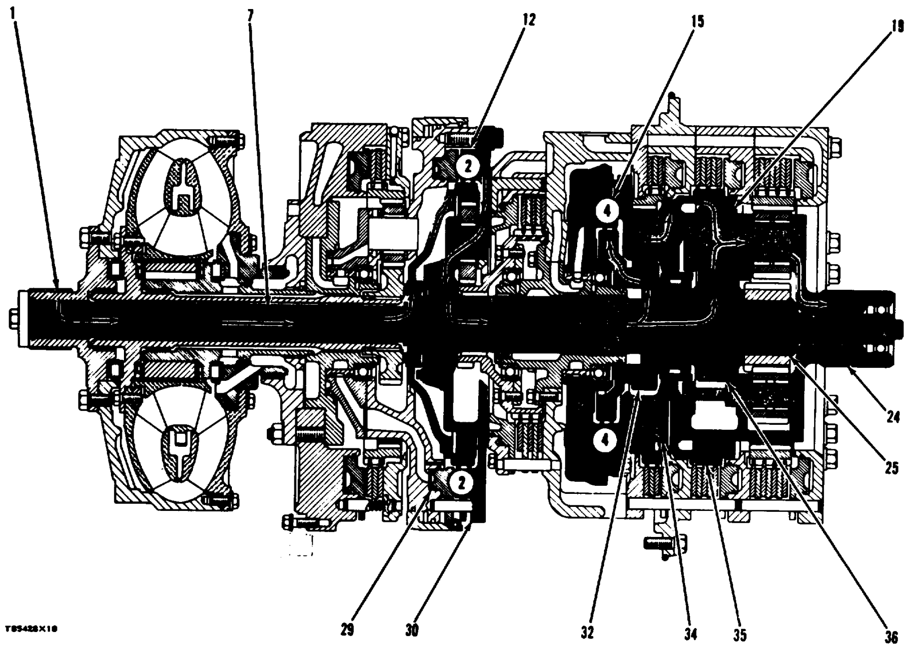


POWER FLOW IN SEVENTH SPEED; No.3 and No.4 CLUTCHES ENGAGED

1. Input flange of torque converter. 7. Input shaft. 13. No.2 planetary gears. 14. No.3 clutch. 15. No.4 clutch. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 29. Ring gear for No.2 clutch. 30. No.2 carrier. 31. No.2 sun and No.3 ring gear. 32. No.4 ring and No.5 sun gear. 34. No.5 carrier. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

Power comes into torque converter flange (1). Splines connect input shaft (7) to the torque converter flange. The flange (1) turns the input shaft. The torque converter does not operate because the one-way clutch is not engaged. Splines connect input shaft to ring gear (29) for the No. 2 clutch. The input shaft turns the ring gear for the No. 2 clutch. No. 2 sun and No. 3 ring gear (31) does not turn because No. 3 clutch (14) is engaged. Since No. 2 sun and No. 3 ring gear (31) does not turn, ring gear (29) for No. 2 clutch turns No. 2 planetary gears (13). The movement of planetary gears (13) causes No. 2 carrier (30) to move around No. 2 sun and No. 3 ring gear (31). Splines connect No. 2 carrier (30) to shaft (25). The No. 2 carrier turns the shaft. Splines connect No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36) to shaft (25). The shaft turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). The power flow is divided as the shaft turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). Since No. 4 clutch (15) is engaged, the No. 4 ring and No. 5 sun gear turns the No. 4 clutch housing. The No. 4 clutch housing is connected to No. 5 carrier (34). The No. 4 clutch housing turns the No. 5 carrier. Since the No. 5 carrier is connected to ring gear (35) for the No. 6 clutch, the ring gear for the No. 6 clutch turns. The No. 6 sun gear (36) turns No. 6 planetary gears (19). Since ring gear (35) for the No. 6 clutch is turning and No. 6 planetary gears (19) are turning, No. 6 and No. 7 carrier (24) turns. Since the No. 6 and No. 7 carrier is also the output shaft, the power goes to the differential.

EIGHTH SPEED



POWER FLOW IN EIGHTH SPEED; No.2 and No.4 CLUTCHES ENGAGED

1. Input flange of torque converter. 7. Input shaft. 12. No.2 clutch. 15. No.4 clutch. 19. No.6 planetary gears. 24. No.6 and No.7 carrier and output shaft. 25. Shaft. 29. Ring gear for No.2 clutch. 30. No.2 carrier. 32. No.4 ring and No.5 sun gear. 34. No.5 carrier. 35. Ring gear for No.6 clutch. 36. No.6 sun gear.

Power comes into torque converter flange (1). 8plines connect input shaft (7) to the torque converter flange. The flange turns the input shaft. The torque converter does not operate because the one-way clutch is not engaged. Splines connect input shaft to ring gear (29) for No. 2 clutch. Since the ring gear (29) for No. 2 clutch is held by No. 2 clutch (12), the ring gear turns the No. 2 clutch housing. The No. 2 clutch housing is connected to No. 2 carrier (30). The No. 2 clutch housing turns No. 2 carrier (30). Splines connect shaft (25) to the No. 2 carrier. The No. 2 carrier turns the shaft. Splines connect No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36) to shaft (25). Shaft (25) turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). The power flow is divided as the shaft turns No. 4 ring and No. 5 sun gear (32) and No. 6 sun gear (36). Since No. 4 clutch (15) is engaged, the No. 4 ring and No. 5 sun gear turns the No. 4 clutch housing. The No. 4 clutch housing is connected to No. 5 carrier (34). The No. 4 clutch housing turns the No. 5 carrier (34). Splines connect the No. 5 carrier to ring gear (35) for the No. 6 clutch. The No. 5 carrier turns the ring gear for the No. 6 clutch. No. 6 sun gear (36) turns No. 6 planetary gears (19). Since the ring gear (35) for the No. 6 clutch is turning and No. 6 planetary gears (19) are turning, the No. 6 and No. 7 carrier (24) turns. Since the No. 6 and No. 7 carrier is also the output shaft, the power goes to the differential.

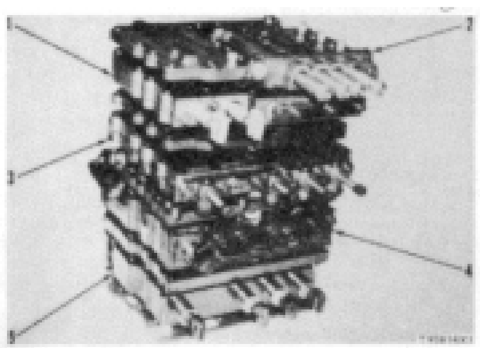
TRANSMISSION HYDRAULIC CONTROLS

The hydraulic controls give both manual and semiautomatic shifts to the power shift transmission. The selection of REVERSE, NEUTRAL, FIRST and SECOND speeds is done manually. The selection of THIRD through EIGHTH speeds is automatic as a result of the position of the selection lever for the transmission and the speed of the output shaft. The semiautomatic controls will not cause the transmission to go into a higher speed (upshift) than the position of the selection lever for the transmission. The controls will automatically make shifts down (downshift). Automatic downshifts stop at SECOND speed.

The hydraulic controls are divided into two groups:

...A semiautomatic control group that has a valve group (2) for governor cut-off, valve group (1) for automatic selection of speed, control group (3) for shift pressure, and a hydraulic governor.

...A control group for the transmission that has a valve group (4) for speed selection and a valve group (5) for pressure control.

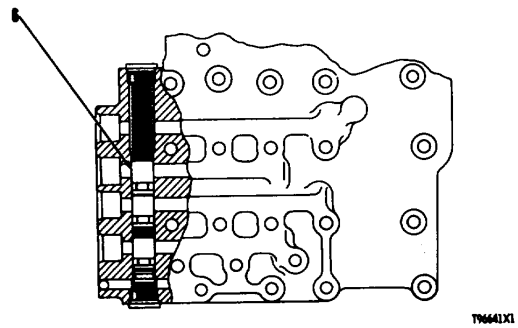


TRANSMISSION HYDRAULIC CONTROLS

1. Valve group for automatic selection of speed. 2. Valve group for governor cut-off. 3. Control group for shift pressure. 4. Valve group for speed selection. 5. Valve group for pressure control.

VALVE GROUP FOR GOVERNOR CUT-OFF

Valve (6) for governor cut-off is in the top cover and manifold for the hydraulic controls. The valve stops the signal of the oil pressure from the governor to the valve group for automatic selection of speed during shifts. This prevents the hydraulic controls from rapidly going from one speed to another (hunting).

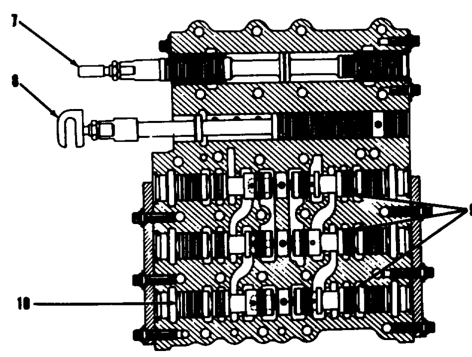


VALVE GROUP FOR GOVERNOR CUT-OFF

6. Valve for governor cut-off.

VALVE GROUP FOR AUTOMATIC SELECTION OF SPEED

The valve group (1) for automatic selection of speed is directly below the top cover and manifold.
This group has a hydraulic shift spool (7), manual selection spool (8), and six automatic selection spools (9) with six slugs (10) that hold spools (9).



VALVE GROUP FOR AUTOMATIC SELECTION OF SPEED

7. Hydraulic shift spool. 8. Manual selection spool. 9. Automatic selection spools (six). 10. Slugs (six).

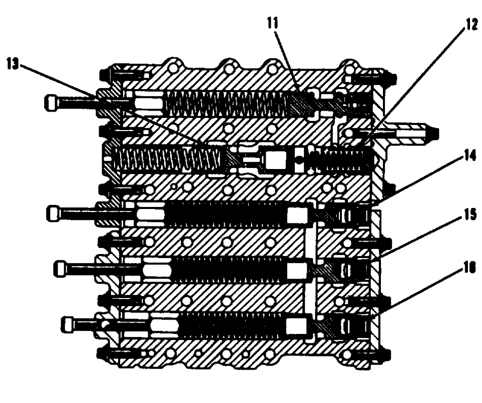
Hydraulic shift spool (7) is fastened, with linkage, to the valve group (4) for speed selection. Hydraulic force moves the spool and causes the transmission to make a shift in both the manual and automatic speeds.

Manual selection spool (8) is fastened, with linkage, to the selection lever for the transmission at the operator's console. It makes a selection, by operator choice, of all manual speeds. It also prevents upshifts of the transmission higher than the position of the selection lever. As an example: The operator moves the selection lever to the 6th speed. Upshifts are made, as the machine speed increases, from 2nd to 3rd, 3rd to 4th, 4th to 5th, and 5th to 6th speeds, but no higher.

Automatic selection spools (9), get constant "reference" pressures from the control group (3) for shift pressure and make a balance of these pressures against the pressure changes from the hydraulic governor. Upshifts and downshifts are automatic when automatic selection spools (9) open and/or close the openings to hydraulic shift spool (7). Slugs (10), at one end of each automatic selection spool (9), prevent movement of the spools and an automatic upshift of the transmission to a higher speed than the position of the transmission selection lever.

CONTROL GROUP FOR SHIFT PRESSURE

The control group (3) for shift pressure has a priority valve (13), a piston (12) for the hold valve, a downshift reduction valve (11), and three upshift reduction valves (14), (15) and (16).



CONTROL GROUP FOR SHIFT PRESSURE

11. Downshift reduction valve. 12. Piston for hold valve. 13. Priority valve. 14. Upshift reduction valve (2nd to 3rd speed upshift). 15. Upshift reduction valve (3rd to 4th, 5th to 6th and 7th to 8th speed upshifts). 16. Upshift reduction valve (4th to 5th and 6th to 7th speed upshifts).

Priority valve (13) sends pressure oil at approximately 125 psi (8.8 kg/cm2) to the semiautomatic controls before any oil goes to the remainder of the system.

Piston (12) for the hold valve is activated by air pressure when the transmission hold pedal, in the operator's compartment, is pushed down: When the pedal is pushed down, the transmission is held in the speed in which it is engaged.

Downshift reduction valve (11) keeps the pressure from getting higher than approximately 125 psi (8.8 kg/cm2) in the semiautomatic controls. This valve also sends pressure oil to the reduction valve spools of the hydraulic governor. It also controls when the transmission is to downshift. Adjustment of valve (11) has an effect on the downshift points of the transmission.

Upshift reduction valves (14), (15) and (16) cause the constant "reference" pressures that work against the pressure changes from the governor at the automatic selection spools (9). Valve (14) makes "reference" pressure available for the automatic upshift from 2nd to 3rd speeds. Valve (15) makes "reference" pressure available for the automatic upshifts for the following speeds: 3rd to 4th, 5th to 6th and 7th to 8th. Valve (16) makes "reference" pressure available for the automatic upshifts for 4th to 5th speed and 6th to 7th speed. Adjustment of valves (14), (15) and (16) has an effect on the upshift points of the transmission.

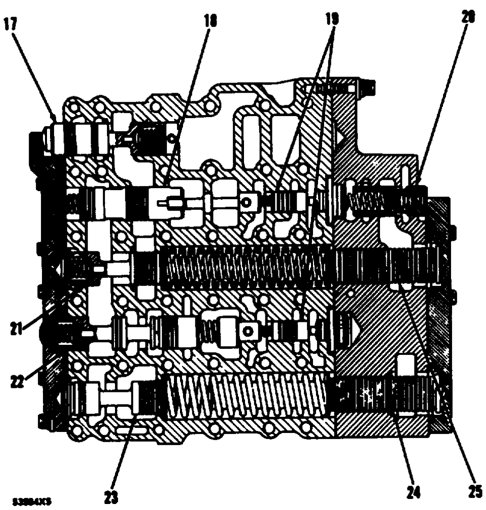
VALVE GROUP FOR SPEED SELECTION

Valve group (5) for speed selection is installed on the clutch housings. A manifold is between valve group (4) and clutch housings. Valve group (5) has four selection spools. The spools are connected to hydraulic shift spool (7) by linkage. The hydraulic shift spool moves the spools. The movement of the spools directs oil through the manifold to the clutches. The position of the spools determine the speed of the transmission.

VALVE GROUP FOR PRESSURE CONTROL

Valve group (4) for pressure control is installed on valve group (5). The following list gives a description of the functions of the valves in the valve group for pressure control:

VALVE	FUNCTION
Relief valve for the inlet to the torque converter (17)	Keeps the pressure in the torque converter from going over 132 psi (9.3 kg/cm2).
Flow control valve (18)	Keeps 15 US. gpm (56.8 lit/min) available to fill the clutches.
Relief valve (20) for load piston (25).	Controls how far the load piston can move.
Modulation relief valve (21)	Keeps the system pressure at a maximum of 410 psi (28.8 kg/cm2).
Safety valve (22)	Keeps oil flow from going to the selection valve if the machine is started in any speed except neutral.
Modulation reduction valve (23)	Controls the increase in pressure in the No. 1, No. 2 and No. 3 clutches.
Load pistons (24) and (25)	Controls the modulation of pressures for the modulation relief valve and the modulation reduction valve.
Check valves (19)	Opens a return passage to release the pressure from behind the load pistons



VALVE GROUP FOR PRESSURE CONTROL

17. Relief valve for inlet to the torque converter. 18. Flow control valve. 19. Check valves. 20. Relief valve for the load piston. 21. Modulation relief valve. 22. Safety valve. 23. Modulation reduction valve. 24. Load piston. 25. Load piston.

HYDRAULIC GOVERNOR

The governor is fastened to the case for the transfer gears. The governor is connected to the output shaft of the transmission by a shaft that goes through the shafts of the transmission. The governor has three valves inside the governor housing. Each valve has a different weight. As, the rpm of the output shaft becomes higher, the valves move away from the center of the governor housing. As the rpm of the output shaft becomes lower, the valves move back toward the center of the governor housing. Since the valves are of a different weight, the valves move at different rpms of the output shaft.

As each valve moves away from the center of the housing, it starts to open a passage to let pressure oil go the inner ends of automatic selection spools (9). As the pressure makes an increase, it causes the hydraulic controls of the transmission to make upshifts. As each valve moves toward the center of the housing, it starts to close the passage to the inner ends of automatic selection spools (9). As the pressure makes a decrease, it causes the hydraulic controls of the transmission to make downshifts.

Since the rpm of the output shaft controls the ground speed of the machine, as the machine goes faster the transmission makes upshifts. As the machine goes slower, the transmission makes downshifts.

SEMIAUTOMATIC CONTROLS OPERATION

When the machine is started in NEUTRAL, oil goes from reservoir (38), through oil pump (29), oil filter (28) and line (10) into control group for shift pressure (1) and manual selection spool (11).

Oil goes by downshift reduction valve (2) to priority valve (5). The priority valve keeps the pressure in the control group for shift pressure to approximately 120 psi (8.4 kg/cm2) before letting oil go through line (27) to valve group for pressure control (40). The oil to manual selection spool (11) is stopped by the spool if it is in REVERSE, NEUTRAL or FIRST speed positions.

Downshift reduction valve (2) sends oil at approximately 90 to 100 psi (6.3 to 7.0 kg/cm2) to hydraulic shift spool (9), upshift reduction valves (14, 19 and 23) and through governor cut-off valve (18) to governor reduction valves (7, 16 and 17).

Upshift reduction valves (14, 19 and 23) send "reference" pressures to the automatic selection spools in valve group for automatic selection of speed (4).

Valve (14) gives a "reference" pressure of approximately 35 psi (2.5 kg/cm2). This reference pressure is sent between slug (24) and the outer end of automatic selection spool (13). Governor reduction valve (17) sends a pressure to the inner end of automatic selection spool (13). The pressure from governor reduction valve (17) is controlled by the ground speed of the machine. The "reference" pressure from valve (14) works against the pressure from governor reduction valve (17). As the ground speed of the machine becomes faster, governor reduction valve (17) starts to move out and send more pressure oil to the inner end of automatic selection spool (13). When the manual selection spool (11) is in a position to make an upshift and the pressure from governor reduction valve (17) is higher than the "reference" pressure from valve (14), the pressure from valve (17) will cause automatic selection spool (13) and it’s slug (24) to move completely to the right. The movement of the automatic selection spool causes the transmission to make an upshift. The 2nd to 3rd speed upshift is controlled by valve (14).

Valve (19) gives a "reference" pressure of approximately 74 psi (5.2 kg/cm2). This "reference" pressure is sent between slugs (24) and the outer ends of automatic selection spools (21, 22 and 25). Governor reduction valves (7, 16 and 17) send pressures, at different rates, to the inner ends of automatic selection spools (12, 22 and 25). The pressures from governor reduction valves (7, 16 and 17) are controlled by the ground speed of the machine. The "reference" pressure from valve (19) works against the pressures from governor reduction valves (7, 16 and 17). As the ground speed of the machine becomes faster, governor reduction valves (7, 16 and 17) start to move out and send more pressure oil to the inner ends of automatic selection spools (12, 22 and 25). When spool (11) is in a position to make an upshift and the pressures from governor reduction valves (7, 16 and 17) are higher than the "reference" pressure from valve (19), the pressures from the reduction valves will cause either spool (12) or (22) or (25) to move. The movement of the automatic selection spools causes the transmission to make upshifts. The upshifts controlled by valve (19) are: 3rd to 4th, 5th to 6th and 7th to 8th speeds.

Valve (23) gives a "reference" pressure of approximately 41 psi (2.9 kg/cm2). This "reference" pressure is sent between slugs (24) and the outer ends of automatic selection spools (21 and 26). Governor reduction valves (7 and 16) send pressures, at different rates, to the inner ends of automatic selection spools (21 and 26). The pressures from governor reduction valves (7 and 16) are controlled by the ground speed of the machine. The "reference" pressure from valve (23) works against the pressures from governor reduction valves (7 and 16). As the ground speed of the machine becomes faster, governor reduction valves (7 and 16) start to move out and send more pressure oil to the inner ends of automatic selection spools (21 and 26). When spool (11) is in a position to make an upshift and the pressures from governor reduction valves (7 and 16) are higher than the "reference" pressure from valve (23), the pressures from the reduction valves will cause either spool (21) or (26) to move. The movement of the automatic selection spools causes the transmission to make upshifts. The upshifts controlled by valve (23) are: 4th to 5th and 6th to 7th speeds.

During shifts, when the system pressure of the transmission controls goes below 200 psi (14.1 kg/cm2), spring pressure moves governor cut-off valve (18) to stop any pressure coming from the governor. The lower pressure is felt through line (20). This action prevents shifts that are not desired and gives a delay in time which lets the clutches go to full pressure for operation between each shift of the transmission, both up and down.

Movement of manual selection spool (11) puts the controls in REVERSE, NEUTRAL and FIRST speeds by opening passages (R, N or 1) in body (4), to let the oil out through the end of spool (11). Pressure oil from downshift reduction valve (2) then moves hydraulic shift spool (9) to close passages (R, N or 1) at spool (9). Hydraulic shift spool (9) is connected to selection spools (45). The movement of hydraulic shift spool (9) then causes the transmission to make a shift.

Any movement of manual selection spool (11) to 2nd speed or higher puts the controls in the automatic range by opening line (10) to manual selection spool (11). If selection spool (11) is in 2nd speed position, the hold passages (2H through 7H), in body (4) are open to the system pressure. The pressure is approximately 450 psi (31.6 kg/cm2) in 2nd speed. The pressure is approximately 350 psi (24.6 kglcm2) in 3rd through 8th speeds. Connection of the hold passages (2H through 7H) is through inside passages (not shown) to the outer ends of slugs (24). When slugs (24) move to hold the automatic selection spools against the inner stops, there is no automatic shift to a speed higher than the speed position of spool (11). Each time the transmission selection lever is moved to the next higher speed, spool (11) opens another passage to let the oil out. When the pressure from the governor reduction valves becomes higher than "reference" pressure, the controls are then in a position to make the next speed available.

A passage in body (4) from hydraulic shift spool (9) is common to a slug chamber in each automatic selection spool. Passage (2) at automatic selection spool (13) is common to passage (2) at hydraulic shift spool (9). When a shift is made from 1st to 2nd speed, manual selection spool (11) opens passage (2) to let oil out the end of the spool. Opening passage (2) causes the downshift reducing oil at hydraulic shift spool (9) to move the spool to the left until it's land covers passage (2). Passage (2) is kept open until a shift is made from 2nd to 3rd speed.

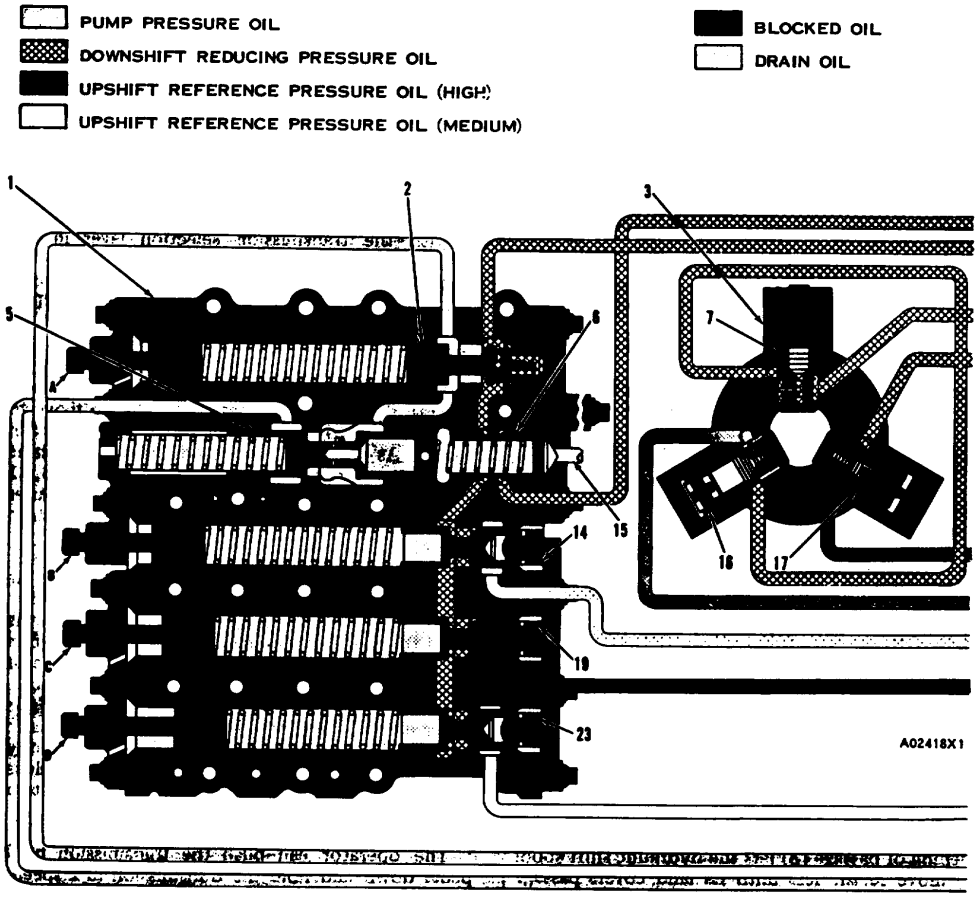
When the shift to 3rd speed is made, manual selection spool (11) opens passage (2H) to let oil out the end of the spool. Automatic selection spool (13) and it's slug (24) move to the right. This opens passage (3) and closes passage (2). The opening of passage (3) lets the hydraulic shift spool (9) move to the left until its land covers passage (3). The shift to 3rd speed is then made. As the shift is made from 2nd to 3rd speed, pressure oil from the downshift reduction valve is opened to passage (2) at hydraulic shift spool (9). This pressure works in the slug chamber of automatic selection spool (13) to hold spool (13) and it's slug (24) to the right against the stop. This pressure, plus governor pressure from the governor reduction valves, gives the necessary time between upshifts and downshifts.

If the transmission selection lever is in 8th speed, the hold passages and the passages common to all automatic selection spools are open to let the oil out by selection spool (11). The connections between passages (3 through 8) and the chambers at spools (13, 22, 26, 25, 21 and 12), in that order, are made inside body (4) for spool (9) (these passages are not shown on the schematic).

With the transmission selection lever in 8th speed position, there is an upshift from 3rd to 4th speed when the pressure from governor reduction valve (17) moves spool (22) to the right. This opens passage (4) to let the oil out. Oil from passage (3) is then kept in the slug chamber at the end of spool (22). As the ground speed of the machine becomes faster, pressure from governor reduction valve (16) causes spool (26) to move to the right and there is an upshift from 4th to 5th speed. As the ground speed of the machine becomes faster, automatic selection spools (25, 21 and 22), in that order, move to the left. This causes the upshifts from 5th to 6th, 6th to 7th and 7th to 8th speeds.

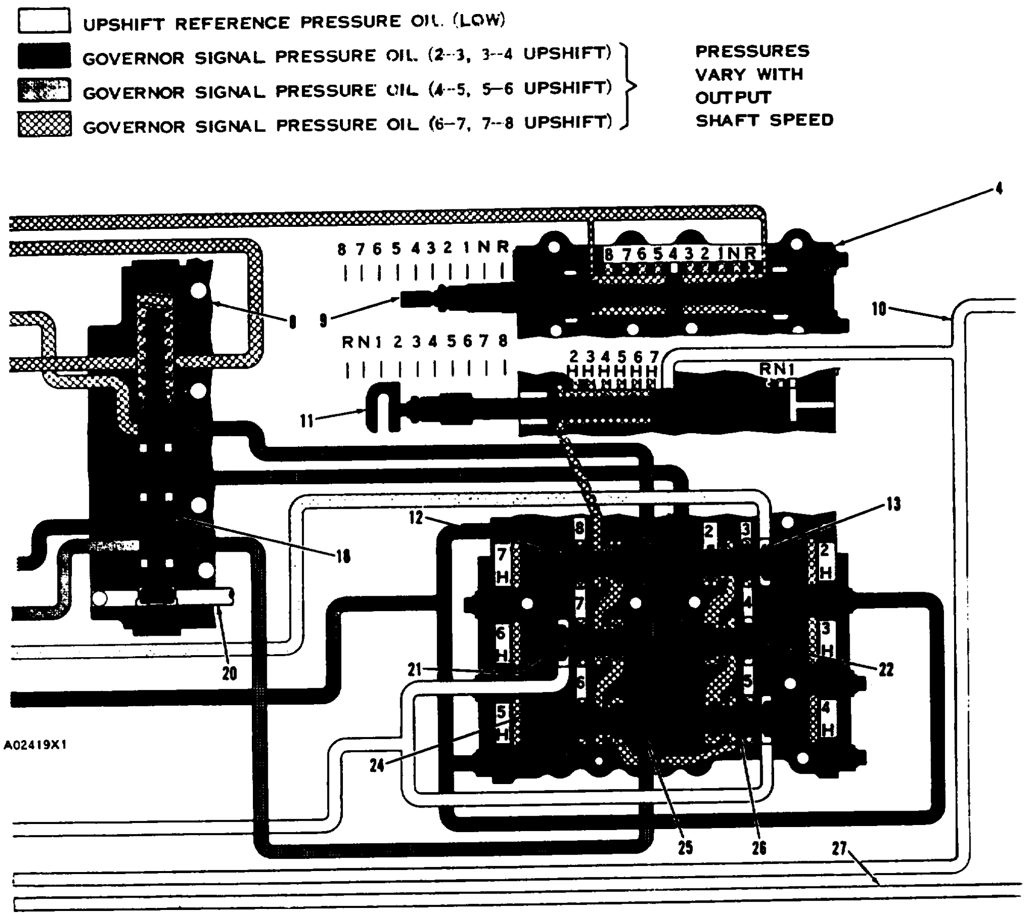
Downshift reduction valve (2) causes all of the six downshifts. Each downshift is made as the speed of the output shaft becomes slower to the point that governor pressure, to the inner end of an automatic selection spool, plus the oil pressure of downshift reduction valve, in the slug chamber, goes below the "reference" pressure sent to the outer end of the spool. As a result, the automatic selection spool moves toward the center of body (4). Hydraulic shift spool (9) then moves to close this passage and the transmission makes a shift to the next lower speed.

The operator can push the transmission hold pedal down and hold the transmission in a speed. As the pedal is pushed down, air is sent through line (15) to piston (6). Piston (6) moves and stops oil pressure to spool (9). The transmission will stay in that speed of the automatic range even if the speed of the output shaft changes. When the hold pedal is released, piston (6) will move and allow oil pressure to go to spool (9).

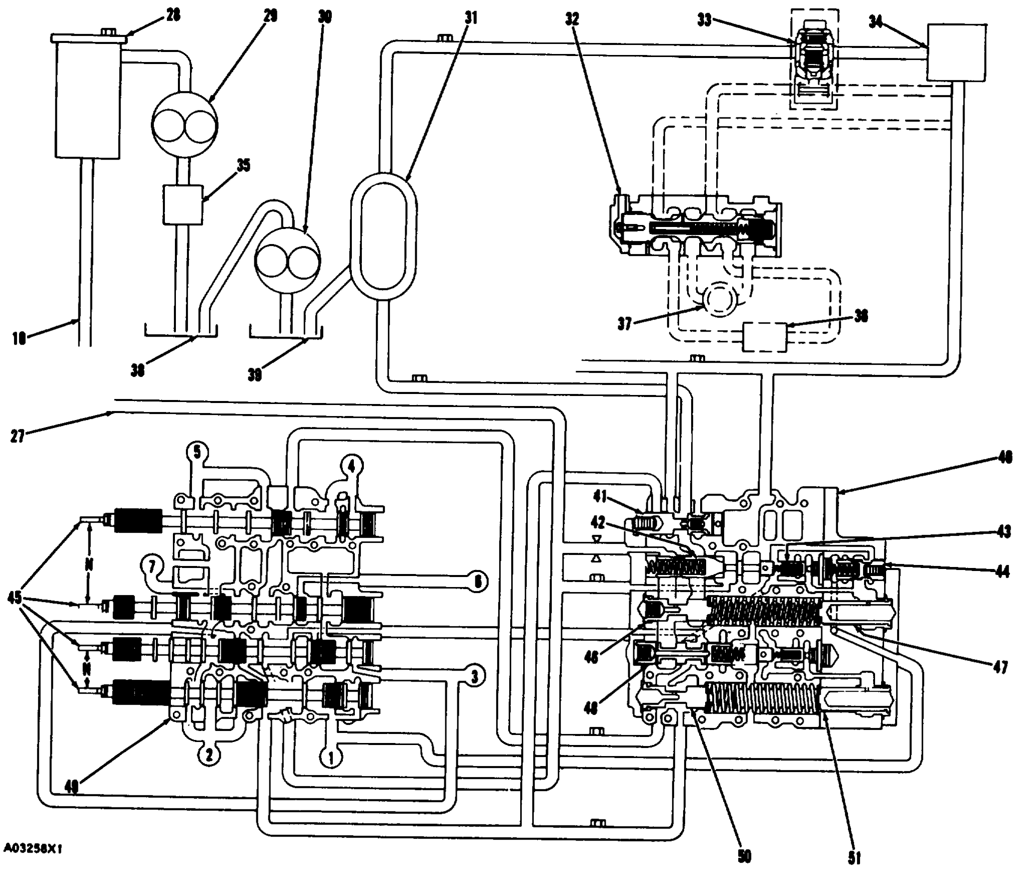


SCHEMATIC OF THE SEMIAUTOMATIC CONTROLS

1. Control group for shift pressure. 2. Downshift reduction valve. 3. Governor. 4. Valve group for automatic selection of speed. 5. Priority valve. 6. Hold valve piston. 7. Governor reduction valve (6th to 7th and 7th to 8th speed upshifts). 8. Top cover and manifold. 9. Hydraulic shift spool. 10. Line from oil filter. 11. Manual selection spool. 12. Automatic selection spool (7th to 8th shift). 13. Automatic selection spool (2nd to 3rd shift). 14. Upshift reduction valve (2nd to 3rd upshift). 15. Air line from transmission hold pedal. 16. Governor reduction valve (4th to 5th and 5th to 6th speed upshifts). 17. Governor reduction valve (2nd to 3rd and 3rd to 4th speed upshifts). 18. Governor cut-off valve. 19. Upshift reduction valve (3rd to 4th, 5th to 6th and 7th to 8th speed upshifts). 20. Line from P2 in the transmission controls. 21. Automatic selection spool (6th to 7th shift). 22. Automatic selection spool (3rd to 4th shift). 23. Upshift reduction valve (4th to 5th and 6th to 7th speed upshifts). 24. Slugs (six). 25. Automatic selection spool (5th to 6th shift). 26. Automatic selection spool (4th to 5th shift). 27. Oil line to valve group for pressure control. A. Adjustment screw for all downshift points. B. Adjustment screw for 2nd to 3rd upshift point. C. Adjustment screw for (3rd to 4th, 5th to 6th and 7th to 8th upshift points). D. Adjustment screw for 4th to 5th and 6th to 7th upshift points.



NOTE: The spools are not positively in the position in which they would be when in a sequence of an automatic shift. The basic idea of this schematic is to help the user understand the operation of the semiautomatic controls.



TRANSMISSION CONTROLS IN NEUTRAL AND ENGINE IS NOT RUNNING

10. Line from oil filter. 27. Oil line to valve group for pressure control. 28. Oil filter. 29. Oil pump. 30. Scavenge pump. 31. Torque converter. 32. Control valve for the retarder. 33. Temperature control valve. 34. Transmission oil cooler. 35. Magnetic screen. 36. Oil cooler for the retarder. 37. Retarder. 38. Oil reservoir in the bevel gear case. 39. Oil reservoir in the transmission case. 40. Valve group for pressure control. 41. Inlet relief valve for the torque converter. 42. Flow control valve. 43. Check valves (two). 44. Relief valve for the load piston. 45. Selection spools (four). 46. Modulation relief valve. 47. Load piston. 48. Safety valve. 49. Selection valve body. 50. Modulation reduction valve. 51. Load piston.

PRESSURE AND SPEED SELECTION CONTROLS

Safety Valve

When the machine is started in NEUTRAL the safety valve gets in position as follows: The oil comes through line (27) to valve group for pressure control (40). Part of the oil is sent to selection valve body (49). Passages inside the body send the oil to the chamber near the right end of the safety valve (48). The oil goes through holes in the safety valve and through the poppet valve and pushes against the cover to move safety valve (48) to the right. This action lets the oil go back to selection valve body (49) and to the clutches.

If the machine is started in any speed except NEUTRAL, the passage from selection valve body (49) to the right end of safety valve (48) is open to let the oil go to reservoir (39). Since the passage is open to reservoir (39), there cannot be an increase in the pressure of the oil. Safety valve (48) cannot move. This prevents the oil from going to the clutches.

Converter Drive (FIRST, SECOND and REVERSE)

When a shift is made to FIRST SPEED, the oil and valves move as follows:

The oil comes through line (27) to valve group for pressure control (40). At the valve group for pressure control, the flow of oil divides into separate circuits.

Part of the flow of oil goes through an orifice to the left end of the flow control valve (42). There is a change of approximately 25 psi (1.8 kg/cm2) from one side of the orifice to the other. The orifice and flow control valve (42) makes sure that there are 15 US. gpm (56.8 lit/min) to fill the clutches. When the flow is more than 15 US. gpm (56.8 lit/min), the oil in the chamber at the right end of flow control valve (42) pushes the valve to the left. This lets the remainder of the oil go to the poppet end of inlet relief valve (41) for the torque converter.

The oil from the left end of flow control valve (42) goes around the valve to modulation relief valve (46). The oil goes through an orifice in the valve and pushes against body (40). This action causes an increase in pressure which moves modulation relief valve (46) to the right. At the same time, oil is sent through passages to check valve (43), reset valve (44) and load piston (47). Orifices in the passages cause a short delay in the increase of the pressure to relief valve (44) and load piston (47). The pressure oil from modulation relief valve (46) moves check valve (43) to the right to stop the oil behind relief valve (44) and load piston (47) from going back to reservoir (39). This lets the oil in the chamber behind load piston (47) make an increase.

At the same time that the oil from the left end of modulation relief valve is sent to load piston (47), oil is sent to safety valve (48).

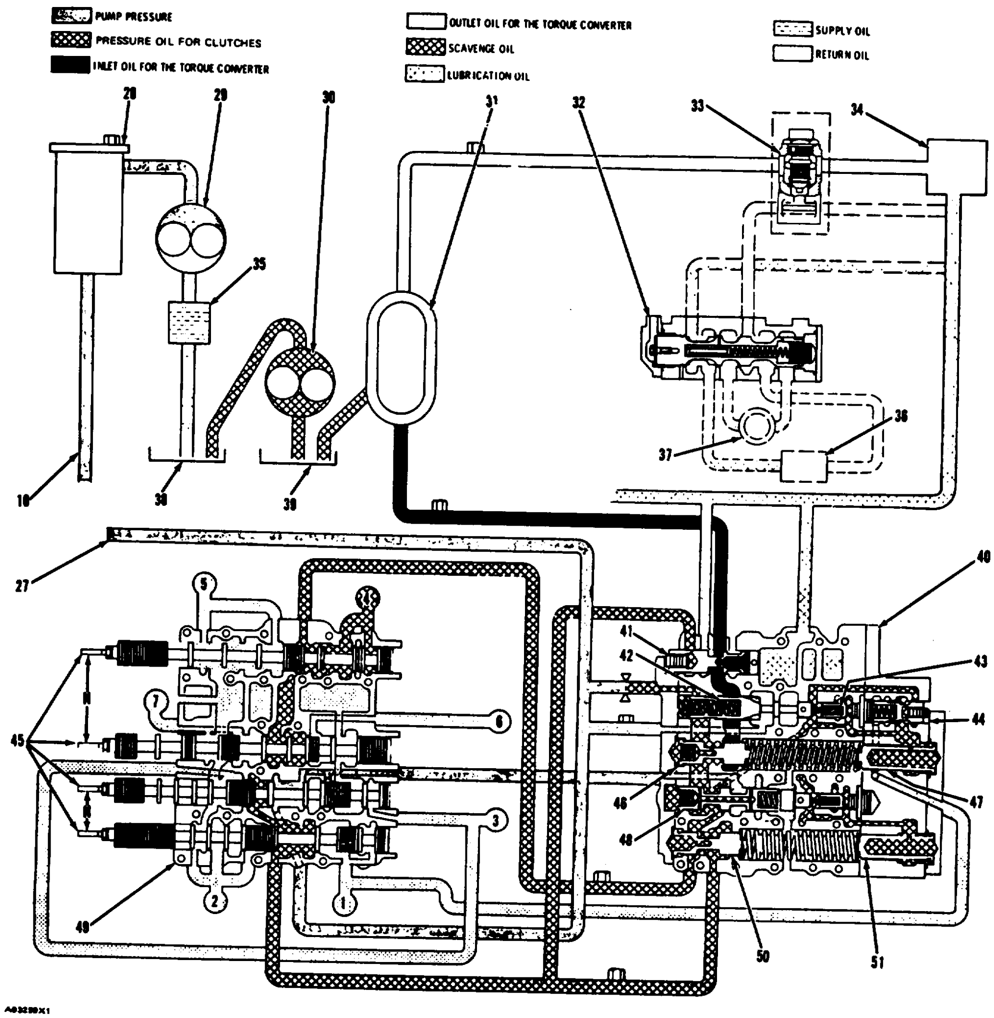
From safety valve (48) the oil is sent around the modulation reduction valve (50) to selection valve body (49). The position of spools (45) allows the oil to fill the No. 6 clutch and make an increase in pressure. The oil also goes from safety valve (48) through the hole in the center of modulation reduction valve (50) into the chamber at the left end of the valve. The pressure of the oil in the chamber pushes against the cover and moves modulation reduction valve (50) to the right.

At the same time, oil goes through a passage to the other check valve (43) and load piston (51).
The orifice in the passage to load piston (51) causes a short delay in the increase of the pressure and lets the check valve stop the oil from going to reservoir (39). An increase in pressure behind load piston (51) moves it to the left. The action of modulation reduction valve (50) and load piston (51) causes the pressure for the No. 1, No. 2 and No. 3 clutches to go higher.

The oil from the right end of modulation reduction valve (50) is divided into two separate circuits. Part of the oil is sent to the slug end of inlet relief valve (41) for the torque converter. The pressure of the oil at the slug end and the pressure oil at the poppet end of the inlet relief valve (41) work against each other. This action keeps the inlet oil pressure to the torque converter at a specific value. The other part of the oil is sent to the bottom of selection valve body (49).

The oil that goes into the bottom of selection valve body (49) is sent by spools (45) to fill the No. 1 clutch. There is a connection between the No. 1 clutch and the chamber at the left end of relief valve (44). When the No. 1 clutch is engaged, as in FIRST, SECOND and REVERSE, the pressure of the oil in the chamber at the left holds relief valve (44) to the right against the cover. This action lets the oil from modulation relief valve (46) go through the larger orifice at the top. The pressure of the oil pushes load piston (47) completely to the left. This lets the system go to its maximum pressure, for normal operation, in FIRST, SECOND and REVERSE.

At this time, the machine is in operation in FIRST speed. When a shift is made to any other speed, in "Converter Drive" (SECOND or REVERSE), the valves in the pressure control group move as follows:



TRANSMISSION CONTROLS IN NEUTRAL AND ENGINE IS RUNNING

10. Line from oil filter. 27. Oil line to valve group for pressure control. 28. Oil filter. 29. Oil pump. 30. Scavenge pump. 31. Torque converter. 32. Control valve for the retarder. 33. Temperature control valve. 34. Transmission oil cooler. 35. Magnetic screen. 36. Oil cooler for the retarder. 37. Retarder. 38. Oil reservoir in the bevel gear case. 39. Oil reservoir in the transmission case. 40. Valve group for pressure control. 41. Inlet relief valve for the torque converter. 42. Flow control valve. 43. Check valves (two). 44. Relief valve for the load piston. 45. Selection spools (four). 46. Modulation relief valve. 47. Load piston. 48. Safety valve. 49. Selection valve body. 50. Modulation reduction valve. 51. Load piston.

The system pressure goes down to fill pressure. Modulation relief valve (46) closes and oil is sent to the clutch to be filled. Flow control valve (42) and the orifice, prevent the flow of oil that is going to the clutches from going higher than 15 US. gpm (56.8 lit/min). The remainder of the oil flow opens the flow control valve (42) and lets the oil go to torque converter (31) or into the lubrication system for the transmission. At this time, the decrease in pressure lets check valves (43) move to the left. This opens a passage which lets the oil behind load pistons (47) and (51) go back to reservoir (39). This lets load pistons (47) and (51) move to the right. After the clutch is filled, the pressure goes up immediately to the primary setting for modulation relief valve (46). This increase in pressure moves check valve (43) to the right and closes the passage to the reservoir behind load piston (47). The other check valve (43) behind modulation reduction valve (50) makes the same movement. The orifices in the passages going to the load piston chambers let the oil go through at a specific rate. This lets load pistons (47) and (51) move to the left at a specific rate. The gradual increase of pressure on modulation relief valve (46) and modulation reduction valve (50) increases the pressure until load pistons (47) and (51) are against their left stops and the system pressure is at its maximum. Pressure of the oil from the No. 1 clutch keeps relief valve (44) to the right to let the system go to maximum pressure.

Direct Drive (THIRD through EIGHTH)

The normal pressures in "Direct Drive" are different than the pressures for "Converter Drive". The reason is as follows:

The No. 1 clutch will not be engaged when the machine is in "Direct Drive." Since the No. 1 clutch is not engaged, there is no pressure in the chamber at the left end of relief valve (44) for the load piston. The pressure of the oil moves relief valve (44) to the left. When relief valve (44) has moved completely to the left, the large orifice above relief valve (44) is closed. The oil which goes through the small orifice is now the only supply for the load piston cavity. The position of relief valve (44) lets part of the oil go back to the reservoir. Since the oil supply is limited by the orifice and part of the oil can go back to reservoir (39), load piston (47) will not move completely to the left against its stop. As a result, the pressure in the system cannot go as high in "Direct Drive" as it does in "Converter Drive."

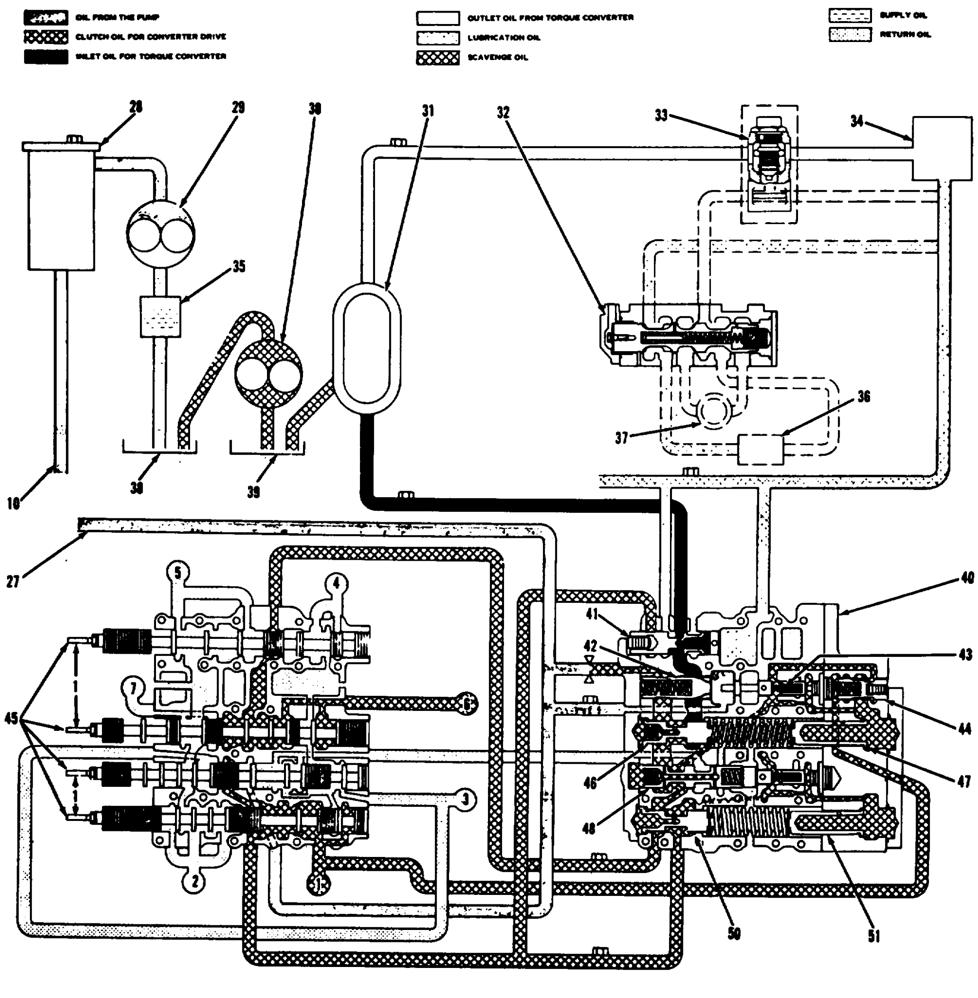
When a shift is made from one "Direct Drive" speed to another "Direct Drive" speed, the valves in pressure. control group (40) move as follows:

As soon as the normal pressure goes down to the fill pressure, modulation relief valve (46) moves to the left. The oil can now fill the clutches for the desired next speed. The oil goes through the flow control valve (42) and the orifice which keeps the flow of oil to the clutches at 15 U.S. gpm (56.8 lit/min). This reduction of flow and pressure lets check valves (43) move to the left. This opens a passage which lets the oil in the load piston chambers go back to reservoir (39). Now load pistons (47) and (51) can move to the right against the cover.

After the clutches are filled, the pressure immediately goes up to the primary setting for modulation relief valve (46). This increase of pressure moves the check valves (43) to the right. This closes the holes that let the oil go back to reservoir (39). The oil goes through the orifices into the chambers behind load pistons (47) and (51) at a specific rate. The pressure of modulation reduction valve (50) goes up at the same rate as the pressure of modulation relief valve (46) until the pressure of modulation reduction valve (50) gets to its primary setting. At this time the oil goes through the orifice to load piston (51) at a lower specific rate than the oil going to load piston (47). The oil, going through the orifices at a specific rate, moves load pistons (47) and (51) at a specific rate. As the pressure goes up, the modulation relief valve (46) and the modulation reduction valve (50) move to the right which causes the pressure in the system to go up. This goes on until the increase in pressure moves relief valve (44) for the load piston to the left. This stops the flow of oil through the large orifice. When relief valve (44) has moved completely to the left, only the small orifice sends oil to the chamber of load piston (47). The position of relief valve (44) lets oil from the small orifice go back to reservoir (39). This keeps the system pressure below the maximum pressure.

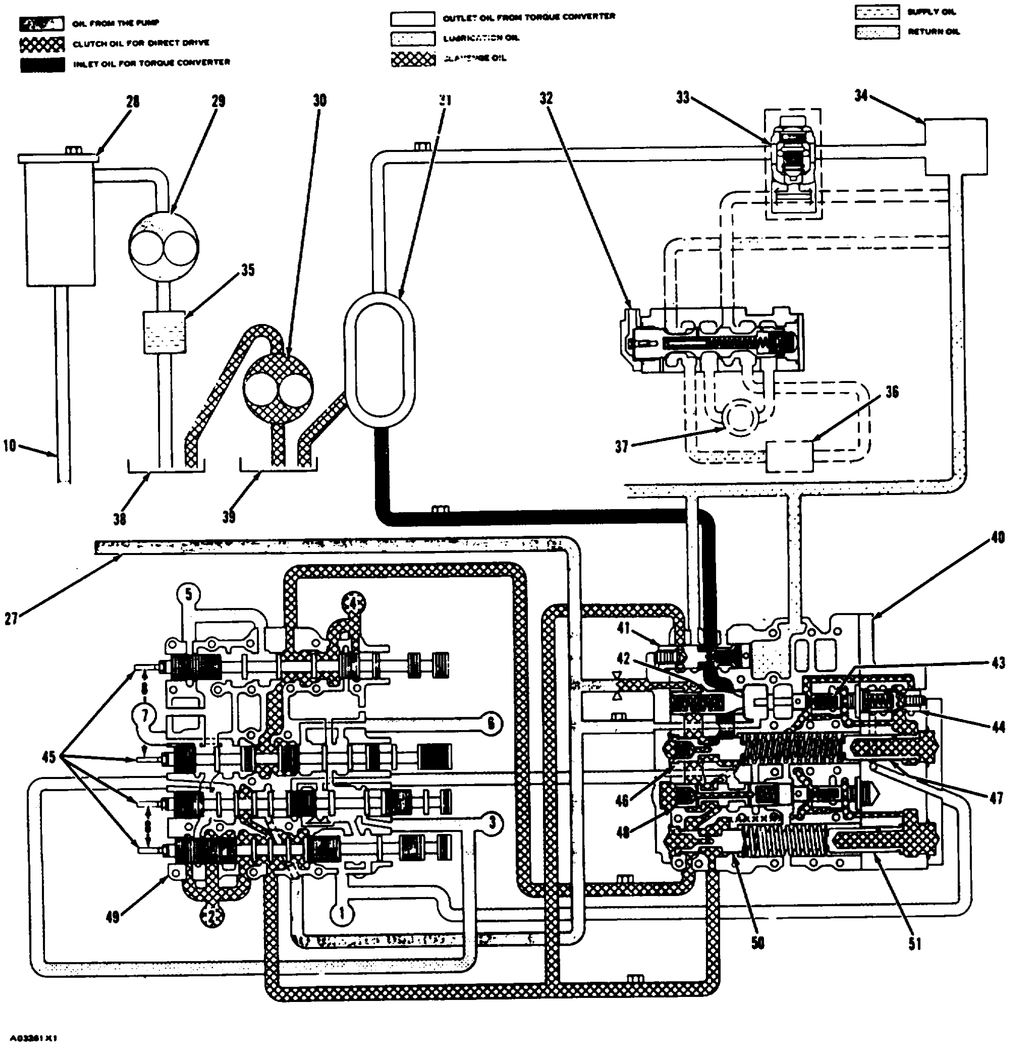
The modulation reduction valve (50) keeps moving until it gets to its stop. The pressure for modulation reduction valve (50) and modulation relief valve (46) are the same when the machine is in "Direct Drive."

The operation of the flow control valve (42) and the converter inlet valve (41) are the same as for "Converter Drive, " except at a lower pressure.



TRANSMISSION CONTROLS IN FIRST SPEED

10. Line from oil filter. 27. Oil line to valve group for pressure control. 28. Oil filter. 29. Oil pump. 30. Scavenge pump. 31. Torque converter. 32. Control valve for the retarder. 33. Temperature control valve. 34. Transmission oil cooler. 35. Magnetic screen. 36. Oil cooler for the retarder. 37. Retarder. 38. Oil reservoir in the bevel gear case. 39. Oil reservoir in the transmission case. 40. Valve group for pressure control. 41. Inlet relief valve for the torque converter. 42. Flow control valve. 43. Check valves (two). 44. Relief valve for the load piston. 45. Selection spools (four). 46. Modulation relief valve. 47. Load piston. 48. Safety valve. 49. Selection valve body. 50. Modulation reduction valve. 51. Load piston.



TRANSMISSION CONTROLS IN EIGHTH SPEED

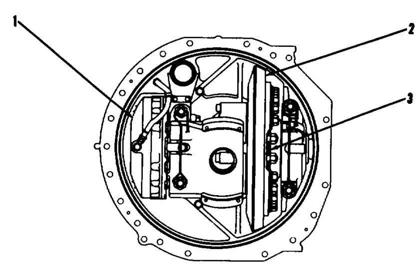
10. Line from oil filter. 27. Oil line to valve group for pressure control. 28. Oil filter. 29. Oil pump. 30. Scavenge pump. 31. Torque converter. 32. Control valve for the retarder. 33. Temperature control valve. 34. Transmission oil cooler. 35. Magnetic screen. 36. Oil cooler for the retarder. 37. Retarder. 38. Oil reservoir in the bevel gear case. 39. Oil reservoir in the transmission case. 40. Valve group for pressure control. 41. Inlet relief valve for the torque converter. 42. Flow control valve. 43. Check valves (two). 44. Relief valve for the load piston. 45. Selection spools (four). 46. Modulation relief valve. 47. Load piston. 48. Safety valve. 49. Selection valve body. 50. Modulation reduction valve. 51. Load piston.

DIFFERENTIAL, DIFFERENTIAL LOCK AND FINAL DRIVE

The differential sends the same amount of torque to each wheel. When one wheel is turning slower than the other, as in a turn, the differential lets the inside wheel to stop or go slower in relation to the outside wheel. The differential still sends the same amount of torque to each wheel.

The output shaft of the transmission is fastened to the differential pinion with splines. The differential pinion turns the ring gear of the differential.
This ring gear is fastened to the differential housing. The differential housing is divided into two parts and has four pinions on a spider and two side gears. The four pinions engage at 90 degree angles with the two side gears. The side gears are fastened to the inner end of the axles.

When the machine is moving in a straight direction with the same amount of traction under each drive wheel, the same amount of torque on each axle holds the pinions so they will not turn on the spider. This gives the same effect as if both drive wheels were on one axle. When different amount of loads are put on the drive wheels, as in a turn, different amount of forces are put on opposite sides of the differential causing the pinions to turn. Turning the pinions makes the inside wheel go slower or stop and the outside wheel goes faster and the tractor is driven with full power in a turn.



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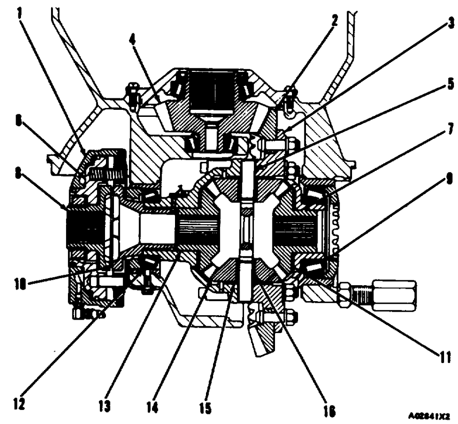
DIFFERENTIAL GROUP (END VIEW)
1. Air cylinder. 2. Ring gear. 3. Differential housing.

The hubs of the differential housings are on tapered roller bearings. Adjustments can be made to the tapered roller bearings. The pinions turn on hardened steel bearings. Both the pinions and side gears turn against thrust washers which take the end thrust against the differential housing.



DIFFERENTIAL GROUP (CROSS SECTION)
1. Air cylinder. 2. Ring gear. 3. Differential housing. 4. Differential drive pinion. 5. Spider. 6. Piston. 7. Side gear. 8. Differential lock jaw (splined to axle). 9. Bearing. 10. Differential lock jaw (splined to differential housing. 11. Thrust washers (two). 12. Bearing. 13. Side gear. 14. Pinions (four). 15. Thrust washers (four). 16. Bearings (four).

Lubricant is thrown around in the differential for lubrication. Flat surfaces on the spider let lubricant go to the pinion bearings and thrust washers.

When one drive wheel has bad traction, the other wheel turns freely. This action causes a loss of power which is stopped by the differential lock.
This is done by sending power to both wheels through a jaw clutch. The jaw clutch lets the differential engage or release while machine is using full power at any speed. The jaw clutch can be engaged at any speed before the wheels start to turn freely. The operator must choose the time he needs to engage the jaw clutch. An example of one such need is, when one wheel starts to turn freely, or a noise is caused by the jaw clutches hitting each other, lower the engine speed to let the jaw clutches engage.

The operator must keep the pedal for the differential lock pushed down to keep the jaw clutches engaged. When the differential lock is engaged, the speed of the wheels is the same. The condition of the surface has no effect on the speed at which the wheels turn. Power is divided and the same amount is sent to each wheel. This stops a loss of power by not letting one wheel turn freely.
Releasing the pedal releases the differential lock.

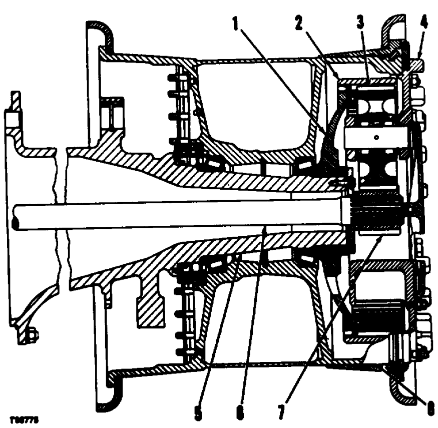
WARNING:
Do not turn the machine while the pedal for the differential lock is pushed down.

When the pedal for the differential lock is pushed down, pressure air from the control valve of differential lock goes to the air cylinder of the differential lock.

The pressure air pushes the piston to the inside causing the jaws to engage. One jaw of the clutch is fastened to the differential housing by splines. The other jaw is fastened to the right axle shaft. When the jaws are engaged, there is a connection between the right axle shaft and the differential housing. The differential gears and the differential housing do not move so this connection causes the effect of one axle drive.

When the pedal is released, the reduction in air pressure to the cylinder causes the piston to move to the outside. The jaws are then not engaged. The springs between housing and piston keep the jaws from being engaged, until air pressure is sent to the cylinder. When the differential is not engaged, the operation of the differential is normal.

FINAL DRIVE



FINAL DRIVE (CROSS SECTION)

1. Final drive hub. 2. Ring gear. 3. Planetary gears. 4. Planetary carrier. 5. Axle housing. 6. Axle shaft. 7. Sun gear. 8. Wheel assembly.

The final drive has a planetary gear system. Ring gear (2) is fastened to final drive hub (1). Final drive hub (1) is fastened to axle housing (5). Ring gear (2) is held in a stationary position. Planetary gear (3) are held by planetary carrier (4). Planetary carrier (4) is fastened to wheel assembly (8).

Sun gear (7) is fastened to axle shaft (6). Axle shaft (6) is turned by the differential. As the sun gear turns it causes the planetary gears and planetary carrier to move around the sun gear in the same direction but at a slower speed. The carrier turns the wheel assembly.

TROUBLESHOOTING

Use this as a reference for the location and correction of problems in the power train. When more checking is necessary, use the 7S8875 or 8M2736 Hydraulic Test Box and FT1106 Engine Speed Control Adapter. Locations of the procure taps and procedures for tests and adjustments are give in the TRANSMISSION TESTING AND ADJUSTING, PART TWO, Chapter 2.

Always make visual checks first. Then check the operation of the machine and go on to check with the instruments.

VISUAL CHECKS

1. Check the oil level in the transmission and differential.
2. Check all oil lines, hoses and connections for leaks or damage. Look for oil on the ground under the machine.
3. Move the control lever to the REVERSE position and all FORWARD positions. The detents must be felt in all positions.
4. Check the transmission control linkage for damage.
5. Let the oil out of the housing for the transmission oil filter. Remove and check the filter element for foreign material. Check the magnetic strainer in the case of the transfer gears.

    a. Aluminum particles give the indication of torque converter failure.
    b. Bronze particles give the indication of worn clutches in transmission.
    c. Rubber particles give the indication of rubber seal or hose failure.
    d. Shiny steel particles give the indication of pump failure.
    e. Iron or steel chips give the indication of broken components in transmission, differential or transfer gears.

If you find bronze, rubber, aluminum, iron or steel particles, all components of the hydraulic system must be washed clean. Do not use parts with damage. Use new parts.

CHECKS DURING OPERATION

With the engine running, move the selection lever to all speed positions. The detents must be felt in all positions.

Operate the machine in each direction and in all speeds. Make note of all noises that are not normal and find their sources. If the operation is not correct, make reference to the CHECK LIST DURING OPERATION for "problems" and "probable causes."

CHECK LIST DURING OPERATION

PROBLEM: Transmission gets hot.
PROBABLE CAUSE:

1. Bad temperature gauge.
2. Low oil level.
3. High oil level.
4. Core of oil cooler not completely open.
5. Low oil flow as a result of pump wear.
6. Magnetic screen not completely open.
7. Long periods of operation with converter at or near stall speed.
8. On machines with retarders, to much use of retarder.

PROBLEM: Transmission lever does not make a shift.
PROBABLE CAUSE:

1. Adjustment of control linkage not correct.
2. Control linkage damaged.
3. Clutch not releasing.

PROBLEM: Slow shifting
PROBABLE CAUSE:

1. Low oil pressure.
2. Adjustment of control linkage not correct.
3. Control group for shift pressure not operating correctly.
4. Air leaks on inlet side of pump.

PROBLEM: Clutches engage very suddenly (rough shifting).

PROBABLE CAUSE:

1. Adjustment of control linkage not correct.
2. Primary setting of the relief valve not correct.
3. Load piston not closing.
4. Valve springs that are weak or have damage.

PROBLEM: Transmission does not operate in any speed or does not engage (slips) in all speeds.

PROBABLE CAUSE:

1. Low oil pressure caused by:
   a. Low oil level.
   b. Control linkage loose or adjustment not correct.
   c. Failure of the oil pump or oil pump drive.
   d. Air leaks on inlet side of pump.
   e. Leakage inside transmission.
   f. Adjustment of the modulation relief valve not correct, or valve does not close.
   g. Spool for flow control valve does not close.
2. Mechanical failure in transmission.
3. Automatic selection group not operating.
4. Failure in torque converter.
5. Failure of the differential or the final drives.

PROBLEM: Machine moves in NEUTRAL.

PROBABLE CAUSE:

1. Adjustment of control linkage not correct.
2. No. 4 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission engages but the machine does not move and the engine stops.

PROBABLE CAUSE:

1. Differential has broken gears and will not turn.
2. Failure in final drives.
3. Too many transmission clutches are being engaged in the transmission.

PROBLEM: Transmission does not operate in REVERSE.

PROBABLE CAUSE:

1. Torque converter failure.
2. No. 7 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission does not operate in FIRST, THIRD and FOURTH speeds.

PROBABLE CAUSE:

1. No. 6 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission does not operate in SECOND, FIFTH and SIXTH speeds.

PROBABLE CAUSE:

1. No. 5 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission does not operate in SEVENTH and EIGHTH speeds.

PROBABLE CAUSE:

1. No. 4 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission does not operate in THIRD, FIFTH and SEVENTH speeds.

PROBABLE CAUSE:

1. No. 3 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission does not operate in FOURTH, SIXTH and EIGHTH speeds.

PROBABLE CAUSE:

1. No. 2 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission does not operate in REVERSE, FIRST and SECOND speeds.

PROBABLE CAUSE:

1. Torque converter failure.
2. No. 1 clutch not engaged (slips) because of:
   a. Low oil pressure.
   b. Discs and plates have too much wear.

PROBLEM: Transmission makes shifts rapidly (hunts).

PROBABLE CAUSE:

1. Governor cutoff valve not closing.
2. Bad friction between wheels and ground.
3. Shift governor not operating correctly.
4. Shift points out of adjustment.

PROBLEM: Transmission does not make a shift.

PROBABLE CAUSE:

1. Low oil pressure.
2. Shift points out of adjustment.
3. Governor cutoff valve not operating correctly.
4. Hold valve piston not operating correctly.
5. Shift governor not operating correctly.
6. Transmission controls held by detents, valve spools or linkage.

PROBLEM: Transmission does not make a shift up or down.

PROBABLE CAUSE:

1. Low oil pressure.
2. Shift points out of adjustment.
3. Shift governor not operating correctly.
4. Hold valve piston not operating correctly.
5. Control linkage broken or out of adjustment.
6. Automatic selection spool cannot move.

PROBLEM: Transmission shifts up or down at wrong time.

PROBABLE CAUSE:

1. Control linkage broken or out of adjustment.
2. Shift points out of adjustment.
3. Shift governor not operating correctly.
4. Pressure reduction valve not moving and giving very low or no reference pressure.

PROBLEM: Transmission goes beyond a speed without stopping in that speed and will not shift down lower than a specific speed.

PROBABLE CAUSE:

1. Automatic selection spool will not move out of its bore in the valve body.
2. Reference pressure too high.

PROBLEM: Transmission will not make a shift down beyond a specific speed but makes a shift up normally beyond that same specific speed.

PROBABLE CAUSE:

1. Automatic selection spool will not move to the inside of the valve body.
2. Shift governor not operating correctly.

PROBLEM: Transmission operation, with hot oil, is not smooth.

PROBABLE CAUSE:

1. Bolts in valve body not tightened correctly, which causes the parts of the body not to fit or operate.

PROBLEM: Torque converter gets hot.

PROBABLE CAUSE:

1. Bad temperature gauge.
2. Mechanical failure of torque converter.
3. Too much oil leakage in torque converter.
4. Not enough oil to torque converter because of:
   a. Oil pump failure.
   b. Too much oil leakage into transmission.
   c. Inlet relief valve not operating correctly.
5. Too much restriction in oil cooler or oil lines.
6. On machines with retarders, too much use of retarder.
7. Too much operation of machine at stall speed.

PROBLEM: Pump noise not normal.

PROBABLE CAUSE:

1. Loud sounds at short intervals that give an indication that particles are going through the pump is caused by pump cavitation.
2. A constant loud noise is an indication of pump failure.
3. Air at the inlet side of the pump (aeration).

TRANSMISSION SPEED	CLUTCHES ENGAOED IN TRANSMISSION
REVERSE	1 and 7
NEUTRAL	4
FIRST	1 and 6
SECOND	1 and 5
THIRD	3 and 6
FOURTH	2 and 6
FIFTH	3 and 5
SIXTH	2 and 5
SEVENTH	3 and 4
EIGHTH	2 and 4

CHAPTER 2
POWER TRAIN
POWER SHIFT TRANSMISSION
TESTING AND ADJUSTING

INDEX

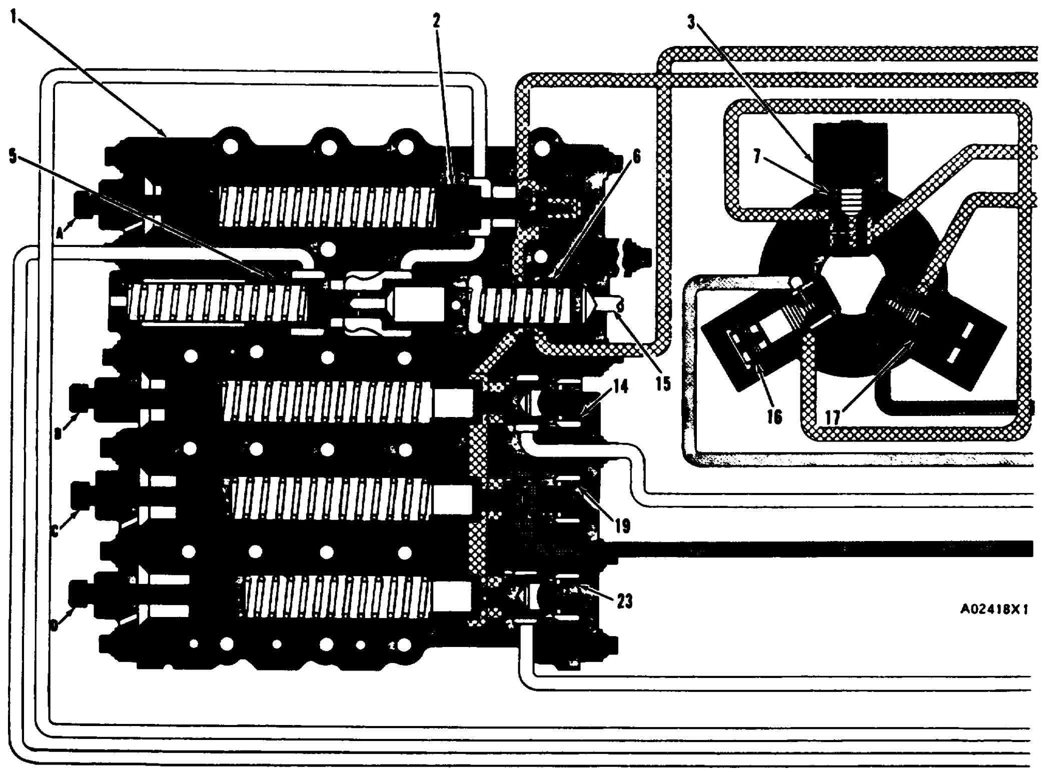
WARNING:

When you make a complete test of the hydraulic controls and/or an adjustment of the shift points, remove both drive axles and disconnect the steering linkage. Let only approved personnel on the machine. Keep other personnel off the machine and in view of the operator.

NOTE:

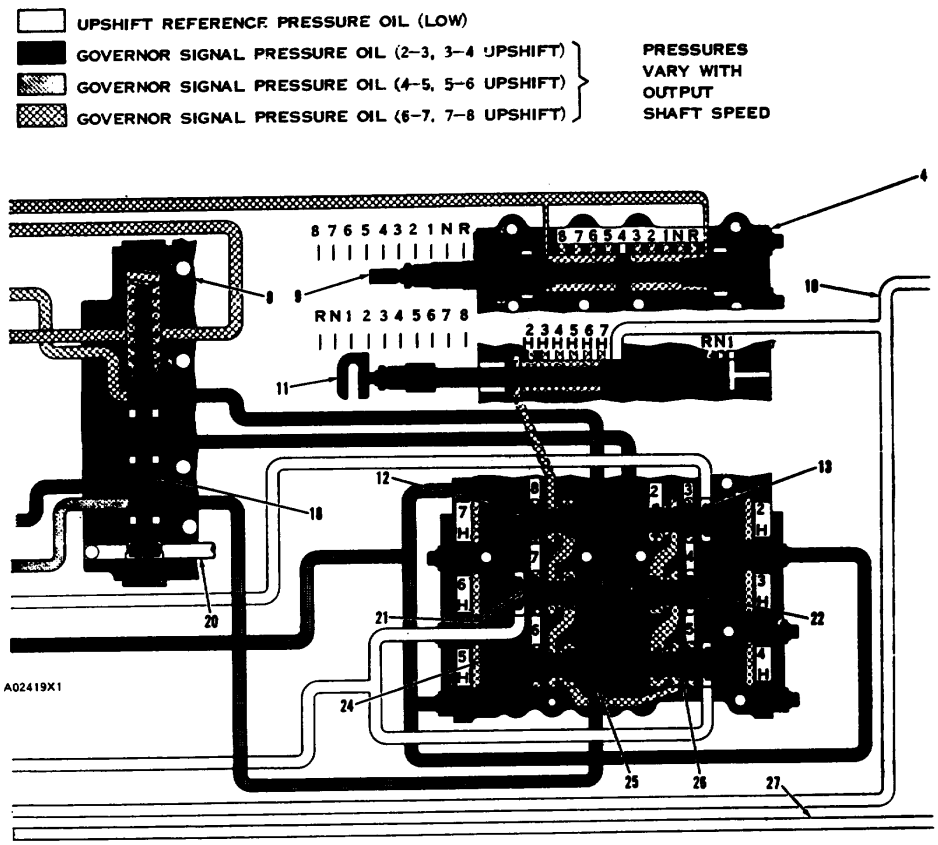
All tests and adjustments must be made with the oil in the hydraulic control system at the temperature of normal operation. Be sure the linkage adjustments are correct before the tests and adjustments are made.

PUMP PRESSURE OIL
DOWNSHIFT REDUCING PRESSURE OIL
UPSHIFT REFERENCE PRESSURE OIL (HIGH)
UPSHIFT REFERENCE PRESSURE OIL (MEDIUM)
BLOCKED OIL
DRAIN OIL

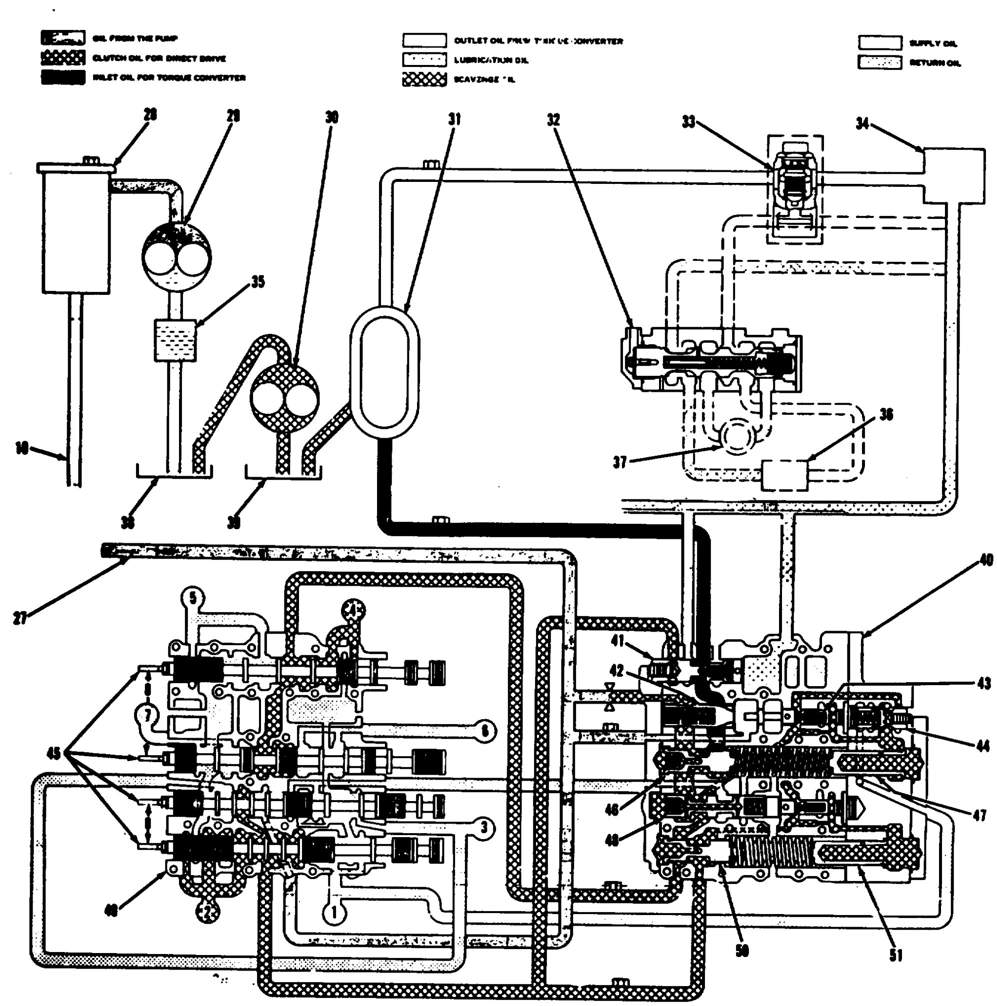


SCHEMATIC OF THE SEMIAUTOMATIC CONTROLS

1. Valve group for shift pressure.
2. Downshift reduction valve.
3. Hydraulic governor.
4. Valve group for automatic selection of speed.
5. Priority valve.
6. Hold valve piston.
7. Governor reduction valve spool (6th to 7th, 7th to 8th speed upshifts and 8th to 7th, 7th to 6th speed downshifts).
8. Top cover and manifold.
9. Hydraulic shift spool.
10. Line from oil filter.
11. Manual selection spool.
12. Automatic selection spool (7th to 8th speed upshift and 8th to 7th speed downshift).
13. Automatic selection spool (2nd to 3rd speed upshift and 3rd to 2nd speed downshift).
14. Upshift reduction valve (2nd to 3rd speed upshift).
15. Air line from transmission hold pedal.
16. Governor reduction valve (4th to 5th, 5th to 6th speed upshifts and 6th to 5th, 5th to 4th speed downshifts).
17. Governor reduction valve (2nd to 3rd, 3rd to 4th speed upshifts and 4th to 3rd, 3rd to 2nd speed downshifts).
18. Governor cut-off valve.
19. Upshift reduction valve (3rd to 4th, 5th to 6th and 7th to 8th speed upshifts).
20. Line from P2 in transmission hydraulic controls.
21. Automatic selection spool (6th to 7th speed upshift and 7th to 6th speed downshift).
22. Automatic selection spool (3rd to 4th speed upshift and 4th to 3rd speed downshift).
23. Upshift reduction valve (4th to 5th and 6th to 7th speed upshifts).
24. Slugs (six).
25. Automatic selection spool (5th to 6th speed upshift and 6th to 5th speed downshift).
26. Automatic selection spool (4th to 5th speed upshift and 5th to 4th speed downshift).
27. Oil line to valve group for pressure control.
A. Adjustment screw for all downshift points.
B. Adjustment screw for 2nd to 3rd upshift point.
C. Adjustment screw for 3rd to 4th, 5th to 6th and 7th to 8th upshift points.
D. Adjustment screw for 4th to 5th and 6th to 7th upshift points.



NOTE: This schematic does not show the controls in any specific speed position.



TRANSMISSION CONTROLS IN 8TH SPEED

10. Line from oil filter to semiautomatic controls.
27. Line from semiautomatic controls.
28. Oil filter.
29. Transmission oil pump.
30. Scavenge oil pump.
31. Torque converter.
32. Retarder control valve.
33. Temperature bypass valve.
34. Transmission oil cooler.
35. Magnetic screen.
36. Retarder oil cooler.
37. Retarder.
38. Oil reservoir in bevel gear case.
39. Oil reservoir in transmission case.
40. Valve group for pressure control.
41. Inlet relief valve for torque converter.
42. Flow control valve.
43. Check valves (two).
44. Relief valve for load piston.
45. Selection spools (four).
46. Modulation relief valve (P1).
47. Load piston.
48. Safety valve.
49. Selection valve body.
50. Modulation reduction valve (P2).
51. Load piston.

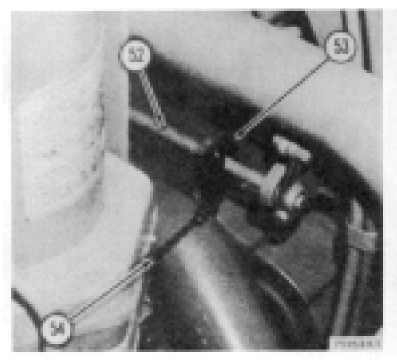
INSTALLATION OF THE FT1106 ENGINE SPEED CONTROL ADAPTER

WARNING:
Before installation of the FT1106 Engine Speed Control Adapter, remove both axles and loosen steering linkage.

1. Install lever (53), spacer and bolt on governor linkage. Install the lever so it is in a position on governor linkage so when it is pulled it will give full travel of the governor linkage.

NOTE:
If lever (53) is not available, a pair of Vise-Grip pliers can be used.

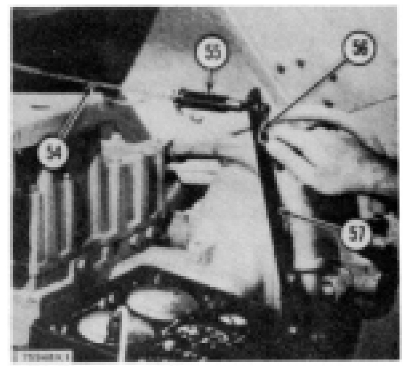
2. Fasten chain (54) to lever (53).
3. Run the chain as straight as possible through open areas to the rear of the tractor.



INSTALLATION OF LEVER ON THE GOVERNOR LINKAGE (Typical Example)
52. Governor linkage. 53. Lever. 54. Chain.

4. Remove one of the bolts from the transfer case. Install bracket (57) on the case using only the bolt.
5. Install lever (56) thru bracket (57). Install yoke (55) on lever (56).
6. Remove slack from chain (54) and connect it to the pin in yoke (55). Use a link in the chain which will give just enough length to start the threads of lever (56) in yoke (55).
7. If the installation is correct, turning lever (56) in a clockwise direction will pull the chain and cause an increase in engine rpm.

