

**Servicemen's  
Reference  
Book**

# Caterpillar

REG. U.S. PAT. OFF.

## Diesel Engines

(4½" BORE 4-CYLINDER)

**D315 INDUSTRIAL**

**D315 ELECTRIC SET**

**D315 MARINE**

**D4 TRACTOR**

**NO. 112 MOTOR GRADER**

**NO. 955 TRAXCAVATOR**

**CATERPILLAR TRACTOR CO. • PEORIA, ILLINOIS, U. S. A.**





## Foreword

**I**T is the purpose of Caterpillar Tractor Co., to build into its products the capability of a long life of useful work. The records of tens of thousands of users testify to success in the achievement of that purpose. It is natural, however, that length of life and cost of operation and maintenance will vary. Top records are the reward of the owners and operators who are diligent and conscientious in the care, operation and maintenance of their machines.

The Operator's Instruction Book, a copy of which is supplied with each machine, tells what to do, and how and when to do it, with regard to the day-to-day lubrication, operation and maintenance of the machine. It is urged that these instructions be studied carefully and reread frequently until the operator is thoroughly familiar with them. By following the instructions, the operator is best assured of obtaining maximum life and performance from his machine and of minimizing the frequency, number and cost of repairs.

Even the best of care will not eliminate the necessity, in course of time, of making minor repairs or complete reconditioning.

Your "Caterpillar" dealer has exceptionally complete facilities for such work. He carries a stock of genuine replacement parts and has in his employ competent factory trained servicemen. For work that cannot be done in the field, dealers have well equipped shops. Both the shop and the field servicemen have many special tools, designed and developed by "Caterpillar", that make easier and quicker the disassembly and assembly operations.

Though most "Caterpillar" owners prefer to make use of the excellent service and shop facilities of their dealers, some are themselves skilled mechanics or have such mechanics in their employ for reconditioning their equipment. To those owners this book, issued as a guide for "Caterpillar" dealer servicemen, will be of equal value.

The special tools pictured in various operations throughout are among the many which can be purchased from dealers. These tools are illustrated and listed in the Catalog for Service Tools, a copy of which is available on request.

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# SPECIFICATIONS

## DIESEL ENGINE

Bore and stroke—number of cylinders . . . . . 4 1/2"x5 1/2"—4 cyl.  
Firing order . . . . . 1-3-4-2

### Camshaft

Bearing, journal diameter . . . . . 2.495 - 2.496 -in.  
Bearing clearance . . . . . .003 - .006 -in.  
Maximum permissible clearance . . . . . .010 -in.  
End clearance . . . . . .006 - .010 -in.  
Maximum permissible end clearance  
(thrust plate and washer) . . . . . .025 -in.  
Camshaft gear backlash . . . . . .003 - .004 -in.  
Maximum backlash . . . . . .010 -in.  
Minimum backlash . . . . . .003 -in.

### Crankshaft

Main journal, diameter . . . . . 3.499 - 3.500 -in.  
Main bearing clearance (aluminum) . . . . . .0055- .0085-in.  
Main bearing clearance (steel backed  
aluminum) . . . . . .0048- .0071-in.  
Maximum permissible clearance . . . . . .015 -in.  
End clearance . . . . . .009 - .015 -in.  
Maximum permissible end clearance . . . . . .030 -in.  
Main bearing stud nuts, torque . . . . . 120 lb. ft.  
Connecting rod, journal diameter . . . . . 2.999 - 3.000 -in.  
Maximum permissible out-of-roundness . . . . . .006 -in.  
Maximum permissible journal wear . . . . . .007 -in.

### Connecting Rod

Connecting rod bearing clearance (aluminum) . . . . . .005 - .0075-in.  
Connecting rod bearing clearance  
(steel backed aluminum) . . . . . .0035- .0055-in.  
Maximum permissible clearance . . . . . .013 -in.  
Connecting rod bolt nuts, torque, minimum . . . . . 58 lb. ft.  
Center-to-center distance between connecting rod  
bearing and piston pin bushing . . . . . 10.249 -10.251 -in.

### Cylinder Liner

Diameter . . . . . 4.500 - 4.501 -in.  
Maximum permissible liner wear  
(at top of ring travel) . . . . . .015 -in.

### Piston Pins

Clearance in rod bushing . . . . . .001 - .0018-in.  
Maximum permissible clearance in rod . . . . . .006 -in.  
Maximum permissible clearance in piston . . . . . .006 -in.

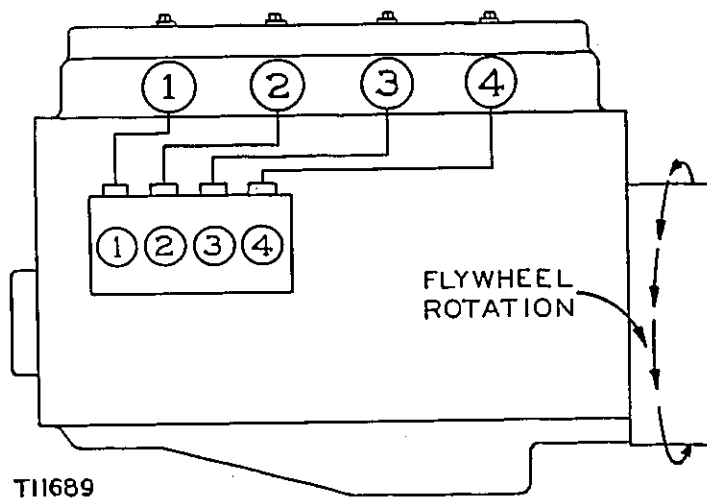
### Piston Rings

Piston ring side clearance  
Top ring . . . . . .003 - .004 -in.  
2nd and 3rd ring . . . . . .0025- .0035-in.  
Oil control ring . . . . . .0015- .0035-in.  
Maximum permissible side clearance in groove  
(top compression ring, new) . . . . . .010 -in.

Ring gap, top .....	.010 - .021 -in.
Ring gap, 2nd and 3rd .....	.010 - .026 -in.
Ring gap, 4th and 5th .....	.013 - .027 -in.
<b>Valves</b>	
Clearance (hot) .....	.010 -in.
<b>Exhaust Valves</b>	
Stem clearance in bushing .....	.005 - .007 -in.
Maximum permissible clearance in bushing .....	.012 -in.
Valve seat angle .....	45°
Valve face angle .....	44 1/4°
<b>Inlet Valves</b>	
Stem clearance in bushing .....	.004 - .006 -in.
Maximum permissible clearance in bushing .....	.012 -in.
Valve seat angle .....	45°
Valve face angle .....	44 1/4°
<b>Valve Timing (Zero Lift)</b>	
Exhaust opens .....	88° BBC
Exhaust closes .....	55° ATC
Inlet opens .....	50° BTC
Inlet closes .....	62° ABC
<b>Valve Spring—Outer (Later Engines)</b>	
Lbs. pressure .....	53
When compressed to .....	1 1/2-in.
<b>Valve Spring—Outer (Earlier Engines)</b>	
Lbs. pressure .....	57.50-62.50
When compressed to .....	2 7/8-in.
<b>Valve Spring—Inner (Later Engines)</b>	
Lbs. pressure .....	18
When compressed to .....	1 1/2-in.
<b>Valve Spring—Inner (Earlier Engines)</b>	
Lbs. pressure .....	9-11
When compressed to .....	2 13/32-in.
<b>Rocker Arm Bushings</b>	
Clearance between shaft and bushings .....	.001 - .003 -in.
<b>Oil Pump</b>	
Clearance between gears and separator plates...	.002 - .004 -in.
<b>Fuel Injection Pump Lifter Setting</b>	
	1.736-in.
<b>Fuel Pump Plunger</b>	
Length .....	2.6575- 2.6577-in.
Maximum wear .....	.005 -in.
<b>Fuel Injection Pump Timing</b>	
	15° BTC
<b>Flywheel Housing</b>	
Bore run-out .....	.010 -in.
Face run-out .....	.010 -in.
Nut torque .....	150 lb. ft.
<b>Flywheel Run-Out</b>	
Outside diameter (Maximum) .....	.006 -in.
Face (Maximum) .....	.006 -in.

	Earlier	Hardened washers and hardened nuts
<b>Cylinder Head</b>		
Tighten nuts (see text for sequence):		
1/2" nuts.....	58 lb. ft.	70 lb. ft.
5/8" nuts.....	130 lb. ft.	140 lb. ft.
<b>Accessory Shaft</b>		
End clearance .....		.003 - .010 -in.
Maximum .....		.025 -in.
<b>Compression Release Clearance (nonadjustable)</b>		
Between rocker arm button, and compression release shaft .....		.120 - .125 -in.
<b>Timing Gear Housing</b>		
Capscrew torque .....		35 lb. ft.
<b>Hour Meter</b>		
Bearing clearance (Maximum) .....		.012 -in.
<b>Pre-combustion Chamber</b>		
Torque .....		200 lb. ft.

The following illustration shows the numbering of the cylinders and of fuel injection pumps.



## STARTING ENGINE

Bore and stroke .....	2 3/4" x 3"—2 cyl.
Brake horsepower .....	10 at 3000 RPM
Spark plug gap .....	.025 -in.

## Camshaft

Bearings, journal diameter, front and rear.....	1.496 - 1.497 -in.
Bearing clearance .....	.0025 - .004 -in.
End clearance .....	.007 - .015 -in.
Maximum permissible end clearance .....	.025 -in.

**Crankshaft**

Main journal, diameter	1.8120-	1.8125-in.
Main bearing clearance	.005 -	.0085-in.
Maximum permissible clearance		.015 -in.
End clearance, front main bearing	.010 -	.015 -in.
Maximum permissible end clearance		.025 -in.
Connecting rod, journal diameter	1.7495-	1.7500-in.
Maximum permissible out-of-roundness (journal)		.003 -in.
Maximum permissible wear on journal		.005 -in.

**Connecting Rod**

Connecting rod bearing clearance (Babbitt)	.002 -	.0035-in.
Maximum permissible clearance		.009 -in.
Center-to-center distance	5.748 -	5.750 -in.

**Cylinder Bore**

Diameter	2.751 -	2.752 -in.
Cylinder bore wear limit (out-of-round)		.004 -in.
Cylinder bore wear limit (taper)		.006 -in.
Piston clearance (skirt)	.004 -	.006 -in.

**Piston Pins**

Clearance in rod bushing	.0008-	.0013-in.
Maximum permissible clearance between bushing and pin		.003 -in.
Clearance in piston	.0004-	.001 -in.
Maximum permissible clearance between piston and pin		.0025-in.

**Piston Rings**

Compression ring gap	.015 -	.028 -in.
Oil ring gap	.015 -	.026 -in.
Compression ring groove clearance	.0015-	.003 -in.
Oil ring groove clearance	.001 -	.0025-in.
Maximum permissible groove clearance (new ring) compression and oil rings		.009 -in.

**Valves**

Clearance (cold nonadjustable)	.007 -	.010 -in.
Exhaust valves		
Stem clearance in bushing	.003 -	.005 -in.
Maximum permissible clearance in bushing (with new valve)		.007 -in.
Valve seat angle		45°
Valve face angle		44¼°

**Inlet valves**

Stem clearance in bushing	.0015-	.003 -in.
Maximum permissible clearance in bushing (with new valve)		.005 -in.
Valve seat angle		45°
Valve face angle		44¼°

**Valve Timing (Zero Lift)**

Exhaust opens	40° BBC
Exhaust closes	5° ATC
Inlet opens	10° BTC
Inlet closes	35° ABC

**Valve Spring**

Lbs. pressure ..... 35-38  
When compressed to ..... 1-29/32-in.

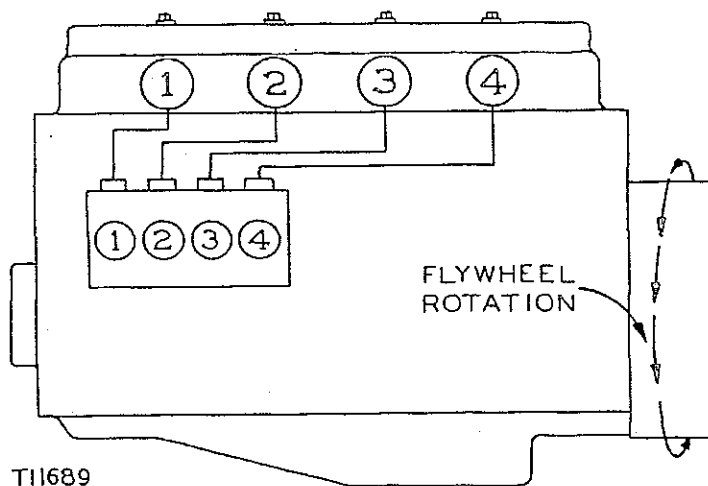
**Carburetor**

Float level .....  $1\frac{1}{8} \pm 3/64$ -in.



Cylinder Head	Earlier	Hardened washers and hardened nuts
Tighten nuts (see text for sequence):		
1/2" nuts.....	58 lb. ft.	70 lb. ft.
5/8" nuts.....	130 lb. ft.	140 lb. ft.
<b>Accessory Shaft</b>		
End clearance .....	.003 -	.010 -in.
Maximum .....		.025 -in.
<b>Compression Release Clearance (nonadjustable)</b>		
Between rocker arm button, and compression release shaft .....	.120 -	.125 -in.
<b>Timing Gear Housing</b>		
Capscrew torque .....		35 lb. ft.
<b>Hour Meter</b>		
Bearing clearance (Maximum) .....		.012 -in.
<b>Pre-combustion Chamber</b>		
Torque .....		200 lb. ft.

The following illustration shows the numbering of the cylinders and of fuel injection pumps.



## STARTING ENGINE

Bore and stroke .....	2 3/4"x3"—2 cyl.
Brake horsepower .....	10 at 3000 RPM
Spark plug gap .....	.025 -in.

## Camshaft

Bearings, journal diameter, front and rear.....	1.496 - 1.497 -in.
Bearing clearance .....	.0025 - .004 -in.
End clearance .....	.007 - .015 -in.
Maximum permissible end clearance .....	.025 -in.



## General Instructions

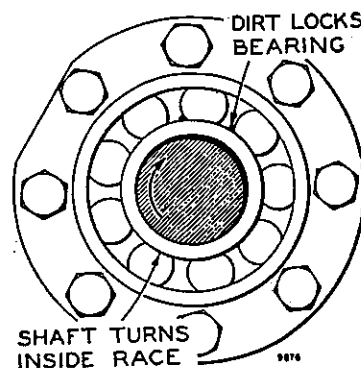
These general instructions will be extremely helpful in following the detailed instructions in the main sections of the book. They should be read and then kept in mind while assembling or disassembling the engine.

### KEEP DIRT OUT

The most important single item in preserving the long life of the engine is to keep dirt out of vital working parts. Caterpillar Tractor Co. has taken precautions to safeguard against dirt entering working parts. Enclosed compartments, seals and filters have been provided to keep the supply of air, fuel, and lubricants clean. It is highly important that the effectiveness of these safeguards be maintained. Filters should be replaced or cleaned regularly. Worn seals or broken gaskets should be replaced immediately.

Anti-friction bearings, properly lubricated with clean lubricant, will last indefinitely. Abrasives in the lubricant will cause rapid wear on the extremely hard races and balls or rollers. Dirt in an anti-friction bearing can cause the bearing to lock, with the result that the shaft will turn in the inner race or the outer race will turn within the cage. Dirt and abrasives in lubricants will embed in bushing-type bearings and act like fine sandpaper against the shaft, causing extremely rapid wear.

EFFECT OF DIRT IN BEARING



Lubricant must be changed at recommended intervals. Use clean containers. Before removing the filler cap, brush away the dirt with the brush provided in the tool kit.

Wear on fuel injection pumps and other parts of the fuel system will be almost negligible if the fuel is perfectly clean. Adequate fuel filters have been provided to safeguard fuel injection equipment. However, dirty fuel caused by careless handling or improper storage facilities will cause wear on the fuel transfer pump, prematurely clog the fuel filter, and eventually result in improper operation of the Diesel engine.

## **MAINTAIN ADJUSTMENTS**

Operating adjustments have been kept to a minimum on "Caterpillar"-built engines but they are important and should be carefully maintained.

Keep the fan belt adjusted to the proper tension to obtain maximum belt life and proper cooling.

Follow the recommendations in the Operator's Instruction Book.

## **INSPECT FREQUENTLY AND CORRECT MINOR TROUBLES**

A bearing changed in time will save a crankshaft. A water leak corrected prevents loss of coolant and an overheated engine. A nut tightened in time will prevent the loss or breakage of an associated part.

## **RECONDITIONING PROCEDURE**

This book has been arranged for the disassembly and reconditioning of the individual assemblies of the engine. If the engine is to be disassembled for complete inspection and reconditioning, let the following procedure be your guide, after the engine has been removed from its particular point of installation.

If possible, determine which assemblies will not be disassembled, in order to remove a group of assemblies as a unit at one time. This will save time and labor if an assembly is not to be reconditioned and if it can be removed from the engine without disturbing the assembly.

1. Remove radiator or heat exchanger and all water lines.
2. Remove oil cooler (if installed separately), oil filters and oil manifold.
3. Remove fan group (if installed), water pump or pumps and regulator housing or adapter housing.
4. Remove air cleaner.
5. Remove starting engine.
6. Remove fuel lines.
7. Remove manifolds, cylinder head and valve mechanism.
8. Remove governor, fuel injection pump housing, fuel filter housing and fuel transfer pump.
9. Remove oil pan, crankcase inspection covers and valve lifters.
10. Remove flywheel, flywheel housing and starter pinion.
11. Remove charging generator (if installed), timing gear cover, timing gears, camshaft, accessory shaft and timing gear housing.

12. Remove suction bells, oil lines, oil pump and oil pump drive.
13. Remove connecting rods and pistons.
14. Remove crankshaft.
15. Remove cylinder liners.

Instructions for removing and disassembling these parts are contained in this Reference Book, although not necessarily in the above order.

## **SAFETY AND WORKMANSHIP SUGGESTIONS**

There are certain practices which should be followed in the interest of safety and good workmanship when working around machinery.

Always show proper respect for weight. Do not attempt to lift heavy parts where a hoist should be used. Never leave heavy parts in an unstable position. When raising a machine make sure that it is blocked securely. Then block it up so that the weight will be supported by the blocks rather than the lifting equipment.

### **Tools**

All service tools should be kept in first class condition. Use the proper tool for the job at hand. Special service tools are available for specific jobs and they should be used when recommended. The use of these tools will save time and prevent damage to parts.

In the following pages puller arrangements are illustrated for separating tightly fitted parts. However, if the machine is being reconditioned in a shop, it may in many cases be easier and faster to use a press. When pulling a bearing or gear from a shaft, always use a centering spacer between the forcing screw and the end of the shaft.

### **Disassembly**

If a part offers unexpected resistance to removal, check carefully to see that all nuts and capscrews have been removed before using force. Possibly some other part is interfering and should be removed first. Parts which are fitted together with tapered splines are always very tight. If they are not tight when disassembled, inspect the tapered splines and discard the part if the splines are worn.

Identical parts, such as pistons and valves, should be kept in order or marked so they can be reinstalled in the same position from which they were removed.

Where shims are used, be sure to remove them all. Tie the shims together and identify them as to their location. Then keep them clean and flat until they are reinstalled.

Whenever fuel injection lines are disconnected, the ends of the lines should be capped with the fittings supplied in the tool kit. Also cap the pumps and valves. This will prevent dirt and other foreign matter from entering the fuel injection system.

## CLEANING AND INSPECTION

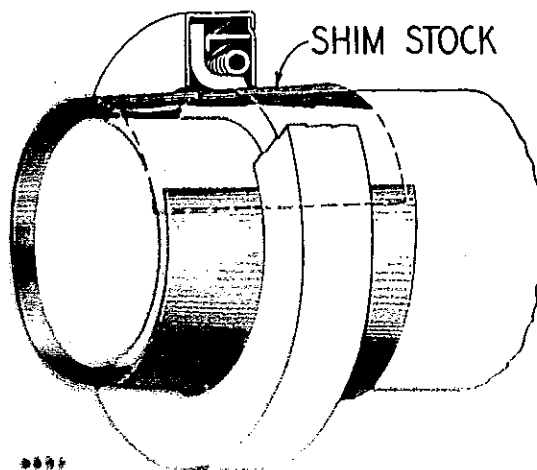
Clean all parts thoroughly after they are removed and inspect them. Be sure all lubricant passages and oil holes are open. Badly worn or damaged parts should not be put back in the machine. Cover all parts to keep them clean until they are installed.

Anti-friction bearings should receive special handling. As soon as a bearing is removed, cover it to keep out dirt and abrasives. Wash bearings in non-inflammable cleaning solution and inspect the races and balls or rollers. Discard the bearings if they are pitted, scored, or burned. If the bearing is serviceable, coat it with light oil and wrap it in clean paper. Do not unwrap new bearings until ready to install them.

## ASSEMBLY

Clean the rust preventive compound from all machined surfaces of new parts before installing them. Be sure to install parts in the proper location and position.

When one part is pressed into another, use white lead or a suitable prepared compound to lubricate the mating surfaces. Tapered parts, however, should be assembled dry. Before assembling parts with tapered splines, be sure the splines are clean, dry and free from burrs. Then press the parts together tightly.

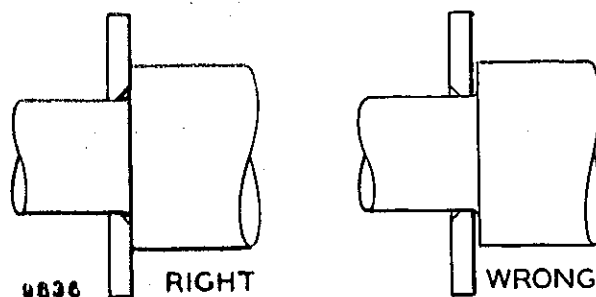


PROTECTING SEAL DURING  
INSTALLATION

Lubricant should be applied to the lip of all shaft-type rubber seals before installation. This will prevent damage to the seal during the initial running until the oil being sealed has contacted the sealing face.

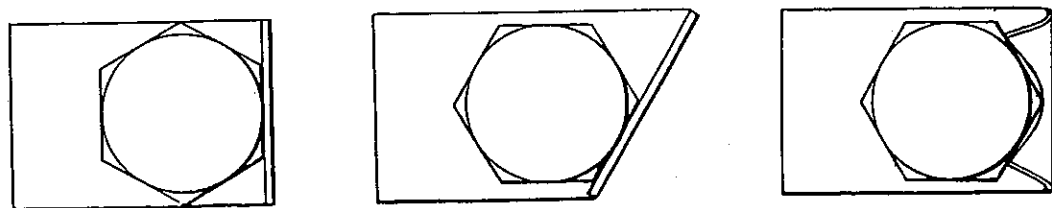
When possible, soak new rawhide seals in warm oil for a half hour before installing. Install the seal with the wiping edge turned in the direction recommended. Be careful not to cut the leather seal as it is installed or when installing a shaft through the seal. Use shim stock if necessary to protect the seal from shoulders or sharp edges during installation. Packing-type seals should always be renewed if the contacting part is removed.

#### HOW TO INSTALL SPACER AGAINST SHOULDER ON SHAFT



When installing a bearing, spacer, or washer against a shoulder on a shaft, be sure the chamfered side is toward the shoulder. If the washer is turned in the wrong direction the radius may interfere and prevent the washer from seating against the shoulder.

Do not install bushings by driving them in with a hammer. Use a press if possible and be sure to apply the pressure directly in line with the bore. If a bushing must be driven in, use a bushing driver or a bar with a smooth flat end. If the bushing has an oil hole, be sure it is aligned with the oil hole in the part into which it is assembled.



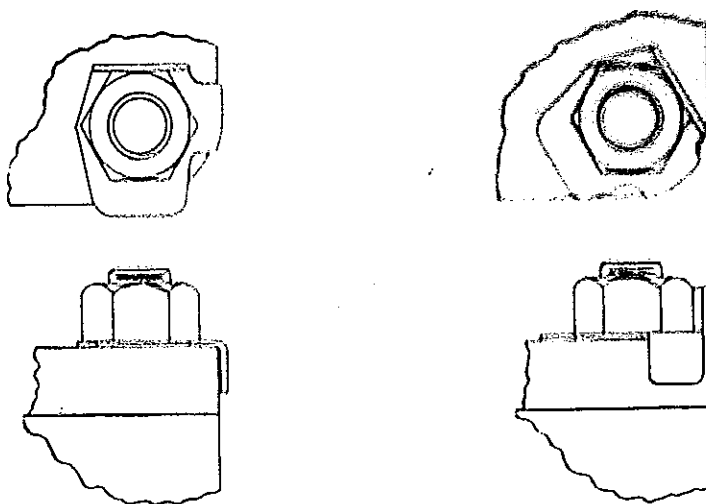
SHARP BENDS

9837 RIGHT

RIGHT

WRONG

#### HOW TO INSTALL FLAT METAL LOCKS



#### METHOD FOR LOCK POSITIONING AND BENDING

T7617 **RIGHT**

**WRONG**

Install gaskets where required and use new ones if necessary. Never use cork or felt gaskets or seals a second time. Be sure the holes in the gaskets correspond with the lubricant passages in the mating parts. If it is necessary to make gaskets, select stock of the proper type and thickness and be sure to cut sufficient holes in the right places. Blank gaskets can cause serious damage.

Use capscrews of the correct length. A capscREW which is too long may "bottom" before the head is tight against the part it is to hold, and in addition the threads may be damaged when the capscREW is removed.

If a capscREW is too short, there will not be enough threads to hold the part securely.

Lockwashers, cotter pins, or flat metal locks should be used to lock each nut and capscREW. Flat metal locks must be installed properly to be effective. Bend one end of the lock sharply around the edge of the part. Bend the other end sharply against one flat surface of the nut or capscREW head. Do not bend the lock against more than one side of the nut.

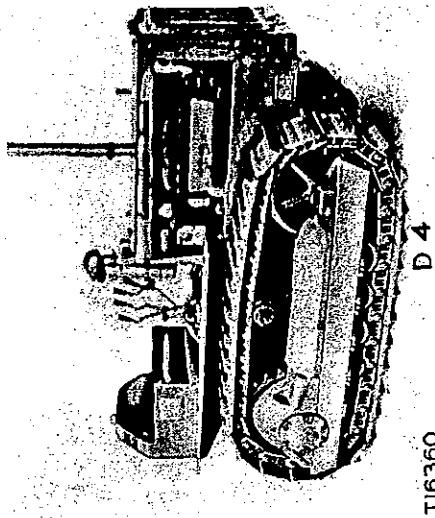
When assembling a machine complete each step in turn. Do not leave one part partially assembled and start assembling some other part. Make all adjustments as recommended. Always check the job after it is completed to see that nothing has been overlooked.