NOTE:
If the threads are tight, it will be necessary to hold yoke (55) while turning lever (56).



INSTALLATION OF BRACKET ON TRANSFER CASE (Typical Example)

54. Chain 55. Yoke 56. Lever. 57. Bracket.

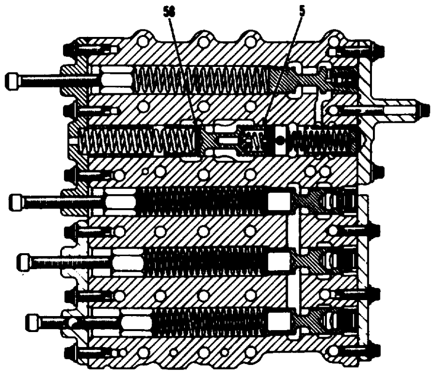
PRESSURE TEST FOR THE HYDRAULIC CONTROLS

WARNING:
When you make a complete test of the hydraulic controls, remove both axles and loosen the steering linkage.

See the TRANSMISSION PRESSURE AND ADJUSTMENT CHART.

1. Check operation of the safety valve:
   a. Move the transmission selection lever to REVERSE position.
   b. Start the engine and run it at 750 rpm.
   c. The semiautomatic controls must cause the transmission controls to make a shift into REVERSE.
   d. Oil pressure for the pump at pressure tap (F) must go up to a minimum of 120 psi (830 kPa).

NOTE:
To change pressure, add or remove spacers (58) for priority valve (5). See the SPACER CHART.



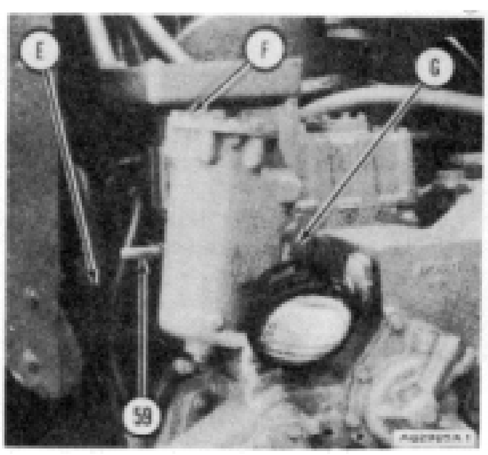
CONTROL GROUP FOR SHIFT PRESSURE

5. Priority valve. 58. 7M1397 Spacers.

e. Oil pressure at taps (I) P1 and (J) P2 must be 0 psi (O kPa).

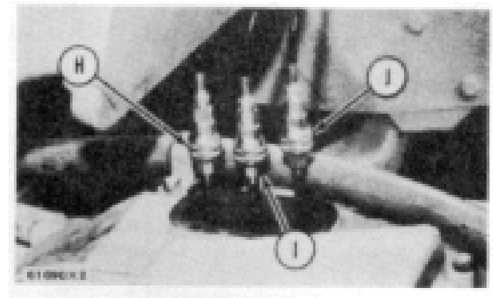
f. Move the transmission selection lever, at the operator's console, to NEUTRAL. The transmission must make a shift and oil pressure at taps (I) P1 and (J) P2 must go up to a minimum of 275 psi (1900 kPa).

g. Run the engine at 900 rpm. Oil pressure for the pump at pressure tap (F) must be 20 to 32 psi (140 to 220 kPa) higher than at tap (I) P1.



LOCATION OF THE PRESSURE TAPS OUTSIDE THE TRANSMISSION CASE

59. Transmission selection shaft. E. Pressure tap for outlet oil pressure from torque converter. F. Pressure tap for transmission oil pump pressure. G. Pressure tap for transmission lubrication pressure (behind oil filter on transfer case).



LOCATION OF THE PRESSURE TAPS INSIDE THE TRANSMISSION TOP COVER

H. Pressure tap for converter inlet pressure. I. Pressure tap for relief valve pressure, (P1). J. Pressure tap for reduction valve, (P2).

2. Check the operation of the hold valve:

   a. Move the transmission selection lever to EIGHTH speed.
   b. Make the engine rpm go up until the transmission makes the shifts up to EIGHTH speed.
   c. Push the transmission hold pedal down. Make a check for a minimum of 65 psi (450 kPa) air pressure to the transmission hold valve.
   d. Run the engine at 750 rpm. The transmission must not make a downshift out of EIGHTH speed.
   e. While keeping the transmission hold pedal pushed down, move the transmission selection lever through each speed to NEUTRAL. The transmission must not make a downshift out of EIGHTH speed.
   f. Release the transmission hold pedal. The transmission must now make the shifts to NEUTRAL.

3. Checking system pressures (push hold pedal down):
   a. Fasten a lever or Vise-Grips to the end of shaft (59).
   b. Run the engine at 2250 rpm. (Keep the transmission hold pedal pushed down so the semiautomatic controls will not cause the transmission to make a shift.
   c. Manually make a shift to REVERSE and FIRST and SECOND speeds. The pressure at taps (I) P1 and (J) P2 must be 400 to 420 psi (2750 to 2890 kPa).

d. Manually make the shifts to THIRD through EIGHTH speeds. The pressure at taps (I) P1 and (J) P2 must be 285 to 305 psi (1970 to 2085 kPa).

e. Do the following with the transmission in NEUTRAL unless the following instructions say differently:

... Oil pressure at taps (I) P1 and (J) P2 must be 285 to 305 psi (1970 to 2085 kPa).

... Lubrication pressure at tap (G) must be 16 to 22 psi (110 to 150 kPa).

... Lubrication pressure must not go down more than 2 psi (14 kPa) when a shift is made from NEUTRAL to REVERSE or from NEUTRAL to FIRST or SECOND speeds.

... Lubrication pressure must not go down more than 8 psi (55 kPa) when a shift is made from NEUTRAL to THIRD through EIGHTH speeds.

... Oil pressure for converter inlet at tap (H) must be 55 to 70 psi (380 to 480 kPa) with the transmission in FIRST, SECOND and REVERSE.

f. Run the engine at 750 rpm: ... Oil pressure at taps (I) P1 and (J) P2 must be a minimum of 380 psi (2635 kPa) in FIRST, SECOND and REVERSE.

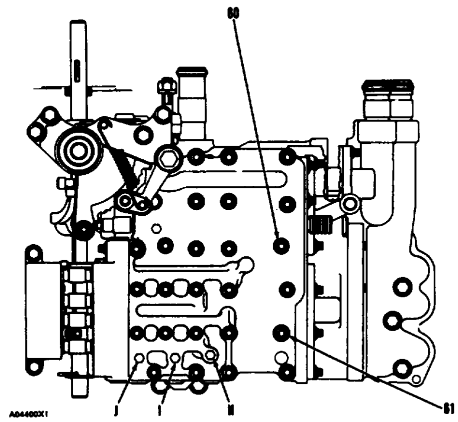
... Oil pressure at taps (I) P1 and (J) P2 must be a minimum of 275 psi (1900 kPa) in NEUTRAL and THIRD through EIGHTH speeds.

... There must be an indication of lubrication pressure at tap (G) in all speeds.

... There must be a pressure of 1 psi minimum (7 kPa) for torque converter inlet at tap (H) in REVERSE, and FIRST and SECOND speeds.

4. If the pressure at tap (J) P2 is either high or low, a check of the initial P2 pressure is necessary:

   a. Remove bolt (61) from the top of the hydraulic controls for the transmission.
   b. Install a 0 to 150 psi (O to 1030 kPa) pressure gauge in pressure tap (J) P2.
   c. Put transmission selection shaft (59) in the NEUTRAL position.



LOCATION OF INITIAL PRESSURE TAPS (P1 and P2)

60. Bolt. 61. Bolt. H. Pressure tap for converter inlet pressure. I. Pressure tap for P1 pressure. J. Pressure tap for P2 pressure.

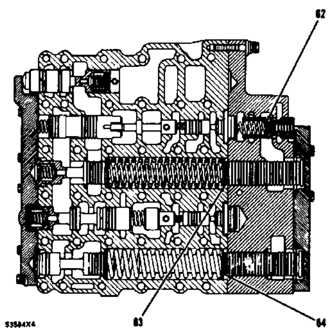
   d. Run the engine at 750 rpm.
   e. The pressure at tap (J) P2 must be 60 ± 3 psi (415 ± 20 kPa).
   f. If the pressure is not correct, an adjustment can be made by adding or removing spacers (64). See SPACER CHART for the change in pressure per spacer.

5. If the pressure at tap (I) P1 is either high or low, a check of the initial P1 pressure is necessary:

   a. Remove bolt (60) from the top of the hydraulic controls for the transmission.
   b. Install a 0 to 150 psi (O to 1030 kPa) pressure gauge in pressure tap (I) P1.
   c. Put the transmission selection shaft (59) in the NEUTRAL position.
   d. Run the engine at 750 rpm.
   e. The pressure at tap (I) P1 must be 45 ± 3 psi (310 + 20 kPa).
   f. If the pressure is not correct, an adjustment can be made by adding or removing spacers (63). See SPACER CHART for the change in pressure per spacer.

6. After the adjustment of P1 initial pressure, it may be necessary to make an adjustment to the relief valve (44) for the load piston:

   a. Install bolt (60).
   b. Install a 0 to 600 psi (O to 4150 kPa) pressure gauge in tap (I) P1.
   c. Put transmission selection shaft (59) in the NEUTRAL position.
   d. Run the engine at 2250 rpm.
   e. The pressure at tap (I) P1 must be 300 ± 5 psi (2030 + 35 kPa).
   f. If the pressure is not correct, an adjustment can be made by adding or removing spacers (62). See SPACER CHART for the change in pressure per spacer.



LOCATIONS OF SPACERS FOR INITIAL PRESSURES

62. Spacers for relief valve (44) for load piston. 63. Spacers for modulation relief valve (46). 64. Spacers for modulation reduction valve (50).

SPACER CHART

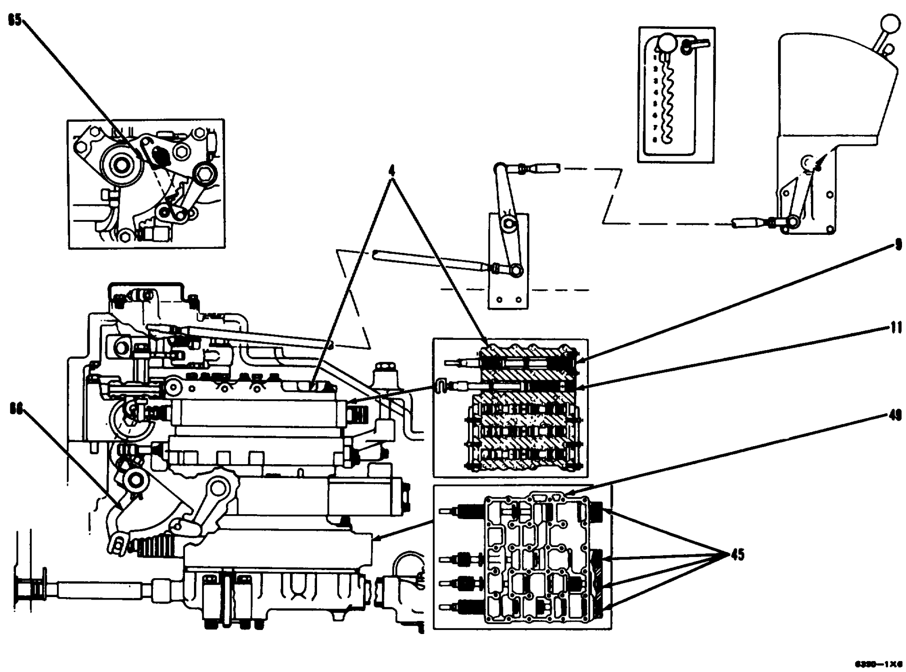
SPACER PART NUMBER	THICKNESS in.	THICKNESS mm	WHERE USED	CHANGE IN PRESSURE psi	CHANGE IN PRESSURE kPa
2S674 (62) 2S675	.016 .036	0.41 0.91	Relief valve (44) for load piston	8.0 18.2	55 125
8S6214 (63) 8S6215	.016 .036	0.41 0.91	Modulation Relief valve (46)	4.5 10.0	31 69
8S6214 (64) 856215	.016 .036	0.41 0.91	Modulation reduction valve (50)	2.5 5.6	17 39
7M1397 (58)	.036	0.91	Priority valve (5)	9.0	62

TRANSMISSION PRESSURE AND ADJUSTMENT CHART							
			TRANSMISSION SPEED				
PRESSURE	**RPM**	**REVERSE**	**NEUTRAL**	**1 and 2**	**3 through 8**	**INITIAL PRESSURE**	**ADJUSTMENT**
TRANSMISSION OIL PUMP	2250	445 to 460 psi (3090 to 3170 kPa)	345 to 360 psi (2370 to 2470 kPa)	445 to 460 psi (3090 to 3170 kPa)	345 to 360 psi (2370 to 2470 kPa)		Add or remove spacers (58) for priority valve (5) See SPACER CHART
	750	390 psi minimum (2705 kPa)	285 psi minimum (1970 kPa)	390 psi minimum (2705 kPa)	285 psi minimum (1970 kPa)	120 to 140 psi (830 to 965 kPa)	
(P1) Push Hold Valve Down	2250	400 to 420 psi (2750 to 2890 kPa)	285 to 305 psi (1970 to 2085 kPa)	400 to 420 psi (2750 to 2890 kPa)	285 to 305 psi (1970 to 2085 kPa)		Add or remove spacers (62) and (63). See SPACER CHART
	750	380 psi minimum (1900 kPa)	275 psi minimum (1900 kPa)	380 psi minimum (2635 kPa)	275 psi minimum (1900 kPa)	45 ± 3psi (310 ± 20 kPa)	
(P2) Push Hold Valve Down	2250	400 to 420 psi (2750 to 2890 kPa)	285 to 305 psi (1970 to 2085 kPa)	400 to 420 psi (2750 to 2890 kPa)	285 to 305 psi (1970 to 2085 kPa)		Add or remove spacers (64) See SPACER CHART
	750	380 psi minimum (2635 kPa)	275 psi minimum (1900 kPa)	380 psi minimum (2635 kPa)	275 psi minimum (1900 kPa)	60 ± 3psi (415 ± 20 kPa)	
TORQUE CONVERTER INLET	2250	55 TO 70 psi (380 to 480 kPa)		55 to 70 psi (380 to 480 kPa)			NONE
	750	1 psi minimum (7 kPa)		1 psi minimum (7 kPa)			NONE
TORQUE CONVERTER OUTLET	1830 ± 65			34 to 44 psi (235 to 305 kPa)			NONE
LUBRICATION	2250	16 to 22 psi (110 to 150 kPa)	16 to 22 psi (110 to 150 kPa)	16 to 22 psi (110 to 150 kPa)	16 to 22 psi (110 to 150 kPa)		NONE
	750	1 psi minimum (7 kPa)	1 psi minimum (7 kPa)	1 psi minimum (7 kPa)	1 psi minimum (7 kPa)		NONE

NOTE:
See specific copy for all conditions that are needed to get all the pressures in the system.

ADJUSTMENT OF THE TRANSMISSION LINKAGE

1. Put the transmission selection lever, at the operator's console, in the FIRST speed position. The detent must be in notch 1 of manual selection cam (65).
2. Make an adjustment to the link end of manual selection spool (11) so the opposite end of the spool is even with the front face of the valve body for the control group for automatic selection of speed (4).
3. Turn selection shaft (59), in the transmission, until the detent is in notch 4 (FOURTH speed position) of hydraulic shift cam (66).
4. Make an adjustment to the link end of hydraulic shift spool (9) so the opposite end of the spool is even with the front face of the valve body for the control group for automatic selection of speed (4).
5. Turn selection shaft (59), in the transmission, until the detent is in notch 1 (FIRST speed position) of hydraulic shift cam (66).
6. Make an adjustment to the link end of selection spools (45) so the opposite end of the spools are even with the front face of selection valve body (49).



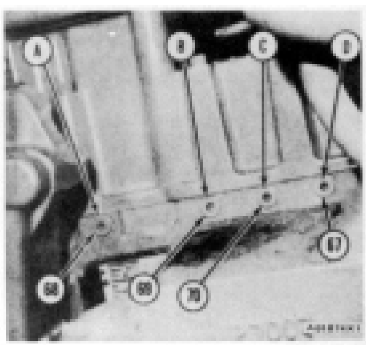
COMPONENTS OF THE TRANSMISSION LINKAGE

4. Control group for automatic selection of speed. 9. Hydraulic shift spool. 11. Manual selection spool. 45. Selection spools. 49. Selection valve body. 65. Manual selection cam. 66. Hydraulic shift cam.

ADJUSTMENT OF SHIFT POINTS

The screws for shift adjustment are inside the transmission case behind plugs (67), (68), (69) and (70). Screw (A) behind plug (68) changes all downshift points and supply oil to the governor. One clockwise turn of screw (A) makes downshift points go DOWN approximately 20 engine rpm.

Screw (B) behind plug (69) changes the 2nd to 3rd speed upshift point. Screw (C) behind plug (70) changes the 3rd to 4th, 5th to 6th and 7th to 8th speed upshift points. Screw (D) behind plug (67) changes the 4th to 5th and 6th to 7th speed upshift points. One clockwise turn of screws (B), (C) and (D) make the upshift points of that specific speed change (see SHIFT POINT CHART) go UP approximately 15 engine rpm.

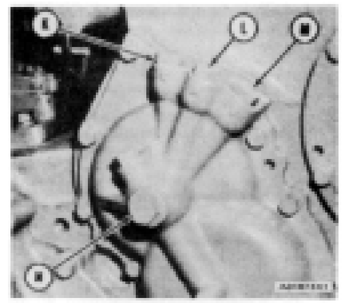


LOCATION OF ADJUSTMENT SCREWS

67. Plug for hole to screw D (for adjustment of reference pressure for 4th to 5th and 6th to 7th speed upshifts) 68. Plug for access hole to screw A (for adjustment of reference pressure for all downshifts). 69. Plug for access hole to screw B (for adjustment of reference pressure for 2nd to 3rd speed upshift). 70. Plug for access hole to screw (C) (for adjustment of reference pressure for 3rd to 4th. 5th to 6th and 7th to 8th speed upshifts).

1. Start the engine and let the transmission oil get to normal temperature of operation.
2. Put the transmission selector lever, at the operator's console, in 2nd speed position and run engine at 1500 rpm.
3. Check the supply oil to the governor at test location (N). Pressure should be 85 to 94 psi (590 to 650 kPa).
4. If supply pressure for governor is not in tolerance, turn adjustment screw (A) to get correct pressure.

NOTE:
Supply pressure for governor is changed when an adjustment is made to a downshift point.



LOCATION OF PRESSURE TAPS FOR THE GOVERNOR

K. Governor shift pressure (6th through 8th speeds).
L. Governor shift pressure (2nd through 4th speeds).
M. Governor shift pressure (4th through 6th speeds).
N. Supply pressure for governor.

5. Put the transmission selector lever in 3rd speed position and make the engine rpm go up to get a 2nd to 3rd speed upshift.
6. Put the transmission selector lever in 4th speed position and run engine at 1900 rpm.
7. Slowly make the engine rpm go up and turn screw (C), as necessary, to get a 3rd to 4th speed upshift when the engine is running at 2055 ± 30 rpm.
8. Slowly make the engine rpm go down and turn screw (A), as necessary, to get a 4th to 3rd speed downshift when the engine is running at 1440 + 30 rpm.
9. Slowly make the engine rpm go down and turn screw (A), as necessary, to get a 3rd to 2nd speed downshift when the engine is running at 1262 $\underline{+}^{30}$ rpm.

NOTE:
To make an adjustment of the 3rd to 2nd speed downshift, it may be necessary to also turn screw (B).

10. Put the transmission selector lever in 5th peed position and run engine at 1900 rpm.
11. Slowly make the engine rpm go up and turn screw (D), as necessary, to get a 4th to 5th speed upshift when the engine is running at 2055 ± 30 rpm.

12. Put the transmission selector lever in 5th speed position and run the engine until the transmission makes the shifts to 5th speed.

13. Put the transmission selector lever in 6th.speed position and run the engine at 1900 rpm.

14. Slowly make the engine rpm go up and turn screw (C), as necessary, to get a 5th to 6th speed upshift when the engine is running at 2055 ± 30 rpm.

15. Put the transmission selector lever in 7th speed position and run the engine at 1900 rpm.

16. Slowly make the engine rpm go up and turn screw (D), as necessary, to get a 6th to 7th speed upshift when the engine is running at 2066 ± 30 rpm.

17. Put the transmission selector lever in 8th speed position and run engine at 1900 rpm.

18. Slowly make the engine rpm go up and turn screw (C), as necessary, to get a 7th to 8th speed upshift when the engine is running at 2056 ± 30 rpm.

19. To make an adjustment of the downshift points:

    a. Put the transmission selector lever in the position of the next lower speed.
    b. Slowly make the engine rpm go down and turn screw (A), as necessary, to get a downshift when the engine is running at the rpm shown in SHIFT POINT CHART.

SHIFT POINT CHART		
SHIFT	**ENGINE SPEED**	**SCREW**
3rd to 2nd	1262 ± 30 rpm	A
3rd to 4th	2055 ± 30 rpm	C
4th to 3rd	1440 ± 30 rpm	A
4th to 5th	2055 ± 30 rpm	D
5th to 4th	1449 ± 30 rpm	A
5th to 6th	2055 ± 30 rpm	C
6th to 5th	1440 ± 30rpm	A
6th to 7th	2066 ± 30rpm	D
7th to 6th	1449 ± 30 rpm	A
7th to 8th	2056 ± 30 rpm	C
8th to 7th	1440 ± 30 rpm	A

20. Make a check of all the upshift and downshift points and make sure all points are in tolerance. See SHIFT POINT CHART.

21. If an adjustment cannot be made to the shift points or a shift point, make a check of the operation of the governor as follows:

    a. Install a 0 to 150 psi (0 to 1030 kPa) pressure gauge in each of the pressure taps (K), (L) and (M).

    b. Refer to GOVERNOR PERFORMANCE CHART for approximate pressures of the governor at each shift point.

    c. Do Steps 1 through 21 again and check the pressures of the governor.

    d. If the pressures of the governor are not correct, clean or install a new governor.

GOVERNOR PERFORMANCE CHART					
Selection Shaft (59) Speed	Shift	Engine	Pressure	Approximate Pressure	
Position	Point	rpm	Tap	psi	kPa
3rd	3 to 2**	1262 ± 30	L	25	170
3rd 4th	3 to4* 4 to 3*	2055 ± 30 1440 ± 30	L	74*** 67	510 460
4th 5th	4 to 5** 5 to 4	2055 ± 30 1449 ± 30	M	41 37	285 255
5th 6th	5 to 6 6 to 5	2055 ± 30 1440 ± 30	M	74*** 67	510 460
6th 7th	6 to 7 7 to 6	2006 ± 30 1449 ± 30	K	41 37	285 255
7th 8th	7 to 8 8 to 7	2055 ± 30 1440 ± 30	K	74*** 67	510 460

*Make an adjustment to these shift points first.
*Make an adjustment to these shift points second.
***The pressure of these shift points must be within .5 Psi (3.5 kPa) of each other. The engine peed of these shift points must be within 5 rpm of each other. If there conditions can be obtained, the governor is operating correctly.

CHAPTER 3
POWER TRAIN
DISASSEMBLY AND ASSEMBLY

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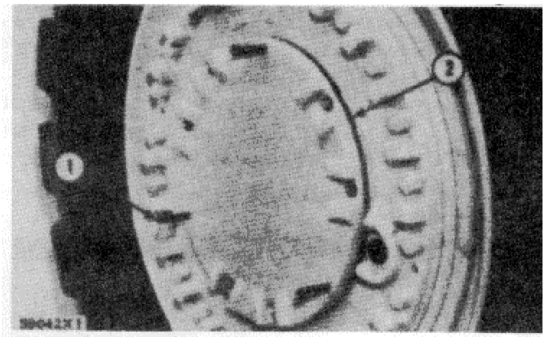
INDEX Page

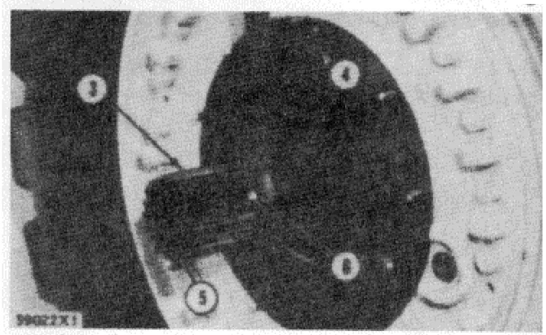
AXLES

REMOVE AXLES



1. Let the oil out of the final drives.

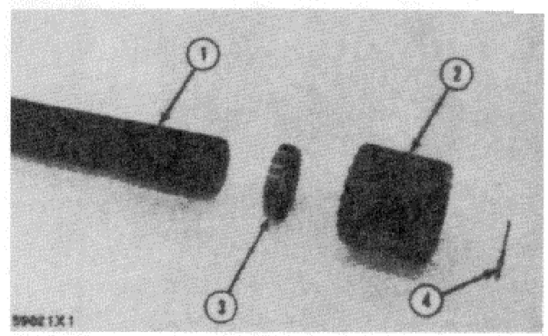
2. Remove nuts that hold cover (2). Remove final drive cover with three 1/2"-13NC forcing screws (1).



3. Pull axle (4) out and fasten a hoist to it. Remove axle. Weight is 90 lb. (40 kg).

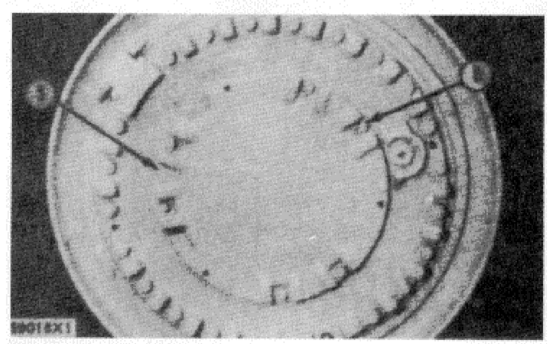
4. Remove ring (5), gear (3) and spacer (6) from axle.

INSTALL AXLES



1. Install spacer (3), gear (2) and ring (4) on axle (1).

2. Install the axle using a hoist.

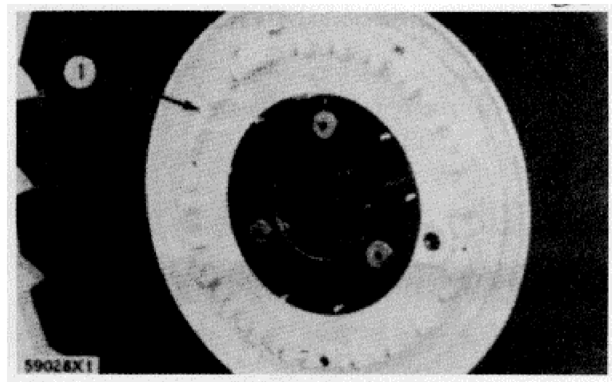


3. Install final drive cover (5), washers and nuts (6).

4. Fill final drives with oil to correct level.

FINAL DRIVE

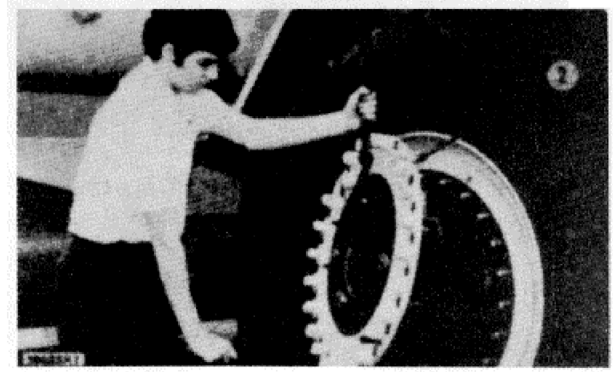
REMOVE FINAL DRIVES



start by:
a) remove axles

1. Remove the nuts (1) that hold the final drive to the wheel.
2. Fasten a hoist to the final drive.
3. Remove final drive (2). Weight is 300 lb. (136 kg).

INSTALL FINAL DRIVES



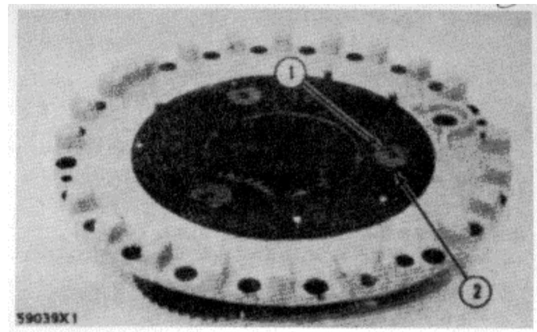
1. Put final drive in position with a hoist.
2. Install washers and nuts.

end by:
a) install axles

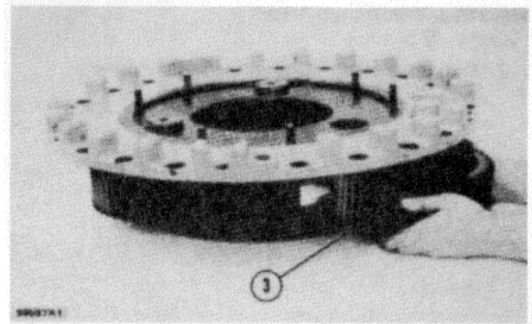
FINAL DRIVES

DISASSEMBLE FINAL DRIVES

start by:
a) remove final drives



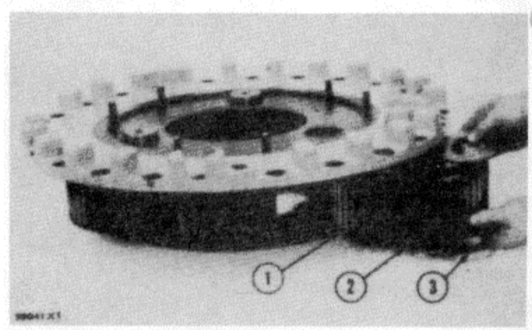
1. Remove ring (2) and shaft (1).



2. Remove spacers and gear (3).

3. Remove bearings and spacers from the gear.

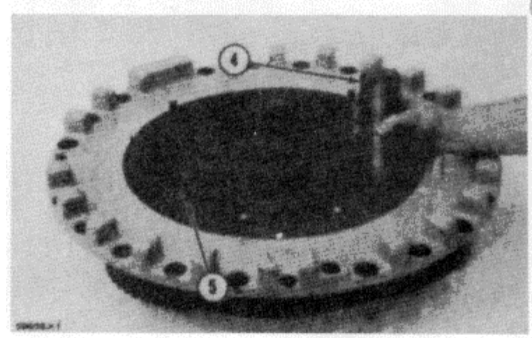
ASSEMBLE FINAL DRIVES



1. Install two bearings and spacer in gear with spacer between the bearings.

2. Put the gear (1) in position in the final drive carrier.

3. Install one steel washer (2) and one brass washer (3) on each side of gear (1) with the steel washer against the gear and the brass washer against the final drive carrier.



4. Install the shaft (4) so the machined flat part of the shaft is toward the outside.

5. Install a ring (5) on each of the shafts.

end by:
a) install final drives

FINAL DRIVE GEAR AND HUB

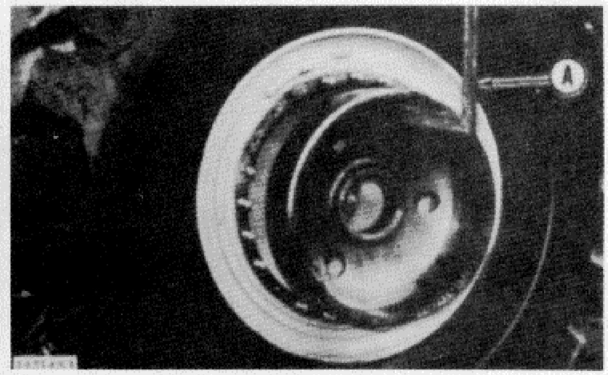
REMOVE FINAL DRIVE GEAR AND HUB

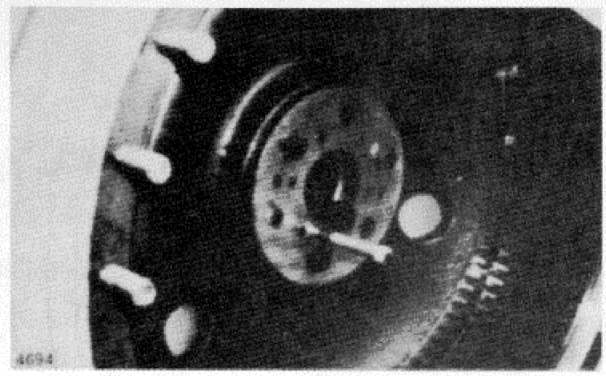
	Tools Needed	A
FT121	Lifting Bracket	1

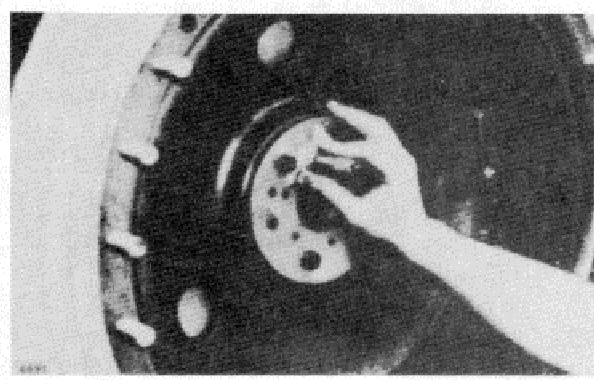
start by:
a) remove final drive

1. Remove bolts and plate.

2. Remove ring gear and hub as a unit with tool (A). Weight is 90 lb. (41 kg).







INSTALL FINAL DRIVE GEAR AND HUB

1. Fasten a hoist and install ring gear and hub as a unit with tool (A).
2. Install retainer without shims. Use three bolts installed equal distance apart.
3. While wheel is turned, tighten the bolts to a torque of 25 lb. ft. (35 N-m). Tighten each bolt one time only.
4. While wheel is turned, tighten the bolts to a torque of 50 lb. ft. (70 N-m). Tighten each bolt one time only.
5. Use a depth micrometer to measure through the holes with threads in the retainer and find the average depth to end of axle housing.
6. Use an outside micrometer to measure the thickness of the retainer at the holes with threads and find the average thickness.
7. Find the difference between the two average measurements. This difference is the measured gap.
8. Remove retainer. Install enough shims so their thickness is .012 in. (0.30 mm) more than the measured gap.
9. Install retainer. While the wheel is turned, tighten the bolts to a torque of 100 ± 10 lb. ft. (135 ± 14 N-m). Install lockwire.

end by:
a) install final drives

WHEELS

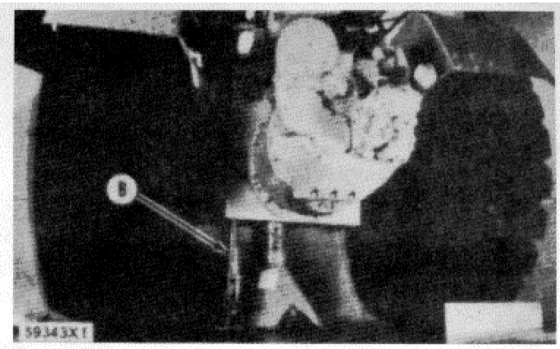
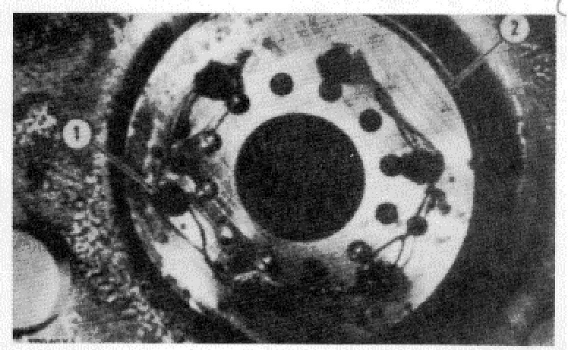
REMOVE WHEELS

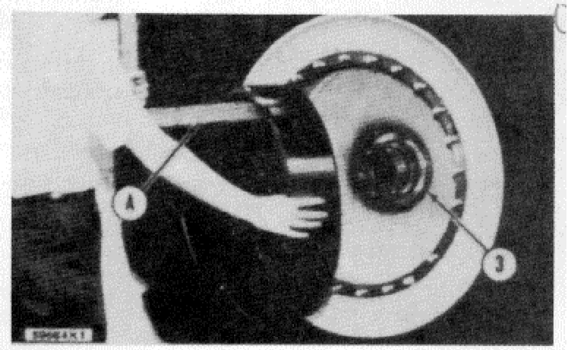
	Tools Needed	A	B	C	D
8S7640	Stand			1	
8S7611	Tube			1	
8S7630	Stand			1	
8S7621	Tube			1	
8S7650	Cylinder		1		
8S7610	Base Assembly		1		
FT121	Lifting Bracket	1			
8S7615	Pin		1	2	
FT901	Bracket				1

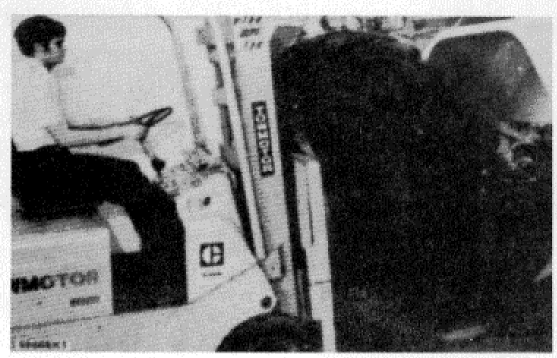
start by:
a) remove final drives

Release the brake as follows:
a) Disconnect the air lines to the rotochamber.
b) Connect shop air to the air inlet at the top of the rotochamber. Keep the air supply constant.
c) Connect shop air to the inlet for the parking brake at the lower side of the rotochamber. Keep the air supply constant.
d) Turn the air supply to the top of the rotochamber off and the brake will release.
e) Disconnect air supply and connect air lines to rotochamber after installation.

1. Use tooling (B) and a hydraulic pump to lift the side of the tractor at the edge of the differential case until the tire is clear of the floor.
2. Put tooling (C) under the edge of the differential case and the frame at the front of the tractor. Lower the tractor on the stands.
3. Put a block under the outer edge of the wheel being removed.
4. Remove lockwire, bolts (1), retainer (2) and shims that hold the hub.
5. Remove ring gear and hub using tool (A). Weight is 200 lb. (91 kg).
6. Remove bearing cone (3).
7. Fasten the wheel to a lift truck with tool (D) and a chain.
8. Use a lift truck to remove the wheel. Weight is 2200 lb. (998 kg).





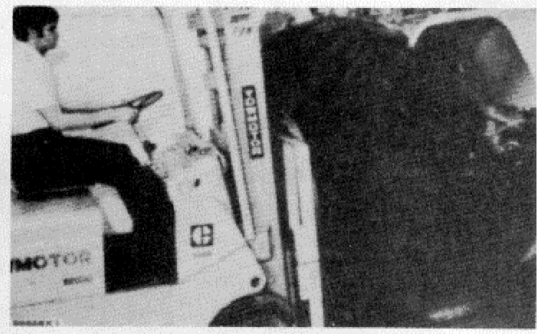
WHEELS

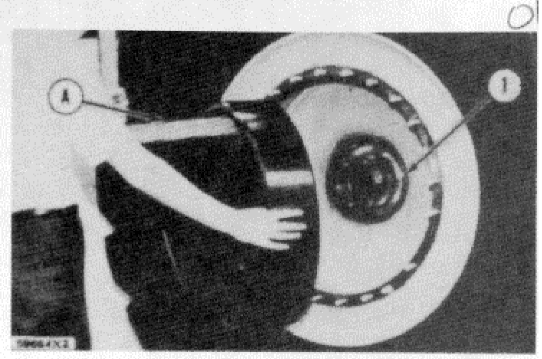
INSTALL WHEELS

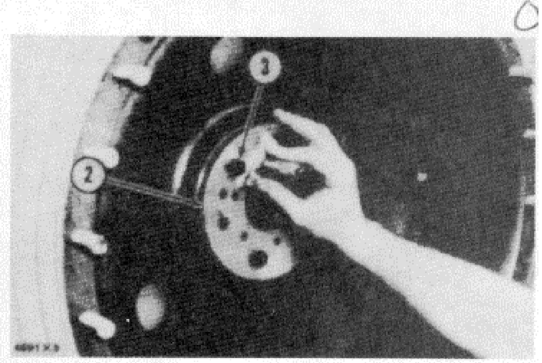
	Tools Needed	A	B	C	D
8S7640	Stand			1	
8S7611	Tube			1	
8S7630	Stand			1	
8S7621	Tube			1	
8S7660	Cylinder		1		
8S7610	Base Assembly		1		
FT121	Lifting Bracket	1			
8S7615	Pin		1	2	
FT901	Bracket				1

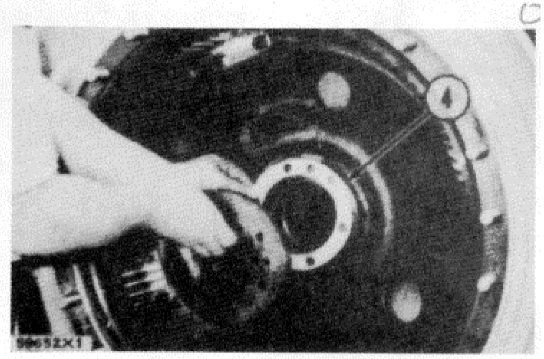
1. Fasten the wheel to a lift truck with tool (D) and a chain. Put the wheel in position with the lift truck.
2. Install bearing cone (1).
3. Install ring gear and hub with tool (A).
4. Install retainer (2) without shims. Use three bolts (3) installed equal distance apart.
5. While wheel is turned, tighten bolts to a torque of 25 lb. ft. (35 N-m). Tighten each bolt one time only.
6. While wheel is turned, tighten the bolts to a torque of 50 lb. ft. (70 N-m). Tighten each bolt one time only.
7. Use a depth micrometer to measure through the holes with threads in the retainer and find the average depth to end of axle housing.
8. Use an outside micrometer to measure the thickness of the retainer at the holes with threads and find the average thickness.
9. Find the difference between the two average measurements. This difference is the measured gap.
10. Remove retainer. Install enough shims (4) so their thickness is .012 in. (0.30 mm) more than the measured gap.
11. Install retainer. While the wheel is turned, tighten the bolts to a torque of 100 ± 10 lb. ft. (135 ± 14 N-m).
12. Install lockwire. Remove tooling (B) and (C).
13. Make brake adjustment. See TESTING AND ADJUSTING, PART THREE, Chapter 3, Section I.

end by:
a) install final drives





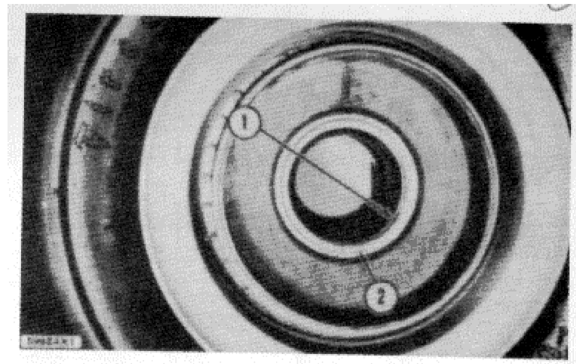




WHEEL BEARINGS AND SEALS

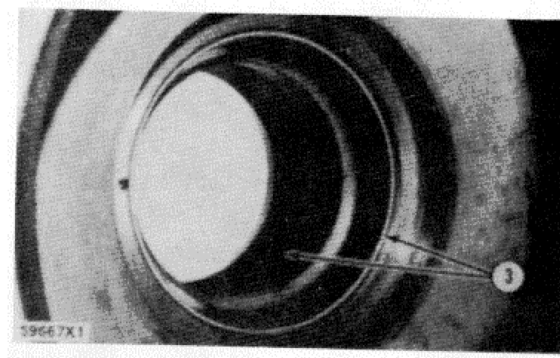
REMOVE WHEEL BEARINGS AND SEALS

start by:
a) remove final drive gear and hub
b) remove wheels

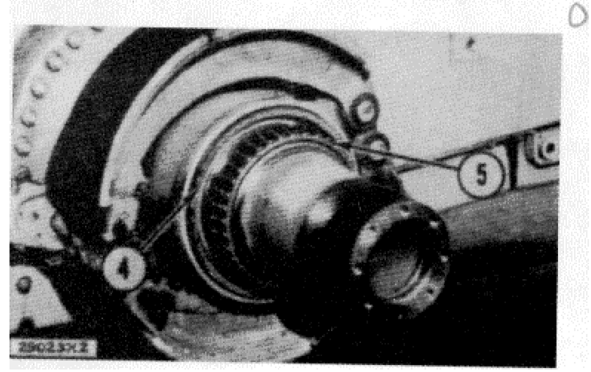


1. Remove Duo-Cone seal (1) from the wheel.

2. Remove retainer (2) from the wheel.



3. Remove bearing cups (3) from wheel.



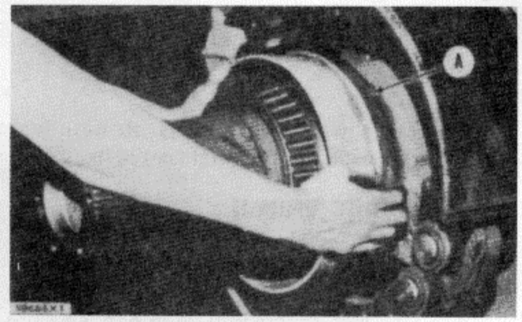
4. Remove bearing (5), race, and Duo-Cone seal (4).

WHEEL BEARINGS AND SEALS

INSTALL WHEEL BEARINGS AND SEALS

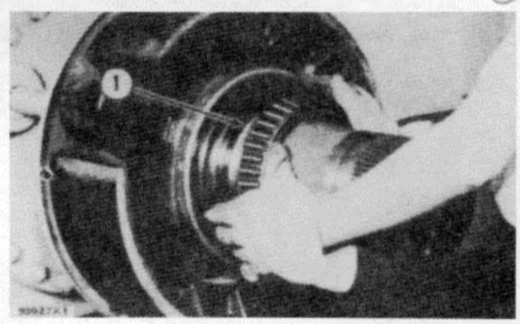
	Tools Needed	A
1S4320	Duo-Cone Seal Installer	1

1. Install Duo-Cone seal on axle housing with tool (A).

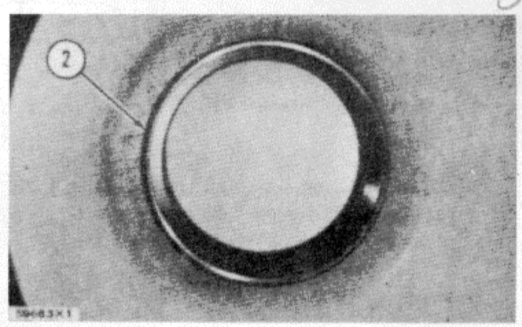


2. Heat wheel bearing in oil at a temperature of 275°F (135°C) for thirty minutes.

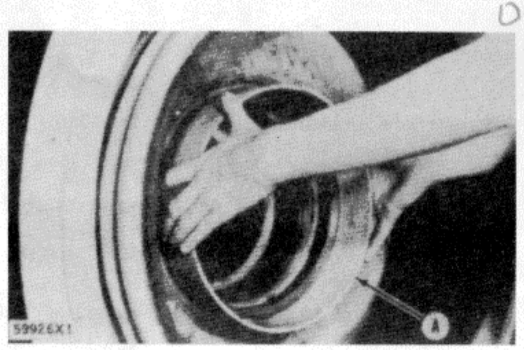
3. Put the bearing (1) in position on the axle housing.



4. Install the wheel bearing cups (2) in the wheel.



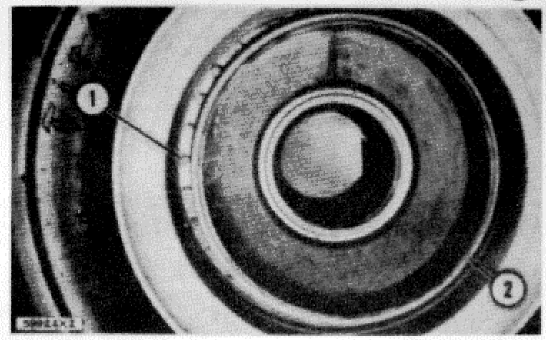
5. Install seal retainer in the wheel. Install Duo-Cone seal in wheel with tool (A).



end by:
   a) install wheels
   b) install final drive gear and hub

BRAKE DRUMS & BRAKE SHOES

REMOVE BRAKE DRUMS



start by:
a) remove wheels

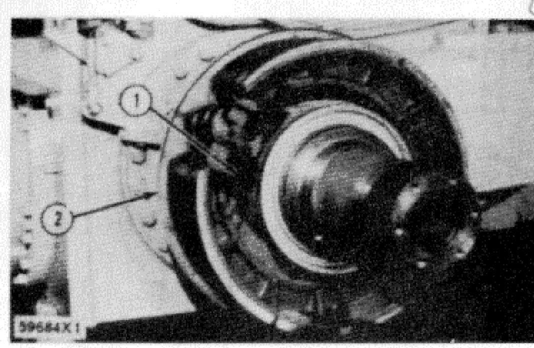
1. Remove nuts (1) and washers. Remove brake drum (2) with a hoist. Weight is 126 lb. (57 kg).

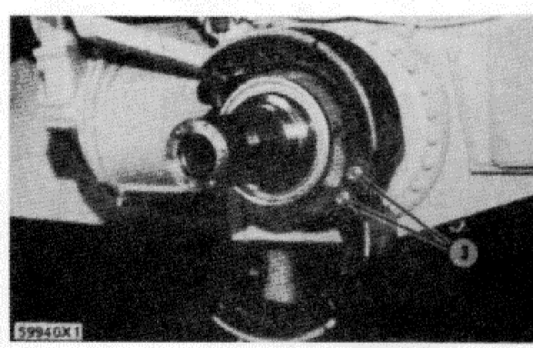
INSTALL BRAKE DRUMS

1. Put brake drum in position using a hoist.
2. Install nuts and washers that hold it. Tighten nuts to a torque of 95 ± 5 lb.ft. (128.8 ± 6.8 N-m).

end by:
a) install wheels

REMOVE BRAKE SHOES





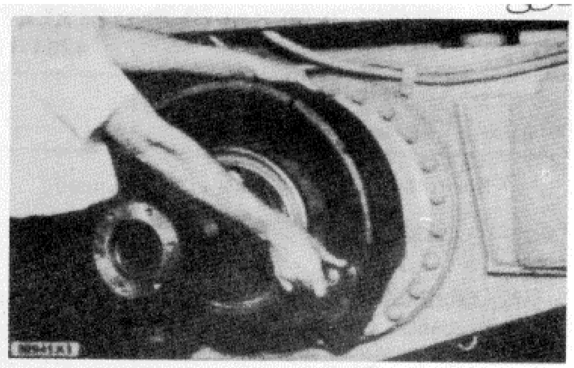
start by:
a) remove wheels

1. Remove bearing cone and Duo-Cone seal from axle housing.
2. Remove guards (2).
3. Remove brake springs (1).
4. Remove lockwire and bolts that hold pins (3).
5. Remove spring, retainer and felt washer that hold pins.
6. Remove pins and brake shoes. Weight of each shoe is 45 lb. (20 kg).

BRAKE SHOES, BRAKE CAMSHAFTS & SLACK ADJUSTERS

INSTALL BRAKE SHOES

	Tools Needed	A
8M7912	Seal Installer	1



1. Put the brake shoes in position and install the pins that hold them.

2. Install felt washer, retainer, and spring on the pins.

3. Install two bolts and lockwire that hold pins.

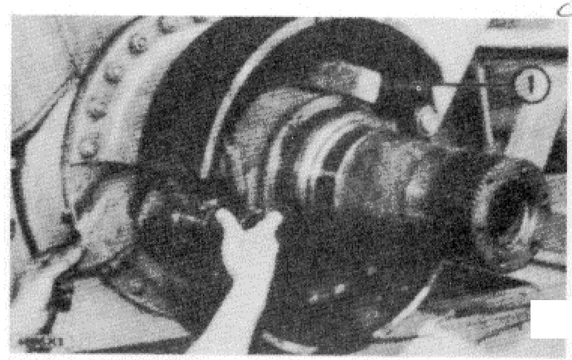
4. Install brake spring and guards.

5. Install Duo-Cone seal using tool (A). Install bearing cone on the axle housing.

end by:
a) install wheels

REMOVE BRAKE CAMSHAFTS AND SLACK ADJUSTERS

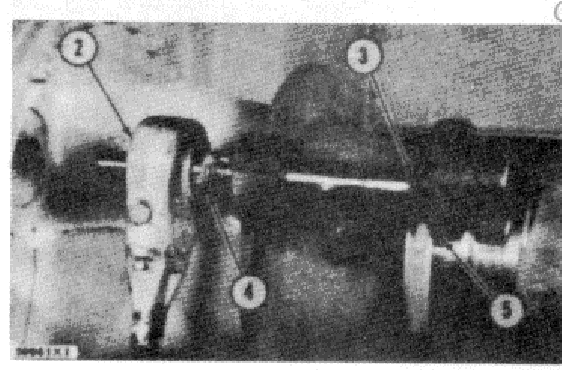
start by:
a) remove wheels



1. Remove seal, retainer and bearing cone from axle housing.

2. Put blocks (1) between brake shoes and axle housing to give clearance for removal of camshafts.

3. Remove the pin that fastens the rod of the rotochamber to the slack adjuster.



4. Remove ring (4) from the groove in the camshaft.

5. Pull the camshaft (5) out of the axle housing. Remove slack adjuster (2), ring (4), and washer (3) from camshaft (5).

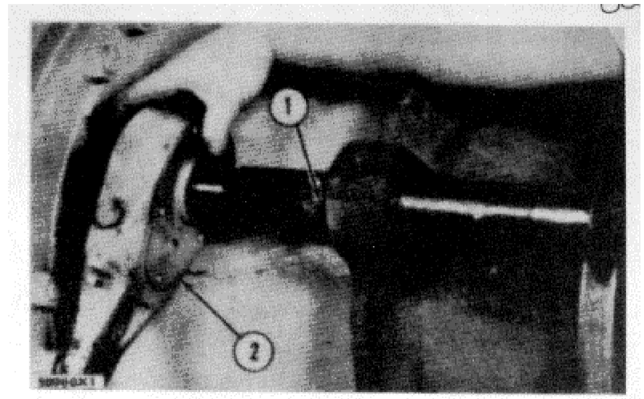
6. Remove camshaft (5) from axle housing.

7. Remove seals and bearings from axle housing.

BRAKE CAMSHAFTS AND SLACK ADJUSTER

INSTALL BRAKE CAMSHAFTS AND SLACK ADJUSTERS 4261-12

	Tools Needed	A
8M7912	Seal Installer	1



1. Install bearings and seals in axle housing.

2. Install all seals with the lips toward the axle housing.

3. Put lubricant on lip of seals.

4. Install washer on camshaft. Put camshaft in position and install washer, ring (1) and slack adjuster (2) on camshaft.

5. Push end of camshaft into the axle housing. Put ring (1) in the groove in the camshaft.

6. Install the pin that fastens the rod of the rotochamber to the slack adjuster.

7. Install seal retainer and bearing cone on axle housing.

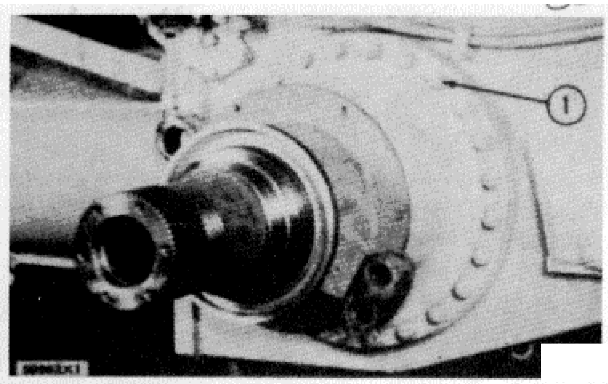
8. Install Duo-Cone seal using tool (A). Remove spacer.

9. Make brake adjustment. See TESTING AND ADJUSTING, PART THREE, Chapter 3, Section I.

end by.
 a) install wheels

AXLE HOUSING

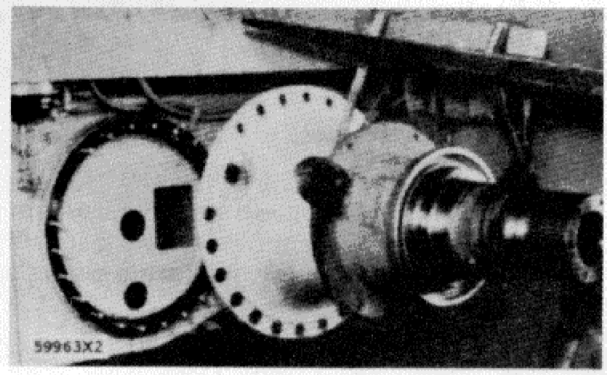
REMOVE AXLE HOUSING



start by:
- a) remove brake shoes
- b) remove brake camshafts and slack adjusters

1. Let the oil out of the differential case.
2. Use a lift truck as a support for the axle housing.
3. Remove nuts (1) and washers.
4. Remove axle housing. Weight is 455 lb. (206 kg).

INSTALL AXLE HOUSING



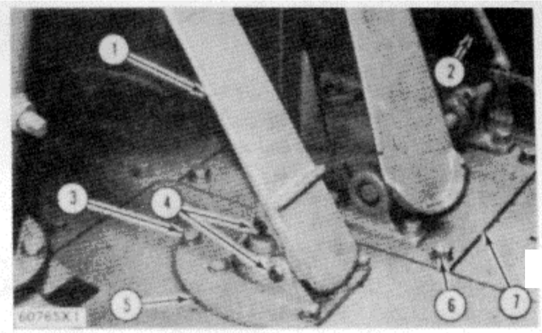
1. Put the axle housing in position with a lift truck and install the washers and nuts that hold it.
2. Tighten the nuts to a torque of 290 ± 20 lb.ft. (393.2 ± 27.1 N.m).

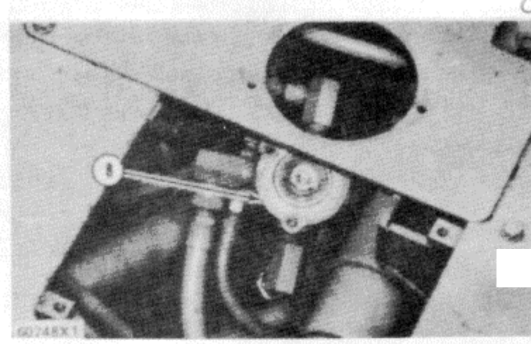
end by.
- a) install brake camshafts and slack adjusters
- b) install brake shoes

BRAKE CONTROL VALVE

REMOVE BRAKE CONTROL VALVE

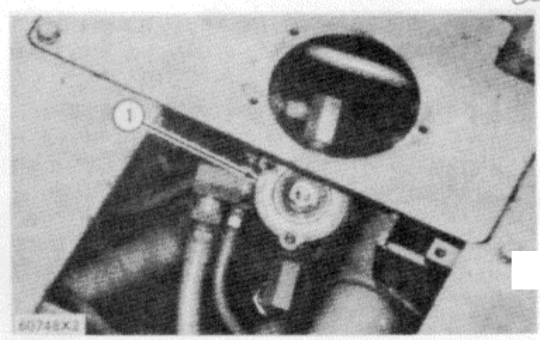
1. Let the air out of the air reservoirs.
2. Disconnect the governor linkage from control lever (2).
3. Remove four bolts (6) and floor plate (7).
4. Remove cotter pins and pins (4). Remove treadle (1).
5. Remove six bolts (3) and plate (5).
6. Pull the control valve (8) away from the floor plate. Disconnect five air lines from the valve. Put identification marks on the valve and air lines for installation purposes.
7. Remove the control valve (8).

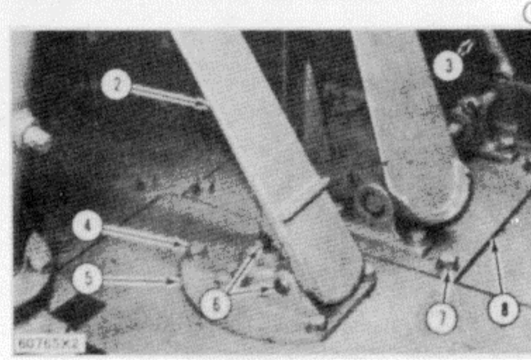




INSTALL BRAKE CONTROL VALVE

1. Connect the five air lines to the valve (1) in their original positions.
2. Put the valve in position and install plate (5)and six bolts (4).
3. Install plate (8) and four bolts (7).
4. Connect the governor linkage to control lever (3).
5. Put the treadle (2) in position and install the pins (6) and cotter pins that hold it. Make a bend in the legs of the cotter pins.





BRAKE CONTROL VALVE

DISASSEMBLE BRAKE CONTROL VALVE

start by:
a) remove brake control valve

1. Remove retainer (4), bolt (3) and washer, seat (2), rubber spring (1), piston (5) and spring (6) from the body.

2. Remove ring (I 5), washer (13), screw (14) and washer, diaphragm (9) and spring (7). Remove seat (12), O-ring seal (II), spring (10) and valve (8) from the body.

(SEE ILLUSTRATION ON NEXT PAGE)

ASSEMBLE BRAKE CONTROL VALVE

1. Install new O-ring seals.

2. Install valve and spring in the body. Install O-ring seal on seat.

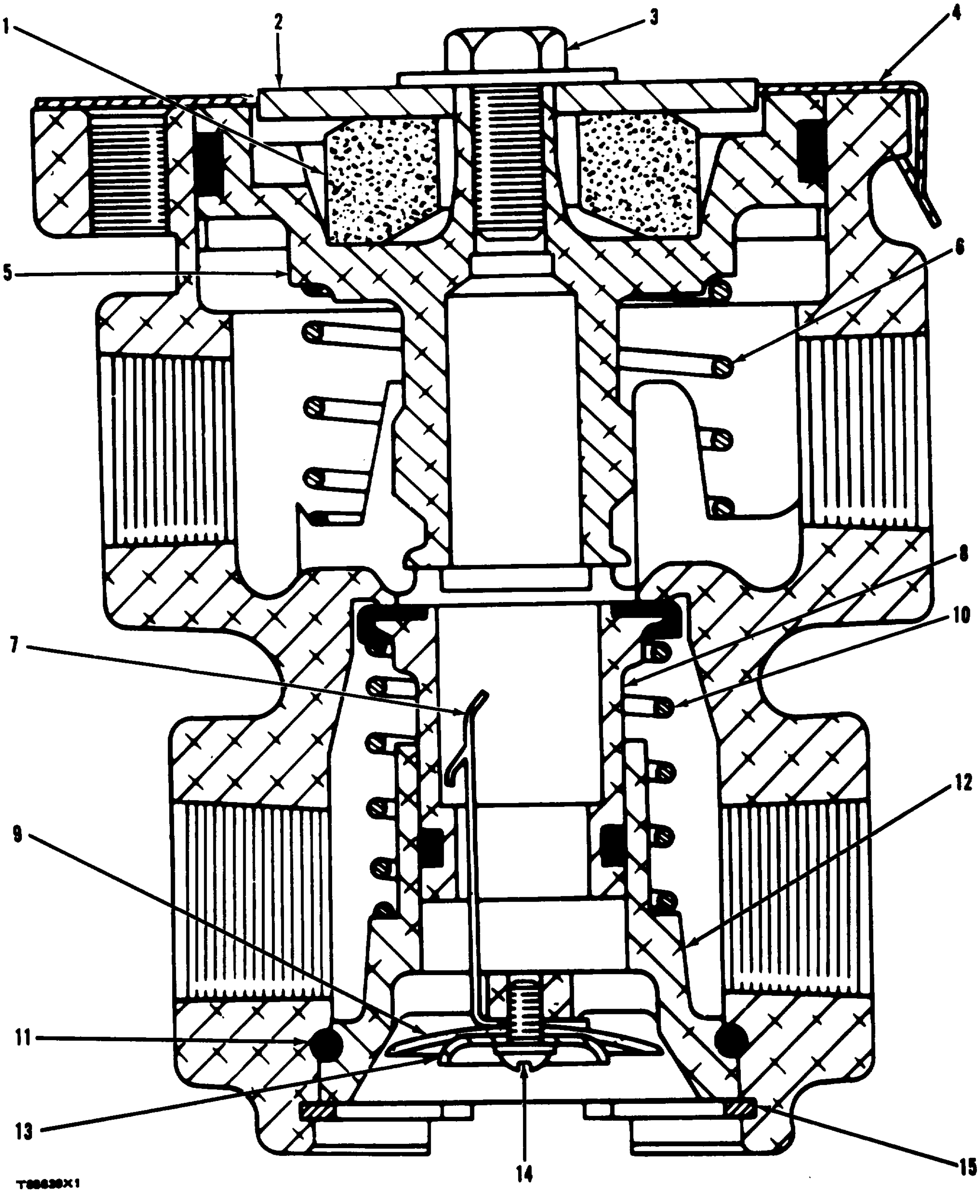
3. Install seat, spring, diaphragm, washer and screw.

4. Install ring and washer.

5. Install spring and piston. Install rubber spring with concave side (part that curves inward) toward inside. Install seat, washer and screw. Install retainer on the body.

end by:
a) install brake control valve

BRAKE CONTROL VALVE



BRAKE ACTUATORS

REMOVE BRAKE ACTUATORS

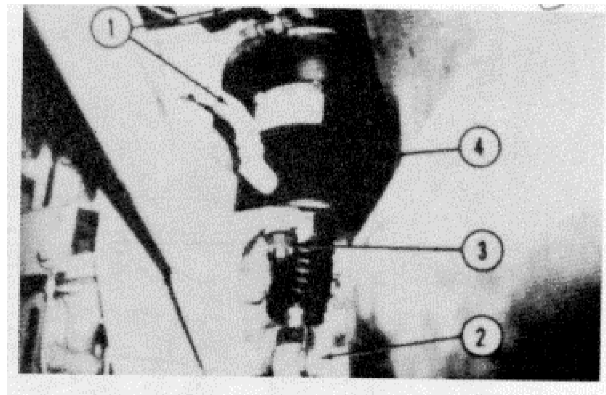
WARNING: Vent all air from air tanks before attempting brake actuator removal.

1. Disconnect two air lines (1) from brake actuator.

2. Apply shop air to spring chamber to release tension on slack adjuster. Disconnect push rod yoke by removing cotter pin and pin (2).

3. Remove or reposition slack adjuster to prevent contact with yoke when air in chamber is released.

4. Disconnect shop air to spring chamber. Remove two nuts (3); then carefully remove brake actuator (4) from bracket.



INSTALL BRAKE ACTUATORS

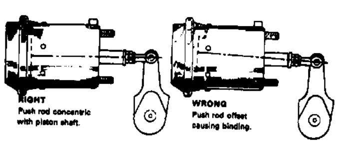
1. Position brake actuator (4) on mounting bracket; then install two nuts (3). Tighten nuts to 110-150 pounds foot torque.

2. Apply shop air to spring chamber to compress spring. Adjust slack adjuster so that it is perpendicular to the push rod at 50% of stroke.

3. Connect yoke to slack adjuster. Install pin (2) and new cotter pin.

4. Remove shop air.

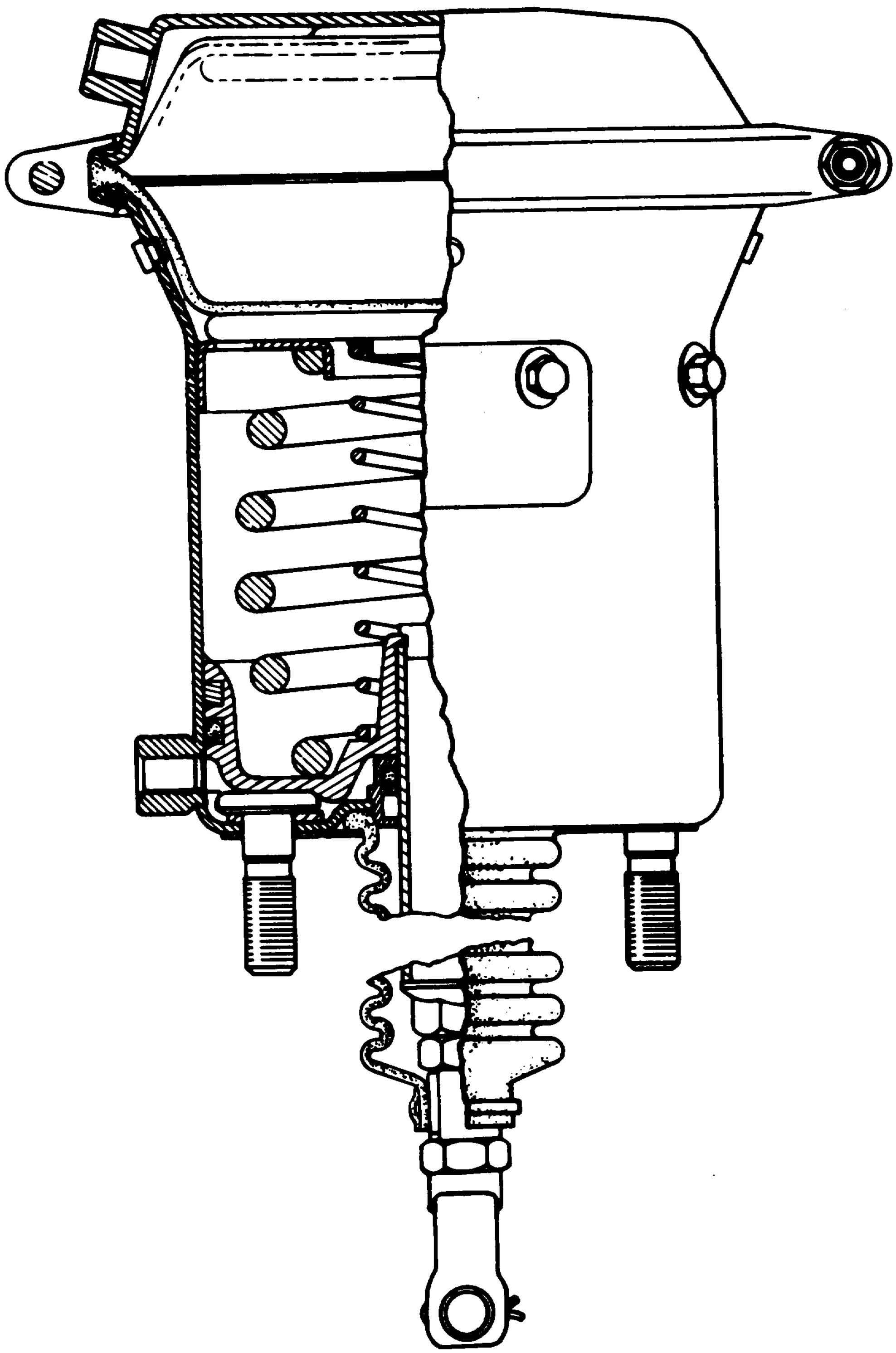
5. Connect two air lines (1). With spring brake released, check clearance between flange nut and piston neck for 1/6 inch to 1/8 inch gap. Tighten jam nut.



6. See diagram above. Apply service brake. Check push rod operation. Push rod should clear opening in piston shaft at minimum and maximum service brake stroke.

7. Adjust the service brakes so push rod travel is as short as possible without brake shoes dragging.

BRAKE ACTUATOR WITH PARKING BRAKE



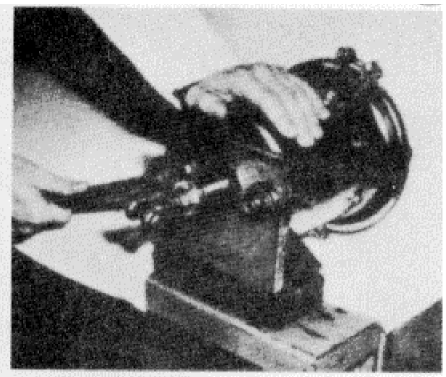
BRAKE ACTUATOR WITH PARKING BRAKE

DISASSEMBLE BRAKE ACTUATOR WITH PARKING BRAKE

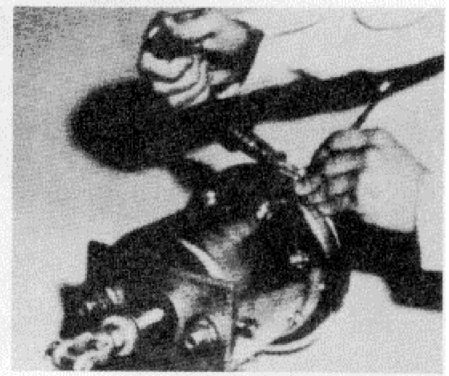
	Tools Needed	A
4036108	Maxitool and 90° bracket	1

start by:
a) remove brake actuators

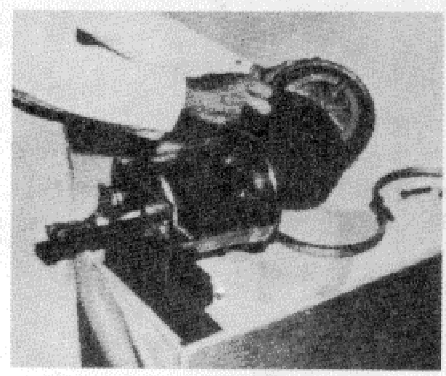
1. Mount brake actuator on 900 bracket and secure with stud nuts.



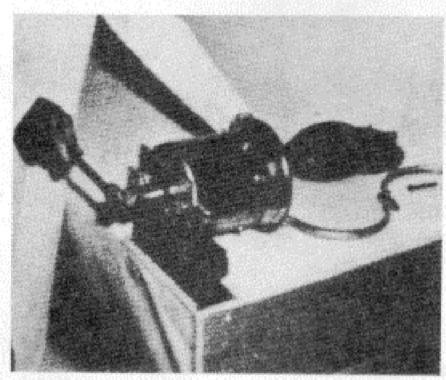
2. Note location of pressure plate inlet port with respect to spring chamber. Loosen clamp band nuts and bolts and remove clamp band halves.



3. Remove pressure plate and diaphragm.

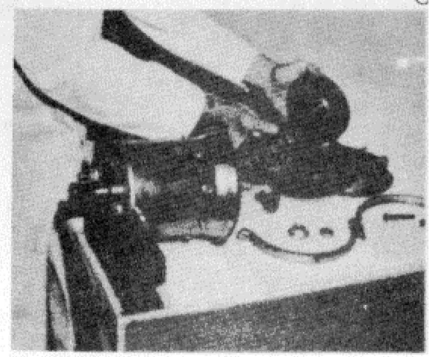


4. Press down on push rod plate to remove jam nut and flange nut securing push rod.

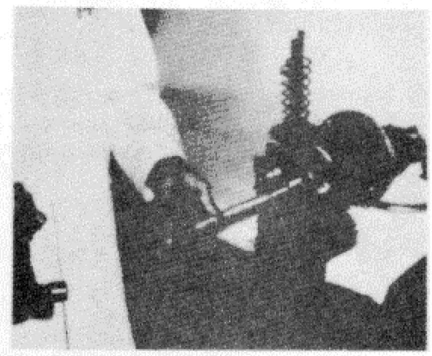


BRAKE ACTUATOR WITH PARKING BRAKE

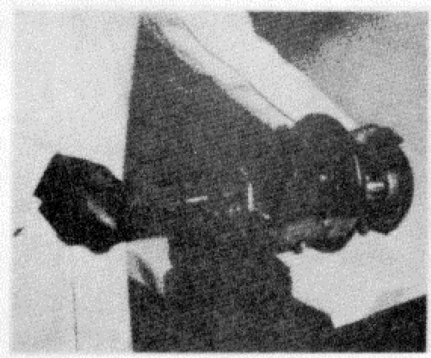
5. Pull out push rod assembly (push rod, spring retainer and return spring).



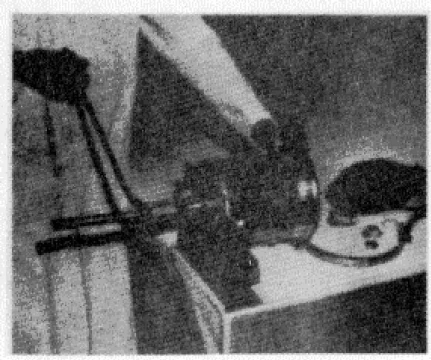
6. Free push rod bushing from cylinder boss by inserting Maxitool shaft through piston tube and tapping lightly. Remove bushing from cylinder.



7. Insert Maxitool, from the back of unit, through the piston tube. Insert machined end of Maxitool bushing into piston neck. Screw nut on in back of bushing and tighten.

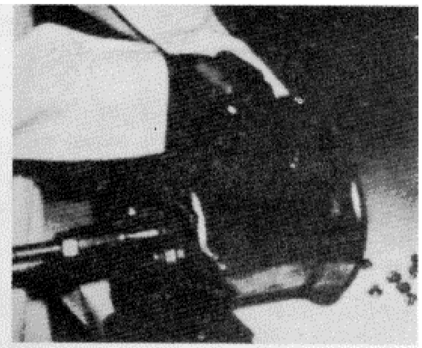


8. Tighten nut until Maxitool is centered and resting firmly against the spring support releasing spring pressure.

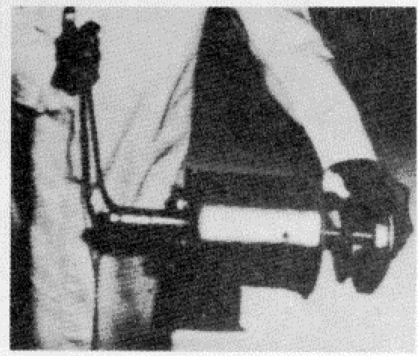


BRAKE ACTUATOR WITH PARKING BRAKE

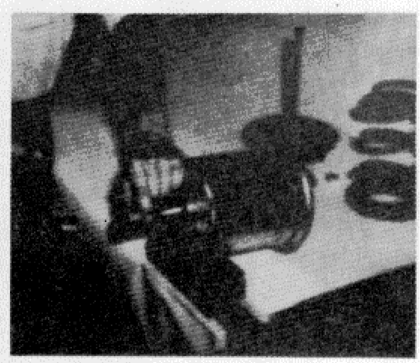
9. Remove the eight capscrews holding the spring support.



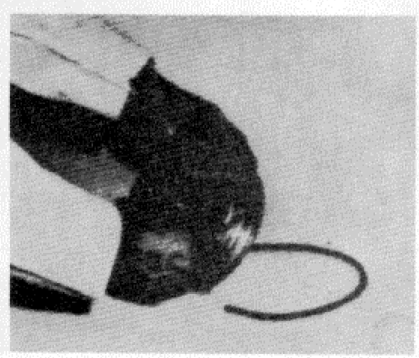
10. Gradually back off the nut on the Maxitool until all pressure is off the spring. Remove the Maxitool, power spring and spring support.



11. Using the Maxitool guide collar on piston neck, drive piston assembly from cylinder boss. Remove piston assembly from cylinder.

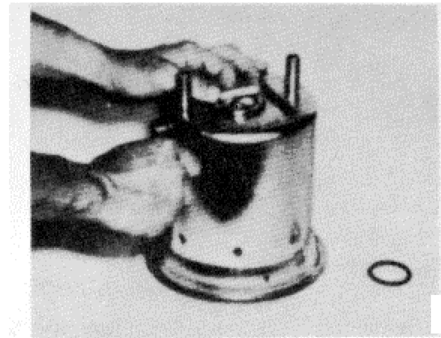


12. Remove felt wiper ring and "O" ring from piston.

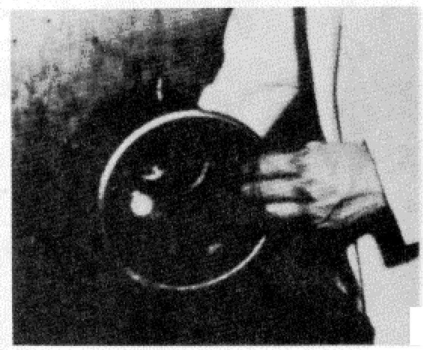


BRAKE ACTUATOR WITH PARKING BRAKE

13. Remove "O" ring and nylon bushing from cylinder center boss. Use a sharp pointed instrument to remove bushing; work clockwise from cut to pry bushing out of groove; then, remove backup ring.



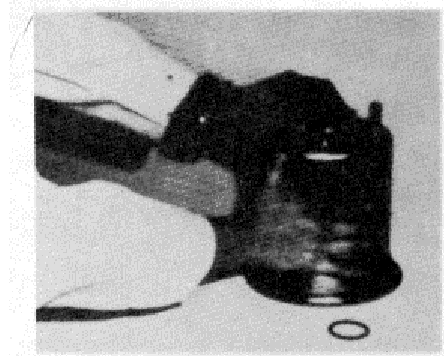
14. Wash all metal parts in cleaning solvent.



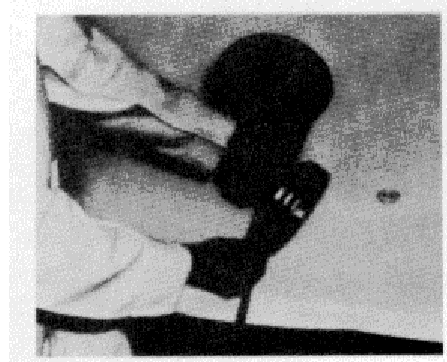
ASSEMBLE BRAKE ACTUATOR (WITH PARKING BRAKE)

	Tools Needed	A
4036108	Maxitool and 90° bracket	

1. Install nylon bushing in cylinder center boss groove. Bushing must be installed so that side with bevel edge faces toward inside of cylinder. Lubricate and install small "O" ring in other groove.

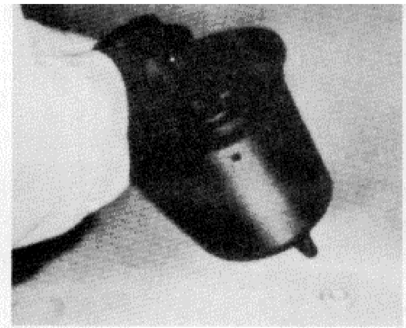


2. Lubricate and install large "O" ring in bottom groove of piston (groove nearest neck) and saturated felt wiper ring in top groove.

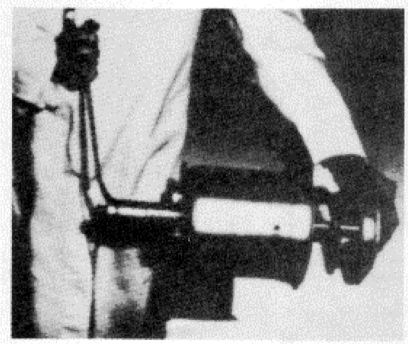


BRAKE ACTUATOR WITH PARKING BRAKE

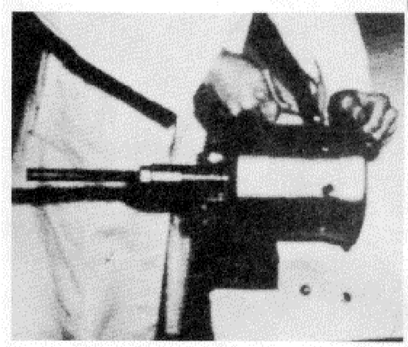
3. Insert piston assembly all the way into cylinder, holding felt wiper ring in place as piston is inserted.



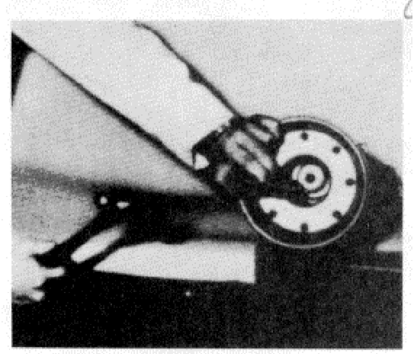
4. Assemble spring support and power spring onto Maxitool and insert through piston assembly. Run on Maxitool guide collar and 34" nut. Tighten nut slightly and center spring over piston hub and spring support.



5. Tighten nut down until holes in spring support align with cylinder holes. Install the eight cap screws securing spring support to cylinder, alternately tightening. (Approximately 125 in./lbs.)

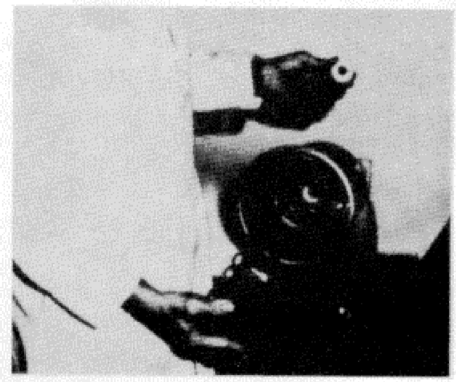


6. Remove Maxitool. Install push rod bushing into piston; tap lightly, making sure it is seated properly.

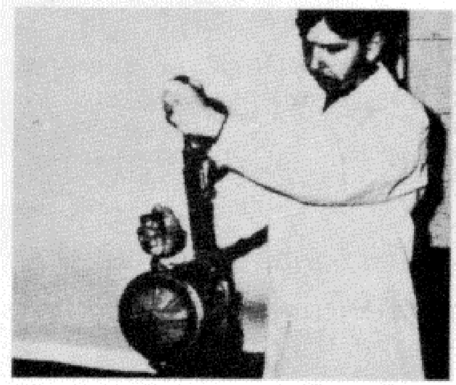


BRAKE ACTUATOR WITH PARKING BRAKE

7. Assemble spring retainer and push rod return spring, install through bushing and piston tube, then secure with flange nut.

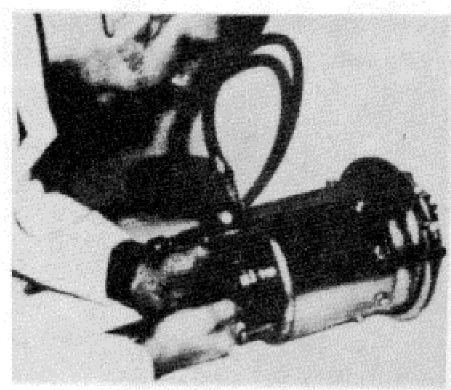


8. Install diaphragm with crowned surface in pressure plate and center over cylinder. Apply pressure to top of plate to squeeze diaphragm. Align clamp band assembly with pressure plate and cylinder. Torque bolts to 120-180 in./lbs.



9. Apply shop air to spring chamber. Run flange nut on piston rod to provide Y,," to "' gap at piston neck. Secure with jam nut. Test both chambers for air leaks. Maximum permissible leakage per chamber is 1 lb./min. with total volume of 200 cu. in./100 psi test pressure.

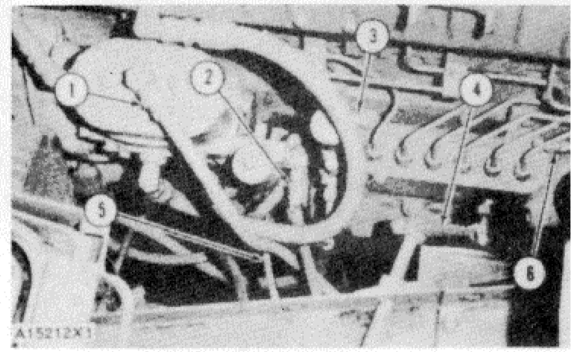
   end by:
   a) install brake actuators



ENGINE AND DRIVE SHAFT

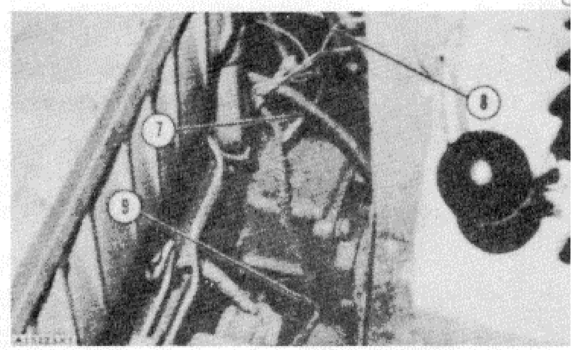
REMOVE ENGINE AND DRIVE SHAFT AS A UNIT

start by:
a) remove hood
b) remove crankcase guards
c) remove radiator



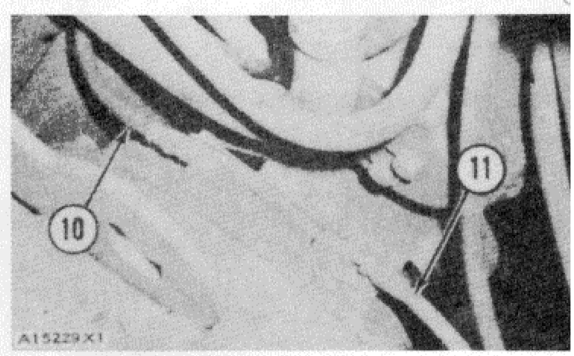
1. Remove engine oil and hydraulic oil.

2. Disconnect battery cables from the engine.



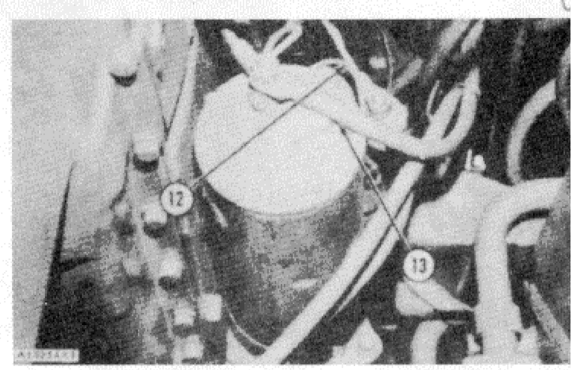
3. Disconnect lines (1), (2), (3) and (6). Disconnect tachometer drive cable (5).

NOTE: Put identification on all lines, cables, wires and tubes.



4. Disconnect governor linkage (4).

5. Disconnect lines (8) and (9). Disconnect tube (7).

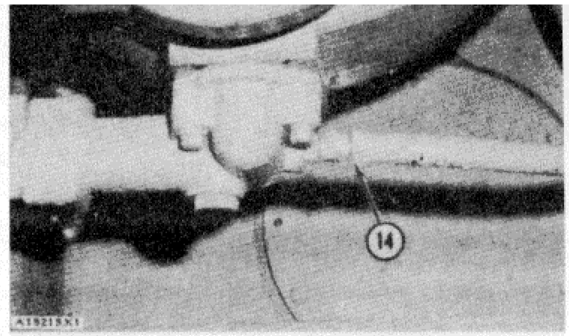


6. Remove lines (10) and (11) on top of drive shaft housing.

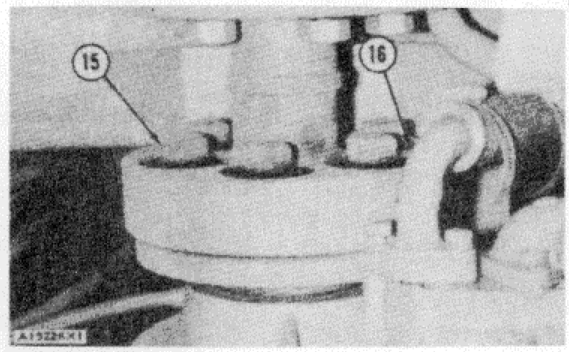
7. Disconnect all cables (13) and wires (12) from the starter.

ENGINE AND DRIVE SHAFT

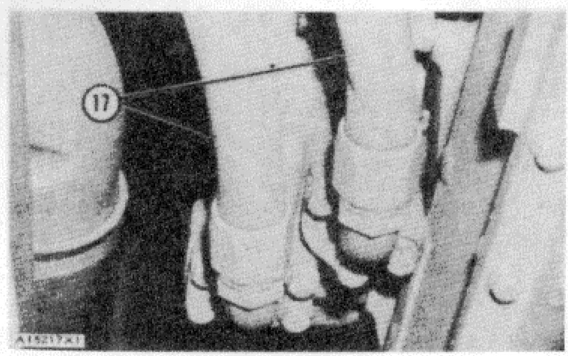
8. Remove hydraulic return line (14) for the seat.



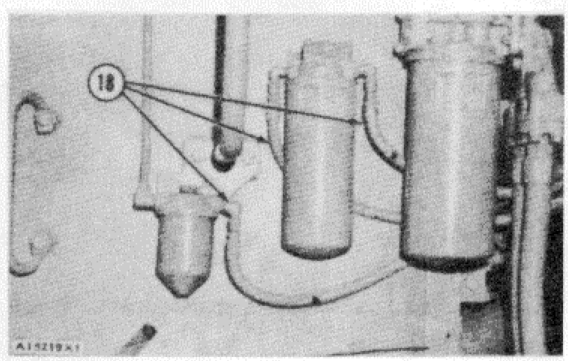
9. Remove hose (16) and bolts (15) from drive shaft coupling.



10. Disconnect hoses (17) from oil filter base.

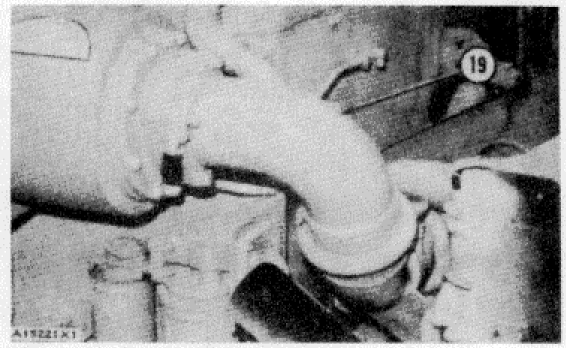


11. Disconnect lines (18) from the oil and fuel filters.

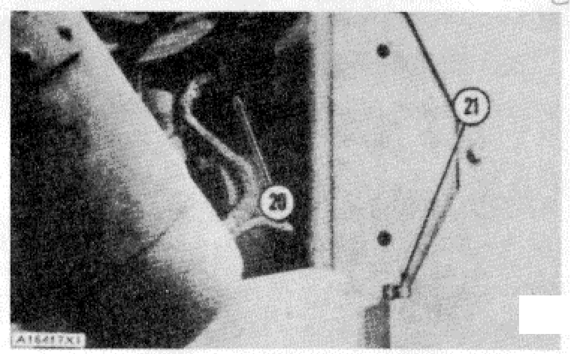


ENGINE AND DRIVE SHAFT

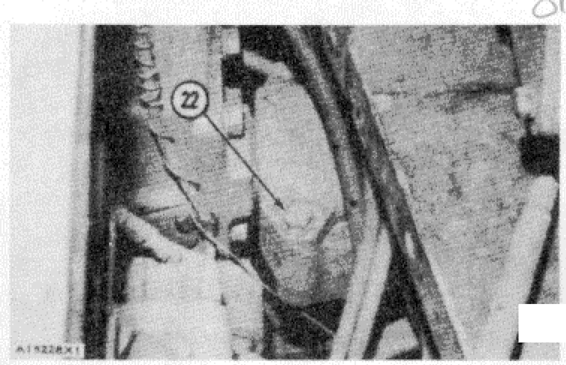
12. Remove the air inlet elbow (19) from turbocharger and air cleaner. Remove oil level gauge. Disconnect oil level gauge guide assembly.



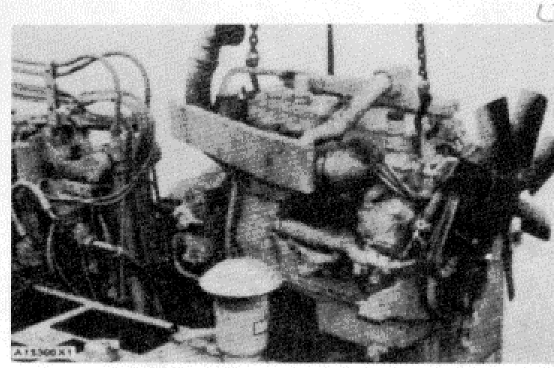
13. Remove wire cage (20) from the frame. Fasten a hoist to the engine. Remove bolts (21) from the front support.



14. Remove bolts (22) from the engine rearmounts.



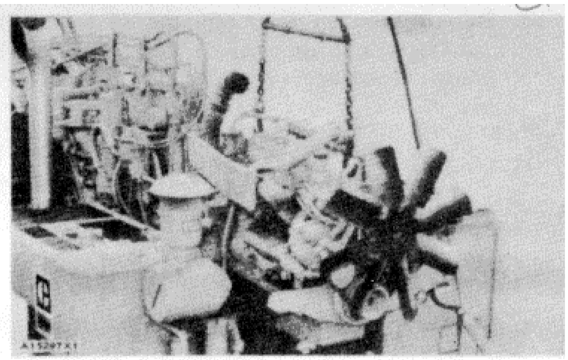
15. Remove engine and drive shaft as a unit. Weight of the unit is 3150 lb. (1429 kg).



ENGINE AND DRIVE SHAFT

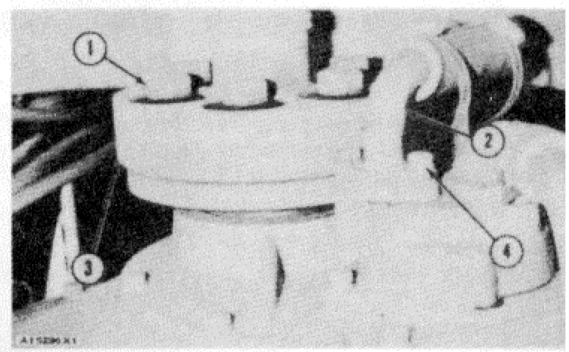
INSTALL ENGINE AND DRIVE SHAFT AS A UNIT

1. Put engine and drive shaft in position in the -fine with a hoist.

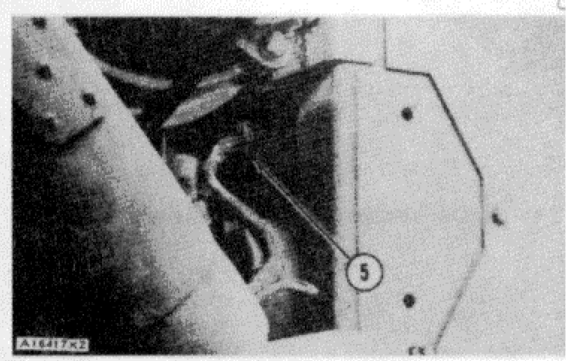


2. Install bolts for the rear mounts. Install bolts for the front support.

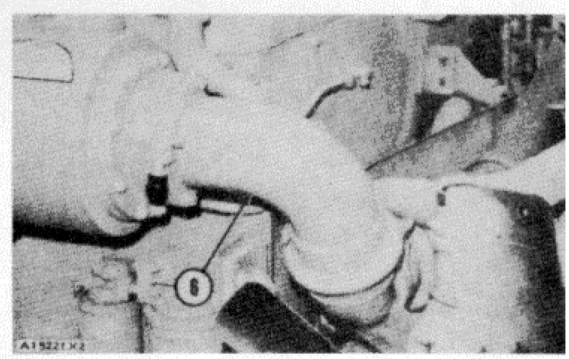
3. Connect coupling (3) to drive shaft and install bolts (1). Tighten the bolts to a torque of 320 ± 15 lb.ft. (44.3 ± 2.1 mkg). Install hose (2) and bolts (4).



4. Install wire cage (5) on machine frame.

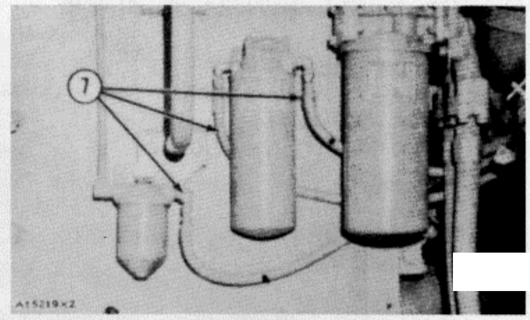


5. Install the air inlet elbow (6) to the turbocharger and air cleaner. Connect oil level gauge guide assembly and install oil level gauge.



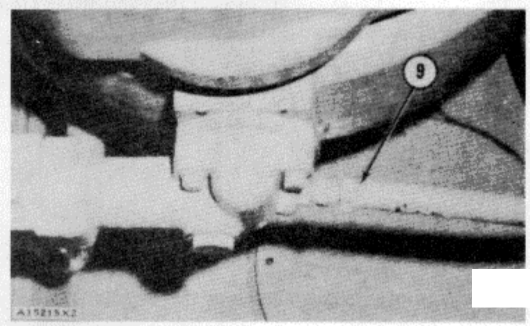
ENGINE AND DRIVE SHAFT

6. Connect lines (7) to the oil and fuel filters.

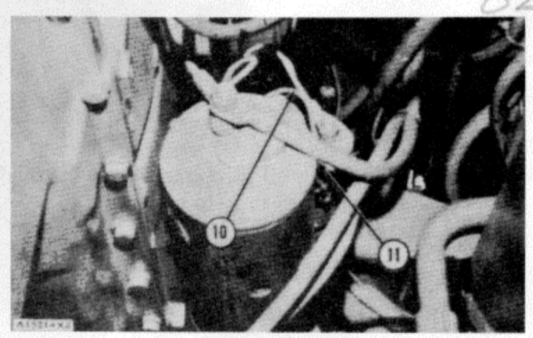


7. Connect hoses (8) to the oil filter base.

8. Install hydraulic return line (9) for the seat.

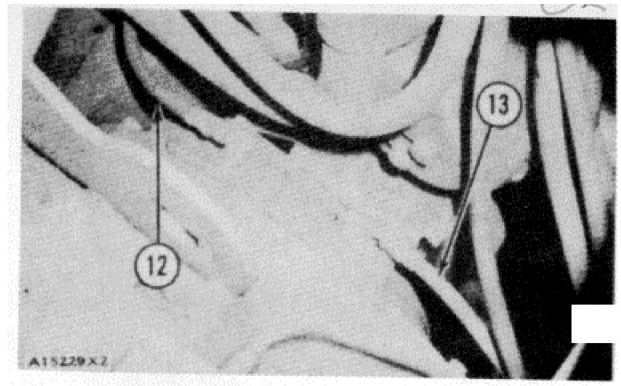


9. Connect all cables (11) and wires (10) to the starter.

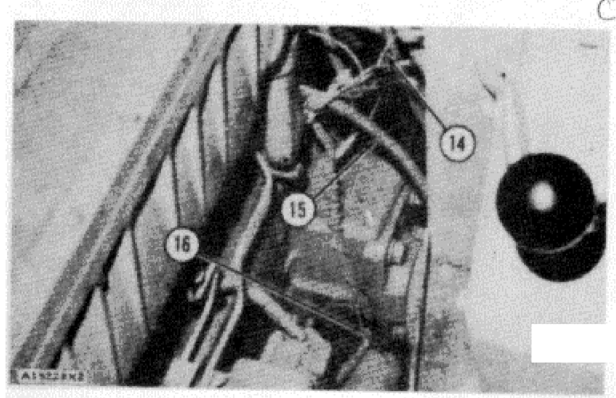


ENGINE AND DRIVE SHAFT

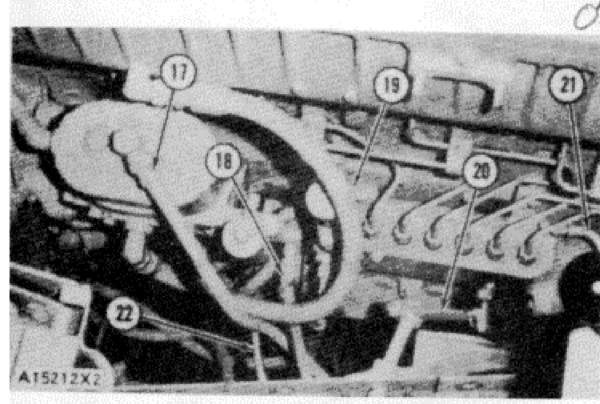
10. Install lines (12) and (13) on top of the drive shaft housing.



11. Connect lines (14) and(16). Connect tube (15).



12. Connect lines (17), (18), (19), and (21). Connect tachometer drive cable (22). Connect governor linkage (20).



13. Connect battery cables to the engine.

14. Fill engine with oil to correct level. Fill hydraulic system with fluid to correct level.

end by:
 a) install radiator
 b) install crankcase guards
 c) install hood

Retarder And Drive Shaft Group

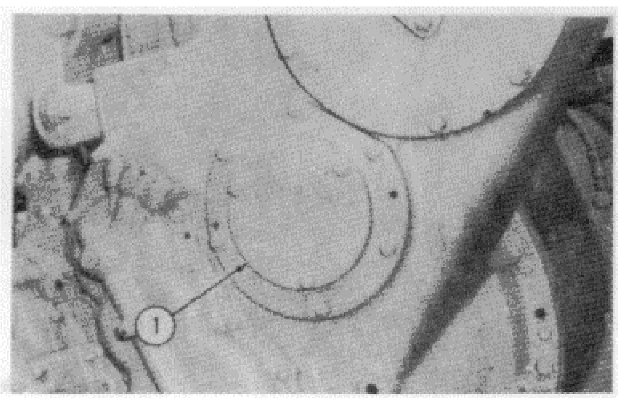
Remove Retarder And Drive Shaft Group 3120, 325311

Tools Needed		A
5P9736	Link Bracket	1

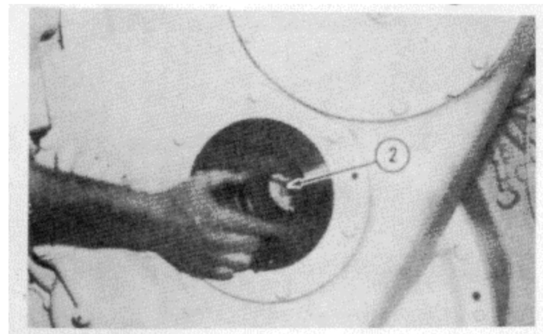
START BY:

a) remove supplemental steering pump
b) remove retarder control valve
c) remove scavenge pump

1. Remove the plug from the bottom of the sump screen housing to drain the oil from the flywheel housing. Only a small amount of oil is present.

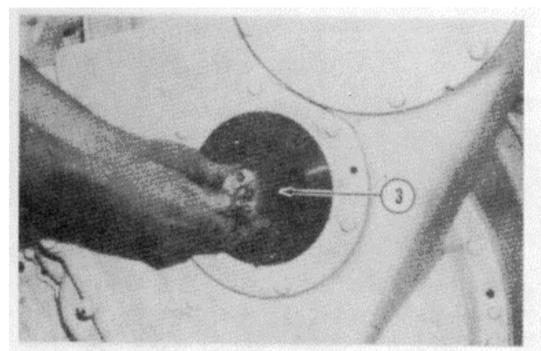


2. Remove three bolts, plate (1) and the 0-ring seal from the transmission.

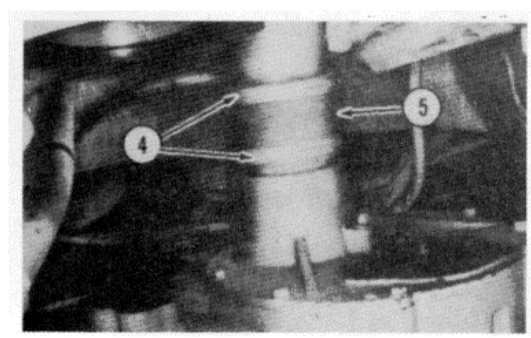


3. Remove spiral ring (2) from the drive shaft.

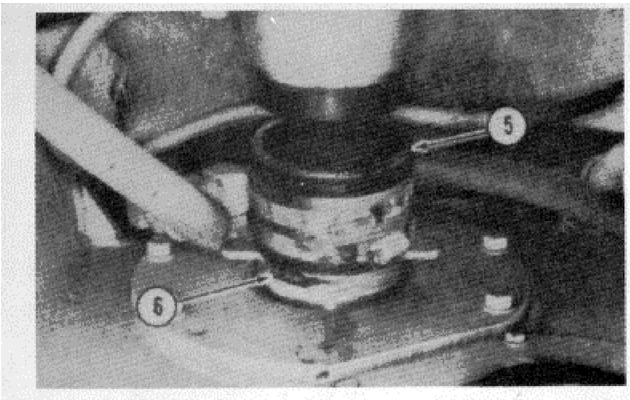
NOTE: It is not necessary to remove the drive shaft from the machine.



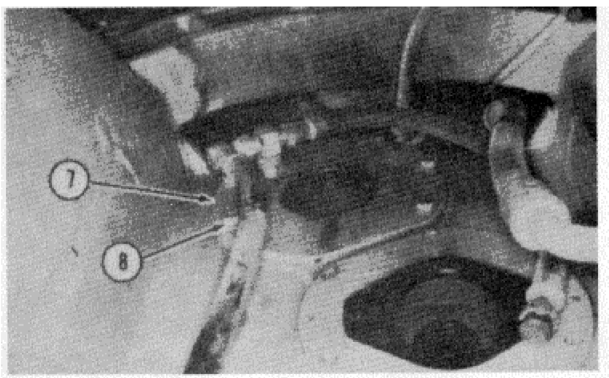
4. Install a 3/8"-16 NC eyebolt into one of the threaded holes in the end of the drive shaft. Pull drive shaft (3) out of the rear of the transmission approximately two feet.



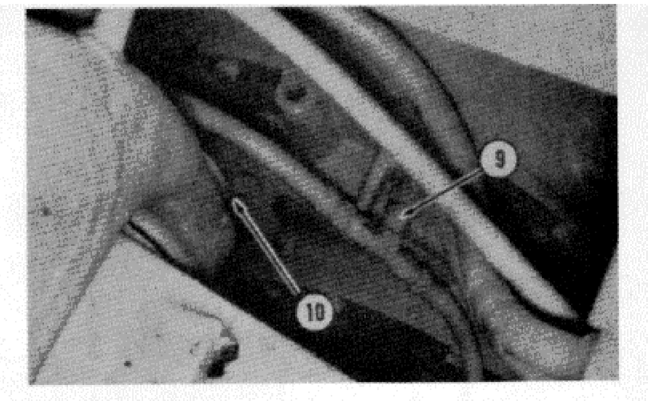
5. Loosen two hose clamps (4) and slide hose (5) toward the rear of the machine.



6. Remove hose (5), tube assembly (6) and the O-ring seal from the differential case as a unit.

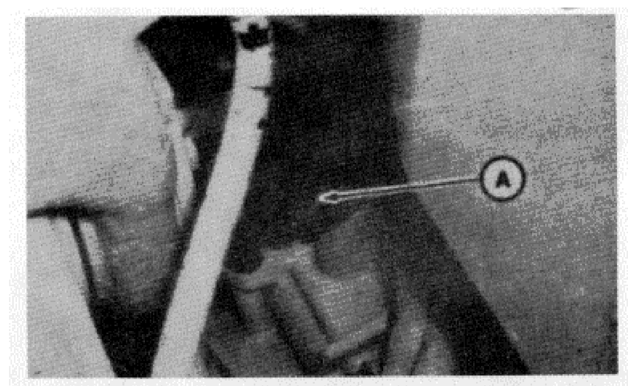


7. Remove six nuts (8), housing (7) and the O-ring seal from the differential case. The hydraulic hose will be removed with housing (7).

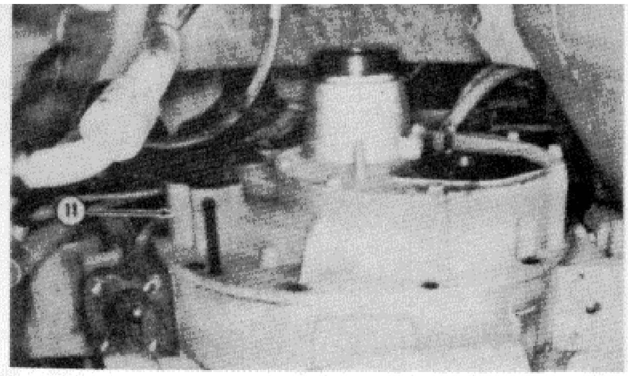


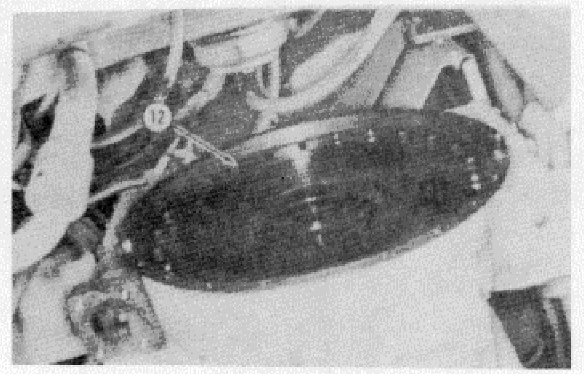
8. Disconnect fitting (9) from the flywheel housing.

9. Remove two bolts and flange (10) from the top of the flywheel housing.



10. Fasten tool (A) and a hoist to the top of the flywheel housing as shown.





11. Remove the nuts and bolts that hold retarder and drive shaft group (11) in position. Install three 7/16"-14 NC forcing screws into the drive shaft group housing as shown. Tighten the forcing screws to loosen the retarder and drive shaft group.

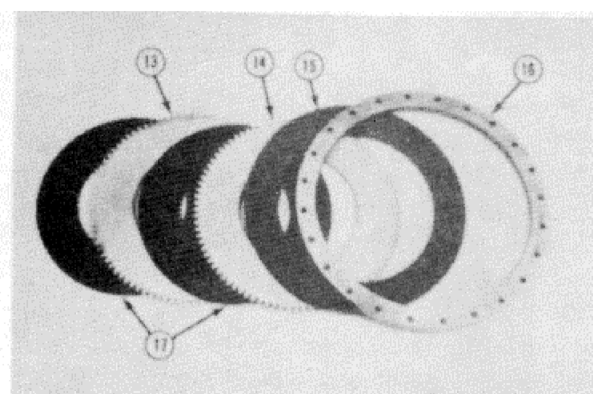
12. Remove retarder and drive shaft group (11) from the machine and lower it to the floor. The weight of the retarder and drive shaft group is 95 kg (210 lb.).

⚠ WARNING

There is spring pressure behind bolts (12). Loosen each bolt evenly until the spring force is completely released.

13. Remove bolts (12) evenly to release the spring pressure.

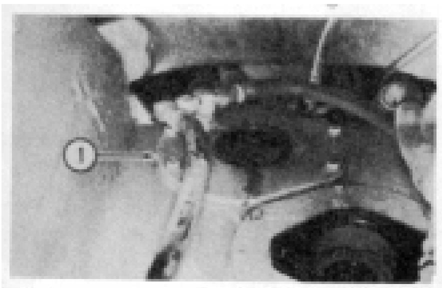
NOTE: When the bolts are removed the discs, plates, retainer and spring are free to fall.



14. Remove retainer (16), spring (15), plate (14), friction discs (17) and disc (13) from the flywheel housing. The retainer, spring, plate and discs as a unit have a weight of 23 kg (50 lb.).

Install Retarder And Drive Shaft Group 3120, 3253-12

Tools Needed		A	B	C
6v3069	Clutch Alignment Tool	1		
5P9736	Link Bracket		1	
6V188	Alignment Tool			1

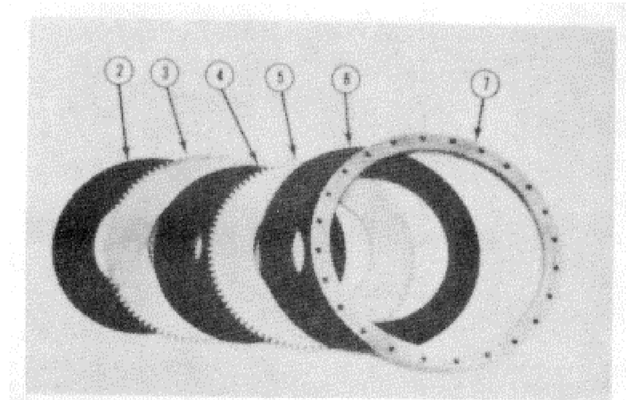


1. Make sure the O-ring seal is in position on the tube in the differential case.

NOTE: Make sure the O-ring seal on the tube in the differential case is in position while an alignment between the tube and housing (1) is made.

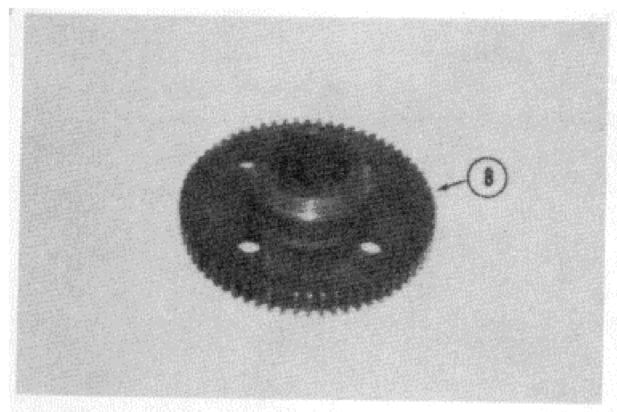
2. Put the O-ring seal in position on housing (1).

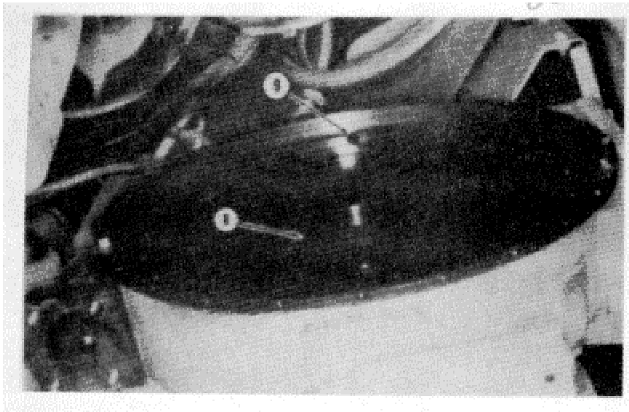
3. Put housing (1) in position in the differential case and install the six nuts that hold it in place.

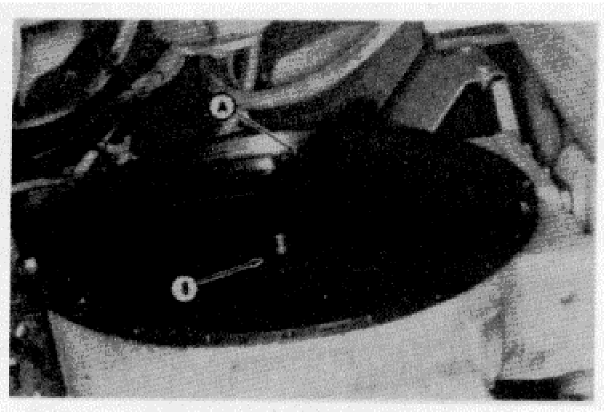


NOTE: Friction discs (2) and (4) must be put in SAE 10W oil for a minimum of one hour before installation.

4. Put friction disc (2), disc (3) and friction disc (4) in position in the flywheel housing.







NOTE: The discs must be held in the flywheel housing while installation of the parts and tooling is made. Gear (spider) (8), used in Step 5, is part of the drive shaft group. To obtain gear (spider) (8) for alignment purposes, the drive shaft group must be disassembled. See Disassemble Retarder And Drive Shaft Group.

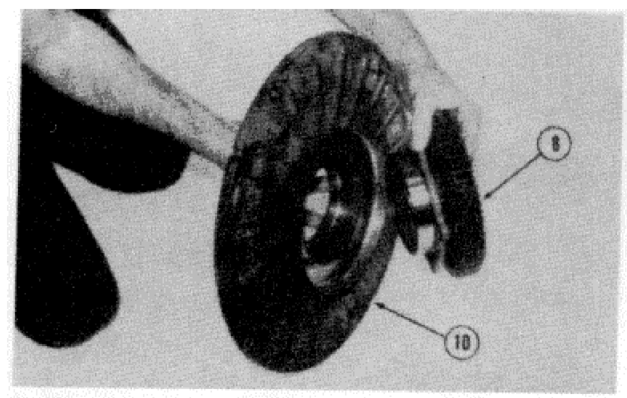
5. Put gear (spider) (8), from the drive shaft group, in position in the flywheel. Make an alignment of the splines in the gear with the splines in friction discs (2) and (4).

NOTE: Spring (6) must be installed in the flywheel housing with the inside diameter of the spring next to retainer (7).

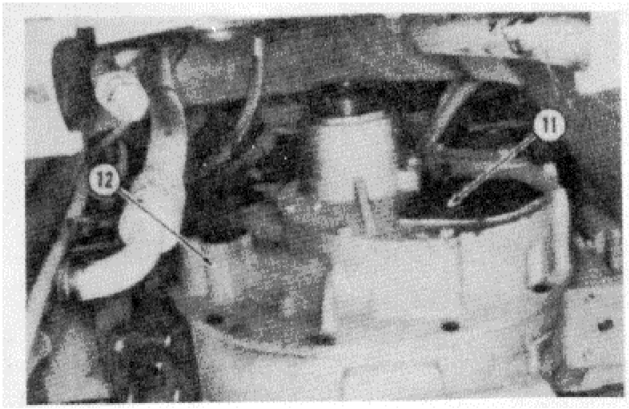
6. Put plate (5), spring (6) and retainer (7) in place in the flywheel housing. Install three bolts (9) to hold the assembly in position. Do not tighten the bolts.

7. Put tooling (A) in position in gear (8) and the flywheel housing. Tooling (A) will put the discs and plate in a center position.

8. Install the bolts that hold the assembly in place. Tighten the bolts to a torque of 56 ± 7 N-m (41 ± 5 lb.ft.). Remove the gear and tooling (A).

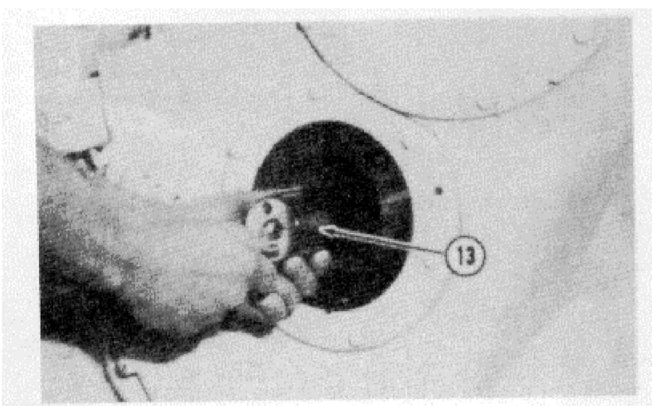


9. Put gear (8) in position in housing (10). Install the four bolts that hold the gear in place. For the correct assembly procedure, see Assembly Retarder And Drive Shaft Group.

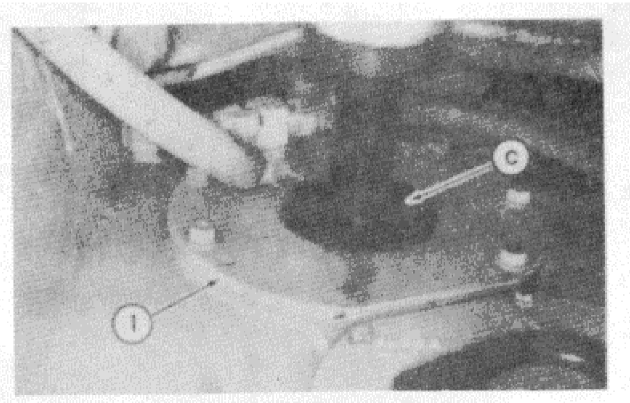


10. Fasten tool (B) to the top of housing (12). Put the housing in position under the machine and fasten a hoist to tool (B) on the housing.

11. Lift the housing into position and slide it on to the studs. Slowly turn drive gear (11) to make an alignment of gear (8) and the friction discs. Install the nuts and bolts that hold the housing in place.



12. Slide drive shaft (13) into the transmission. Make an alignment of the external splines on the drive shaft with the internal splines of the shaft in housing (12).

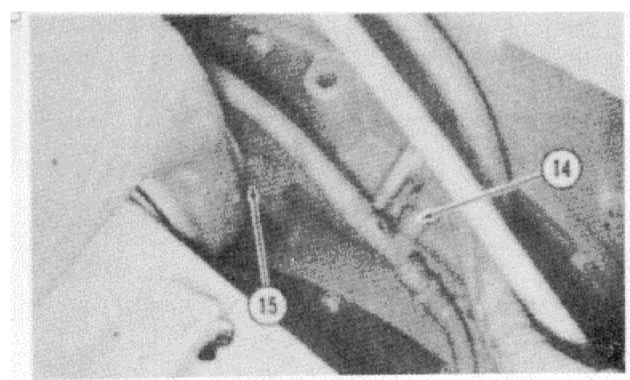


13. Put tooling (C) in the bore of housing (1) to check alignment of the engine with the drive shaft. Turn tooling (C) in the bore around the drive shaft until resistance is felt in both the clockwise and counterclockwise directions.

14. Find the center of free movement (travel) of tooling (C). This position is the direction in which the engine needs to be moved to make an alignment of the engine with the drive shaft.

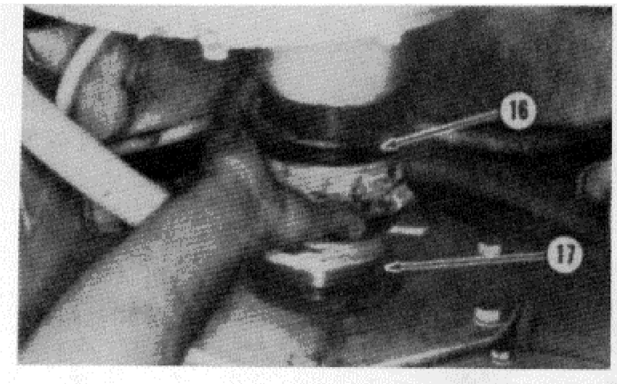
15. Inspect the front and rear engine supports for damage. Make a replacement if necessary.

16. Pull the drive shaft at least two feet out of the rear of the transmission.

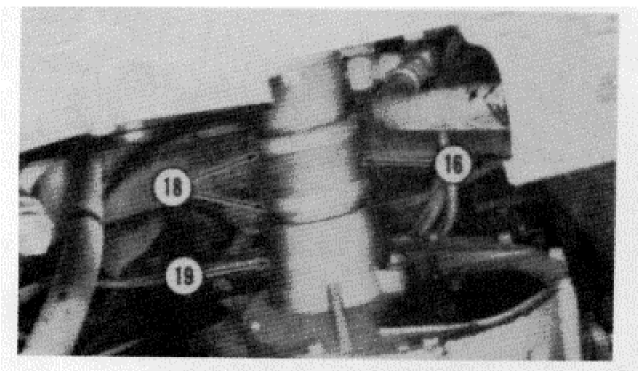


17. Put flange (15) of the lubrication line in position and install the two bolts that hold it in place.

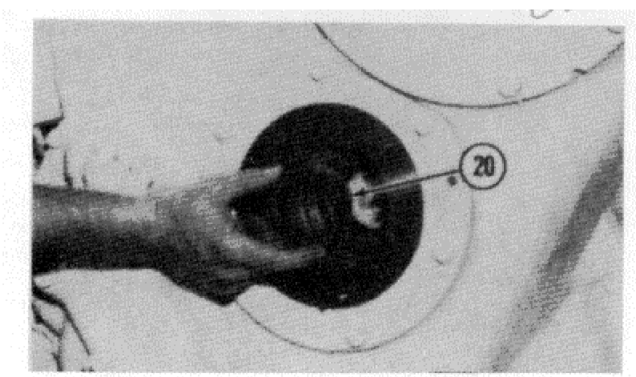
18. Connect fitting (14) to the flywheel housing.



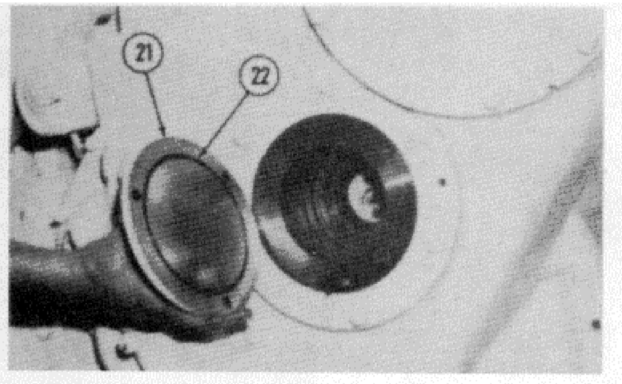
19. Put tube assembly (17), hose (16) and the two hose clamps in position in the housing.



20. Slide hose (16) in position on the tube and cover (19). Put hose clamps (18) in position on hose (16) and tighten them.



21. Push the drive shaft into the transmission. Install spiral ring (20) in the groove of the shaft to hold it in place.



22. Install O-ring seal (22) in cover (21). Put cover (21) in position and install the bolts that hold it in place.

23. Check the oil level in the transmission. Add transmission oil if necessary.

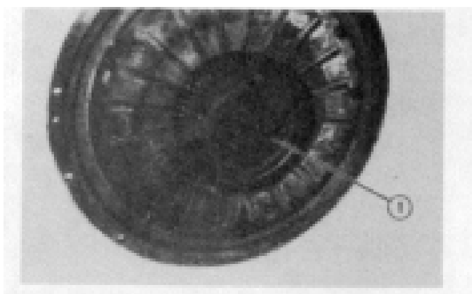
END BY:
a) install scavenge pump
b) install retarder control valve
c) install supplemental steering pump

Retarder And Drive Shaft Group

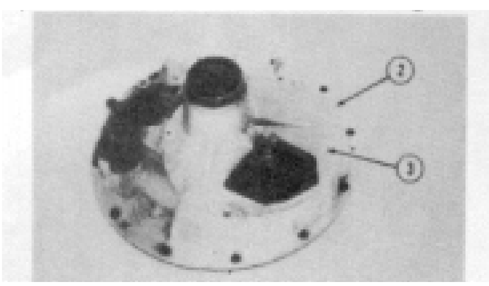
Disassemble Retarder And Drive Shaft Group 3120, 3253-15

Tools Needed		A	B	C
887548	Push-Puller	1		
8H684	Ratchet Wrench	1		
8S6586	Forcing Screen	1		
1H3112	Bearing Cup Puller Attachment	1		
887549	Leg	2		
1P520	Driver Group		1	1
5F7343	Bearing Pulling Attachment		1	

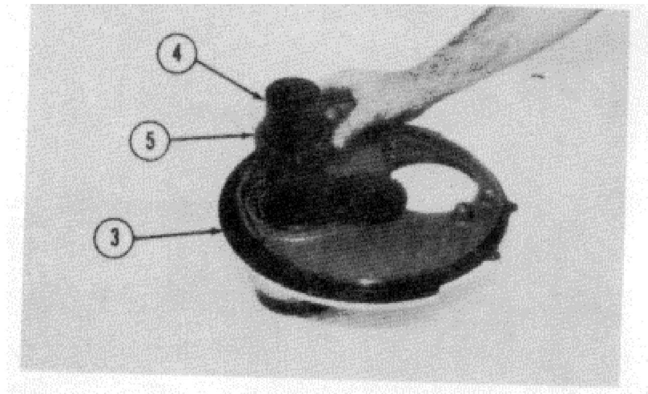
START BY:
a) remove retarder and drive shaft group



1. Remove the bolts and retainer (1) from the shaft.

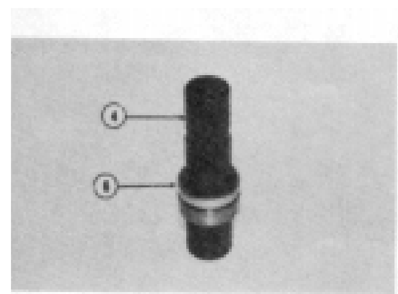


2. Remove bolts (2) that hold cover (3) to the housing assembly. Remove cover (3) and the shaft as a unit.

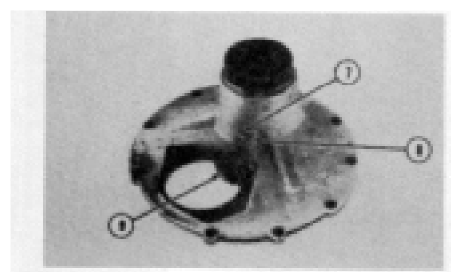


3. Remove gear (5) from shaft (4).

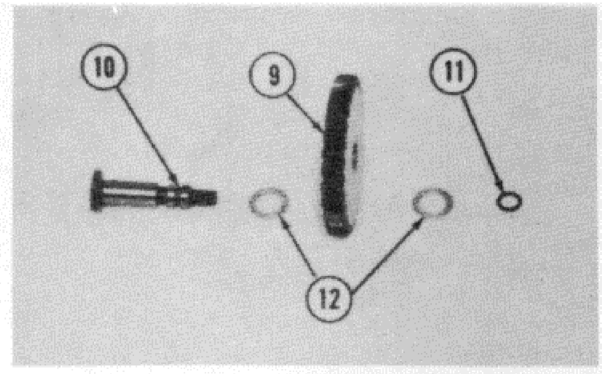
4. Remove cover (3) from the shaft.



5. Remove bearing race (6) from shaft (4).

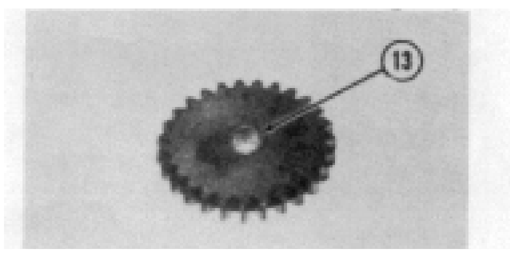


6. Remove nut (7) and washer (8) that hold the shaft and gear (9) to the cover.

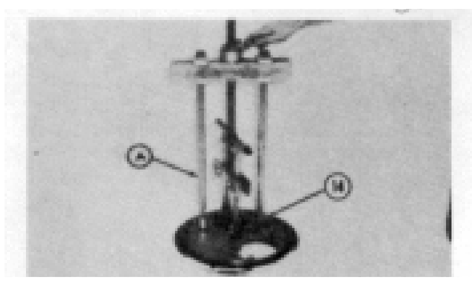


7. Remove shaft (10), washers (12) and gear (9) from the cover.

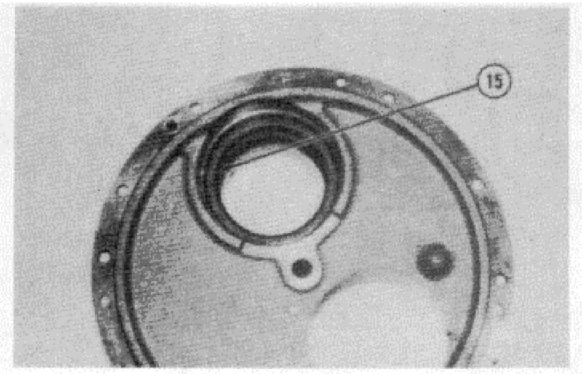
8. Remove O-ring seal (11) from shaft (10).



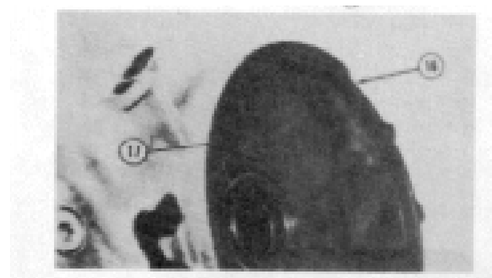
9. Remove bearing (13) from the gear.



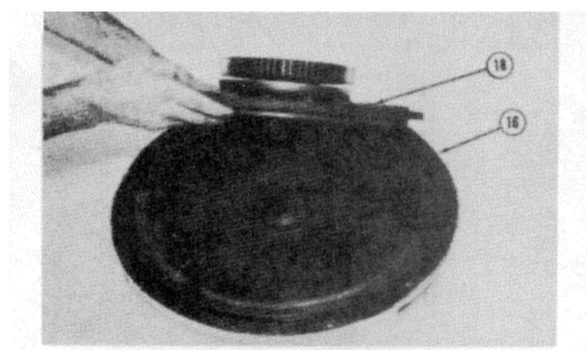
10. Use tooling (A) and remove bearing (14) from the cover.



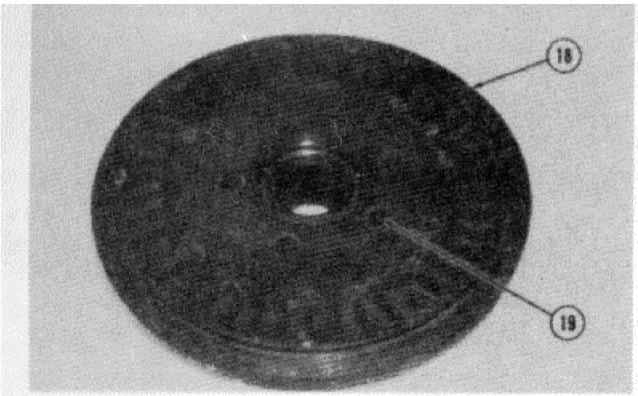
11. Remove lip type seal (15) from the cover.



12. Remove O-ring seal (17) from housing assembly (16).

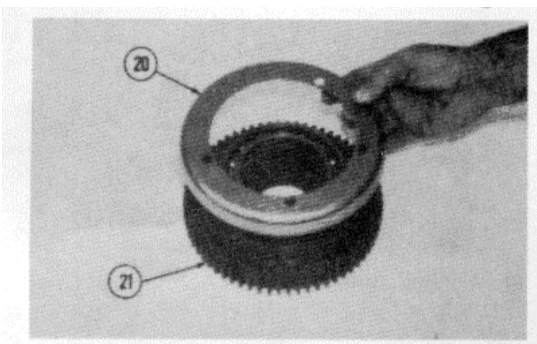


13. Remove twelve bolts and stator (18) from housing assembly (16).

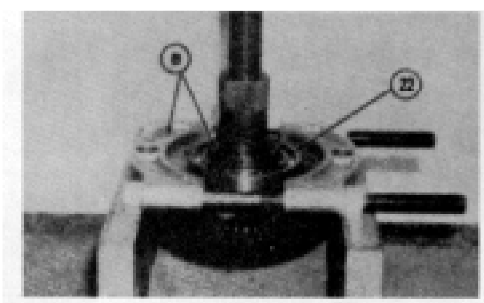


14. Remove bolts (19) that hold the gear assembly to stator (18).

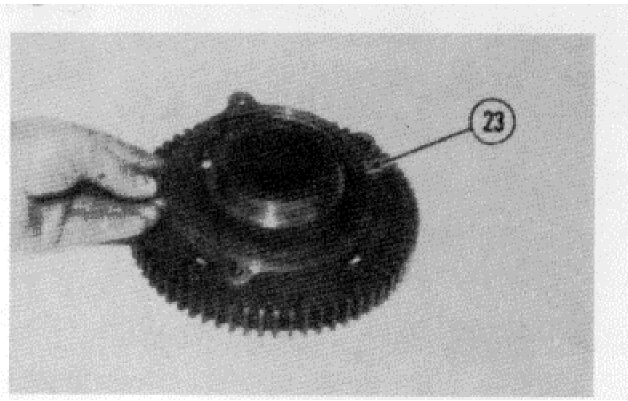
15. Remove stator (18) from the gear assembly.



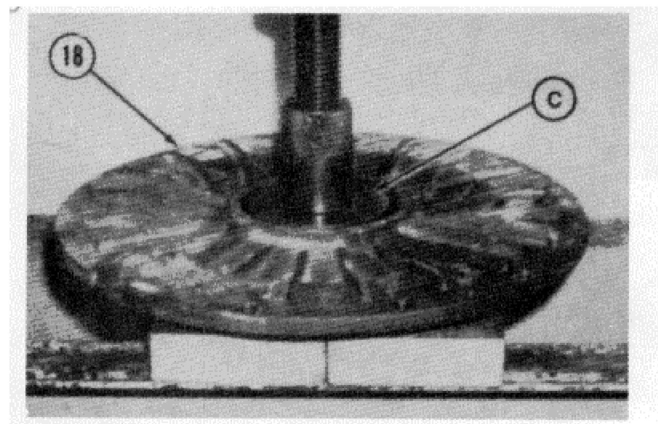
16. Remove deflector (20) from gear assembly (21).



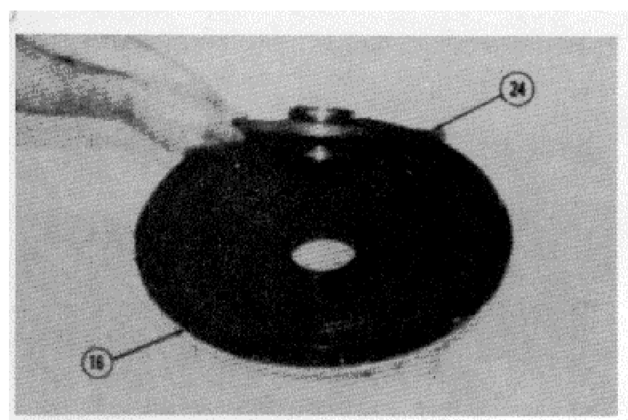
17. Remove bearing (22) from the gear with tooling (B) and a press.



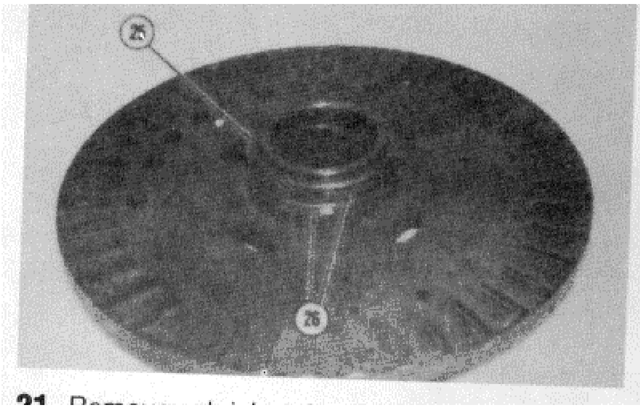
18. Remove retainer (23) from the gear.



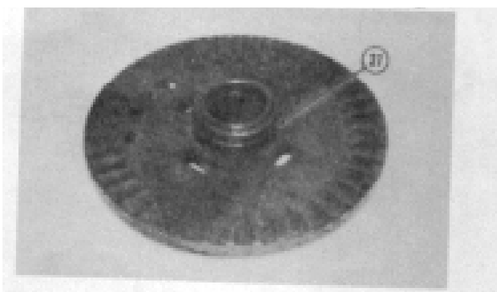
19. Remove the bearing race from stator (18) with tooling (C) and a press.



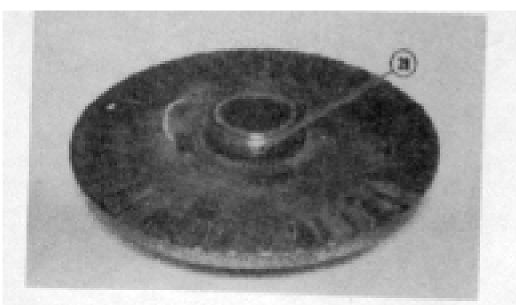
20. Remove rotor (24) from housing assembly (16).



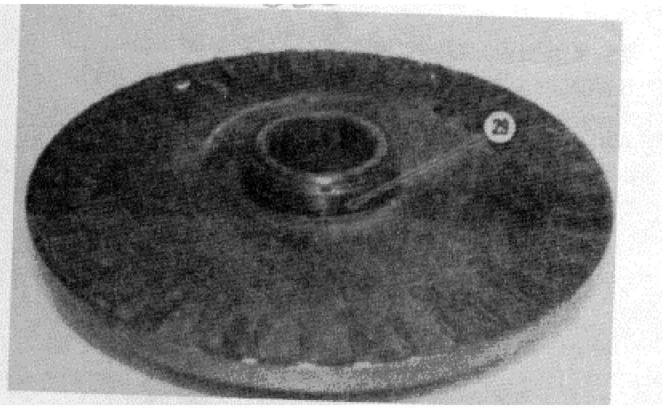
21. Remove retaining ring (25) and two rings (26) from the carrier.



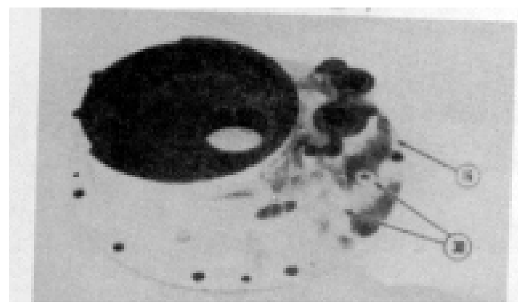
22. If necessary, remove carrier (27) from the rotor. The carrier will be damage if it is removed.



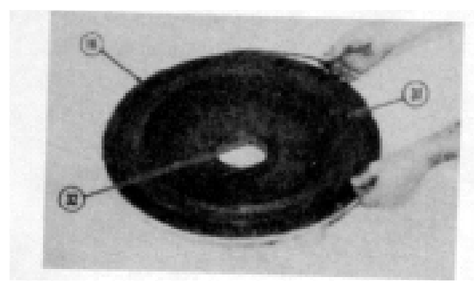
23. Turn the rotor over and remove ring (28) from the carrier.



24. If necessary, remove carrier (29) from the rotor. The carrier will be damaged if it is removed.



25. Remove two plugs (30) and the O-ring seals from housing assembly (16).

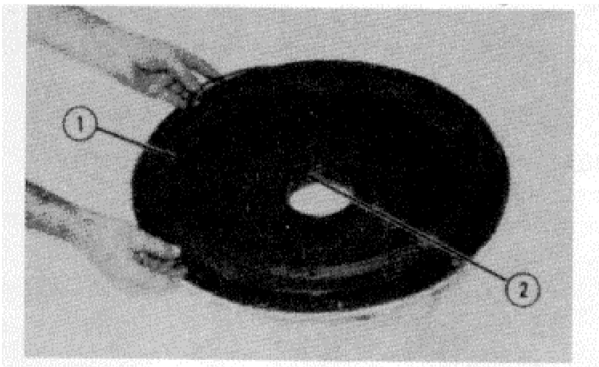


26. Remove bearing race (32) from housing assembly (16).

27. Remove O-ring seal (31) from the housing assembly.

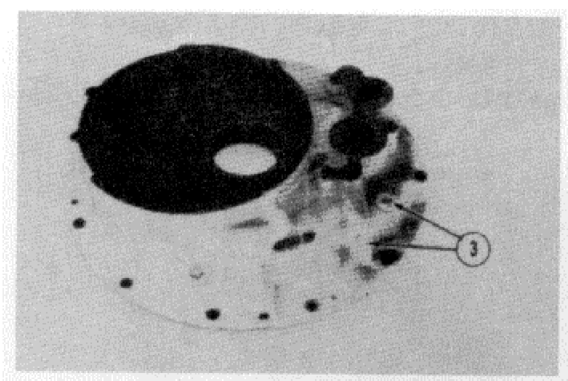
Assemble Retarder And Drive Shaft Group 3120, 3253-16

Tools Needed		A
1P520	Driver Group	1

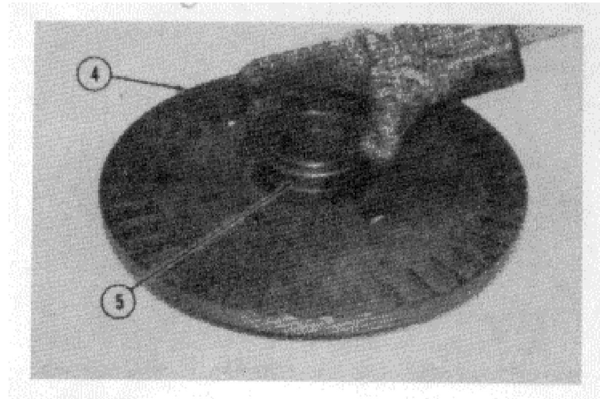


1. Lower the temperature of bearing race (2) and install the bearing race in the housing assembly.

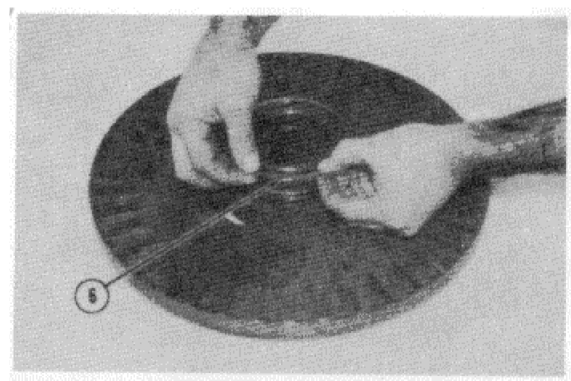
2. Install O-ring seal (1) on the housing assembly.



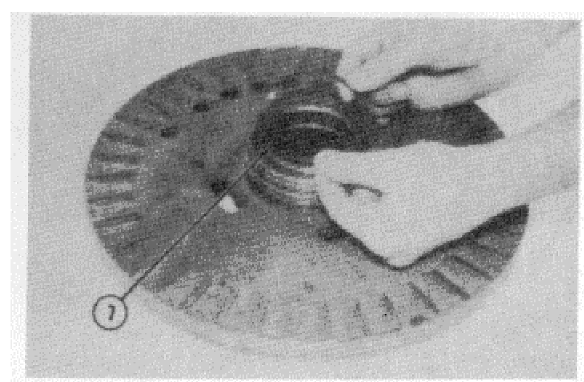
3. Install the O-ring seal on plugs (3). Install plugs (3) in the housing assembly.



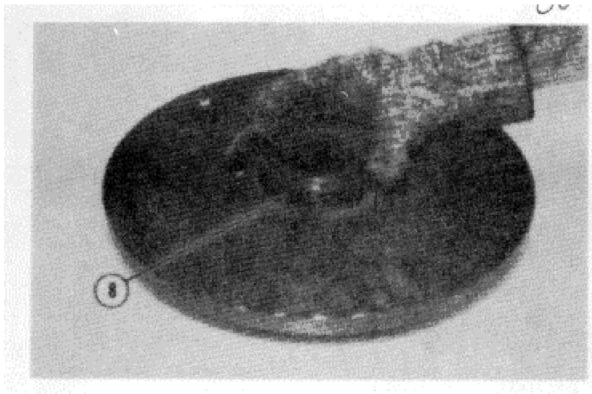
4. Heat the carrier with two ring grooves to a maximum temperature of 135°C (275°F). Install carrier (5) on rotor (4) as shown.



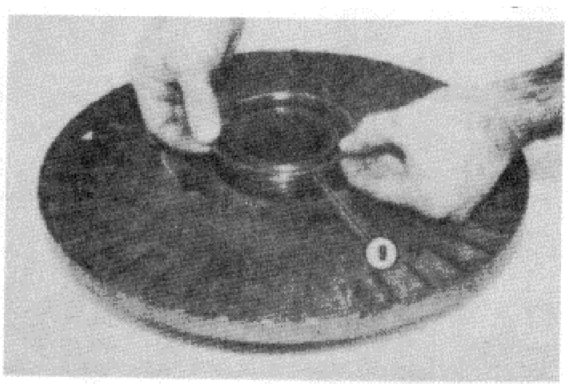
5. Install two rings (6) on the carrier. Make sure the hooked ends of the rings are engaged with each other after the rings are installed.



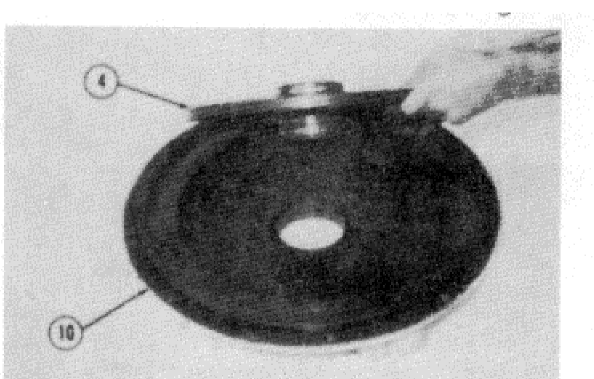
6. Install retaining ring (7) that holds the carrier in position on the rotor.



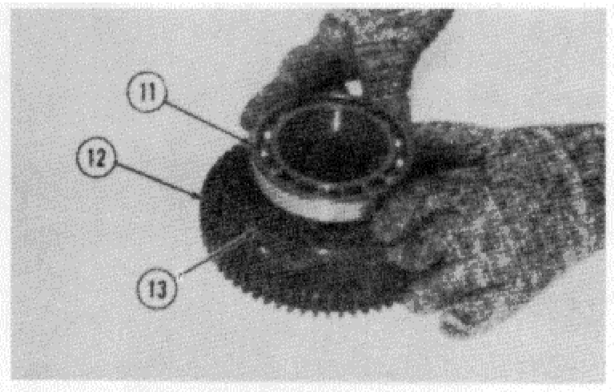
7. Heat the carrier with one ring groove to a maximum temperature of 1350C (275°F). Turn the rotor over and install carrier (8) on the rotor as shown.



8. Install ring (9) on the carrier. Make sure the hooked ends of the ring are engaged with each other after the ring is installed.

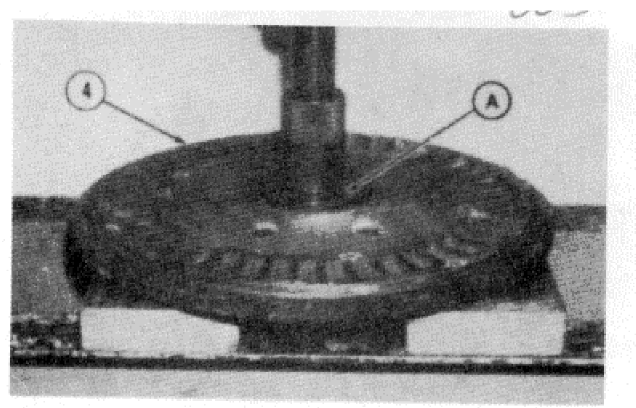


9. Install rotor (4) in housing assembly (10) as shown.

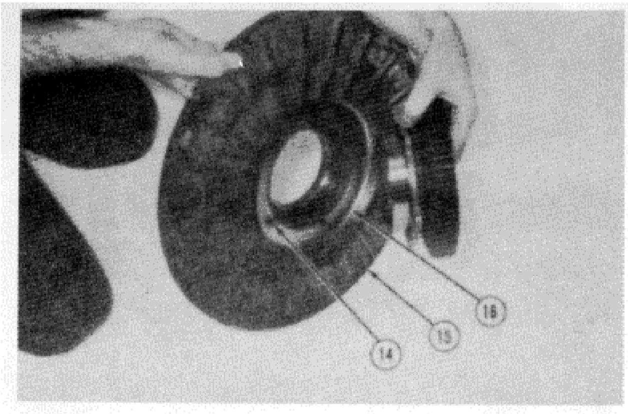


10. Install retainer (13) on gear (12) with the flat side of the retainer toward the gear.

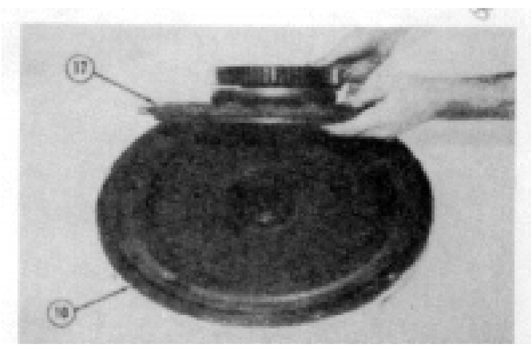
11. Heat the bearing to a maximum temperature of 1350C (2750F). Install bearing (11) on gear (12).



12. Install the bearing race in rotor (4) with tooling (A) and a press.



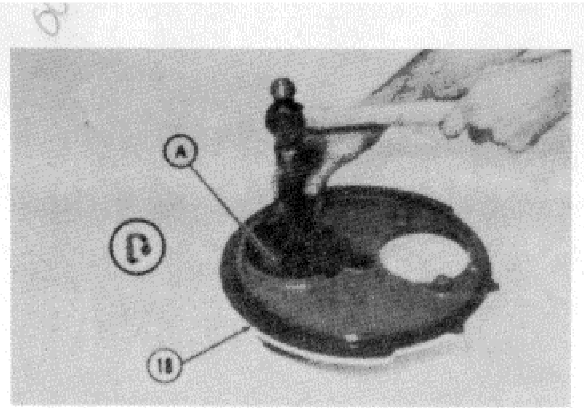
13. Put four bolts (14), deflector (16) and the gear assembly in position on stator (15). Tighten the bolts that hold the gear assembly to a torque of 48 ± 3 N-m (36 ± 2 lb.ft.).

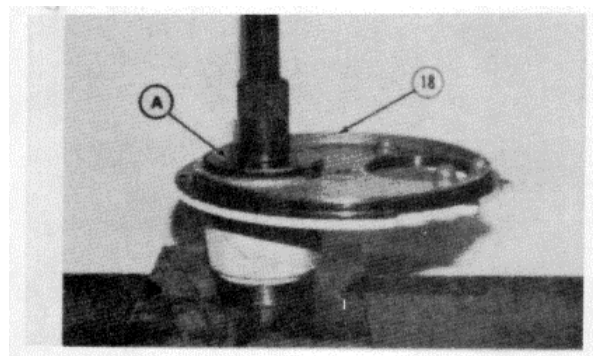


NOTE: Make sure the hooked ends of the rings are engaged with each other and the rings are centered in the grooves of the carrier.

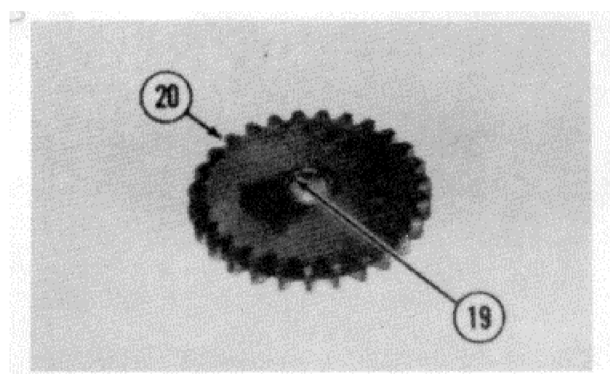
14. Put stator assembly (17) in position on housing assembly (10) and install the twelve bolts that hold it in place.

15. Use tooling (A) and install the lip type seal in cover (18). Install the seal with the lip down and even with the top of the counterbore.

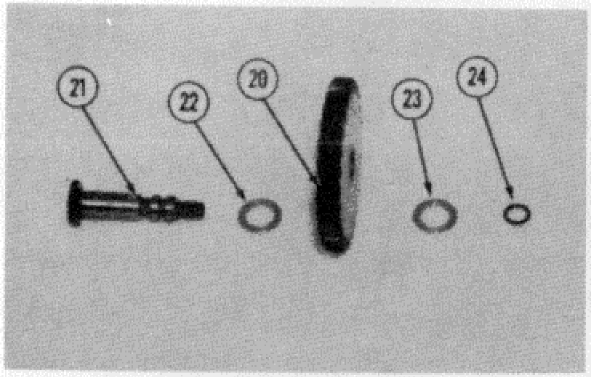




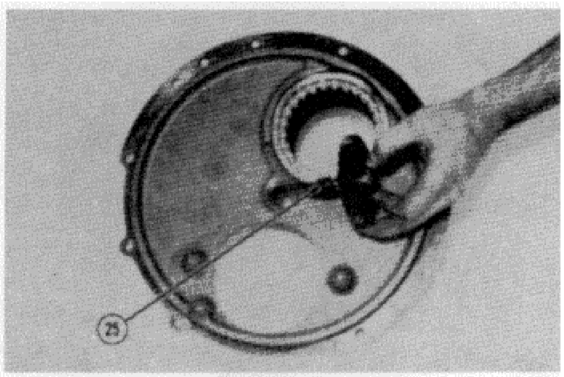
16. Lower the temperature of the bearing. Install the bearing in cover (18) with tooling (A) and a press. Install the bearing until it makes contact with the bottom of the counterbore in cover (18).



17. Install bearing (19) In gear (20) until it is even with the outside surface of the gear.

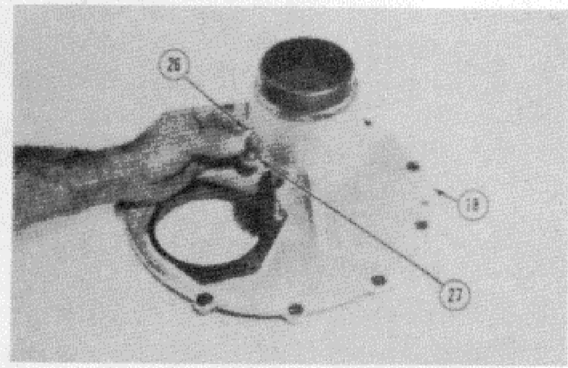


18. Put washer (22), gear (20), washer (23) and O-ring seal (24) in position on shaft (21).



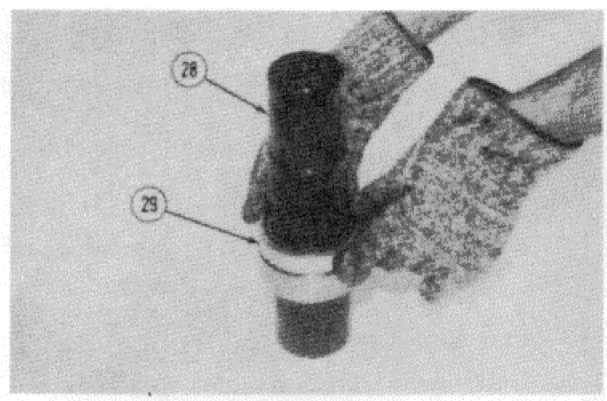
NOTE: Put a small amount of clean transmission oil on the O-ring seal on shaft assembly (25).

19. Install shaft assembly (25) into the cover as shown.

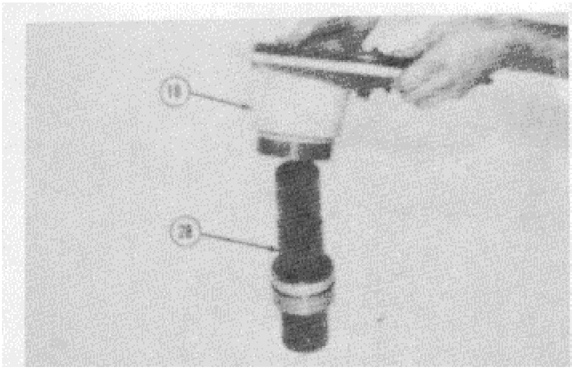


20. Install washer (27) on the end of the shaft assembly with the notch in the washer in alignment with the pin in cover (18).

21. Install nut (26) and tighten it to a torque of 46 + 3 N-m (34 + 2 lb.ft.).

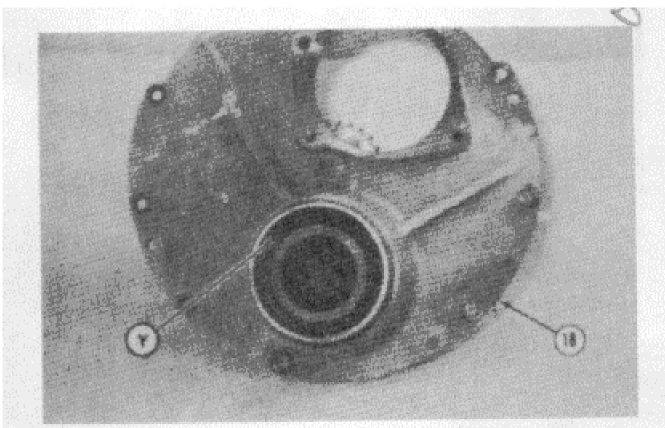


22. Heat bearing race (29) to a maximum temperature of 1350C (2750F). Install the bearing race until is makes contact with the shoulder of shaft (28).

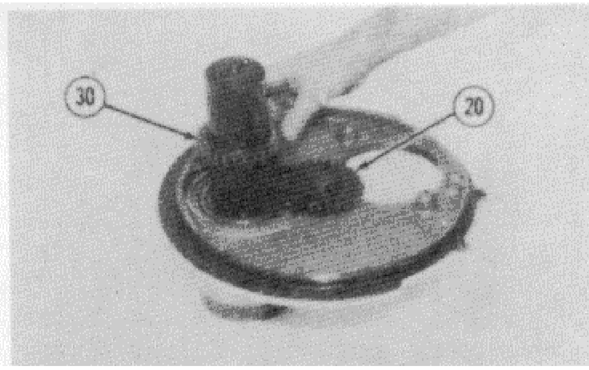


NOTE: Put a small amount of clean transmission oil on the lip of the seal in cover (18) and on the surface of shaft (28) where the seal makes contact.

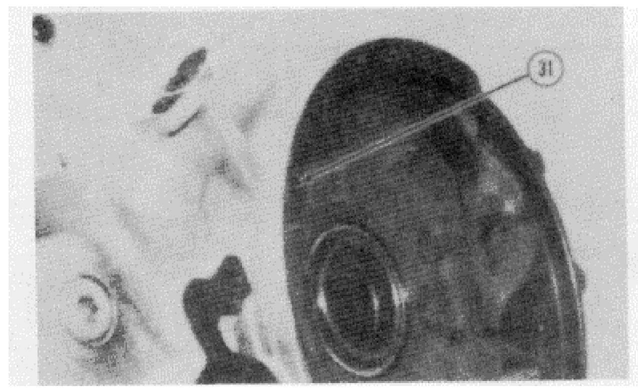
23. Carefully install cover (18) on shaft (28).



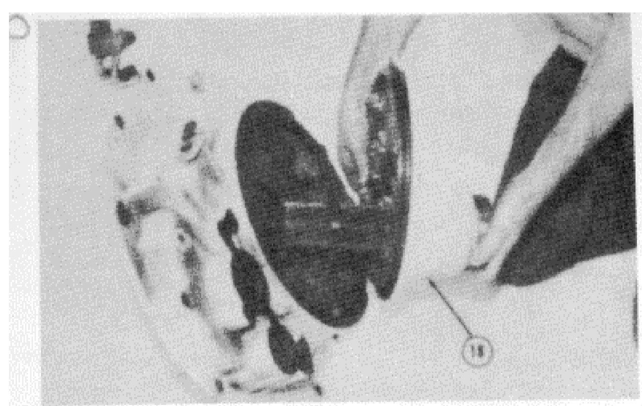
24. After cover (18) has been installed on shaft (28), check the sealing lip and the spring in the lip type seal. Inspect the seal in area (Y) between the cover and shaft. Make sure the spring in the lip type seal and the lip of the seal are in the correct position.