### PREPARATION FOR STARTING

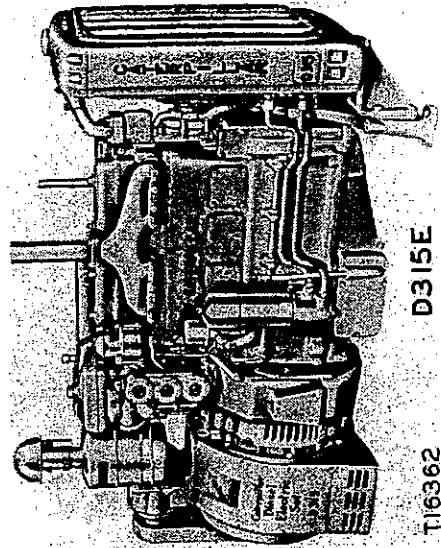
After assembling a machine, lubricate it thoroughly. Fill the various compartments with the type and grade of lubricant recommended in the Operator's Instruction Book. Fill the crankcases of both the Diesel engine and starting engine with the grade of oil recommended for the prevailing temperature. Fill the cooling system with water or anti-freeze solution.



Recheck the various adjustments by operating the machine before returning it to the job. If a machine has been completely rebuilt, it should be run-in gradually before subjecting it to a full load. See the topic, **RUNNING-IN SCHEDULE**.

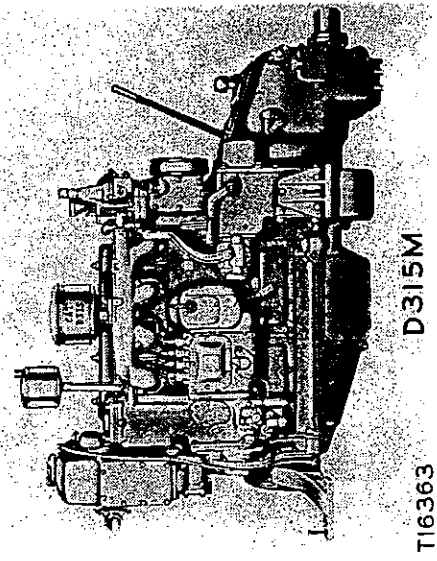


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D 4



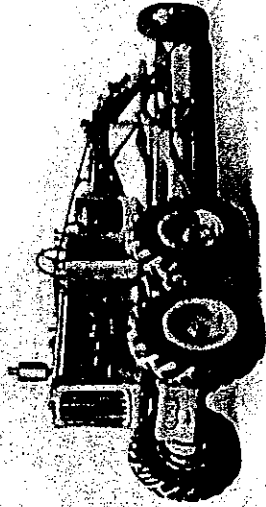
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D315E



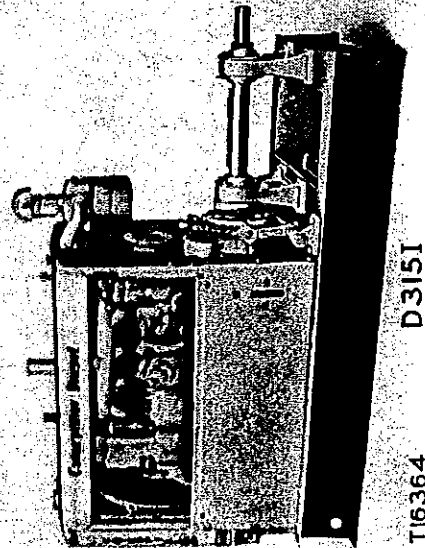
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D315M



T16361

NO.112



T16364

D315I

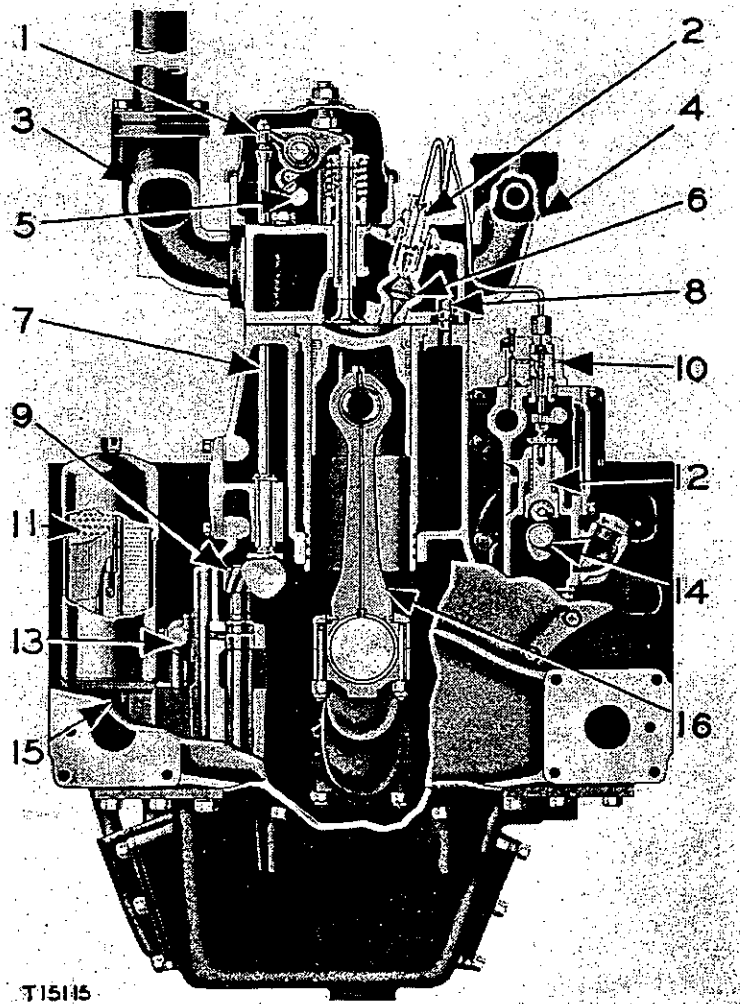
## Introduction

This book contains illustrations and reconditioning information for the 4½" bore, 4-cylinder Diesel Engines.

The following models which are included, are the engines for the D4 Tractor, the No. 112 Motor Grader, the D315 Industrial, the D315 Electric Set and the D315 Marine.

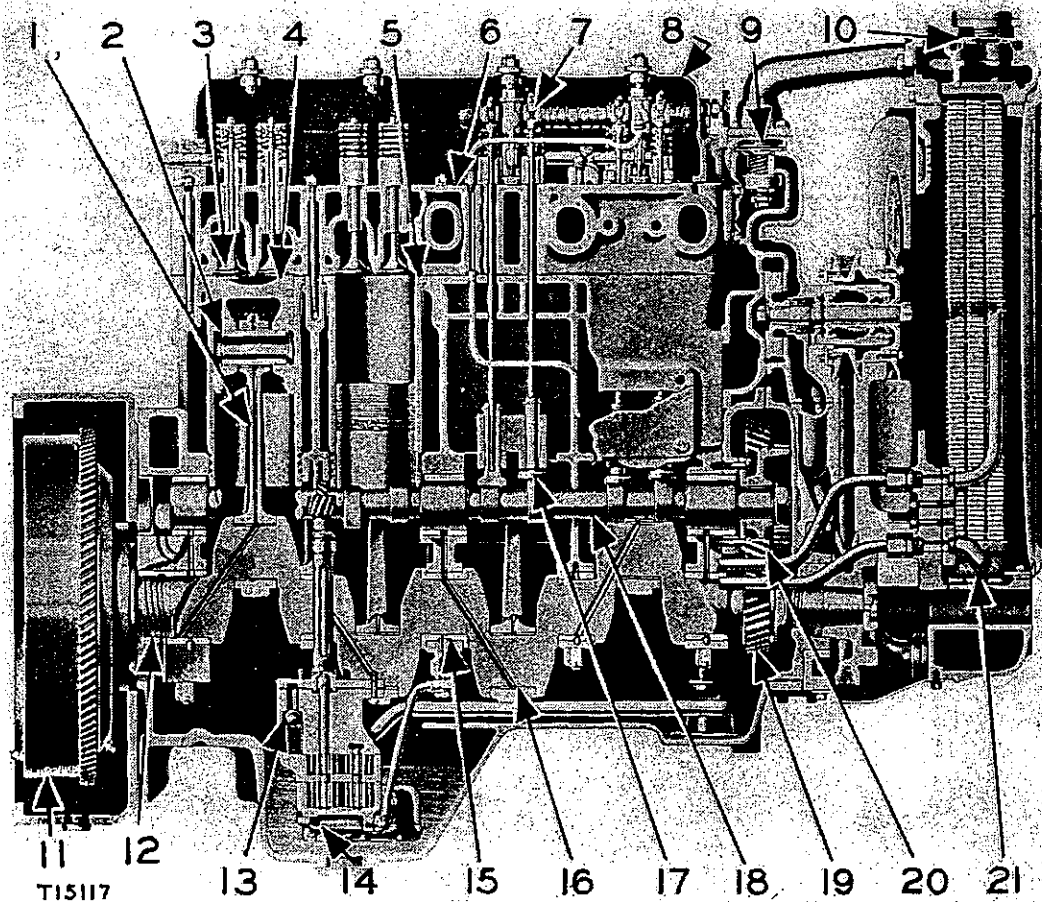
An abbreviation of each model is used: D4 for the engine as used in a D4 Tractor; No. 112, the No. 112 Motor Grader version; D315I, the industrial version; D315E, the engine used in the electric set; and the D315M, the marine version.

Certain items which are standard equipment on some models and are optional or attachments on others, are covered in the appropriate places along with standard parts with no differentiation noted.



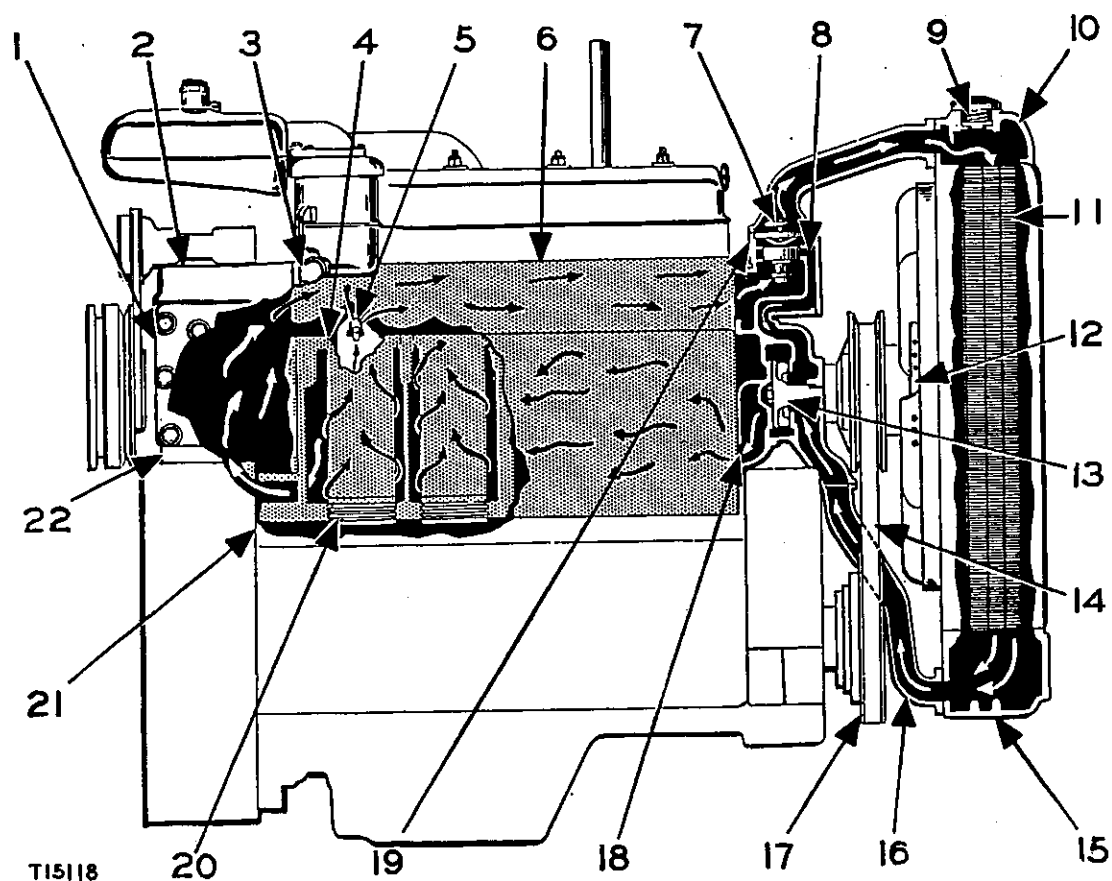
SECTIONAL VIEW OF ENGINE (FRONT)  
(D4 Illustrated)

1-Rocker arm assembly. 2-Fuel injection valve. 3-Exhaust manifold. 4-Inlet manifold. 5-Compression release shaft. 6-Pre-combustion chamber. 7-Push rod. 8-Water director. 9-Oil pump drive gear. 10-Fuel injection pump. 11-Lubricating oil filter element. 12-Fuel pump lifter assembly. 13-Oil manifold. 14-Fuel pump camshaft. 15-Oil filter base. 16-Connecting rod.



CUTAWAY VIEW OF ENGINE (RIGHT SIDE)  
(Earlier D4 Illustrated)

1-Connecting rod. 2-Piston pin. 3-Valve. 4-Piston. 5-Cylinder liner. 6-Cylinder head. 7-Valve rocker arm assembly. 8-Valve cover. 9-Temperature regulator. 10-Pressure overflow assembly. 11-Flywheel. 12-Crankshaft. 13-Pressure relief valve. 14-Oil pump. 15-Center thrust main bearing. 16-Connecting rod bearing. 17-Valve lifter. 18-Camshaft. 19-Crankshaft gear. 20-Camshaft gear. 21-Oil cooler.



### FLOW OF FRESH WATER COOLANT

1-Starting engine cylinder head. 2-Starting engine manifold. 3-Elbow. 4-Cylinder liner. 5-Water director. 6-Cylinder head. 7-Water temperature regulator. 8-By-pass passage. 9-Pressure relief valve. 10-Radiator top tank. 11-Radiator core. 12-Fan assembly. 13-Fresh water pump. 14-Fan belt. 15-Radiator lower tank. 16-Water line. 17-Crankshaft pulley. 18-Cylinder block inlet passage. 19-Regulator housing. 20-Liner seal. 21-Cylinder block. 22-Starting engine cylinder block.

# DIESEL ENGINE

## Cooling Systems

### FRESH WATER COOLING SYSTEM (Radiator-Cooled)

The centrifugal-type fresh water pump (13) circulates the coolant through the cooling system. The water pump and the fan assembly (12) are driven by the fan belt (14) and the crankshaft pulley (17).

The fresh water pump delivers the coolant into the cylinder block inlet passage (18) of the cylinder block (21). The coolant passes through the water jackets which extend practically the full length of the cylinder liners (4). The liner seals (20) prevent leakage.

A portion of the coolant is transmitted into the starting engine and cools the starting engine cylinder block (22), the cylinder heads (1), and the manifold (2). The coolant then passes through the elbow (3) into the cylinder head (6) of the Diesel engine.

When the starting engine is running, the starting engine discharges the warm water into the Diesel engine to aid starting of the Diesel engine. The cooling systems are interconnected.

The greater portion of the coolant passes directly from the cylinder block through the water seals, ferrules and water directors (5) into the cylinder head.

The coolant passes from the cylinder head into the regulator housing (19) and contacts the water temperature regulator (7).

The flow of the coolant from the water regulator to the water pump is as follows: On initial starting (in most cases) the temperature of the coolant is not sufficient to open the water temperature regulator, which remains closed until the engine coolant is approximately 160°F. In this case none of the coolant is admitted to the radiator to be cooled, thus assuring rapid warmup. The coolant flows into the by-pass water passage (8), which is connected to the inlet side of the water pump and returns the coolant to the water pump. Thus, the circuit is completed for the flow of coolant with the regulator in a closed position.

The flow with the water temperature regulator in the open position is as follows: When the engine coolant is at approximately 160°F., the regulator opens and the coolant passes through to the radiator top tank (10). As the coolant passes through the radiator core (11), it is aided in cooling by the fan and is admitted to the radiator bottom tank (15). The water line (16) is attached to the suction side of the water pump, and returns

the coolant to the water pump. A small portion of the coolant flows through the by-pass passage (8) even when the regulator is in the open position.

The fuel filter housing (not shown) is mounted on the left side of the engine. The fuel compartment of the fuel filter housing is warmed by the coolant as it passes through the water passage of an elbow which is attached to the fuel filter housing.

A sealed pressure overflow assembly (9), which is part of the radiator cap, prevents the loss of coolant when the engine is operated on steep inclines. By maintaining a pressure of about six PSI in the cooling system, the sealed pressure overflow reduces the natural loss of coolant by evaporation.

Use soft water or clean rain water in the cooling system whenever possible. If it is necessary to use hard water, it should first be treated with water softener. The use of "Caterpillar" Rust Inhibitor in cooling systems is recommended. This soluble oil will increase the life and efficiency of the cooling system by retarding mineral deposits when hard water is used and by preventing the formation of rust.

## **FRESH WATER AND RAW WATER COOLING SYSTEMS** **(Heat Exchanger-Cooled)**

The flow of fresh water coolant is as follows:

The centrifugal-type fresh water pump (16) circulates the coolant through the fresh water cooling system. The water pump is mounted on the auxiliary drive housing (15), which is attached to the timing gear housing and cover.

The fresh water pump is driven by the auxiliary drive idler gear which in turn is driven by the camshaft gear.

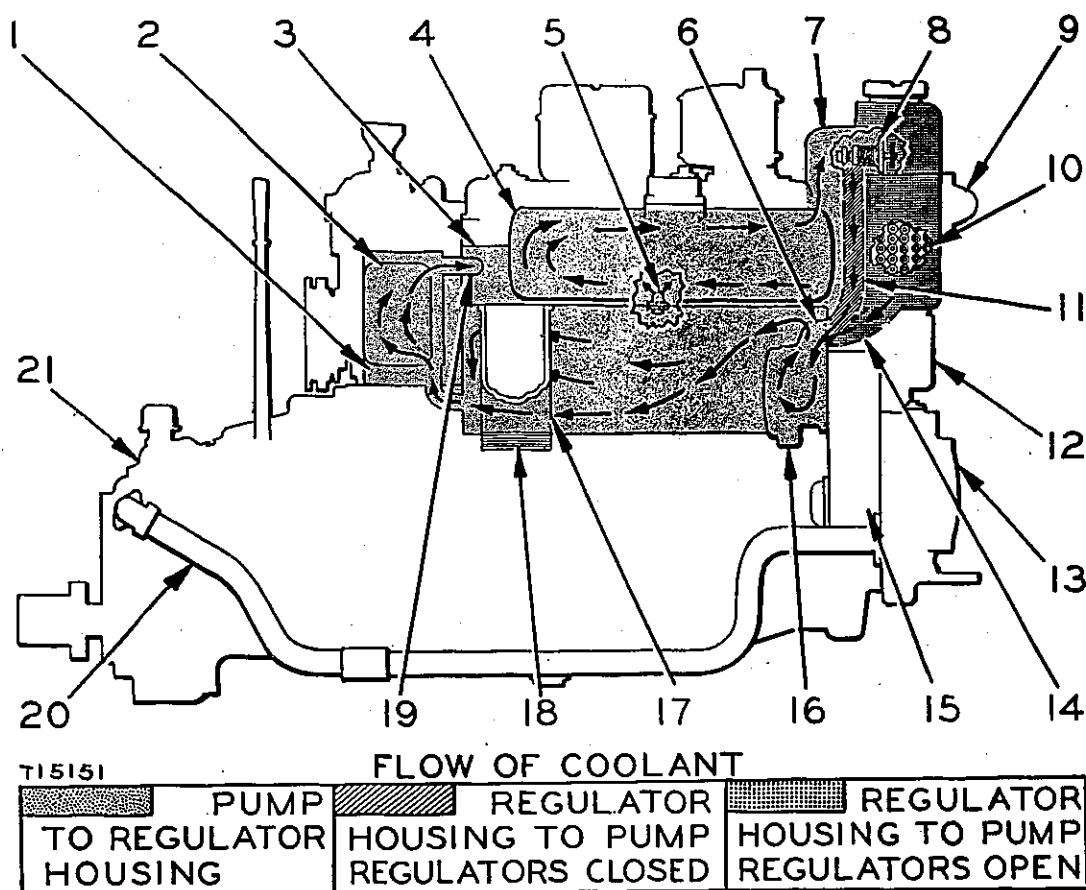
The fresh water pump delivers the coolant into the cylinder block inlet passage (6) and the water-cooled exhaust manifold (4).

The coolant passes through the water jackets which extend practically the full length of the cylinder liners (17). The liner seals (18) prevent leakage.

The engine exhaust gases are cooled as they pass through an inner manifold, which is cast within the water-cooled manifold.

A portion of the coolant is transmitted into the starting engine and cools the starting engine cylinder block (1), and the starting engine cylinder heads (2). This coolant is then delivered through the elbow (19) into the cylinder head (3) of the Diesel engine.





#### HEAT EXCHANGER COOLING SYSTEM

1-Starting engine cylinder block. 2-Starting engine cylinder head. 3-Diesel engine cylinder head. 4-Water-cooled exhaust manifold. 5-Water director. 6-Cylinder block inlet passage. 7-Adapter housing. 8-Water temperature regulator. 9-Raw water outlet pipe. 10-Heat exchanger core assembly. 11-By-pass passage. 12-Oil cooler. 13-Raw water pump. 14-Passage. 15-Auxiliary drive housing. 16-Fresh water pump. 17-Cylinder liner. 18-Liner seal. 19-Water elbow. 20-Pipe. 21-Reverse and reduction gear.

When the starting engine is running, the starting engine discharges warm water into the Diesel engine to aid starting of the Diesel engine. The cooling systems are interconnected.

The greater portion of the coolant passes directly from the cylinder block through the water seals, ferrules and water directors (5) into the cylinder head.

The coolant passes from the cylinder head into the adapter housing (7) and contacts the water temperature regulator (8).

The flow of the coolant from the water regulator to the water pump is as follows: On initial starting, the temperature of the coolant is not sufficient to open the water temperature regulator, which remains closed until the engine coolant is approximately 160°F. In this case none of the coolant is admitted to the heat exchanger to be cooled, thus assuring rapid warm up. The coolant flows into the by-pass passage (11) within the adapter housing, which is connected to the inlet side of the water

pump and returns the coolant to the fresh water pump. Thus, the circuit is completed for the flow of coolant with the regulator in a closed position.

The flow of fresh water coolant with the water temperature regulator in the open position is as follows: When the engine coolant is at approximately 160°F., the regulator opens and the coolant passes around the heat exchanger core assembly (10) to be cooled. The passage (14) returns the coolant to the water pump. A small portion of the coolant flows through the by-pass passage (11) even when the regulator is in the open position.

The fuel filter housing (not shown) is mounted on the left side of the engine. The fuel compartment of the fuel filter housing is warmed by the coolant as it passes through the water passage of an elbow which is attached to the fuel filter housing.

Use soft water or clean rain water in the cooling system whenever possible. If it is necessary to use hard water, it should first be treated with water softener. The use of "Caterpillar" Rust Inhibitor in cooling systems is recommended. This soluble oil will increase the life and efficiency of the cooling system by retarding mineral deposits when hard water is used and by preventing the formation of rust.

The flow of raw water coolant is as follows:

The raw water pump (13) is mounted on the auxiliary drive housing, and is driven in the same manner as the fresh water pump.

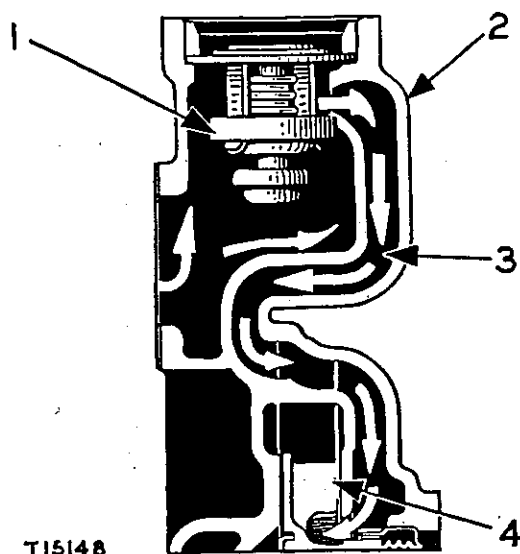
The raw water pump draws the raw water from the source of supply through the inlet pipe into the water compartment of the reverse and reduction gear (21). As the raw water passes through the water compartment, it cools the lubricating oil in the reverse and reduction gear.

The pipe (20) transmits the raw water to the raw water pump, which delivers the raw water into the water compartment of the oil cooler (12). See the topic, FLOW OF RAW WATER THROUGH THE OIL COOLER AND THE HEAT EXCHANGER.

The raw water flows from the oil cooler into the heat exchanger core assembly (10) where it cools the fresh water. The raw water is then discharged by the outlet pipe (9) into the source of supply.

### **FLOW OF COOLANT THROUGH TEMPERATURE REGULATOR HOUSING (All Models)**

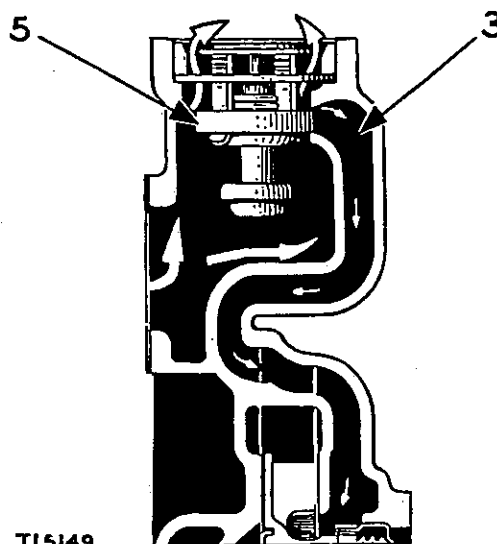
The flow of the coolant through the regulator housing or the adapter housing is similar for all models. The regulators used in the heat exchanger system differ only in the method of installation.



T15148

#### WATER TEMPERATURE REGULATOR CLOSED

1-Regulator (closed). 2-Regulator housing. 3-By-pass passage. 4-Water pump impeller.



T15149

#### WATER TEMPERATURE REGULATOR OPEN

3-By-pass passage. 5-Regulator (open).

The coolant passes into the regulator housing (2) and flows into contact with the water temperature regulators as shown in the schematic illustrations.