25. Install gear (30) on the shaft. Make sure gear (30) engages with gear (20).

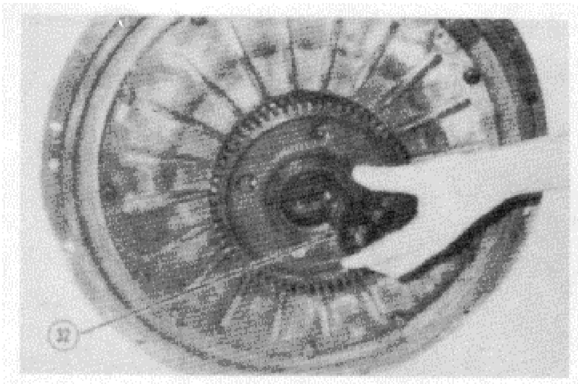


26. Install O-ring seal (31) in the housing.



27. Put cover (18) and the shaft assembly in position in the housing. Make an alignment of the race on the shaft and the bearing in the cover.

28. Install the nine bolts that hold the cover to the housing.



29. Put retainer (32) in position on the shaft and install the bolts that hold it in place.

END BY:
a) install retarder and drive shaft group

Retarder Control Valve

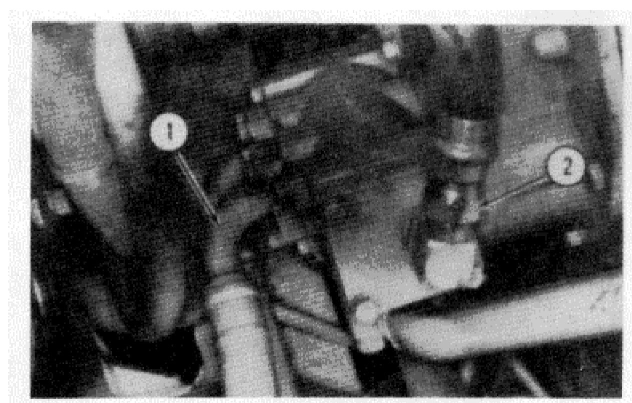
Remove Retarder Control Valve 3123-11

START BY:
a) remove supplemental steering pump

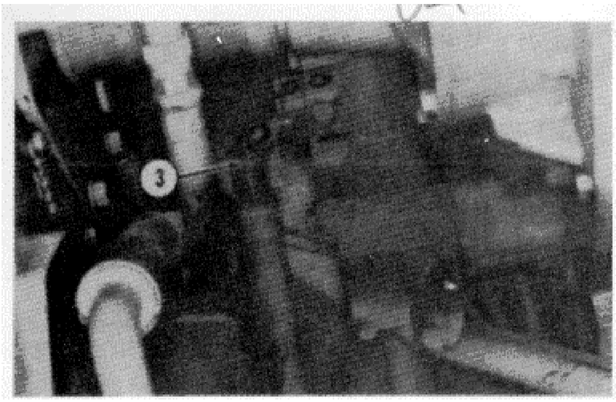
NOTE: The retarder control valve is located directly above the supplemental steering pump. It is not necessary to remove the supplemental steering pump to service the retarder control valve. However, service of the retarder control valve is easier with the supplemental steering pump removed.

⚠ WARNING

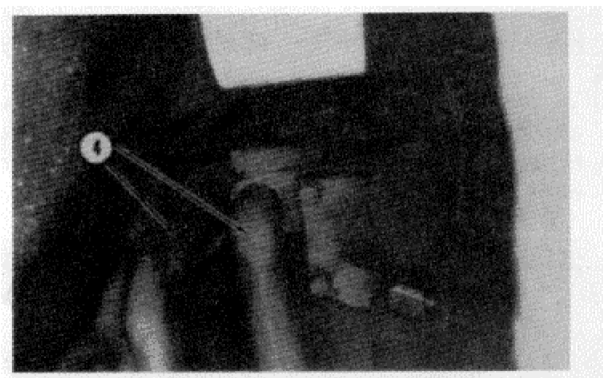
To prevent possible personal injury release all the pressure in the air and hydraulic systems before any lines are disconnected. Be sure the retarder control valve is in the "OFF" position.



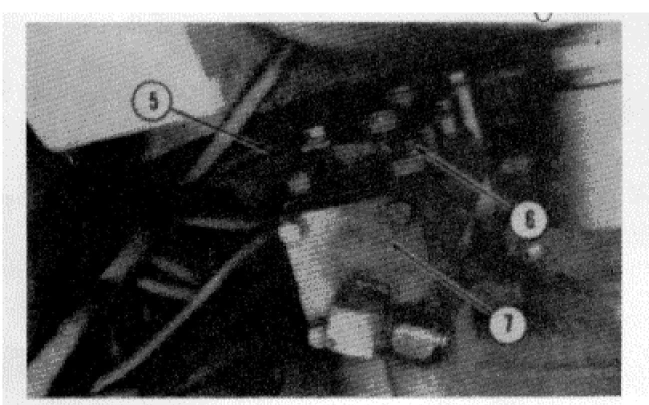
1. Disconnect differential oil line (2) and transmission oil line (1) from the retarder control valve.



2. Disconnect transmission oil line (3) from the retarder control valve.



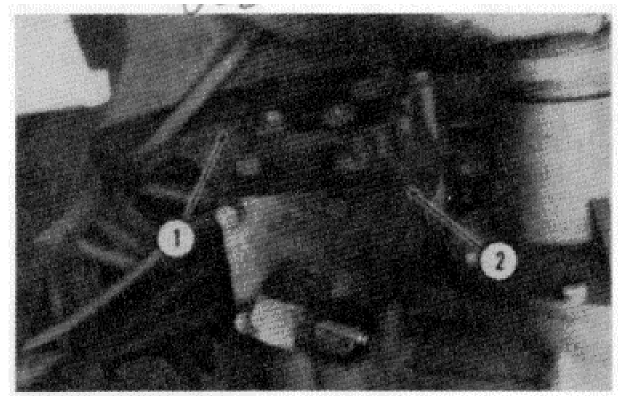
3. Disconnect retarder oil cooler lines (4) from the retarder control valve.



4. Disconnect air line (5) from the top of the retarder control valve.

5. Remove bolts (6) that hold the retarder control valve in place. Remove retarder control valve (7).

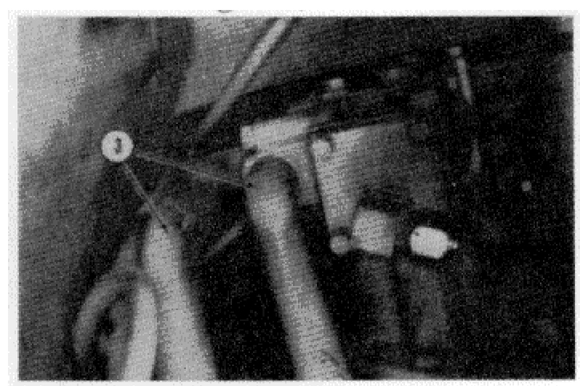
Install Retarder Control Valve 3123-12



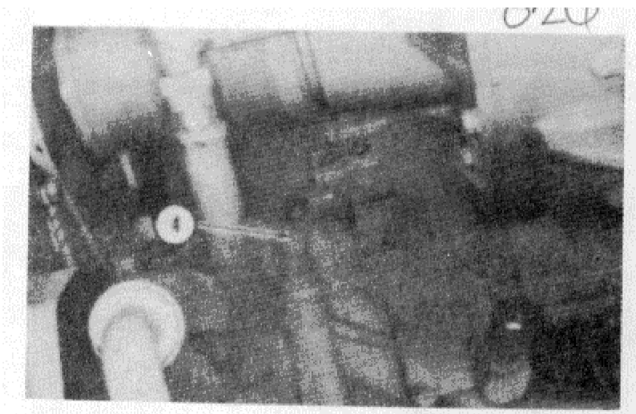
1. Make sure the three O-ring seals are in position on the retarder control valve.

2. Put retarder control valve (2) in position and install the bolts that hold it in place.

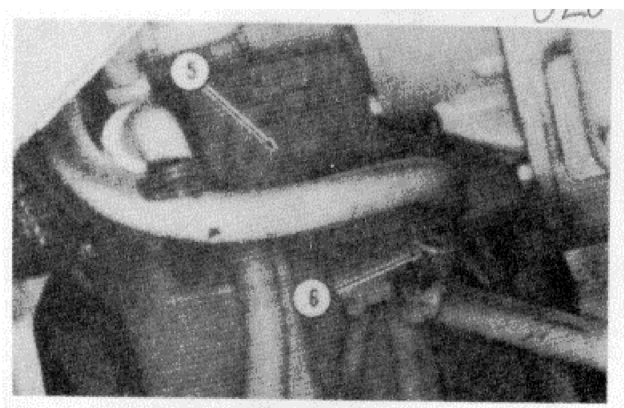
3. Connect air line (1) to the top of the retarder control valve.



4. Make sure the O-ring seals are in position on the ends of oil lines (3). Connect retarder oil cooler lines (3) to the retarder control valve.



5. Make sure the O-ring seal is in position on the end of oil line (4). Connect transmission oil line (4) to the retarder control valve.



8. Make sure the O-ring seal is in position on the end of oil line (5). Connect transmission oil line (5) and differential oil line (6) to the retarder control valve.

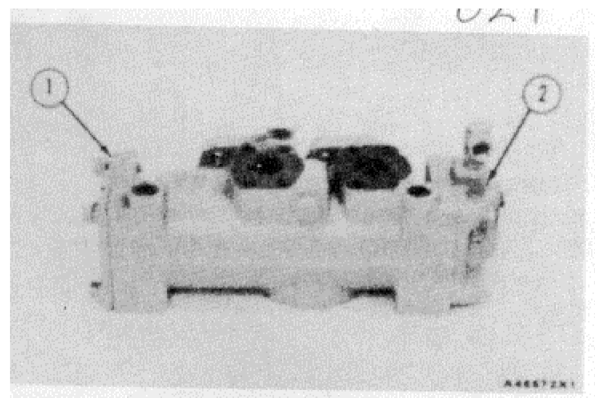
END BY:

a) install supplemental steering pump

Disassemble Retarder Control Valve 3123-15

START BY:

a) remove retarder control valve

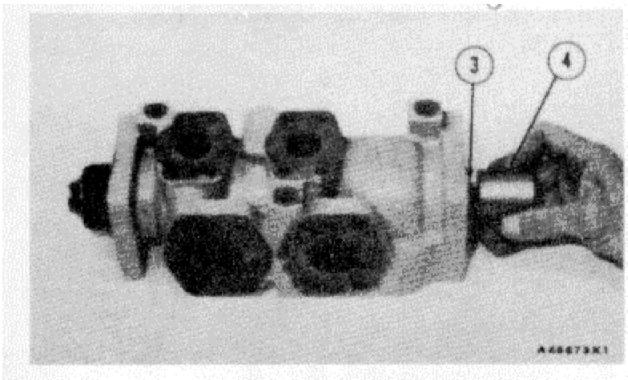


1. Remove the O-ring seals from the face of the retarder control valve.

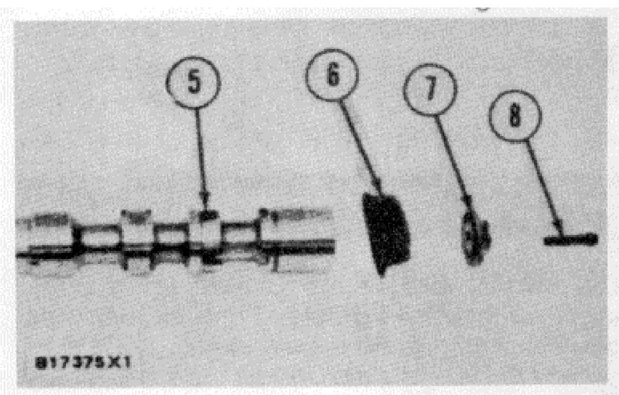
⚠ WARNING

Covers (1) and (2) are under spring pressure. To prevent personal injury hold the covers as the bolts are removed.

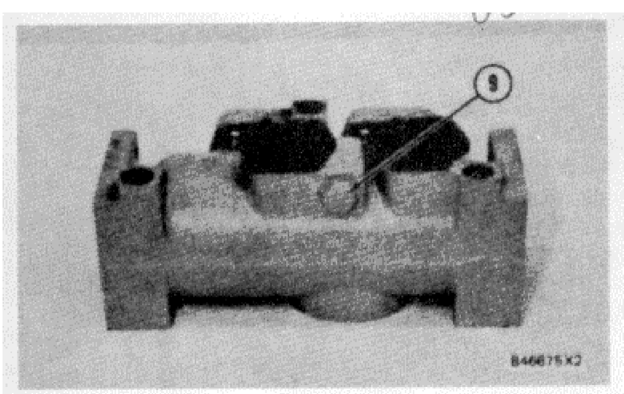
2. Remove covers (1) and (2) from the retarder control valve.



3. Remove slug (4), spring (3), the stop, spring and the valve spool from the retarder control valve. Remove the pin from the end of the valve spool if a replacement is necessary.

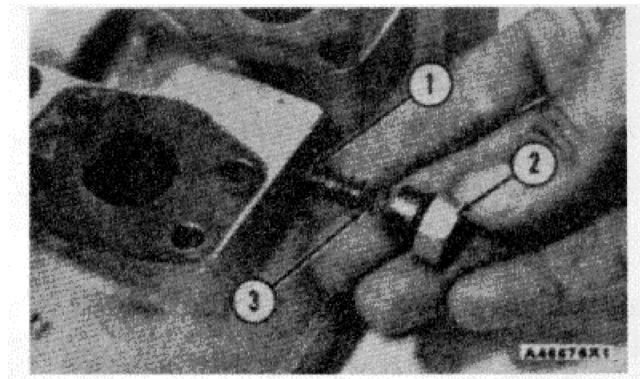


4. Remove bolt (8), stop (7) and diaphragm (6) from valve spool (5).



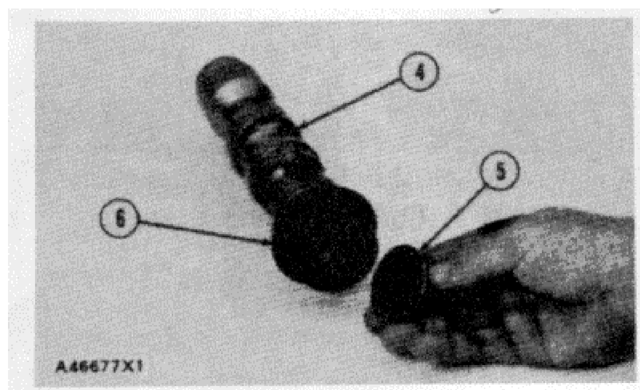
5. Remove plug (s) another spring or plunger from the retarder control valve. Check the condition of the O-ring seal on the plug.

Assemble Retarder Control Valve 3123-16

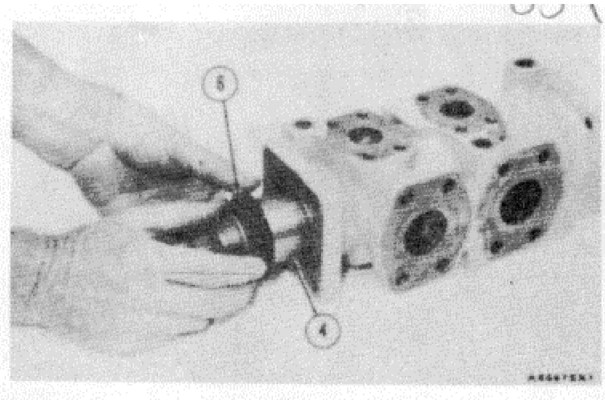


1. Make sure all the parts of the retarder control valve are clean. Put clean oil on the parts. Inspect all O-ring seals for damage and make replacements if needed.

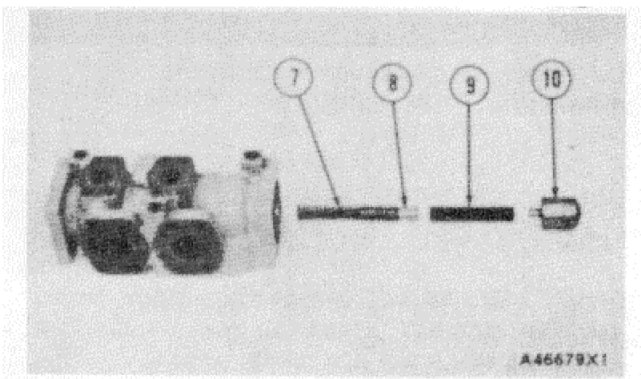
2. Be sure the O-ring seal is in place on plug (2). Install plunger (1), spring (3) and plug (2) in the retarder control valve.



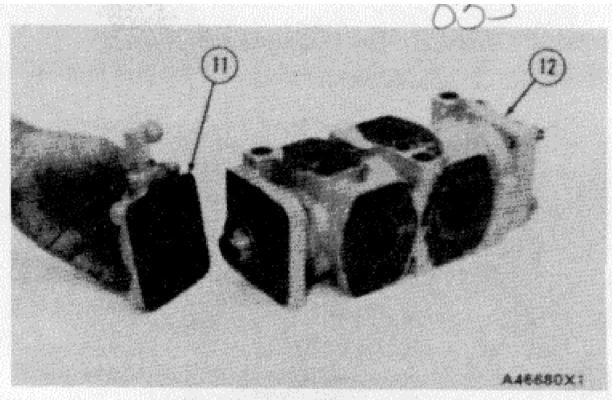
3. Install diaphragm (6) on valve spool (4). Install the bolt in stop (5). Install stop (5) on the valve spool as shown with the hole in the stop in alignment with the pin in valve spool (4).



4. Install valve spool (4) in the retarder control valve as shown. Turn the lip of diaphragm (6) back so it will engage in the groove in the valve body.



5. Install spring (7), stop (8), spring (9) and slug (10) as shown in the retarder control valve.

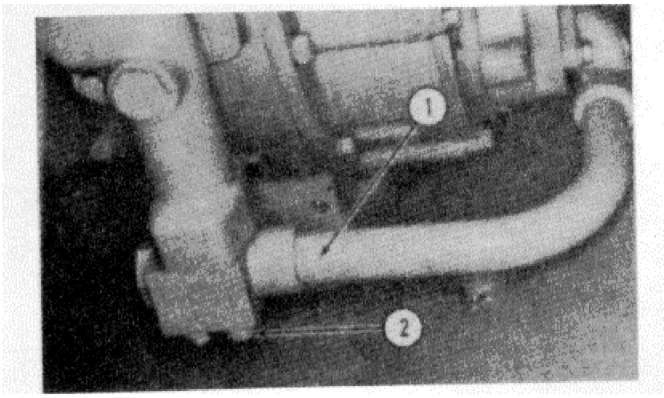


6. Install covers (12) and (11) on the retarder control valve. Make sure the O-ring seal is in position between cover (12) and the body.

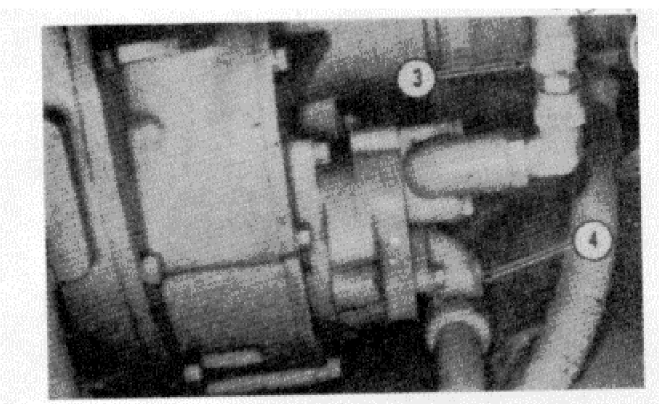
END BY:
a) install retarder control valve

Scavenge Pump

Remove And Install Scavenge Pump 1312-10

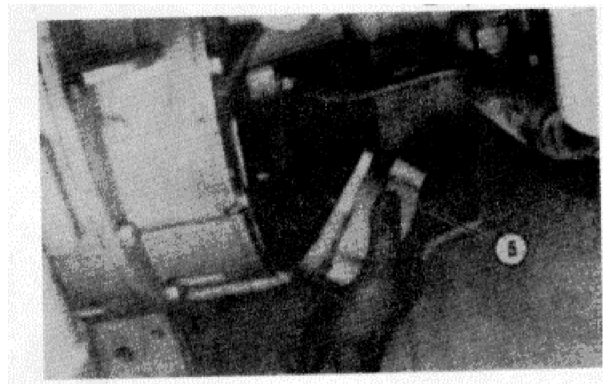


1. Remove four bolts (2) and disconnect tube assembly (1) from the sump screen housing.



2. Remove the two bolts and remove tube assembly (4) from the scavenge pump.

3. Disconnect hose assembly (3) from the scavenge pump.



4. Remove the three bolts, one nut and scavenge pump (5) from the retarder housing.

5. Put scavenge pump (5) in position on the retarder housing and install the three bolts and one nut that hold it in place.

6. Connect hose assembly (3) to the scavenge pump.

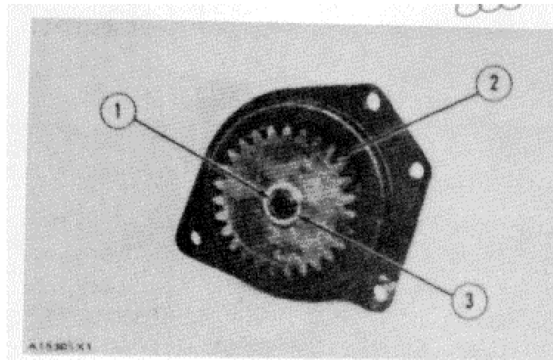
7. Put tube assembly (4) in position on the scavenge pump and install two bolts that hold it in place. / a Put tube; assembly (1) in position on the sump screen housing and install four bolts (2) that hold it in place.

SCAVENGE PUMP

DISASSEMBLE SCAVENGE PUMP

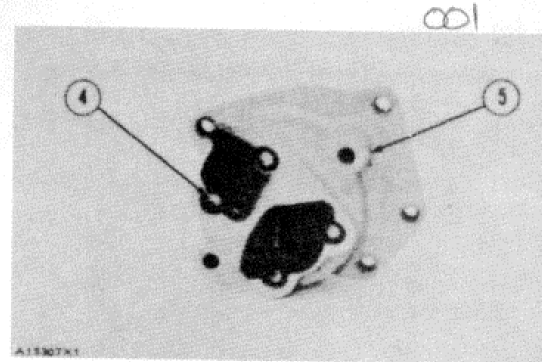
start by:
a) remove scavenge pump

1. Remove snap ring (3), brass washer (1). Remove drive gear (2).



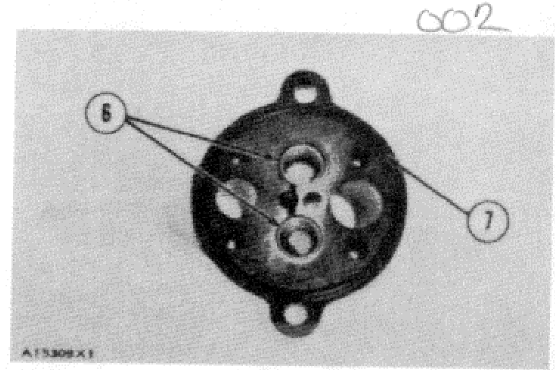
001

2. Remove four bolts (4) and cover assembly (5).



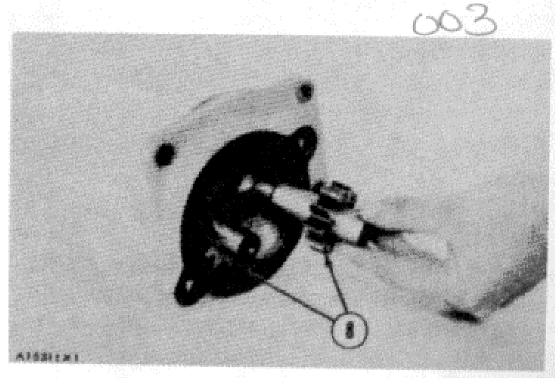
002

3. Remove O-ring seal (7) from cover assembly. Remove two bearings (6). Inspect the O-ring seal and make a replacement if necessary.



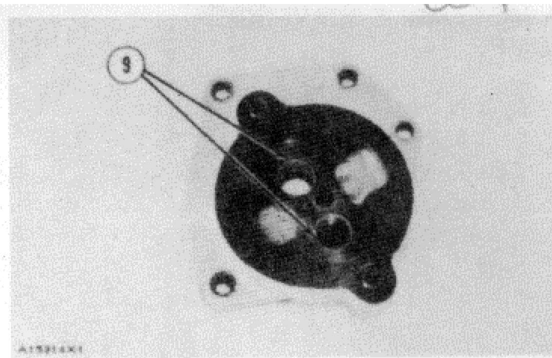
003

4. Remove gears (8) from manifold assembly.



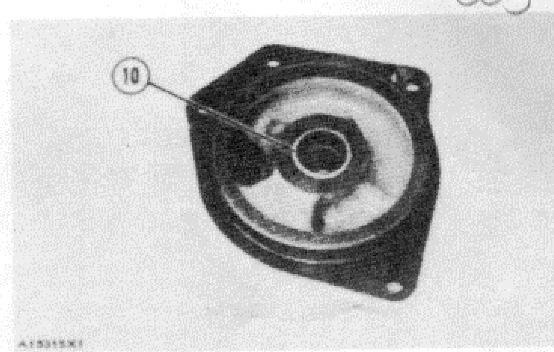
SCAVENGE PUMP

5. Remove bearings (9) from manifold assembly.



005

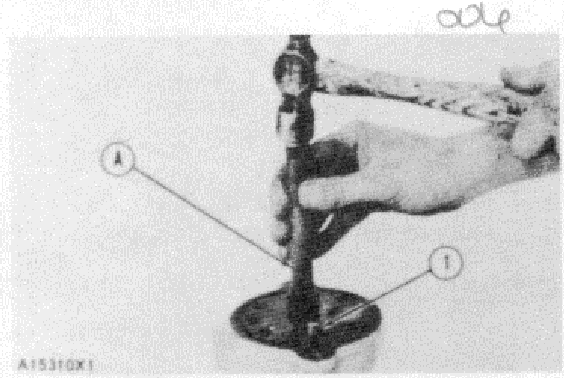
6. Remove seal (10) from manifold assembly.



006

ASSEMBLE SCAVENGE PUMP

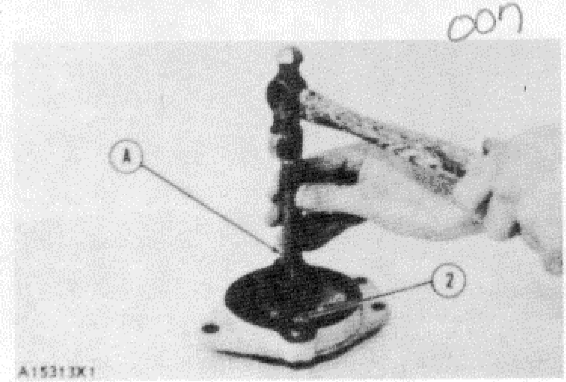
	Tools Needed	A	B
1 P529	Handle	1	1
1P461	Drive Plat	1	
1P463	Drive Plate	1	
1P473	Drive Plate		1



007

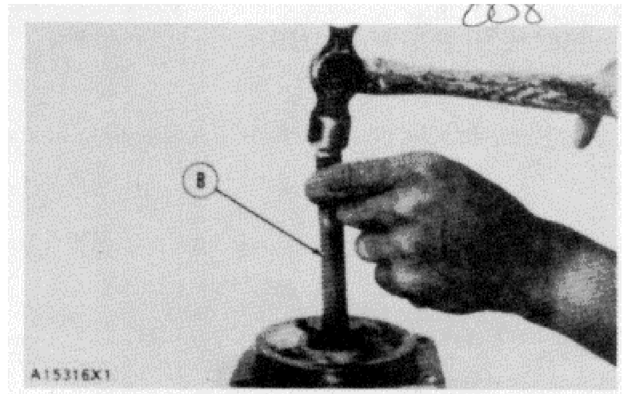
1. Install bearings (I) into cover assembly with tooling (A). Bearings must be .062 in. (1.6 mm) below surface of the cover assembly.

2. Install bearings (2) into manifold assembly, with tooling (A). Bearings must be installed .062 in. (1.6 mm) below inner surface of manifold assembly.

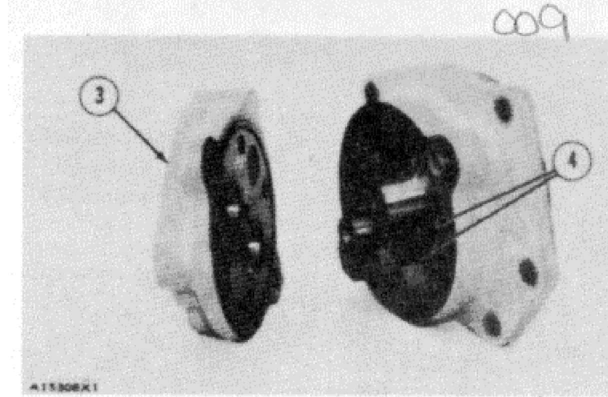


SCAVENGE PUMP

2. Install seal into manifold assembly with tooling (B).

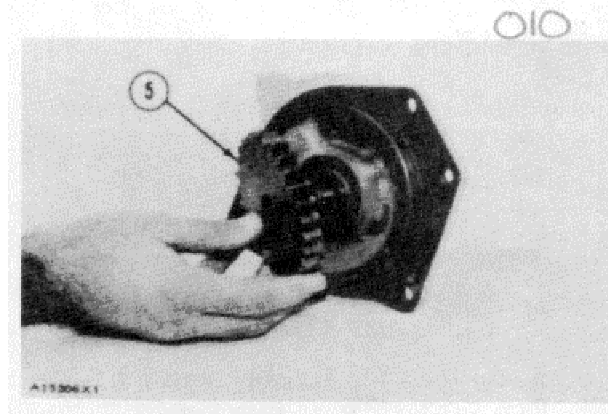


3. Install gears (4) in manifold assembly. Install cover assembly (3) and install the bolts that hold it.



4. Install drive gear (5) on shaft. Install brass washer and snap ring on drive gear.

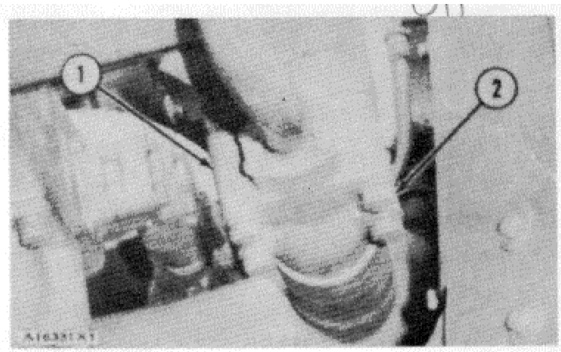
   end by:
   a) install scavenge pump



ELEVATOR AND IMPLEMENT PUMP

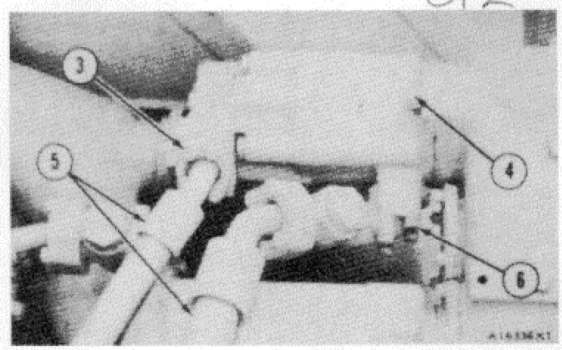
REMOVE ELEVATOR AND IMPLEMENT PUMP

1. Remove four bolts (2) from inlet junction block (l).



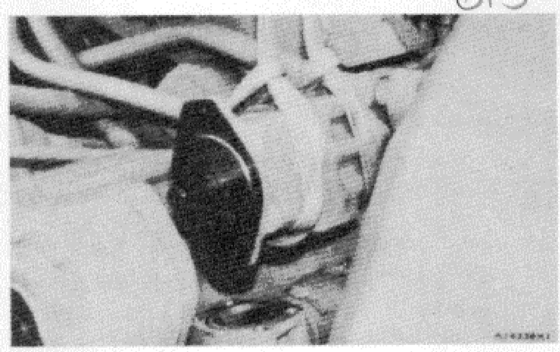
012

2. Remove bolts (3) and (6). Push outlet hoses (5) away from pump.



013

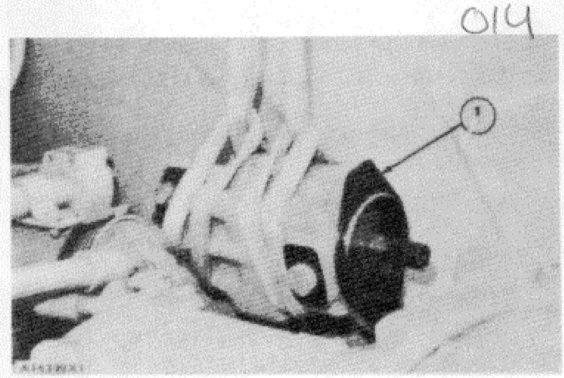
3. Fasten a hoist to pump and remove two bolts (4). Remove pump. Weight of pump is 80 lb. (36 kg).



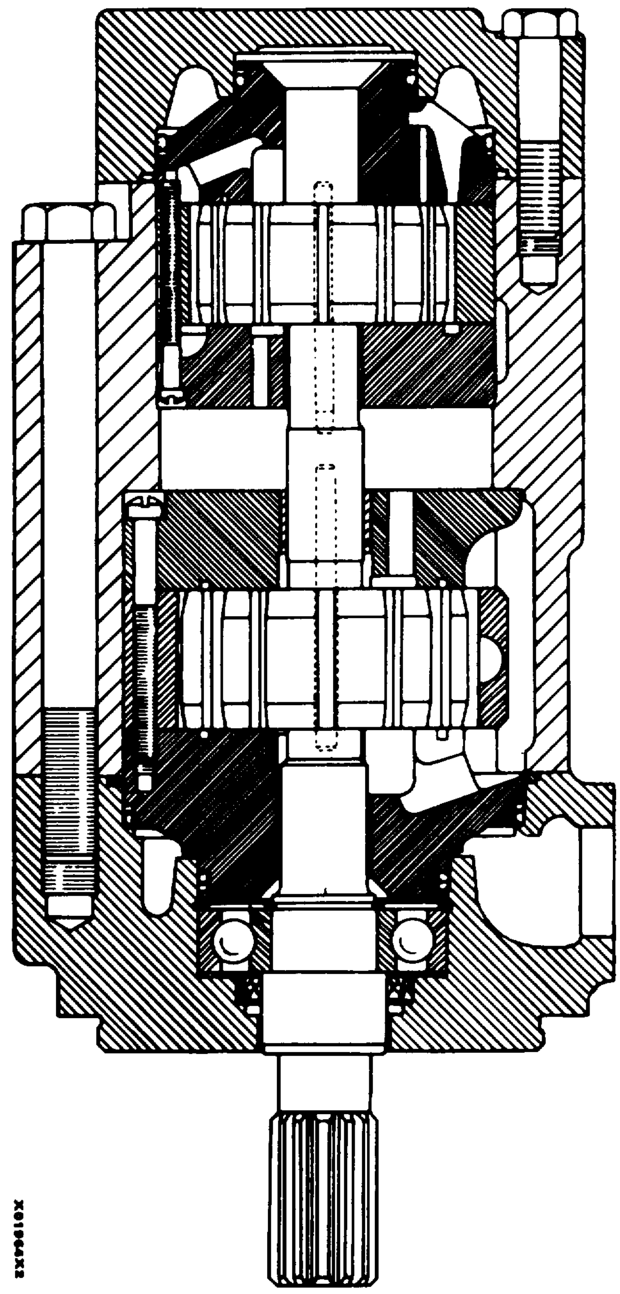
014

INSTALL ELEVATOR AND IMPLEMENT PUMP

1. Put pump (1) in position on pump drive and install two bolts.
2. Install the two outlet hoses and the bolts that hold them to the pump.
3. Install the four bolts that hold pump to the inlet junction block.



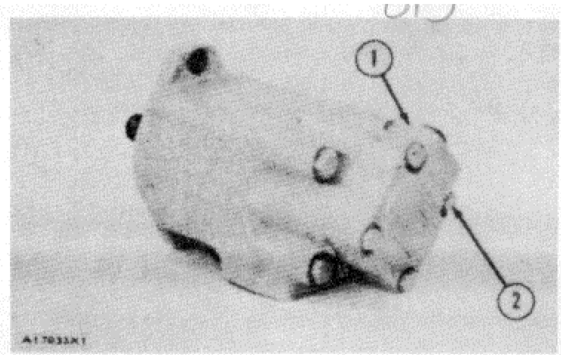
ELEVATOR AND IMPLEMENT PUMP



ELEVATOR AND IMPLEMENT PUMP

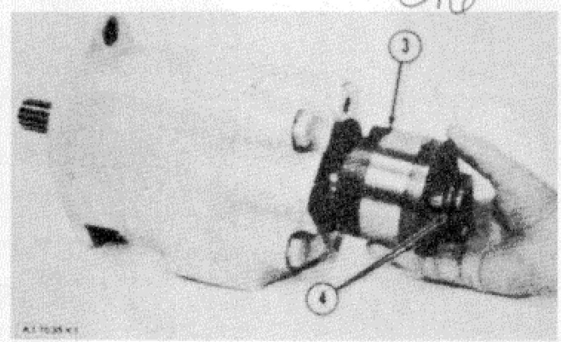
DISASSEMBLE ELEVATOR AND IMPLEMENT PUMP

start by:
a) remove elevator implement pump



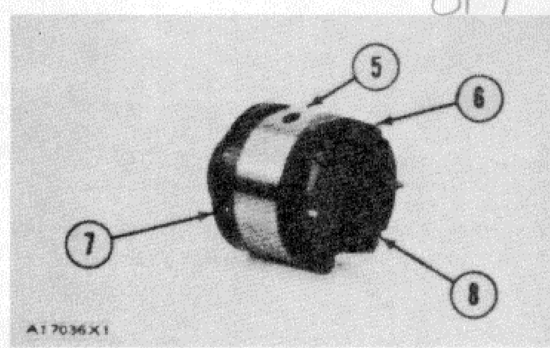
1. Remove four bolts (2) and remove cover (1) from pump. Inspect O-ring seal inside of cover and make a replacement if necessary.

016



2. Pull small cartridge assembly (3) from cover end of pump. Inspect O-ring seals (4) and make replacements if necessary.

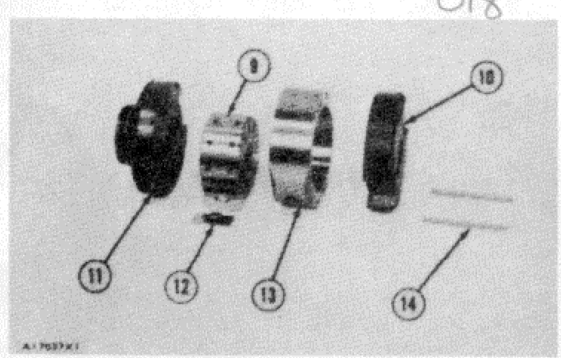
017



3. Put marks on pressure plate (7), cam ring (5) and wear plate (6) and then remove two screws (8).

NOTE: Put marks on all large and small pump sections to make sure of correct assembly and correct oil flow.

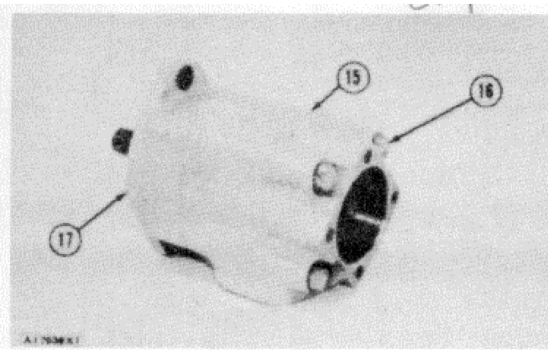
018



4. Remove pins (14), then remove wear plate (10), cam ring (13), rotor (9), vanes (12) and pressure plate (11).

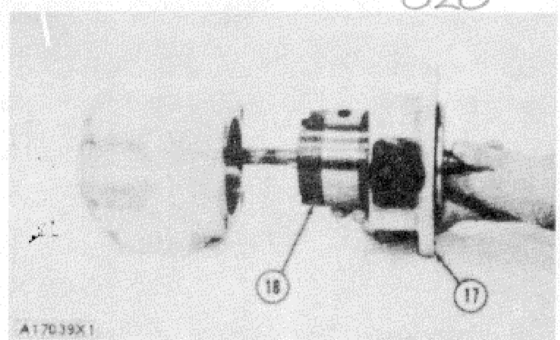
ELEVATOR AND IMPLEMENT PUMP

5. Remove four bolts (16) and remove drive end (17) of pump from housing (15).



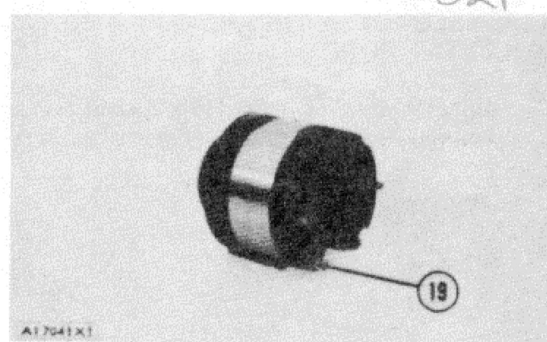
020

6. Pull drive end (17) of pump and large cartridge assembly (18) out of housing. Pull cartridge assembly off of pump shaft. Remove O-ring seals from assembly. Inspect and make replacements if necessary.



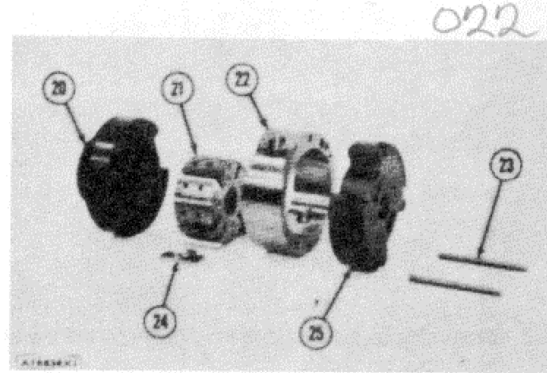
021

7. Remove screws (19) from cartridge assembly.



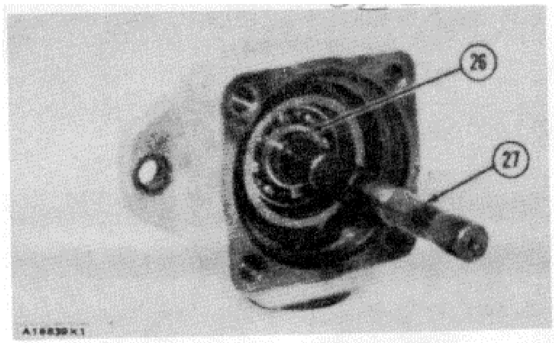
022

8. Remove pins (23), then remove wear plate (25), cam ring (22), rotor (21), vanes (24) and pressure plate (20).

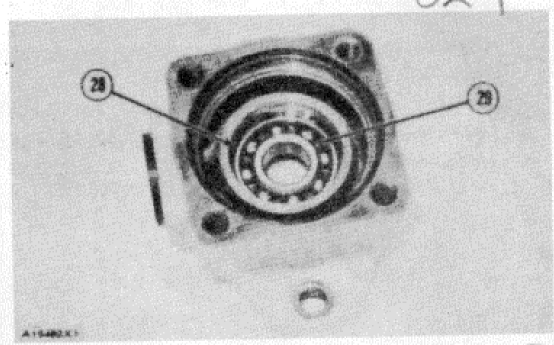


ELEVATOR AND IMPLEMENT PUMP

9. Remove snap ring (26) and push shaft (27) out of housing.



024

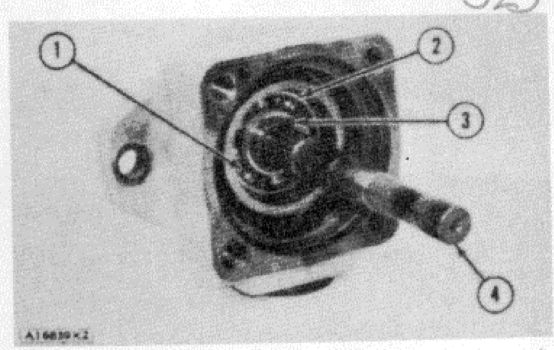


10. Remove seal (28) and bearing (29) from housing.

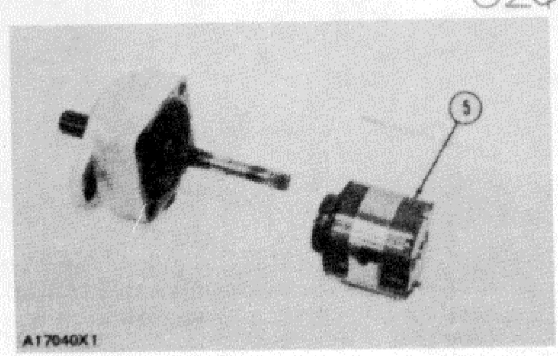
ASSEMBLE ELEVATOR AND IMPLEMENT PUMP

025

1. Install bearing (1), seal (2) and shaft (4) into housing. Install snap ring (3) on shaft.



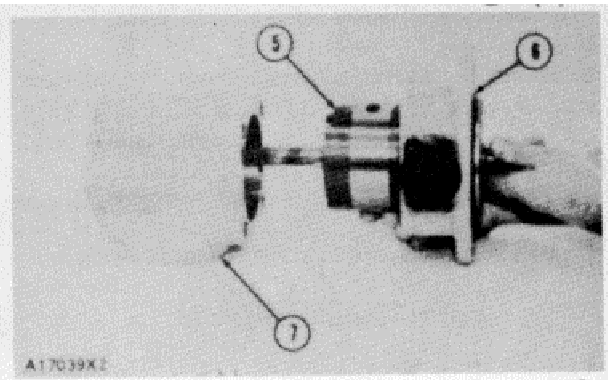
026



2. Assemble large cartridge assembly (5) and install assembly on shaft.

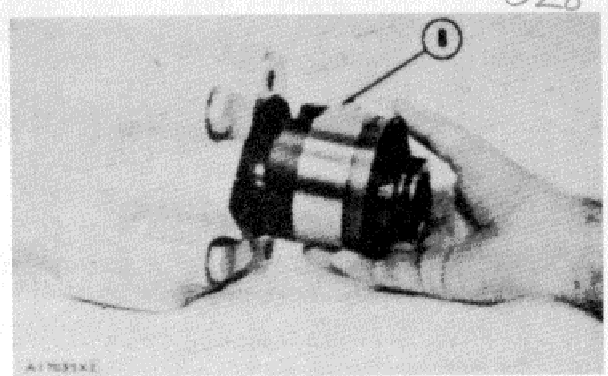
ELEVATOR AND IMPLEMENT PUMP

3. Install large cartridge assembly (5) and drive end (6) of pump into housing (7) as a unit. Install the bolts that hold the unit to the housing. Tighten bolts to a torque of 150 + 10 lb.ft. (203.4 + 13.6 N-m).



028

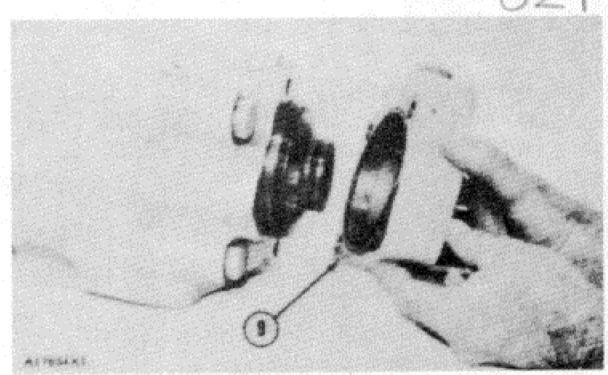
4. Assemble the small cartridge assembly (8) and install it in the housing.



029

5. Install cover (9) on housing and install the bolts that hold it. Tighten the bolts to a torque of 70 + 5, lb.ft. (94.9 -+ 6.8 N.m).

   end by:
   a) install elevator and implement pump



TRANSFER GEARS, TRANSMISSION AND DIFFERENTIAL

REMOVE TRANSFER GEARS, TRANSMISSION AND DIFFERENTIAL AS A UNIT

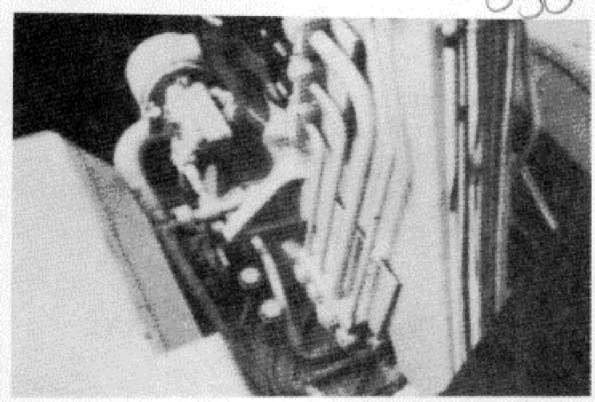
	Tools Needed	A	B
5P3050	Jack Group	1	
8S9906	Ratchet Puller		1

start by:

a) Remove the supplemental steering pump. The drive pinion can be removed with the differential.

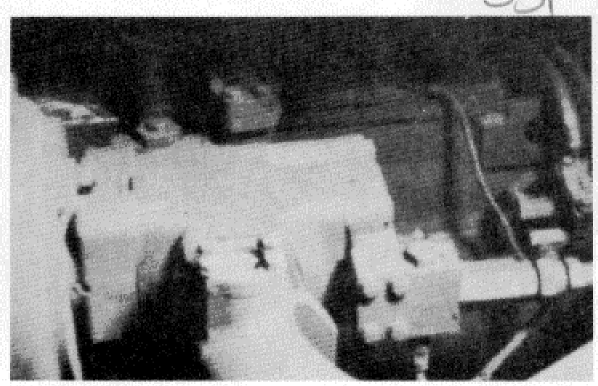
1. Turn the tractor so it is at a right angle to the scraper. Let the hydraulic oil out of the transmission and differential case.

030



2. Disconnect all lines that are connected to the implement and steering pump. Put caps on all lines and hoses to keep out dirt.

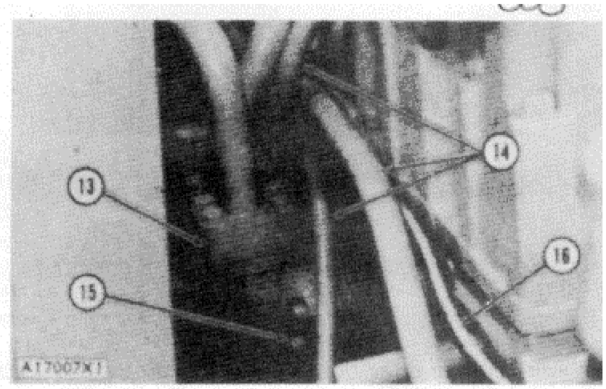
031



3. Remove bolts from inlet pipe. Cap all lines to keep out dirt.

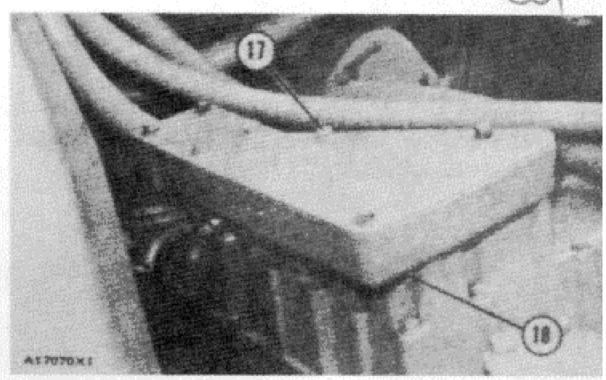
TRANSFER GEARS, TRANSMISSION AND DIFFERENTIAL

4. Remove nuts (15) and remove oil manifold (13). Disconnect lines (14). Disconnect headlamp wire (16). Put caps on lines (14) to keep out dirt.



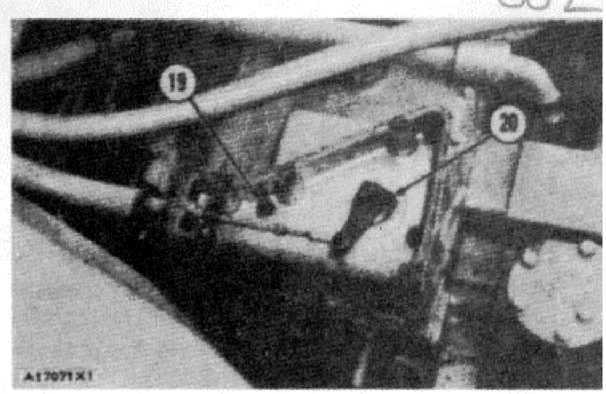
601

5. Remove cover bolts (17) from linkage housing (18) and remove cover.



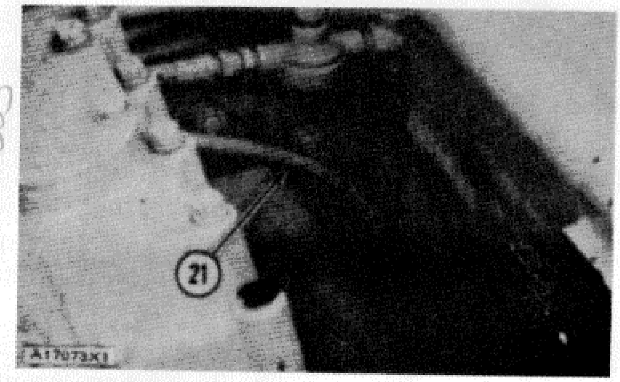
602

6. Remove bolts (19) from housing. Loosen nut (20) and remove linkage from shaft. Push linkage housing to one side.

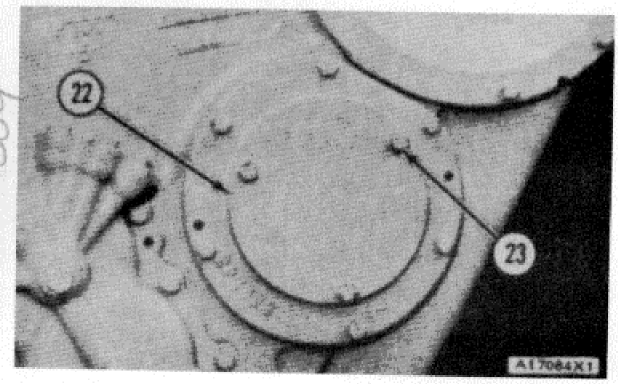


TRANSFER GEARS, TRANSMISSION, AND DIFFERENTIAL

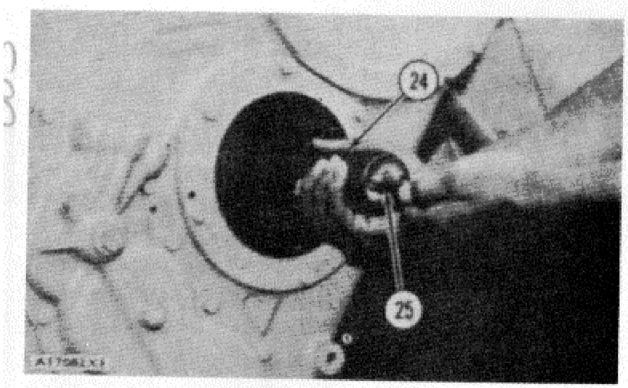
7. Disconnect differential lock airline (21). Put cap on air line (21) to keep out dirt.



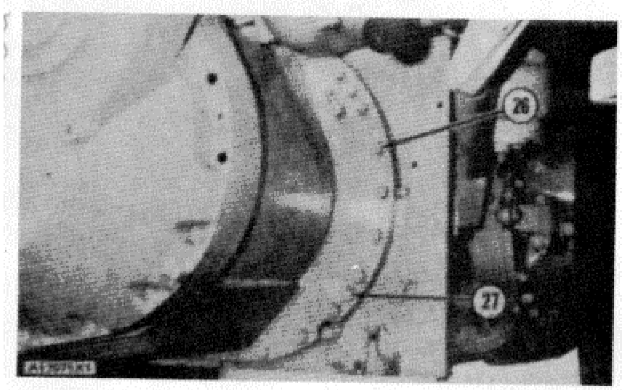
8. Remove three bolts (23) and remove drive shaft %over (22).



9. Install a bolt (25) into one of the threaded holes in the drive shaft. Remove drive shaft (24).

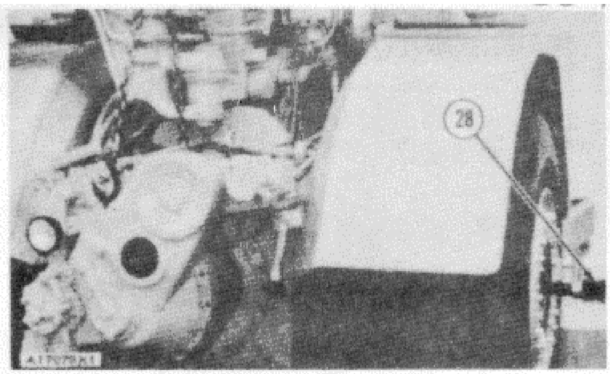


10. Fasten a hoist and tool (B) to transmission for support. Remove nuts (26), but do not remove four bolts (27) that bold the differential to the transmission.



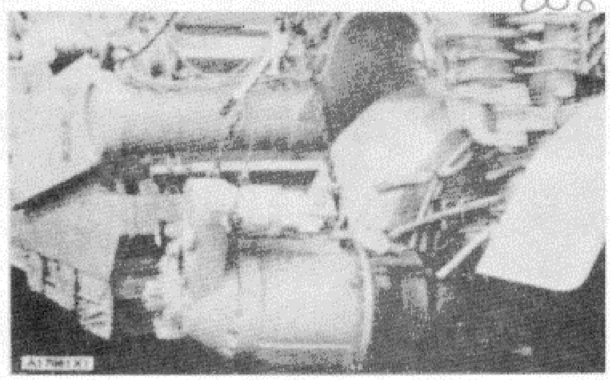
TRANSFER GEARS, TRANSMISSION, AND DIFFERENTIAL

11. Remove axles (28) out far enough to free differential housing.



008

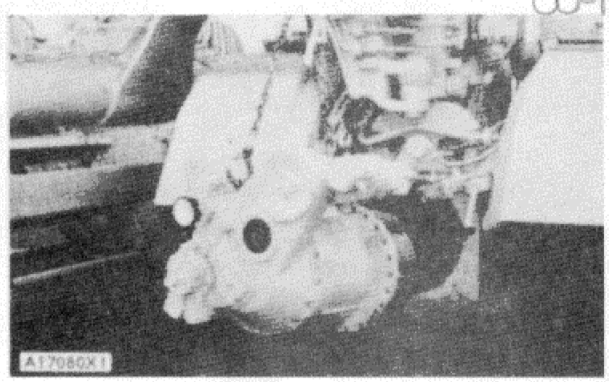
12. Remove transfer gears, transmission and differential as a unit. Weight of the unit is 4500 lb. (2041 kg).



009

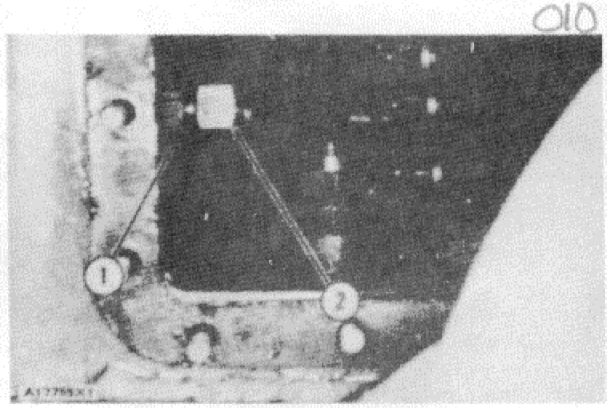
INSTALL TRANSFER GEARS, TRANSNISSION AND DIFFERENTIAL AS A UNIT

1. Remove the access cover from the top of the differential case. Loosen locknut (1) and turn thrust stop (2) on the inside of the differential case to give enough to clearance for installation of the differential. Put the transfer gears, transmission and differential in position and install the washers and nuts that hold the transmission and differential to the frame.



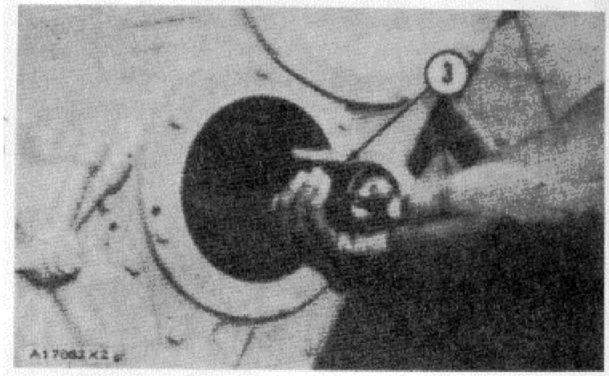
010

2. Turn thrust stop to give a clearance of .002 + .001 in. (0.05 + 0.03 mm) between thrust stop and bearing cap. Tighten locknut. Install access cover on top of the differential case.

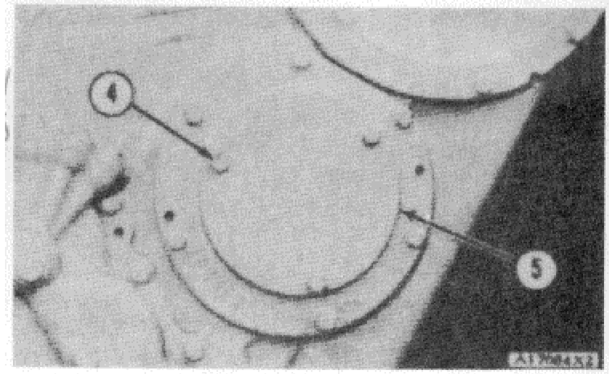


TRANSFER GEARS, TRANSMISSION AND DIFFERENTIAL

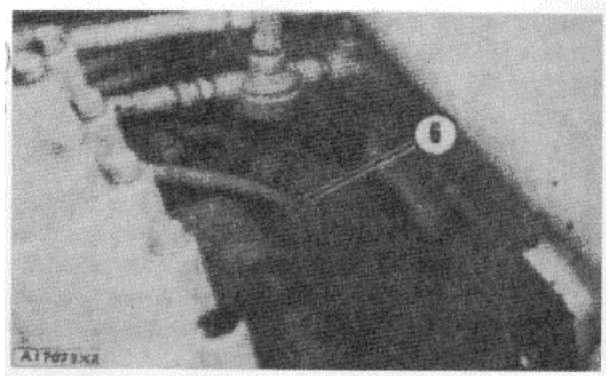
3. Push axles back into differential housing. Install drive shaft (3).



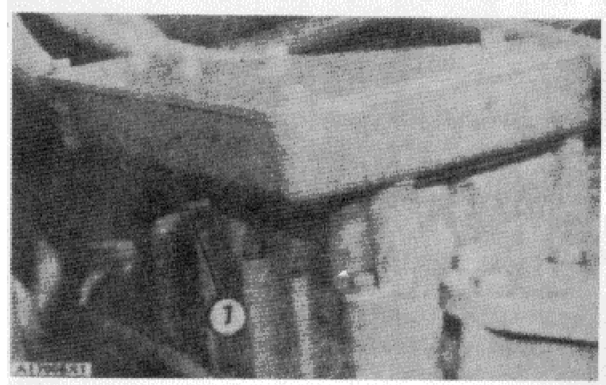
4. Install drive shaft access cover (5) and the bolts (4) that hold it.



5. Remove protection cap from differential lock air line. Install differential lock air line (6).

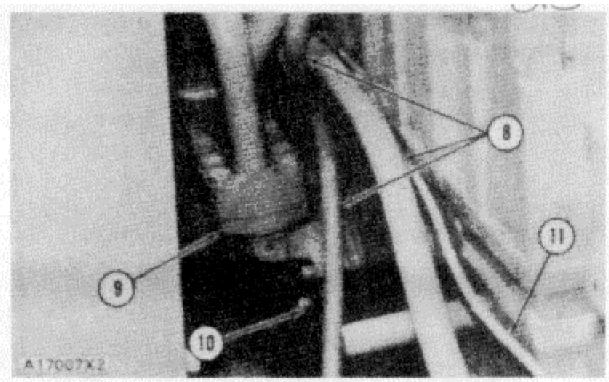


6. Install shift linkage and shift linkage housing (7).



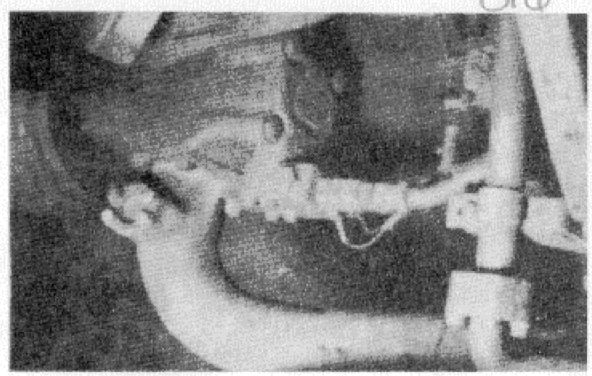
TRANSFER GEARS, TRANSMISSION AND DIFFERENTIAL

7. Connect headlamp wire (1). Remove protection caps from lines (8). Connect lines (8) to their respective positions. Install oil manifold (9) and the nuts (10) that hold it to the transmission.



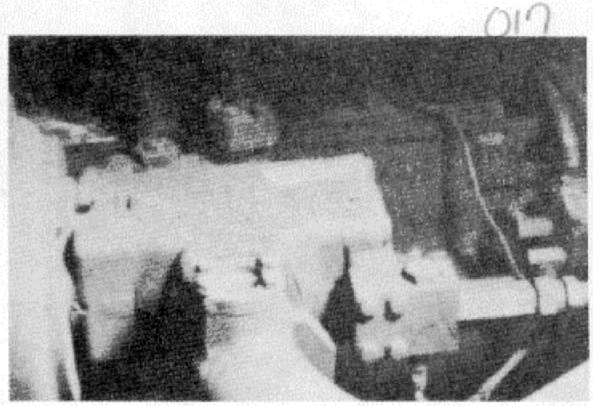
8. Install inlet pipe and bolts.

016



9. Remove protection caps from all lines and hoses. Connect all lines and hoses to the implement and steering pump.

017



10. Fill transmission and differential case with hydraulic oil to the correct level.

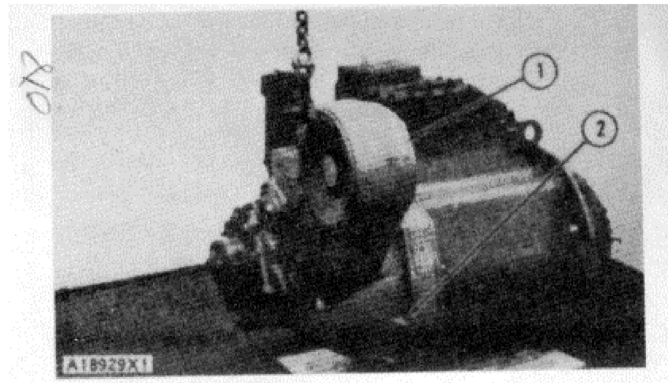
TRANSMISSION AND TRANSFER GEARS

SEPARATION OF TRANSFER GEARS FROM TRANSMISSION

start by:

a) remove transfer gears, transmission and differential as a unit

1. Install a 5/8"- 11 NC forged eyebolt on the transfer gear housing (1) and fasten a hoist.
2. Remove the bolts (2) that hold the transfer gear housing to the transmission housing.
3. Remove transfer gears. Weight is 500 lb. (227 kg).

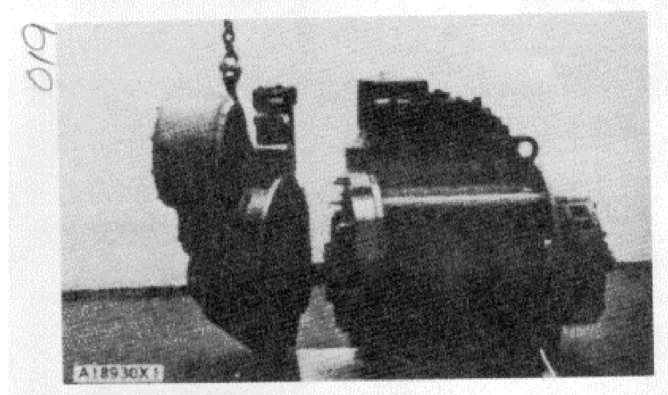


CONNECTION OF TRANSFER GEARS TO TRANSMISSION

1. Put transfer gears in position on the transmission housing with a hoist and install the bolts that hold it.

end by:

a) install transfer gears, transmission and differential as a unit



TRANSFER GEARS

DISASSEMBLE TRANSFER GEARS

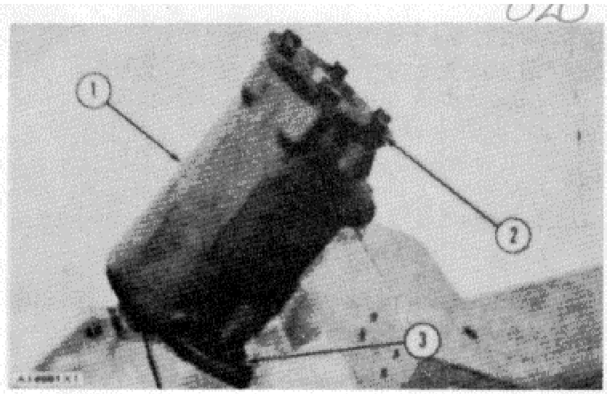
	Tools Needed	A	B	C	D	E	F
1P463	Drive Plate	1					
1P465	Drive Plate	1					
1P529	Handle	1	1				
1P467	Drive Plate		1				
1P469	Drive Plate		1				
1P498	Drive Plate			1			
8B7560	Step Plate			1	1		
887551	Bearing Puller Attachment			1			
887548	Puller Assembly			1			
8B7554	Bearing Cup Pulling Attachment				1	1	
5F7345	Screw				1		
1P518	Drive Plate					1	
5P4170	Step Plate					1	1
1P2321	Puller Assembly						1

start by:

a) remove transfer gears, transmission and differential as a unit

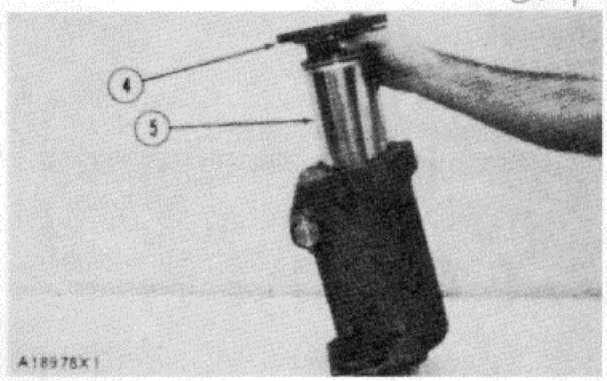
b) separation of transfer gears from transmission

020



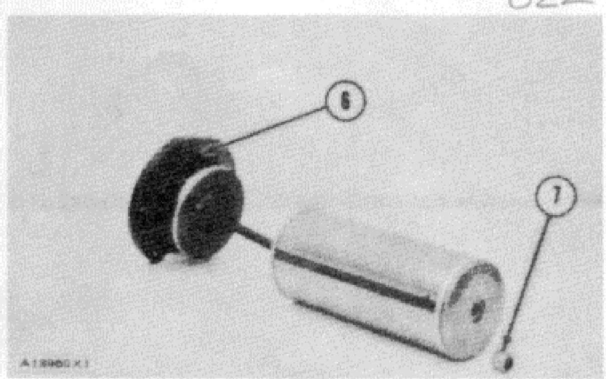
1. Remove transmission oil filter (1) from transfer gear housing after four bolts (3) are removed. Remove bolts (2) from cover assembly.

021



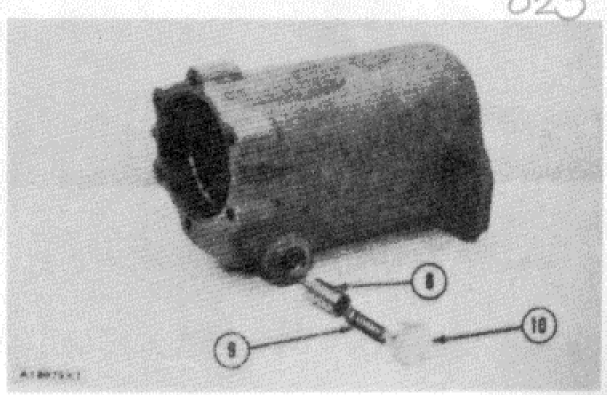
2. Remove cover assembly (4) and filter element (5) from filter housing.

022



3. Make a separation of the filter element (5) from cover assembly (4) after nut (7) is removed. Remove and inspect O-ring seal (6). Make a replacement if necessary.

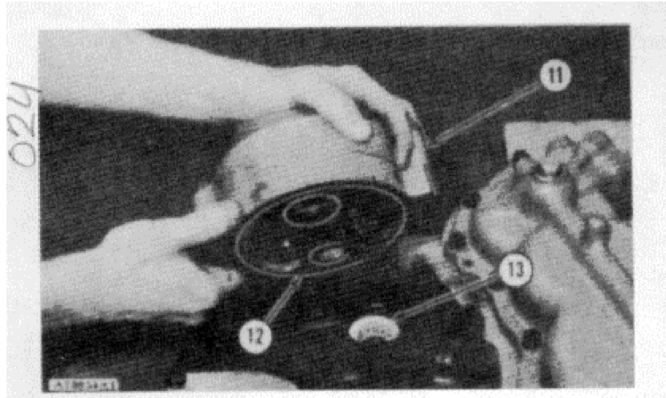
023



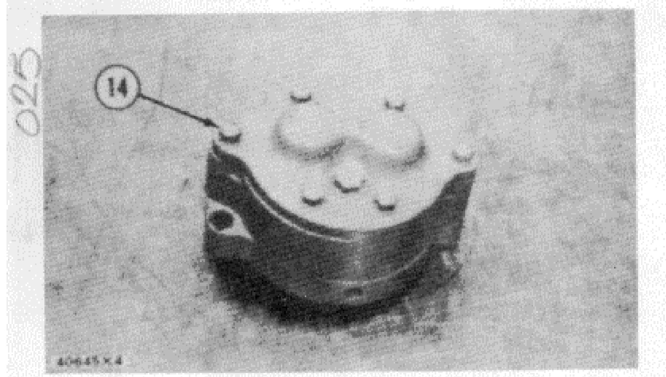
4. Remove plug (10) from filter housing, then remove spring (9) and relief valve (8).

TRANSFER GEARS

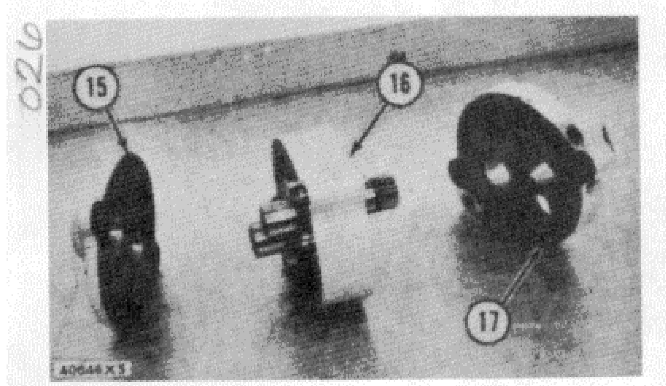
5. Remove two bolts and remove scavenge pump (11). Remove and inspect O-ring seal (12). Make a replacement if necessary. Remove coupling (13) from manifold housing.



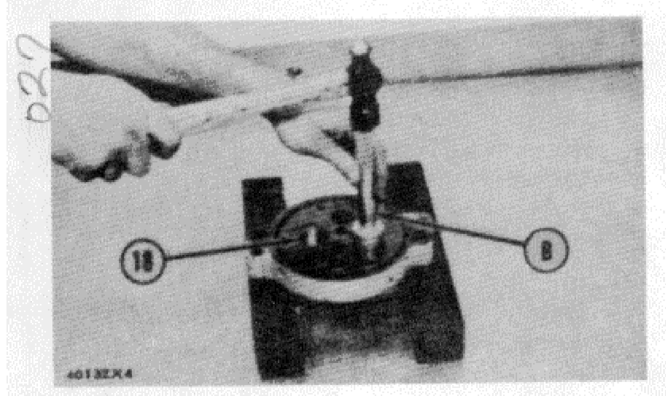
6. Remove bolts (14) from scavenge pump cover.



7. Make a separation of cover (15), body assembly (16) and cover (17).

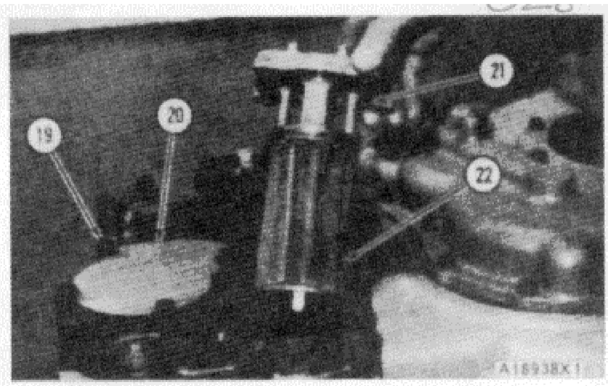


8. Remove bearings (18) from the covers with tooling (B).



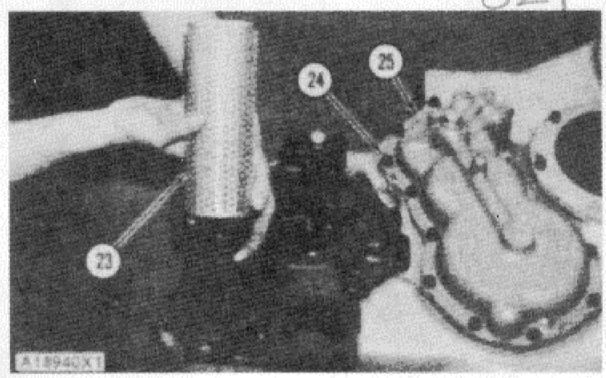
TRANSFER GEARS

9. Remove four bolts to remove filter screen (22). Remove and inspect O-ring seal (21). Make a replacement if necessary. Remove four bolts (19) and cover (20). Remove and inspect O-ring seal from cover (20). Make a replacement of the O-ring seal if necessary.



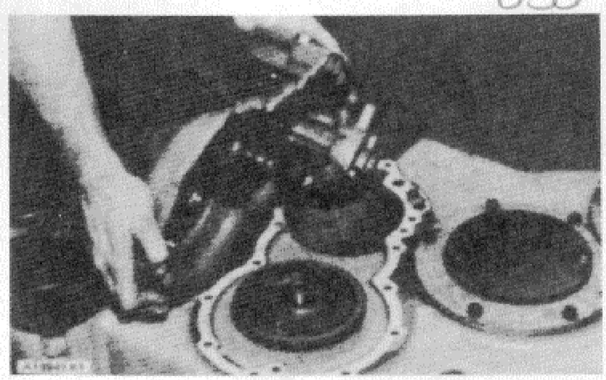
029

10. Remove magnetic filter element (23) from housing. Remove bolts (24) from shift governor (25). Install two 3/8"-16 NC forcing screws into shift governor housing.



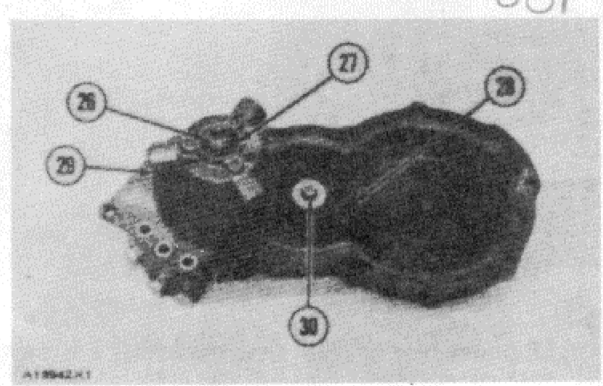
030

11. Remove shift governor and drive assembly from transfer gear housing.



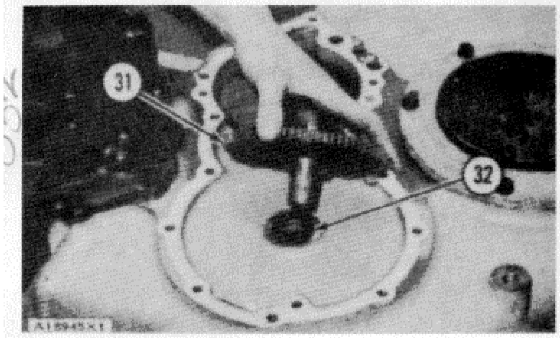
031

12. Remove seal (26) and thrust washer (27) from governor (29). Remove bolt (30) and idler gear (28) from governor housing.

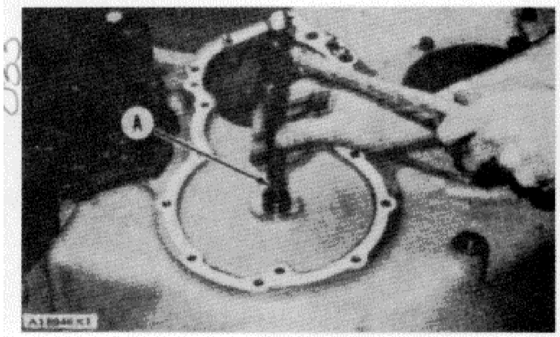


TRANSFER GEARS

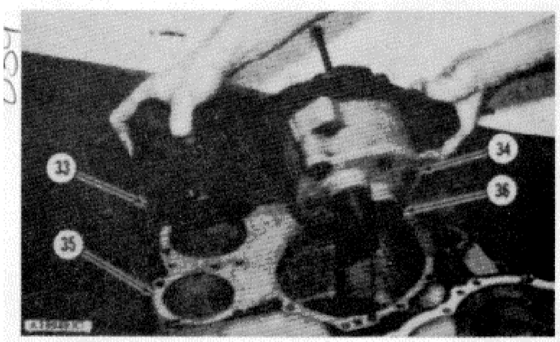
13. Remove governor drive (31) from transfer gear housing. Remove thrust washers (32) from either side of drive gear (31).