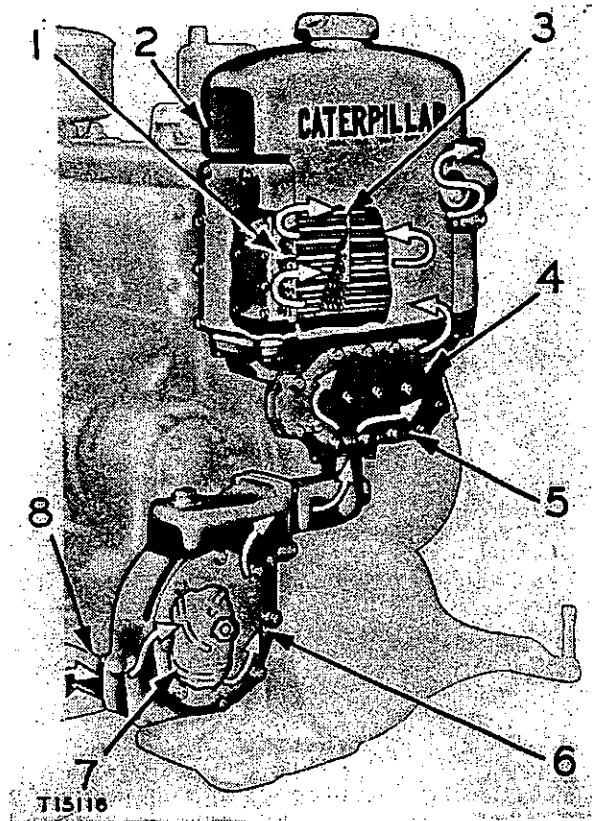
When the temperature of the coolant is less than 160°F., the regulators are in a closed position as illustrated by the regulator (1). The coolant passes into the by-pass passage (3) and then returns to the suction side of the water pump, where it is again picked up by the water pump impeller (4).

When the temperature of the coolant has reached approximately 183°F., the regulators are in the open position as illustrated by the regulator (5). The coolant passes through the regulators and then to the radiator or heat exchanger to be cooled, before it returns to the suction side of the water pump. A small portion of the coolant passes through the by-pass passage (3) to the water pump at all times. See the topic, COOLING SYSTEMS.

### FLOW OF RAW WATER THROUGH THE OIL COOLER AND THE HEAT EXCHANGER

The flow of raw water is as follows: The raw water is drawn into the system at the inlet pipe (8) and flows to the suction side of the raw water pump (6).

The impeller (7) delivers the raw water into the oil cooler (5). The raw water passes around the oil cooler core (4) to cool the oil as it passes through the core.



#### FLOW OF RAW WATER

1-Baffle. 2-Heat exchanger. 3-Heat exchanger core. 4-Oil cooler core.  
5-Oil cooler. 6-Raw water pump. 7-Impeller. 8-Inlet pipe.

The raw water then is delivered to the heat exchanger (2) and is directed by the baffle (1) through the heat exchanger core (3) and then it is returned to the source of supply.

The fresh water is cooled as it passes around the heat exchanger core.

#### OVERHEATING (All Models)

If difficulty is experienced with the engine overheating, check the following possible causes:

##### 1. Coolant Level.

Insufficient coolant in cooling system. If the coolant level has been allowed to fall so low that the coolant is no longer circulating, the engine should be stopped immediately and allowed to cool before adding coolant. If there is still good circulation, add make-up-coolant slowly while the engine is running. These precautions will minimize the possibility of cracking the cylinder head.

##### 2. Fan, (if radiator cooling is used).

Loose fan belt.

### 3. Radiator Clogging — External.

Accumulation of leaves, mud and debris could be between the oil cooler or the radiator core and the radiator guard. In some cases, these accumulations can be removed by flushing with water or compressed air. It may become necessary eventually to remove the radiator guard to clean the cores effectively.

### 4. Water Temperature Regulator.

Failure of water temperature regulator to open. Check the regulator for opening temperature as described in the topic, TESTING TEMPERATURE REGULATOR (ALL MODELS). Observe the amount of scale deposited on the regulator. Too much scale will obstruct its operation. The engine should not be operated with the regulator removed.

### 5. Water Pump.

Badly corroded or worn water pump impeller or impeller loose on shaft.

### 6. Internal Clogging.

Excessive scale or sediment deposits in radiator or heat exchanger, cylinder head and block. Such deposits can cause serious damage to the engine by retarding the transfer of heat from the head and cylinders to the coolant. In such cases, the water temperature may not be above normal. However, loose scale and sediment may deposit in water passages to such an extent that circulation will be retarded, in which case the water temperature may go above normal.

To check for lime and scale in the cooling system, remove one of the pre-combustion chambers and inspect the surface which comes in contact with the coolant. To remove hard scale follow the directions under the topic, CLEANING THE COOLING SYSTEM (ALL MODELS).

### Heat Exchanger — Clogging.

The heat exchanger should be cleaned as recommended in the Operator's Instruction Book when the water temperature is continuously 205°F., or more during normal operation.

### 7. Continuous Overload.

Operating a machine at full throttle under a continuous overload which lugs the engine speed down below its rated speed may also cause overheating. As a correction, the machine should be operated under a lighter load.

8. Altitude.

The altitude at which the machine is operating should be considered when overheating is encountered. The horsepower of the engine is decreased as the altitude increases. Also, the boiling point of water is lower at higher altitudes.

9. Water Temperature Indicator.

It may be that the indicator is not registering correctly. If the indicator is suspected of giving a false reading, install a new one and check the reading.

### **CLEANING THE COOLING SYSTEM (All Models)**

If hard water coolant is used in the cooling system, it will eventually become necessary to remove the lime and scale deposits which gradually build up.

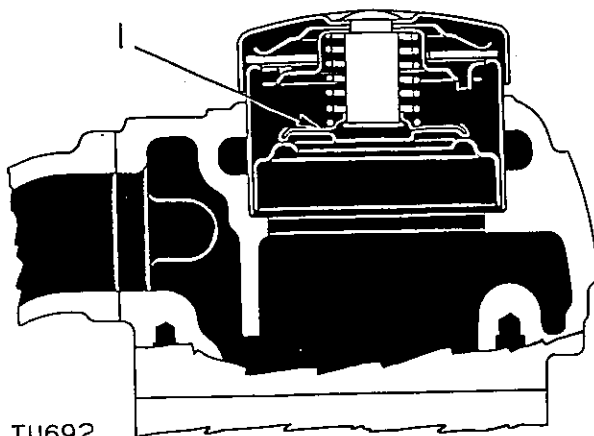
To remove the scale, fill the cooling system with a mixture consisting of five parts of commercial hydrochloric (muriatic) acid, one part formaldehyde, and forty-eight parts water. Mix the formaldehyde and water and then add the acid.

Operate the engine for three hours and then drain the cleaning solution. Flush the system thoroughly to remove all traces of the acid and refill with clean, soft water coolant.

### **SEALED PRESSURE OVERFLOW (Radiator-cooled)**

A sealed pressure overflow assembly is used to prevent loss of coolant through the radiator overflow tube when operating at an angle.

Due to expansion of the coolant by rising temperature, a pressure will be built up in the cooling system each time the engine is started. When



#### **SEALED PRESSURE OVERFLOW**

1-Pressure relief valve.

the pressure rises above 6 PSI, the pressure relief valve (1) opens to relieve the pressure, or, if the cooling system has been overfilled, allowing some coolant to escape through the radiator overflow tube. The valve closes when the temperature of the coolant levels off and remains closed unless there is a further increase in pressure.

### **WATER LINES REMOVAL** (All Models)

When it becomes necessary to remove any of the water lines, they can be removed in most cases without disturbing other assemblies or attachments.

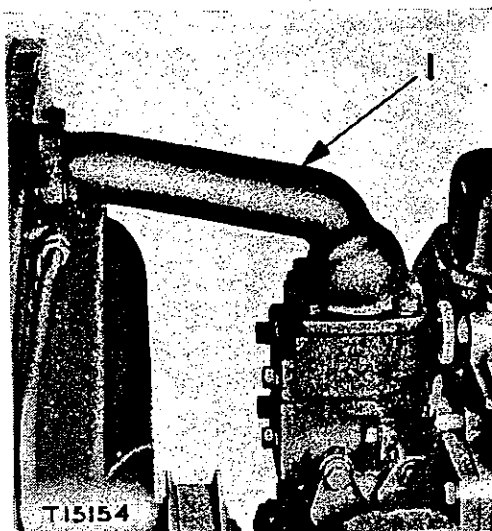
There are various drain plugs installed throughout the cooling system. Drain out only the amount of coolant necessary to permit the removal of the desired assembly without loss of the coolant. (When anti-freeze is drained out it can be drained into a container and reused, if desired).

### **WATER TEMPERATURE REGULATOR** (All Models)

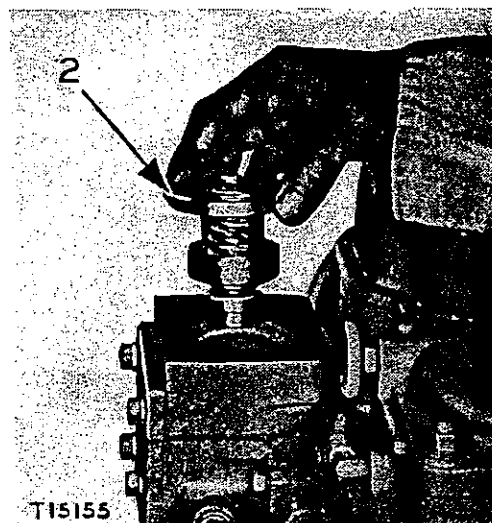
Water temperature regulators are used to restrict the flow of water through the radiator or heat exchanger until the engine is warmed up; after this the function of the regulators is to maintain the most efficient engine operating temperature.

#### **Temperature Regulator Removal and Installation (Radiator-cooled)**

Drain enough coolant from the system to lower the coolant level to a point slightly below the regulator.



**ELBOW REMOVAL**  
1-Elbow.



**REMOVING REGULATOR**  
2-Regulator.

Remove the elbow (1).

Lift out the temperature regulator (2) on later engines.

Earlier engines have the regulator held in place by a retainer.

Remove the regulator retainer by using a 3B7184 Regulator Retainer Puller.

The hook ends of the puller fit into the notches cut in the retainer ring for that purpose.

The temperature regulator can be lifted from the regulator housing after the retainer has been removed.

Before installing the regulator, be sure that all collections of rust or corrosion are removed from the bore in the regulator housing. See that the regulator seats in the bore evenly.

The retainer must be installed with the notches entering the bore of the regulator housing. Tap the retainer into the housing until it seats firmly against the regulator.

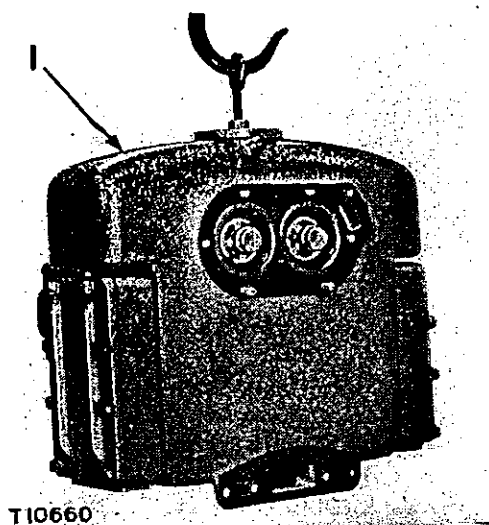
#### Temperature Regulator Removal and Installation (Heat Exchanger-Cooled)

Remove the heat exchanger (1) as described in the covering topic.

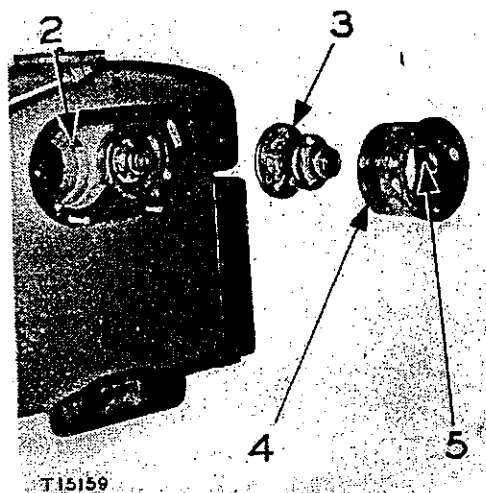
Remove the retainer (4).

Remove any scale or sediment that may have collected in the housing.

Lift out the regulator (3).



**HEAT EXCHANGER REMOVAL**  
1-Heat exchanger.



**REGULATOR REMOVAL**  
2-Passage. 3-Regulator. 4-Retainer.  
5-Passage.



The regulators can be tested as described in the topic, TESTING TEMPERATURE REGULATORS (ALL MODELS), and cleaned as described in the topic, CLEANING TEMPERATURE REGULATORS.

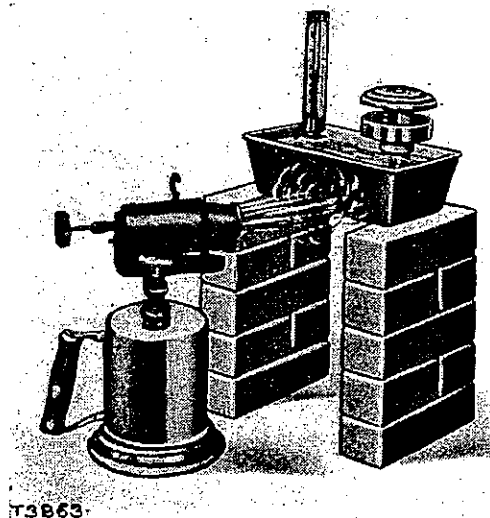
When installing the retainer, align the passages (2) and (5).

### Testing Temperature Regulator (All Models)

The opening temperature of the regulator should be approximately 166°-170°F., and the regulator should be fully open at 183°F. The regulator can be tested in the following manner:

1. Remove the regulator from the regulator housing.
2. Suspend the regulator in a pan of water as shown.
3. Apply heat to the pan and stir the water to maintain uniformity.
4. Observe the opening temperature of the regulator.

TESTING WATER TEMPERATURE  
REGULATOR



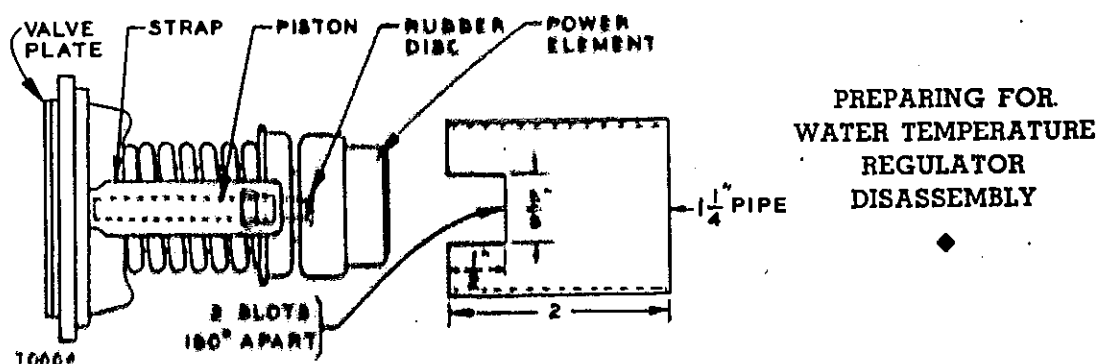
If the regulator does not operate correctly, due to accumulated rust, scale or sludge, it can be cleaned. See the covering topic.

### Cleaning Temperature Regulator (All Models)

Accumulations of rust, scale and sludge may restrict the action of the regulator. This type regulator can be easily disassembled for cleaning the piston, which in many instances is all that is required to restore the regulator to service.

Using a tool as illustrated in the line drawing, a regulator can be disassembled in the following manner:

1. Place the tool over the power element and compress the spring with the aid of a vise.



2. Remove the retaining straps.
3. Remove the unit from the vise, lift off the valve plate and pull out the piston.

#### NOTE

Later regulators have a boot type seal around the piston. A small washer, which is staked in the counterbore at the top of the piston, must be removed before removing the piston and seal. This will prevent damage to the seal.

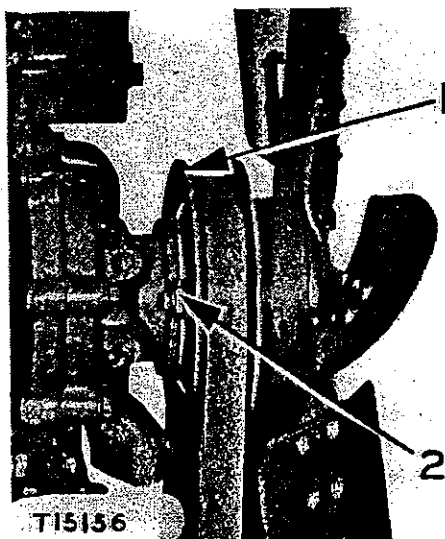
4. Be careful not to lose the small disc on the inner end of the piston.
5. Clean off the piston with crocus cloth and lubricate it with water pump grease.
6. Replace the disc and the piston and reassemble.

### FAN, WATER PUMP AND REGULATOR HOUSING

#### Removal and Installation

If the radiator is removed, most parts of the fan assembly can be replaced without removing the water pump housing from the engine. The following procedure is given with the radiator removed for better illustration. However, the water pump or the water pump and regulator housing, can be removed as a unit without removing the radiator.

1. Remove the radiator, as described in the topic, RADIATOR REMOVAL.
2. Remove the locks (2).
3. Unscrew the adjusting ring (1) off the pulley hub enough to permit removal of the fan belt.
4. After the fan belt has been removed, screw the adjusting ring forward and remove the capscrews which secure the water pump (3)



**PREPARING TO REMOVE FAN  
AND PUMP**  
1-Adjusting ring. 2-Lock.



**REMOVING FAN AND PUMP**  
3-Water pump. 4-Regulator  
housing.

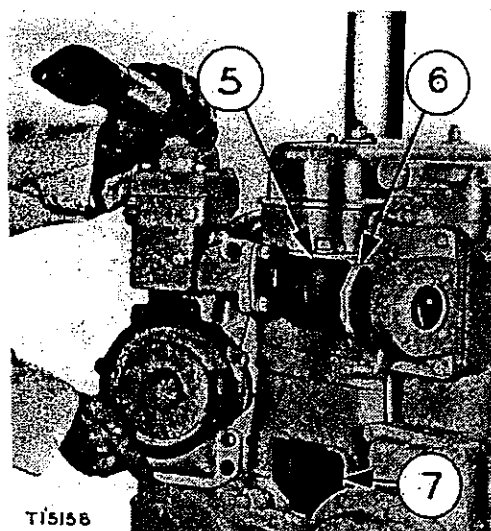
to the regulator housing (4) and remove the fan and water pump as a unit.

5. Remove the capscrews which secure the regulator housing to the cylinder head (5), cylinder block (7) and the elbow (6) and lift the housing off.

Clean all mating surfaces and use new gaskets at time of installation.

#### REGULATOR HOUSING REMOVAL

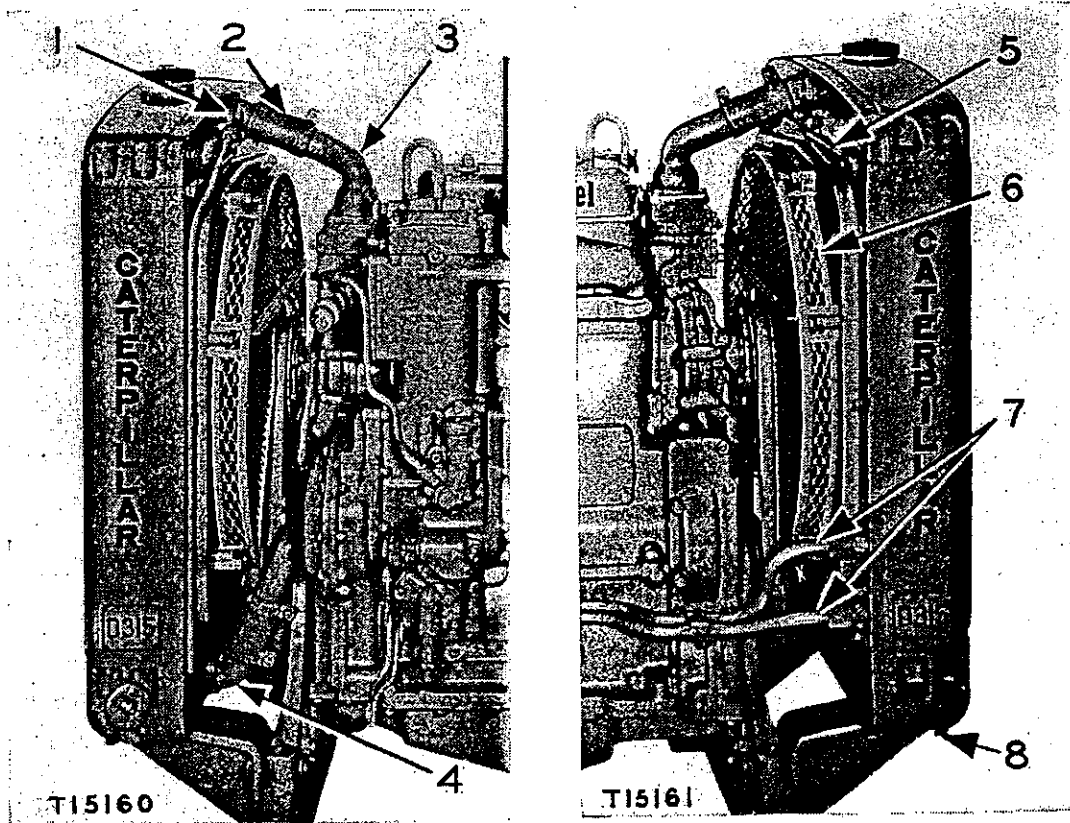
5-Cylinder head. 6-Elbow.  
7-Cylinder block.



## RADIATOR

### Radiator Removal

1. Drain the cooling system and the oil cooler.
2. Disconnect the flange (1) from the radiator top tank.



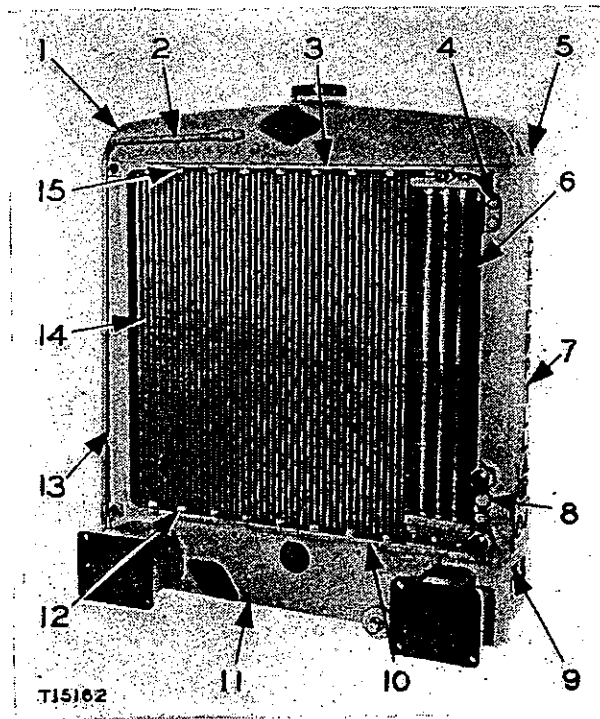
#### DISCONNECTIONS FOR RADIATOR REMOVAL

- 1-Flange. 2-Hose. 3-Upper elbow. 4-Lower elbow. 5-Metal shield.  
6-Guard. 7-Oil tubes. 8-Capscrew.

3. Disconnect the elbow (3) from the regulator housing and remove the upper elbow, the hose (2) and the flange as a unit.
4. Remove the lower elbow (4).
5. Remove the guard (6) and the metal shields (5).
6. Disconnect the oil tubes (7).
7. Remove the mounting capscrews (8) at each side of the radiator bottom tank and lift the radiator off the radiator mounting brackets.

## Radiator Disassembly

1. Remove the radiator front guard.
2. Disconnect and remove the overflow drain tube (2) from the radiator top tank (1).
3. Remove all the capscrews (12) and (15) and the metal strips (3) and (10) at the front and rear of the radiator.
4. Remove the capscrews (5) at each side of the top tank and lift the top tank off.
5. Remove the capscrews (9) at each side of the radiator bottom tank (11) and take off the left side plate (13).



**RADIATOR DISASSEMBLY (D4 Illustrated)**

1-Radiator top tank. 2-Overflow drain tube. 3-Metal strip. 4-Capscrew. 5-Capscrew. 6-Oil cooler. 7-Right side plate. 8-Capscrew. 9-Capscrew. 10-Metal strip. 11-Radiator bottom tank. 12-Capscrew. 13-Left side plate. 14-Water radiator core. 15-Capscrew.

6. Lift the right side plate (7) and the oil cooler (6) off the bottom tank as a unit.
7. In the event the oil cooler is to be separated from the right side plate (7), remove the capscrews (4) and (8), then pull the plate off the cooler.

8. Inspect and if not in good condition, replace the gasket located between the lower inside surface of the side plate and the related pad on the oil cooler.
9. Lift the water radiator core (14) off the bottom tank (11).