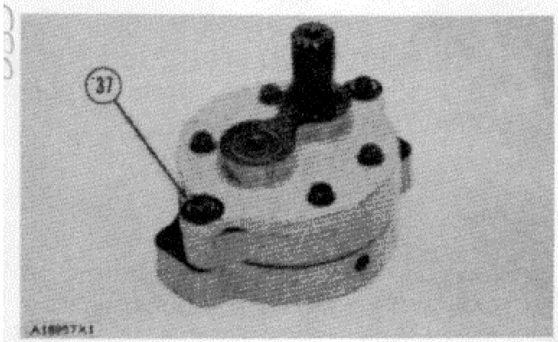
14. Remove drive gear bearing with tooling (A).



15. Remove bolts from manifold assembly. Install 3/8"-16 NC forcing screws and make a separation of manifold assembly (33) from the dowels. Remove and inspect gasket (35). Remove two bolts (36) and transmission pump (34) from manifold assembly. Remove. and inspect O-ring seals from bottom of transmission pump.

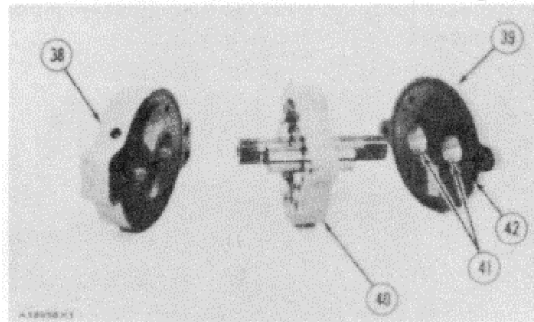


16. Remove bolts (37) from transmission pump cover.

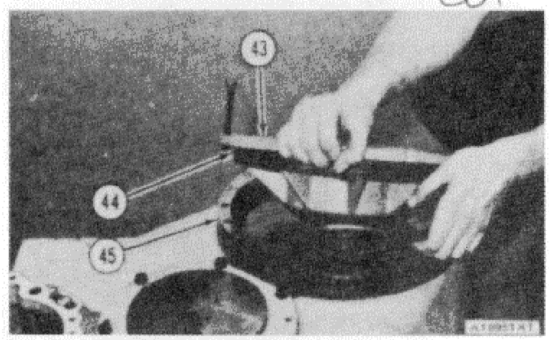


TRANSFER GEARS

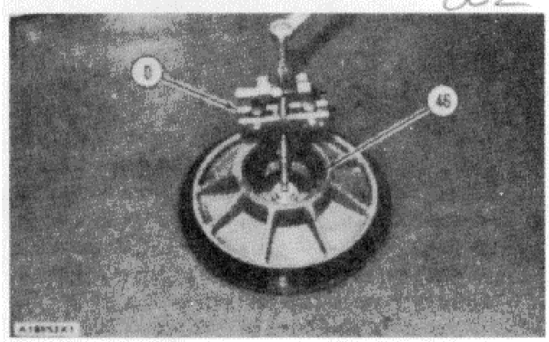
17. Make a separation of cover (38), body assembly (40) and cover (39). Remove bearings (41) from covers. Remove and inspect O-ring seals (42) from covers (38) and (39).



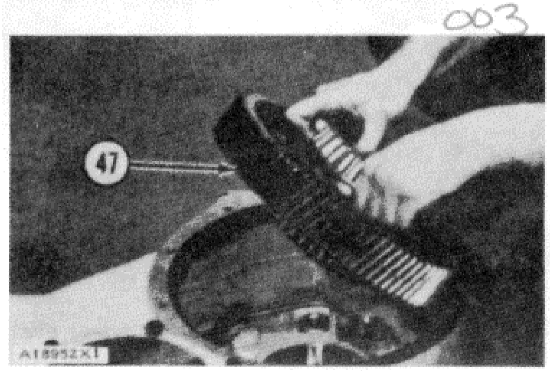
18. Remove bolts from pump drive gear cage (43). Install two 3/8"-16 NC forcing screws and remove cage. Remove and inspect O-ring seal (44). Make a replacement if necessary. Remove shims (45).



19. Remove bearing race (46) from pump drive gear cage with tooling (D).

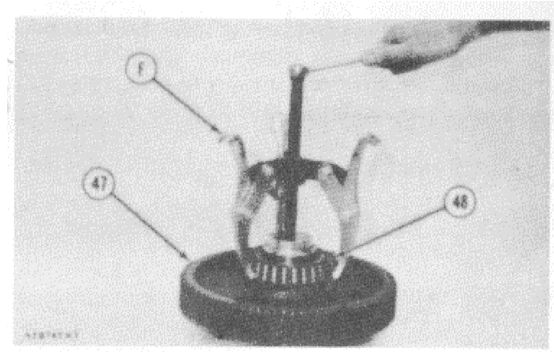


20. Remove pump drive gear assembly (47) from transfer gear housing.

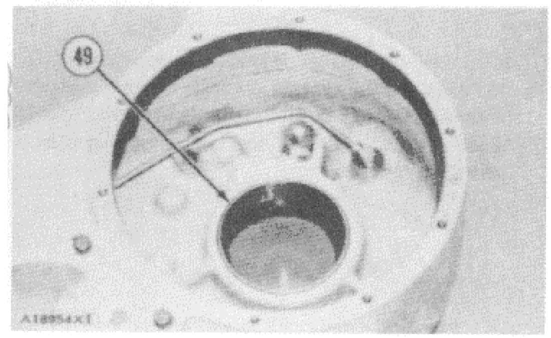


TRANSFER GEARS

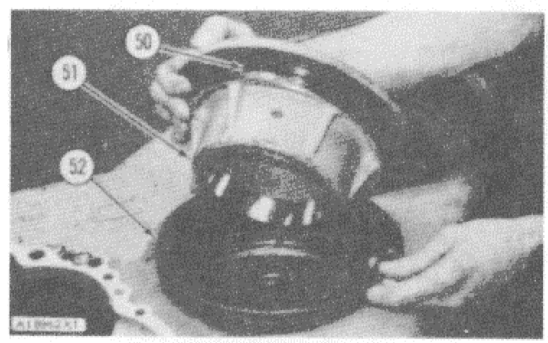
21. Remove bearing cones (48) from gear (47) with tooling (F).



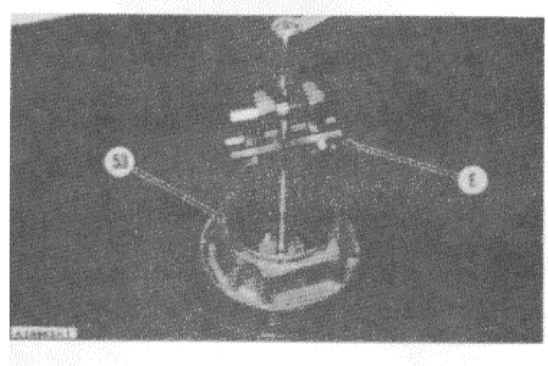
22. Remove bearing cup (49) from housing with a hammer and punch.



23. Remove bolts from drive gear cage (51). Install two 3/8"-16NC forcing screws and remove cage. Remove and inspect O-ring seal (50). Make a replacement if necessary. Remove shims (52).

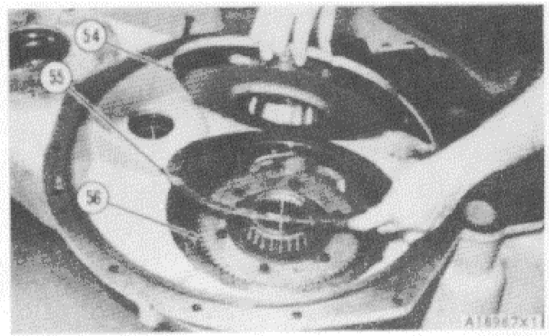


24. Remove bearing cup (53) from cage with tooling (E).



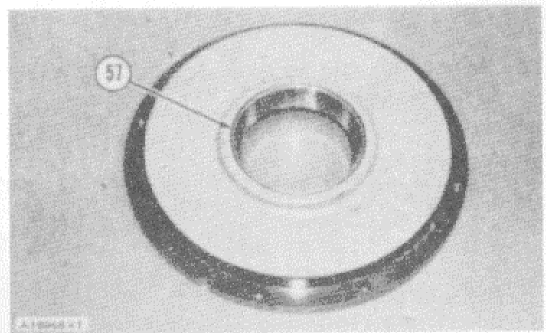
TRANSFER GEARS

25. Turn transfer gear housing over. Remove bolts from transmission drive gear cage (54). Install two 3/8"-16 NC forcing screws and remove cage. Remove shims (55).



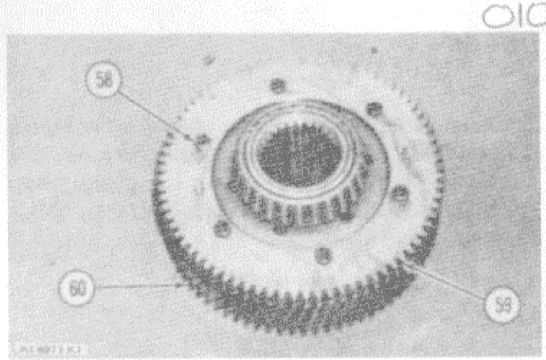
009

26. Remove bearing cup (57) from transmission drive gear cage with a hammer and punch. Remove transmission drive gear assembly (56) from transfer gear housing.



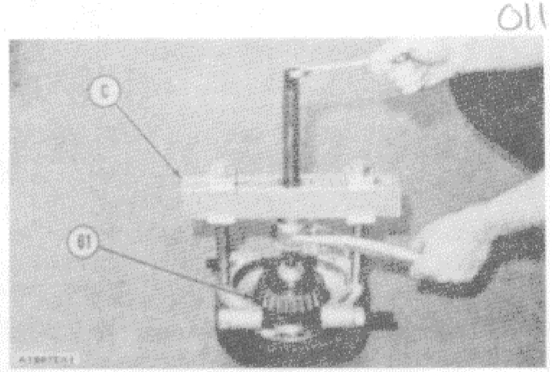
010

27. Remove six bolts (58) and remove gear (59) from gear (60).



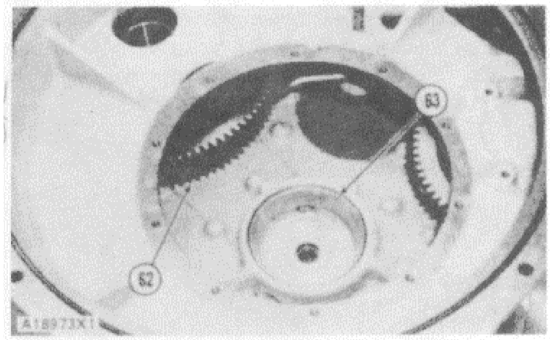
011

28. Remove bearing cones (61) from gear (60) with tooling (C).

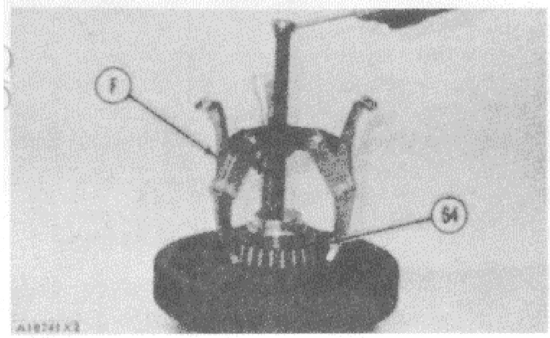


TRANSFER GEARS

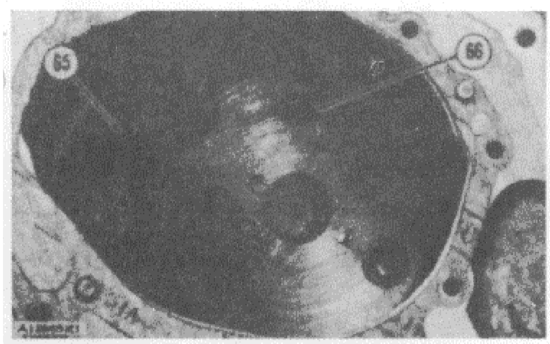
29. Remove bearing cup (63) from transfer gear housing with a hammer and punch. Remove drive gear assembly (62).



30. Remove bearing cones (64) from gear with tooling (F).

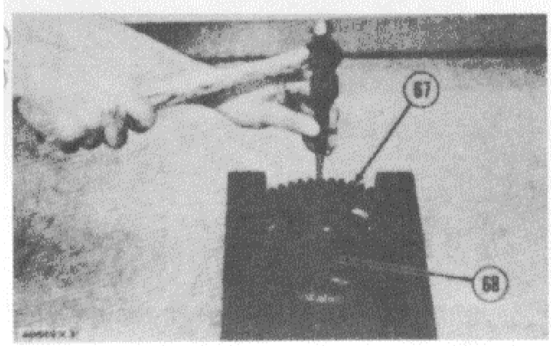


31. Turn transfer gear housing over. Remove three bolts (66) that hold idler gear (65). Remove idler gear.

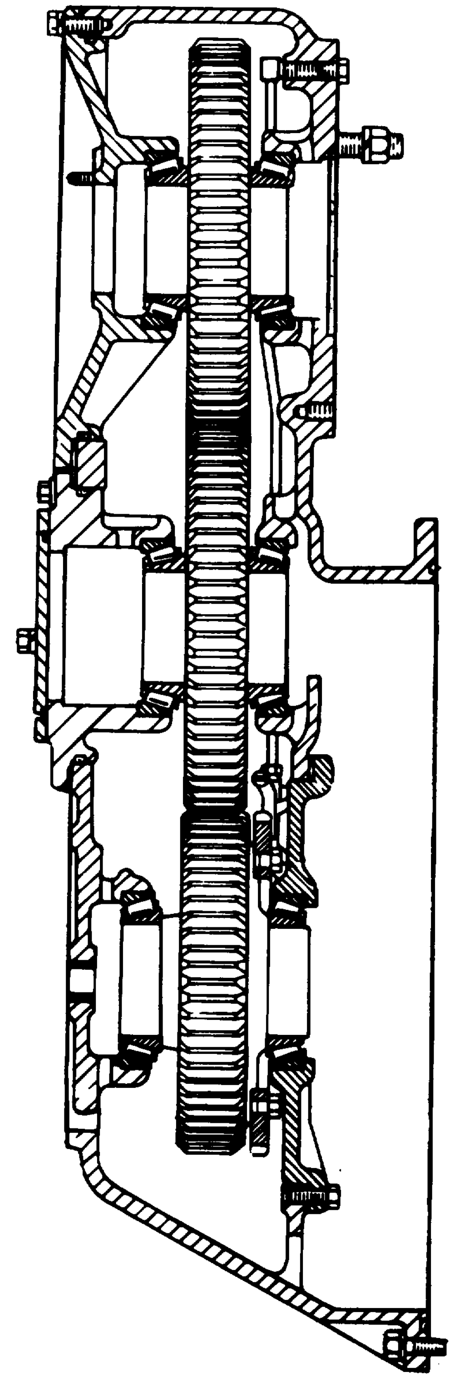


32. Remove retaining ring from cage assembly on gear (67). Make a separation of bearing and cage assembly from gear (67) with a hammer and punch.

NOTE: Punch goes through one of the holes (68).



TRANSFER GEARS



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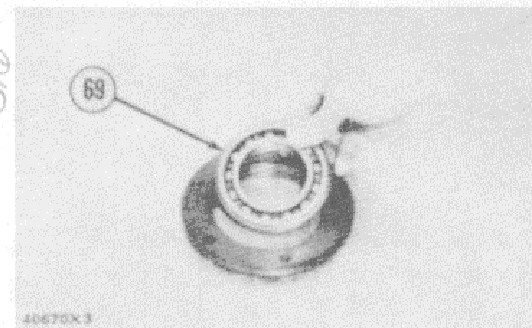
TRANSFER GEARS

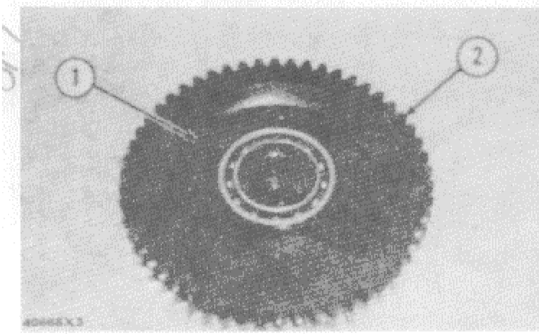
33. Remove bearing (69) from cage assembly.



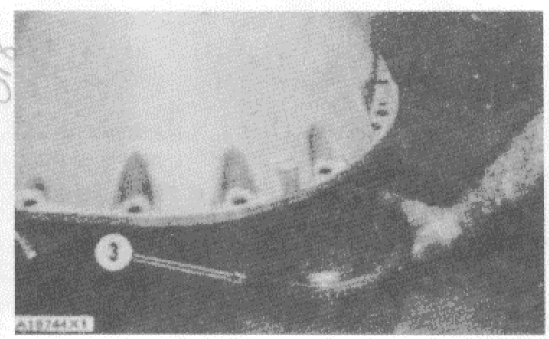
ASSEMBLE TRANSFER GEARS

Tools Needed		A	B	C	D	E
1P531	Handle	1	1			
1P524	Drive Plate	1		1		
1P525	Drive Plate		1			
1P532	Handle			1		
1 P529	Handle				1	
1P466	Drive Plate				1	
1P474	Drive Plate				1	
8S2328 Indicator Group	Dial Test					1

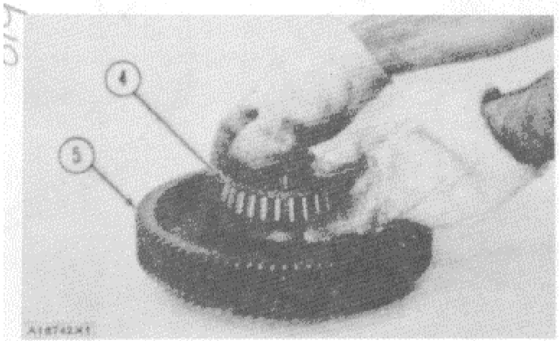
1. Put bearing cage (1) on idler gear (2). Install bearing assembly with a hammer and punch. Install snap ring that holds bearing.



2. Install the idler gear (3) into the transfer gear housing with three bolts.

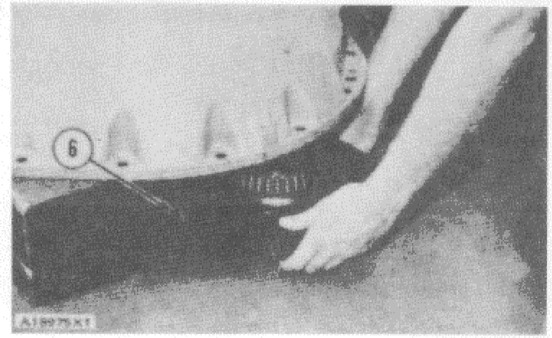


3. Heat bearing cones (4) to a maximum temperature of 300°F (149°C) and install them on the drive gear (5).

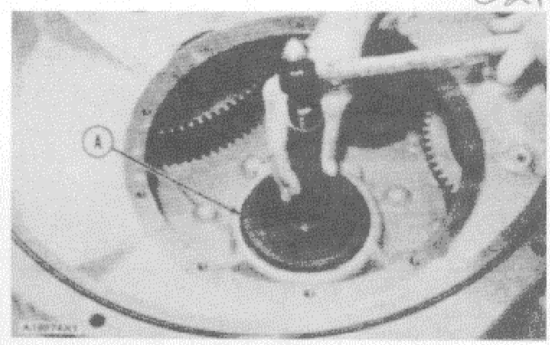


TRANSFER GEARS

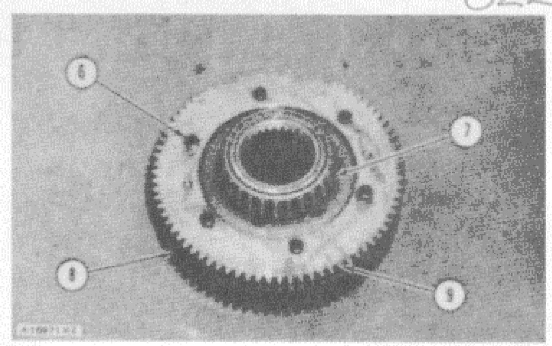
4. Install the drive gear assembly (6) into the transfer gear housing.



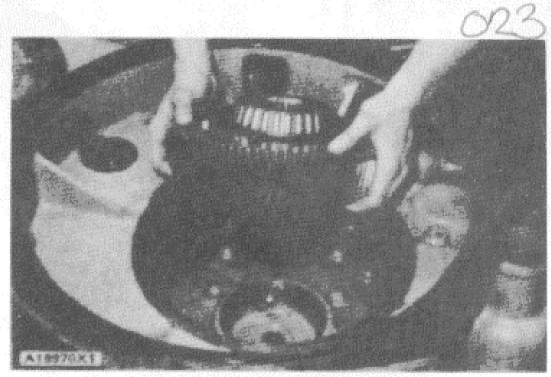
5. Lower the temperature of the bearing race for the transmission drive gear. Put it in position, then use tooling (A) to make sure it correctly makes a seat.



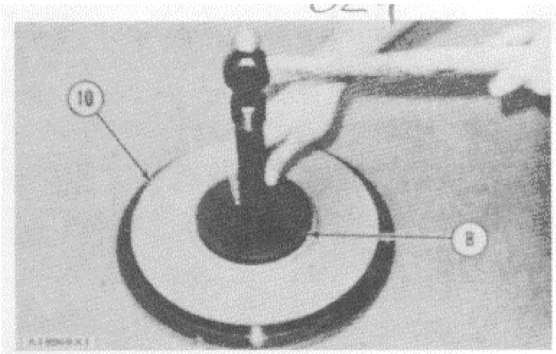
6. Heat bearing cones (7) to a maximum temperature of 300°F (149°C) and install them on the transmission drive gear (8). Install gear (9) on transmission drive gear with six bolts (6). Tighten bolts to a torque of 36±2 lb. ft. (48.8 ± 2.7 N•m).



7. Install transmission drive gear assembly into transfer gear housing.

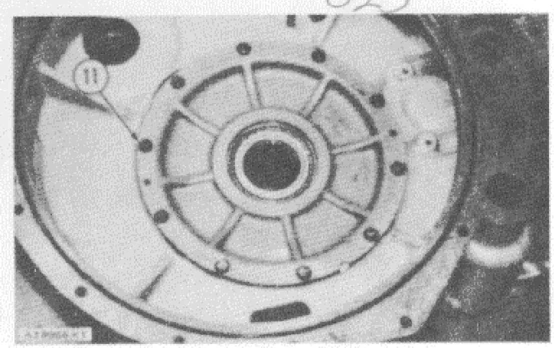


TRANSFER GEARS



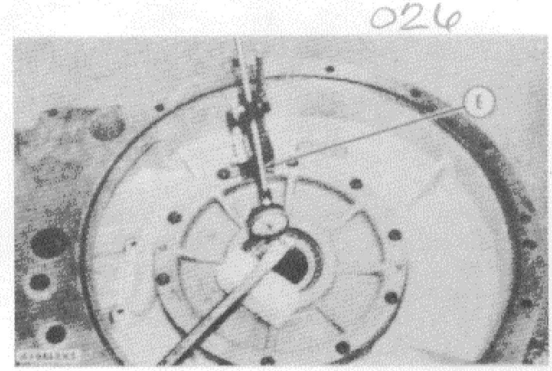
8. Lower the temperature of the bearing race for the transmission drive gear cage (10). Put it in position, then use tooling (B) to make sure it correctly makes a seat.

025



9. Install shims, transmission drive gear cage and bolts (11).

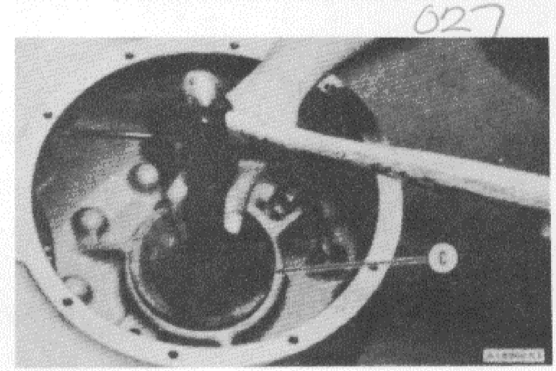
026



10. Install tooling (E) and measure end play in the gear. Add or remove shims under cage to get .006 ± .002 in. (0.15 ± 0.05 mm) end play in gear.

NOTE: Final torque for bolts (11) that hold cage to case is 36 ± 2 lb. ft. (48.8 ± 2.7 N•m).

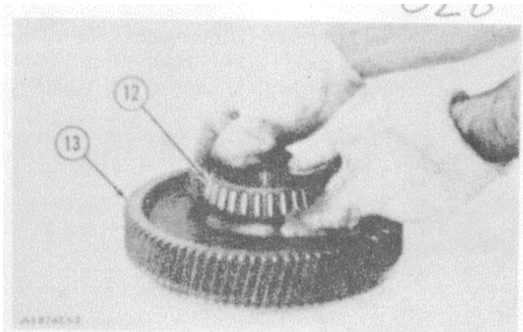
027



11. Turn transfer gear housing over. Lower the temperature of the bearing race for the pump drive gear. Put it in position, then use tooling (C) to make sure it correctly makes a seat.

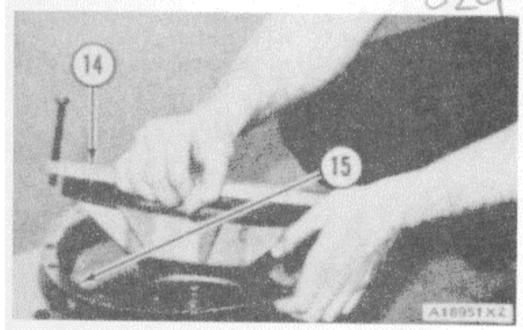
TRANSFER GEARS

12. Heat the bearing cones (12) for the pump drive gear (13) to a maximum temperature of 300°F (149°C). Install the bearing cones on the gear. Install the gear in transfer gear housing.



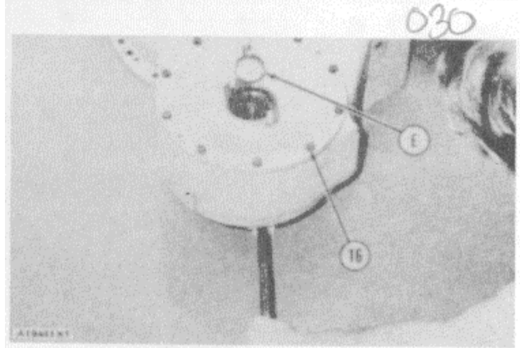
029

13. Lower temperature of the bearing cup for the pump drive gear cage (14). Put bearing cup in position, then use tooling (B) to make sure it makes a correct seat. Install new O-ring seal on cage (14) and install shims (15) and cage (14) on transfer gear housing. Install bolts that hold cage to housing.



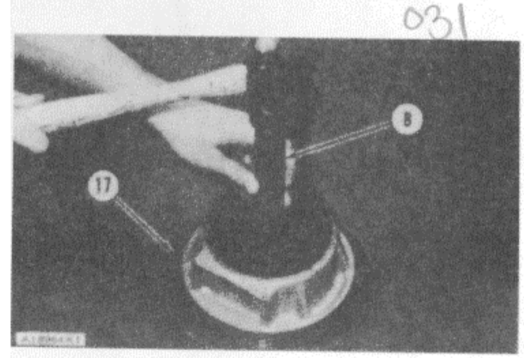
030

14. Install tooling (E) and measure end play in gear. Add or remove shims under cage to get .006 ± .002 in. (0.15 ±0.05 mm) end play in gear. Tighten bolts (16) to a final torque of 36 ±2 lb. ft. (48.8 ±2.7 N•m).



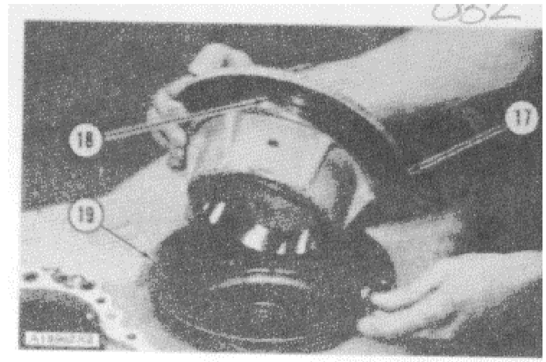
031

15. Lower the temperature of the bearing cup for the drive gear cage (17). Put cup in position, then use tooling (B) to make sure it makes a correct seat.

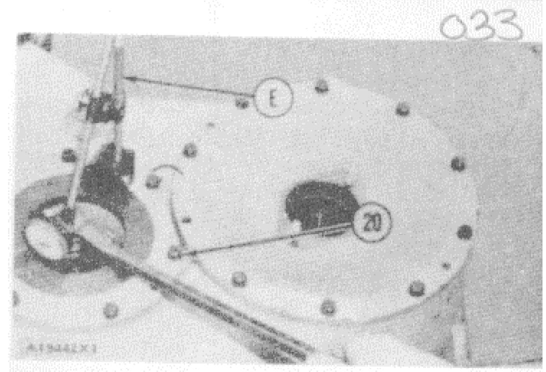


TRANSFER GEARS

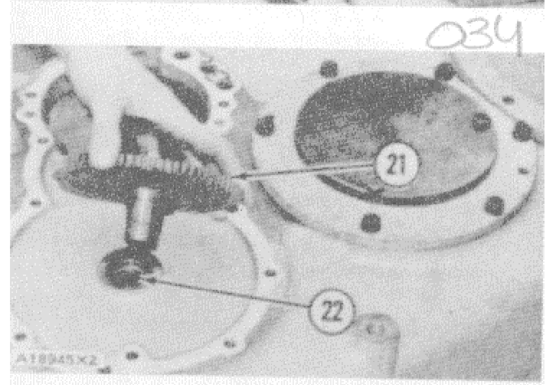
16. Install new O-ring seal (18) on cage (17). Install shims (19) and cage (17) on transfer gear housing. Install bolts that hold cage to housing.



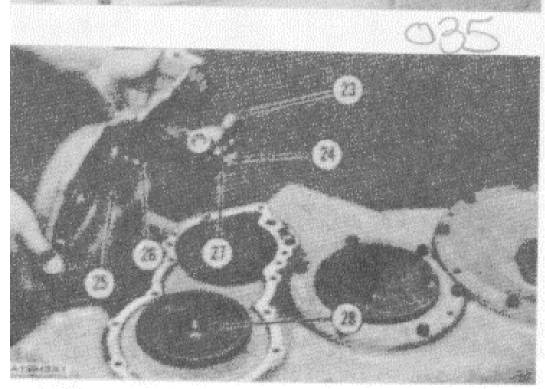
17. Install tooling (E) and measure end play in gear. Add or remove shims under cage to get .006 ± .002 in. (0.15 ±0.05 mm) end play in gear. Tighten bolts (20) to a final torque of 36±2 lb. ft. (48.8 ± 2.7 N°m).



18. Install bearing (22) in case. Install governor drive gear (21).

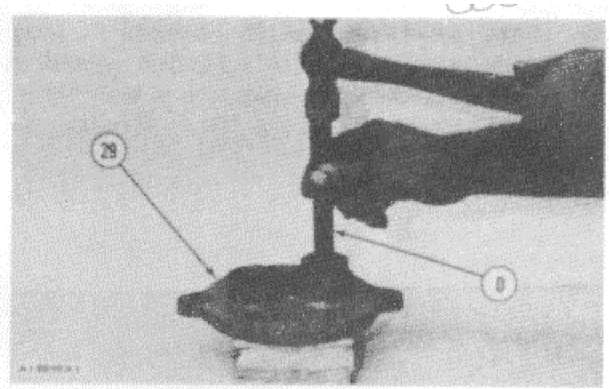


19. Install thrust washers (28) on both sides of governor drive gear. Install idler gear (25) on governor housing. Tighten bolt (26). Install governor (23), thrust washers (27) and O-ring seal (24) on shaft. Install governor housing on transfer gear housing.

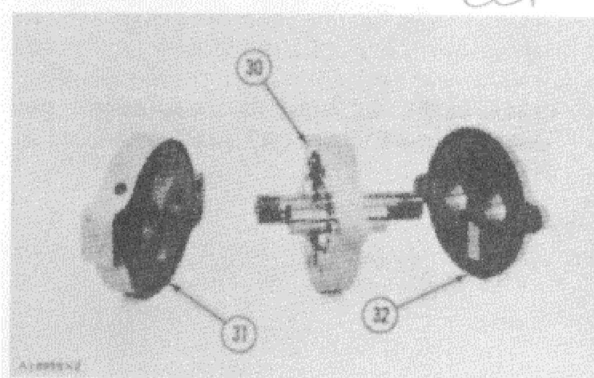


TRANSFER GEARS

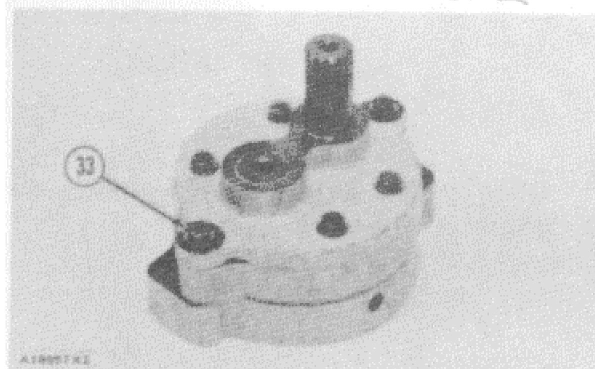
20. Install bearings in transmission pump covers (29) with tooling (D).



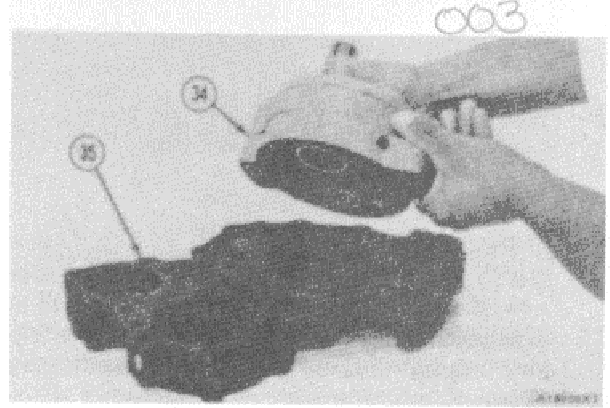
21. Assemble cover (31), body assembly (30) and cover (32) for the transmission pump.



22. Install bolts (33) that hold cover. Install O-ring seals on bottom of pump.

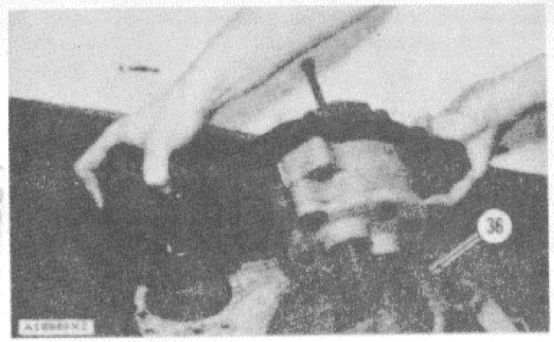


23. Install transmission pump (34) on manifold assembly (35) with two bolts.

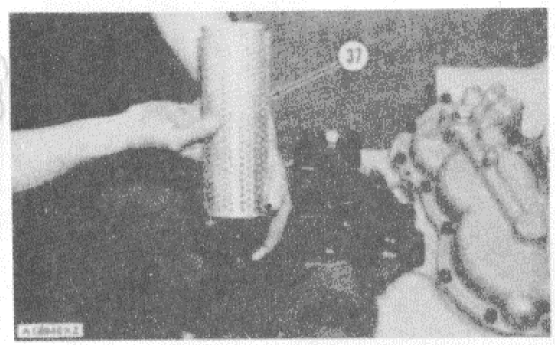


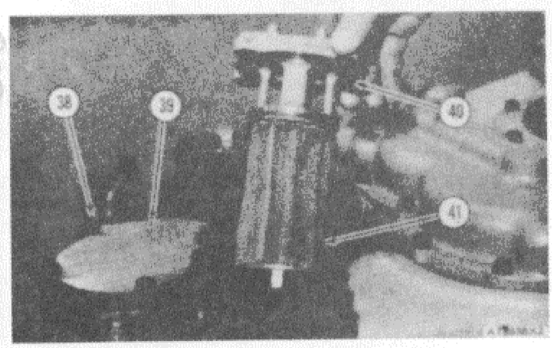
TRANSFER GEARS

24. Install a new gasket (36) for manifold assembly on the transfer gear housing. Install manifold assembly and the bolts that hold it.

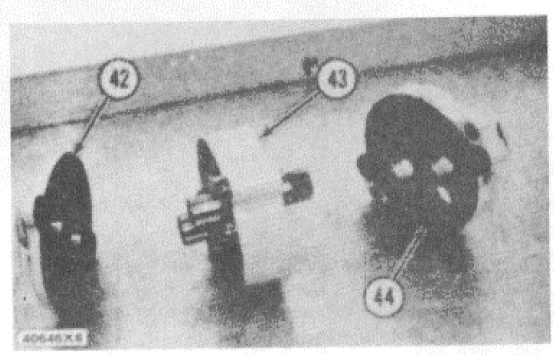


25. Install magnetic filter (37) into transfer gear housing. Install cover (39) and bolts (38).





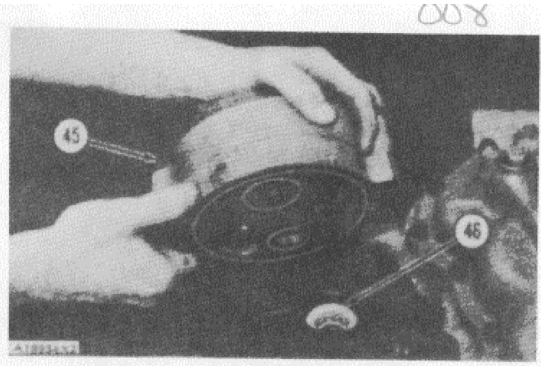
26. Install a new O-ring seal (40) on cover of filter screen (41). Install filter screen in transfer gear housing with four bolts.



27. Install bearings in scavenge pump covers. Assemble cover (42), body assembly (43) and cover (44). Install O-ring seals on bottom of pump.

TRANSFER GEARS

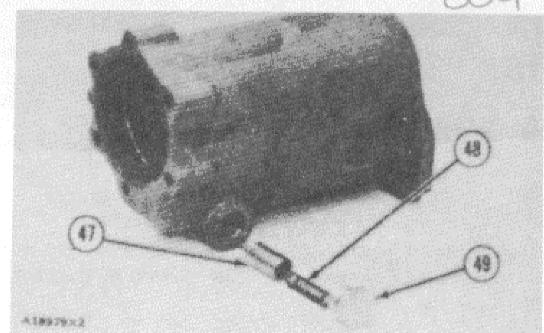
008



28. Install coupling (46) in manifold assembly. Install scavenge pump (45) on manifold assembly.

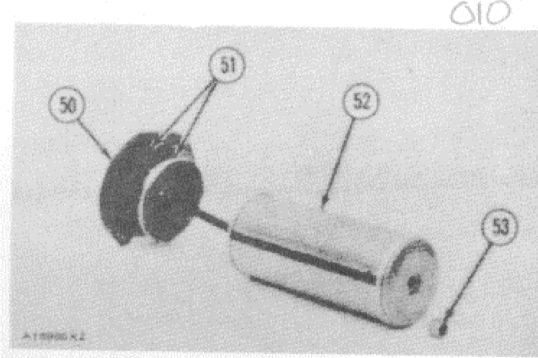
29. Install relief valve (47), spring (48) and plug (49) into transmission oil filter housing. Tighten plug to a torque of 35 ± 5 lb. ft. (47.5 ± 6.8 N•m).

009



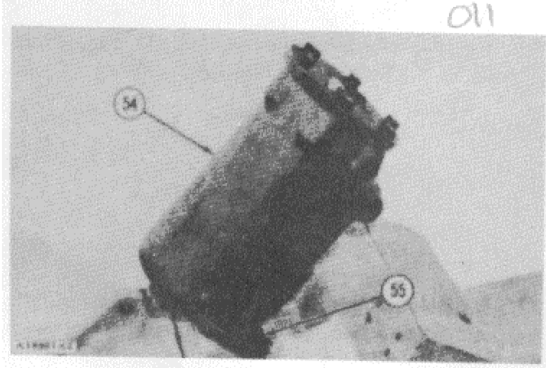
30. Install a new O-ring seal (51) on filter cover (50). Install filter element (52) on cover with nut (53). Tighten the nut to a torque of 120 ± 24 lb. in. (13.6 2.7 N.m). Install filter element assembly in transmission oil filter housing.

010



31. Put transmission oil filter housing (54) on the transfer gear housing and install the four bolts (55) that hold it.

011

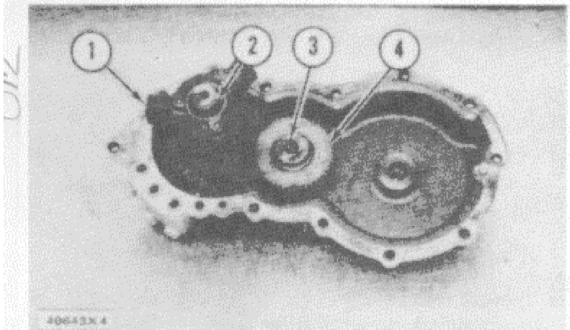


end by:

a) connection of transfer gears to transmission
b) install transfer gears, transmission and differential as a unit.

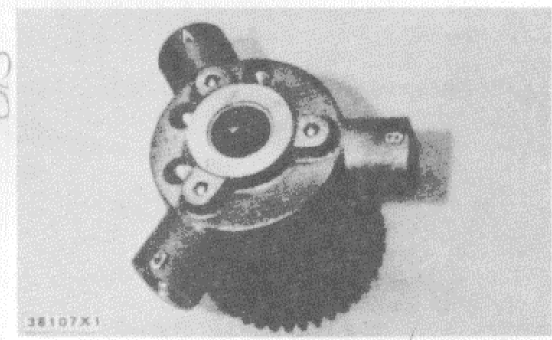
TRANSMISSION GOVERNOR

DISASSEMBLE TRANSMISSION GOVERNOR

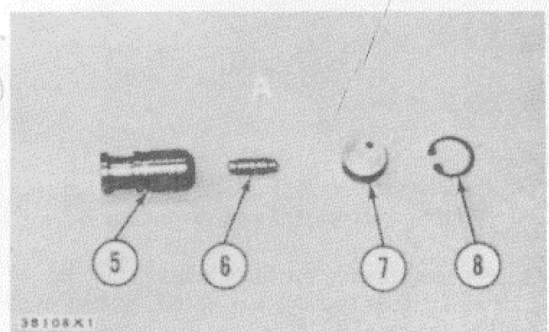


start by:
a) disassemble transfer gears

NOTE: See DISASSEMBLE AND ASSEMBLE OF TRANSMISSION TRANSFER GEARS for REMOVAL AND INSTALLATION of TRANSMISSION GOVERNOR.

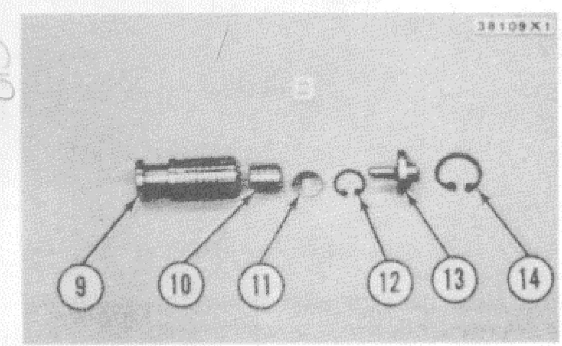


1. Remove bolt (3) that holds idler gear (4). Remove O-ring seal (2) from governor shaft and remove governor (1).



2. Disassemble governor valve bodies according to letters A, B and C.

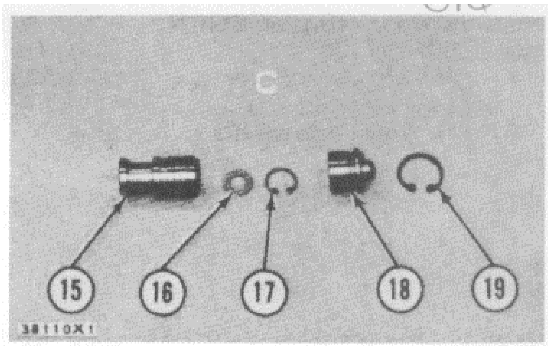
3. Remove retaining ring (8), stop (7), slug (6) and spool (5) from valve body A.



4. Remove retaining ring (14), stop (13), retaining ring (12), spacer (11), slug (10) and spool (9) from valve body B.

TRANSMISSION GOVERNOR

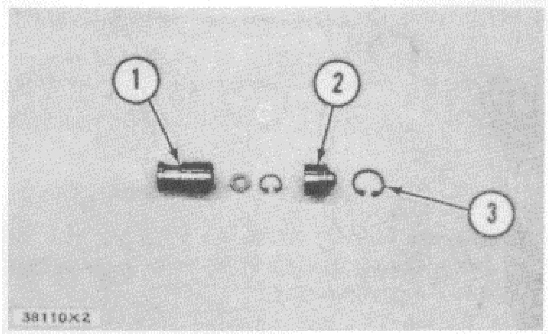
5. Remove retaining ring (19), stop (18), ring (17), . spacer (16) and spool (15) from valve body C.



017

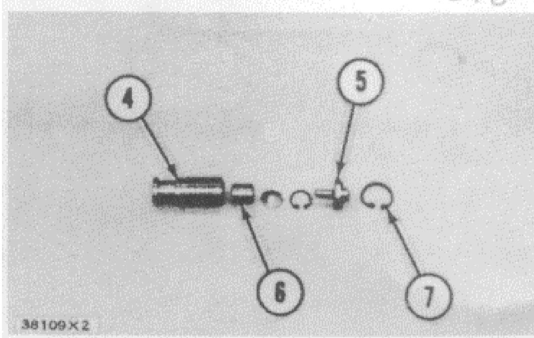
ASSEMBLE TRANSMISSION GOVERNOR

1. Install spool (1), spacer, ring, stop (2) and ring (3) into valve body C.



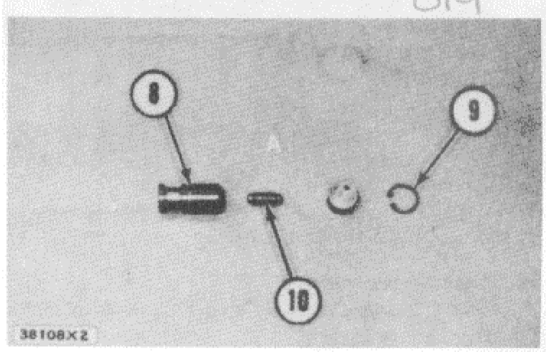
018

2. Install spool (4), slug (6), spacer, ring, stop (5) and retaining ring (7) into valve body B.

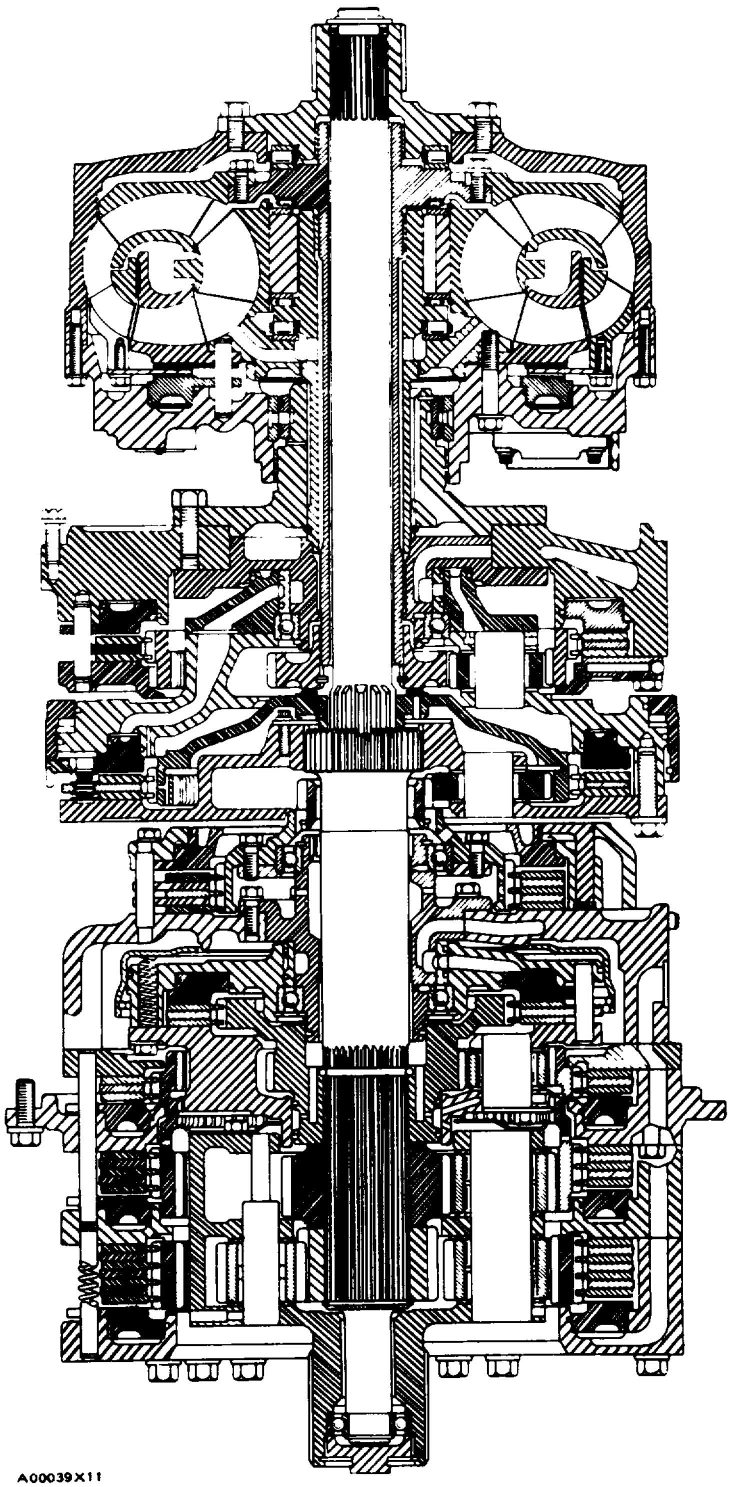


019

3. Install spool (8), slug (10), stop and ring (9) into body A.



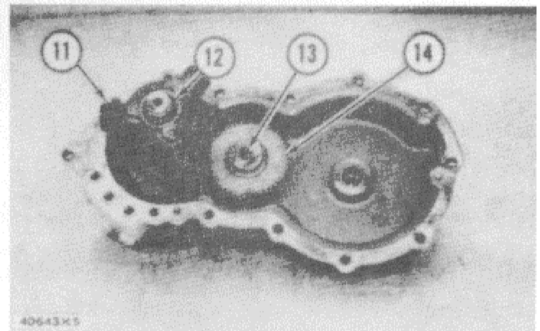
TRANSMISSION



TRANSMISSION GOVERNOR, TRANSMISSION

4. Put governor (11) on shaft and install O-ring seal (12) on shaft. Install idler gear (14) and bolt (13).

   end by:
   a) assemble transfer gears

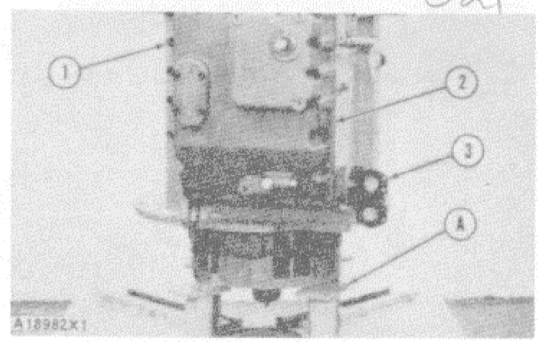


021

DISASSEMBLE TRANSMISSION

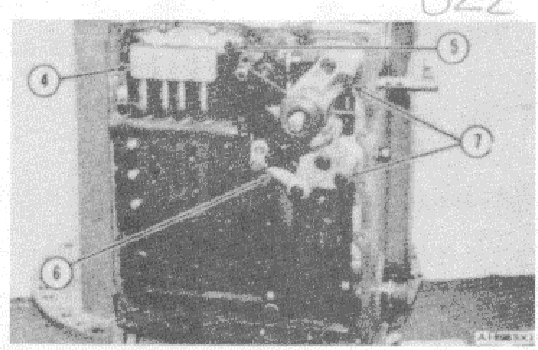
	Tools Needed	A	B	C
1P2420	Transmission Stand	1		
FT833	Clamp		1	
1P529	Handle			1
1P524	Drive Plate			1
1P503	Drive Plate			1

start by:
a) remove transfer gears, transmission and differential as a unit.
b) separation of transfer gears from transmission.



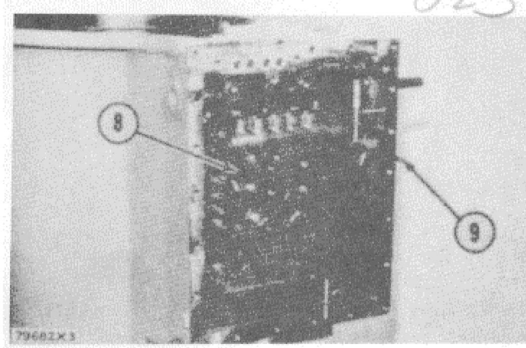
022

1. Install transmission on tool (A). Remove twenty bolts (1) and cover (2). Remove hose junction (3).



023

2. Remove bolts (7) and remove control valve linkage (6).

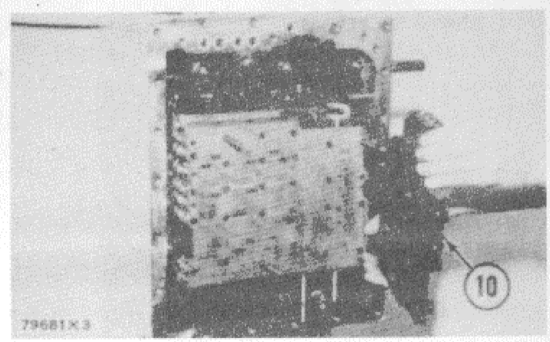


3. Remove bolts (5) and remove oil manifold (4).

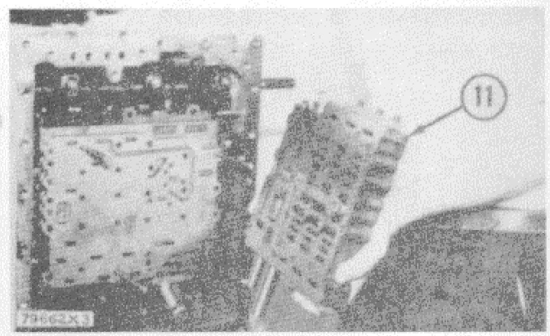
4. Install three 5116"-18 NC guide pins (9)6 1/2 in. long and remove the remainder of bolts (8) from governor cutoff valve.

TRANSMISSION

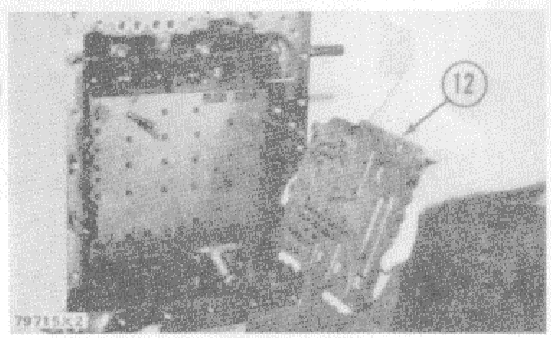
5. Remove governor cutoff valve (10).



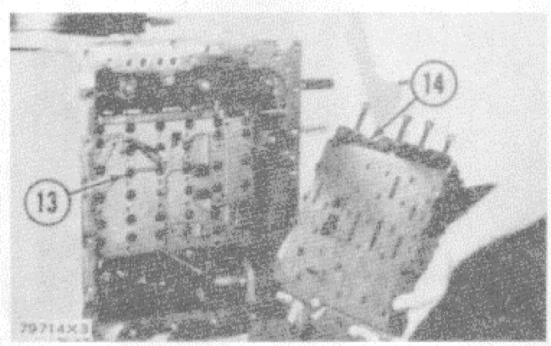
6. Remove automatic selector valve group (11).



7. Remove spacer plate (12).

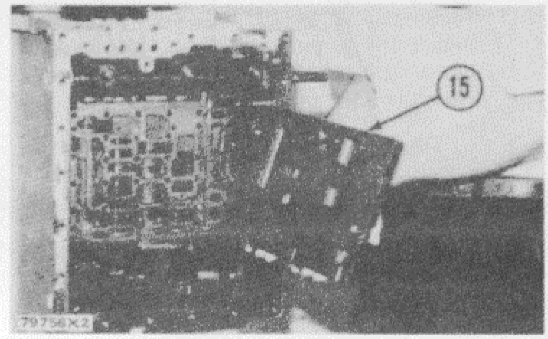


8. Remove shift pressure control valve (14). Remove bolts (13).



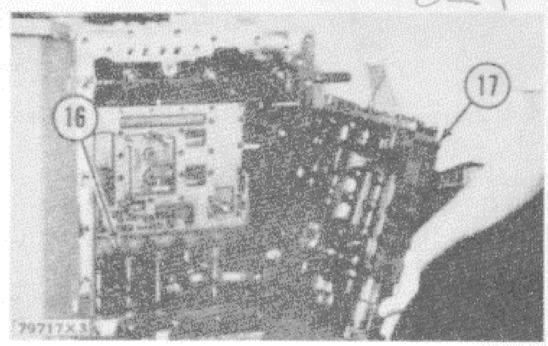
TRANSMISSION

9. Remove spacer plate (15).



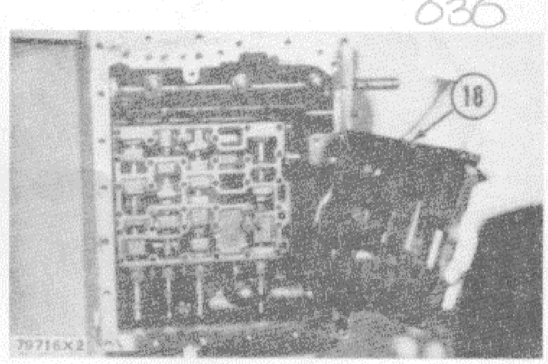
029

10. Remove pressure control valve group (17). Remove six bolts (16).



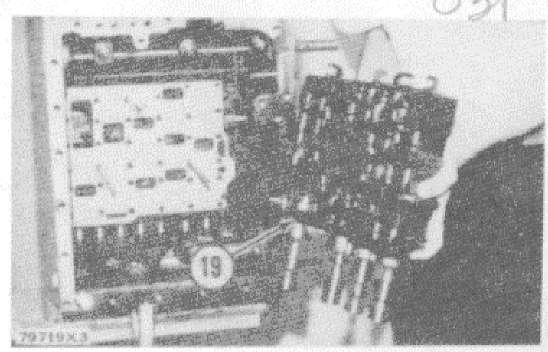
030

11. Remove manifold (18).



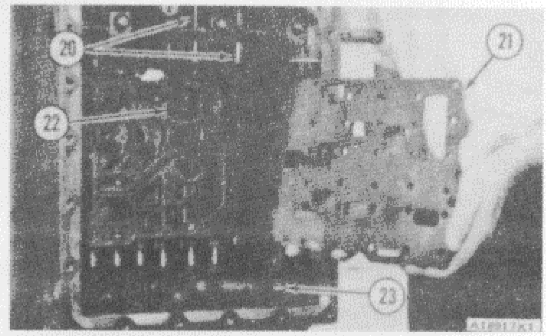
031

12. Remove selector valve group (19).



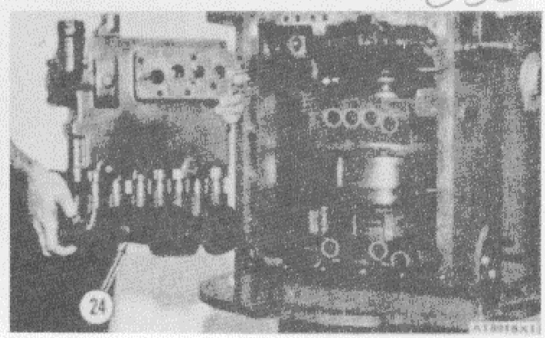
TRANSMISSION

13. Remove spacerplate (21). Remove clips from oil tubes (20) and remove oil tubes. Pull oil tube (23) out from side of housing. Remove all bolts (22) from the oil manifolds.



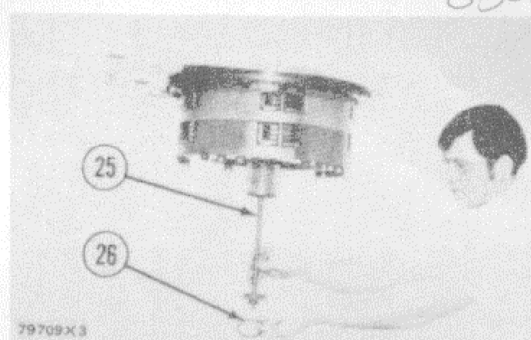
033

14. Remove oil manifolds (24) as a unit from housing.



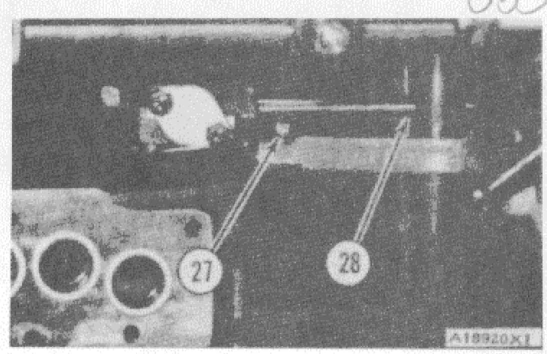
034

15. Install two 1/2"-13 NC forged eyebolts. Remove bolts that hold transmission to stand. Fasten a hoist and lift transmission. Remove snap ring (26) and remove governor drive shaft (25) from the bottom.



035

16. Install transmission back on stand and remove eleven bolts (27) from top of case. Pull oil tube (28) out from side of housing.

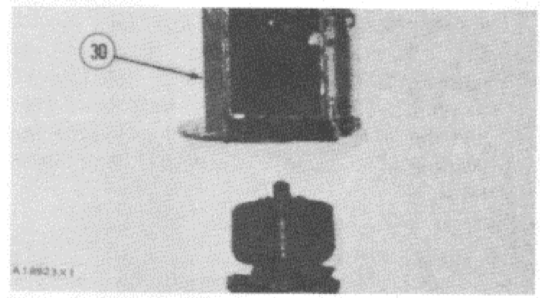


TRANSMISSION

17. Remove eighteen bolts (29) from bottom of transmission case.

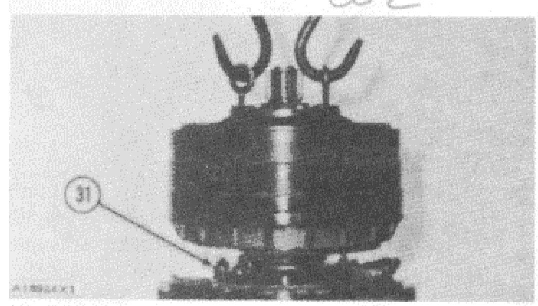
001

18. Fasten a hoist and remove transmission case (30) from the clutch assemblies.



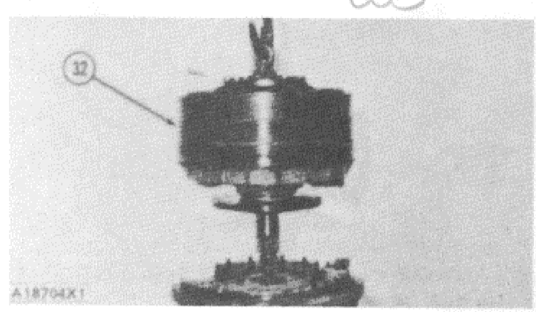
002

19. Install two 1/2"-13 NC forged eyebolts in torque converter. Install a hoist and remove nine nuts (31) that hold torque converter to the No. 1 clutch assembly.



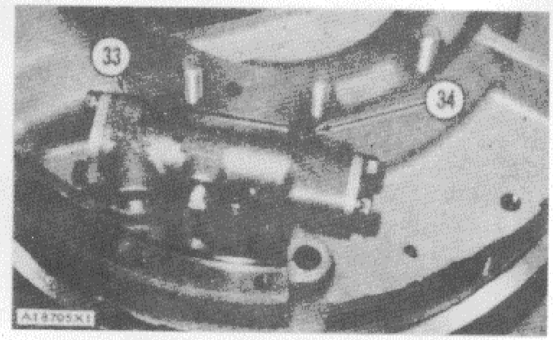
003

20. Remove torque converter (32) from No. 1 clutch assembly. Weight of torque converter is 300 lb. (136 kg).

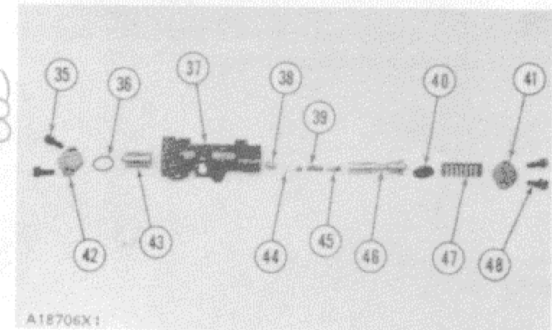


TRANSMISSION

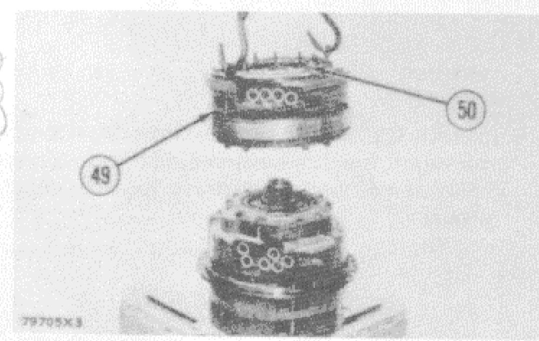
21. Remove reducing valve (33) for No. 1 clutch assembly after three bolts (34) are removed.



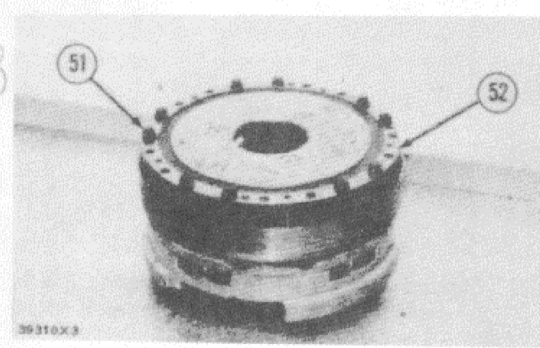
22. Remove two bolts (48), end plate (41) from valve housing (37). Remove spring (47) and four spacers (40). Remove spool assembly (46). Remove slug (38), ring (44), retainer spring (39) and plunger (45) from spool assembly (46). Remove two bolts (35), end plate (42) from other end of housing (37). Remove O-ring seal (36) from housing (37). Remove piston (43) from housing (37).



23. Install two nuts (50) on torque converter mounting studs and install 3/8"16 NC forged eyebolts. Fasten a hoist and remove No. 1 and No. 2 clutch assemblies (49). Weight is 350 lb. (159 kg).

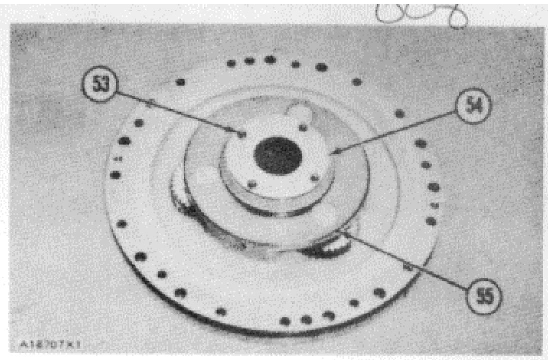


24. Remove bolts (51) and plate (52) from No. 2 clutch housing.



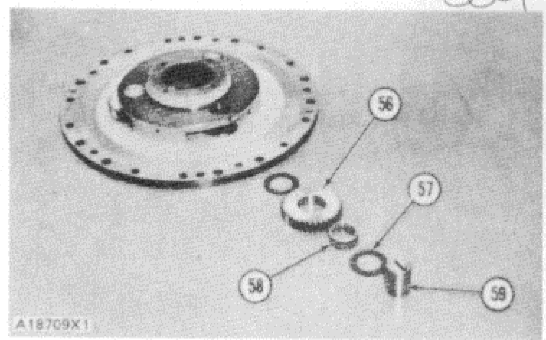
TRANSMISSION

25. Remove bolts (53) and cover (54) from No. 2 planet carrier. Push pins (55) into center of No. 2 planet gear shafts with a hammer and punch.



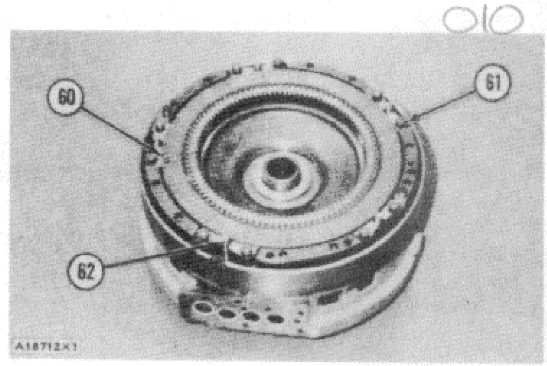
009

26. Push shafts (59) out of the planet gears and remove gears (56), thrust washers (57) and bearings (58).



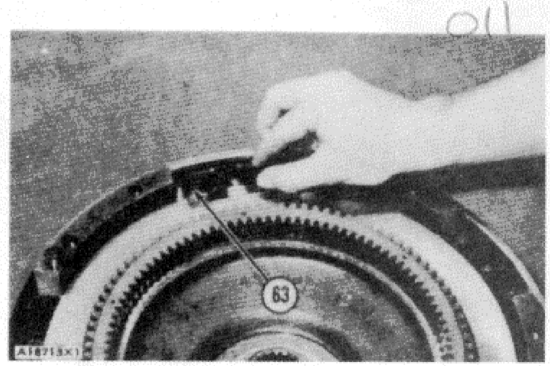
010

27. Remove springs (61), pins (62), discs and plates (60).



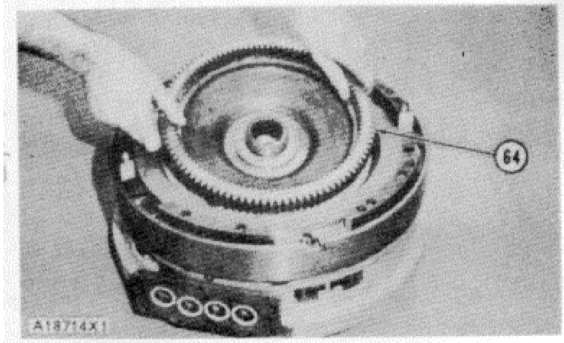
011

28. Remove No. 2 piston retaining clips (63).

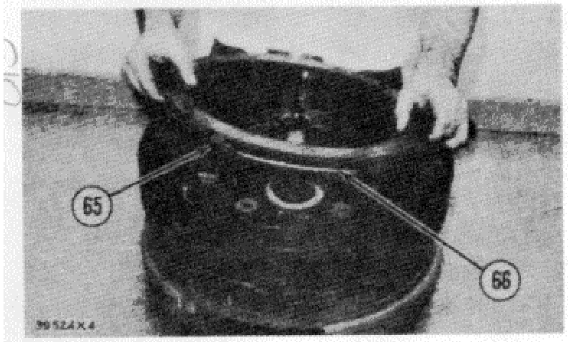


TRANSMISSION

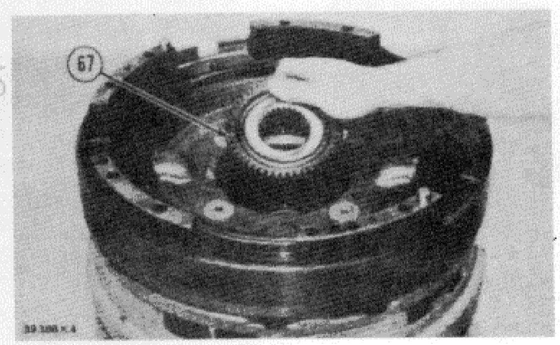
29. Remove No. 2 clutch ring gear (64).



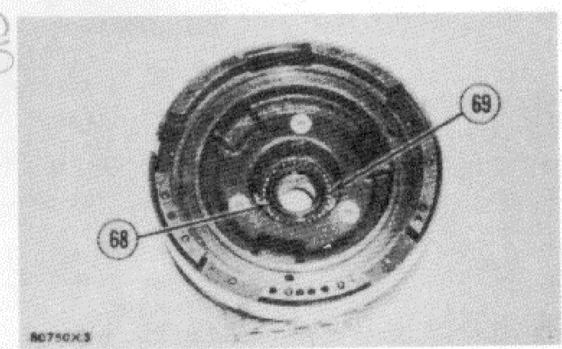
30. Remove No. 2 clutch piston (65). Remove and inspect seal ring (66). Make a replacement if necessary.



31. Remove No. 1 sun gear (67).

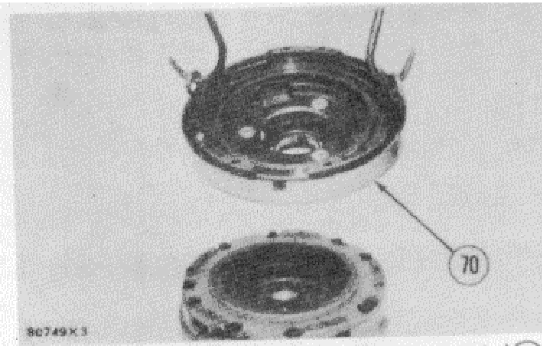


32. Remove snap ring (68) that holds bearing (69).



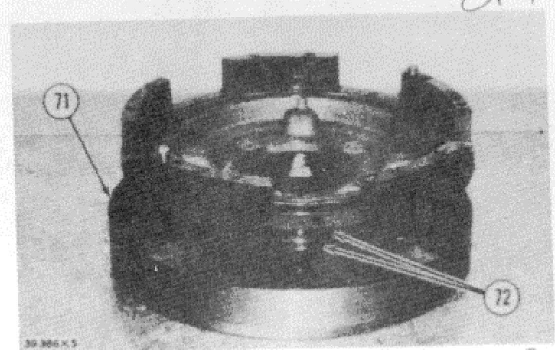
TRANSMISSION

33. Install two 1/2"-13 NC forged eyebolts. Fasten a hoist and remove No. 2 clutch housing and No. 1 carrier (70) as a unit.



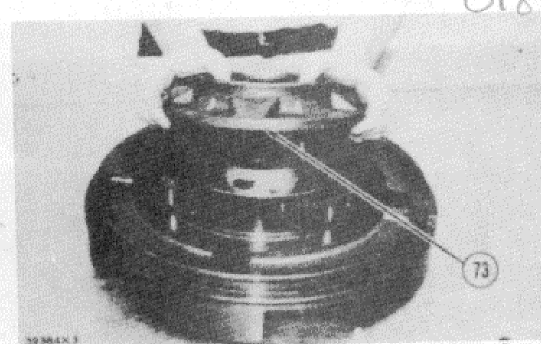
017

34. Remove balance piston (71). Remove and inspect seal rings (72). Make replacements if necessary.



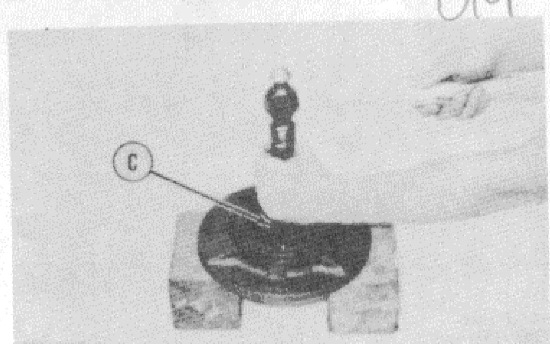
018

35. Turn housing over and make a mark of the position of oil manifold on carrier. Remove bolts and locks from manifold. Remove manifold (73) with two 3/8"-16 NC forcing screws.



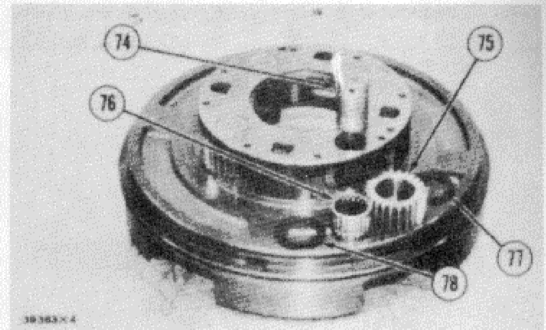
019

36. Remove bearing from manifold with tooling (C).

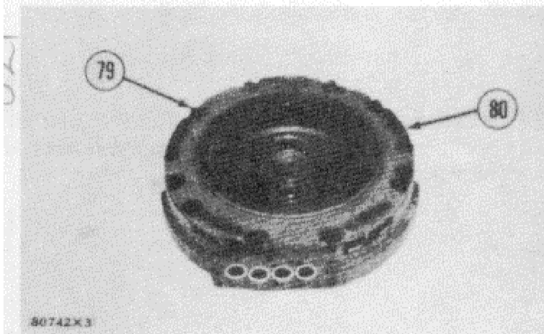


TRANSMISSION

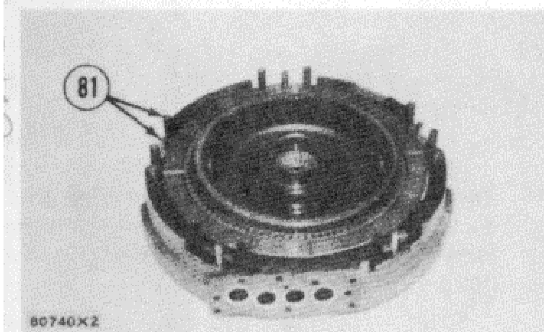
37. Push pins into center of planet gear shafts. Remove shafts (74), thrust washers (77) and (78), gears (75) and bearings (76).



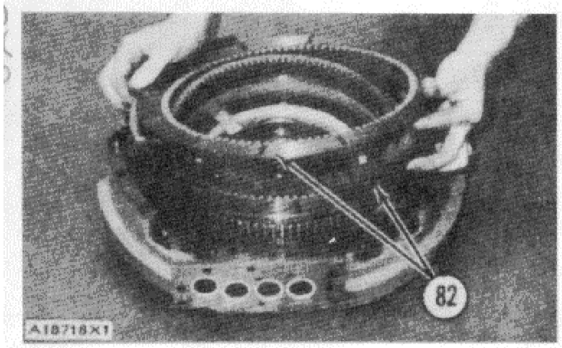
38. Remove bolts (79) and No. I clutch cover (80).



39. Remove springs and pins (81).

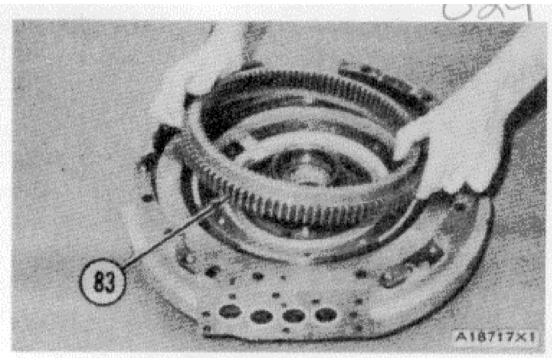


40. Remove No. 1 clutch discs and plates (82).



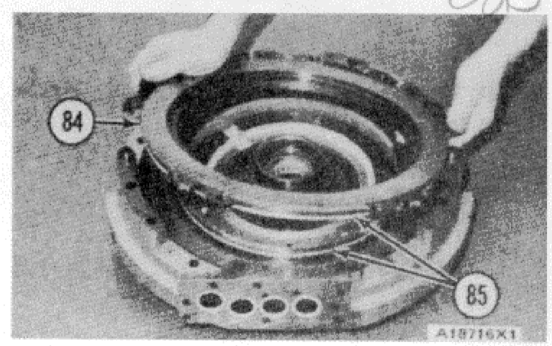
TRANSMISSION'

41. Remove No. 1 clutch ring gear (83).



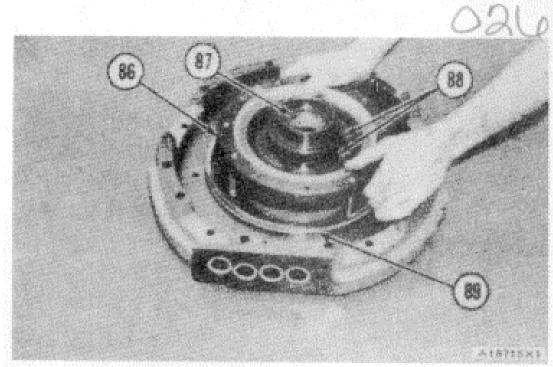
025

42. Remove No. 1 clutch piston (84). Remove and inspect seal rings (85). Make replacements if necessary.



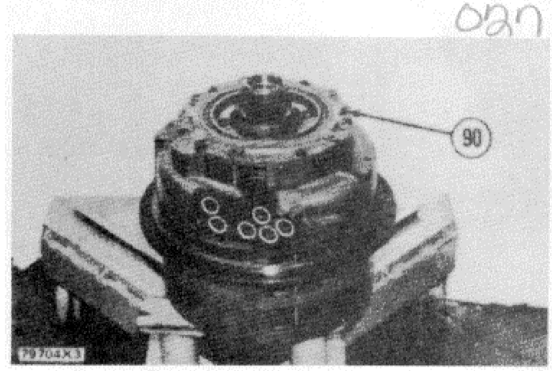
026

43. Remove two nuts from the manifold studs. Remove the center manifold (86). Remove two seal rings (88) and bearing (87) from center manifold. Remove and inspect seal ring (89). Make a replacement if necessary.



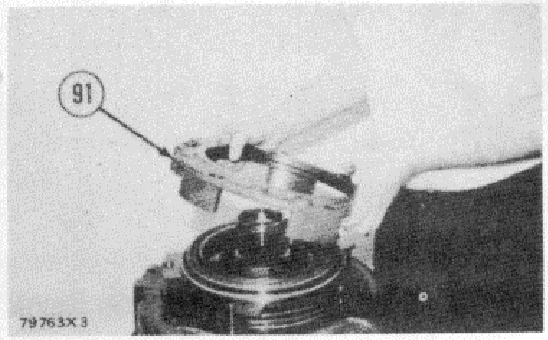
027

44. Remove bolts (90) from No. 3 clutch housing.

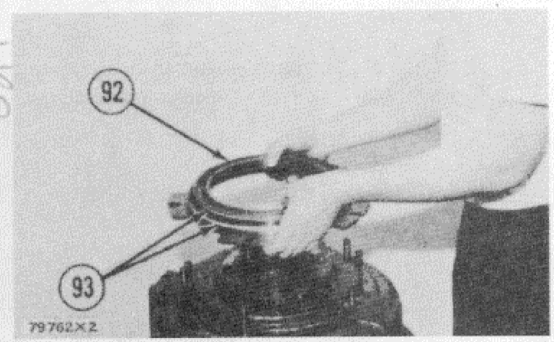


TRANSMISSION

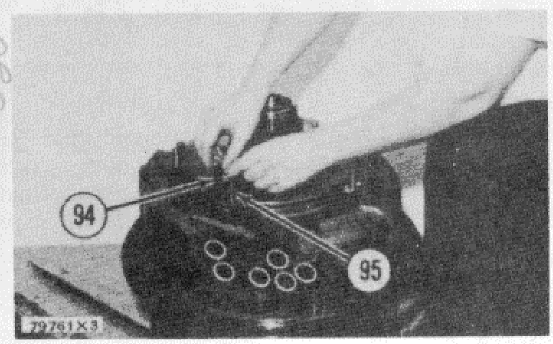
45. Remove No. 3 clutch housing (91).