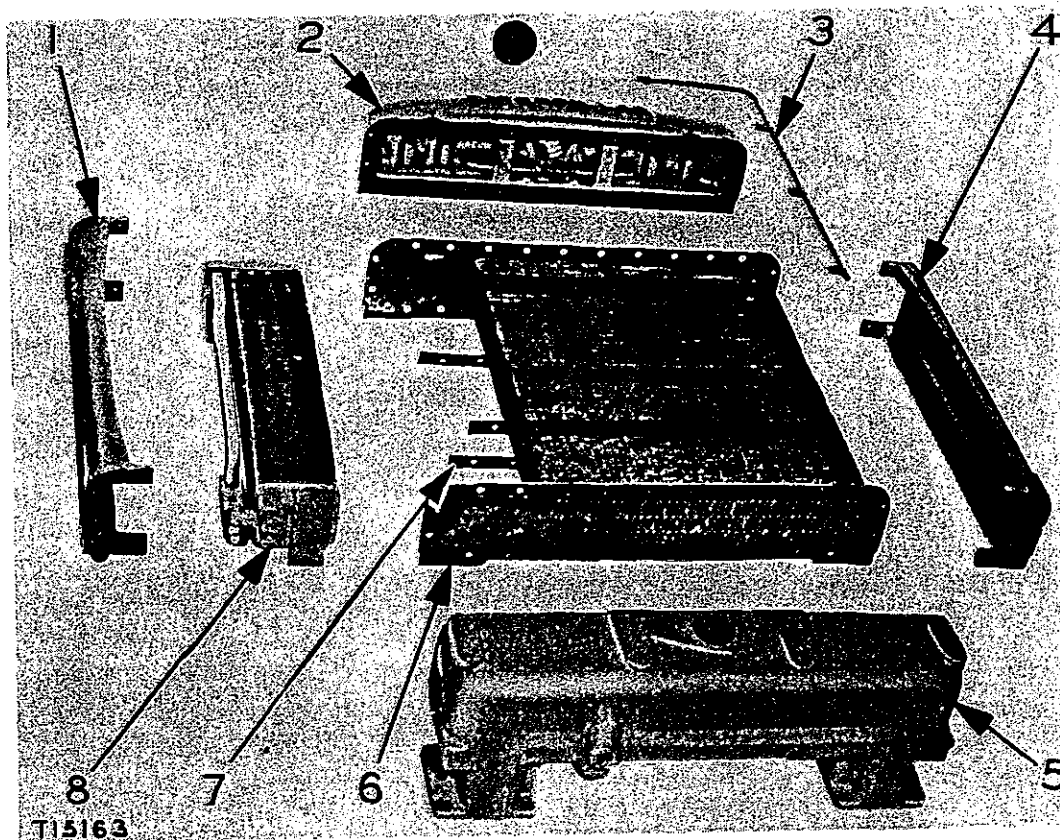
### Radiator Inspection, Cleaning and Assembly

Before assembling the radiator, inspect all gaskets and sealing surfaces.

Clean the radiator water core (6) and the oil cooler (8) of all accumulations of debris between the fins and tubes, by flushing with water or blowing with compressed air from the engine side of the core. Such accumulations decrease the efficiency of the cooling system and may cause the engine to overheat.

Clean the inside portion of both the radiator top tank (2) and the bottom tank (5) of any accumulation of sediment, with a solution of sal-soda.

With the gasket in place on the bottom tank, set the radiator water core in place on the tank.



**RADIATOR ASSEMBLY**

1-Right side plate. 2-Radiator top tank. 3-Overflow tube. 4-Left side plate. 5-Radiator bottom tank. 6-Radiator water core. 7-Metal strip. 8-Oil cooler.

Place the left side plate (4) in position and start the two capscrews at the bottom to hold it in place.

Assemble the oil cooler (8) to the right side plate (1), then place the plate and cooler into position on the bottom tank (5).

Place the gasket on top of the water core (6) and set the radiator top tank (2) in position on the core and side plates.

Position the metal strips (7) at the front and rear of the radiator and start all capscrews, including those which hold the top tank to the side plates.

Tighten all capscrews evenly to assure a good water seal between the water core (6) and the top tank (2) and bottom tank (5).

Test the radiator for possible leaks before installing the radiator on the engine. This can be accomplished by plugging both the radiator inlet and outlet opening and filling with water.

Leave the water in the radiator for a long enough period of time to detect any seepage that might occur.

Install the overflow tube (3).

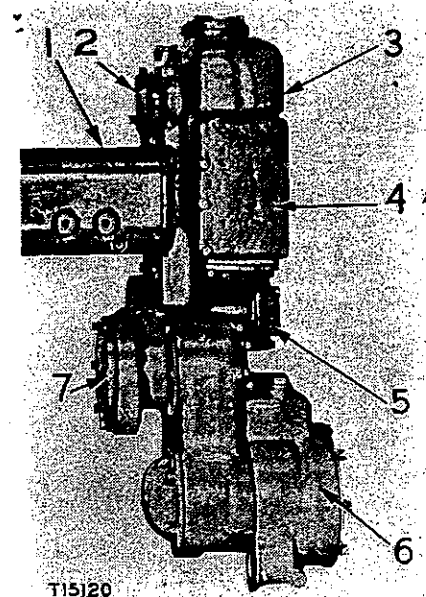
## HEAT EXCHANGER

Heat exchangers are used to cool the fresh water coolant.

The heat exchanger (3) is attached to the adapter housing (2) at the front of the engine.

### HEAT EXCHANGER

1-Water cooled exhaust manifold. 2-Adapter housing. 3-Heat exchanger. 4-Clean-out cover. 5-Oil cooler. 6-Raw water pump. 7-Fresh water pump.



T15120

The raw water pump (6) delivers raw water into the oil cooler (5) and then into the heat exchanger, where it passes through the passageways of the heat exchanger core.

The fresh water which is used for engine cooling is admitted to the heat exchanger through the adapter housing from the water-cooled exhaust manifold (1) and cylinder head and flows around the outside of the heat exchanger core and is cooled. Then it is returned to the fresh water pump (7).

Zinc plates and/or plugs (which are replaceable) are installed in the raw water compartment for the purpose of localizing any electrolytic action which may be set up.

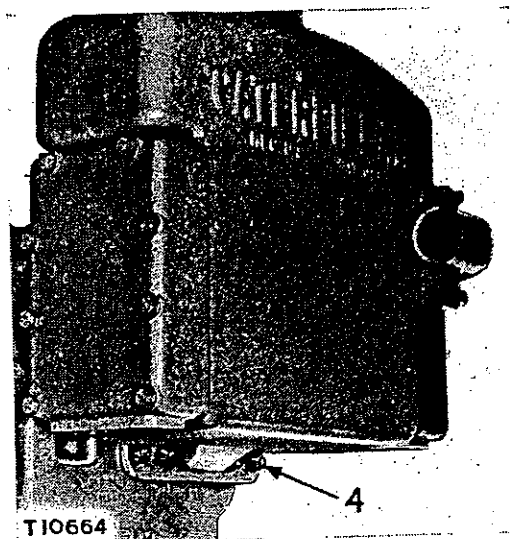
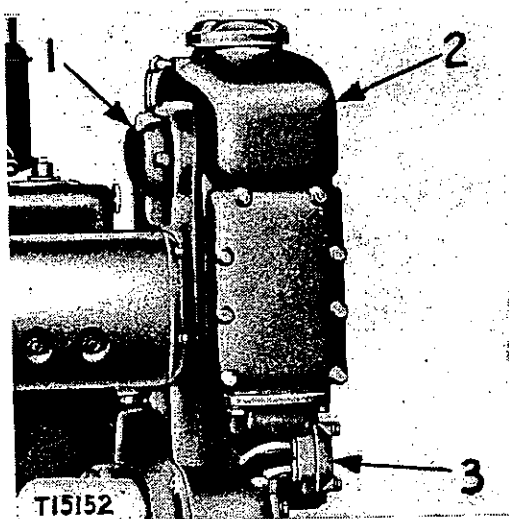
The zinc plates are mounted on the clean-out cover (4) and can be inspected by closing the sea valve, draining the raw water system and removing the clean-out cover.

The zinc plates should be inspected at least once a month to determine their condition.

### Heat Exchanger Removal and Installation

The heat exchanger (2) can be removed in the following manner:

1. Close the sea valve, drain the raw water system and disconnect the heat exchanger outlet pipe.
2. Drain the fresh water system.
3. Remove the oil cooler (3) as described in its respective topic, and cover the oil lines. The oil cooler is mounted below the heat ex-



### PREPARING FOR HEAT EXCHANGER REMOVAL

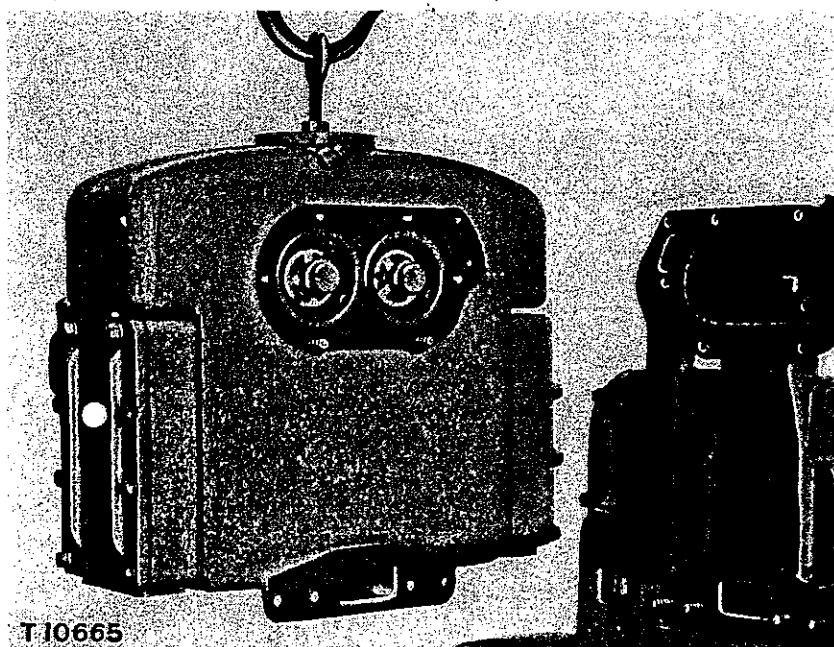
1-Adapter housing. 2-Heat exchanger. 3-Oil cooler. 4-Nut and lockwasher.



changer and should be removed first in order to facilitate the removal of several nuts and lockwashers at the bottom of the heat exchanger.

4. Remove the capscrews, nuts and lockwashers connecting the heat exchanger to the adapter housing (1).
5. Support the heat exchanger with a suitable hoist and remove the nuts and lockwashers (4) at the bottom, holding the heat exchanger to the adapter housing.
6. Lift off the heat exchanger as illustrated.

Before reinstalling the heat exchanger, inspect the regulators and clean out any scale or rust.



REMOVING HEAT EXCHANGER

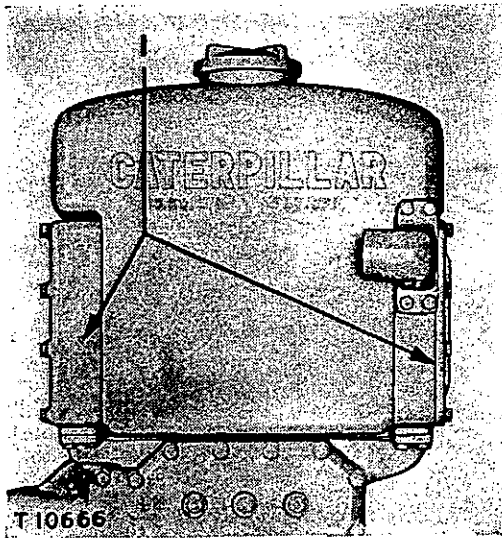
### Heat Exchanger Disassembly and Assembly

The heat exchanger core should be cleaned when the water temperature is continuously 205°F. or more during operation.

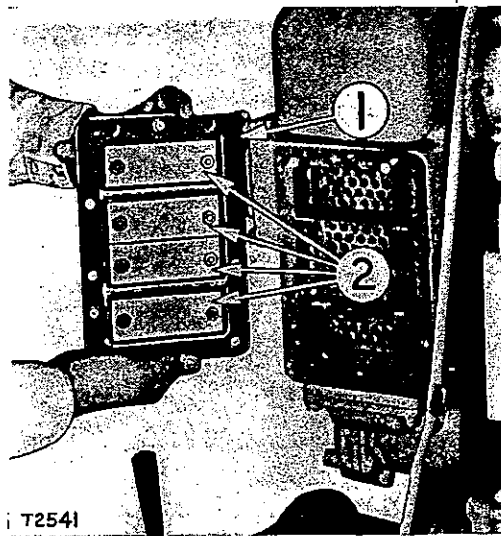
The core can be cleaned or removed with the heat exchanger installed on the engine in the following manner:

Drain the fresh water cooling system to a level below the heat exchanger.

Close the sea valve, and drain the raw water.



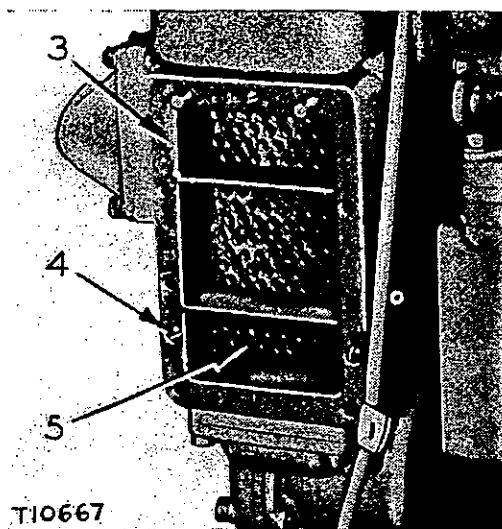
**REMOVING CLEAN OUT COVERS**  
1-Clean out covers.



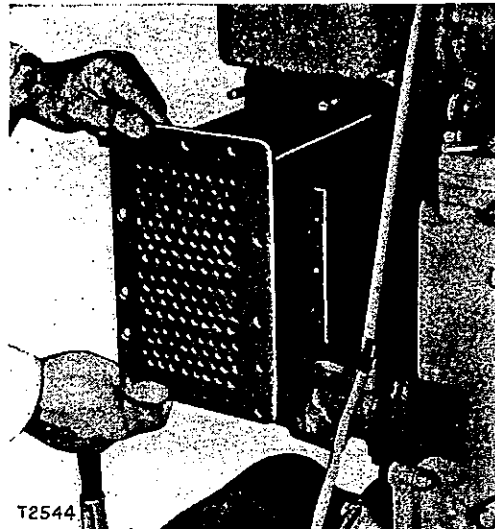
**ZINC PLATES**  
1-Clean out cover. 2-Zinc plates.

Remove the clean out covers (1), and then remove the end cover on the core assembly. A rod not larger than 9/32 inches in diameter can be used to push through the tubes of the core to remove accumulations.

Four zinc plates (2) are bolted to the inside of the small clean out cover for the purpose of localizing any electrolytic action which may be set up. They should be inspected at least once a month to determine the amount of corrosion in the raw water system.



**PREPARING TO REMOVE HEAT EXCHANGER CORE**  
3-Cover. 4-Screw. 5-Heat exchanger core.



**REMOVING HEAT EXCHANGER CORE**

### CAUTION

Do not be deceived by the outside appearance of the zinc plates. Strike them lightly with a small hammer and replace if they crack or crumble.

If they are not deteriorated badly, but appear to be corroded, they can be cleaned by scraping.

The core assembly (5) can be removed by removing the screws (4) and the cover (3).

Remove the heat exchanger core as illustrated.

If it is desired to remove the water temperature regulators, see the topic, TEMPERATURE REGULATOR REMOVAL AND INSTALLATION (HEAT EXCHANGER-COOLED).

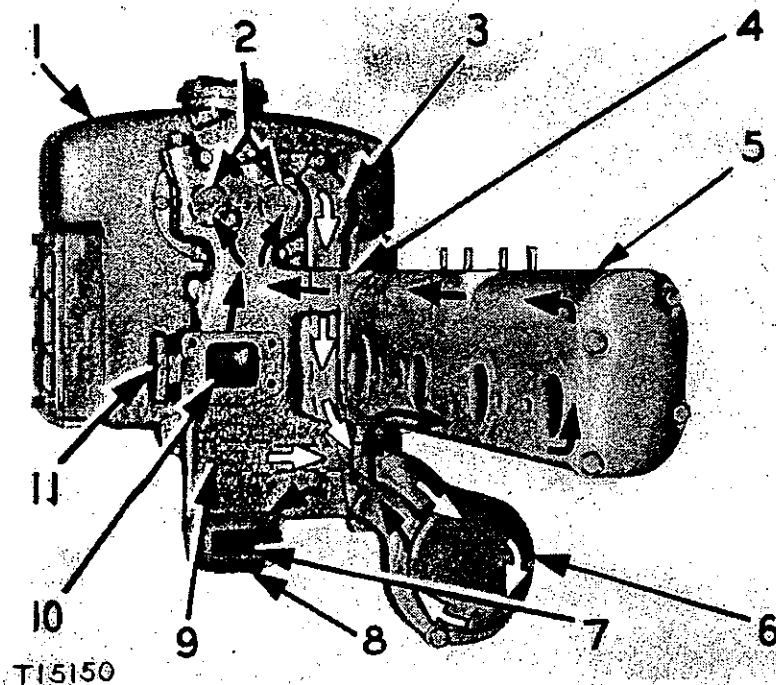
### ADAPTER HOUSING

The adapter housing (8) transmits the fresh water coolant from the fresh water pump (6) into the cylinder block through the passage (7). After the coolant passes through the cylinder block and into the cylinder head, the coolant re-enters the adapter housing at the passage (10). The coolant then flows to the top of the adapter housing where it comes in contact with the temperature regulators (2) which are located in the heat exchanger (1).

A portion of the coolant is also delivered from the fresh water pump through a passage into the water-cooled exhaust manifold (5). After this coolant passes through the manifold it flows through the passage (4) and then it also contacts the temperature regulators. When the regulators are closed, due to insufficient heat of the coolant, all the coolant flows through the by-pass passage (3) to the suction side of the fresh water pump and recirculates.

When the regulators are open the coolant passes around the heat exchanger core and re-enters the adapter housing at the passage (9) then returns to the suction side of the fresh water pump.

The outlet hole (11) transmits the coolant into an elbow which is attached to the fuel filter housing. See the topic, FRESH WATER AND RAW WATER COOLING SYSTEMS (HEAT EXCHANGER-COOLED).

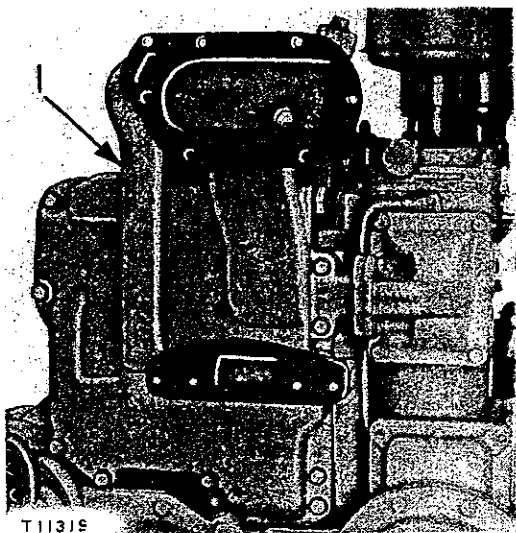


#### FLOW OF FRESH WATER THROUGH ADAPTER HOUSING

- 1-Heat exchanger. 2-Regulators. 3-By-pass passage. 4-Passage (to regulators).  
 5-Water-cooled exhaust manifold. 6-Fresh water pump. 7-Passage (outlet).  
 8-Adapter housing. 9-Passage (from heat exchanger). 10-Passage (inlet).  
 11-Passage (to water elbow).

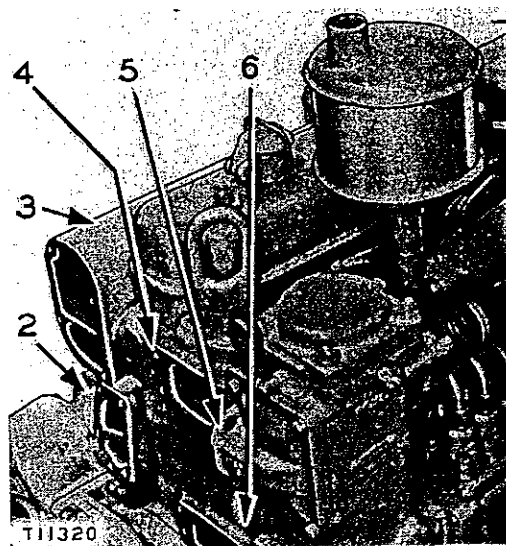
#### Adapter Housing Removal and Installation

In order to remove the adapter housing (1), first remove the oil cooler and the heat exchanger, as described in their respective topics.



#### PREPARING FOR ADAPTER HOUSING REMOVAL

- 1-Adapter housing.



#### ADAPTER HOUSING REMOVED

- 2-Fresh water pump. 3-Water-cooled exhaust manifold. 4-Cylinder head.  
 5-Water elbow. 6-Cylinder block.

Remove the capscrews holding the adapter housing to the fresh water pump (2), the water-cooled exhaust manifold (3), the cylinder head (4), the water elbow (5) and the cylinder block (6).

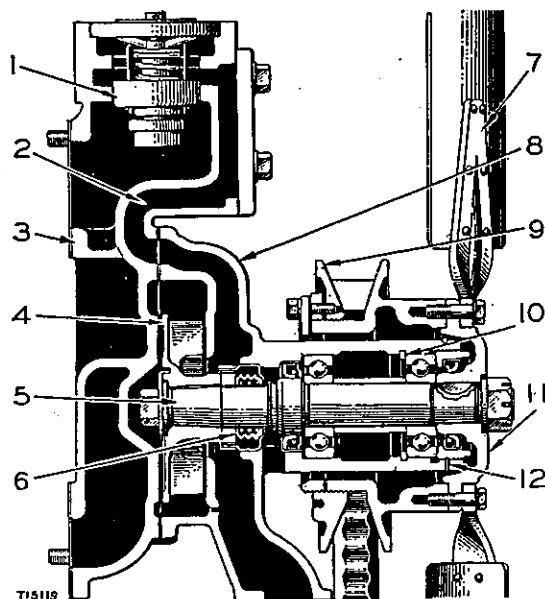
Clean the mating surfaces, and install new gaskets at the time of assembly, being sure to install the gaskets correctly, otherwise a water passage may be restricted.

### FAN AND FRESH WATER PUMP

On all engines (except those cooled by the heat exchanger system), the fan and the fresh water pump are attached to the regulator housing, which in turn is attached to the cylinder block and the cylinder head.

The water temperature regulator (1) is installed into the regulator housing (3).

The water pump shaft (5) carries both the fan hub (11) and the water pump impeller (4) and operates in two ball bearings. The front ball bearing is held in place by the bearing retainer ring (10) and the bearing retainer, which is secured by the lock ring (12). Two leather lip-type seals prevents lubricant leakage from the bearings.



FAN AND WATER PUMP CROSS-SECTION

1-Water temperature regulator. 2-By-pass passage. 3-Regulator housing. 4-Impeller. 5-Pump shaft. 6-Water seal assembly. 7-Fan spider assembly. 8-Pump housing. 9-Fan belt adjusting ring. 10-Bearing retainer ring. 11-Fan hub. 12-Lock ring.

A carbon-faced, self-adjusting seal (6) in contact with a machined face on the impeller (4) prevents water leakage. A drain to the outside of the housing (8) is provided for both water or lubricant leakage.

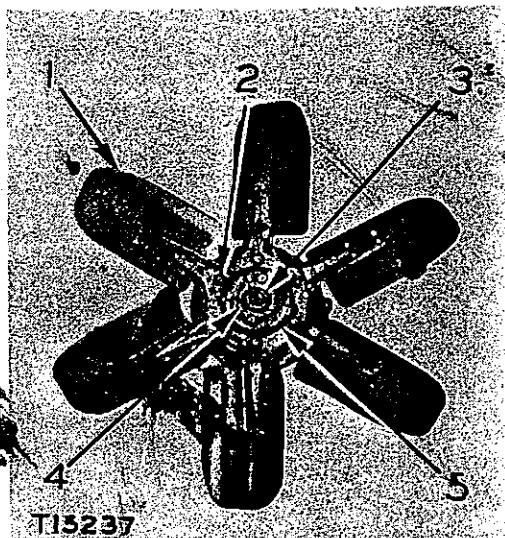
## Fan and Water Pump Disassembly and Assembly

Remove the series of capscrews (2) which attach the fan assembly (1) to the fan hub (5) and lift the fan from the hub.

Remove the lock (4) and the nut (3).

### NOTE

The nut (3) on earlier models was locked with a cotter pin instead of the metal lock (4).



### REMOVING THE FAN ASSEMBLY FROM THE FAN HUB

1-Fan assembly. 2-Capscrew. 3-Nut. 4-Lock. 5-Fan hub.



### REMOVING THE FAN HUB FROM THE PULLEY HUB

5-Fan hub. 6-Pulley hub. 7-Water pump drive shaft. 8-Water pump housing.

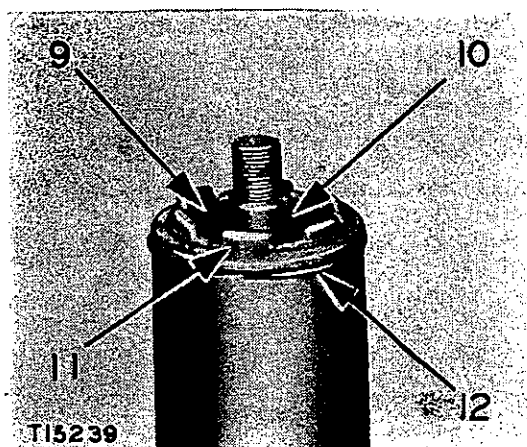
3. Remove the flat metal washer located directly back of the nut (3).
4. Remove the fan hub (5) from the water pump drive shaft (7) with the 8B7546 Puller and the 8B7560 Step Plate.
5. Lift the pulley hub and ring (6) off the water pump housing (8).
6. Remove the retainer ring (12) and the bearing retainer (11) from the water-pump housing.
7. Remove the fan hub key (10) from the water pump drive shaft.

If the grease seal (9) located in the bearing retainer (11) is damaged or badly worn, it should be replaced with a new seal.

When installing the seal in the retainer, have the lip of the seal turned inward in the retainer.

### REMOVING BEARING RETAINER

9-Grease seal. 10-Key. 11-Bearing retainer. 12-Retainer ring.



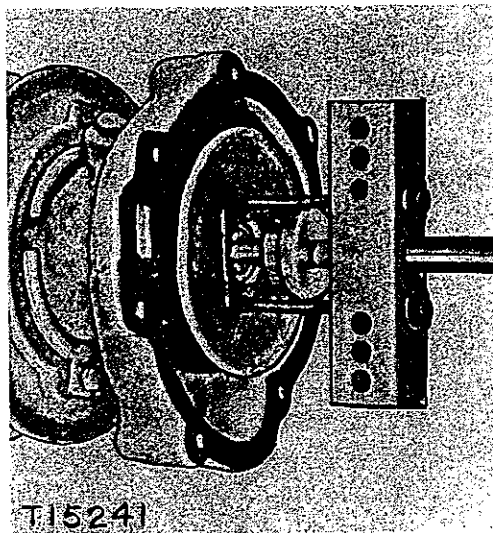
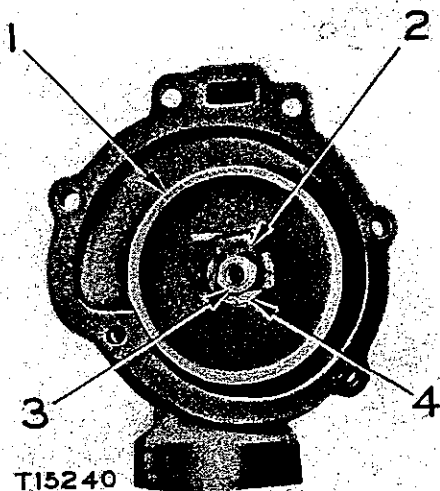
If a new retainer (11) is installed in the water pump housing, a retainer ring hole must be drilled in the retainer.

The hole should be drilled as follows:

Tighten the retainer in the housing, use the ring hole in the housing as a pilot and drill with a  $9/64$ " drill to a depth of  $7/16$ " from the outer surface of the pump housing.

### Impeller Removal

Lay the pump housing on its side, straighten the lock (2) and remove the nut (3), lock (2), washer (4) and the cork seal directly back of the washer.



REMOVING THE IMPELLER  
1-Impeller. 2-Lock. 3-Nut. 4-Washer.

Remove the impeller (1) by using the 5F7465 Puller, the 8B7560 Step Plate, two  $\frac{1}{4}$ "-20 (NC) capscrews,  $3\frac{1}{2}$ " long and two flat metal washers as illustrated.

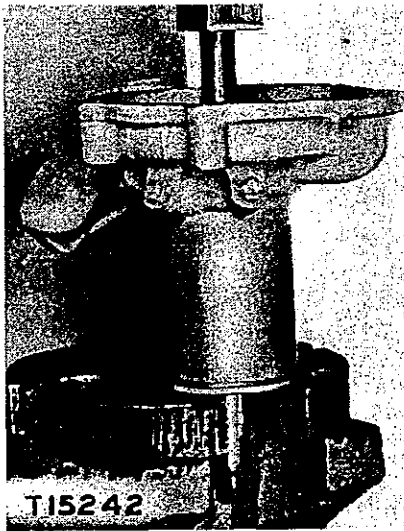
### **Pump Drive Shaft and Bearing Removal**

Place the pump housing under a press as illustrated.

Using a length of  $\frac{1}{2}$ " ID pipe  $3\frac{1}{2}$ " long, placed over the end of the pump drive shaft for a pressing tool, press the drive shaft from the housing just far enough to gain access to the outer drive shaft bearing.

#### **NOTE**

The drive shaft must not be pressed from the housing at this time, more than the distance required to expose the shaft outer bearing. Pushing the shaft farther would result in damage to the retainer ring located within the pump housing directly back of the outer bearing.



**PRESSING THE PUMP DRIVE SHAFT  
PARTIALLY FROM THE PUMP HOUSING**

Pull the pump drive shaft outer bearing (1) from the drive shaft (2) with the 8B7547 Puller and the 8B7560 Step Plate.

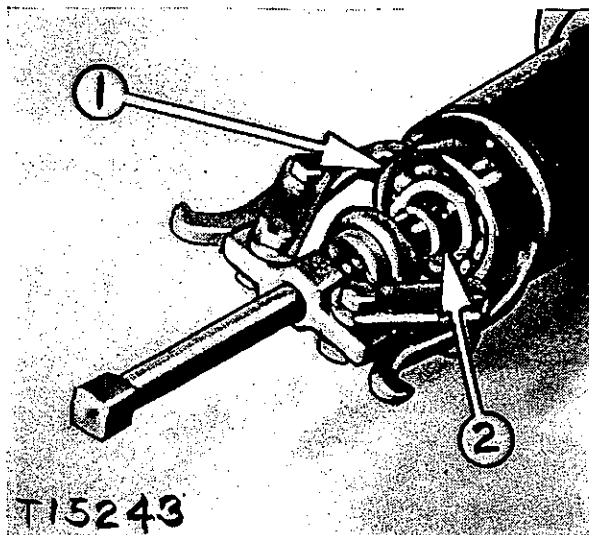
After the bearing (1) has been pulled from the drive shaft, remove the retainer ring (3) and the bearing spacer (4).

Place the pump housing under a press in the same manner used before.

Use the pipe pressing tool used before and press the drive shaft and the shaft inner bearing from the housing.

The shaft inner bearing can be removed from the drive shaft, by pressing the shaft out of the bearing if so desired.





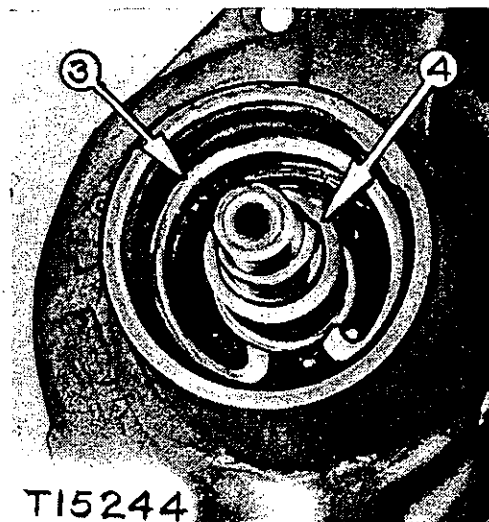
#### PULLING DRIVE SHAFT OUTER BEARING

1-Outer bearing. 2-Pump drive shaft.

The pump can be reassembled in reverse order of disassembly. Be sure the pump is properly lubricated before being placed into operation.

#### SPACER AND RETAINER RING REMOVAL

3-Retainer ring. 4-Bearing spacer.

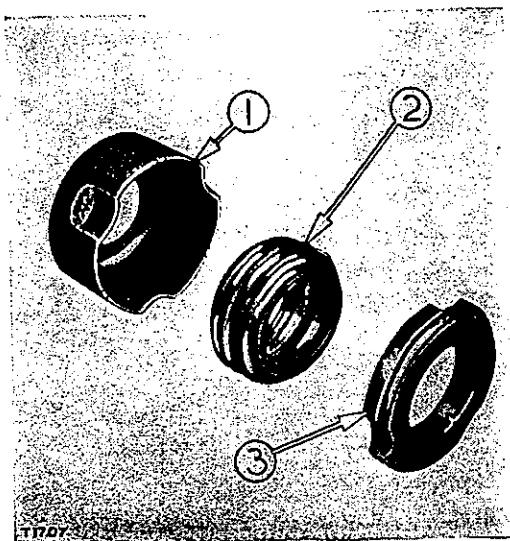


#### Water Pump Water Seal and Inner Grease Seal Replacement (Radiator-cooled)

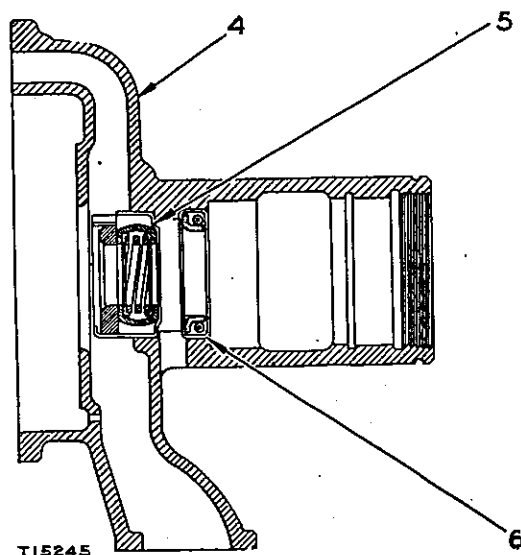
Water leaking from the drain opening in the underside of the pump indicates that the water seal should be replaced.

The seal (5) is an assembly of a carbon thrust washer (3) and a spring enclosed by a neoprene bellows (2). These two parts which make up the replaceable unit are contained in a brass case (1) which is pressed in the water pump housing.

Inspect the impeller bearing surface which contacts the carbon thrust washer. The contact surface must be a smooth lapped finish, free of roughness, nicks or burrs.



**SEAL ASSEMBLY**  
1-Case. 2-Neoprene bellows.  
3-Carbon thrust washer.



**LOCATION OF THE BELLOWS-TYPE  
WATER SEAL AND INNER GREASE  
SEAL**  
4-Water pump housing. 5-Bellows-type  
water seal. 6-Inner grease seal.

It is not necessary to remove the brass case (1) from the water pump housing (4) for seal replacement. The carbon thrust washer and the bellows seal are removed from the brass case by bending back the three ears holding them in place.

When replacing the carbon thrust washer be careful not to crack or scratch it. After the bellows seal and thrust washer are installed in the brass case, see that the washer moves freely under finger pressure.

If the brass case has been damaged, it is necessary to completely disassemble the water pump before it can be removed.

When installing a new brass case, coat the case and housing bore with a suitable compound or lubricant to avoid shearing the brass case and also to provide a positive seal against water leakage.

Make sure the brass case bottoms squarely in the bore so the carbon washer will bear evenly against the impeller contact surface.

#### **CAUTION**

The flange on the case can be bent if excessive pressure is applied after the case bottoms.

If it becomes necessary to replace the inner grease seal (6), the pump must also be disassembled.

Press the old seal out and install a new one having the lip of the seal toward the fan end of the water pump housing when pressing it into place.

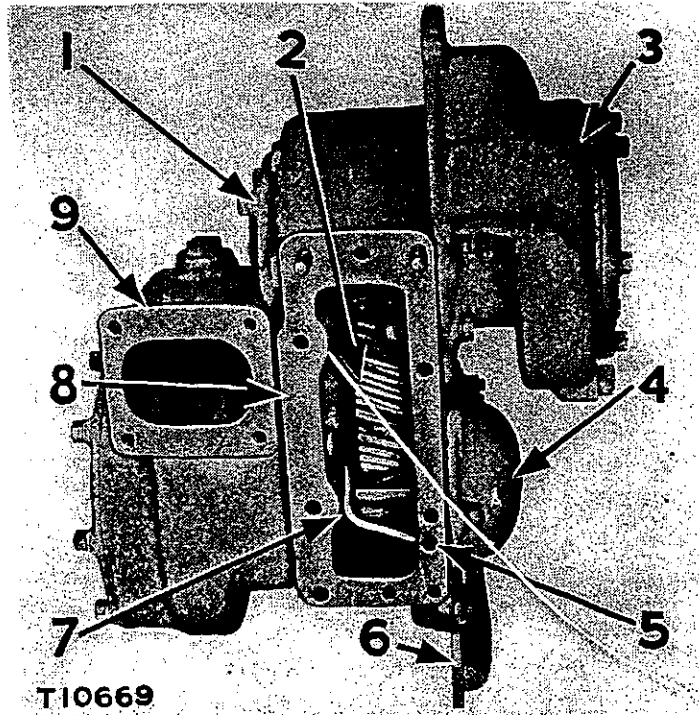
## FRESH WATER PUMP LUBRICATION (Radiator-Cooled)

The lubrication of a fresh water pump for a radiator-cooled engine is described in the topic, FAN AND FRESH WATER PUMP.

## FRESH WATER AND RAW WATER PUMP LUBRICATION

The oil is supplied to the hole (5) and the oil tube (7) in the auxiliary drive housing (8) from the oil manifold.

A passage in the raw water pump (9) is in alignment with the oil tube (7). The bushings and shaft are lubricated and the excess oil returns through passages to the bottom of the auxiliary drive housing.



### LUBRICATION OF WATER PUMPS (Earlier Model Illustrated)

1-Cover. 2-Auxiliary drive idler gear. 3-Fresh water pump. 4-Cover. 5-Oil hole.  
6-Pipe. 7-Oil tube. 8-Auxiliary drive housing. 9-Raw water pump.

The oil tube also supplies oil for the idler gear (2) and idler gear shaft. A portion of the oil goes from the idler gear shaft to passages which lubricate the fresh water pump (3).

Attachments, such as auxiliary power take-offs, generators, and the like, are installed in place of covers (1) and (4) and are driven by the gears on the end of the pump shafts. Some of these attachments are lubricated through oil holes that are exposed after the covers are removed.

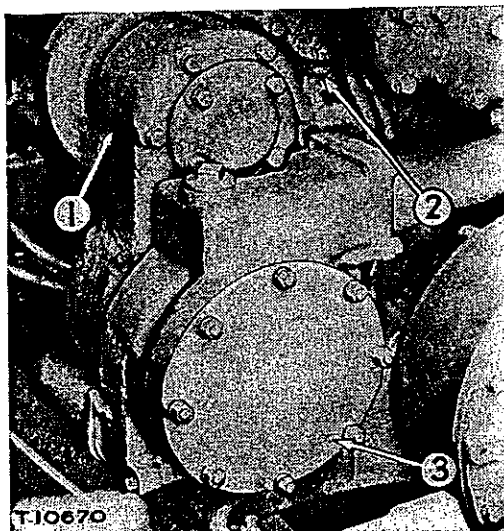
All excess oil collects in the bottom of the auxiliary drive housing and drains out a hole into the pipe (6), which is attached to the timing gear housing. On later models the pipe (6) is attached to the side cover on the right side of the oil pan.

### RAW WATER PUMP

The raw water pump (3) is of the centrifugal-type and it circulates the raw water throughout the heat exchanger cooling system.

The raw water pump is mounted on the auxiliary drive housing (1) which in turn is mounted on the timing gear housing and cover (2).

The camshaft gear drives the auxiliary drive gear which in turn drives the raw water pump.



### RAW WATER PUMP

1-Auxiliary drive housing. 2-Timing gear housing and cover. 3-Raw water pump.

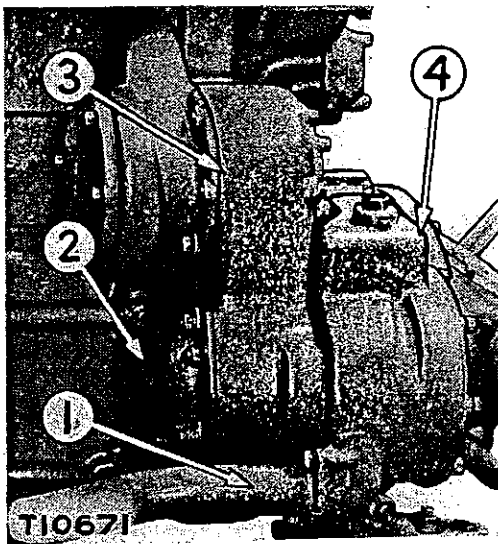
### Raw Water Pump Removal and Installation

Remove the capscrews holding the raw water inlet line (1) to the raw water pump (4).

Remove the nuts and lockwashers holding the water pump and the cover (2) to the auxiliary drive housing (3).

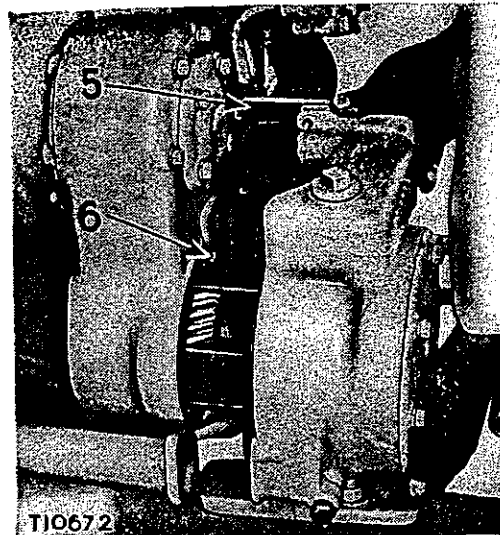
Remove the capscrews and lockwashers connecting the raw water pump to the oil cooler water elbow (5) and remove the raw water pump as illustrated.

Clean the mating surfaces and install new gaskets being careful not to cover the oil hole (6) which supplies oil to the raw water pump.



#### PREPARING TO REMOVE RAW WATER PUMP

1-Inlet line. 2-Cover. 3-Auxiliary drive housing. 4-Raw water pump.

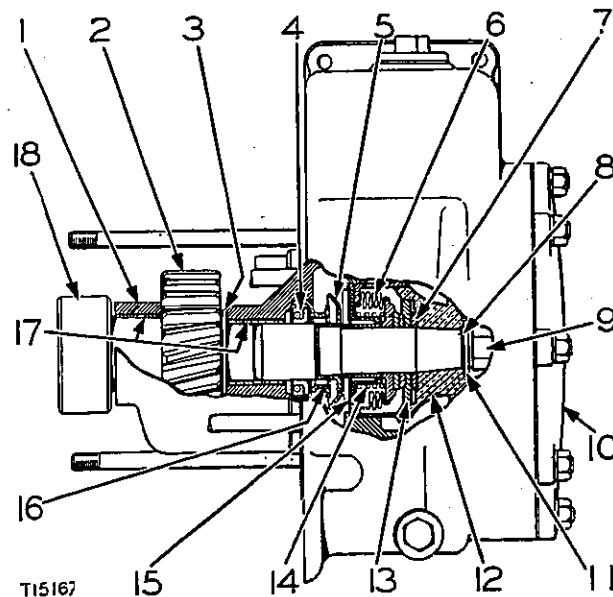


#### REMOVING PUMP

5-Water elbow. 6-Oil hole.

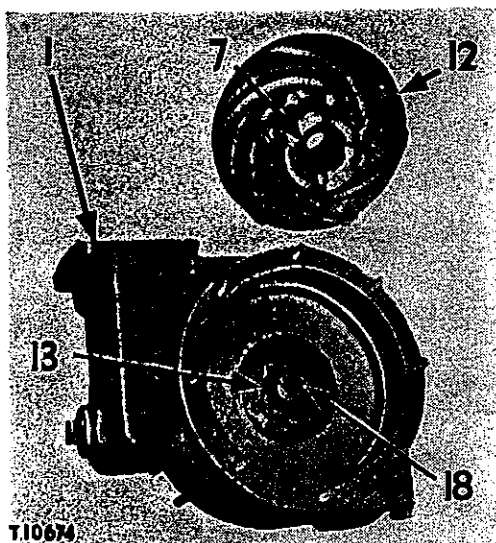
### Raw Water Pump Disassembly and Assembly

Water leaking from the drain opening on the underside of the raw water pump indicates that parts of the water seal should be replaced. The water seal consists of the spring (14), the bellows assembly (6), the plate (13) and the seal (7).



#### CROSS-SECTION OF RAW WATER PUMP (SCHEMATIC)

1-Housing assembly. 2-Gear. 3-Thrust washer. 4-Oil seal. 5-Thrower. 6-Bellows assembly. 7-Seal. 8-Cork seal. 9-Nut and lock. 10-Cover and gasket. 11-Washer. 12-Impeller. 13-Plate. 14-Spring. 15-Retainer. 16-Baffle. 17-Bushing. 18-Shaft assembly.



#### IMPELLER REMOVED

1-Housing assembly. 7-Seal. 12-Impeller. 13-Plate. 18-Shaft assembly.

When oil is leaking through this opening, the oil seal (4) should be replaced.

The raw water pump can be disassembled in the following manner.

Remove the cover (10) and gasket.

Remove the nut (9), the washer (11) and the cork seal (8).

Remove the impeller (12) using two 5/16"-18 (NC) capscrews approximately 6" long and the 5F7465 Puller.

#### CAUTION

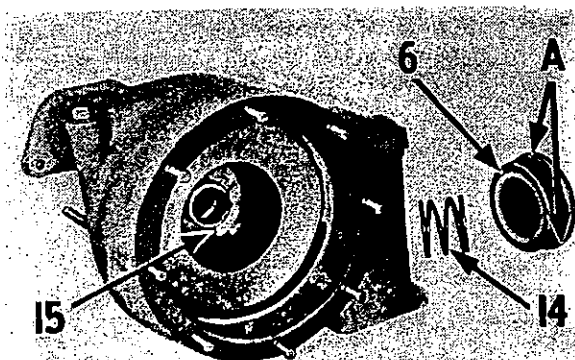
The water seal assembly which is directly in back of the impeller can be damaged, if the puller capscrews are inserted too far through the impeller.

Remove the key from the shaft assembly, which prevents the impeller from rotating on the shaft.

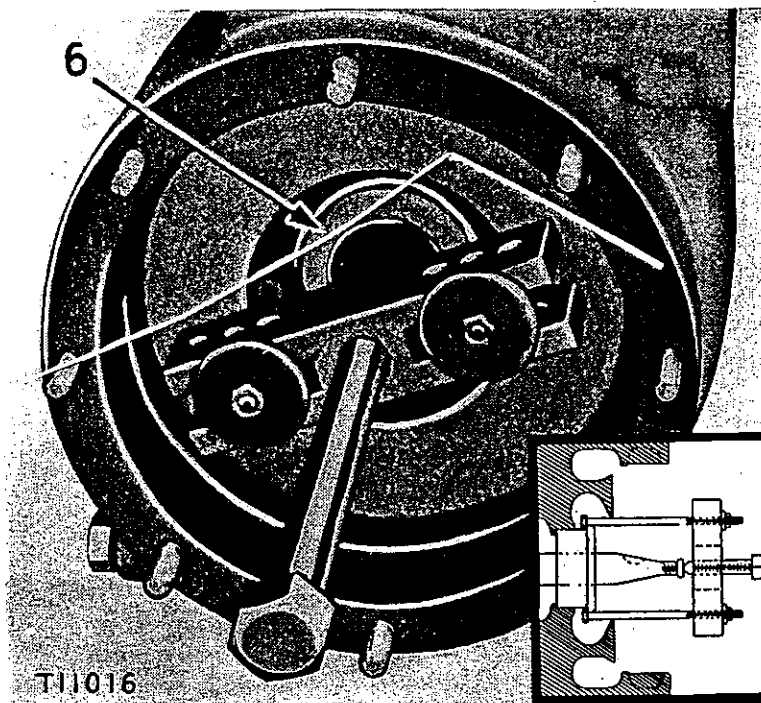
Remove the seal (7) and the plate (13) and inspect them for wear.

#### BELLOWS ASSEMBLY REMOVED

A-Location to hook bolts while pulling bellows assembly. 6-Bellows assembly. 14-Spring. 15-Retainer.

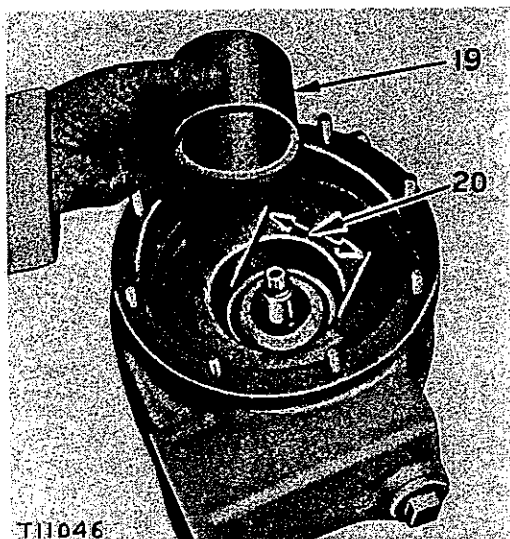


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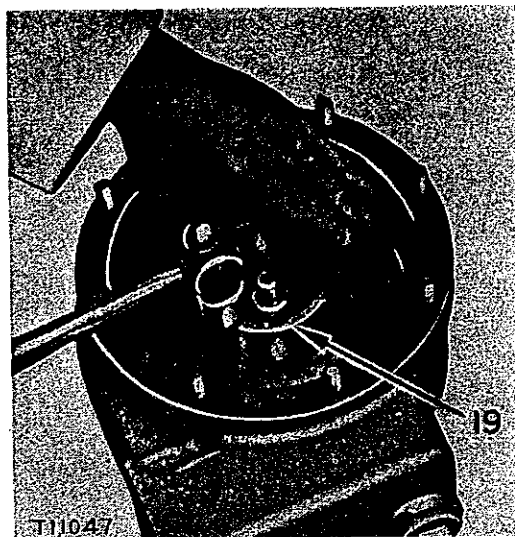


**PULLING BELLOWS ASSEMBLY**  
6-Bellows assembly.

Remove the bellows assembly (6) by using the 5F7465 Puller, and the same capscrews as used to pull the impeller, with 5/16"-18 (NC) nuts. The capscrews can be hooked in back of the bellows assembly as indicated by the arrows (A). These capscrews must be aligned diametrically with each other, in order to pull evenly. (The bellows assembly can be removed, either before or after the shaft assembly (18) has been removed.)



**INSTALLING BELLOWS ASSEMBLY**  
19-Sleeve. 20-Outside shoulder (of bellows assembly).



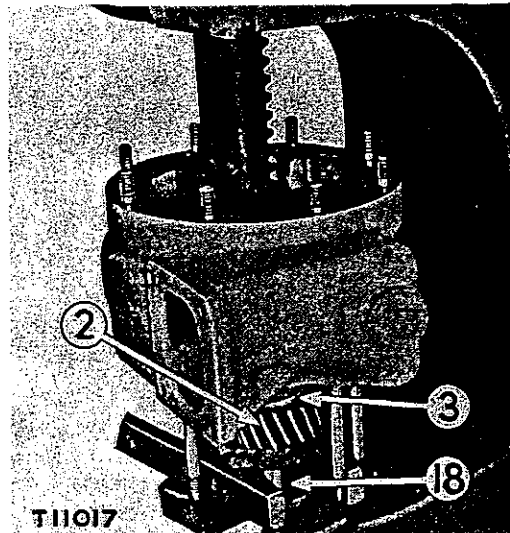
**USING A SLEEVE TO INSTALL BELLOWS ASSEMBLY**  
19-Sleeve.

The bellows assembly can be installed by using a sleeve (19) similar to the one shown in the illustration. With a sleeve of the same diameter as the outside shoulder (20) of the bellows assembly, drive or press on the sleeve to install the bellows assembly.

Support the pump housing (1) on two pieces of bar stock and press out the shaft assembly (18). Remove the gear (2) and the thrust washer (3). The end thrust is taken by the thrust washer. If excessive wear is shown, the washer should be replaced with a new one.

#### PRESSING OUT SHAFT ASSEMBLY

2-Gear. 3-Thrust washer.  
18-Shaft assembly.

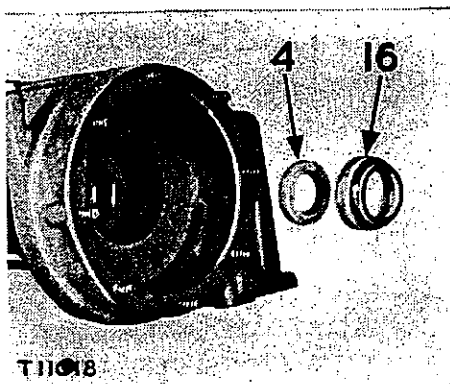


Remove the spring (14), the retainer (15) and the thrower (5).

Remove the baffle (16) and the oil seal (4).

When installing the oil seal, coat the outside circumference with a sealing compound to prevent leakage and install the lip of the seal toward the gear.

The bushings (17) are replaceable and can be removed and installed by the use of an arbor press.



#### OIL SEAL REMOVED

4-Oil seal. 16-Baffle.