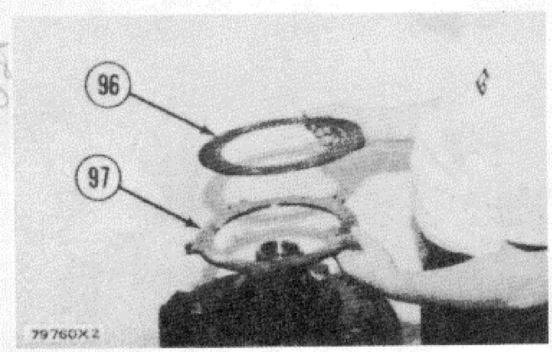
46. Remove No. 3 clutch piston (92). Remove and inspect seal rings (93).



47. Remove five pins (95) and five springs (94).

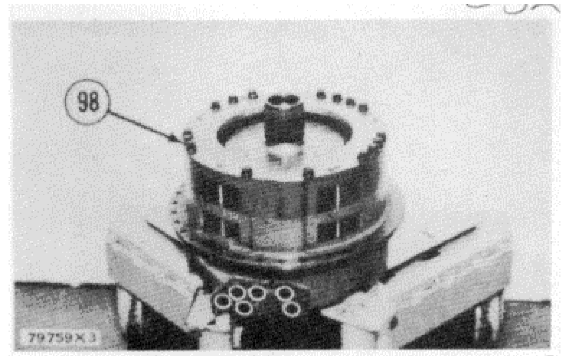


48. Remove No. 3 clutch discs (97) and clutch plates (96).



TRANSMISSION

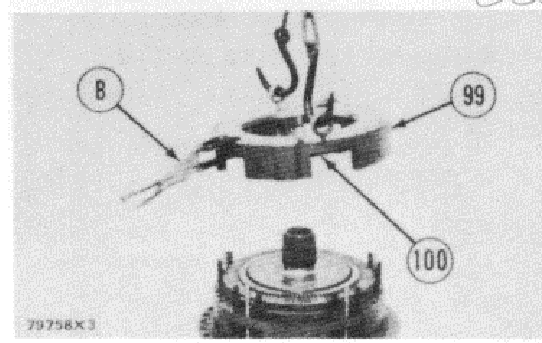
49. Fasten a hoist and put the transmission on the input end. Weight is 600 lb. (272 kg).



50. Remove clutch housing bolts (98).

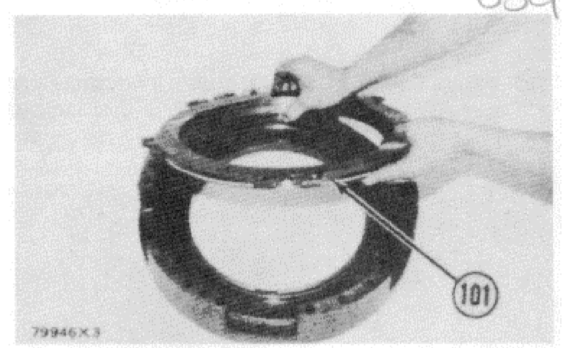
033

51. Fasten a hoist to the No. 7 clutch housing. Use tool (B) to keep piston (100) in position and remove clutch housing (99) and piston as a unit. Weight is 65 lb. (29 kg).



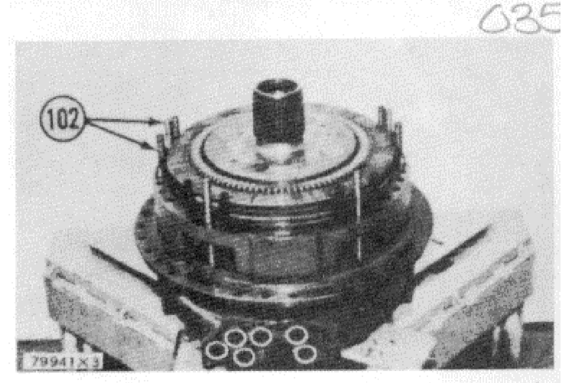
034

52. Remove No. 7 clutch piston and seal ring (101). Inspect and make a replacement of the seal ring if necessary.



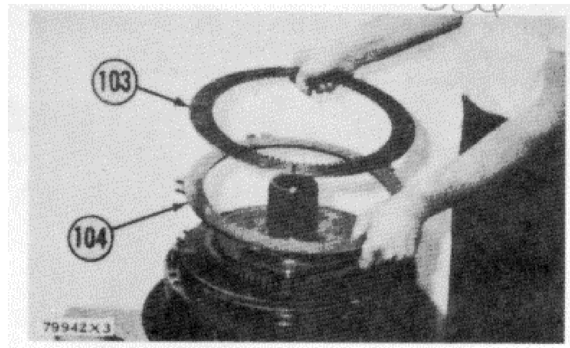
035

53. Remove pins and springs (102).

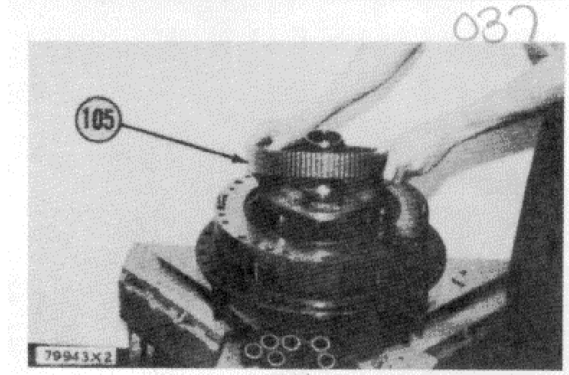


TRANSMISSION

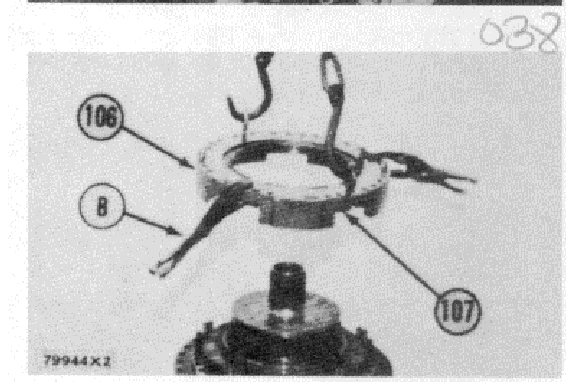
54. Remove No. 7 clutch discs (103) and plates (104).



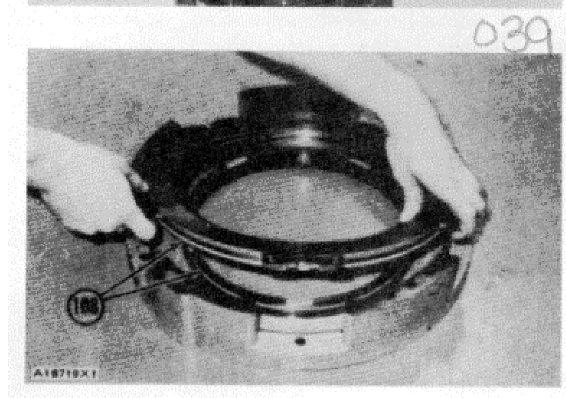
55. Remove No. 6 clutch ring gear (105).



56. Fasten a hoist to the No. 6 clutch housing. Use tool (B) to keep the piston (107) in position and remove clutch housing (106) and piston as a unit.

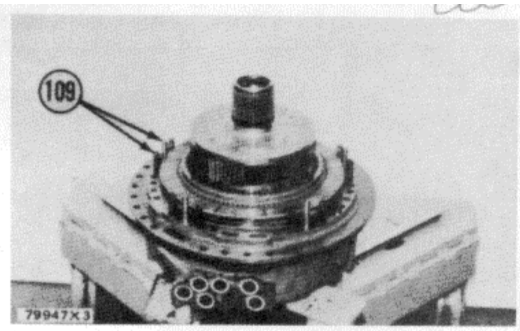


57. Remove No. 6 clutch piston and seal rings (108). Inspect and make a replacement of the seal rings if necessary.



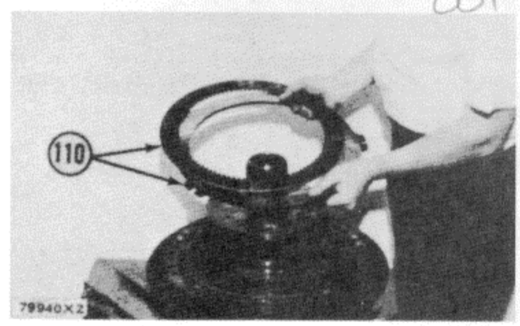
TRANSMISSION

58. Remove No. 6 clutch pins and springs (109).



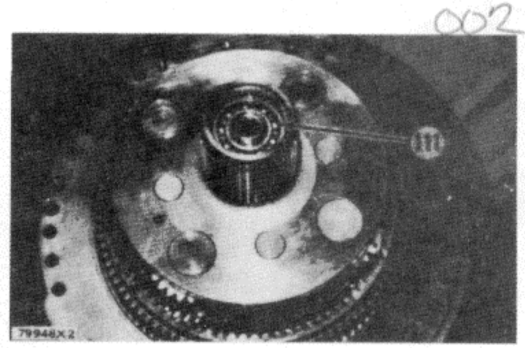
001

59. Remove No. 6 clutch discs and plates (110).



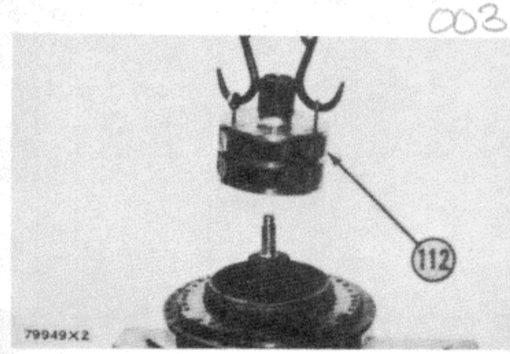
002

60. Remove snap ring (111) from top of No. 6 and No. 7 clutch carrier assembly.



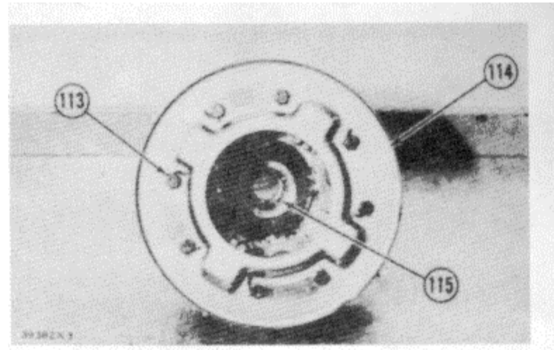
003

61. Install 3/8"-16 NC forged eyebolts. Fasten a hoist and remove No. 6 and No. 7 clutch carrier assembly (112). Weight is 75 lb. (34 kg).

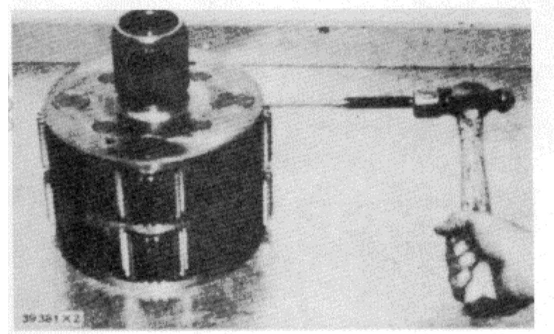


TRANSMISSION

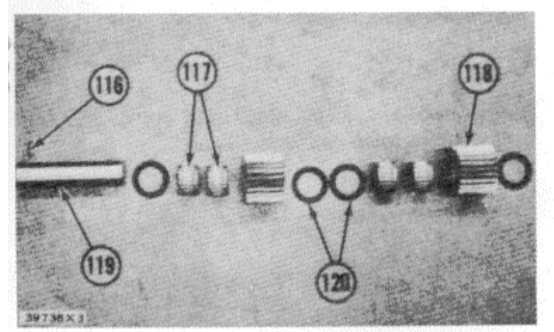
62. Remove cover (114) from carrier after bolts (113) and locks are removed. Remove bearing (115).



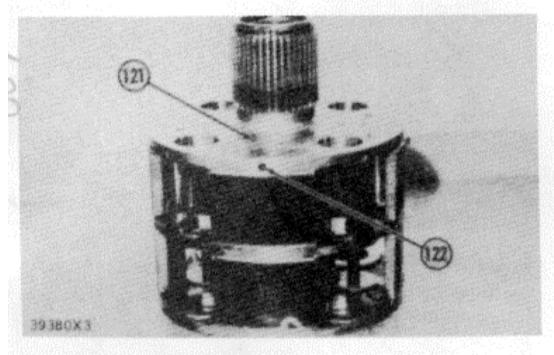
63. Push pins into shafts with a hammer and punch.



64. Push shafts out of carrier and remove gears (118), thrust washers (120) and bearing (117). After removal of shafts, remove pins (116) from shafts (119).

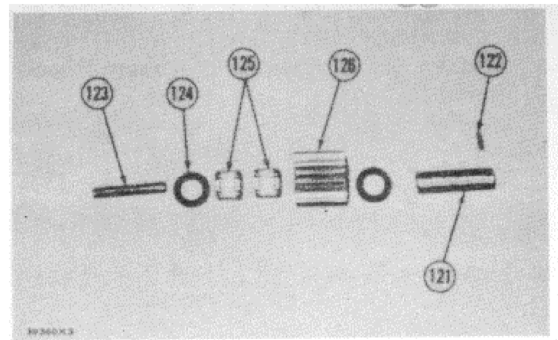


65. Push pins (122) into inner planet shafts (121) and push shafts from carrier.



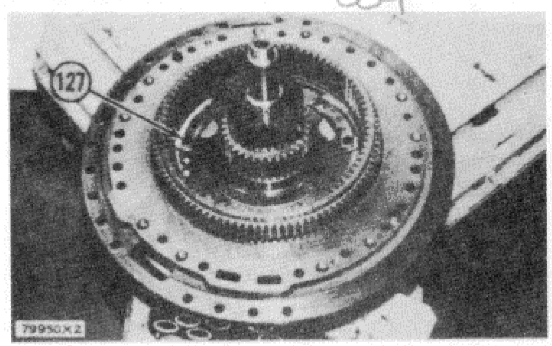
TRANSMISSION

66. Remove pins (122), thrust washers (124), bearings (125), gears (126) and tubes (123) from shafts (121).



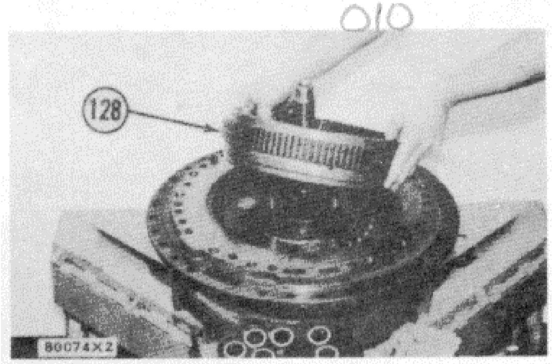
009

67. Remove six bolts (127) and remove locks from the No. 6 clutch ring gear.



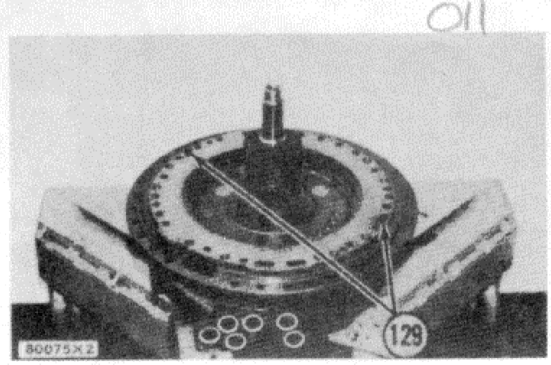
010

68. Remove No. 6 clutch ring gear (128).



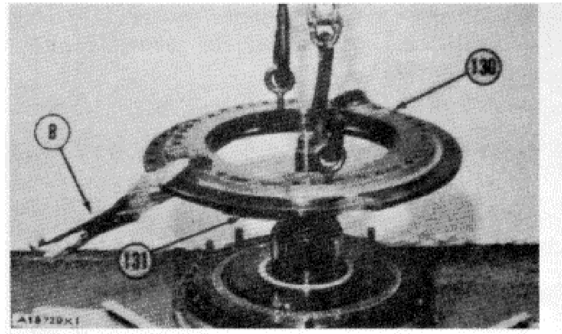
011

69. Remove two bolts (129) from the No. 5 clutch housing.

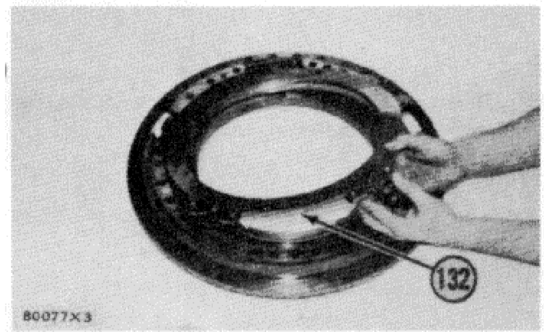


TRANSMISSION

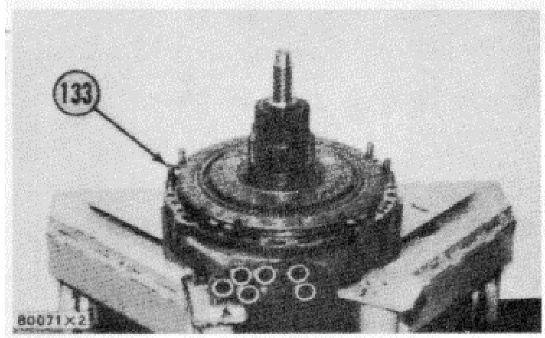
70. Fasten a hoist to the No. 5 clutch piston housing (130). Use tool (B) to keep piston (131) in position and remove piston and clutch assembly as a unit.



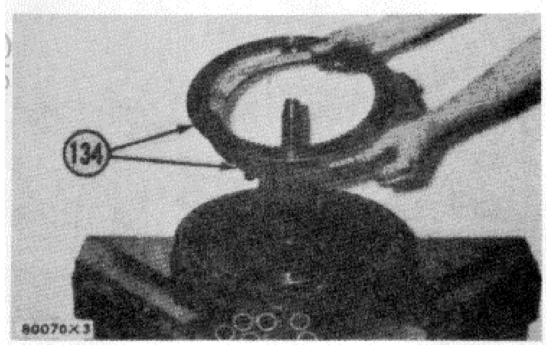
71. Remove No. 5 piston and seal ring (132) from the clutch housing. Inspect and make a replacement of the seal if necessary.



72. Remove No. 5 clutch springs (133).

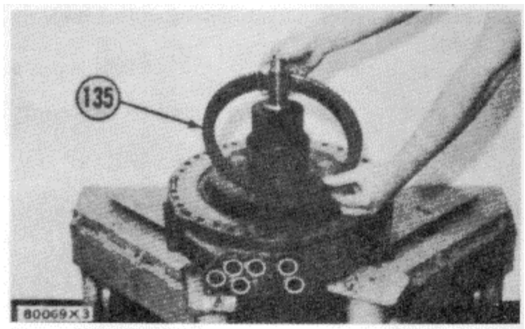


73. Remove No. 5 clutch discs and plates (134).



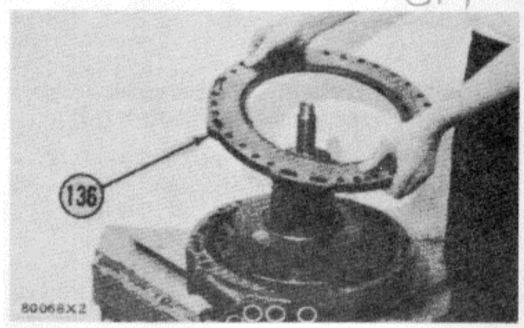
TRANSMISSION

74. Remove No. 5 clutch ring gear (135).



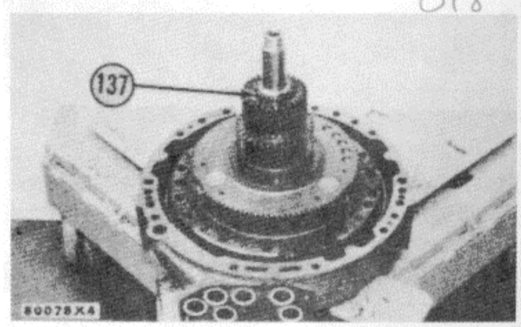
017

75. Remove No. 5 clutch plate (136).



018

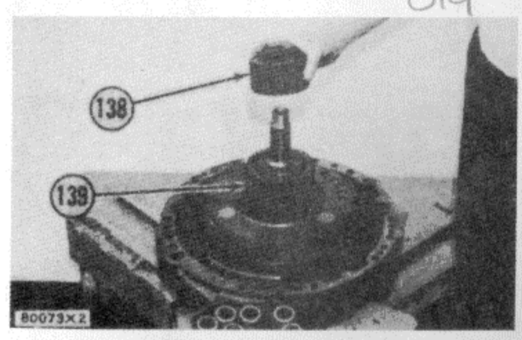
76. Remove snap ring (137) from No. 6 and No. 7 sun gears.



019

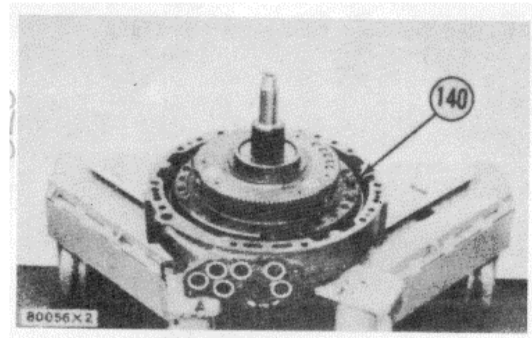
77. Remove No. 7 sun gear (138).

78. Remove No. 6 sun gear (139).

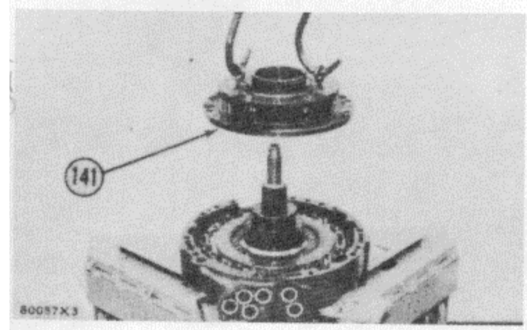


TRANSMISSION

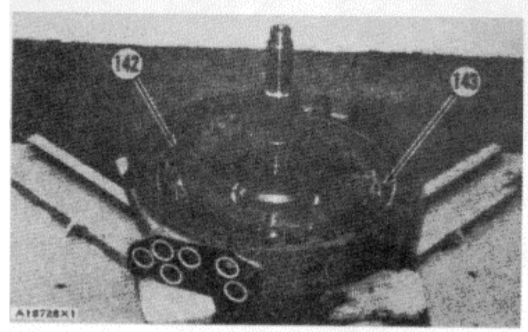
79. Remove No. 4 clutch retaining bolts (140).



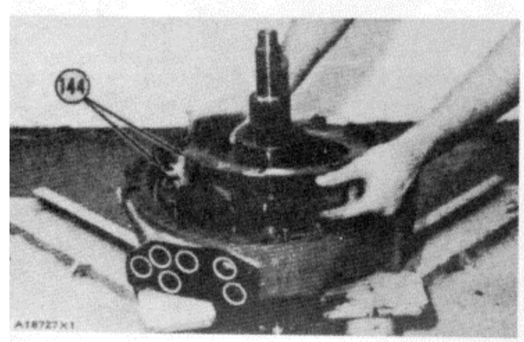
80. Install two 3/8"-16 NC forged eyebolts. Fasten a hoist and remove the No. 5 carrier (141).



81. Remove No. 4 clutch springs (142) and pins (143).



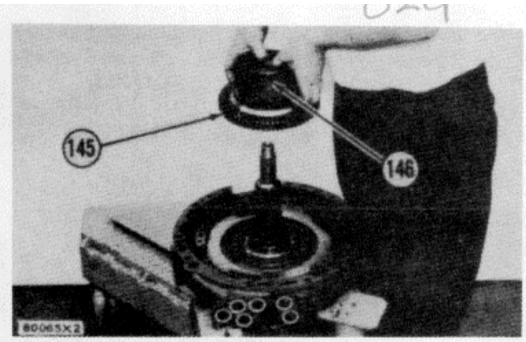
82. Remove No. 4 clutch discs and plates (144).



TRANSMISSION

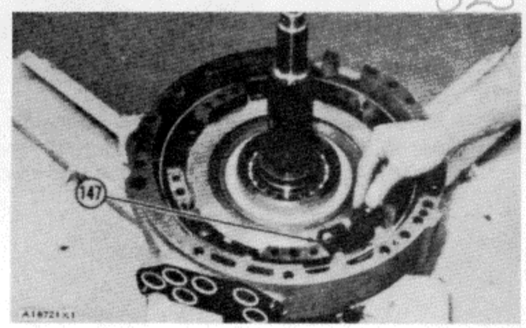
83. Remove No. 4 clutch gear and No. 5 sun gear (145). Remove and inspect seal rings (146). Make replacements if necessary.

024



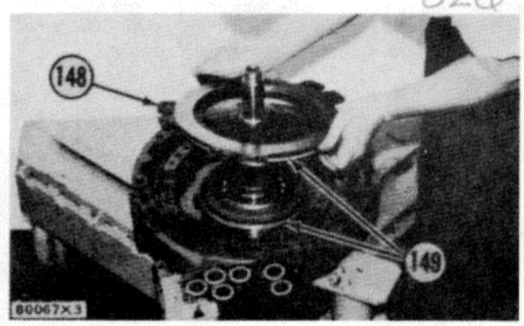
025

84. Remove No. 4 clutch piston retaining clips (147).



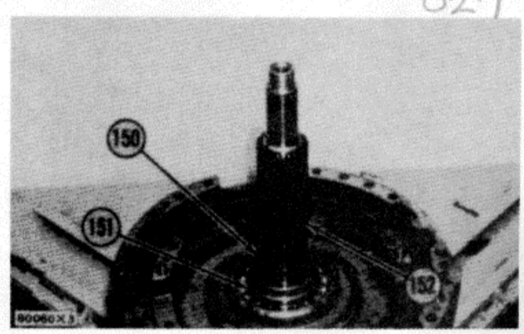
026

85. Remove No. 4 clutch piston (148). Remove seal rings. Inspect the seal rings and make replacements if necessary.



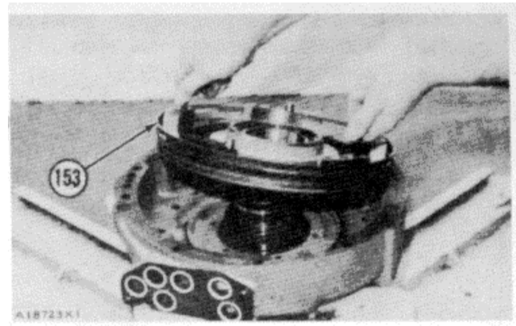
027

86. Remove piston ring seal and snap ring (151) that holds bearing. Remove snap ring (150) from shaft. Remove shaft (152).

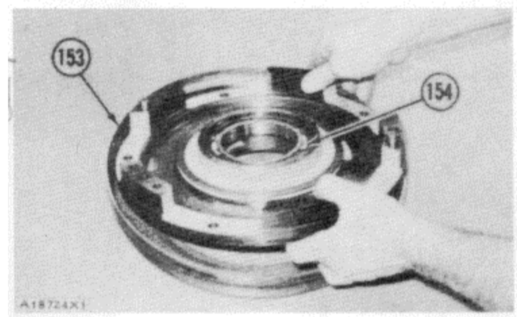


TRANSMISSION

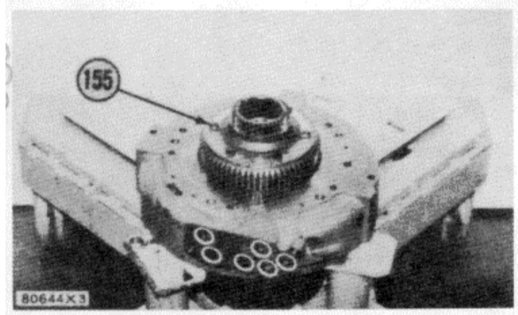
87. Install two 3/8"-16 NC x 4 in. long bolts in No. 4 clutch balance piston (153). Lift balance piston and clutch housing out as a unit.



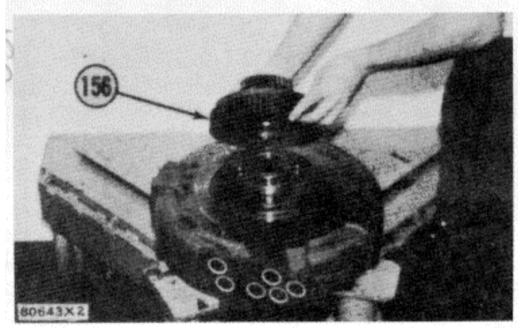
88. Remove balance piston (153) from housing. Remove bearing (154) from clutch housing. Remove and inspect seal ring from balance piston. Make a replacement if necessary.



89. Turn manifold over and remove the bolts (155) and locks that hold the No. 3 clutch gear.

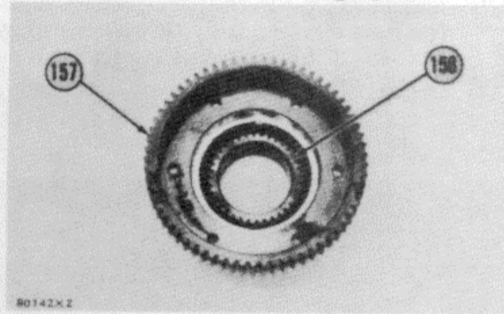


90. Remove No. 3 clutch gear (156).



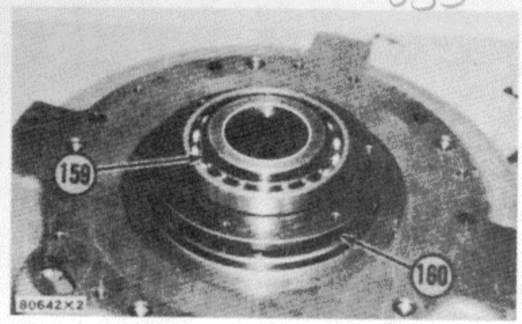
TRANSMISSION

91. Remove gear (157) from hub (158).



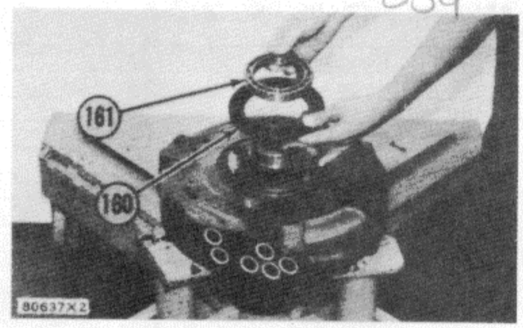
033

92. Remove snap ring (159) that holds bearing. Install two 3/8"-16 NC forcing screws in plate (160).



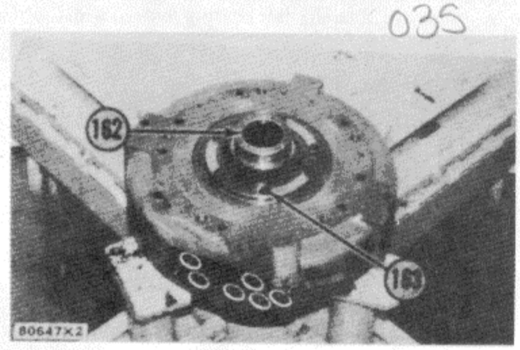
034

93. Remove bearing (161) and plate (160).



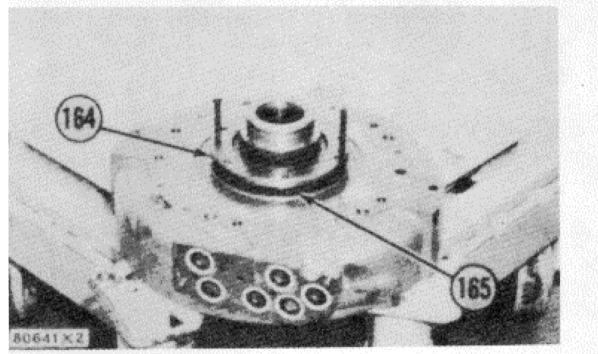
035

94. Remove shaft bearing (162), bolts (163) and locks.

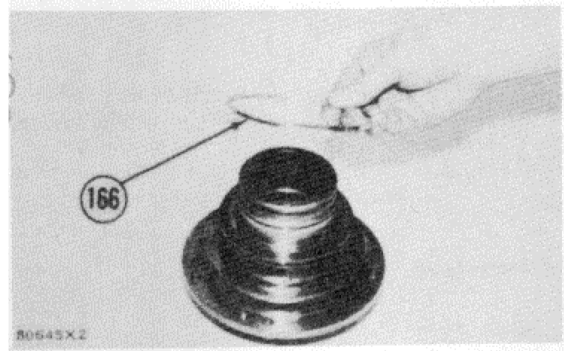


TRANSMISSION

95. Install two 3/8"-16 NC forcing screws in plate (164) and remove it from the shaft. Install two 3/8"-16 NC forcing screws in cage (165) and remove it from the manifold.



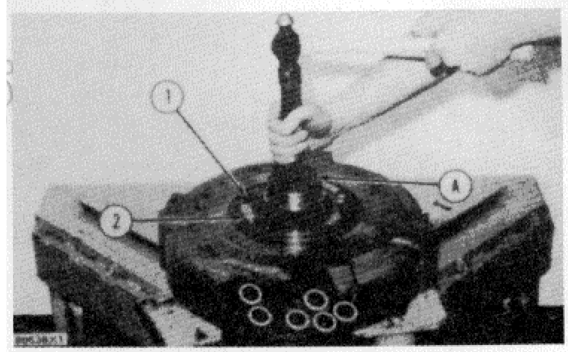
96. Remove and inspect seal rings (166).



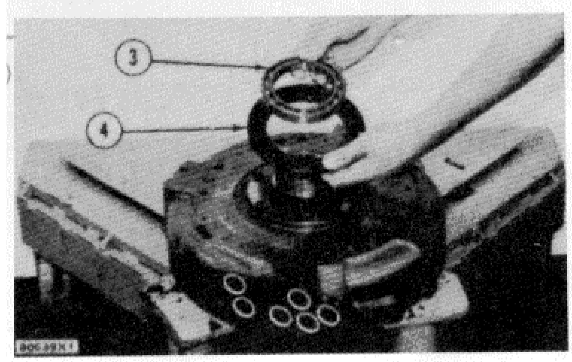
ASSEMBLE TRANSMISSION

	Tools Needed	A	B	C
1PS31	Hand	1		
1P487	Dive Plate	1		
1P493	Drive Plate	1		
FT833	Clamp		1	
1P529	Handle			1
1P524	Drive Plate			1
1P503	Drive Plate			1

1. Install seal rings on cage and install cage in the manifold. Install plate (2), bolts (1) and locks on the cage. Install shaft bearing in cage with tooling (A).

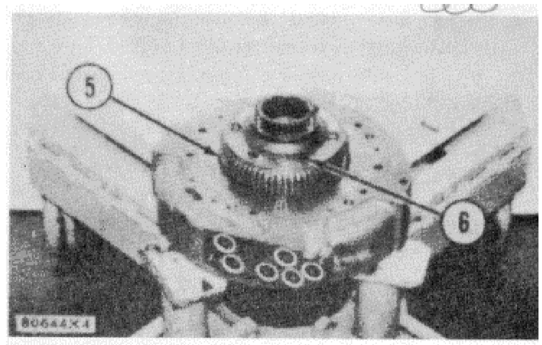


2. Install plate (4) and bearing (3). Install snap ring.



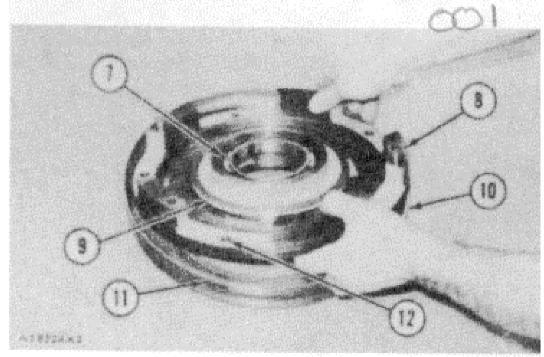
TRANSMISSION

3. Install gear in hub. Install No. 3 clutch gear (5) with bolts (6) and locks.



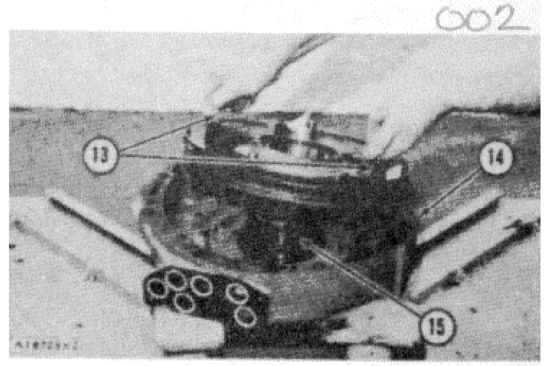
001

4. Install bearing (7) into No. 4 balance piston (8). Install seal ring (9) on piston. Install No. 4 balance piston (8) into housing (10). Put holes (12) in alignment with center of openings (slots) (11).



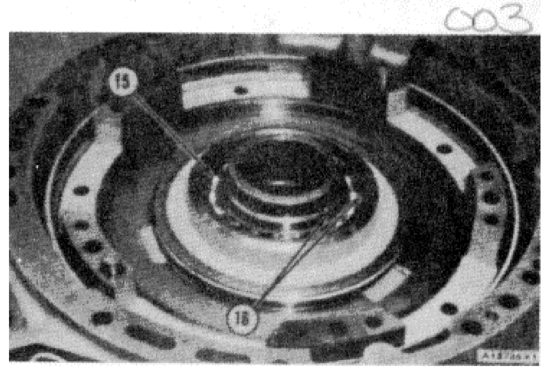
002

5. Install No. 4 balance piston (8) and housing (10) as a unit into manifold (14). Make sure opening (slot) in bearing is in alignment with ball bearing (15). Remove forcing screws (13).



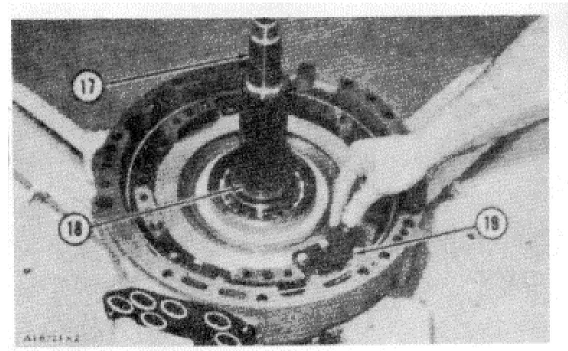
003

6. Install the snap rings (16) that hold bearing (15).

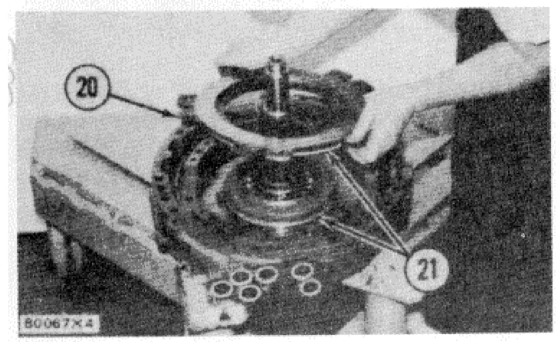


TRANSMISSION

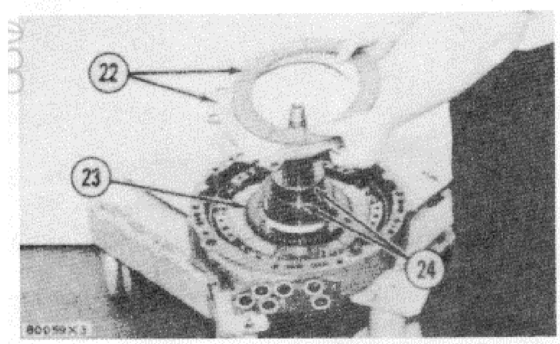
7. Install shaft (17) and the snap ring (18) that holds it. Install piston retaining clips (19).



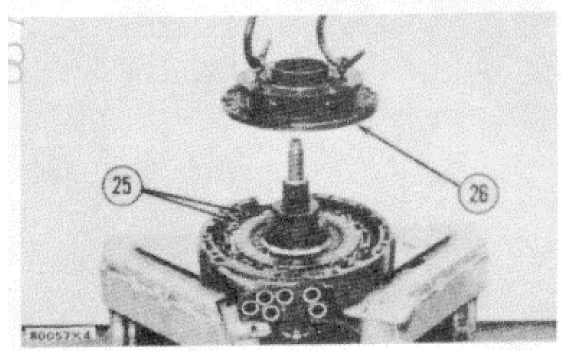
8. Install No. 4 clutch piston (20) and seal rings (21).



9. Install No. 4 clutch gear and No. 5 sun gear (23). Install seal rings (24). Install No. 4 clutch discs and plates (22).

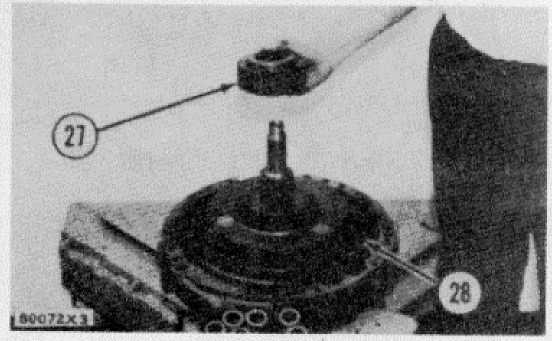


10. Install No. 4 clutch springs and pins (25). Install the No. 5 carrier (26).



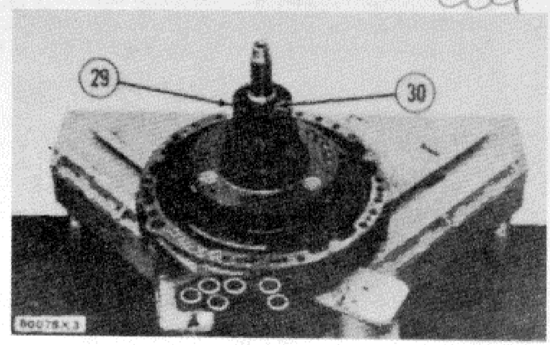
TRANSMISSION

11. Install No. 4 clutch retaining bolts (28). Install No. 6 sun gear (27).



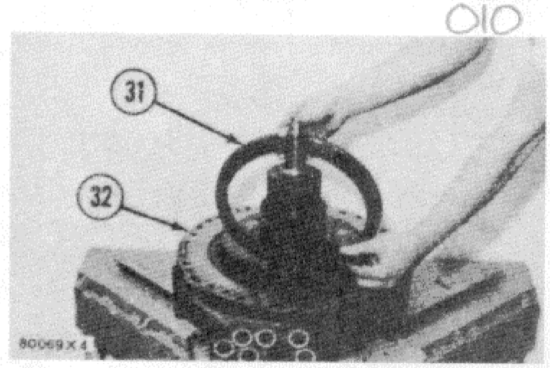
009

12. Install No. 7 sun gear (29). Lift the shaft enough to install the snap ring (30) that holds No. 6 and No. 7 sun gears.



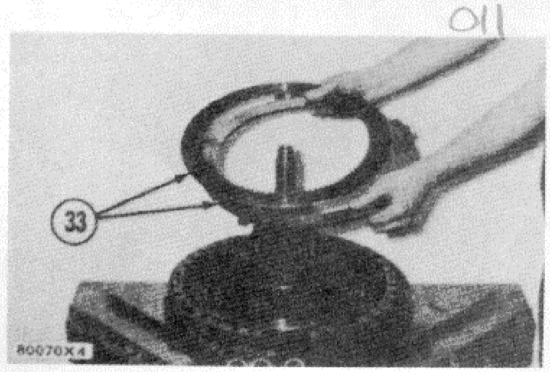
010

13. Install No. 5 clutch plate (32). Install No. 5 clutch ring gear (31).



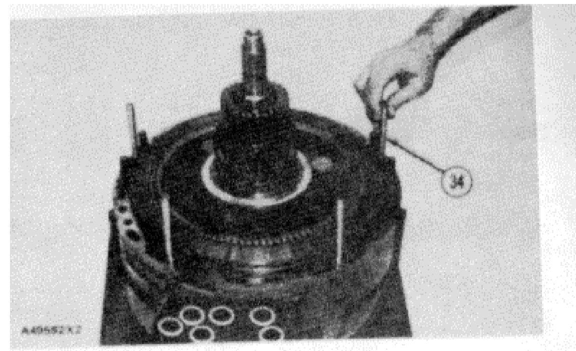
011

14. Install No. 5 clutch discs and plates (33).



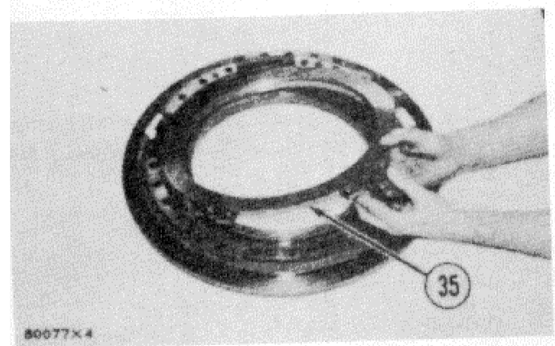
TRANSMISSION

15. Install springs and pins (34) in clutch plate.

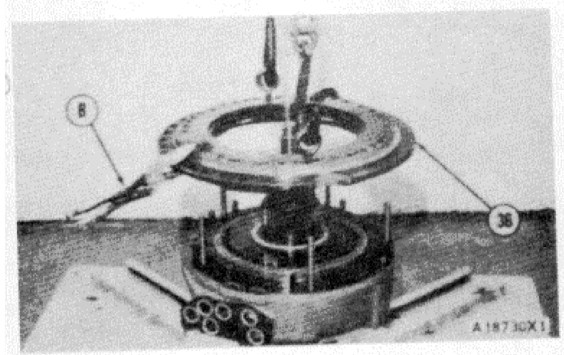


16. Install seal rings in No. 5 clutch piston (35) and No. 5 clutch housing (36). Install piston (35) into the housing.

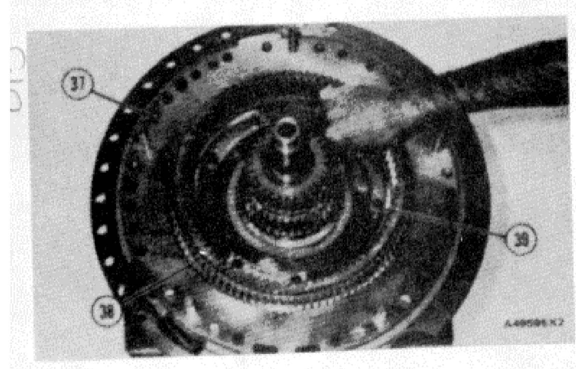
17. Install tool (B) on the housing to hold the piston in place. Fasten a hoist and put No. 5 clutch housing (36) in position on manifold.



18. Install two bolts (37) in the No. 5 clutch housing.

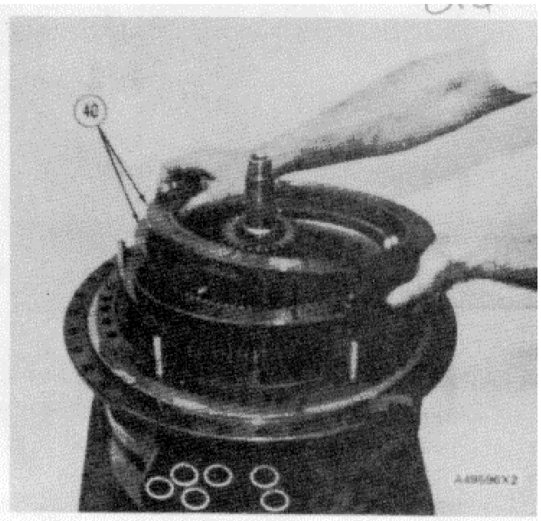


19. Install No. 6 clutch ring gear (38) with bolts (39) and locks.



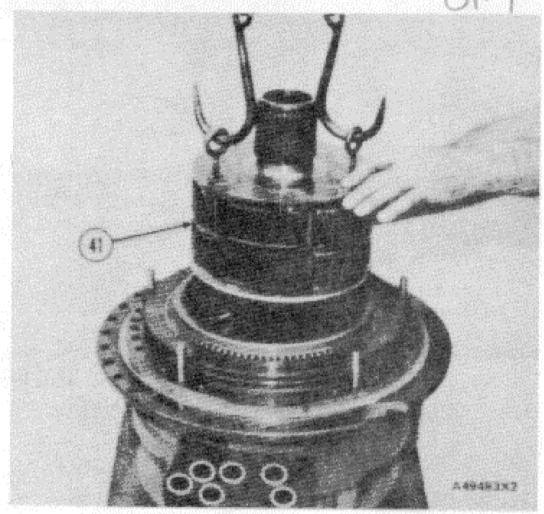
TRANSMISSION

20. Install No. 6 clutch discs and plate (40).



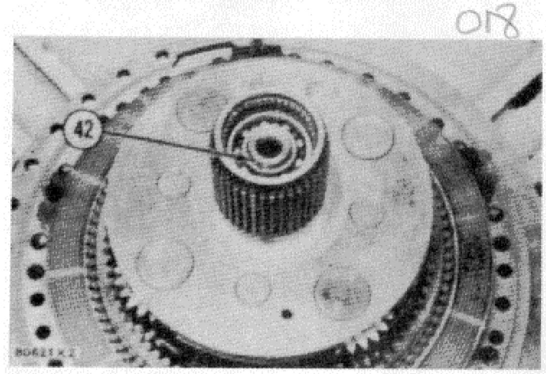
017

21. Assemble No. 6 and No. 7 carrier assembly. Fasten a hoist to No. 6 and No. 7 carrier assembly (41) and install it in the housing.



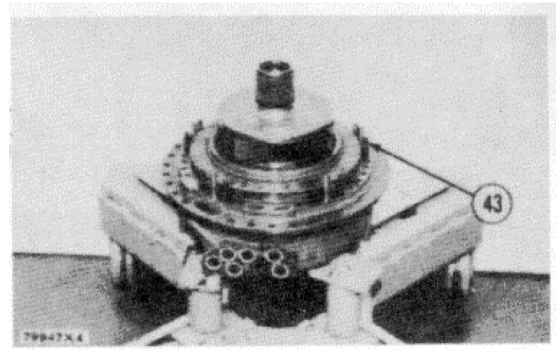
018

22. Install snap ring (42) that holds carrier bearing.

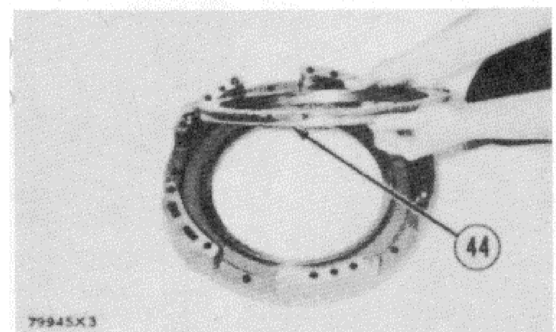


TRANSMISSION

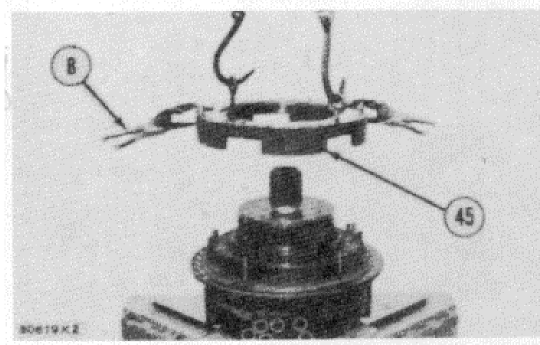
23. Install No. 6 clutch springs (43).



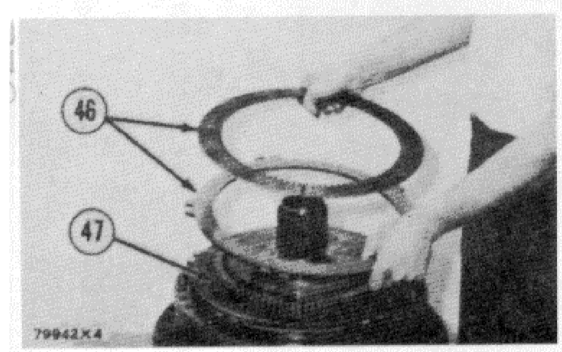
24. Install seal rings in No. 6 clutch piston (44) and No. 6 clutch housing (45). Install piston (44) into the housing.



25. Install tool (B) on the housing to hold the piston in place. Fasten a hoist and put No. 6 clutch housing (45) in position on the manifold.

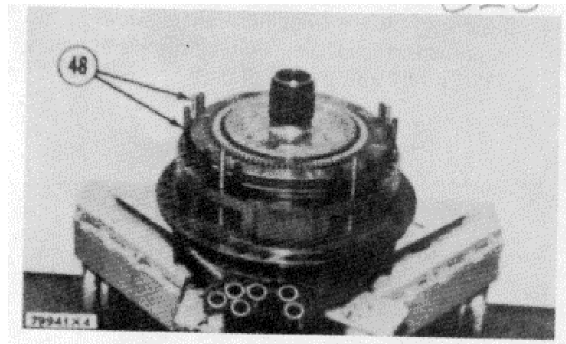


26. Install No. 6 clutch ring gear (47). Install No. 7 clutch discs and plates (46).



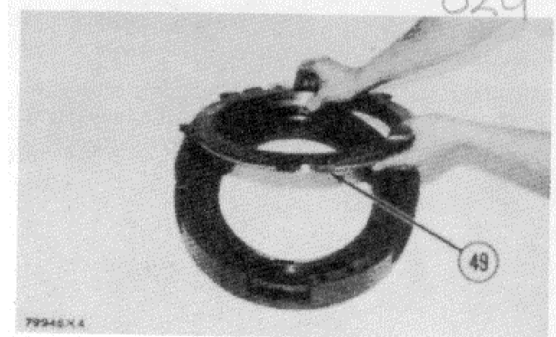
TRANSMISSION

27. Install pins and springs (48).



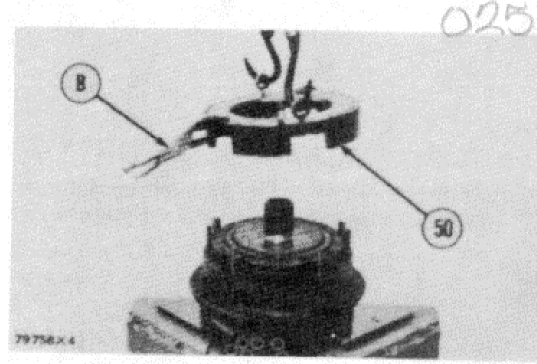
024

28. Install seal rings in No. 7 clutch piston (49) and No. 7 clutch housing (50). Install piston into the housing.



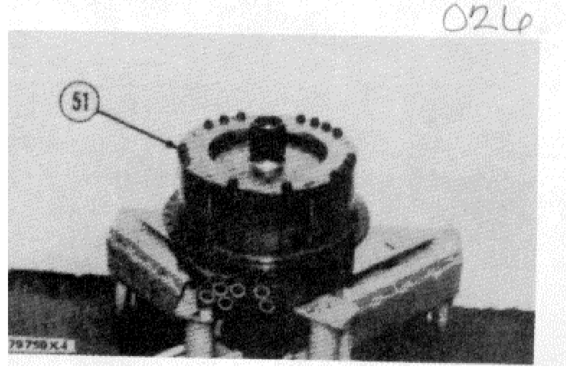
025

29. Install tool (B) on the housing to hold the piston in place. Fasten a hoist to No. 7 clutch housing (50) and put it in position on the housing.



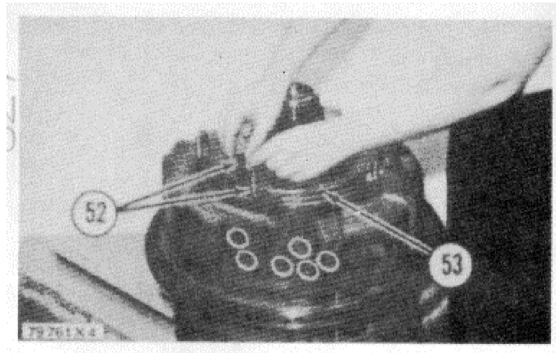
026

30. Install the clutch retaining bolts (51) and tighten them to a torque of 85 ± 5 lb. ft. (115.2 ± 6.8 N•m).

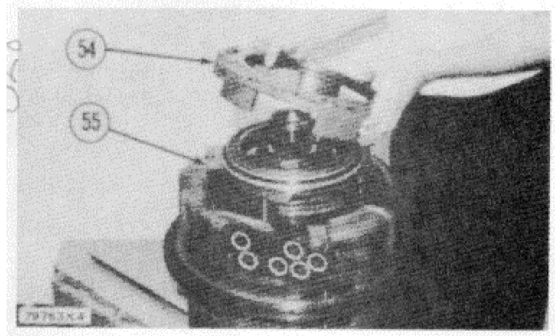


TRANSMISSION

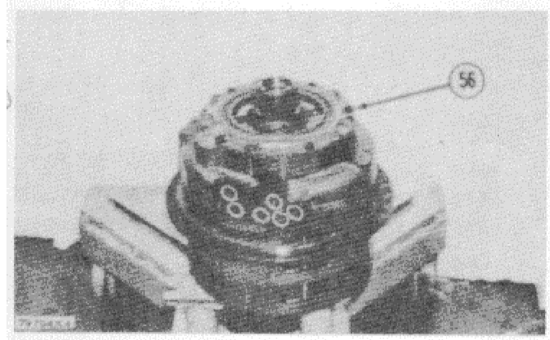
31. Fasten a hoist and put the transmission on the output end. Install No. 3 clutch discs and plates (53). Install springs and pins (52).



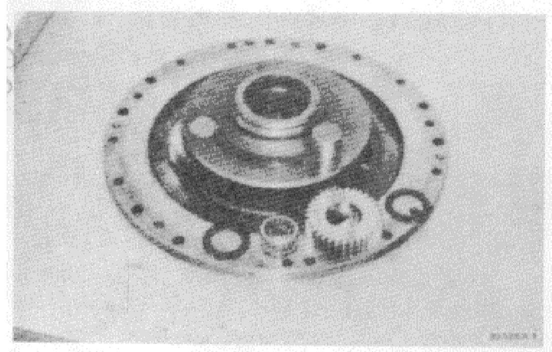
32. Install seal rings in No. 3 clutch piston (55). Install the piston on No. 3 clutch discs and plates. Install No. 3 clutch housing (54) on piston.



33. Install bolts (56) in No. 3 clutch housing and tighten to a torque of 36 ± 2 lb. ft. (48.8 ± 2.7 N•m).

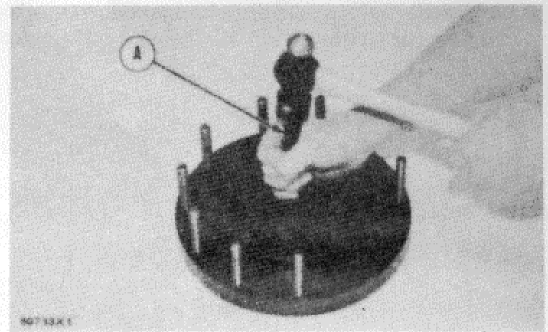


34. Install washers, bearings, gears, shafts and pins in the No. 2 carrier housing.



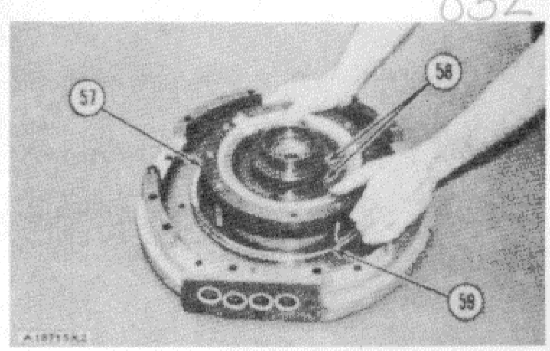
TRANSMISSION

35. Install bearing in center manifold with tooling (A). Install piston seal rings on manifold.



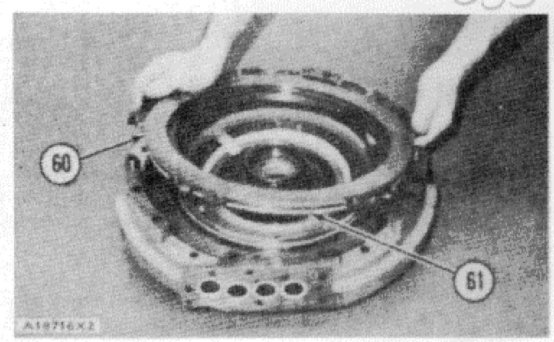
032

36. Install seal ring (59) in No. 1 clutch housing. Install two seal rings (58) in center manifold. Install center manifold (57) in No. 1 clutch housing.



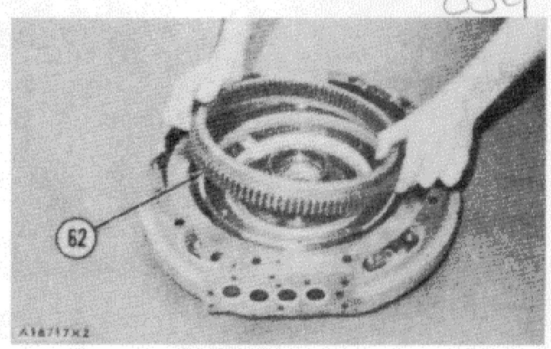
033

37. Install a new seal ring (61) in No. 1 clutch piston. Install No. 1 clutch piston (60) in housing.



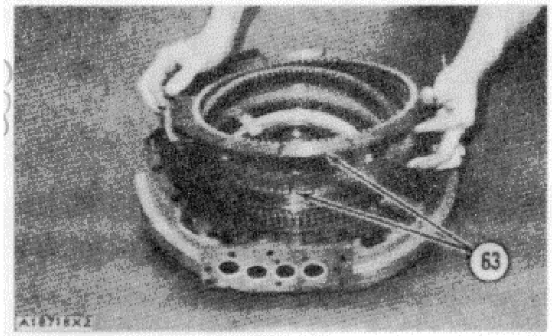
034

38. Install No. 1 clutch ring gear (62).

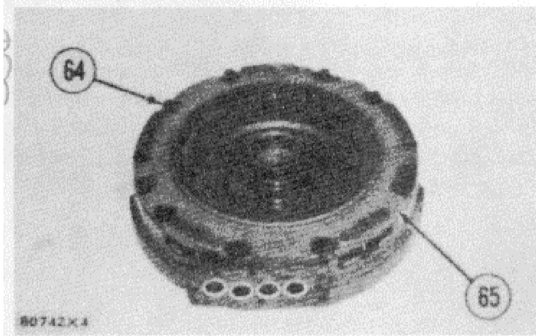


TRANSMISSION

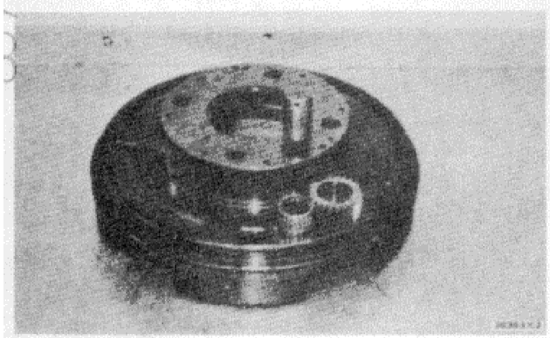
39. Install No. 1 clutch discs and plates (63). Install pins and springs.



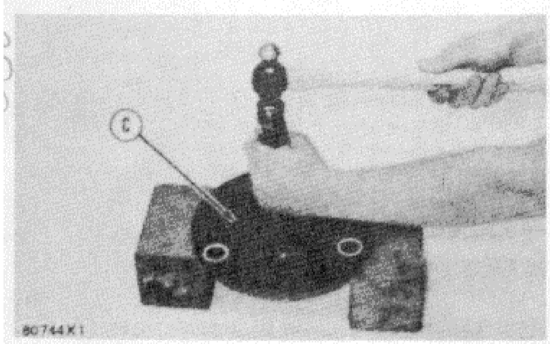
40. Install No. 1 clutch cover plate (65) and retaining bolts (64). Tighten bolts to a torque of 85 ±5 lb. ft. (115.2 ±6.8 N•m).



41. Install washers, bearings, gears, shaft and pins in the No. 1 carrier. Make pins even with housing.

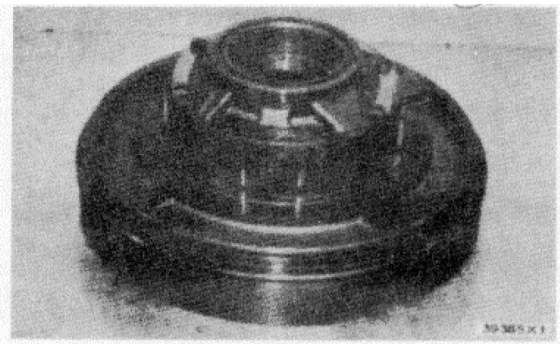


42. Install bearing in manifold with tooling.



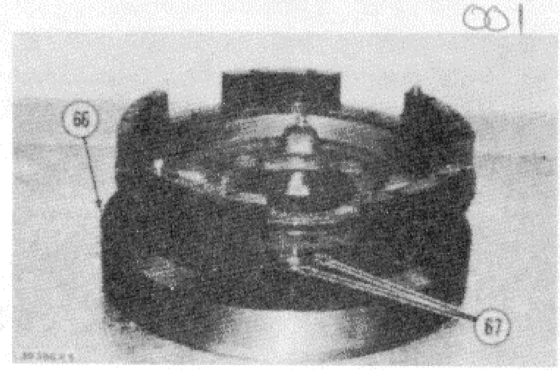
TRANSMISSION

43. Install manifold on carrier while an alignment with mark on carrier is made. Install locks and bolts on the manifold and install the carrier on the No. 2 clutch.



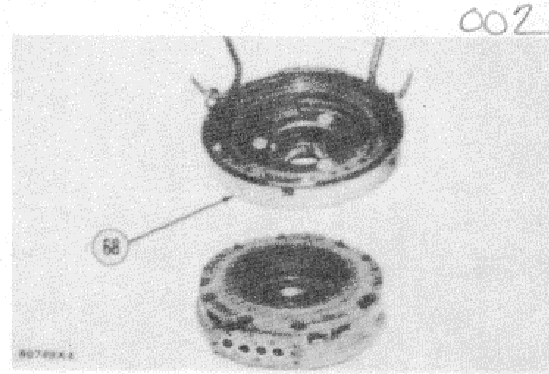
001

44. Install seals (67) and balance piston (66) on No. 2 clutch housing.



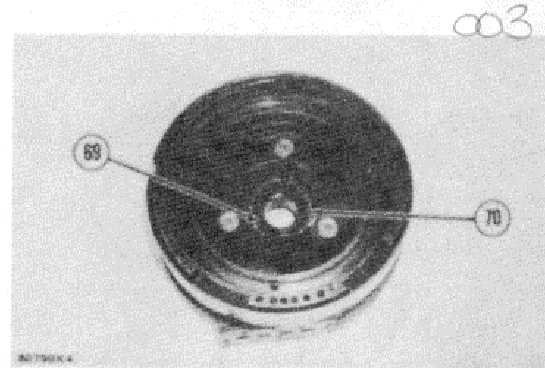
002

45. Make an alignment of locating ball with groove (slot) in bearing and install No. 2 clutch housing (68) on No. 1 clutch assembly.



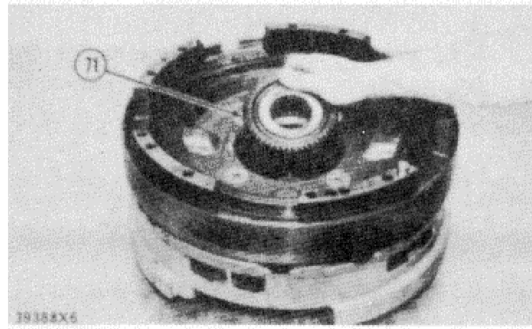
003

46. Install snap ring (69) that holds bearing (70).

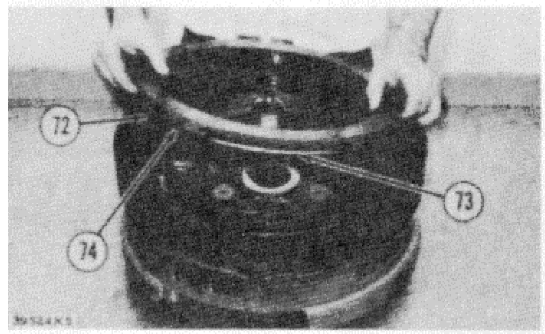


TRANSMISSION

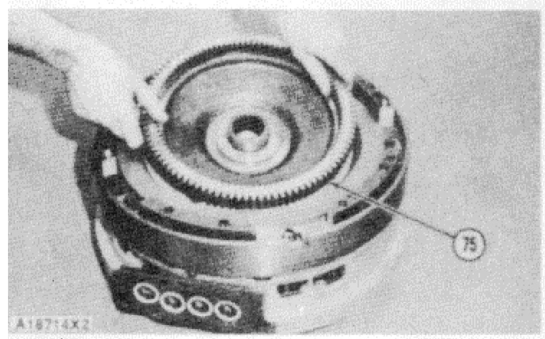
47. Install No. 1 sun gear (71).



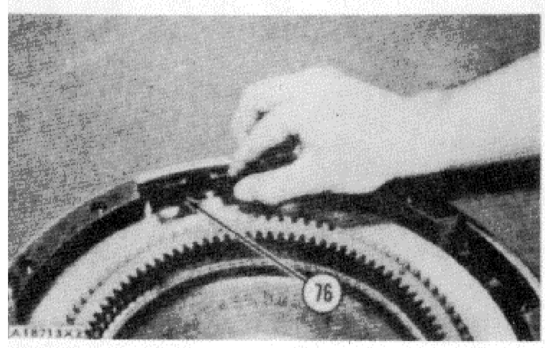
48. Install seal ring (73). Install No. 2 clutch piston (72) and make sure to put larger opening (slot) (74) on clutch piston in alignment with opening (slot) on balance piston.



49. Install ring gear (75).

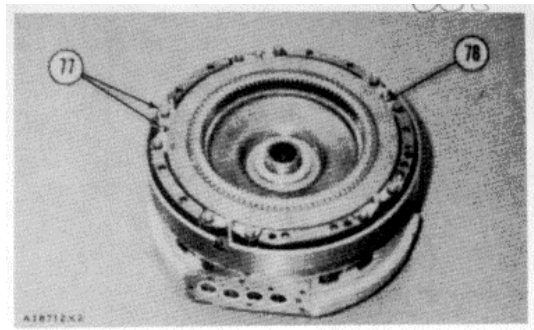


50. Install No. 2 piston retaining clips (76).



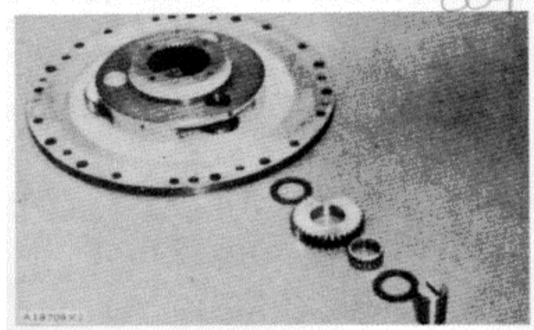
TRANSMISSION

51. Install No. 2 discs and plates (78). Install pins and springs (77).



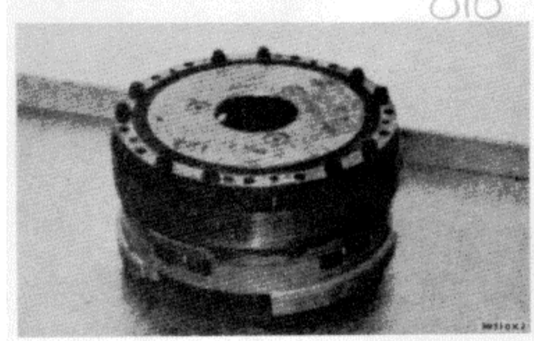
009

52. Install washers, bearings, gears, shafts and pins in No. 2 clutch carrier. Make pins even with housing.



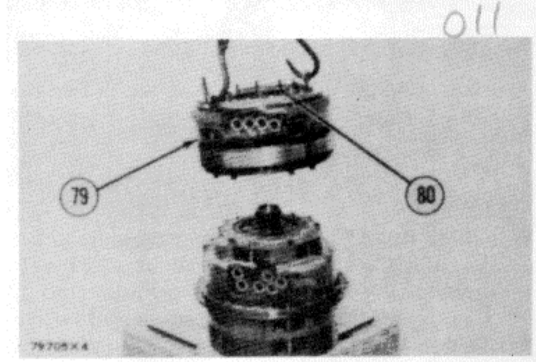
010

53. Install the No. 2 clutch carrier assembly in the No. 2 clutch housing. Tighten bolts to a torque of 85 ± 5 lb.ft. (115.2 ± 6.8 N-m).



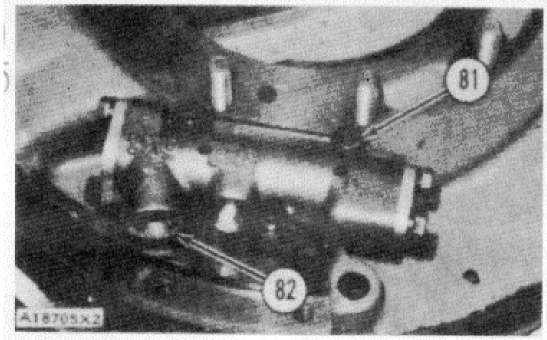
011

54. Turn No. 2 clutch carrier assembly over. Install two nuts (80) on torque converter studs and two 3/8"-16 NC forged eyebolts. Fasten a hoist to No. 1 and No. 2 clutch assemblies (79) and install on No. 3 clutch. Remove the two nuts from the studs.

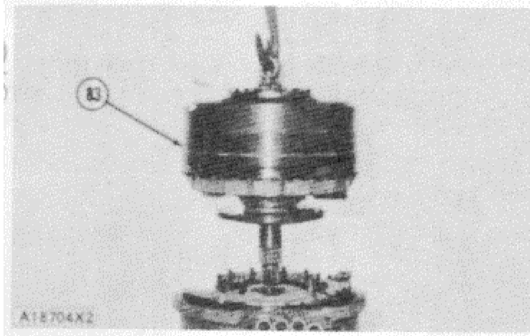


TRANSMISSION

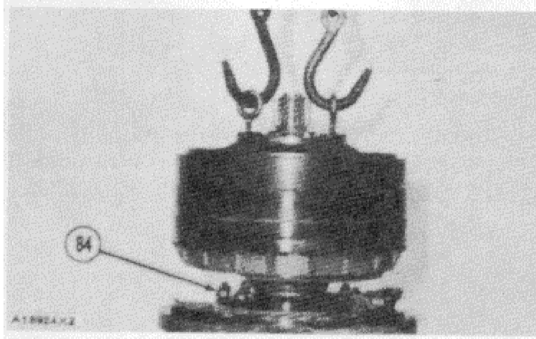
55. Assemble reducing valve (82) and install it on the No. 1 and No. 2 clutch assemblies with three bolts (81).



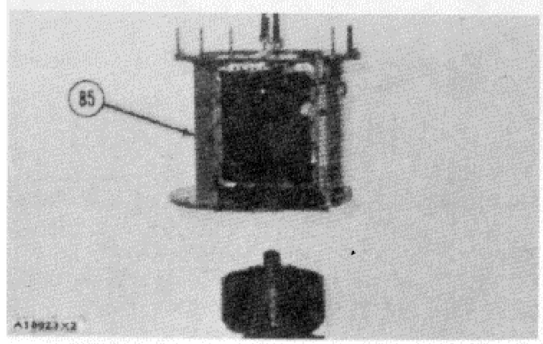
56. Install two 1/2"-13 NC forged eyebolts in the torque converter. Fasten a hoist and install the torque converter (83) on the No. 1 and No. 2 clutch assemblies.



57. Install nine nuts (84) that hold the torque converter to the No. I clutch assembly.



58. Install two 1/2"-13 NC forged eyebolts in the transmission case. Fasten a hoist and install transmission case (85). Install eighteen bolts at bottom of transmission case and install twelve bolts at the top.



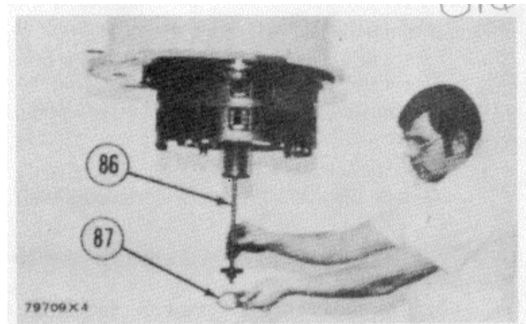
TRANSMISSION

59. Fasten a hoist to the transmission and lift the transmission enough to install governor drive shaft (86) and snap ring (87).

NOTE: Check to make sure the pistons are free in their clutch housings as follows:

a) Put air (free of water) under a pressure of 100 to 150 psi (7.0 to 10.5 kg/cm2) (690 to 1035 kPa) into seven oil passages that have identification on them with an FT834 Air Nozzle.
b) There must be .12 to .25 in. (3.0 to 6.4 mm) of movement for each piston.
c) If the pistons do not move the distance in Step (b), put a small amount of oil in the seven passages. Follow procedure in Step (a) again. If the pistons still do not move, the transmission must be disassembled and the pistons checked.

60. Put the transmission on the stand and install the oil manifolds (88). Slide oil tube into reducing valve.
61. Install ten bolts (89) in the oil manifolds. Tighten the bolts to a torque of 35 ± 3 lb.ft. (47.5 ± 0.4 mkg). Install guide pins (92) and install spacer plate (91). Install oil tubes (90) into oil manifolds. Install the clips that hold the tubes. Push oil tube (93) into oil manifolds.
62. Install the selector valve group (94).



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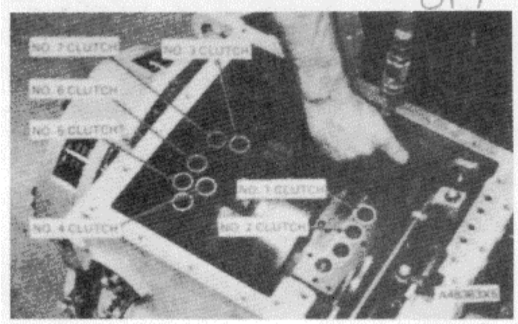

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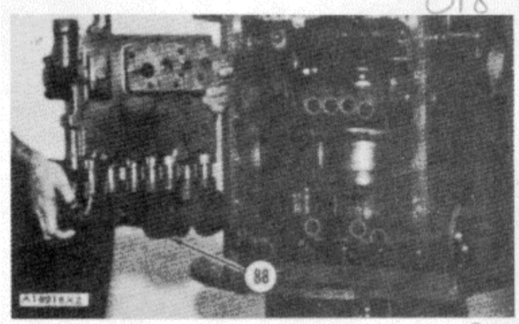

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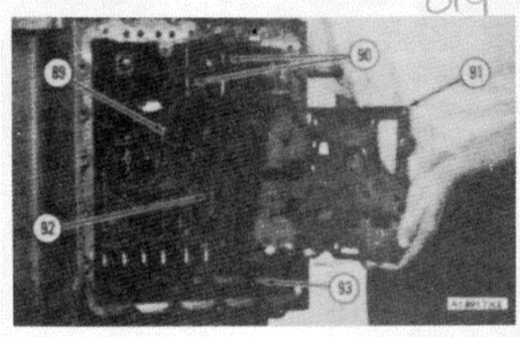
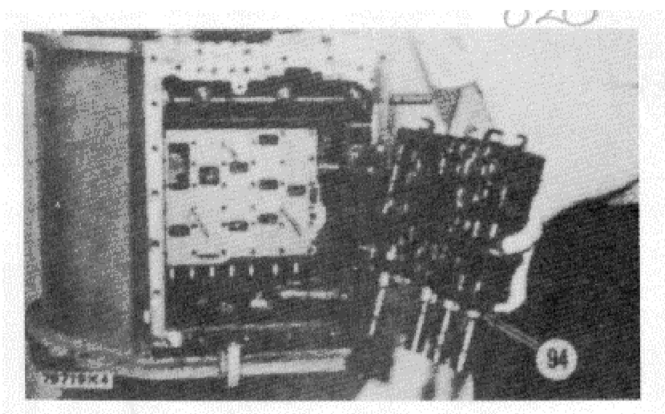




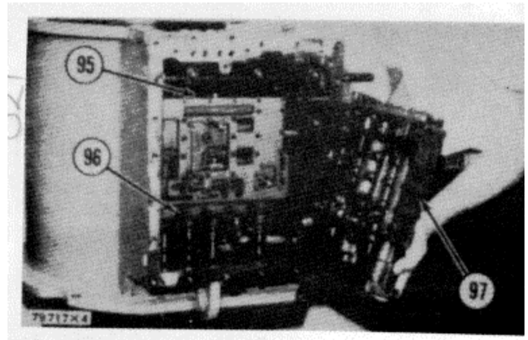
TRANSMISSION

63. Install manifold (95), six bolts (96) and the pressure control valve group (97). Tighten the bolts to a torque of 22 ± 3 lb.ft. (29.8 ± 4.1 N-m). Make an adjustment to the selector valve spools as follows:

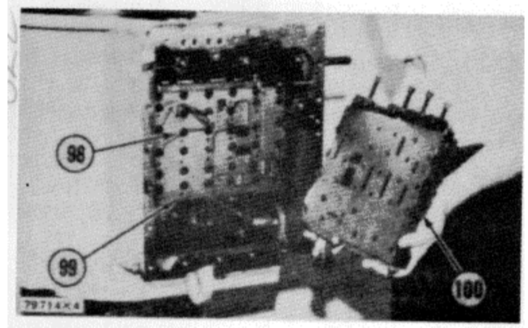
    a) After installation of selector valve group (94) and manifold (95) turn horizontal shaft to "FIRST" speed position.