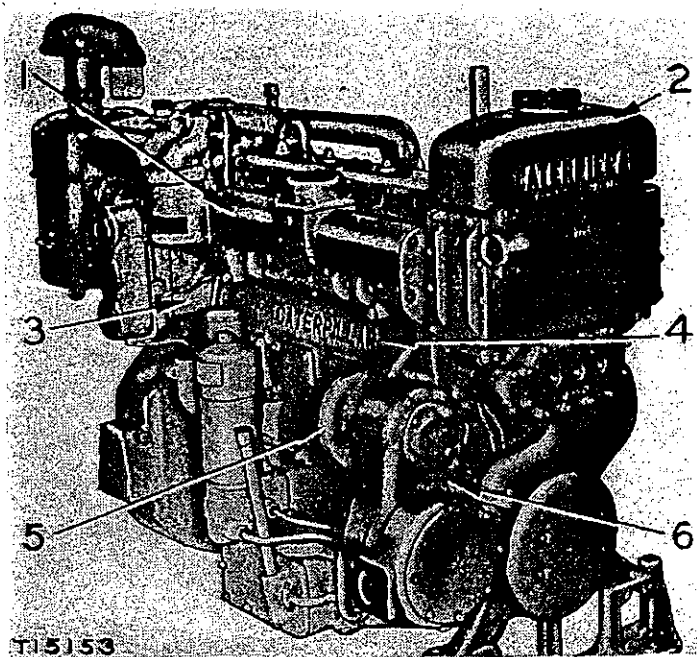


After installing the shaft assembly, check the end clearance. The correct end clearance should be .002"-.006" with a maximum clearance of .015".

### **FRESH WATER PUMP (Heat Exchanger-Cooled)**

The fresh water pump (5) is located on the right forward side of the engine and is mounted on the auxiliary drive housing (6).

The pump is driven by the camshaft gear through the auxiliary drive idler gear.



#### **LOCATION OF FRESH WATER PUMP**

1-Water cooled exhaust manifold. 2-Heat exchanger. 3-Starting engine. 4-Cylinder block. 5-Fresh water pump. 6-Auxiliary drive housing.

The fresh water pump circulates the fresh water throughout the cylinder block (4) and the cylinder head, the starting engine (3), the water-cooled exhaust manifold (1) and the heat exchanger (2).

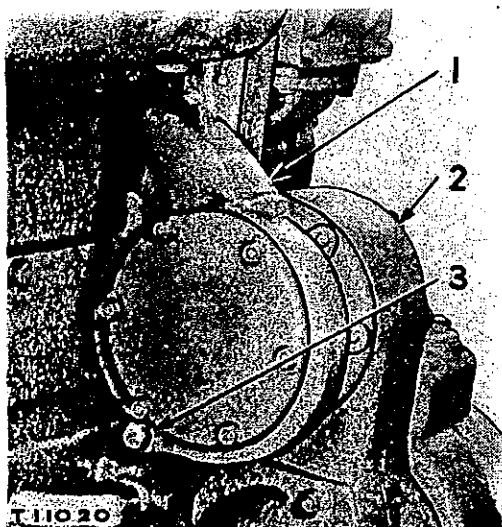
The water seal on a fresh water pump can be removed and installed without having the water pump removed from the engine. See the topic, FRESH WATER PUMP WATER SEAL REPLACEMENT (HEAT EXCHANGER-COOLED).

## Fresh Water Pump Removal and Installation (Heat Exchanger-Cooled)

The fresh water pump can be removed in the following manner.

Drain the fresh water coolant by removing the drain plug (3).

Remove all the capscrews holding the fresh water pump (1) to the auxiliary drive housing (2) and the adapter housing and remove the pump.



### PREPARING TO REMOVE WATER PUMP

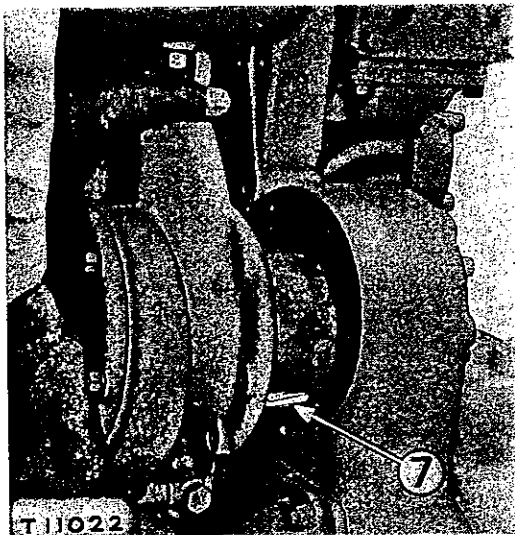
1-Fresh water pump. 2-Auxiliary  
drive housing. 3-Drain plug.



### WATER PUMP REMOVED

4-Water passages. 5-Auxiliary drive  
idler gear. 6-Oil supply hole.

When installing the water pump, clean all the mating surfaces and use new gaskets. Be careful when installing gaskets so as not to restrict the water passages (4) or the oil supply hole (6).



### INSTALLING WATER PUMP

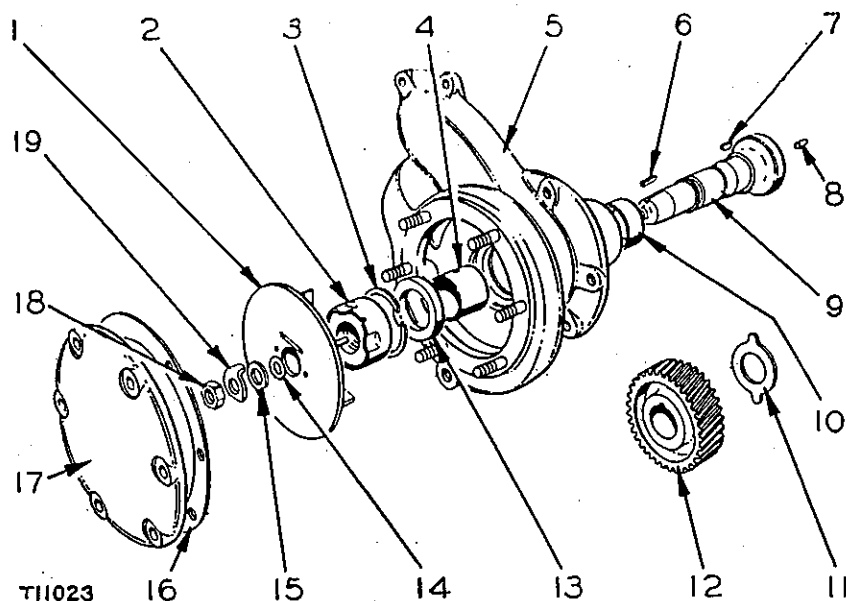
7-Water pump gear.

The water pump gear (7) may need to be rotated slightly in either direction, in order to permit it to mesh properly with the auxiliary drive idler gear (5).

### Fresh Water Pump Disassembly and Assembly (Heat Exchanger-Cooled)

The fresh water pump can be disassembled far enough while installed on the engine to replace or recondition the water seal. For this reason the procedure of disassembly is described with the pump installed on the engine until the water seal can be removed, then the removal of the remaining parts is described after the pump has been removed from the engine.

Remove the cover (17) and the gasket (16).



#### FRESH WATER PUMP (Heat Exchanger-Cooled)

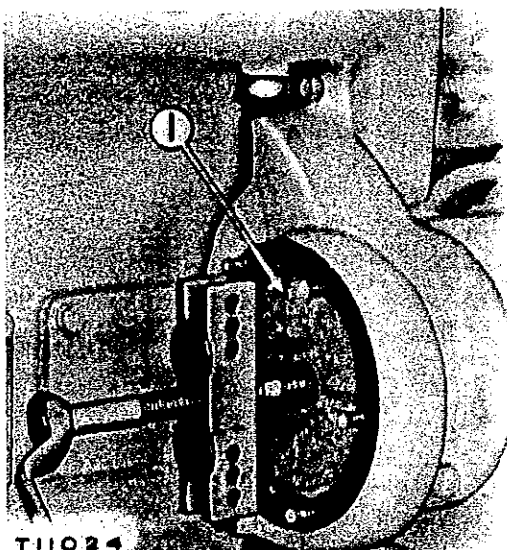
1-Impeller. 2-Water seal assembly. 3-Snap ring. 4-Bushing. 5-Housing assembly. 6-Key. 7-Key. 8-Pin. 9-Shaft assembly. 10-Bushing. 11-Thrust washer. 12-Gear. 13-Oil seal. 14-Cork seal. 15-Washer. 16-Gasket. 17-Cover. 18-Nut. 19-Lock.

Bend the lock (19) and remove the nut (18) and lock, the washer (15) and the cork seal (14).

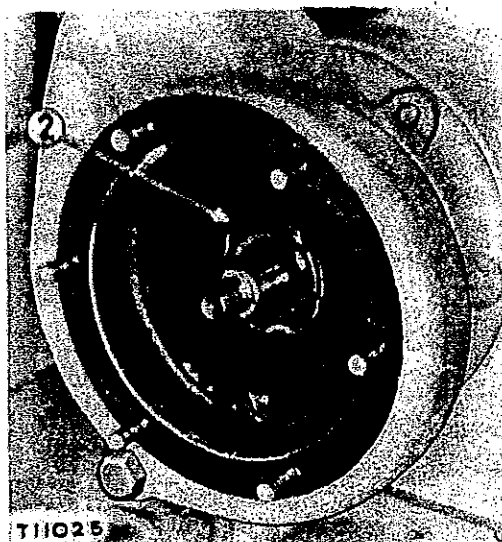
Using the 5F7465 Puller and two 1/4"-20 (NC) capscrews approximately 4" long and a centering spacer, remove the impeller (1) as illustrated.

#### CAUTION

The water seal assembly (2) which is directly in back of the impeller, can be damaged if the puller capscrews are inserted too far through the impeller.



**PULLING IMPELLER**  
1-Impeller.



**LOCATION OF WATER SEAL**  
2-Water seal assembly.

The water seal assembly (2) can be replaced or reconditioned as described in the topic, FRESH WATER PUMP WATER SEAL REPLACEMENT (HEAT EXCHANGER-COOLED).

Install a new carbon thrust washer and neoprene bellows if necessary. Inspect the impeller bearing face for wear, since it is in contact with the carbon thrust washer. The impeller bearing face must have a smooth lapped finish.

If further disassembly is necessary, remove the pump from the engine.

Remove the key (6) and remove the water seal assembly (if the oil seal (13) is to be removed).

Place the water pump on an arbor press and support the pump housing (5).

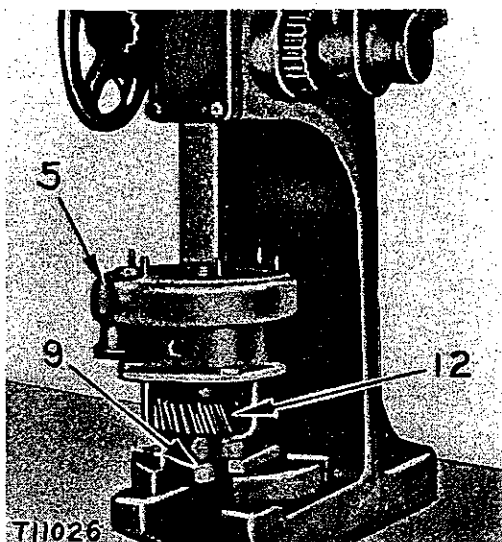
Press out the shaft assembly (9) as illustrated and remove the gear (12) and the thrust washer (11). The end thrust is taken by the thrust washer, if excessive wear is shown, it should be replaced with a new one.

Remove the snap ring (3) and the oil seal (13).

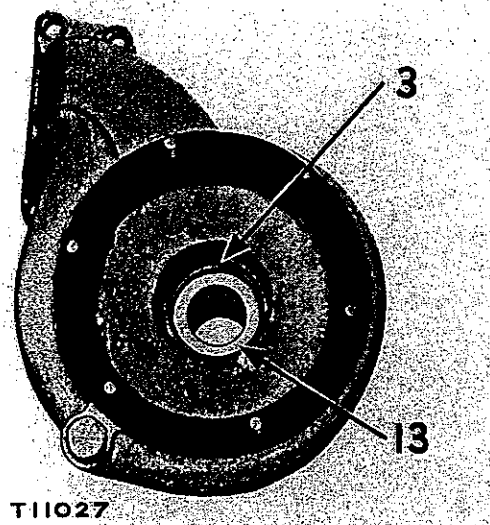
The bushings (4) and (10) are replaceable.

When installing the oil seal, coat the outside circumference with a sealing compound to prevent leakage, and install the lip of the seal toward the gear.

Inspect the key (7), the shaft assembly and the gear for burrs or roughness at the time of assembly.



**PRESSING OUT SHAFT ASSEMBLY**  
 5-Housing assembly. 9-Shaft assembly.  
 12-Gear.



**REMOVING OIL SEAL**  
 3-Snap ring. 13-Oil seal.

The pin (8) is part of the shaft assembly. The shaft is drilled to provide a method of lubricating the bushings and the pin is used to plug this hole after the shaft is drilled.

After installing the shaft assembly, check the end clearance. The correct end clearance should be .002"-.006" with a maximum clearance of .015".

### **Fresh Water Pump Water Seal Replacement (Heat Exchanger-Cooled)**

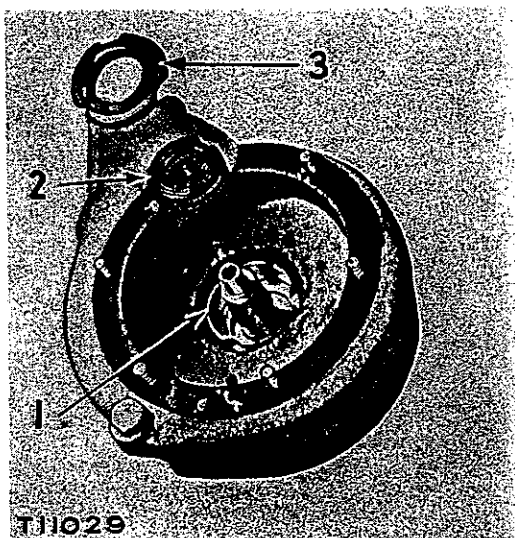
The water seal assembly (4) in a fresh water pump can be removed and installed without removing the water pump from the engine. (The water pump has been removed for better illustration only).

Water leaking from the drain opening in the underside of the water pump indicates that the water seal should be replaced.

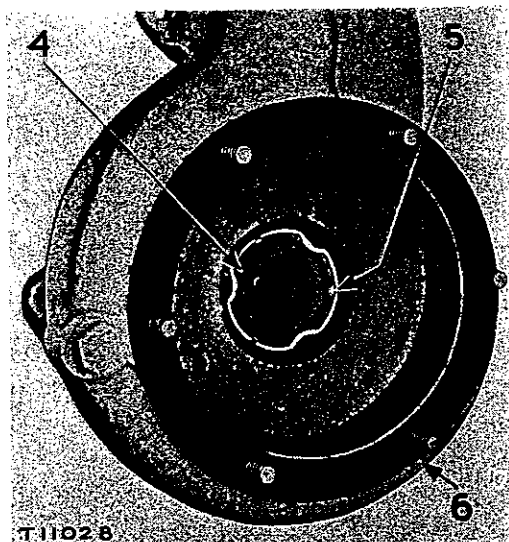
See the topic, FRESH WATER PUMP DISASSEMBLY AND ASSEMBLY (HEAT EXCHANGER-COOLED), for the procedure of removing the parts necessary to make the water seal accessible.

The water seal assembly consists of a carbon thrust washer (3) and a spring enclosed by a neoprene bellows (2). These two parts which make up the replaceable unit are contained in a brass case (1) which is pressed in the water pump housing (6).

It is not necessary to remove the brass case (1) from the water pump for seal replacement.



**WATER SEAL DISASSEMBLED**  
1-Case. 2-Bellows assembly.  
3-Carbon thrust washer.



**LOCATION OF WATER SEAL ASSEMBLY**  
(Shaft removed for better illustration only)  
4-Water seal assembly. 5-Locking ears. 6-Water pump housing.

The carbon thrust washer and the bellows seal are removed from the brass case by bending back the three locking ears (5) holding them in place.

Install a new carbon thrust washer and neoprene bellows if necessary. Inspect the impeller bearing face for wear, since it is in contact with the carbon thrust washer. The impeller bearing face must have a smooth lapped finish.

When replacing the carbon thrust washer be careful not to crack or scratch it. After the bellows seal and thrust washer are installed in the brass case, bend the locking ears and see that the washer moves freely under finger pressure.

If the brass case has been damaged, it can be removed and installed without removing the water pump. However, in most cases it would be more practical to remove the pump and further disassemble it to make the brass case more accessible.

When installing a new brass case, coat the case and the housing bore with a suitable compound or lubricant to avoid shearing the brass case and also to provide a positive seal against water leakage.

Make sure the brass case bottoms squarely in the bore so the carbon washer will bear evenly against the impeller contact surface.

Complete the assembly of the water pump.

## AUXILIARY WATER PUMP

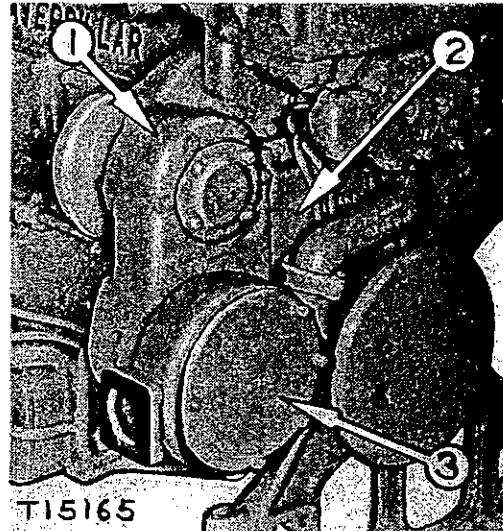
The auxiliary water pump (3) is of the centrifugal type and it circulates the coolant throughout the heat exchanger or expansion tank.

The water pump is mounted on the auxiliary drive housing (1) which in turn is mounted on the timing gear housing and cover (2).

The camshaft gear drives the auxiliary drive gear which in turn drives the water pump.

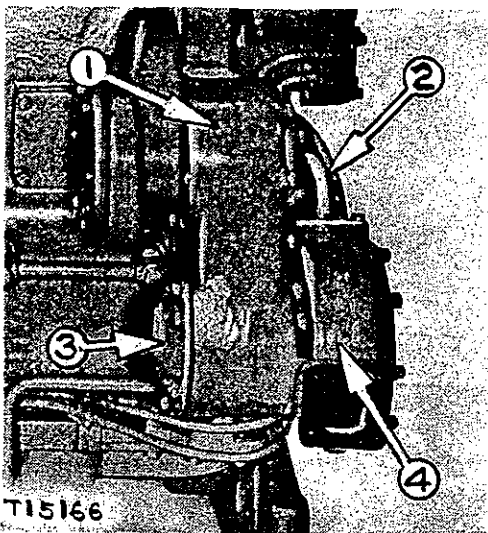
### AUXILIARY WATER PUMP

1-Auxiliary drive housing. 2-Timing gear cover. 3-Auxiliary water pump.

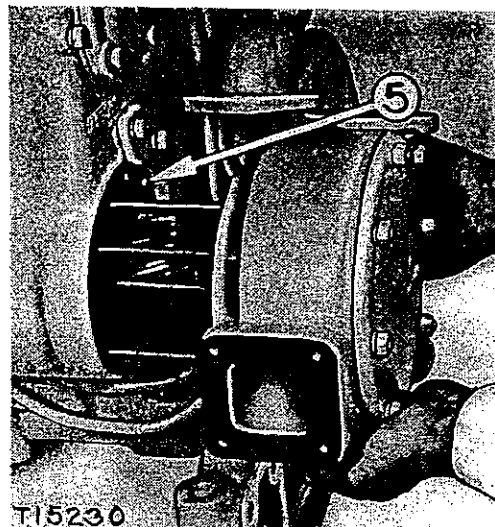


### Auxiliary Water Pump Removal and Installation

Remove the nuts and lockwashers holding the pump (4) and the cover (3) to the auxiliary drive housing (1).



PREPARING TO REMOVE PUMP  
1-Drive housing. 2-Elbow. 3-Cover.  
4-Pump.



PUMP REMOVAL  
5-Oil hole.

Remove the capscrew and lockwashers connecting the water pump to the oil cooler water elbow (2) and remove the pump as illustrated.

At the time of installation, clean the mating surfaces and install new gaskets being careful not to cover the oil hole (5) which supplies oil to the auxiliary water pump.

### Impeller Removal

The pump can be disassembled in the following manner.

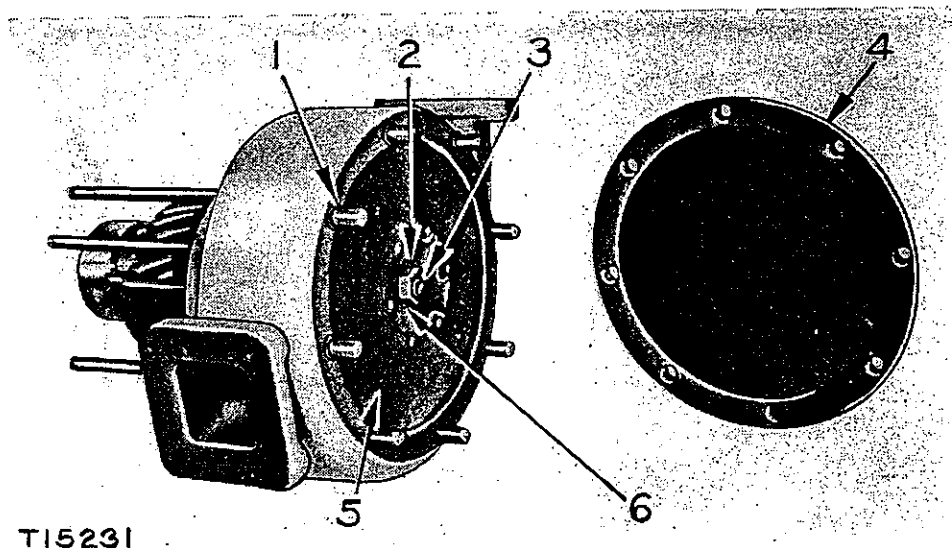
Remove the cover (4), the "O" ring seals (1) from around each stud, then remove the gasket.

Remove the nut (3), lock (2), washer (6) and the seal.

Remove the impeller (5) using two 5/16"-18 (NC) capscrews approximately 6" long and the 5F7465 Puller.

#### CAUTION

The water seal assembly which is directly in back of the impeller can be damaged if the puller capscrews are inserted too far through the impeller.



#### IMPELLER REMOVAL

1-"O" ring seal. 2-Lock. 3-Nut. 4-Cover. 5-Impeller. 6-Washer.

Remove the key from the shaft assembly, which prevents the impeller from rotating on the shaft.

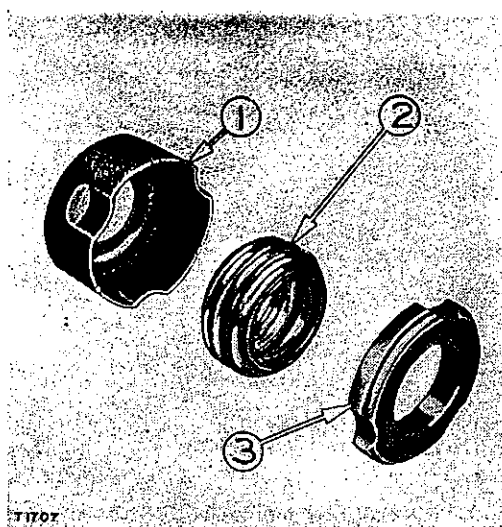


## Water Seal Replacement

Water leaking from the opening on the underside of the pump indicates that the water seal should be replaced.

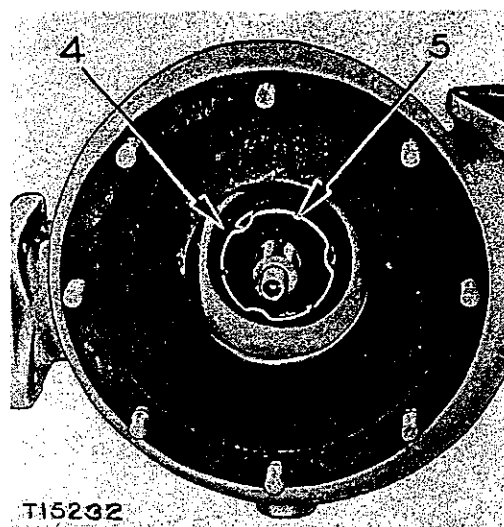
To service the water seal only, it is not necessary to remove the pump from the engine. Remove the cover and impeller and the seal is then accessible.

The seal is an assembly of a carbon thrust washer (3) and a spring enclosed by a neoprene bellows (2). These two parts which make up the replaceable unit are contained in a brass case (1) which is pressed into an adapter (4) in the water pump housing.



### SEAL ASSEMBLY

1-Case. 2-Neoprene bellows.  
3-Carbon thrust washer.



### PREPARING TO REMOVE SEAL AND THRUST WASHER

4-Adapter. 5-Ear.

Inspect the impeller bearing surface which contacts the carbon thrust washer. The contact surface must be a smooth lapped finish.

It is not necessary to remove the brass case from the adapter in the housing for seal replacement. The carbon thrust washer and the bellows seal can be removed from the brass case by bending back the three ears (5) holding them in place.

When replacing the carbon thrust washer be careful not to crack or scratch it. After the bellows seal and thrust washer are installed in the brass case, see that the washer moves freely under finger pressure.

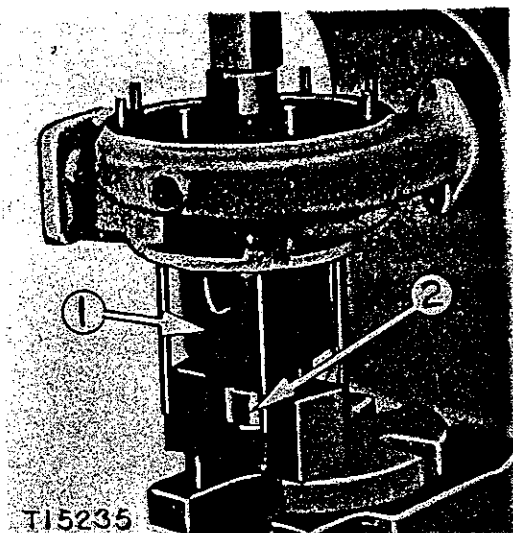
If the brass case has been damaged, it is necessary to completely disassemble the water pump before it can be removed.

## Water Pump Shaft Removal

Support the pump housing (1) on two pieces of bar stock and press out the shaft assembly (2)

Remove the stud to permit removal of the gear

The end thrust is taken by the thrust washer. If excessive wear is shown, the washer should be replaced with a new one.