NOTE: "FIRST" speed position is when the detent is in the third notch of the cam.

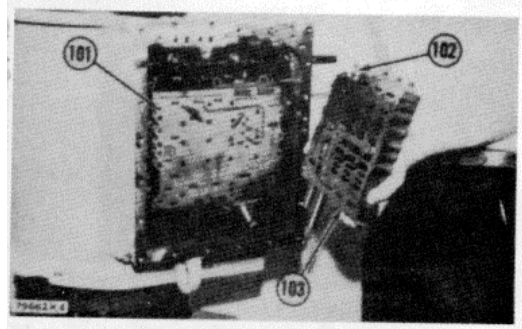
    b) The end of each selector valve spool must be even with the face of the valve body.
    c) If the adjustment is not correct, loosen the nuts on the spools and turn the spools until the end of the spool is even with the face of the valve body. Hold the spool and tighten the nut to a torque of 25 ± 5 lb.ft. (33.9 ± 6.8 N-m). See ADJUSTMENT OF TRANSMISSION CONTROL LINKAGE in TESTING AND ADJUSTING.



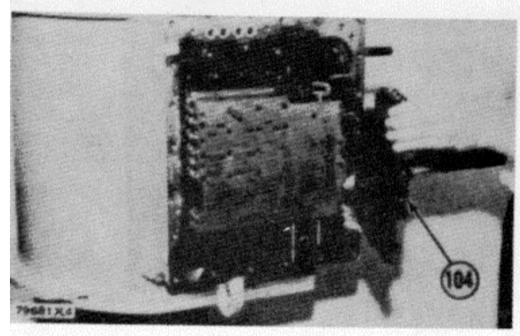
64. Install plate (99) and bolts (98). Install pressure control valve (100) for automatic shift. Tighten the bolts to a torque of 22 ± 3 lb.ft. (29.8 ± 4.1 N-m).



65. Install plate (101) and automatic selector valve group (103). Make sure valve spool (102) is put on shift bar before bolts that hold automatic selector valve group are tightened.



66. Install governor cutoff valve (104).



TRANSMISSION

67. Install bolts (105) and remove guide pins (106). Tighten bolts to a torque of 22 ± 3 lb. ft. (29.8 ± 4.1 N-m).
68. Install manifold (109) and bolts (107). Install control valve linkage (110) and bolts (108). Tighten bolts (107) and (108) to a torque of 25 ± 3 lb.ft. (33.9 ± 4.1 N-m). Make an adjustment to control valve linkage (110) as follows:
    a) Move the control lever to the "FIRST" speed position.
    b) If the adjustment is correct, the detent will be in third notch of the cam. The third notch has a "1" on it and is the "FIRST" speed position.
    c) If the adjustment is not correct, make an adjustment to the length of the linkage until it is correct.

Check the adjustment of the manual selector spool as follows:

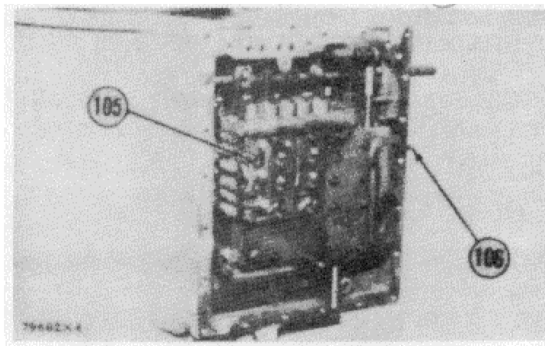
a) Disconnect the linkage from the transmission at the shaft.
b) Turn shaft until the detent is in the third notch ("FIRST" speed notch) of the cam.
c) The end of the manual selector spool must be even with the face of the valve body.
d) If the adjustment is not correct, loosen nut and make an adjustment until the manual spool is even with the face of the valve body. Hold the manual selector spool and tighten nut to a torque of 15 ± 3 lb.ft. (20.3 ± 4.1 N-m).

Check the adjustment of the hydraulic shift valve spool as follows:

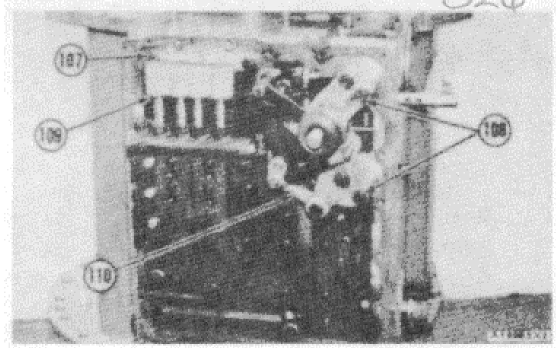
a) Fasten a pair of vise grip pliers to horizontal shaft.
b) Move the horizontal shaft to the "FOURTH" speed position.

NOTE: "FOURTH" speed position is when detent is in the sixth notch of the cam.

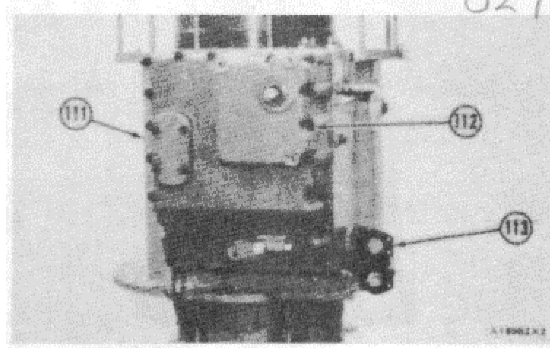
c) The end of the hydraulic shift valve spool must be even with the face of valve body.
d) If the adjustment is not correct, loosen nut and make an adjustment until hydraulic shift valve spool is even with the face of the valve body. Hold the hydraulic shift valve spool and tighten nut to a torque of 15 ± 3 lb.ft. (20.3 ± 4.1 N-m). See ADJUSTMENT OF TRANSMISSION CONTROL LINKAGE in TESTING AND ADJUSTING.



026



027

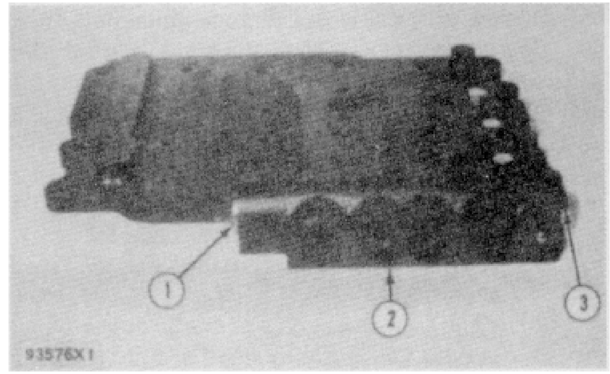


69. Install cover (111) and bolts (112). Install hose junction (113).
    end by:
    a) connection of transfer gears to transmission
    b) install transfer gears, transmission and differential as a unit

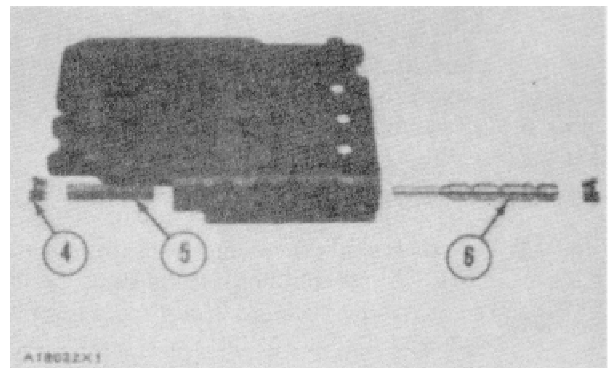
TRANSMISSION HYDRAULIC CONTROL VALVES

DISASSEMBLE TRANSMISSION HYDRAUUC CONTROL VALVES

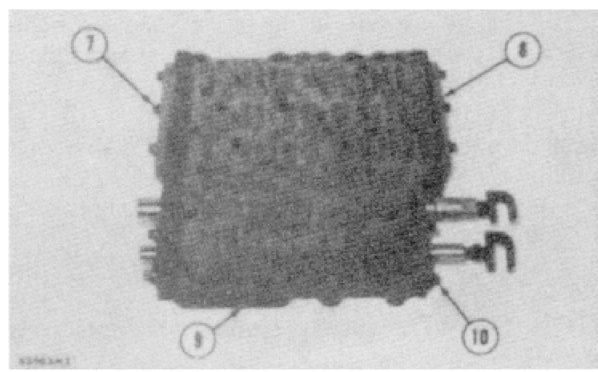
NOTE: See DISASSEMBLE AND ASSEMBLE TRANSMISSION for removal and installation of control valves.



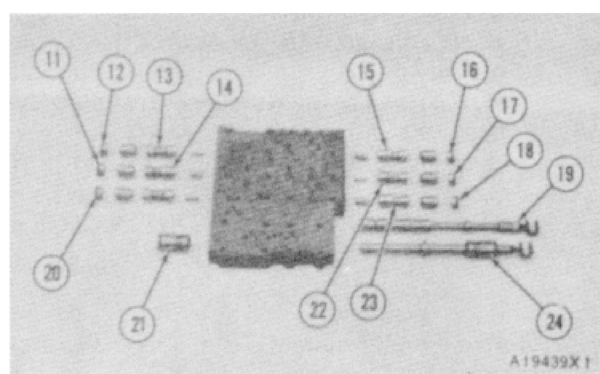
1. Remove plugs (1) and (3) from governor cutoff valve body (2). Inspect seals (4).



2. Remove governor cutoff valve spool (6) and spring (5).



3. Remove bolts (10). Remove bolts (7) and plates (8) from automatic selector valve body (9).

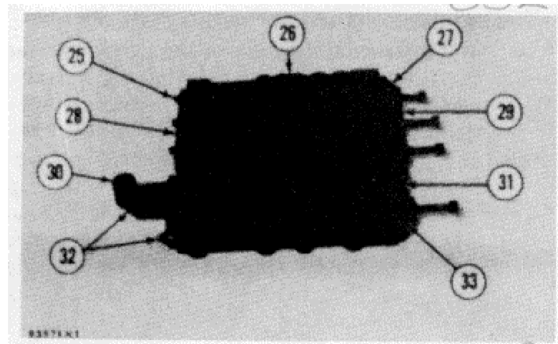


4. Remove hydraulic shifter valve spool (24), sleeve (21) and manual selector valve spool (19). Remove stop (18). Inspect seal on stop. Remove slug, valve spool (23) for 7th to 8th shift and slug. Remove stop (20), slug, valve spool (21) for 2nd to 3rd shift and slug. Remove stop (17), slug, valve spool (22) for 6th to 7th shift and slug. Remove stop (11), slug, valve spool (14) for 3rd to 4th shift and slug. Remove stop (16), slug, valve spool (15) for 5th to 6th shift and slug. Remove stop (12), slug, valve spool (13) for 4th to 5th shift and slug.

NOTE: Valve spools are identified by letters on the valve body. Keep valve spools and their parts together so they can be assembled correctly.

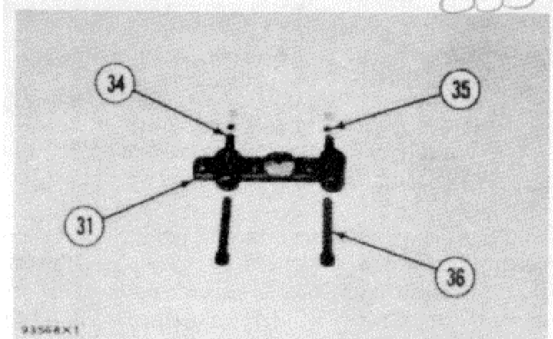
TRANSMISSION HYDRAULIC CONTROL VALVES

5. Remove bolts (33) and cover (31), bolts (27) and cover (29) from shift pressure control valve body (26). Remove bolts (25) and plate (28). Remove bolts (32) and cover (30).



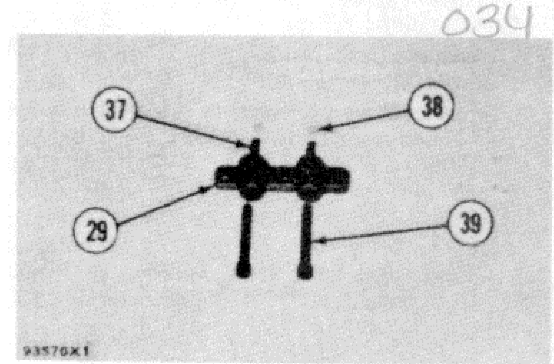
033

6. Remove adjusting screws (36), then remove shims (35) and springs (34) from cover (31).



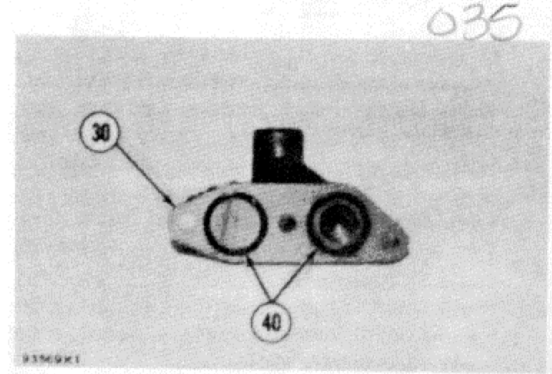
034

7. Remove adjusting screws (39), then remove shims (38) and springs (37) from cover (29).



035

8. Remove and inspect O-ring seals (40) from cover (30).



TRANSMISSION HYDRAULIC CONTROL VALVES

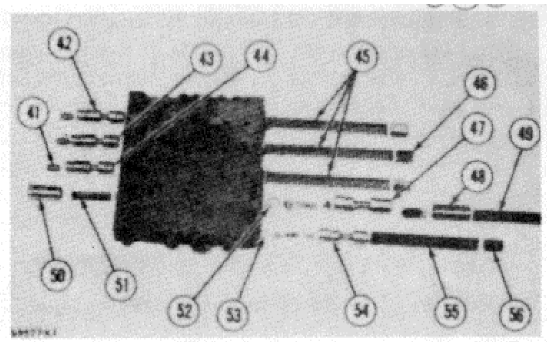
9. Remove spacer (56), spring (55) and down-shift reducing valve spool (54). Remove ring (53), retainer, spring and plunger from valve (54). Remove spring (49), spacer (48), spacers and priority valve spool (47). Re-move ring (52), retainer, spring and plunger from valve (47). Remove slugs (46) and springs (45). The springs can be identified by color markings. Remove hold valve piston (50) and spring (51). Remove slug (41) and 2nd to 3rd upshift valve spool (44). Remove slug and valve spool (43) for 3rd to 4th, 5th to 6th and 7th to 8th upshifts. Remove slug and valve spool (42) for 4th to 5th and 6th to 7th upshifts.

10. Remove bolts (62) from cover (63). Remove bolts (61) from body assembly (60). Make a separation between body assembly (60) and pressure control valve body (59).

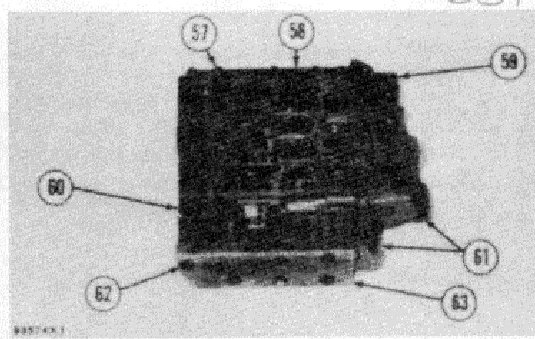
NOTE: The parts being removed from the pressure control valve are shown in two separate illustrations. Illustration 94650X1 shows parts being removed from bottom of valve. Illustration 93565X1 shows parts being removed from the top.

11. Remove load piston (77) and spacers (75) from body assembly (60). Remove retainer (73), spacer (70), spring (68) and retainer (66) from pressure control valve body (59). Remove stop (64) from valve body (59). Remove load piston (80) and spacers (79) from body assembly (60). Remove retainer (78), spring (76), spring (72) and retainer from valve body (59). Remove stop (65) from valve body (59). Remove spring (67), spacers (69) and slug (74) from load piston reset valve spool (71).

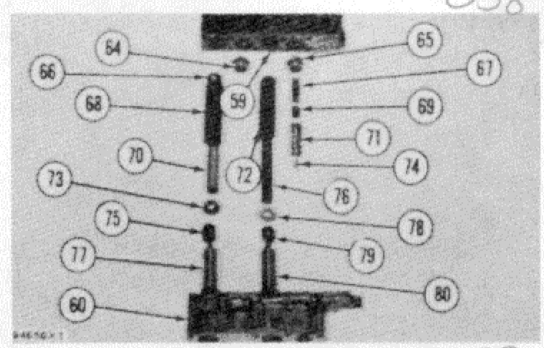
12. Remove modulating reducing valve spool (90) from valve body (59). Remove plunger (89), spring, spring (85) and safety valve spool (81). Remove ring (82), retainer, spring and poppet from valve spool (81). Remove modulating relief valve spool (83). Remove ring (86), retainer, spring and poppet from valve spool (83). Remove slug (87), spring, flow control valve spool (84) and spring. Remove relief valve spool (91) and slug (88). Remove ring, retainer, spring and poppet from relief valve spool (91) (not shown in illustration).



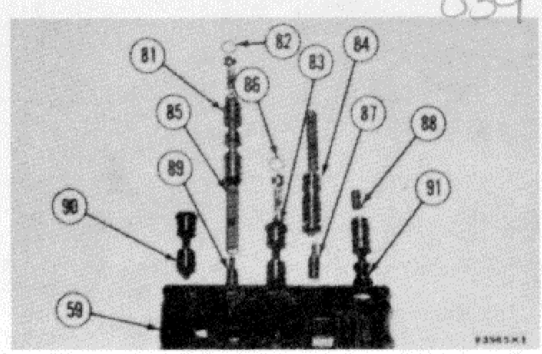
037



038

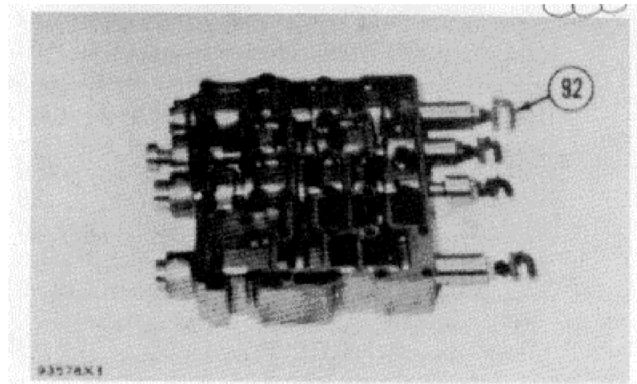


039

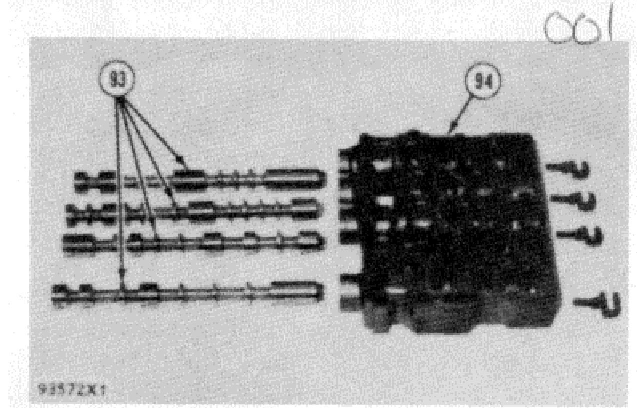


TRANSMISSION HYDRAULIC CONTROL VALVES

13. Remove link assemblies (92) from selector valve spools.



14. Remove selector valve spools (93) from manual selector valve body (94).

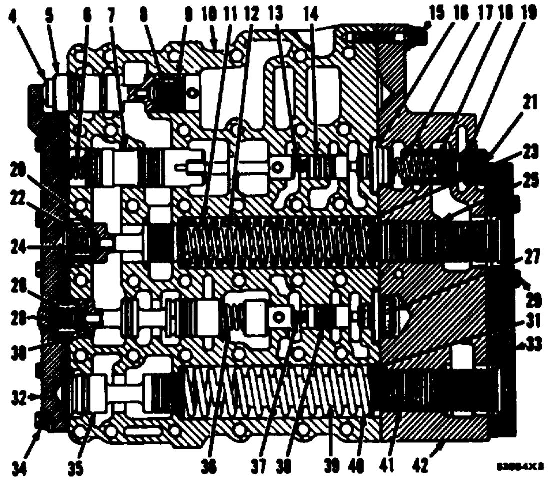


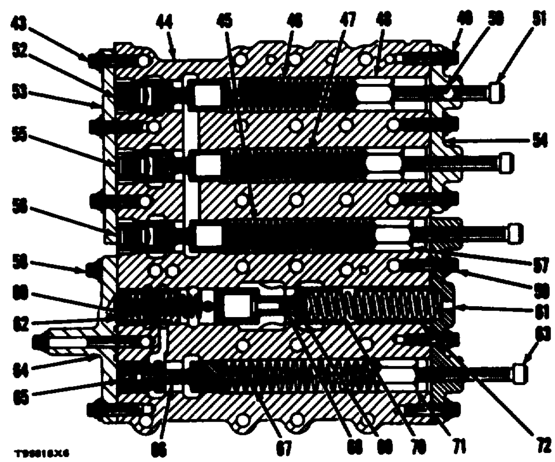
ASSEMBLE TRANSMISSION HYDRAULIC CONTROL VALVES

1. Install selector valve spools (3) into manual selector valve body (2). Install link assemblies (1) on selector valve spools.

TRANSMISSION HYDRAULIC CONTROL VALVES

2. Install poppet, spring (8), retainer and ring (9) into relief valve spool (5). Install slug (4) and install relief valve spool into pressure control valve body (10). Install plunger (14), spring (13) into valve body and install stop (16). Install flow control valve spool (7). Install spring (6) into valve. Install poppet, spring (22), retainer and ring (24) into modulating relief valve spool (20). Install valve spool into pressure control valve body. Install spring (11) and spring (12). Install retainer (23). Install poppet, spring (26), retainer and ring (28) into safety valve spool (30). Install valve into valve body. Install spring (36), spring (37), plunger (38) and stop (27). Install modulating reducing valve spool (35) into valve body. Install retainer, spring (40), spacer (39) and retainer (31). Install cover (32) and bolts (34) on valve body. Install spacers and load piston (41) into body assembly (42). Install spacers and load piston (25) in body assembly. Install spring (17), spacers (18) and slug (21) into reset valve spool (19). Install valve spool into body assembly. Install cover (33) and bolts (29) on body assembly. Install bolt (15). Tighten bolts (15), (29) and (34) to a torque of 22 ± 3 lb. ft. (3.0 ± 0.4 mkg).



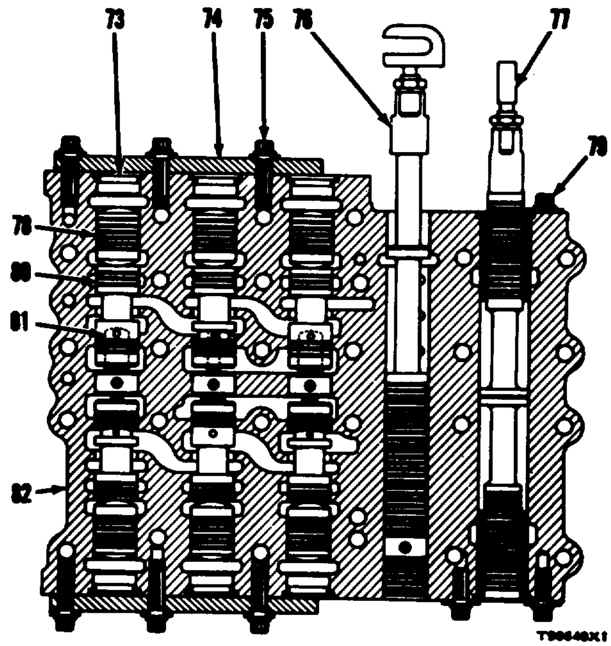


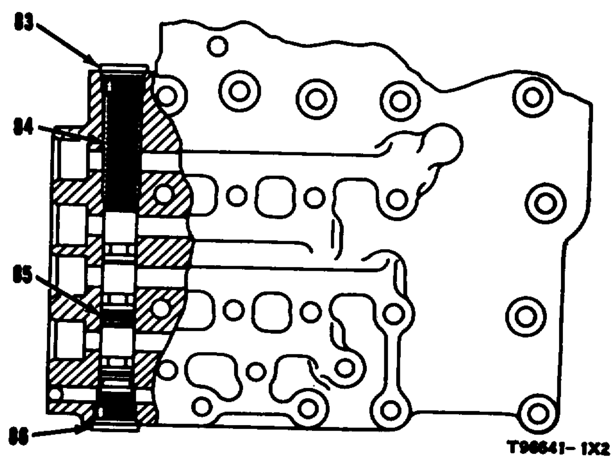
3. Install slug (52) into reducing valve spool and install valve spool (for 4th to 5th and 6th to 7th upshifts) into shift pressure control valve (44). Install spring (46). Install slug (44) into reducing valve spool and install valve spool (for 3rd to 4th, 5th to 6th and 7th to 8th upshifts) into control valve body. Install spring (47). Install slug (56) into reducing valve spool and install valve spool (for 2nd to 3rd upshift) into control valve body. Install spring (45). Install plate (53) and bolts (43). Install springs (50), plugs and spacers behind each adjustment screw (51) for cover (54). Install spacers (48) behind springs (46) and (47). Install cover (54) and bolts (49). Install spring (60) into hold valve piston (62). Install piston into control valve body. Install poppet spring, retainer, ring, spacer (69) and spring (70) into priority valve spool (68). Install spacer (72). Install poppet, spring, retainer and ring (65) into downshift reducing valve spool (66) and install valve into control valve body. Install cover (64) and bolts (58). Install spacer (57), spring (67) and spacer (71). Install springs, plugs and spacers behind each adjustment screw (63) for cover (61). Install cover (61) and bolts (59). Tighten bolts (43), (49), (58) and (59) to a torque of 22 ± 3 lb. ft. (3.0 ± 0.4 mkg).

TRANSMISSION HYDRAULIC CONTROL VALVES

4. Install slug (81) in valve spool (80). Install spool in automatic selector valve body (82). Install slug (78) and stop (73). Assemble remaining spools in same order as above keeping them in their respective locations. See Step 4 in DISASSEMBLE TRANSMISSION HYDRAULIC CONTROL VALVES. Install cover (74) and bolts (75). Install manual selector valve spool (76) and hydraulic shifter valve spool (77) in valve body. Install retainer and bolt (79) that holds hydraulic shifter valve spool. Tighten bolts (75)and (79)to a torque of 22 ± 3 lb. ft. (3.0 ± 0.4 mkg).

5. Install spring (84) and governor cutoff valve spool (85). Install plugs (83) and (86). Tighten plugs to a torque of 35 ± 5 lb. ft. (4.8 ± 0.7 mkg).

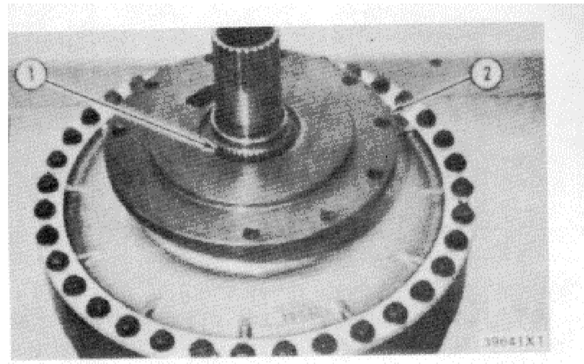




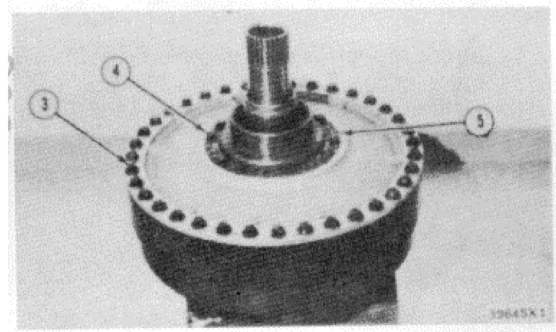
TORQUE CONVERTER

DISASSEMBLE TORQUE CONVERTER

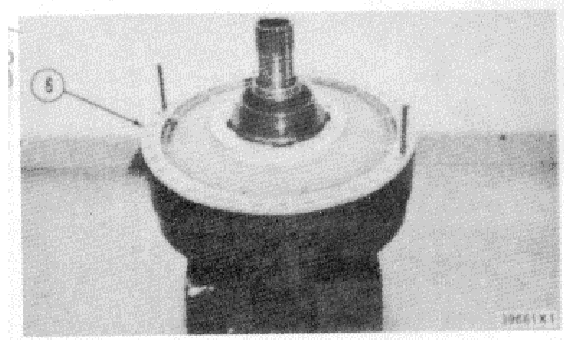
start by:
a) disassemble transmission



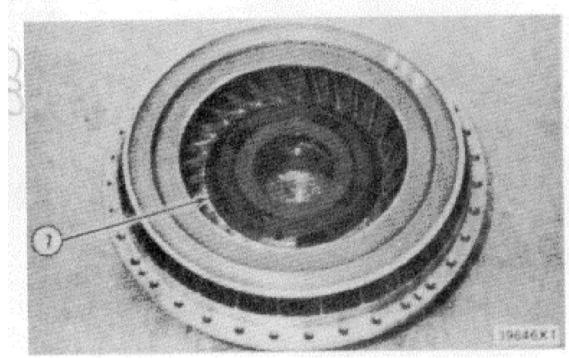
1. Remove retaining ring (1) and support assembly (2).



2. Remove bolts (3) and (4) and plate (5).



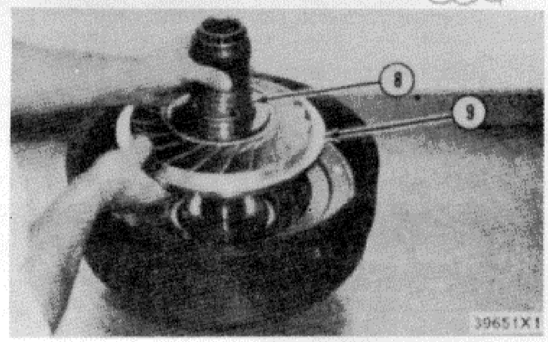
3. Remove impeller (6) from housing using two 3/8"- 16NC forcing screws.



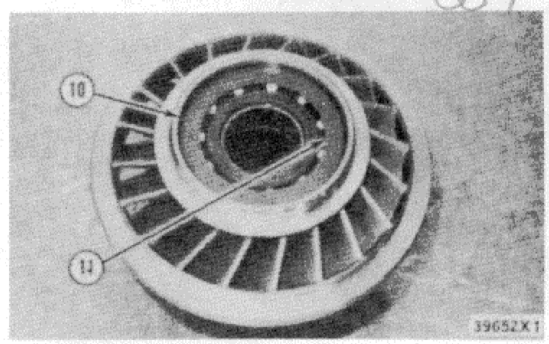
4. Remove hub (7) from impeller (6).

TORQUE CONVERTER

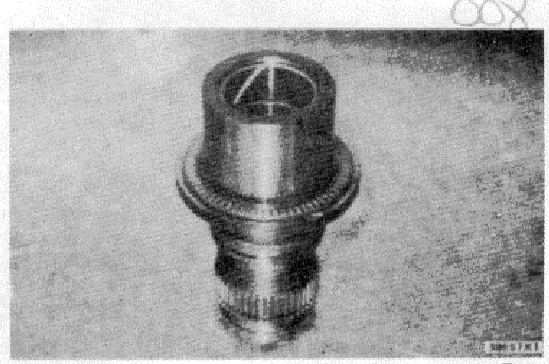
5. Remove stator (9) and carrier assembly (8) from turbine.



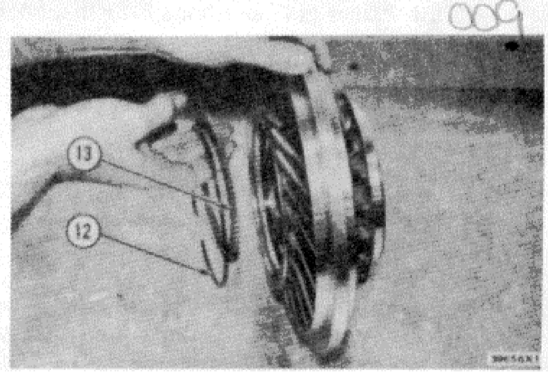
6. Remove retaining ring (10) and thrust bearing plate (11) from stator.



7. Turn stator assembly on opposite side and remove carrier shaft from stator. Hold stator, turn shaft clockwise to free overrunning clutch, and pull shaft from stator. Over-running clutch rollers and springs will fall on bench. Remove bearing from inside of stator carrier shaft.

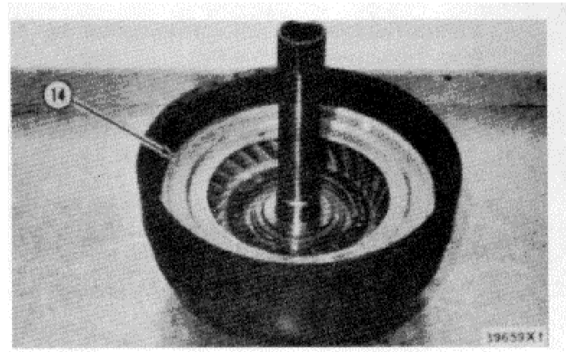


8. Remove retaining ring (12) and thrust bearing plate (13).

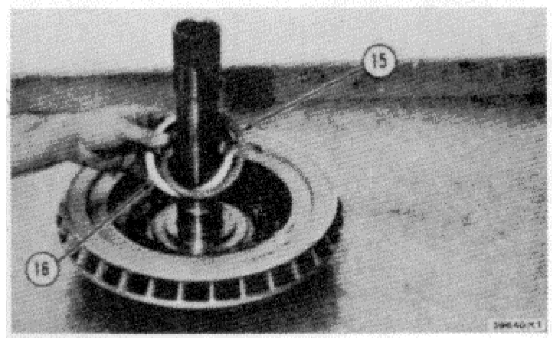


TORQUE CONVERTER

9. Remove cam ring from stator only if a replacement stator is to be installed. Heat new stator in oil and carefully put splines in alignment when installing cam ring into new stator.

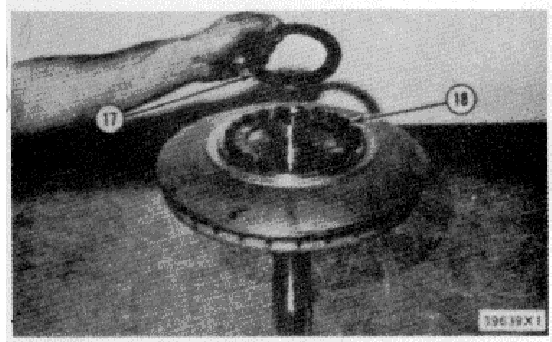


10. Remove turbine assembly (14) from housing. Remove thrust washer from housing.

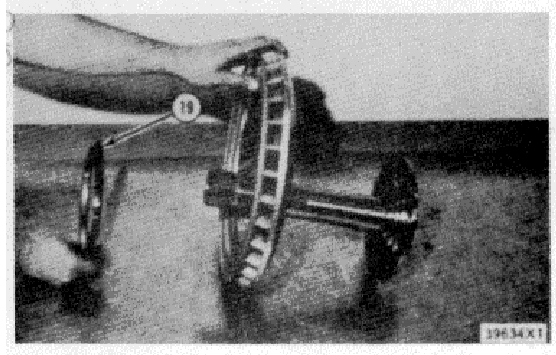


11. Remove bearing (15) and race (16) from turbine.

12. Turn turbine on opposite side and remove thrust washer (17) and bolts (18) that hold the turbine to the shaft.

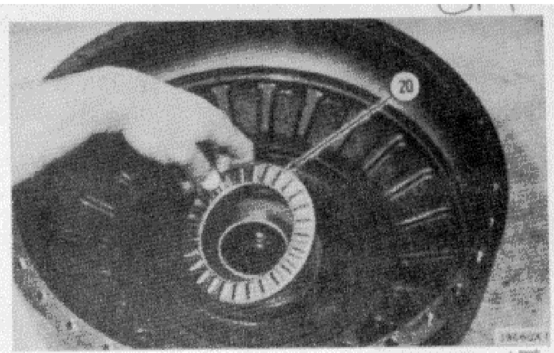


13. Put a mark on the turbine and shaft for installation purposes. Remove the turbine and retainer plate (19) from the shaft.



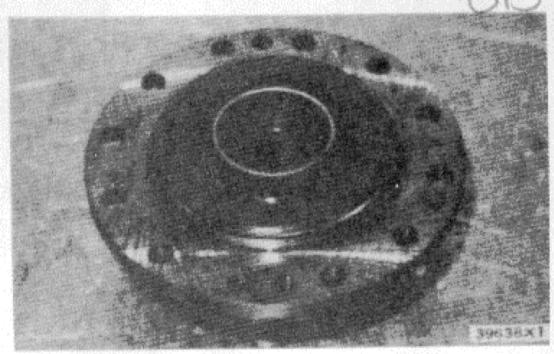
TORQUE CONVERTER

14. Remove bearing (20) and race from housing.

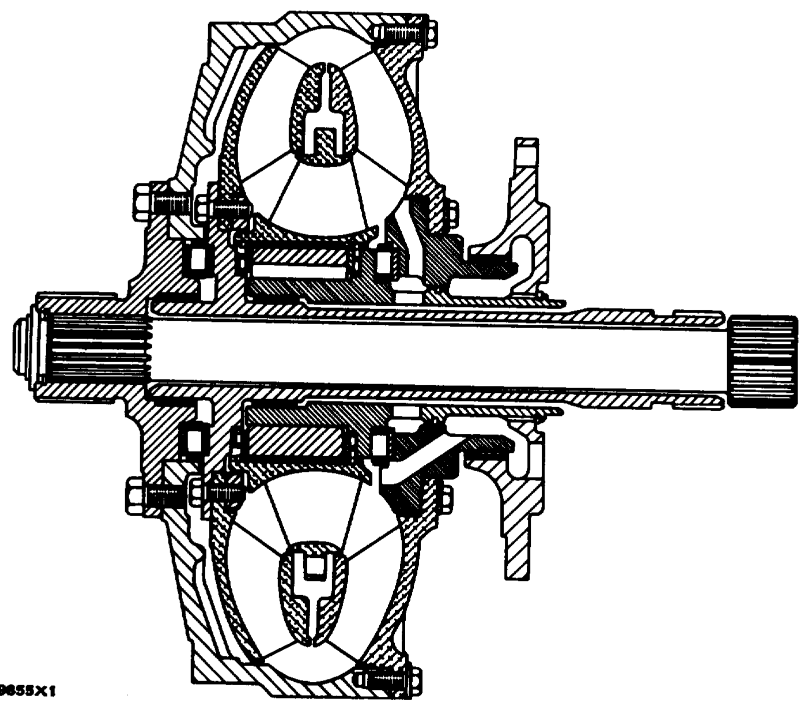


15. Remove input flange from housing.

015



16. Remove bearing from flange.



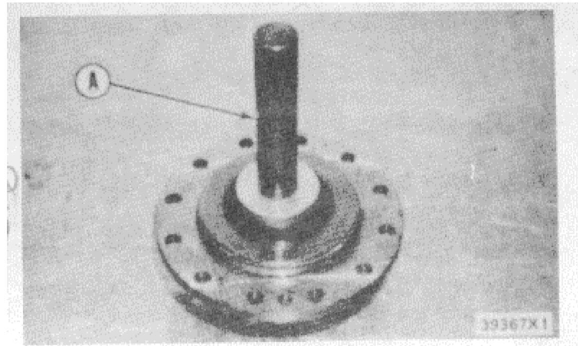
T99655X1

TORQUE CONVERTER

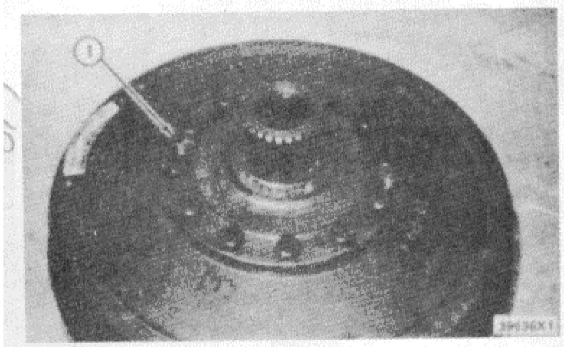
ASSEMBLE TORQUE CONVERTER

	Tools Needed	A
1P31	Handled	1
1P79	Drive Plate	1

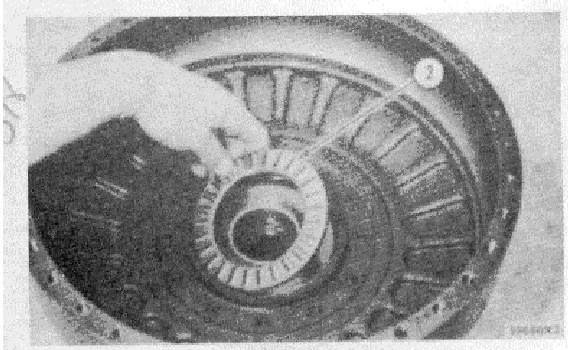
1. Install bearing in input flange with tooling (A).



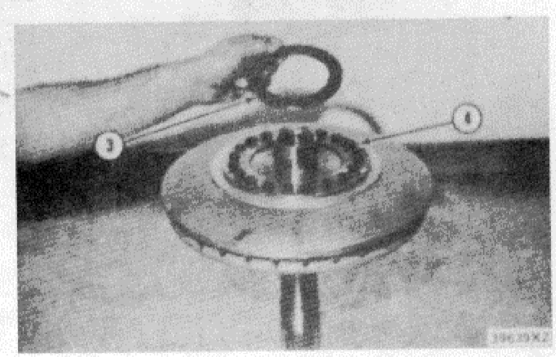
2. Install input flange (1) on housing.



3. Install thrust bearing (2) and race in housing.

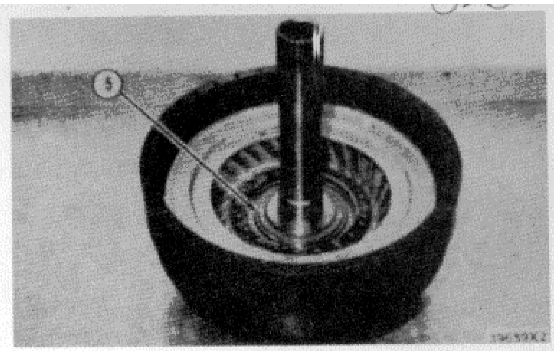


4. Install shaft and retainer into turbine. Tighten bolts (4) to a torque of 36 ± 2 lb. ft. (5.0 ± 0.3 mkg). Install race (3) of thrust bearing on end of shaft.



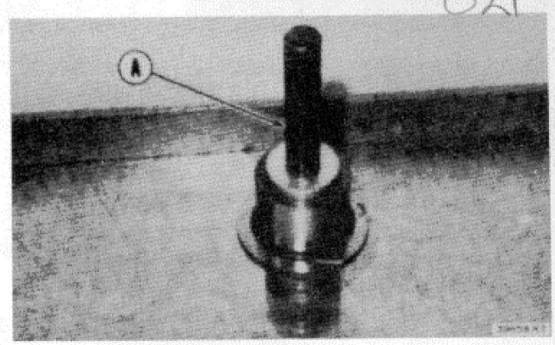
TORQUE CONVERTER

5. Install turbine assembly into housing. Install race and thrust bearing (5) on shaft.



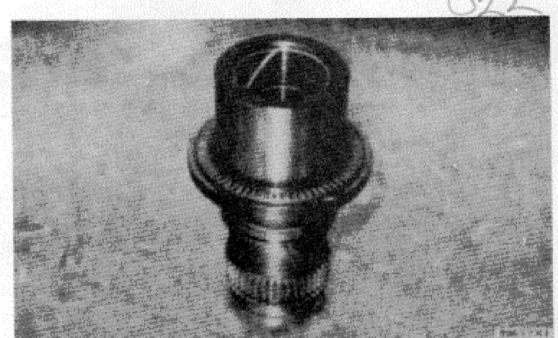
021

6. Install bearing in carrier shaft with tooling (A).



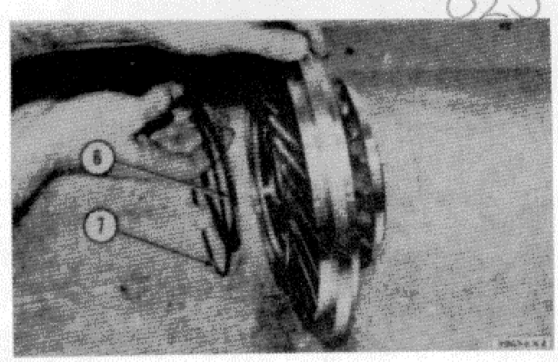
022

7. Install ring seal and thrust bearing on shaft of carrier.



023

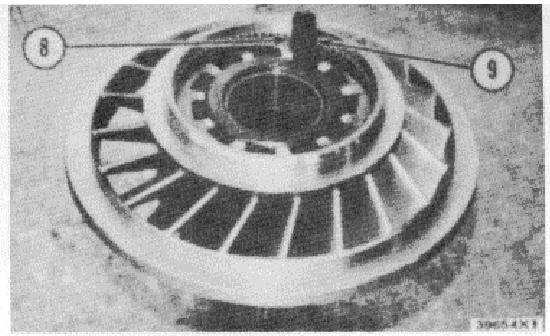
8. Install plate (6) and retainer (7) on impeller side of stator.



9. Install stator on carrier shaft. If necessary, heat the stator to a maximum temperature of 300°F (149°C).

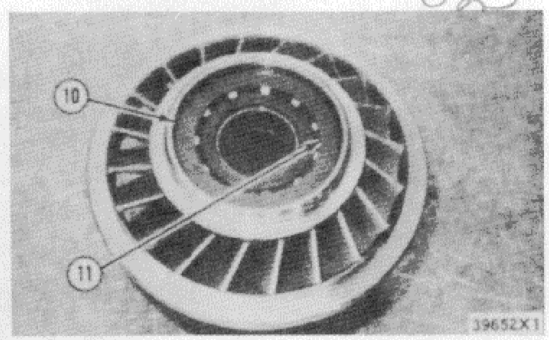
TORQUE CONVERTER

10. Install clutch rollers (9) and springs (8) in stator.



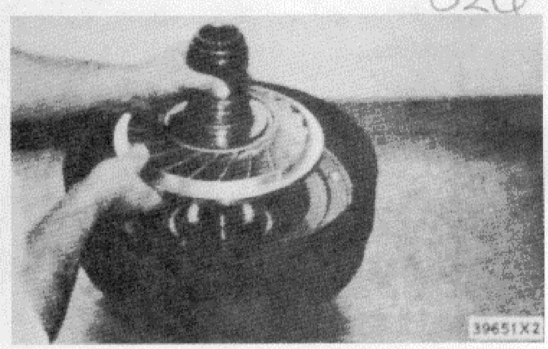
025

11. Install plate (11) and retaining ring (10).



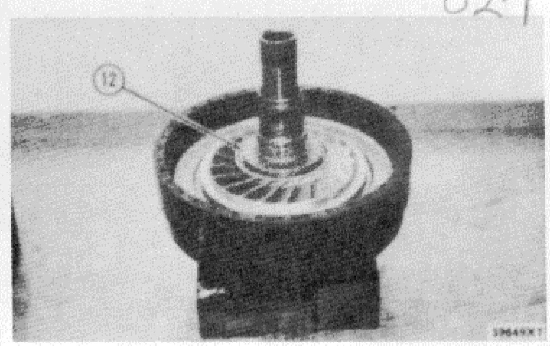
026

12. Install stator assembly into turbine.



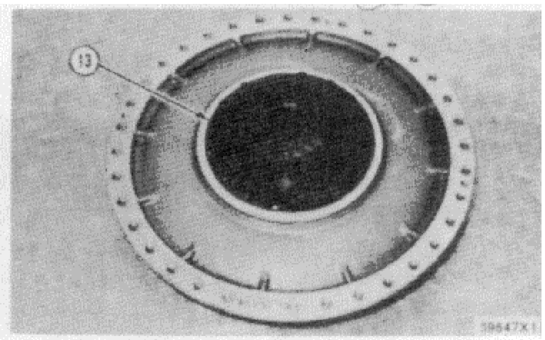
027

13. Install thrust bearing (12) on stator.



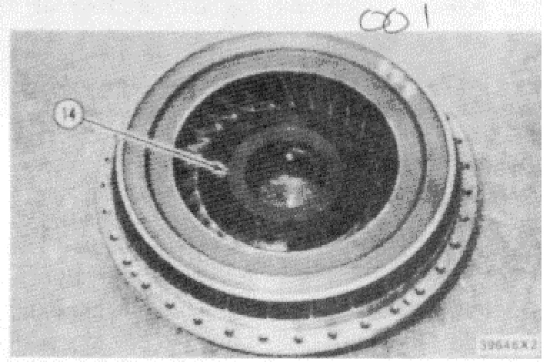
TORQUE CONVERTER

14. Install hub (13) in impeller and tighten bolts to 36 ± 2 lb.ft. (5.0 ± 0.3 mkg).



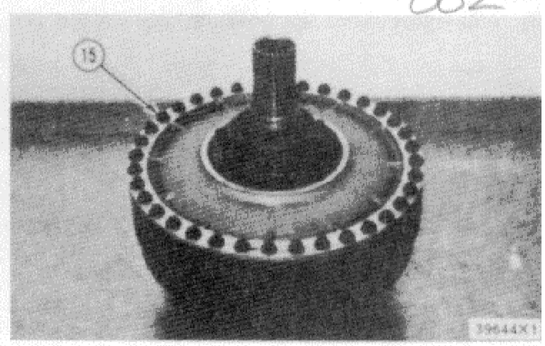
001

15. Install race (14) of thrust bearing in impeller hub. Put oil on race so it will not fall when you install the impeller assembly.



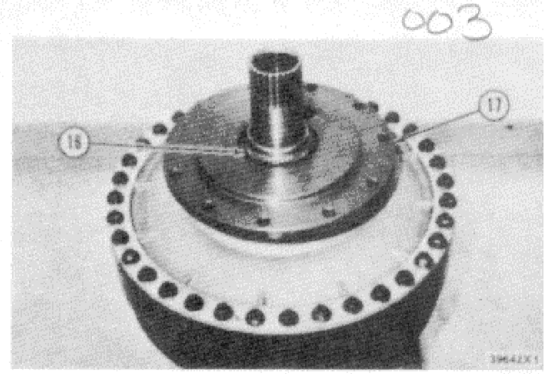
002

16. Install the impeller assembly on the converter housing. Tighten retaining bolts (15) to 36 ± 2 Ib.ft. (5.0 t 0.3 mkg).



003

17. Install support assembly (17) and retaining ring (16).



end by:
a) assemble transmission

DIFFERENTIAL

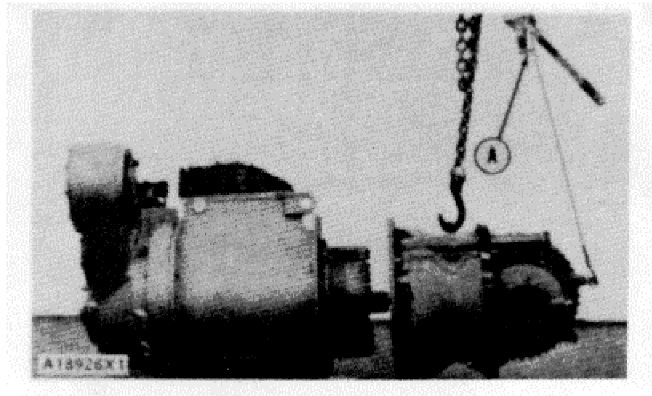
SEPARATION OF DIFFERENTIAL FROM TRANSMISSION

	Tools Needed	A
8S9906	Ratchet Puller	1

start by:

a) remove transfer gears, transmission and differential as a unit

1. Install a 1/2"-13 NC forged eyebolt in the differential and fasten a hoist. Use tool (A) for an added support.
2. Remove the four bolts that hold the differential to the transmission.
3. Remove the differential. Weight of the differential is 900 lb. (408 kg).



CONNECTION OF DIFFERENTIAL TO TRANSMISSION

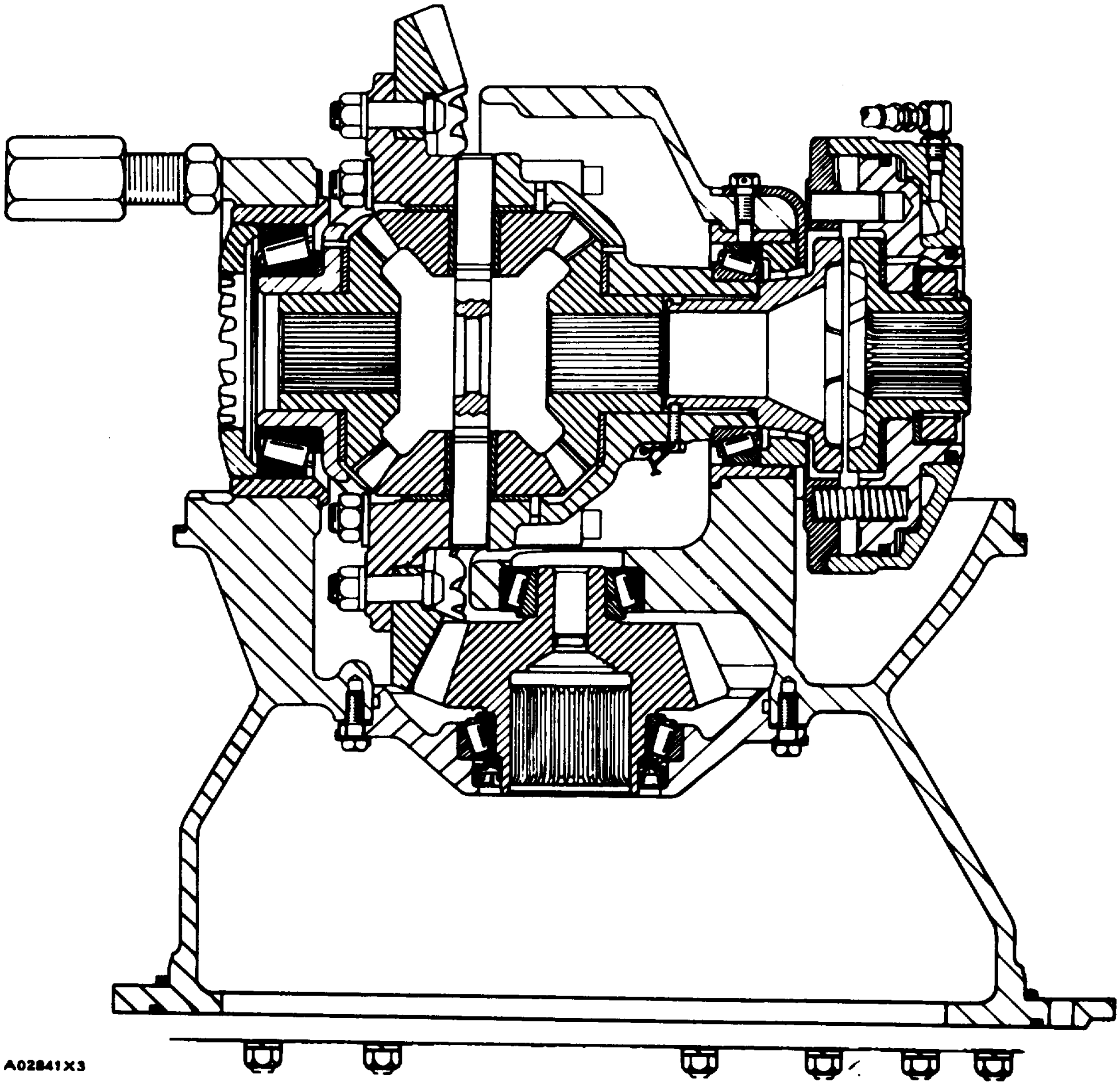
	Tools Needed	A
8S9906	Ratchet Puller	1

1. Put the differential in position on the transmission with a hoist and tool (A).
2. Install the four bolts that hold the differential to the transmission. Remove the hoist and tool (A).

end by:

a) install transfer gears, transmission and differential as a unit.

DIFFERENTIAL



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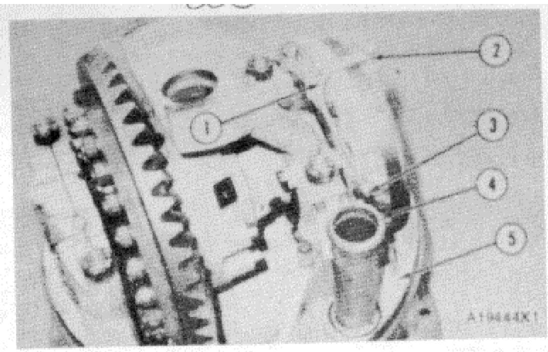
DIFFERENTIAL

DISASSEMBLE DIFFERENTIAL

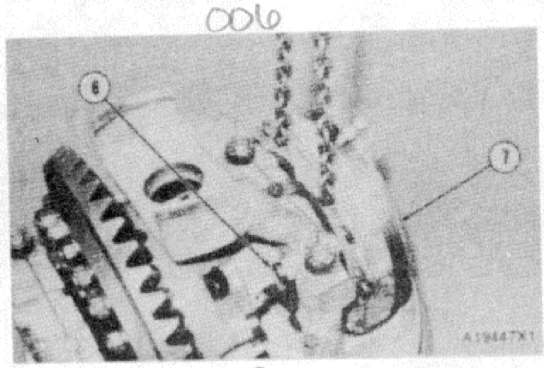
	Tools Needed	A	B	C	D	E	F	G	H
2P8312	Snap Ring Pliers	1							
1P532	Handle		1						
1P524	Drive Plate		1				1		
5F7343	Bearing Pulling Attachment			1	1			1	1
1H3107	Puller Assembly			1	1	1		1	1
7F9540	Hydraulic Ram			1	1			1	1
1P521	Drive Plate			1					
1P517	Drive Plate				1				
1H3108	Leg					2			
1H3112	Bearing Cup Puller Attachment					1			
1P531	Handle						1		
1P513	Drive Plate						1		
1P512	Drive Plate							1	
1P477	Drive Plate								1
5P3100	Pump Group		1	1			1	1	
8H684	Ratchet Box Wrench				1				

start by:

a) separation of differential from transmission



006



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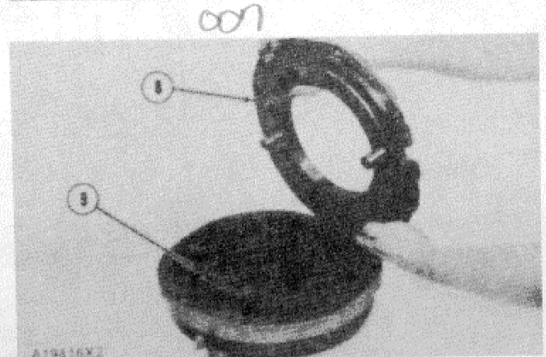
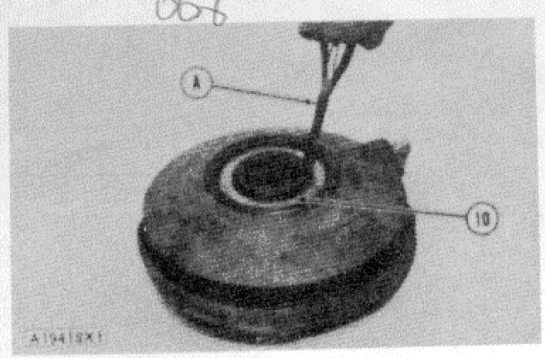


008



1. Disconnect air line (1) at fittings (2) and (5). Remove clamp (3) and remove air line. Remove tube (4).

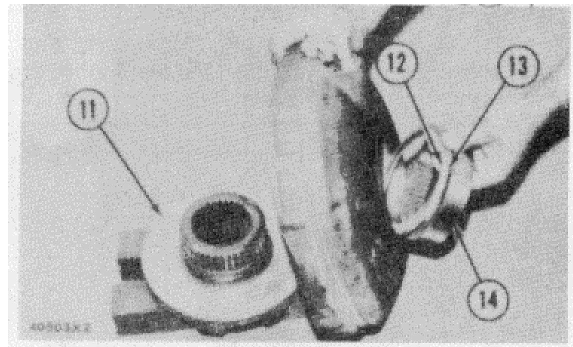
2. Fasten a hoist to the differential lock (7). Remove four bolts (6) and remove differential lock. Weight of the differential lock is 85 lb. (38.6 kg).

3. Remove bolts then remove cover (8) from the differential lock. Remove springs (9).

4. Turn differential lock over and remove snap ring (10) with tool (A).

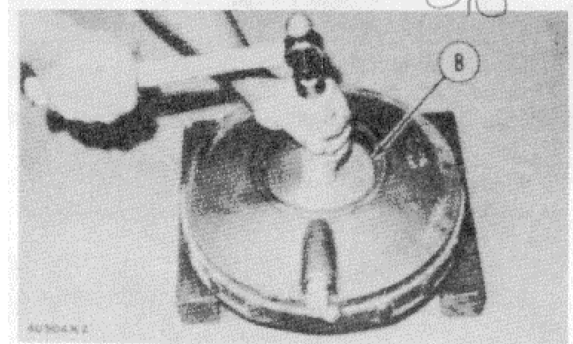
DIFFERENTIAL

5. Remove jaw (11), washers (12) and (13) and spacer (14) from cylinder assembly.



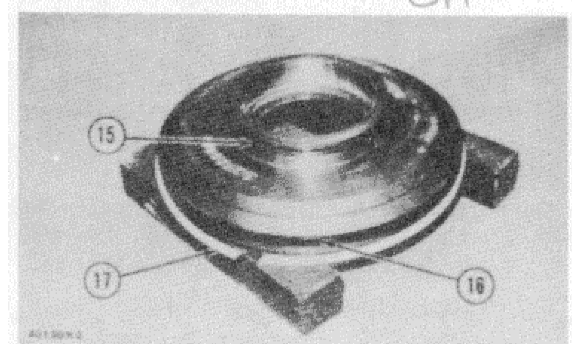
010

6. Remove piston from cylinder with tooling (B).



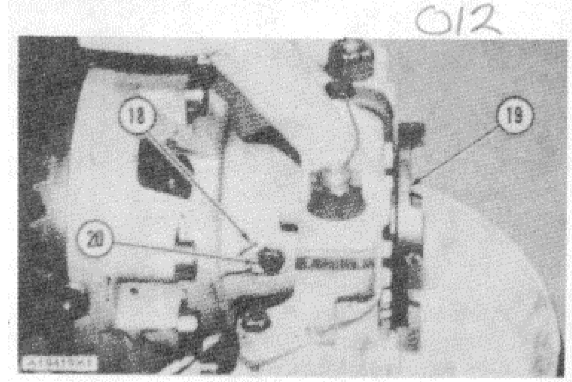
011

7. Remove and inspect teflon ring (17) and O-ring seals (16) and (15). Make replacements if necessary.



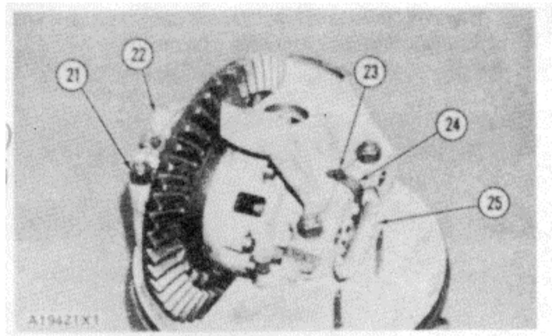
012

8. Cut wire (18) from bolts (20). Remove bolts (20), then remove jaw (1I 9).

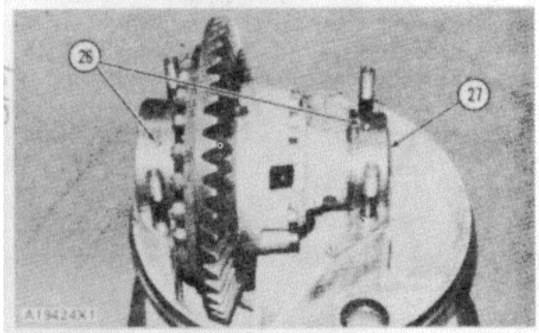


DIFFERENTIAL

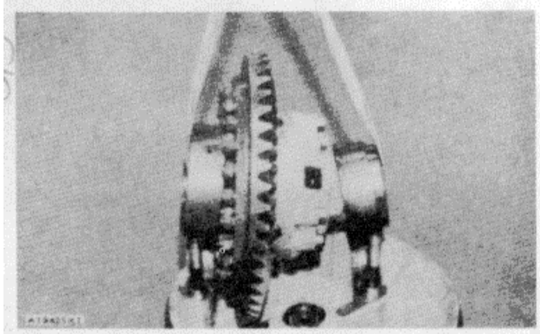
9. Cut wire from bolt (23). Remove bolt and lock .(24). Remove adjusting ring (25). Do the same for the rear adjusting ring. Remove bearing cap nuts (21) and bearing caps (22).



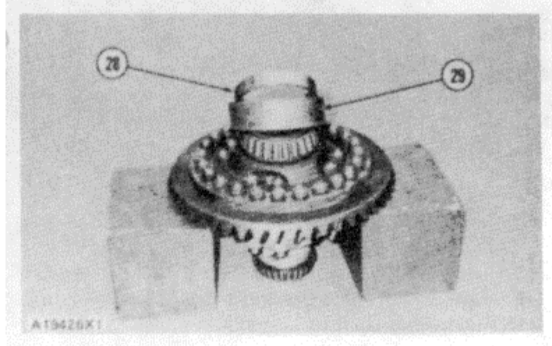
10. Remove two dowels (26) from bearing cages (27).



11. Fasten a hoist to the differential and ring gear unit and remove it from housing. Weight of the differential and ring gear unit is 270 lb. (122 kg).

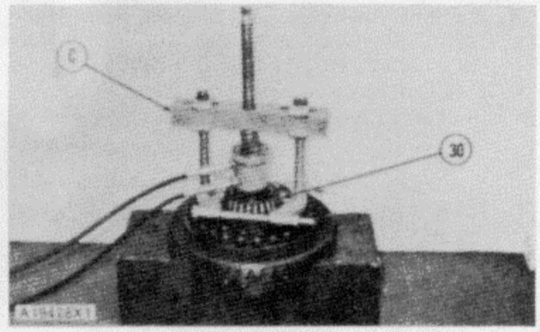


12. Put the differential and ring gear on blocks with the ring gear teeth down. Remove bearing cages (29) and bearing cups (28).



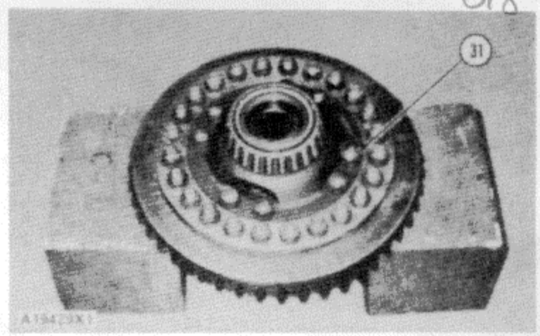
DIFFERENTIAL

13. Carrier bearing (30) will be damaged if removed. Use tooling (C) if bearing has to be removed. Illustration only shows tooling needed if bearing cone has to be removed.



018

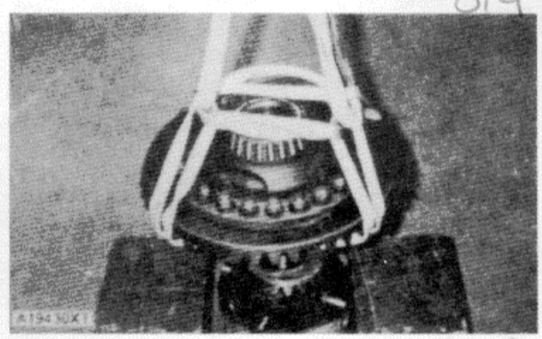
Illustration shows bearing not removed.



019

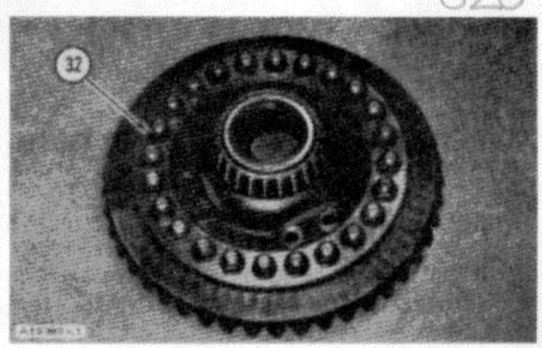
14. Remove differential case nuts (31).

15. Fasten a hoist and remove half of differential, case and ring gear. Weight is 135 lb. (61.2 kg).



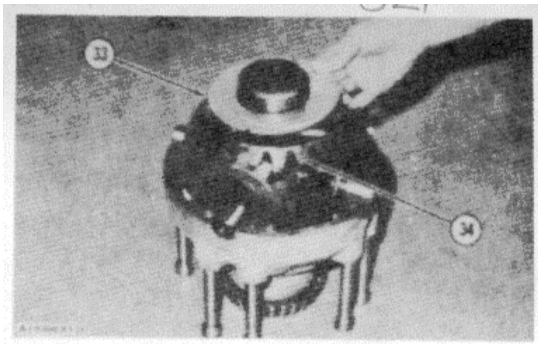
020

16. Remove nuts (32) and make aseparation between ring gear and differential case half.



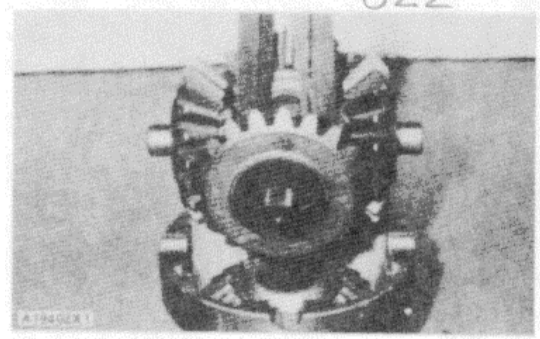
DIFFERENTIAL

17. Remove thrust plate (33) and side gear (34).



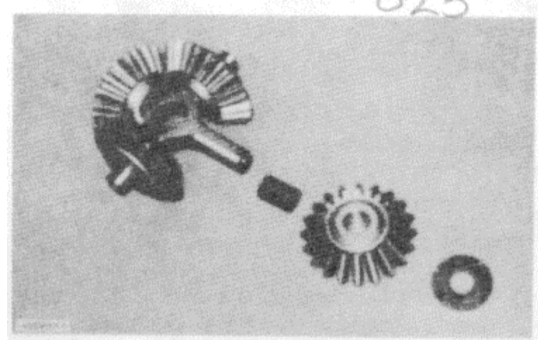
022

18. Remove differential pinion gears as an assembly.



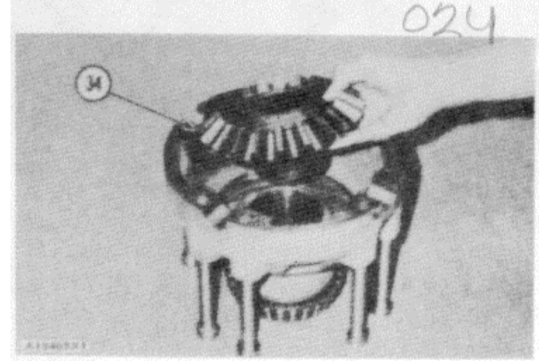
023

19. Remove pinion gears, washers and bearings from spider.



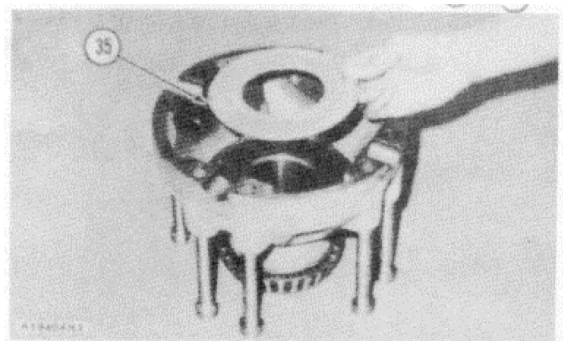
024

20. Remove side gear (34) from housing.



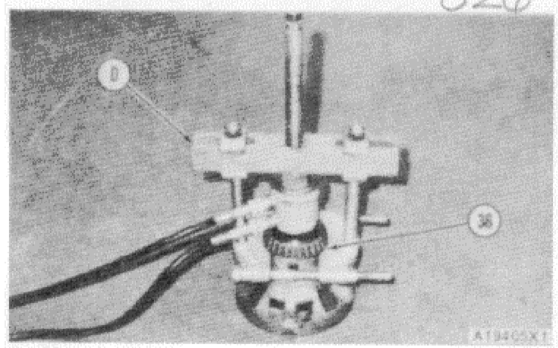
DIFFERENTIAL

21. Remove thrust plate (35) from housing.



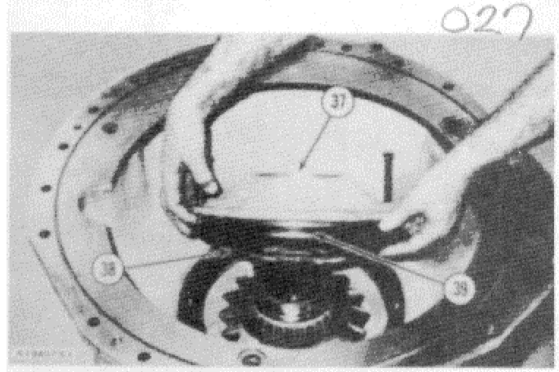
026

22. Remove bearing cone (36) from differential case with tooling (D).



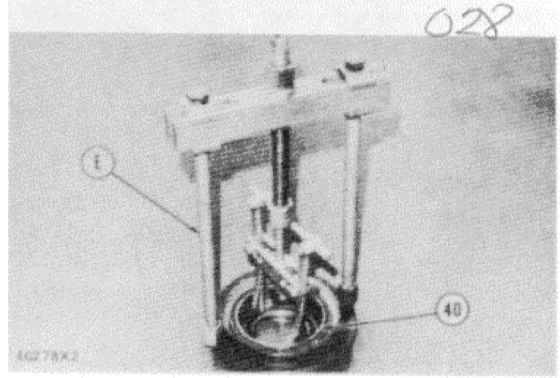
027

23. Turn differential housing over with the input end up. Remove bolts and lock tabs from retainer (37). Install two 1/2"-13 NC forcing screws into retainer (37) and remove it from pinion bearing. Remove and inspect O-ring seal (39). Make a replacement if necessary. Remove shims (38).



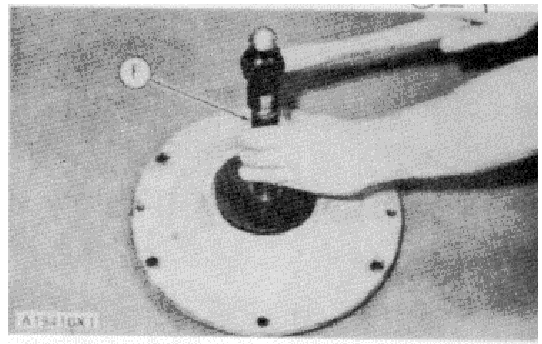
028

24. Remove outer bearing cup (40) from retainer with tooling (E).

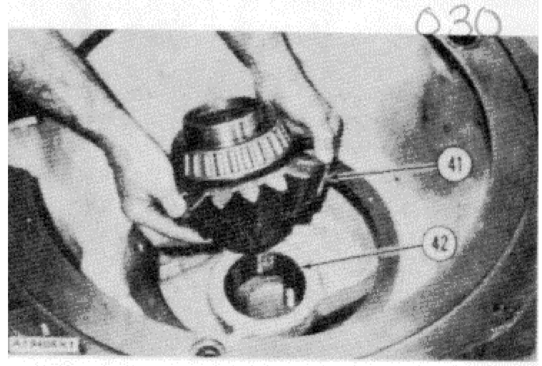


DIFFERENTIAL

25. Remove seal from retainer with tooling (F).

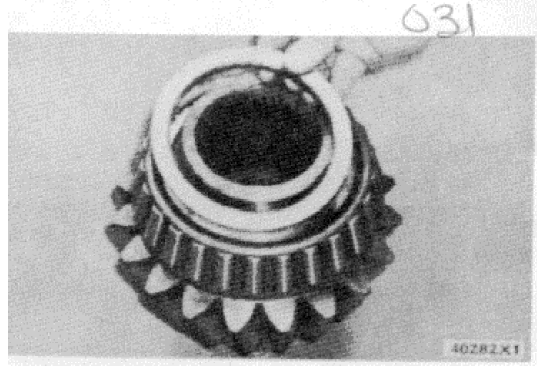


030



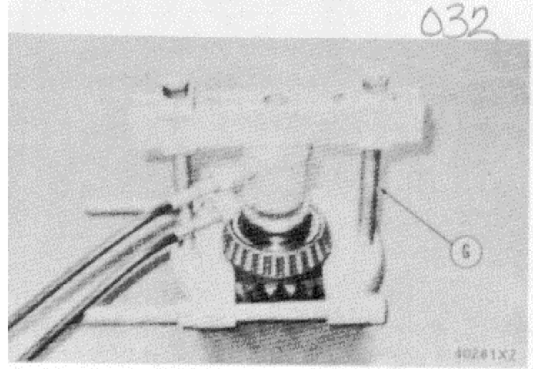
26. Remove pinion assembly (41). Remove bearing cup (42) from carrier housing.

031



27. Remove seal ring from pinion assembly.

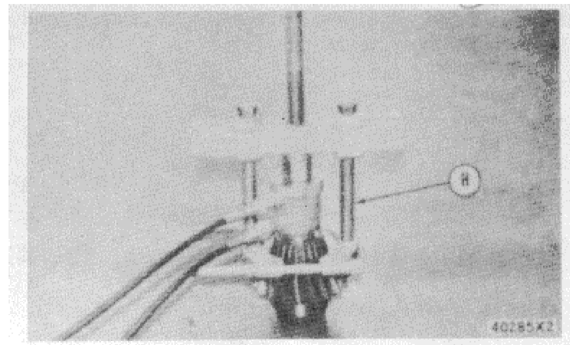
032



28. Remove large pinion bearing cone with tooling (G).

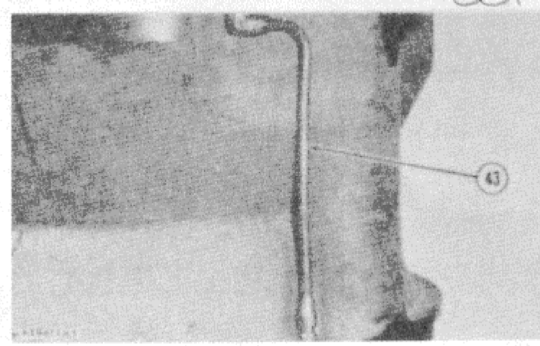
DIFFERENTIAL

29. Remove smaller pinion bearing cone with tooling (H).



001

30. Remove air hose assembly (43).



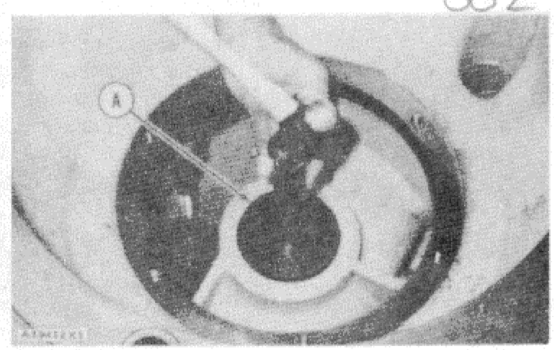
002

ASSEMBLE DIFFERENTIAL

	Tools Needed	A	B	C
1P531	Handle	1		
1P515	Drive Plate	1		
8B7554	Bearing Cup Puller			
	Attachment		1	
5F7345	Screw		1	
8S2328	Dial Test Indicator Group			1

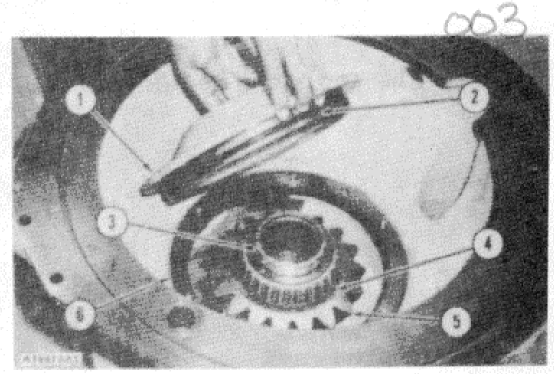
1. Install the air hose assembly on the carrier housing.

2. Lower temperature of pinion bearing cup. Install the cup into carrier housing with tooling (A).



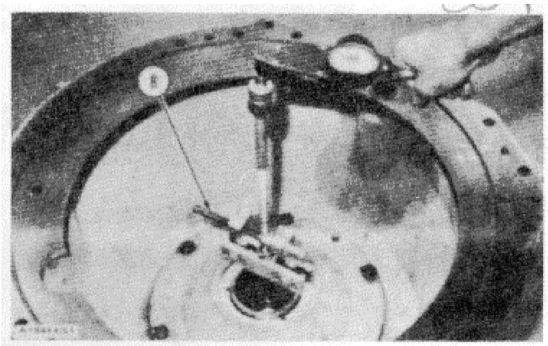
003

3. Heat pinion bearing cone (4) to a temperature of 275°F (135°C) and install them on pinion (5). Install seal ring (3) on pinion. Install pinion assembly into carrier housing. Lower the temperature of bearing race for retainer (1). Install race in retainer. Install a new O-ring seal (2) on retainer. Install shims (6). Install retainer and the bolts that hold it.



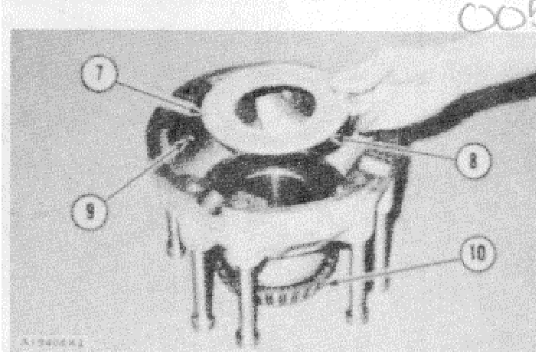
DIFFERENTIAL

NOTE: Do not install seal in retainer until after preload adjustment has been made.