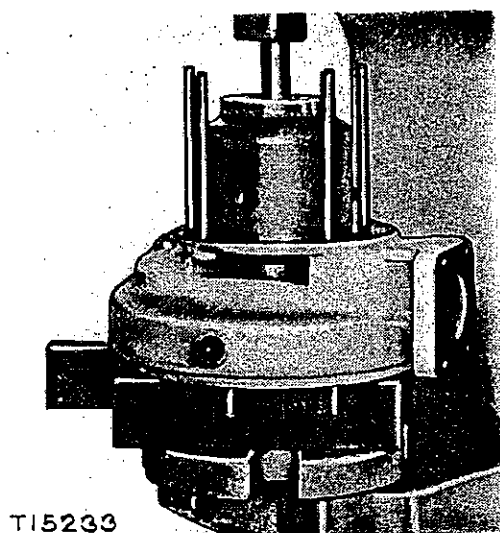


## SHAFT REMOVAL

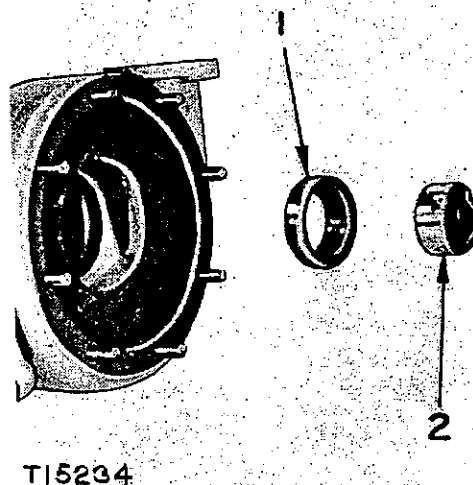
1-Pump housing. 2-Shaft assembly.

## Water Seal and Adapter Removal

To remove the adapter (1) and the water seal assembly (2) the shaft must first be removed.



REMOVING ADAPTER AND SEAL ASSEMBLY



ADAPTER AND SEAL ASSEMBLY REMOVAL

1-Adapter. 2-Seal assembly.

Place the pump on blocks as shown and place a washer of suitable size over the adapter. With a piece of bar stock of suitable size placed upon the washer, press the adapter and the water seal out as an assembly.

The seal can then be pressed out of the adapter.

### **Baffle, Oil Seal And Bushing Removal**

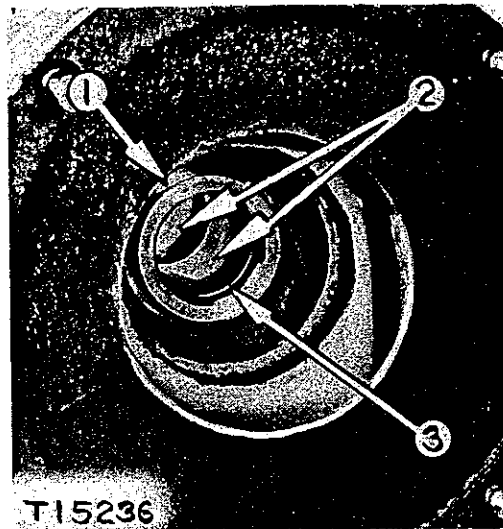
Press the baffle (1) and the oil seal (3) from the housing. When installing the oil seal, coat the outside circumference with a sealing compound to prevent leakage.

The seal can be pressed from the baffle.

The bushings (2) are replaceable and can be removed with the aid of an arbor press.

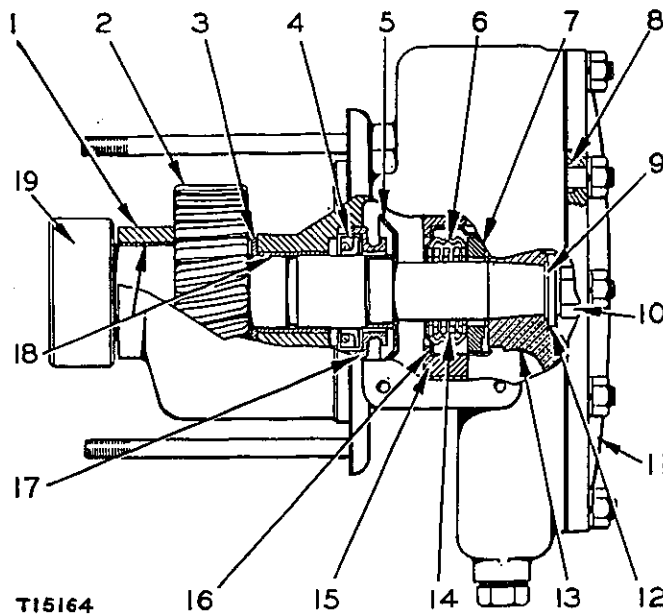
#### **BAFFLE, OIL SEAL AND BUSHING REMOVAL**

1-Baffle. 2-Bushings.  
3-Oil seal.



### **Auxiliary Water Pump Assembly**

1. Press the bushings (18) into the housing (1).
2. Place the gear (2) and the thrust washer (3) in their proper locations in the housing assembly.
3. Install the key which prevents the gear from turning on the shaft (19) and press the shaft through the housing, gear and thrust washer. After installing the shaft assembly, check the end clearance. The end clearance should be .002"-.006" with a maximum clearance of .015".
4. Press the oil seal (4) into the baffle (17) with the lip of the oil seal pointing away from the baffle, then press the baffle into the bore in the housing with the lip of the oil seal toward the gear. A piece of



### CUTAWAY VIEW OF AUXILIARY WATER PUMP

- 1-Housing assembly. 2-Gear. 3-Thrust washer. 4-Oil seal. 5-Thrower. 6-Bellows assembly. 7-Carbon thrust washer. 8-"O" ring seal. 9-Seal. 10-Nut. 11-Cover. 12-Washer. 13-Impeller. 14-Spring. 15-Adapter. 16-Case. 17-Baffle. 18-Bushings. 19-Shaft assembly.

shim stock will facilitate installation of the oil seal around the shaft and prevent damage to the seal.

5. Install the thrower (5) on the shaft, using a piece of pipe as a driver.
6. When installing the seal assembly, which consists of the brass case (16), neoprene bellows (6), spring (14) and thrust washer (7) into the adapter (15), coat the case and adapter bore with a suitable compound to avoid shearing the brass case. This will also provide a positive seal against water leakage.

### NOTE

When installing the seal assembly, be careful not to crack or scratch the carbon thrust washer. After the seal assembly is installed, see that the washer moves freely under finger pressure.

7. Press the case into the adapter until it bottoms squarely against the flange of the adapter. To prevent damage to the case, avoid excessive pressure after it bottoms.
8. Coat the outer surface of the adapter with a sealing compound; and with the aid of a suitable sleeve for a driver, install the adapter and seal assembly in the housing bore.
9. Install the key which secures the impeller (13) on the shaft and install the impeller.
10. Install the seal (9), washer (12), lock and nut (10). Tighten the nut and bend the lock.

11. Install the gasket, "O" ring seals (8), cover (11) and the lockwashers and nuts which secure the cover.
12. Replace the stud which was removed to permit removal of the gear.

### **RAW WATER PUMP (Gear-Type—Earlier Engines)**

The raw water pump is mounted at the lower front side of the auxiliary drive housing and is driven by a drive gear assembly located within the housing.

#### **Raw Water Pump Removal**

Disconnect the pipe at the raw water pump.

Remove the capscrews and lift the pump off the auxiliary drive housing.

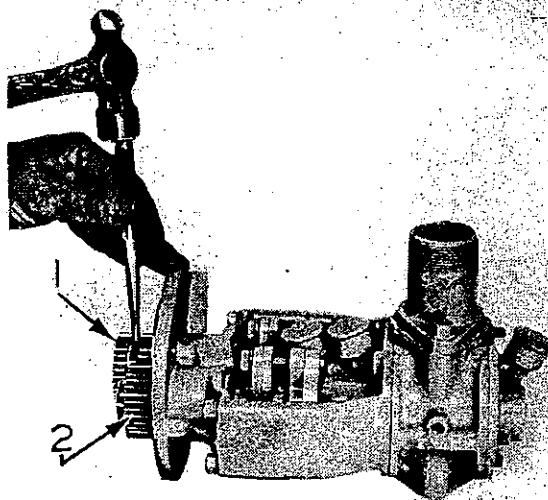
#### **Drive Gear Removal**

The drive gear (1) and driven gear (2) are keyed and pinned to the pump shafts.

The pin is of the tapered-type and must be driven out as shown, with a drift placed against the small end of the pin.

#### **REMOVING TAPERED PINS FROM THE GEARS**

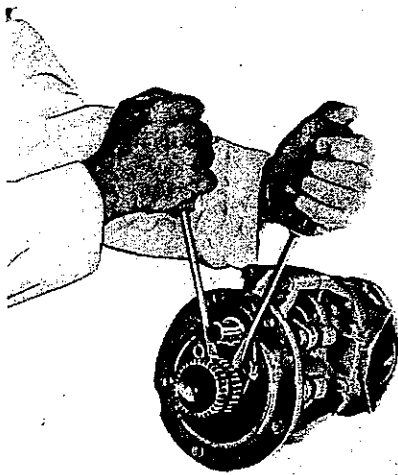
1—Drive gear. 2—Driven gear.



T11993

After the tapered pins have been removed, pry the gears off the shafts by wedging two screwdrivers between the gears and the metal plate directly back of the gears.

Do not pry against the pump housing directly.



## REMOVING THE DRIVE GEARS

T11994

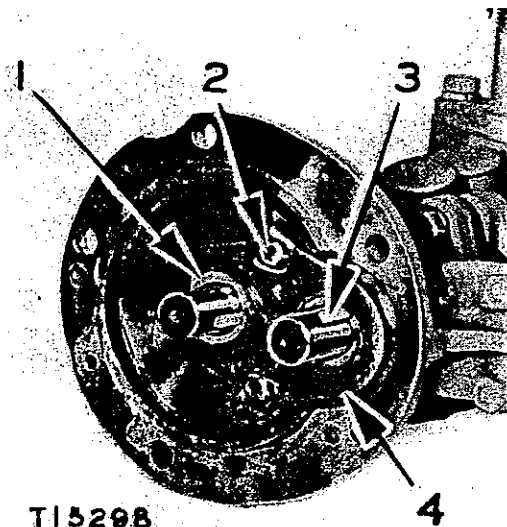
If it should become necessary to position the screwdrivers where they will contact the pump housing, place flat metal spacers between the pump housing and the screwdrivers to prevent damage to the housing.

### Retainer Plate, Ring and Washer Removal

Straighten the locks and remove the capscrews (2), retainer plate (4), (the two small spacer washers between the retainer plate and the pump housing) and the washers (1).

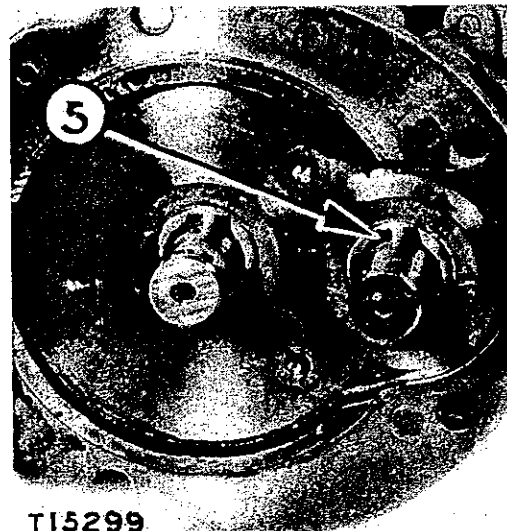
Remove the keys (3).

Remove the retainer rings (5).



T15298

**PLATE AND WASHER REMOVAL**  
1-Washer. 2-Capscrew. 3-Key.  
4-Retainer plate.



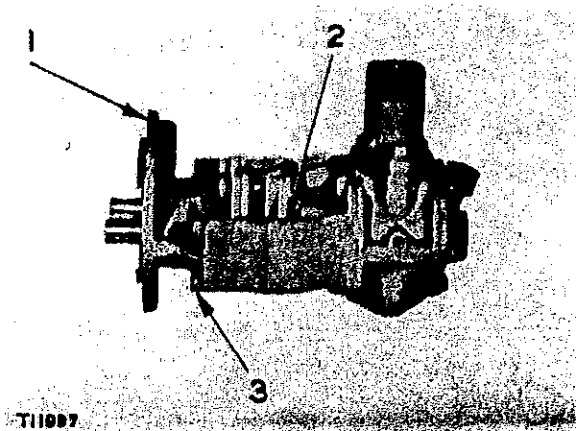
T15299

**RETAINER RING REMOVAL**  
5-Retainer ring.

## Removing the Body Assembly

Remove the nuts (3) and the lock washers.

Separate the body assembly (1) from the bracket assembly (2) and pull the body assembly off the pump shafts.



### BODY ASSEMBLY REMOVAL

1-Body assembly. 2-Bracket assembly. 3-Nut.

The body assembly (1) is serviced as an assembly only.

The assembly consists of the body (5) and two bushings (4) which provide a bearing surface for the pump shafts.

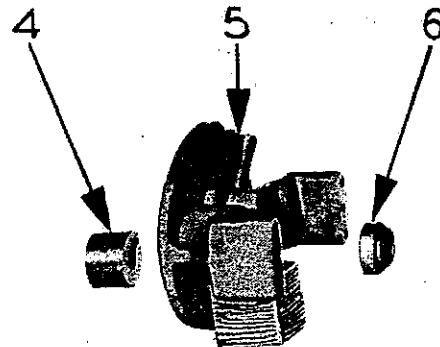
The two seal assemblies (6) are serviced separately and are pressed into the body opposite the bushings (4).

Rarely will it become necessary to replace the seal assemblies. However, the seals can be removed and installed as follows if it becomes necessary to do so:

1. Place the body assembly under a press having the seal side of the body up.

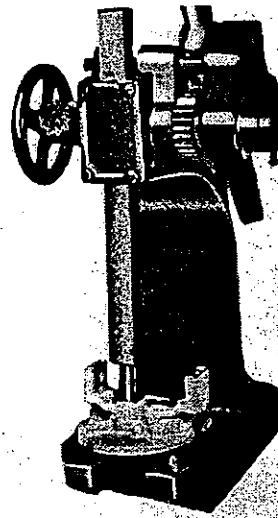
### BODY DISASSEMBLED

4-Bushing. 5-Body. 6-Seal assembly.



## PRESSING BUSHING FROM BODY

T11999



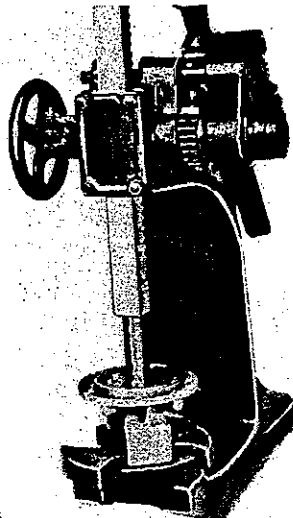
2. Use a short length of pipe or rod, having an outside diameter of  $\frac{7}{8}$ " for a pressing tool and press the bushings from the body.
3. Turn the body over so the seals will be down and press the seals out of the body, using a length of pipe having an outside diameter of approximately  $1\frac{1}{4}$ " for a pressing tool.

## NOTE

When installing the bushings in the body, see that the end of the bushing having the counterbore provided for the retainer ring, is turned outward. Align the oil holes in the bushing with the matching holes in the body and press the bushing into the body until the outer face of the bushing is flush with the surface of the body.

## PRESSING SEAL FROM BODY

T12000





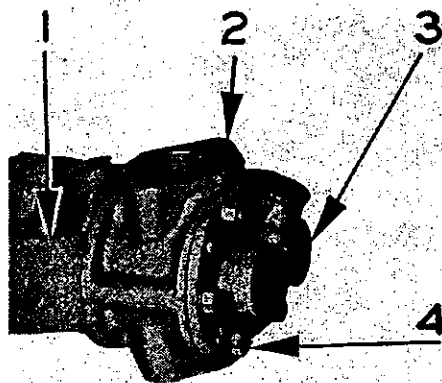
4. Install the oil seal assembly in the body having the lip of the seal toward the bushing.
5. Press the seal into the housing until the shoulder on the large diameter of the seal case is flush with the body.

### Removing the Pump End Cover

Remove the nuts (4) and the lockwashers.

Remove the pump end cover (3). The pump housing (2) can be separated from the bracket (1) if desired, by pulling it off the studs of the bracket.

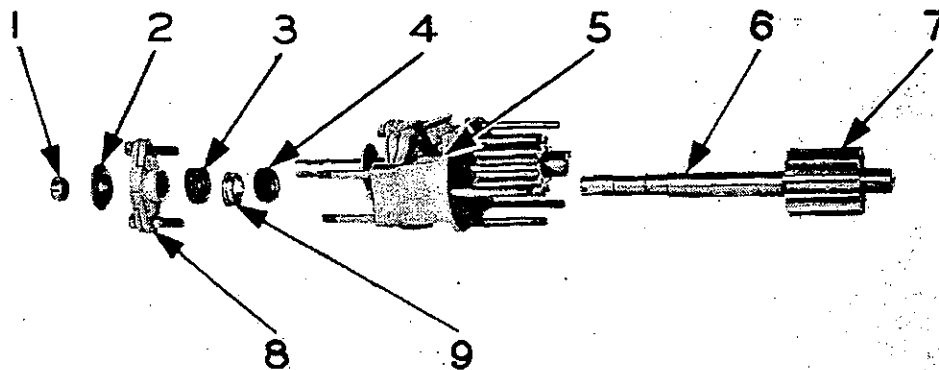
**REMOVING THE PUMP END COVER**  
 1-Bracket. 2-Pump housing. 3-End cover.  
 4-Nut.



TI2003

### Shaft Removal

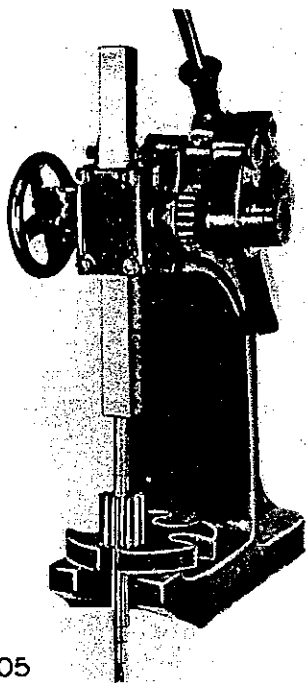
Tap or pull the slinger (2) and the sleeve (1) off the pump shaft (6).



TI2004

### DRIVE SHAFT REMOVAL

1-Sleeve. 2-Slinger. 3-Packing. 4-Packing. 5-Bracket. 6-Pump shaft.  
 7-Brass gear. 8-Gland. 9-Bushing.



T12005

## REMOVING BRASS GEAR FROM SHAFT

Remove the capscrews and packing gland (8).

Pull the shaft (6) and brass gear (7) out of the bracket (5).

Pull the packing (3), bushing (9) and packing (4) from the bore in the bracket, by using a piece of wire having a small hook bent at one end.

The remaining shaft and gear can be removed in the same manner.

Remove the gear (7) by pressing the shaft (6) from the gear as illustrated.

## Assembling Raw Water Pump

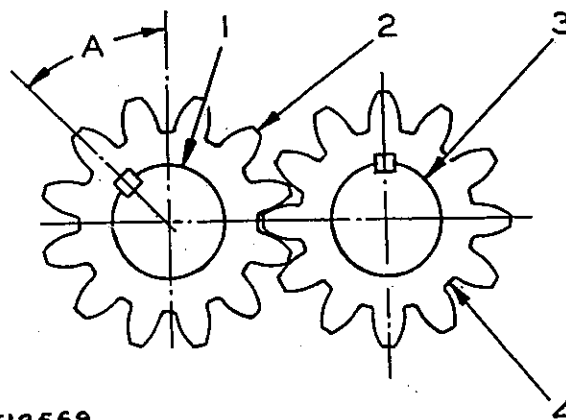
Assemble the raw water pump in the reverse order of disassembly to the point of installing the gears.

Observing the pump from the brass gear end, with the pump drive shaft to the right side, the following steps should be followed:

1. Position the keyways on both shafts in a vertical position.
2. Press the brass drive gear (4) onto the drive shaft (3), having the puller holes toward the end of the shaft.
3. Rotate the driven shaft (1) so that the keyway of the shaft is one and one-half gear teeth of the brass driven gear (2) is off the vertical centerline as illustrated at (A).

### INSTALLING BRASS GEARS

- 1-Driven shaft. 2-Brass driven gear.  
3-Drive shaft. 4-Brass drive gear.  
A-Keyway one and one-half teeth  
off vertical centerline of driven shaft.



T13569

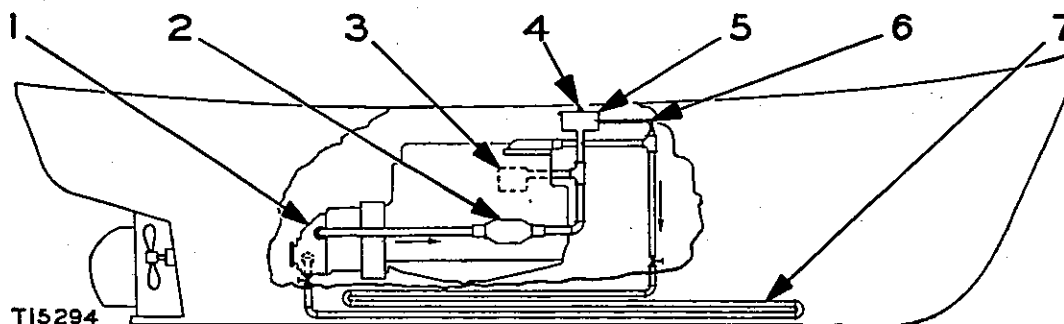
4. Press the brass driven gear onto the driven shaft, with the shaft in this position.
5. Without changing the position of the drive and driven shafts, press the steel drive and driven gears onto their respective shafts.
6. Install the pins in the gears and shafts.
7. Adjust the running clearance on the face of the brass gears.

### EXPANSION TANK

Expansion tanks are used on closed fresh water cooling systems to hold a reserve supply of coolant and eliminate the possibility of air locking.

The expansion tank is attached to the adapter housing at the front of the engine.

Expansion tanks are used with marine engines when an outboard cooling system, commonly known as keel cooling, is employed. The following illustration shows a keel cooling system without an auxiliary water pump.

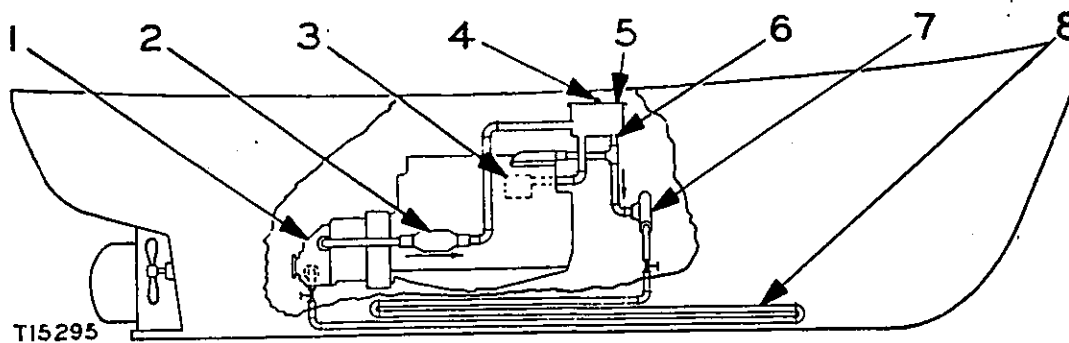


T15294

### KEEL COOLING SYSTEM WITHOUT AUXILIARY WATER PUMP (SCHEMATIC)

- 1-Marine gear housing. 2-Oil cooler. 3-Fresh water pump. 4-Vent.  
5-Expansion tank. 6-Vent tube. 7-Cooling pipe.

When small diameter pipe and greater lengths are used, the coolant friction through the pipes will increase. It may then be desirable to use an auxiliary water pump as shown in the following illustration.



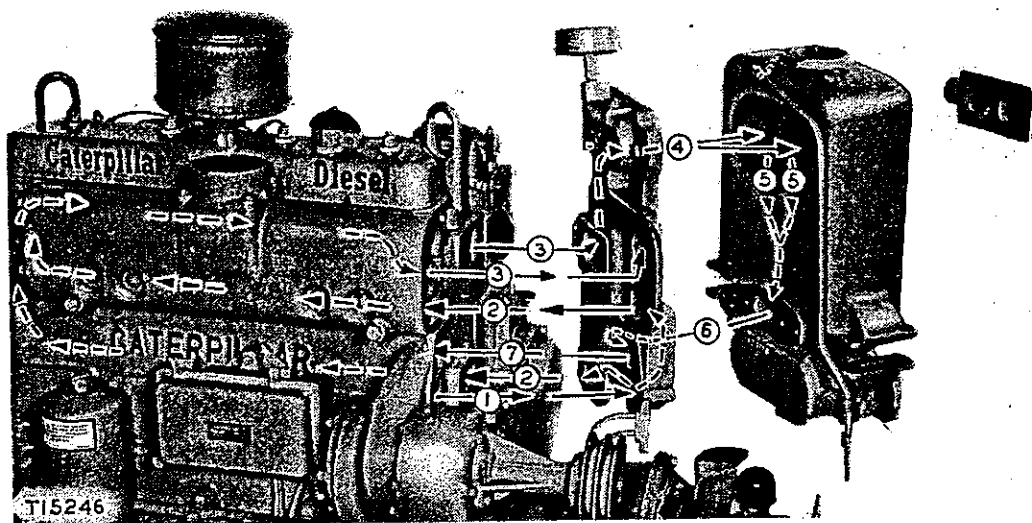
**KEEL COOLING SYSTEM WITH AUXILIARY WATER PUMP (SCHEMATIC)**  
 1-Marine gear housing. 2-Oil cooler. 3-Fresh water pump. 4-Vent. 5-Expansion tank.  
 6-Restricted opening. 7-Auxiliary water pump. 8-Cooling pipe.