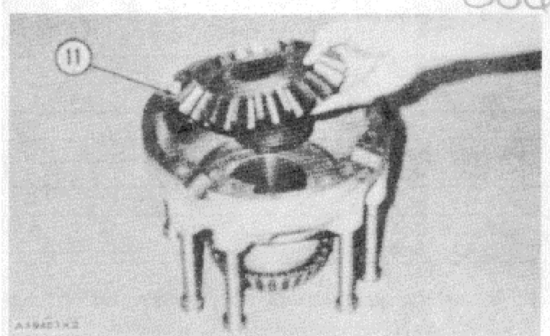
005

4. Use shims as necessary behind retainer to put enough preload on the pinion bearing so the torque needed to turn the pinion is 20 ± 5 lb. in. (2.3 ± 0.6 N•m). Use tooling (B) to turn the pinion slowly while the adjustment is made. After adjustment is made remove the retainer and install seal in retainer.



006

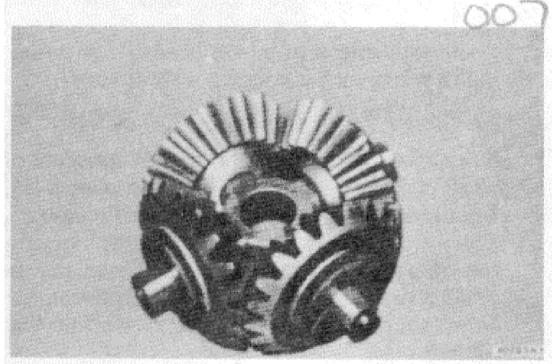
5. Turn differential carrier housing over so output end is up. Heat bearing (10) to a temperature of 275°F (135°C) and install it on case. Install thrust plate (8) with (slot) groove (7) in alignment with pin (9).



007

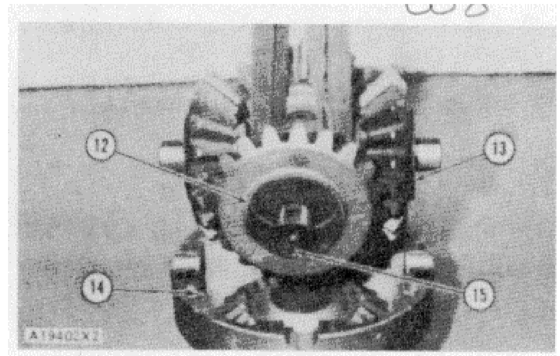
6. Install bottom side gear (11) on thrust plate.

7. Assemble bearings, gears and washers on spider.

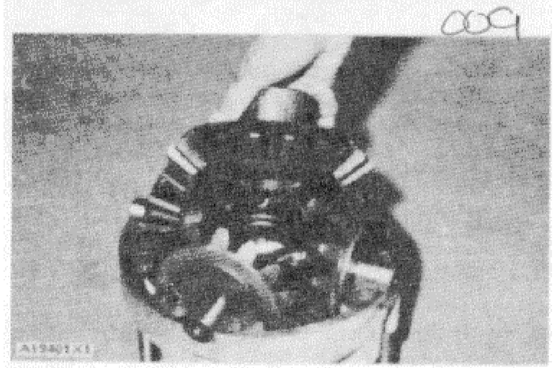


DIFFERENTIAL

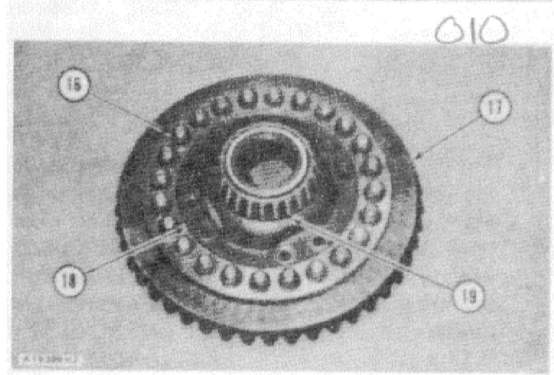
8. Install pinion gears (13) into differential case. Put grooves (slots) (15) in thrust washers (12) in alignment with pins (14) in case.



9. Install top side gear. Put grease on thrust plate and install it in the flange half of the differential case. Put grooves (slots) in thrust plate in alignment.

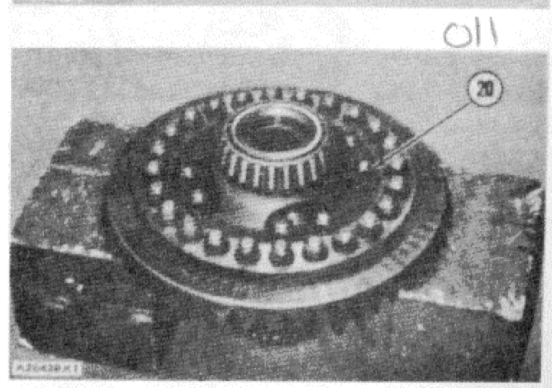


10. Install ring gear (17) on differential case half (18). Install nuts (16) and tighten them to a torque of 265 ±10 Ib. ft. (359.3 ±13.6 N•mm).



NOTE: If bearing cone (19) was removed during disassembly heat it to a maximum temperature of 275°F (135°C) and install it on differential case half.

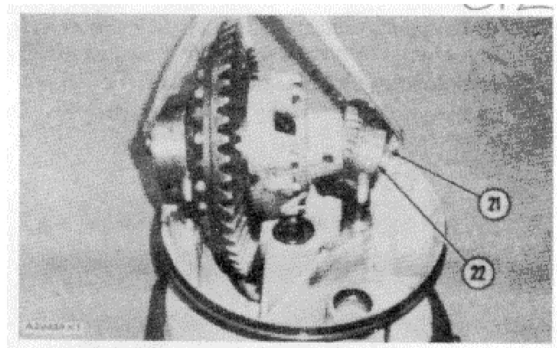
11. Install ring gear and differential case half on other differential half with a hoist. Install nuts (20) and tighten them to a torque of 220 ± 10 lb. ft. (298.3 + 13.6 N•m).



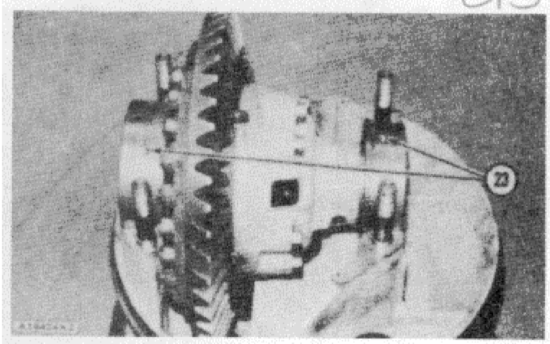
DIFFERENTIAL

12. Install bearing cups, bearing cages (22) and adjusting rings (21) on the differential assembly. Fasten a hoist to the differential assembly and install it on the differential carrier housing.

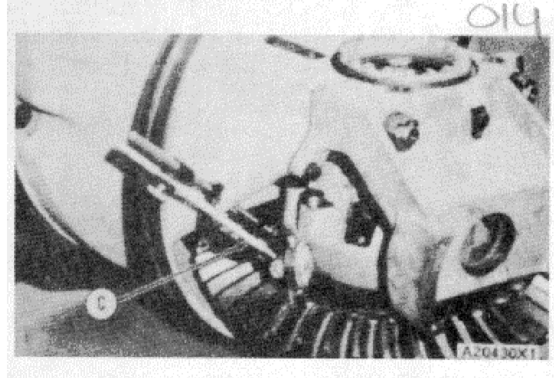
13. Install dowel pins (23) in bearing cages.



013



014



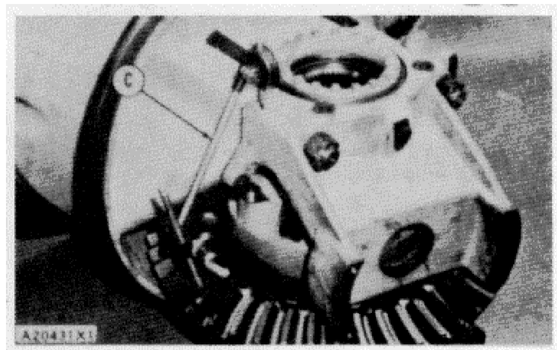
14. Install bearing caps so the dowel pins are in alignment with the holes in the bearing caps. Install nuts on studs. Tighten nuts to a torque of 640 ± 80 lb. ft. (867.7 ±108.5 N•m).

NOTE: If replacement of studs is necessary, tighten them to a torque of 240 ± 20 lb. ft. (325.4± 27.1 N•m).

15. Put the carrier in a position so the centerline for the axle is vertical and the ring gear is toward the top. Install tool (C) and measure the gear clearance (backlash) between ring gear and pinion gear. Turn both adjusting rings (21) the same amount and in the same direction until the gear clearance (backlash) is .014 ± .005 in. (0.36 ± 0.13 mm).

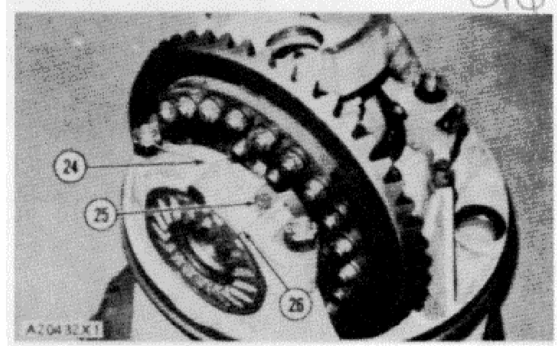
DIFFERENTIAL

16. Use tool (C) and put preload on carrier bearings by rotation of the upper adjusting ring to increase the indication of the dimension by .007 ±.002 in. (0.18 ± 0.05 mm). Check ring gear to pinion gear clearance (backlash) and make an adjustment if necessary.



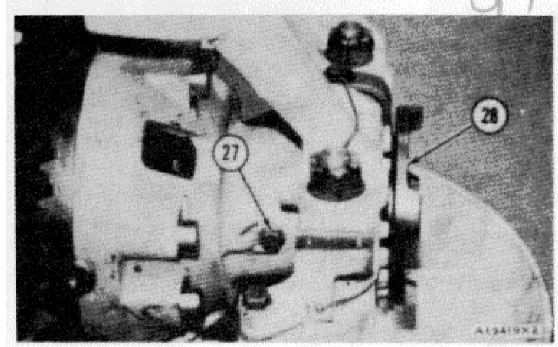
016

17. Put differential carrier housing in its original position. Install locks (26) for the adjusting rings. Install bolts (25) and lockwires (24).



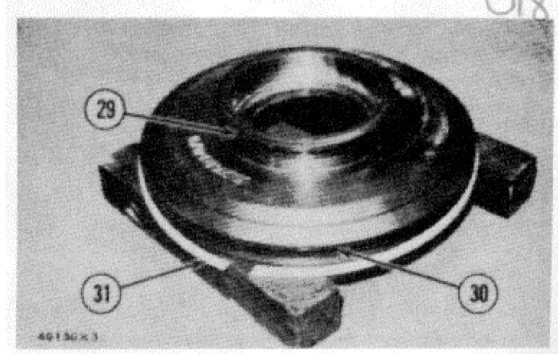
017

18. Install jaw (28) with lockbolts (27) and lockwire.



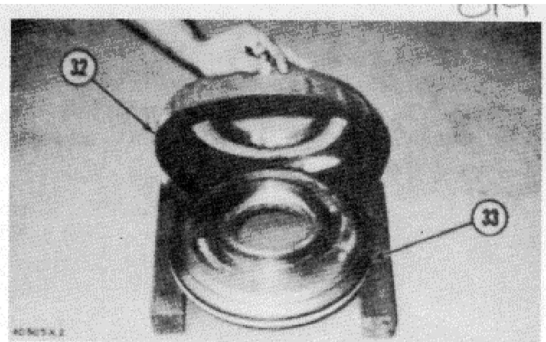
018

19. Install teflon ring (31) and new O-ring seals (30) and (29) on piston.



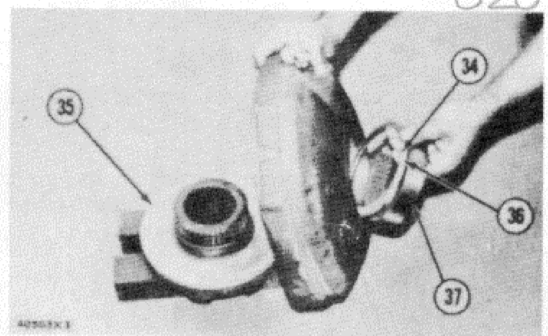
DIFFERENTIAL

20. Install cylinder (32) on piston (33).



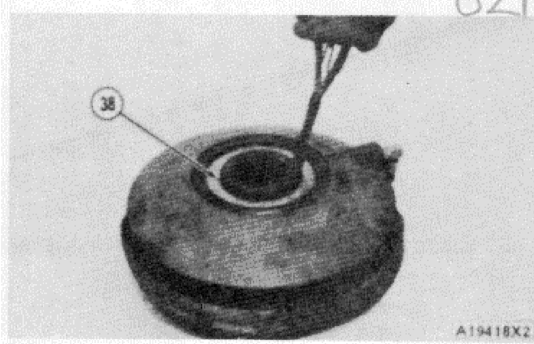
020

21. Install spacer (37), washers (36) and (34) and jaw (35) in cylinder.



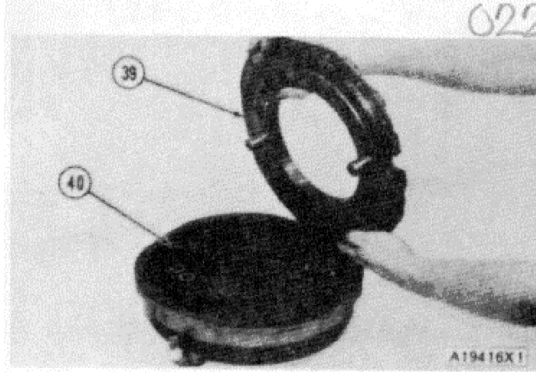
021

22. Install retaining ring (38) on jaw.



022

23. Turn differential lock assembly over and install springs (40). Install cover (39) and bolts.

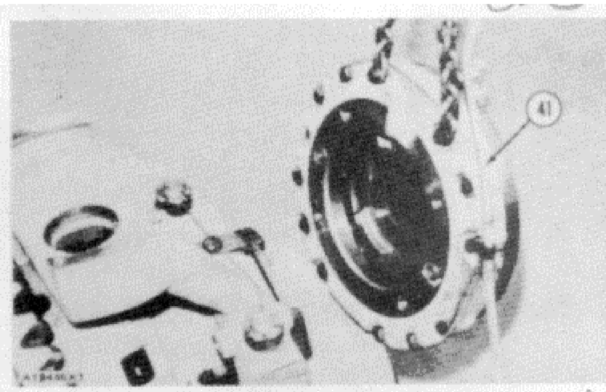


DIFFERENTIAL

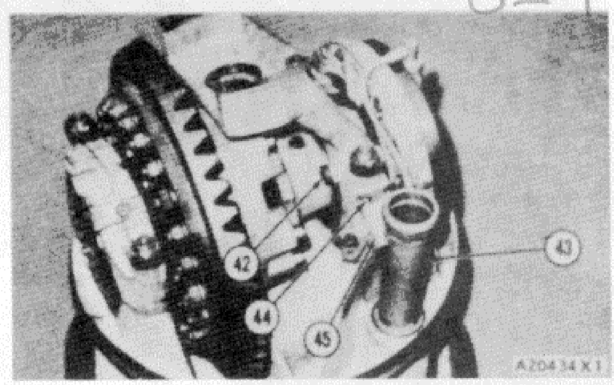
24. Install air line (41) on differential lock assembly. Fasten a hoist to the assembly and install it on the differential.

25. Install bolts (42) that hold the differential lock assembly. Connect air line to its fittings. Install tube (43), bracket (45) and two bolts (44) and lock.

end by:
  a) connection of differential to transmission



024

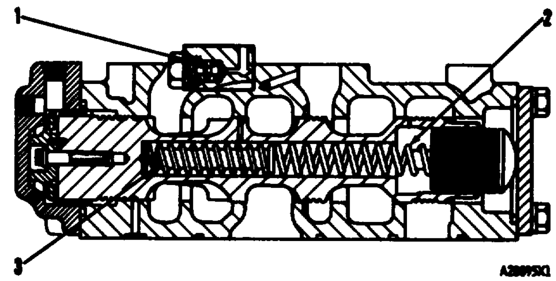


CHAPTER 4
POWER TRAIN_
SPECIFICATIONS

NOTE: For Systems Operation, Testing and Adjusting, make reference to TRACTOR POWER TRAIN.

INDEX **Page**

CONTROL VALVE FOR THE RETARDER (8P7703)



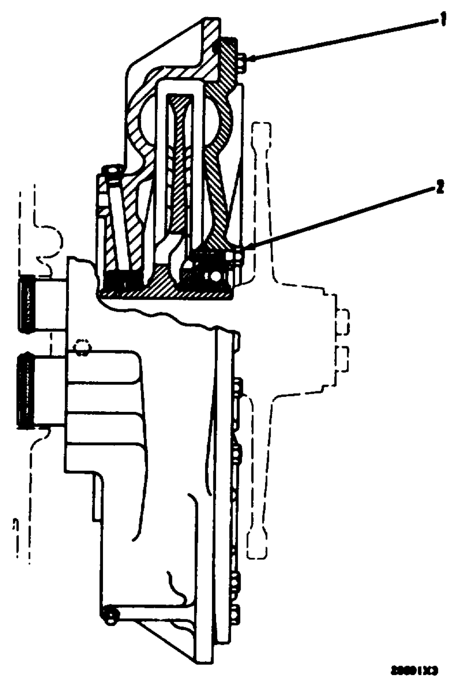
(1) 9H2367 Spring for retarder lubrication:

Length under test force ....937 in. (23.80 mm)
Test force .... 33 ± .03 lb. (1.5 ± 0.1 N)
Free length after test .....1.156 in. (29.36 mm)
Outside diameter............344 in. (8.74 mm)

(2) 1S5046 Spring for the retarder slug:
Length under test force .... 3.81 in. (96.8 mm)
Test force .... 30 ± 2.4 lb. (135 ± 11 N)
Free length after test ....4.00 in. (101.8 mm)
Outside diameter...........766 in. (19.46 mm)

(3) 2S6538 Spring for retarder control:
Length under test force .... 3.00 in. (76.2 mm)
Test force .... 30 ± 2.4 lb. (135 11 N)
Free length after test ...... 4.88 in. (124.0 mm)
Outside diameter...........766 in. (19.46 mm)

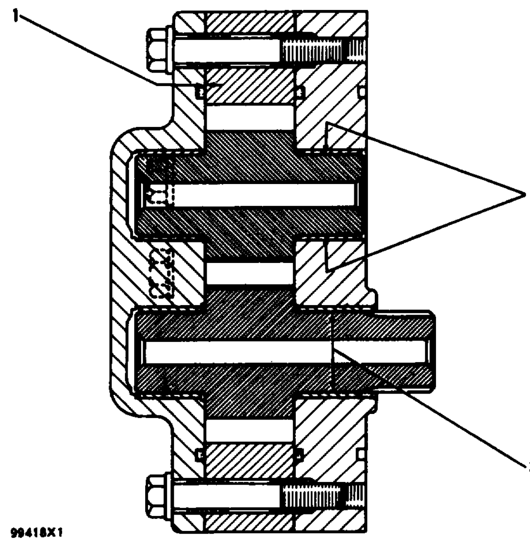
HYDRAULIC RETARDER



(1) Torque for the bolts that hold the stator to the retarder housing .... 36 ± 5 lb. ft. (46 ± 7 N•m)

(2) Torque for bolts that hold the stator to the bearing retainer ...... 36 ± 5 lb. ft. (46 ± 7 N•m)

OIL PUMP OF THE TRANSFER GEARS FOR THE TRANSMISSION (3P203)



Rotation is clockwise when seen from the drive gear.

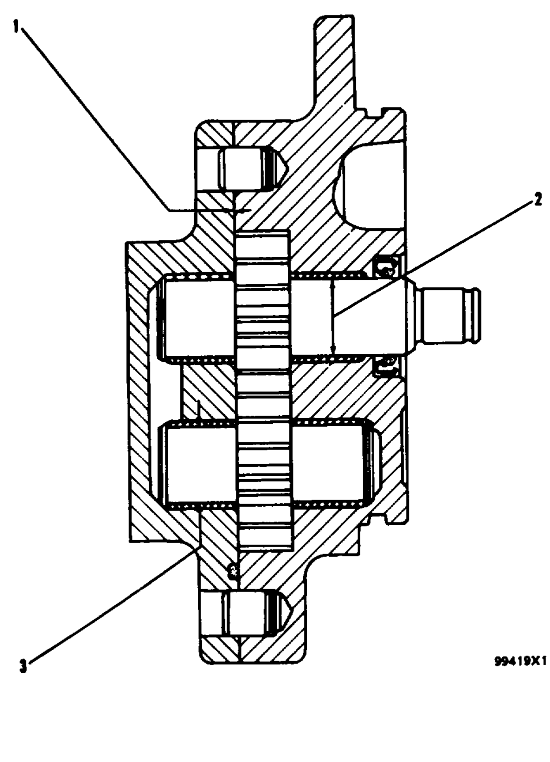
For bench test use SAE 10W oil at 120°F (49°C)
Output .... 41.9 U.S. gpm (159 liter/min)
with pump at .... 2400 rpm
at a pressure of .... 60 psi (415 kPa)

(1) Clearance between the gears and the cover............. 0019 to .0035 in. (0.05 to 0.09 mm)

(2) Diameter of the shafts .... 1.2495 to 1.2499 in. (31.737 to 31.747 mm)

(3) Bore of the manifold and base bearings ....1.2511 to 1.2517 in. (31.778 to 31.793 mm)

OIL PUMP FOR THE FLYWHEEL HOUSING (8D6050)



Rotation is clockwise when seen from the drive gear.

For bench test use SAE 10W oil at 120°F (49°C)
Output 8.3 U.S. gpm (31.5 liter/min)
with pump at .... 1900 rpm
at a pressure of .... 60 psi (415 kPa)

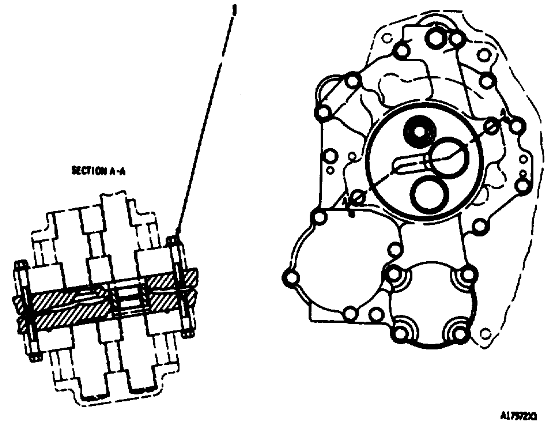
(1) Clearance between the gears and the cover.......... .0019 to .0041 in. (0.05 to 0.10 mm)

(2) Bore of the manifold and cover bearings.......... 8760 to .8766 in. (22.251 to 22.266 mm)

(3) Diameter of the shafts.............. 8745 to .8749 in. (22.212 to 22.223 mm)

MANIFOLD AND SCREENS GROUP

(1) Torque for two bolts..........36 ± 2 lb. ft. (46 ± 3 N•m)



OIL PUMP FOR THE TRANSMISSION (3P204)

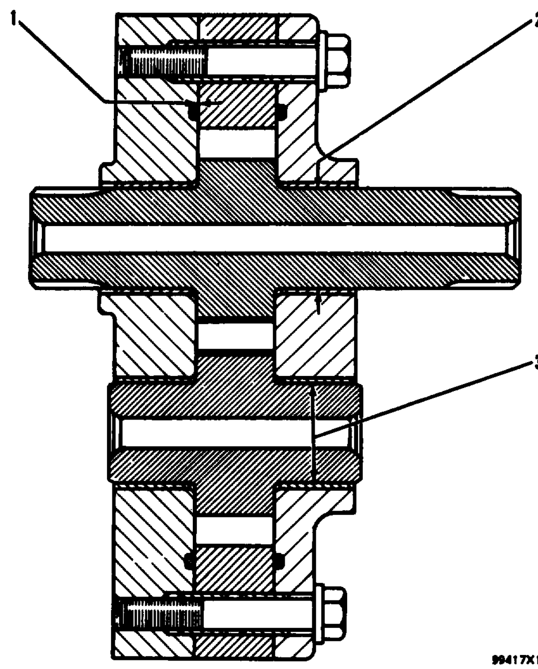
Rotation is clockwise when seen from the drive gear.

For bench test use SAE .10W oil at ....120°F (49°C)
Output .... 24.8 U.S. gpm (93.9 liter/min)
with pump at .... 1800 rpm
at a pressure of ...... 450 psi (3100 kPa)

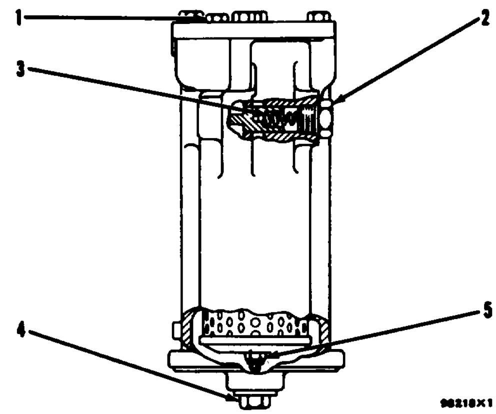
(1) Clearance between the gears and the cover......0019 to .0035 in. (0.05 to 0.09 mm)

(2) Diameter of the shafts...................... 1.2495 to 1.2499 in. (31.737 to 31.747 mm)

(3) Bore of the manifold and base bearings.................. 1.2511 to 1.2517 in. (31.778 to 31.793 mm)

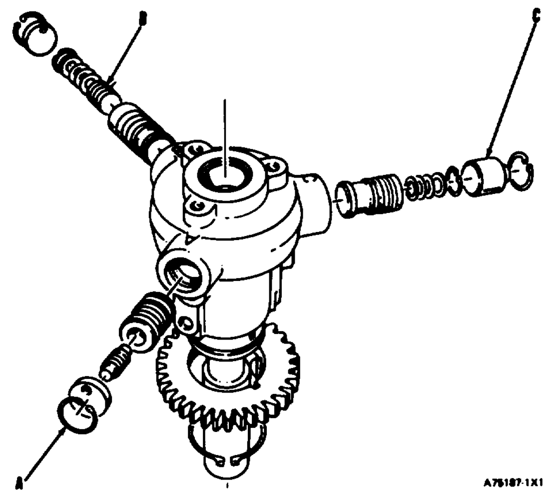


OIL FILTER FOR THE TRANSMISSION



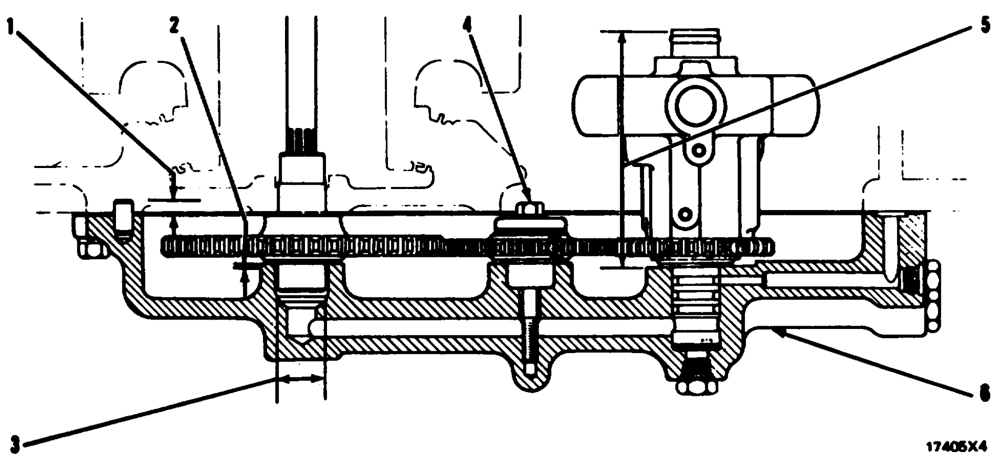
(1) Torque of the plug ..... 35 ± 5 lb. ft. (45 ± 7 N•m)
(2) Torque of the plug ..... 35 ± 5 lb. ft. (45 ± 7 N•m)
(3) 2S5816 Spring:
Length under test force .... 1.35 in. (34.3 mm)
Test force .... 12.2 ± .98 lb. (54.2 ± 4.4 N)
Free length after test .... 1.86 in. (47.2 mm)
Outside diameter............562 ± .067 in. (14.27 ± 1.70 mm)
(4) Torque of the plug ....35 ± 5 lb. ft. (45 ± 7 N•m)
15) Torque for the nut that holds the filter element in position .... 120 ± 24 lb. in. 13.6 ± 8 N•m)

SHIFT GOVERNOR AND DRIVE



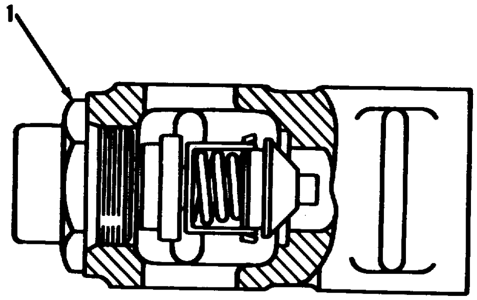
(1) Distance from dowel to housing (6) ....28 in. (7.1 mm)
(2) Depth bearing must be installed below surface of housing (6) .... .020 in. (0.50 mm)
(3) Inside diameter of bearing after installation (new).......... 1.0000 .0003 in. (25.400 ± 0.008 mm)
(4) Torque for bolt...............20 + 2 lb. ft. (25 ± 3 N•m)
(5) Install governor shaft to dimension.............4.969 ± .005 in. (126.21 ± 0.13 mm)

NOTE: Governor reduction valve "A" must be assembled into bore "A", governor reduction valve "B" must be assembled into bore "B", and governor reduction valve "C" must be assembled into bore "C" Install snap rings with bevel down.



TEMPERATURE CONTROL VALVE FOR TRANSMISSION OIL

(1) Torque for the valve .... 65 ± 5 lb. ft. (90 ± 7 N•m)
Valve must start to at.............. 135°F (57°C)
Valve must completely close at........... 170°F (77°C)

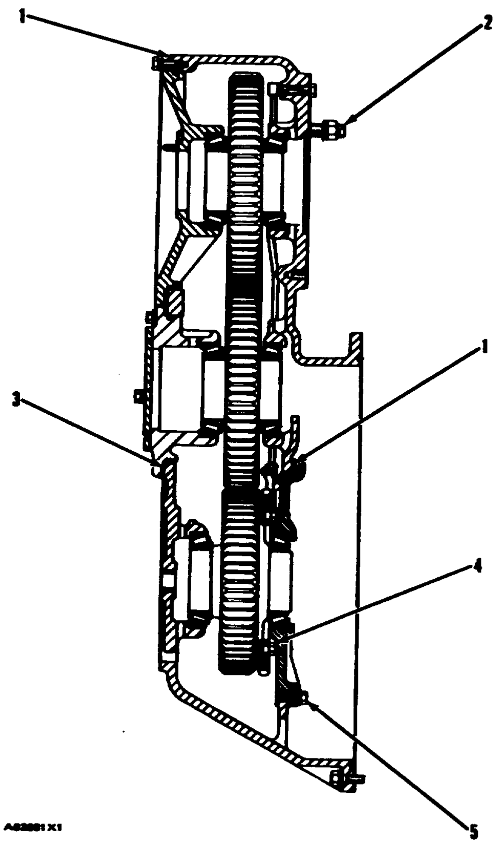


TRANSMISSION TRANSFER GEARS

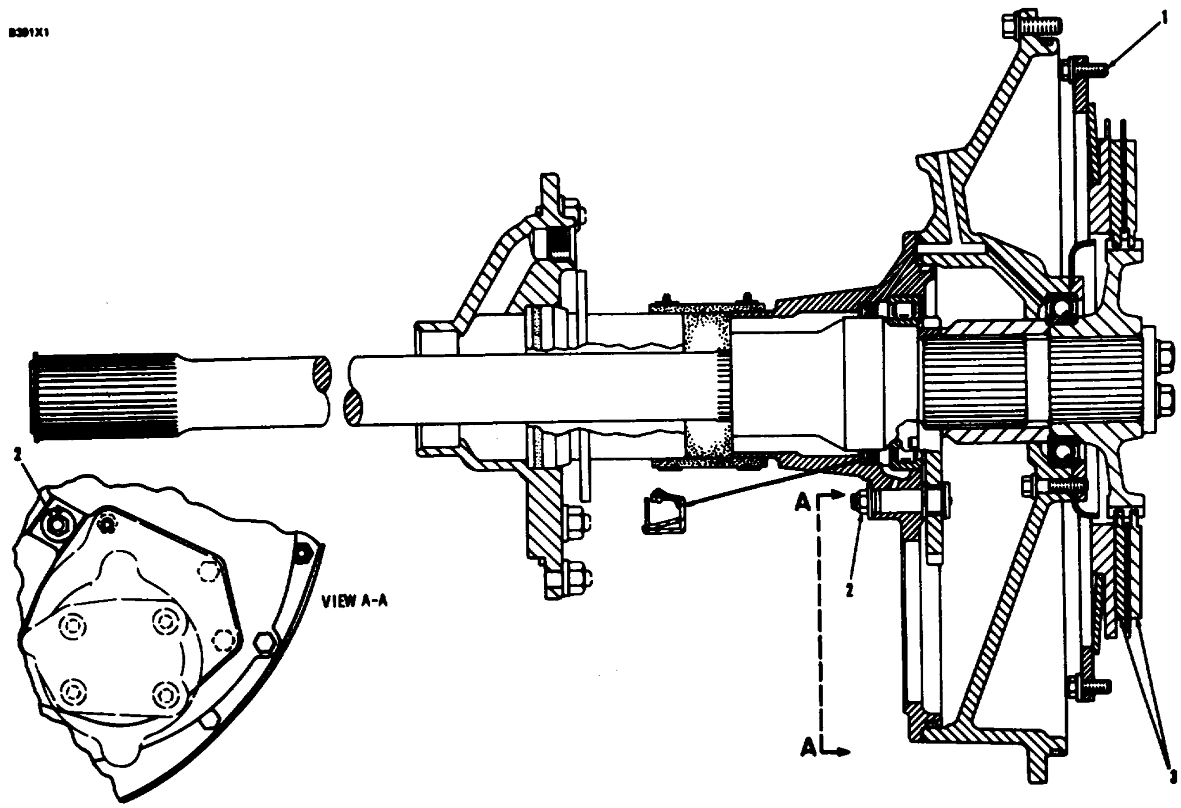
Torque for the bolts that hold the bearing cage for the pump drive to the transfer case...............................36 ± 2 lb. ft. (46 3 N•m)

Torque for the studs that hold the transfer case to the transmission case....40 ± 5 lb. ft (55 ± 7 N•m)

(1) Use shims as needed to get the correct end play of bearings...... .006 ±.002 in. (0.15 ± 0.05 mm
(2) Torque for the studs....... 75 ± 10 lb. (100 ± 14 N•m)
(3) Use shims as needed to get the correct end play of bearing .... .006 ± .002 in (0.15 ± 0.05 mm)
(4) Torque for the six bolts........... 36 ± 2. lb. ft. (46 ± 3 N•m)
(5) Torque for the ten bolts .... 36 ± 2. lb. ft. (46 + 3 N•m)



DRIVE SHAFT GROUP



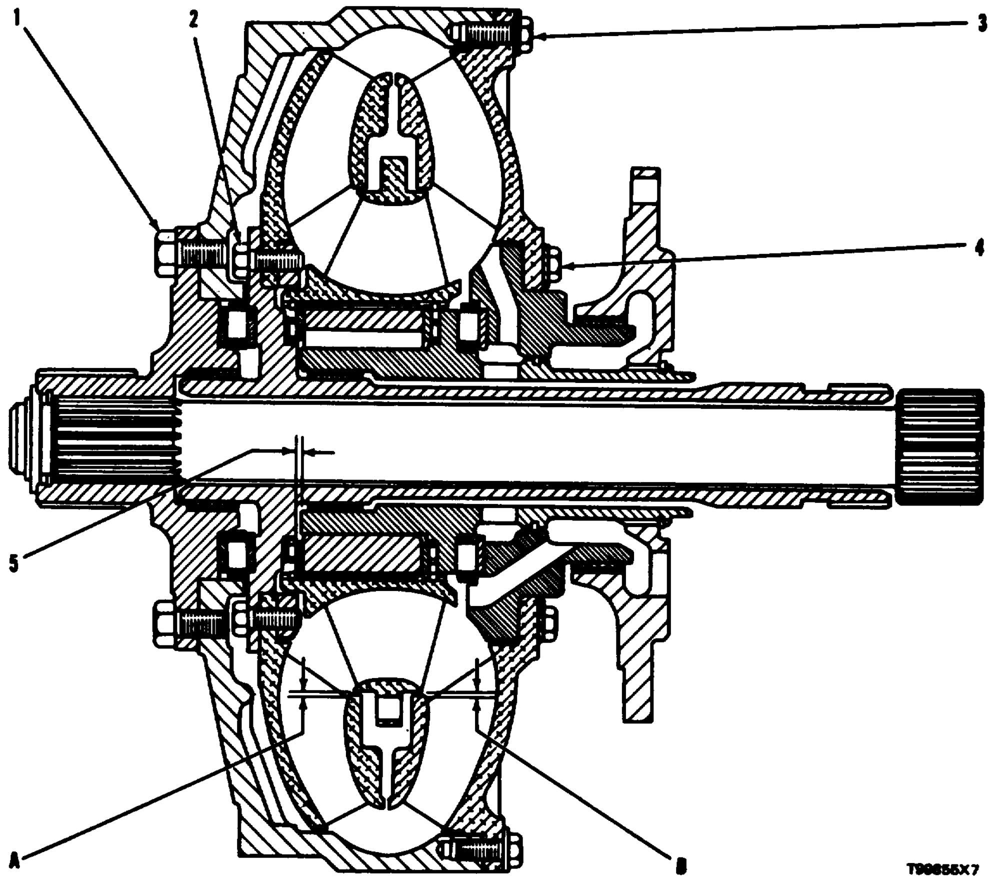
(1) Torque for 24 bolts ....40 ± 5 lb. ft. 155 ± 7 N•m)

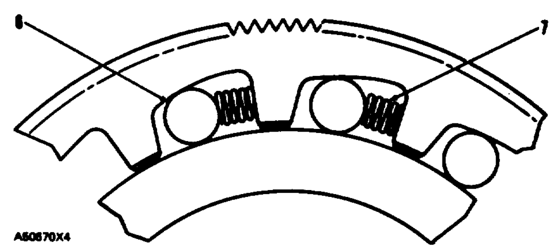
(2) Torque for nut.............................37 ± 5 lb. ft. (50 ± 7 N•m)

NOTE: Before assembly of discs (3), soak in 10W oil for one hour.

TORQUE CONVERTER

(1T1065)





(1) Torque for 12 bolts that hold the flange to housing .... 81 ± 4 lb. ft. (111 ± 5 N•m)

(2) Torque for 20 bolts that hold the hub to the turbine .... 36 ± 2 lb. ft. (46 ± 3 N•m)

(3) Torque for 36 bolts that hold the impeller to housing .... 36 ± 2 lb. ft. (46 ± 3 N•m)

(4) Torque for 12 bolts that hold the hub to the impeller .... 36 ± 2 lb. ft. (46 ± 3 N•m)

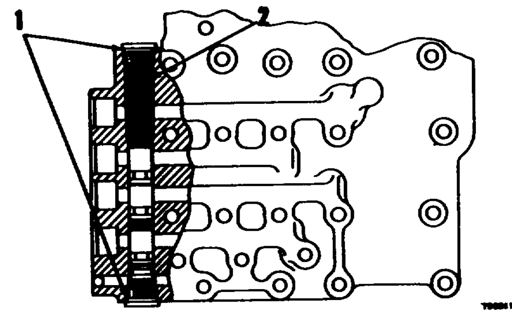
(5) End clearance between the stator carrier and the turbine hub ...... .005 to .077 in. (0.13 to 1.96 mm)

(6), (7) Always install new springs (7) and rollers (6) in the one-way clutch. Install springs with maximum number of loops to outside of cam. Stator should turn freely in a counterclockwise direction only.

Clearance between		Across the diameter	Running*
(A) Turbine & Stator	new	.028 to .036 in. (0.71 to 0.91 mm)	.014 to .018 in. (0.36 to 0.46 mm)
(B) Impeller & Stator	max. worn	.054 in. (1.37 mm)	.027 in. (0.68 mm)

*Half the clearance across the diameter.

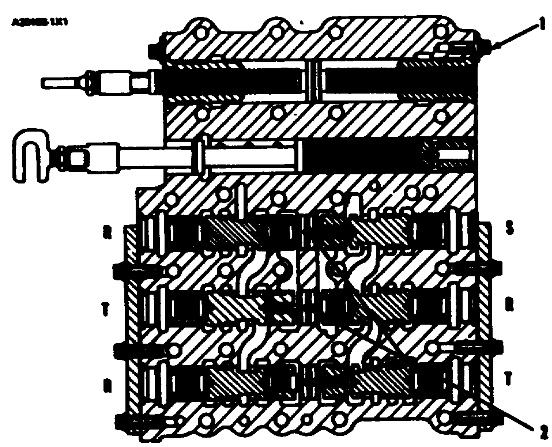
GOVERNOR CUTOFF VALVE
(952818)



(1) Torque for two plug 35 ± 5 lb. ft. (45 ± 7 N•m)

(2) 8S9128 Spring:
Color code ....light green stripe
Length under test force .2.05 in. (52. 1 mm)
Test force ....26.6 ± 2.1 lb. (119 ± 10N)
Free length after test .....2.89 in. (73.4 mm)
Outside diameter ....596 in. (15.15 mm)

AUTOMATIC SELECTOR VALVE
(13P.1)

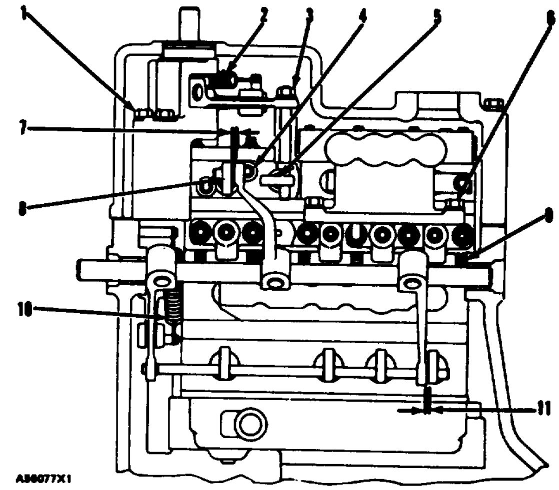


NOTE: Assemble spools (R) into bores (R), spools (T) into bores (T), and spool (S), into bore (S).

(1) Torque for eight bolts ....22 ± 3.b. ft. (28 ± 4 N•m)

(2) Install the dowels so they are below the surface of each face of the valve body.

HYDRAULIC CONTROLS FOR THE TRANSMISSION



(1) Torque for the bolts that hold bracket to housing..... 35 ± 3 lb. ft. (45 + 4 N•m)

(2) 4M1768 Spring:
Length under test force .... 4.24 in. (107.7 mm)
Test force .... 15.2 ± 1.2 lb. (68 ± 5 N)
Free length after test .... 3.76 in. (95.5 mm)
Outside diameter .... 62 in. (15.7 mm)

(3) Torque for spacer nut.......... 256 ± 3 lb. ft. (35 ± 4 N•m)

(4) Torque for 12 point bolts on valve groups.............. 22 + 3 lb. ft. (28 ± 4 N•m)

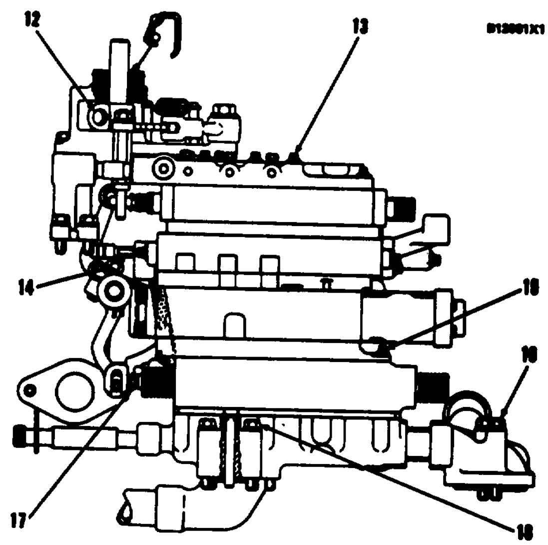
(5) Torque for nut on manual selector spool.................25 ± 5 lb. ft. (35 ± 7 N•m)

(6) Torque for the bolts that hold manifold to the housing .... 35 ± 3 lb. ft. (45 ± 4 N•m)

(7) Clearance between the lever and the link .... 09 in. (2.3 mm)

(8) Torque for nut on hydraulic shift spool .... 15 ± 3 lb. ft. (20 ± 4 N•m)

(9) Torque for the bolts that hold automatic selector valve to shift pressure valve ... 22 3 lb. ft. (28 ± 4 N•m)



(10) 4S86569 Spring:
Length under test force .... 4.72 in. (119.9 mm)
Test force .... 14.3 ± 1.1 lb. (64 ± 5 N)
Free length after test ....4.05 in. (102.9 mm)
Outside diameter....... .2 in. (15.7 mm)

(11) Clearance between the lever and the link .... 06 in. (1.6 mm)

(12) Torque for the nut on the cam looking pins .... 25 ± 3 lb. ft. (35 ± 4 N•m)

(13) Torque for the bolts that hold governor cutoff valve to automatic selector valve .... 22 ± 3 lb. ft. (28 ± 4 N•m)

(14) Torque for the nuts on the lever locking pins................ 25 ± 3 lb. ft. (35 ± 4 N•m)

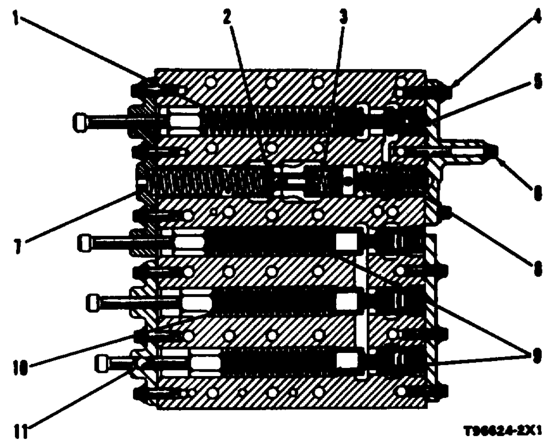
(15) Torque for the bolts that hold automatic shift group to pressure and selector valve group .... 22 ± 3 lb. ft. (28 ± 4 N•m)

(16) Torque for the bolts that hold oil manifold to clutches... 35 ± 3 lb. ft. (46 ± 4 N•m)

(17) Torque for nuts on selector valve spools............... 25 ± 5 lb. ft. (35 ± 7 N•m)

(18) Torque for the bolts that hold manifold to clutches..........35 ± 3 lb. ft. (46 ± 4 N•m)

SHIFT PRESSURE VALVE
(3P2973)



(1) 8P5159 Spring:
Length under test force .... 3.63 in. (92.2 mm)
Test force .... 69.23 ± 5.54 lb. (308.0 ± 24.6 N)
Free length after test ....5.88 in. (149.4 mm)
Outside diameter .... 859 in. (21.82 mm)

(2) 7M1397 Spacer for the priority valve:
Thickness of one 7M1397 Spacer...........036 in. (0.91 mm)
Each 7M1397 Spacer will change the oil pressure to the semiautomatic controls by .... 9 psi (60 kPa)

(3) 5M9548 Spring:
Length under test force .... 84 in. (21.3 mm)
Test force .... 1.00 ± .08 lb. (4.0 ± 0.4 N)
Free length after test . 1.34 in. (34.0 mm)
Outside diameter .... 48 in. (12.2 mm)

(4) Torque for 11 bolts .... 22 ± 3 lb. ft. (28 ± 4 N•m)

(5) 4M2381 Spring:
Length under test force .....48 in. (12.2 mm)
Test force .... 517 ± .041 lb. (2.30 ± 0.18 N)
Free length after test ....89 in. (22.6 mm)
Outside diameter .... 300 in. (7.62 mm)

(6) Torque for the bolt ..... 22 ± 3 lb. ft. (28 ± 4 N•m)

(7) 8M6402 Spring:
Length under test force 3.38 in. (85.9 mm)
Test force .... 189 ± 15 lb. (840 ± 67 N)
Free length after test 4.35 in. (110.5 mm)
Outside diameter 780 in. (19.81 mm)

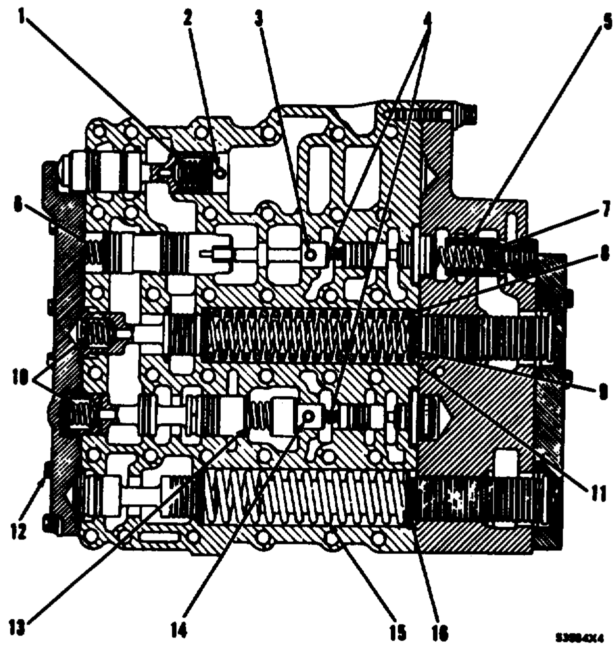
(8) 1S7501 Spring:
Length under test force .... 1.81 in. (46.0 mm)
Test force .... 21.2 ± 1.6 lb. (94 ± 7 N)
Free length after test .....2.48 in. (63.0 mm)
Outside diameter ....590 in. (15.0 mm)

(9) P9585 Spring:
Color code .... red stripe
Length under test force .... 3.96 in. (100.6 mm)
Test force .... 8.07 ± .65 lb. (36.0 ± 29 N)
Free length after test ....5.50 in. (139.7 mm)
Outside diameter ....859 in. (21.82 mm)

(10) S7008 Spring:
Color code..................... yellow stripe
Length under test force .... 3.90 in. (99.1 mm)
Test force .... 15.7 ± 1.3 lb. (70 ± 6 N)
Free length after test..... 8.33 in. (211.6 mm
Outside diameter........... 89 in. (21.82 mm)

(11) 73801 Spring (not shown) for adjustment bolts:
Length under test force ....374 in. (9.50 mm)
Test force .... 70 ± 6 lb. (310 ± 27 N)
Free length after test..... 47 in. (13.89 mm)
Outside diameter............375 in. (9.53 mm)

PRESSURE CONTROL VALVE FOR THE TRANSMISSION (8P2800)



(1) 4M2381 Spring for the inlet relief valve for torque converter:
Length under test force .....48 in. (12.2 mm)
Test force ....517 + .041 lb. (2.30 ± 0.18 N)
Free length after test ....89 in. (22.6 mm)
Outside diameter ....300 in. (7.62 mm)

(2), (3), (14) Install dowels so they are below the surface of each face of the valve body.

(4) 3S8059 Spring for the check valves (two).
Length under test force 1.35 in. (34.3 mm)
Test force ....3.02 + .24 lb. (13.5 ± 1.1 N)
Free length after test .....1.78 in. (45.2 mm)
Outside diameter .... 297 in. (7.54 mm)

(5) 3S1374 Spring of the relief valve for the load piston:
Length under test force .... 1.44 in. (36.6 mm)
Test force .... 22.4 ± 1.8 lb. (100 ± 8 N)
Free length after test ....1.84 in. (46.7 mm)
Outside diameter .... 62 in. (14.27 mm)

(6) 4M2399 Spring for the flow control valve:
Color code ...... light blue stripe
Length under test force 2.24 in. (56.9 mm)
Test force .... 24.4 ± 2 lb. (109 ± 9 N)
Free length after test ....3.26 in. (82.8 mm)
Outside diameter .... 600 in. (15.24 mm)

(7) Spacers of the relief valve for the load pistons:
Thickness of one 2S674 Spacer ...... 036 in. (0.91 mm)
One 2S674 spacer will change pressure .... 18.2 psi (125 kPa)
Thickness of one 2S675 Spacer .... 016 in. (0.41 mm)
One 2S675 spacer will change pressure .... 8.1 psi (56 kPa)

(8) 2S667 Spring (outer) for the load piston and modulation relief valve:
1st Test:
Length under test force........ 4.989 in. (128.72 mm)
Test force........ 21.4 ± 3.0 lb. (96 ± 13 N)
2nd Test:
Length under test force.......3.719 in. (94.46 mm)
Test force........ 246.0 ± 9.9 lb. (1095 ± 44 N)
Free length after test .... 5.11 in. (129.8 mm)
Outside diameter .... 1.297 in. (32.94 mm)

Pressure Control Valve For The Transmission (Cont.)

(9) 2S668 Spring (inner) for the load piston and modulation relief valve:
1st Test:
Length under test force .... 4.989 in. (126.72 mm)
Test force .... 13.6 ± .9 lb. (60 ± 4 N)
2nd Test:
Length under test force ...3.719 in. (94.46 mm)
Test force ......68.4 ± 2.6 lb. (305 ± 12 N)
Free length after test .... 5.30 in. (134.6 mm)
Outside diameter........812 in. (20.62 mm)

(10) 6M9948 Spring for the poppet valves (two):
Length under test force.....84 in. (21.3 mm)
Ten force ...... 1.00 ± .08 lb. (4.0 ± 0.4 N)
Free length after test ....1.34 in. (34.0 mm)
Outside diameter ....48 in. (12.2 mm)

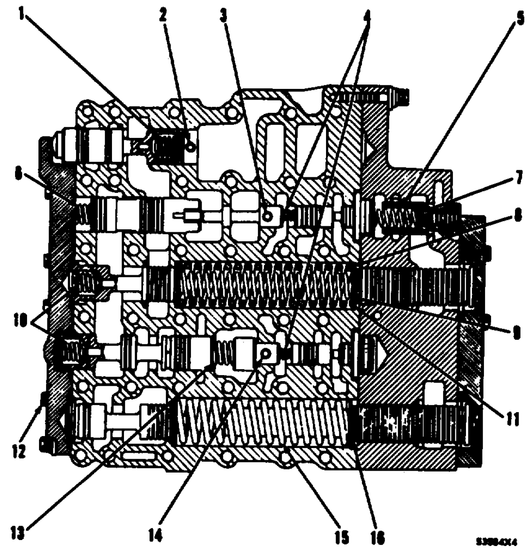
(11) Spacers for modulation relief valve:
Thickness of one 8S6214 Spacer.....016 in. (0.41 mm)
One 8S6214.. Spacer will change pressure........ 4.5 psi (31 kPa)
Thickness of one 8S6215 Spacer.....036 in. (0.91 mm)
One 8S6215 Spacer will change pressure........ 10 pi (70 kPa)

12) Torque for the bolts that hold the cover to the body.... 22 ± 3 lb. ft. (28 ± 4 N•m)

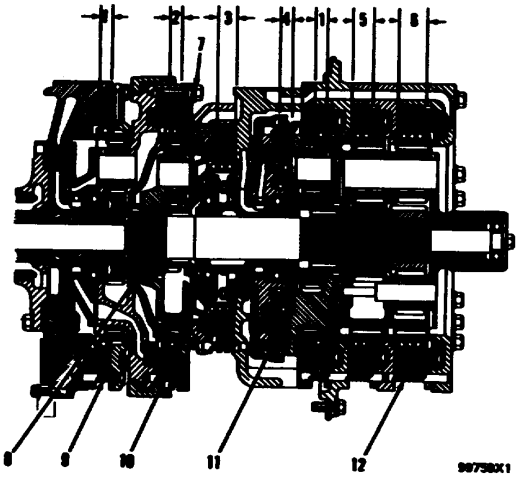
(13) 283020 Spring:
Color code .... light green stripe
length under test force............... 2.12 in. (53.8 mm)
Test force...... 10 ± .8 lb. (45 ± 4 N)
Free length after test ....3.68 in. (93.5 mm)
Outside diameter ....700 in. (17.78 mm)

(15) 587774 Spring for modulation reduction valve:
Color code .... light green stripe
1st Test:
Length under test force ......4.86 in. (124.08 mm)
Test force ......48.1± 3.4 lb. (214 ±16 N)
2nd Test:
Length under test force .. 3.542 in. (89.97 mm)
Test force ......211.7 ± 8.4 lb. (942 ± 38 N)
Free length after test ....5.218 in. (134.1 mm)
Outside diameter ....1.3756 in. (34.93 mm)

(16) Spacers of the modulation reduction valve:
Thickness of one 8S214 Spacer....016 in. (0.41 mm)
One 8S6214 Spacer will change pressure........ 2.5 psi (17 kPa)
Thickness of one 8S6215 Spacer.....036 in. (0.91 mm)
One 886216 Space will change pressure .... 5.6. psi (38 kPa)



TRANSMISSION
(2P9311)



(1) Thickness of one new plate and two new discs for the No. 1 and No. 5
clutches...............679 to .697 in. (17.25 to 17.70 mm)
Thickness of one new
2P4472 Plate ....247 to .253 in. (6.27 to 6.43 mm)
Thickness of one new 5M6122
Disc.................. .216 to .222 in. (5.49 to 5.64 mm)

(2) Thickness of one new plate and two new disc for the No. 2
clutch........................679 to .697 (17.25 to 17.70 mm)
Thickness of one new
3S40 Plate ....247 to .222 in. (6.27 to 6.43)
Thickness of one new 3P3561
of 9P4251 Disc.........216 to .222 in. (5.49 to 5.64 mm)

(3) Thickness of two new plates and three new disc for the No. 3
clutch................ 1.070 to 1.100 in. (27.18 to 27.94 mm)
Thickness of one new
1K8953 Plate ....247 to .253 in. (6.27 to 6.43 mm)
Thickness of one new 4S8694
or 9P4254 Disc ....192 to .198 in. (4.88 to 5.03 mm)

(4) Thickness of one new plate and two new discs for the No. 4
clutch................ .631 to .649 in. (16.03 to 16.48 mm)
Thickness of one new
3S44 Plate ....247 to .253 in. (6.27 to 6.43 mm)
Thickness of one new
4S8724 Disc.............192 to 1.98 in. (4.88 to 5.03 mm)

(5) Thickness of two new plates and three new discs for the No. 6
clutch.............1.142 to 1.172 in. (29.01 to 29.77 mm)
Thickness of one new
2P4472 Plate ....247 to .253 in. (6.27 to 6.43 mm)
Thickness of one new
5M6122 Disc............216 to .222 in. (5.49 to 5.64 mm)

(6) Thickness of three new plates and four new discs for the
No. 7 clutch...... 1.605 to 1.647 in. (40.77 to 41.83 mm)
Thickness of one new
2P4472 Plate ....247 to .253 in. (5.49 to 5.64)
Thickness of one new
5M6122 Disc............216 to .222 in. (5.49 to 5.64

(7) Torque for the 20 bolts..... 85 ± 5 lb. ft. (115 ± 7 N•m)

(8) Torque for the 4 bolts....... 25 ± 3 lb. ft. (35 ± 4. N•m)

(9) 4M9592 Spring:
Length under test force........1.375 in. (34.93 mm)
Test force................26.2 ± 1.3 lb. (116 ± 6 N)
Free length after test..... 1.76 in. (44.7 mm)
Outside diameter......562 in. (14.38 mm)

Transmission (Cont.)

(10) 9M6193 Spring Assembly:

1st Test:

Length under test force .... 49 in. (12.4 mm)

Test force ......24.6 ± 2.5 lb. (110 ± 11 N)

2nd Test:

Length under test force .... 38 in. (9.7 mm)

Test force ......46.2 ± 4.2 lb. (206 ± 19 N)

Assembled length .560 ± .005 in. (14.22 ± 0.13 mm)

(11) 6F6678 Spring:

Length under test force........1.938 in. (49.21 mm)

Test force...... 26.5 ± 2.1 lb. (118 ± 9 N)

Free length after test ...... 2.438 in. (61.91 mm)

Outside diameter ....500 in. (12.70 mm)

(12) 1M9691 Spring:

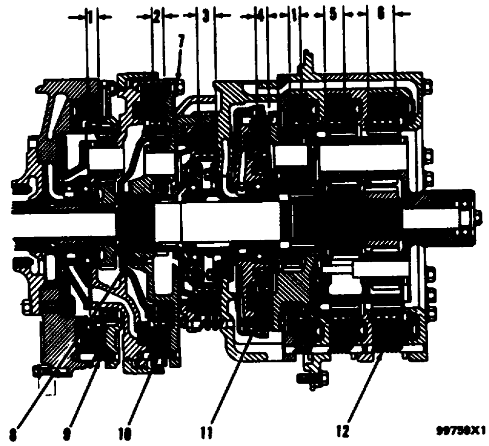
Color code ....red

Length under test force........... 2.47 in. (62.7 mm)

Test force..................28.04 ± 1.4 lb. (125 ± 6 N)

Free length after test .... 3.07 in. (78.0 mm)

Outside diameter .... 563 in. (14.30 mm)



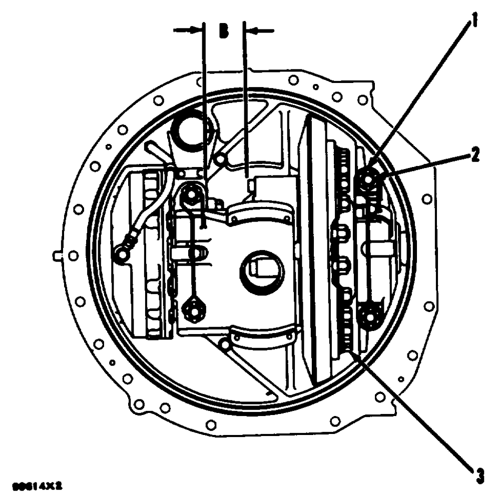
DIFFERENTIAL AND BEVEL GEAR (8D5060)

(1) Torque for the nuts that hold the bearing caps to the carrier............ 640 ± 80 lb. ft. (865 ± 110 N•m)

(2) Torque for the studs that hold the bearing caps to the carrier............ 240 ± 20 lb. ft. 1320 ± 25 N•m)

(3) Torque for the nuts that hold the bevel gear to the differential case (with lubricant on threads and tightened ...... by hand). 265 ± 10 lb. ft. (360 ± 14 N•m)

(9) Torque for the nuts that hold the cases together .....220 + 10 lb. ft. (295 + 14 N•m)



Adjustment For The Differential end Bevel Gear:

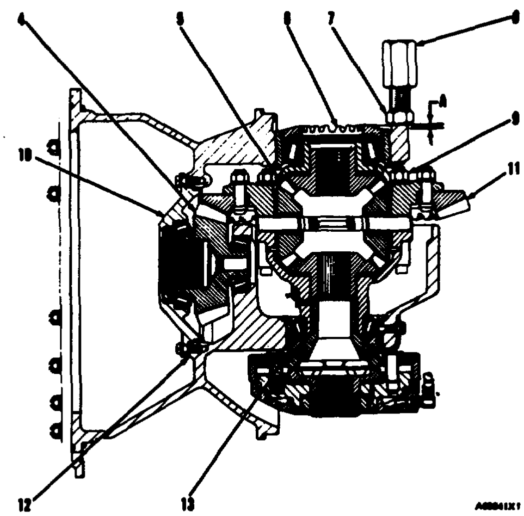
1. Install the bearings on pinion (4) and install pinion (4) in the carrier.
2. Use shims (12) as necessary behind retainer (10) to put enough preload on the pinion bearings so the torque needed to turn pinion (4) is..................... 20 ± 5 lb. in. (2.3 ± 0.6 N•m)

NOTE: Do not install the seal in retainer (10) until after the adjustment is made. Turn the pinion slowly while making the adjustment.

3. Install gears (5) in the differential case. Turn the gears. The torque needed to turn gears (5) must not be more than .... 25 lb. ft. (35 N•m)
4. Install the differential assembly in the carrier. Put the carrier in a position so the centerline for the axle is vertical and adjustment ring (6) is down.

Differential and Bevel Gear (Cont.)

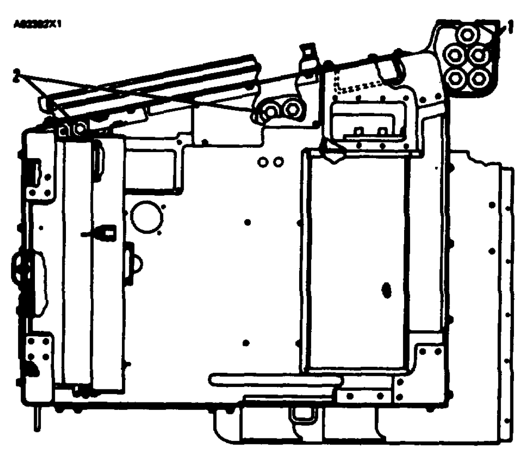
5. Install the bearing caps.
6. Turn adjustment ring (6) to get approximate amount of free movement (backlash) between bevel gear (11) and pinion (4).
7. Using a dial indicator, measure the amount of change in dimension (B). Turn adjustment ring (13), to get the maximum preload on carrier bearings, until dimension (B) has an increase of .... .007 ± .002 in. (0.18 ± 0.06 mm)
8. Using a dial indicator, measure the backlash between bevel gear (11) and pinion (4). Turn adjustment rings (6) and (13) the same amount and in the same direction until the backlash is .... 014 ±.005 in. (0.36 ± 0.13 mm)



NOTE: If the adjustment rings are turned like this, there will be no change in the preload of the bearings.

9. After installing the differential in the machine, remove the cover from the top of the differential housing. Loosen nut (8) and turn stop (7) so clearance (A) between stop (7) and the bearing cap is .... 002 ± .001 in. (0.05 ± 0.03 mm)
10. Tighten nut (8) and install the cover.

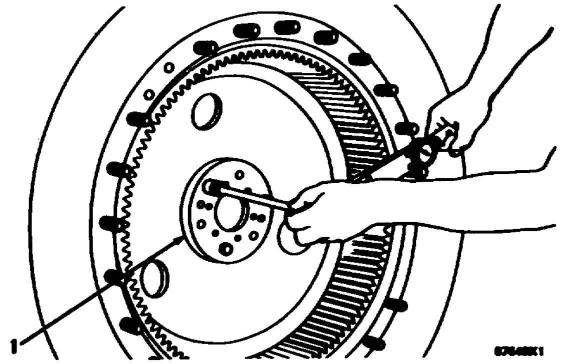
OPERATOR COMPARTMENT

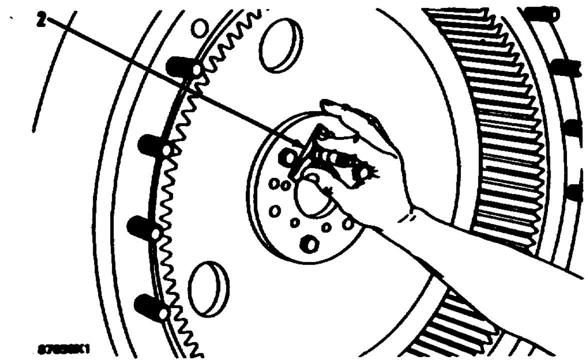


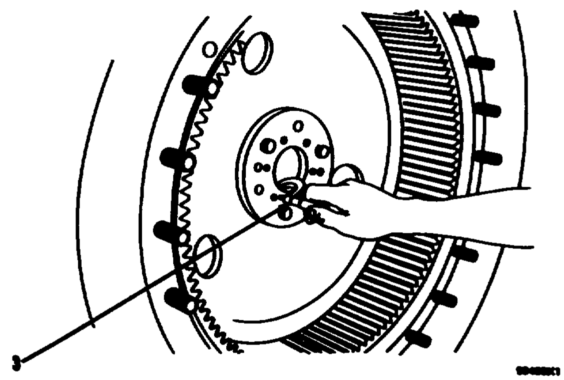
TYPICAL EXAMPLE

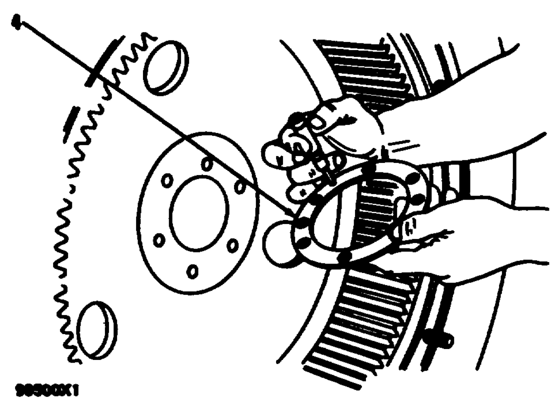
(1), (2) Torque for 19 bolts .... 320 ± 15 lb. ft. (436 ± 20 N•m)

ADJUSTMENT OF THE WHEEL BEARINGS







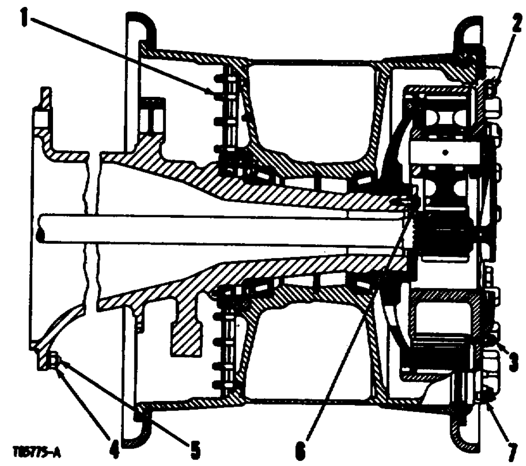


NOTE: Before adjustment of the wheel bearings is started, check to be sure the bearing cups have a tight seat against the bottom of the bore in the wheel. Use a .001 in. (0.03 mm) or .002 in. (0.05 mm) feeler gauge to check for any clearance behind the bearing cup. If any clearance is found, use a bearing driver or press to move the bearing cup until it has a tight seal with no clearance.

ADJUSTMENT ON THE MACHINE:

1. Put the wheel and bearings in position on the axle housing.
2. Install the hub and ring gear.
3. Install retainer (1) without shims (4). Use three bolts as shown.
4. While the wheel is turned, tighten the bolts to 25 lb. ft. (35 N•m). Tighten each bolt one time only.
5. While the wheel is turned, tighten the bolts to 50 lb. ft. (70 N•m). Tighten each bolt one time only.
6. Use a depth micrometer (2) to measure through the holes with threads in the retainer and find the average depth.
7. Use an outside micrometer (3) to measure the thickness of the retainer at the holes with threads and find the average thickness.
8. Find the difference between in two average measurements. This difference is the distance between the end of the axle housing and the retainer.
9. Remove retainer. Install enough shims (4), between the axle housing and the retainer, so their thickness is .012 in. (0.30 mm) more than the distance found in Step 7.
10. Install retainer (1). While turning the wheel, tighten the bolts that hold retainer to the axle housing to a torque of............... 100 ± 10 lb. ft. (135 ± 14 N•m)

FINAL DRIVE, WHEELS, BRAKES AND AXLES



Torque for the bolts that hold the plate to the cover of the final drive .... 25 ± 5 lb. ft. (35 ± 7 N•m)

(1) Torque for the studs that hold the brake drum to the wheel .... 40 ± 5 lb. ft. (55 ± 7 N•m)
Torque for the nuts that hold the brake drum to the wheel .... 95 ± 5 lb. ft. (130 ± 7 N•m)

(2) Torque for the studs that hold the carrier of the final drive to the wheel......... 110 ± 5 lb. ft. (149 ± 7 N•m)

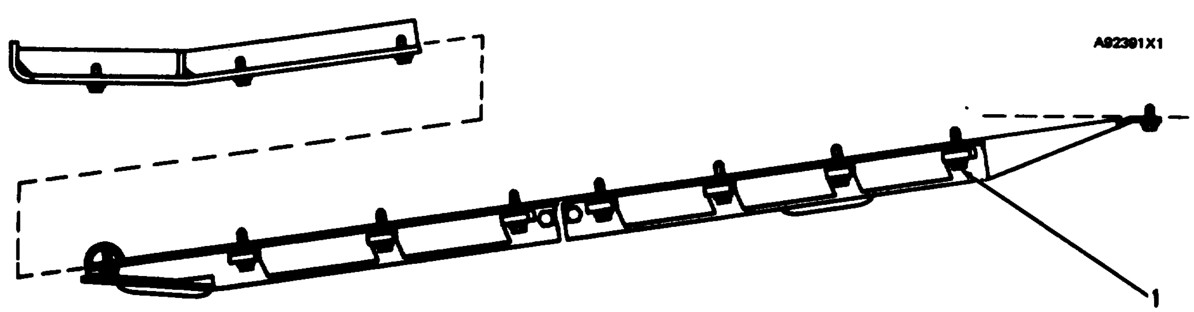
(3) Torque for the studs that hold the carrier of the final drive to the cover .... 40 ± 5 lb. ft. (55 ± 7 N•m)

(4) Torque for the nuts that hold the axle housing to the differential case .... 220 ± 10 lb. ft. (295 ± 15 N•m)

(5) Torque for the studs that hold the axle housing to the differential case .... 110 ± 15 lb. ft. (149 ± 20 N•m)

(6) Torque for the bolts that hold the ring to the axle housing................................ 100 ± 10 lb. ft. (135 ± 14 N•m)

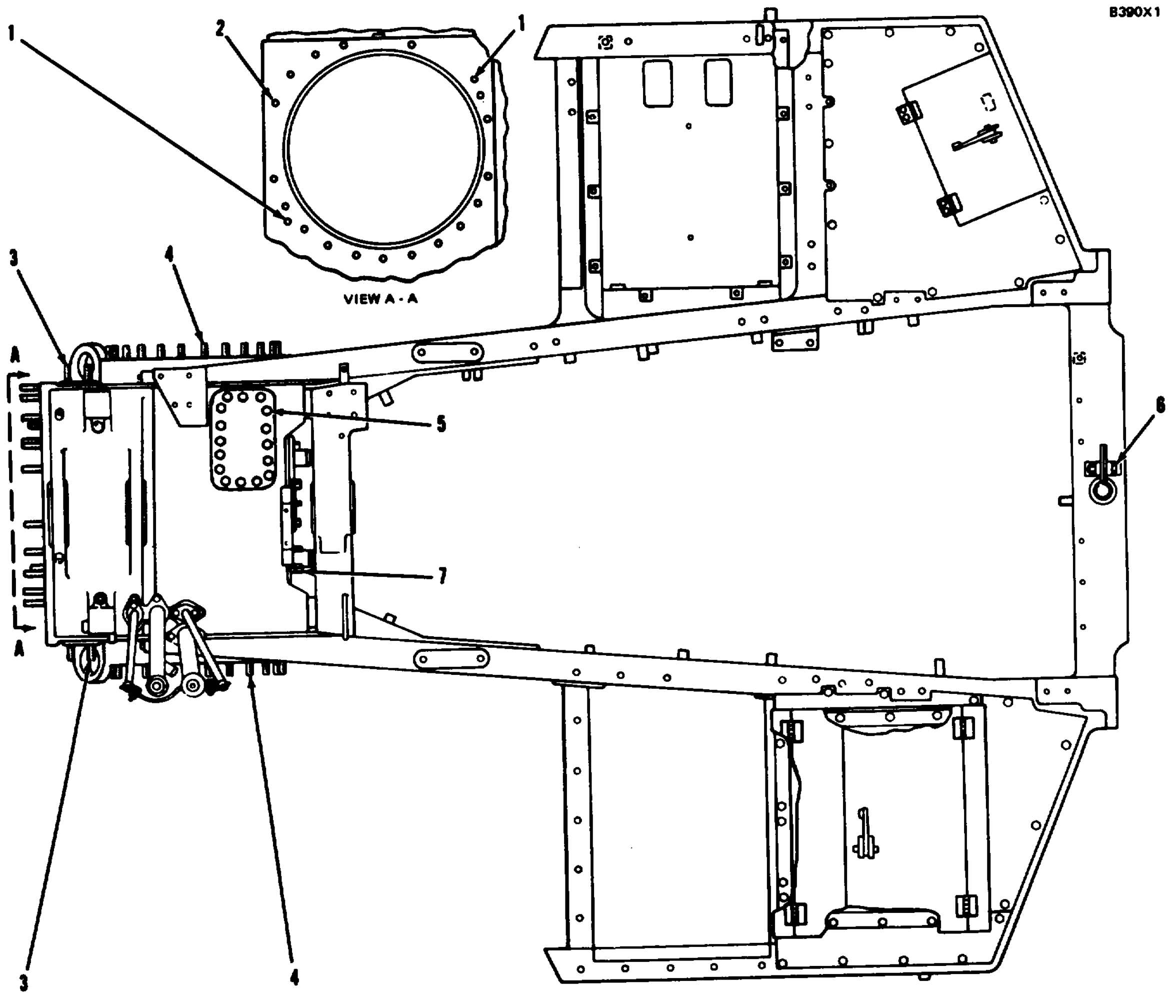
(7) Torque for the valve stem....... 75 ± 5 lb. in. (8.5 ± 0.6 N•m)



TYPICAL EXAMPLE

(1) Torque for 24 bolts that hold the guards to the frame ....185 ± 10 lb. ft. (254 ± 14 N•m)

CASE AND FRAME GROUP



(1) Torque for two studs............... 75 ± 10 lb. ft. (100 ± 14 N•m)

(2) Torque for 18 studs................ 75 ± 10 lb. ft. (100 ± 14 N•m)

(3) Torque for six studs................ 110 ± 15 lb. ft. (149 ± 20 N•m)

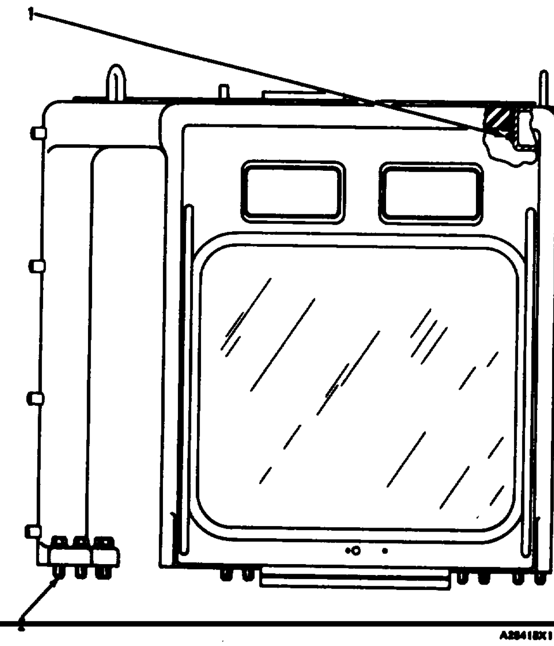
(4) Torque for 44 studs................ 110 ± 15 lb. ft. (149 ± 20 N•m)

(5) Torque for 16 studs.................20 ± 3 lb. ft. (25 ± 4 N•m)

(6) Torque for locknut...................35 ± 5 lb. ft. (45 ± 7 N•m)

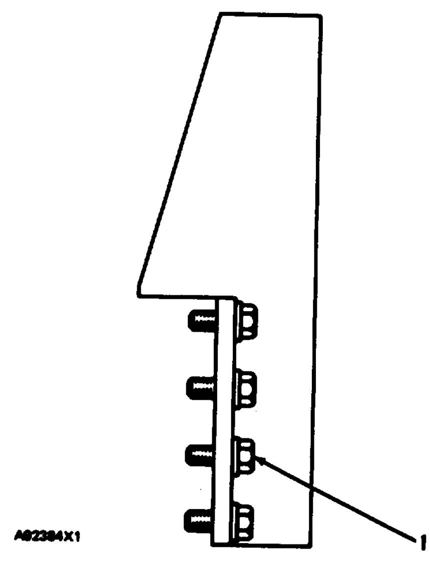
(7) Torque for six studs ....40 ± 5 lb. ft. (55 ± 7 N•m)

OPEN ROLLOVER PROTECTIVE STRUCTURE (ROPS)



(1) Torque for three bolts .... 18± 5 lb. ft. (24 ± 7 N•m)
(2) Torque for 16 bolts .... 545 ± 20 lb. ft. (740 ± 26 N•m)

FRONT BUMPER



(1) Torque for eight bolts .... 525 ± 20 lb. ft. (715 ± 26 N•m)

By Order of the .Secretary of the Army:

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

Official*:*

DONALD J. DELANDRO
Brigadier General, United States Army
The Adjutant General

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THE METRIC SYSTEM AND EQUIVALENTS

LINEAR MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches
1 Meter = 100 Centimeters = 1000 Millimeters = 39.37 Inches
1 kilometer = 1000 Meters = 0.621 Miles

WEIGHTS

1 Gram = 0.001 Kilograms = 1000 Milligrams = 0.035 Ounces
1 Kilogram = 1000 Grams = 2.2 Lb.
1 Metric Ton = 1000 Kilograms = 1 Megagram = 1.1 Short Tons

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces
1 Liter = 1000 Milliliters 33.82 Fluid Ounces

SQUARE MEASURE

1 Sq. Centimeter = 100 Sq. Millimeters = 0.155 Sq. Inches
1 Sq. Meter = 10,000 Sq. Centimeters = 10.76 Sq. Feet
1 Sq. Kilometer = 1,000,000 Sq. Meters = 0.386 Sq. Miles

CUBIC MEASURE

1 Cu. Centimeter = 1000 Cu. Millimeters = 0.06 Cu. Inches
1 Cu. Meter = 1,000,000 Cu. Centimeters = 35.31 Cu. Feet

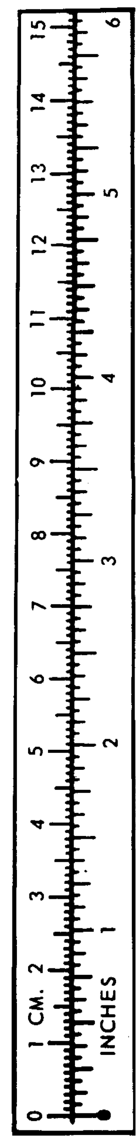
TEMPERATURE

5/9 (°F - 32) = °C
212° Fahrenheit is equivalent to 100° Celsius
90° Fahrenheit is equivalent to 32.2° Celsius
32° Fahrenheit is equivalent to 0° Celsius
9/5 (°C + 32) = °F

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Kilometers	0.836
Square Miles	Square Hectometers	2.590
Acres	Cubic Meters	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Milliliters	0.765
Fluid Ounces	Liters	29.573
Pints	Liters	0.473
Quarts	Liters	0.946
Gallons	Grams	3.785
Ounces	Kilograms	28.349
Pounds	Metric Tons	0.454
Short Tons	Newton-Meters	0.907
Pound-Feet	Kilopascals	1.356
Pounds per Square Inch	Kilometers per Liter	6.895
Miles per Gallon	Kilometers per Hour	0.425
Miles per Hour		1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
Liters	Gallons	0.264
Grams	Ounces	0.035
Kilograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pound-Feet	0.738
Kilopascals	Pounds per Square Inch	0.145
Kilometers per Liter	Miles per Gallon	2.354
Kilometers per Hour	Miles per Hour	0.621



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