### Flow Of Coolant Using Expansion Tank

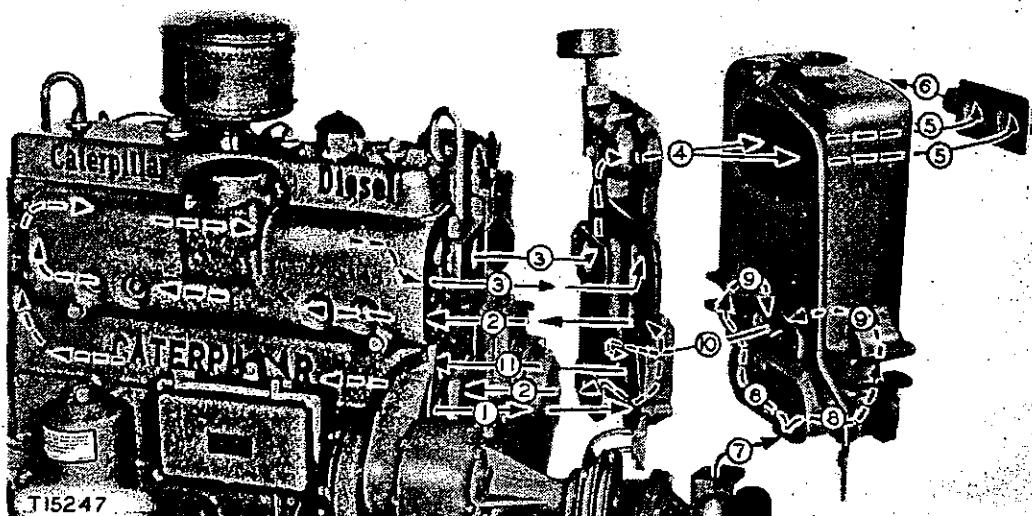
The coolant flows from the outlet of the fresh water pump at (1), then through passages into the adapter housing and enters the lower portion of the Diesel block and water-cooled exhaust manifold at (2).

After the coolant passes through the cylinder block and into the cylinder head, the coolant re-enters the adapter housing at (3). The coolant then flows to the top of the adapter housing where it comes in contact at (4) with the temperature regulators, which are located in the upper compartment of the expansion tank.

The portion of coolant delivered from the pump into the water-cooled exhaust manifold flows through the jacket in the manifold and returns to the adapter housing at (3) where it merges with the coolant flowing from the cylinder head.



**FLOW OF COOLANT (REGULATORS CLOSED)**



**FLOW OF COOLANT (REGULATORS OPEN)**

When the temperature regulators are in the closed position, the coolant flows through the by-pass passages at (5), which are located under the regulators, into the lower compartment of the expansion tank.

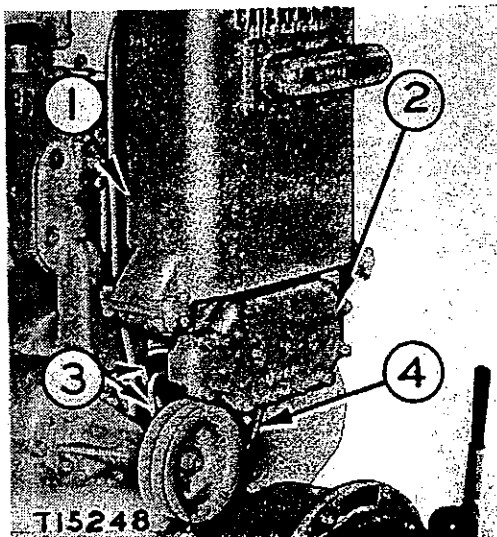
The coolant then flows from the expansion tank at (6) into a passage in the adapter housing, and returns to the inlet side of the pump at (7).

When the temperature regulators are in the open position, the flow of coolant through the by-pass passages is almost eliminated by the regulators. The coolant flows through the regulators at (5) and out of the elbow on the front of the expansion tank at (6). The coolant then flows through the cooling tubes, which are immersed in water. The coolant flows through the cooling jacket of the marine gear housing, if so equipped, and through a pipe into the oil cooler at (7). The coolant flows around the oil cooler core at (8) and then enters the lower compartment of the expansion tank. The flow continues through the expansion tank at (9) and then into a passage in the adapter housing at (10). The coolant then returns to the inlet side of the pump at (11).

### **Expansion Tank Removal and Installation**

The expansion tank (1) can be removed in the following manner:

1. Drain the coolant from the engine.
2. Remove the oil cooler (2) in the following manner to facilitate the removal of several nuts and lockwashers at the bottom of the expansion tank.
3. Drain the lubricating oil from the oil filter base and the oil tubes.



### EXPANSION TANK REMOVAL AND INSTALLATION

1-Expansion tank. 2-Oil cooler. 3-Oil tubes. 4-Pipe.

4. Disconnect the oil tubes (3) and cover the tubes to prevent dirt entering the lubrication system.
5. Remove the capscrews holding the water pipe (4) to the oil cooler.
6. Remove the bolts which secure the oil cooler to the expansion tank (1) and lift off the oil cooler.
7. Remove the capscrews, nuts and lockwashers connecting the expansion tank to the adapter housing.
8. Remove the capscrews which secures the clip on the overflow drain tube.
9. Support the expansion tank with a suitable hoist and remove the nuts and lockwashers at the bottom of the tank and remove it.
10. Clean all mating surfaces and install new gaskets at the time of assembly.

### Regulator Removal

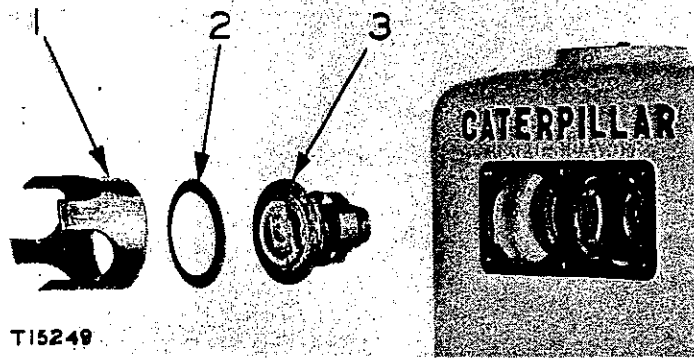
It is not necessary to remove the expansion tank from the engine to remove the regulators.

Remove the elbow from the front of the tank.

Remove the retainers (1) by pulling alternately on the extended portions of the retainers.

After the retainers have been removed, remove the springs (2) and lift out the regulators (3).

The regulators can be tested as described in the topic, TESTING TEMPERATURE REGULATORS, and cleaned as described in the topic, CLEANING TEMPERATURE REGULATORS.



**REGULATOR REMOVAL**  
1-Retainer. 2-Spring. 3-Regulator.

## Lubricating System

### FLOW OF LUBRICATING OIL (All Models)

The oil pump assembly (25) is attached to the bottom of the cylinder block (28) and is located within the engine oil pan (24).

The pump is driven by a drive gear cut on the engine camshaft.

The oil pump assembly (25) on the D4 Tractor consists of a main section (21) and an auxiliary section (22).

The main section of the pump draws oil through the main suction bell (20) and supplies it to the proper lubricant points throughout the engine.

The auxiliary section (22) draws oil through the front suction bell and tube assembly (16) from the oil pan front sump (15) and returns it to the main sump (23) of the oil pan, when the D4 Tractor is being operated on an incline.

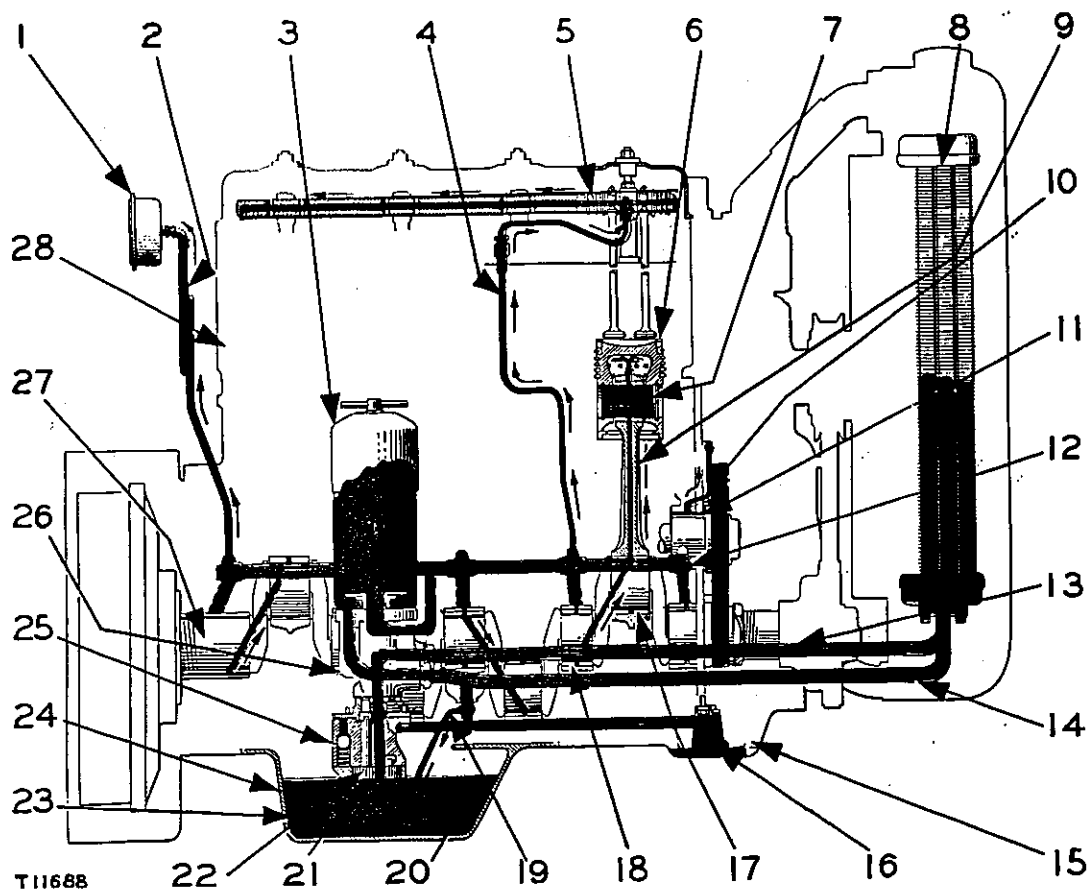
The No. 112 Motor Grader is also subjected to incline operation, but does not require the auxiliary section of the pump, since the oil pan is so designed that the oil flows back by gravity to the main sump of the oil pan.

Other models require only the main oil pump section (21).

Two types of filtering systems have been used, namely the full-flow filter system and the by-pass filter system.

The by-pass system was used on earlier models and filtered only a certain portion of the oil.

The full-flow system became effective on later models and provides for filtering all the engine oil.



**LUBRICATING SYSTEM (Earlier Model D4 Tractor Illustrated)**

1-Oil pressure gauge. 2-Tube. 3-Oil filter. 4-Tube. 5-Rocker arm assembly. 6-Piston. 7-Piston pin. 8-Oil cooler. 9-Connecting rod. 10-Drilled passage. 11-Camshaft bushing. 12-Oil manifold. 13-Oil tube from filter base to oil cooler. 14-Oil tube from oil cooler to filter base. 15-Front sump of oil pan. 16-Front suction bell and tube assembly. 17-Connecting rod bearing. 18-Main bearing. 19-Oil return tube. 20-Main suction bell. 21-Main section of oil pump. 22-Auxiliary section of oil pump. 23-Main sump. 24-Oil pan. 25-Oil pump. 26-Oil filter base. 27-Crankshaft. 28-Cylinder block.

### NOTE

The oil filter base of either type filter system contains an oil cooler by-pass valve and a filter by-pass valve. These valves permit oil to by-pass either the cooler or the filter or both, and flow to the oil manifold, in case the cooler and the filter becomes restricted or clogged.

See the topics, FLOW OF OIL THROUGH THE OIL FILTER AND THE OIL FILTER BASE (BY-PASS FILTER SYSTEM) and FLOW OF OIL THROUGH THE OIL FILTER AND THE OIL FILTER BASE (FULL-FLOW FILTER SYSTEM), for description of each system.

The flow of oil throughout the engine is the same for all engine models with the exception of slight differences within the filter and filter base of each type filter system.



The flow of oil is as follows: The main section (21) of the oil pump, draws its supply of oil from the main sump (23) of the engine oil pan (24), through the main suction bell (20).

The oil is delivered from the oil pump assembly to the oil cooler (8), through a drilled passage in the filter base (26) and the tube (13).

The cooled oil is returned to another passage in the filter base through the tube (14).

From the filter base the oil enters the oil filter (3) where it is thoroughly filtered.

From the filter the oil returns to a passage in the filter base which delivers the filtered oil to the oil manifold (12).

The oil manifold distributes the oil throughout the engine as follows:

Through drilled passages in the block, oil is delivered to the main bearings (18) and the camshaft bushings (11).

Oil flows from the main bearings through drilled passages in the crankshaft (27), to the connecting rod bearings (17).

From the connecting rod bearings the oil flows upward through a drilled passage in the connecting rods (9) to lubricate the piston pins and cool the heads of the pistons (6).

Oil is supplied to the rocker arm assembly (5) through the tube (4).

A drilled passage (10) at the front of the cylinder block delivers a portion of the oil supplied to the oil groove cut on the back of the camshaft front bushing, to the front main bearing and an oil ferrule in the timing gear housing to lubricate the timing gears. See the topic, TIMING GEAR LUBRICATION (ALL MODELS), for a full description of timing gear lubrication.

The tube (19) returns pressure oil from the center main bearing to the oil pump pressure regulating valve which controls the oil pressure at the main bearings. On later models, the tube (19) connects to a drilled passage which connects the oil manifold to the crankshaft rear main bearing. See the topic, PRESSURE REGULATING VALVE (ALL MODELS), for information on this valve.

On engines equipped with a balancer, an oil line connects to the tube (19) to supply lubricant to the bushings, shafts and gears of the balancer.

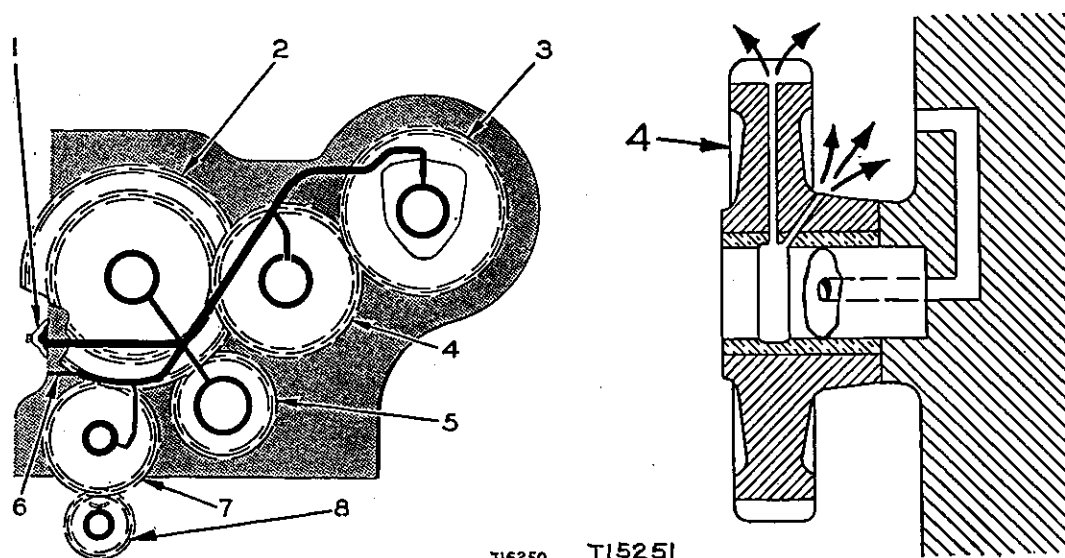
The oil pump also contains a pressure relief valve which prevents the oil pressure from becoming too great due to cold oil or restriction in the system. See the topic, OIL PUMP DISASSEMBLY (ALL MODELS EXCEPT D4 TRACTORS).

The tube (2) delivers oil from the oil manifold (12) to the oil pressure gauge (1) which registers the oil pressure within the lubricating system.

### TIMING GEAR LUBRICATION (All Models)

For the complete lubrication system, see the topic, FLOW OF LUBRICATING OIL (ALL MODELS).

After the lubricating oil is forced from the oil manifold (1) to drilled passages in the cylinder block, to the main bearings and the camshaft bearings, the flow of oil is as follows:



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### TIMING GEAR LUBRICATION

1-Oil manifold. 2-Camshaft gear. 3-Accessory drive gear. 4-Idler gear. 5-Crankshaft gear. 6-Passage to auxiliary drive housing. 7-Balancer idler gear. 8-Balancer drive gear (later engines).

The accessory shaft idler gear (4) is drilled and acts as an oil slinger to throw oil onto the teeth of the camshaft gear (2) and the accessory shaft gear (3).

The camshaft gear teeth are in turn, in mesh with the teeth of the crankshaft gear (5) and the balancer idler gear (7). Thus, oil is distributed on these gears.

The balancer drive gear (8) is partly submerged in the oil that has collected in a pocket in the front of the oil pan and lubricates the mating teeth of the balancer idler gear.

The bushing for the balancer drive gear (8) is lubricated by the oil that collects in the oil pocket in the balancer drive gear bracket.

An oil tube delivers the oil to the accessory shaft bearing assembly. This same tube also delivers oil to the passage (6) in the cylinder block to lubricate attachments that may be installed to the timing gear housing and that are driven by the camshaft gear.

### **OIL PRESSURE GAUGE (All Models)**

When the engine is warm and running at rated engine speed, the gauge should register in the "operating range." A lower pressure reading is normal at low idling speeds.

**LUBRICATING OIL PRESSURE GAUGE**



If for any reason the oil gauge ceases to register, the engine should be stopped immediately until the difficulty can be determined and corrected.

### **LOW OIL PRESSURE (All Models)**

A small orifice in the gauge connection prevents rapid gauge fluctuation. This orifice should be checked for dirt in event the gauge becomes inoperative.

If the oil pressure gauge indicates a low oil pressure or none at all check for the following:

1. Low oil level.
2. Clogged oil filters.
3. Defective oil gauge or clogged or broken tube to the gauge.
4. Clogged oil pump screen.
5. Leaking connections.

6. Loose bearings.
7. Pressure regulating valve worn or stuck, restricting the flow of oil.
8. Worn oil pump gears.
9. Pressure relief valve worn or not operating correctly.

### OIL PAN REMOVAL AND INSTALLATION (All Models)

The oil pan removal and installation as described in this topic is after the engine has been removed from its installation.

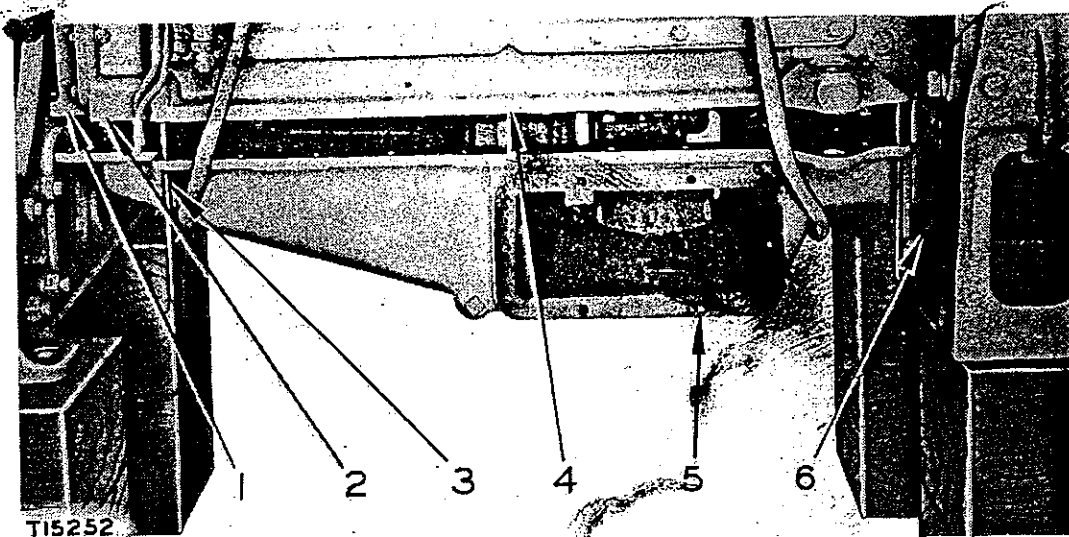
Drain the lubricating oil and remove all the capscrews holding the oil pan (5) to the flywheel housing (6).

Remove the inspection covers from both sides of the oil pan.

If a hoist and suitable cables are available, place the cables around the oil pan as illustrated to support the oil pan.

Remove all the capscrews holding the oil pan to the cylinder block (4), the timing gear housing (2) and the timing gear cover (1) and remove the oil pan.

The oil pan can also be installed using this method, with the use of guide pins (3) to align the oil pan holes with the capscrew holes in the cylinder block, at the time of installation.



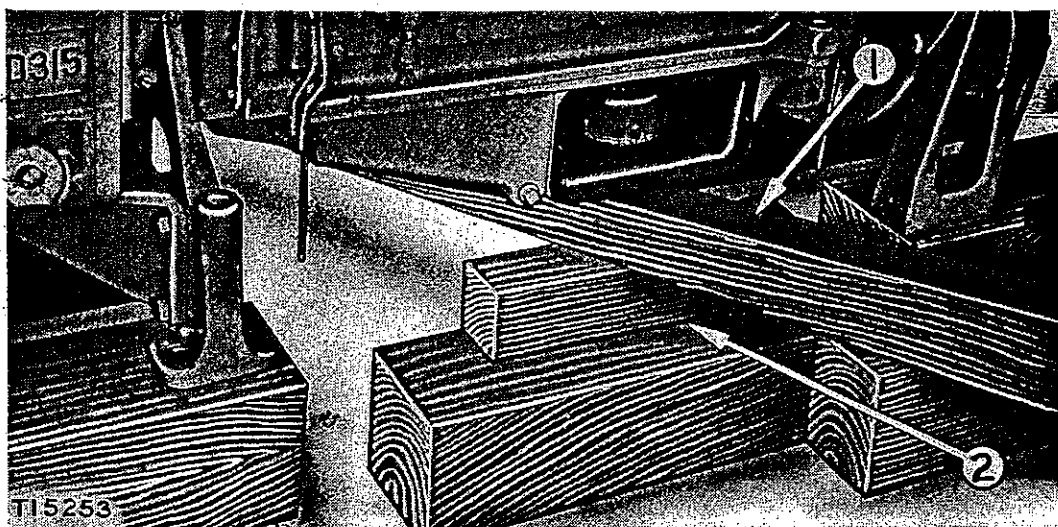
#### REMOVING OIL PAN USING A HOIST

- 1-Timing gear cover. 2-Timing gear housing. 3-Guide pin.  
4-Cylinder block. 5-Oil pan. 6-Flywheel housing.

## Oil Pan Removal and Installation (Alternate Method)

If cables and hoist are not available, the oil pan can also be removed by using a suitable length of wood (1) and blocks (2) as follows:

1. Place the engine on blocks of sufficient height to permit oil pan removal.
2. Place the length of wood under the deep portion of the oil pan.
3. Raise the length of wood until it is in contact with the bottom of the pan, then wedge the wood blocks (2) under the length of wood to hold the pan in that position.
4. Remove the inspection covers from both sides of the pan.
5. Remove two capscrews at each side of the oil pan and install four guide pins as illustrated, to prevent the pan from slipping sideways when being lowered from the engine.
6. Remove all capscrews that secure the oil pan to the engine cylinder block, flywheel housing, timing gear housing and timing gear housing cover.
7. Lift up on the outer end of the length of wood and remove the wood blocks (2).



REMOVING OIL PAN USING LENGTH OF WOOD AND BLOCKS

1—Length of wood. 2—Blocks.

8. Lower the pan until the length of wood (1) rests flat on the floor, then using the wood as a slide rail pull the pan from under the engine.

The pan can be installed by using the same equipment and reversing the procedure.

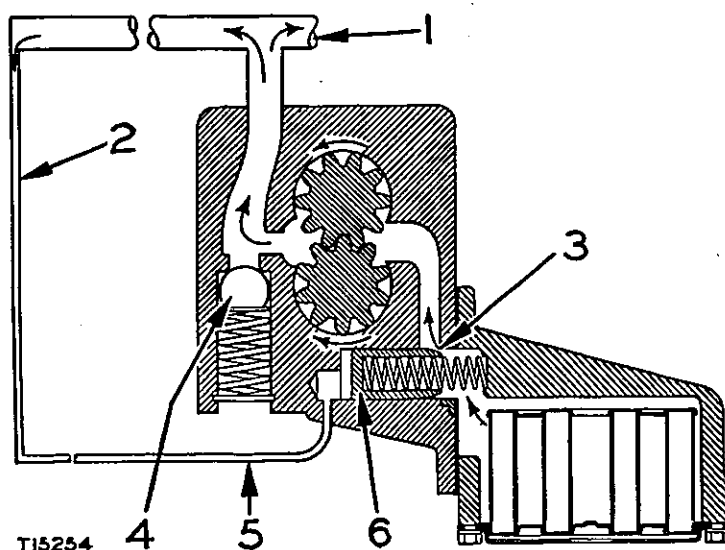
## OIL PUMP (All Models)

This illustration shows the operation of a controlled inlet-type oil pump. The basic pump is a gear-type positive displacement pump. By controlling the inlet, the oil pressure at the bearings is limited to approximately 30 PSI at rated engine speeds, in the following manner.

The passage (2) is drilled into the passage which connects the oil manifold (1) to the crankshaft rear main bearing. The passage (2) connects to the tube (5) which returns pressure oil to a spring-loaded piston (6) that acts as a valve. On earlier models, a tube from the crankshaft center main bearing returns pressure oil to the piston (6). As the oil pressure on the piston increases, the piston is moved over the inlet (3) to the pump, reducing the amount of oil entering the pump, and thereby preventing a further rise in pressure.

If the pressure from the oil manifold falls below normal, the spring moves the piston back, allowing a greater amount of oil to enter the pump, which results in an increase in pressure.

A spring-loaded ball-type relief valve (4) is located on the discharge side of the pump to prevent excessive pressure when the oil is cold or restricted. This valve is set to open at 90 PSI, and is non-adjustable.

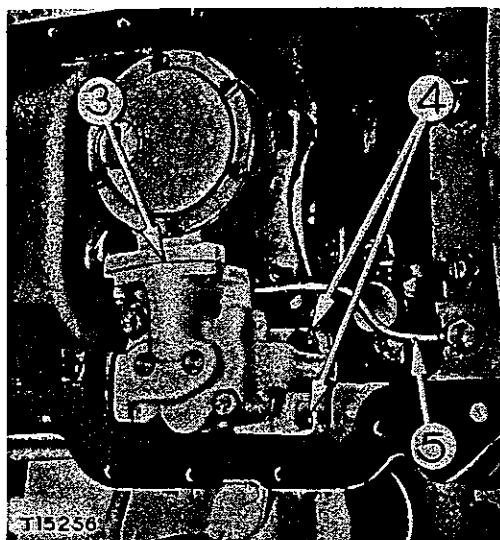
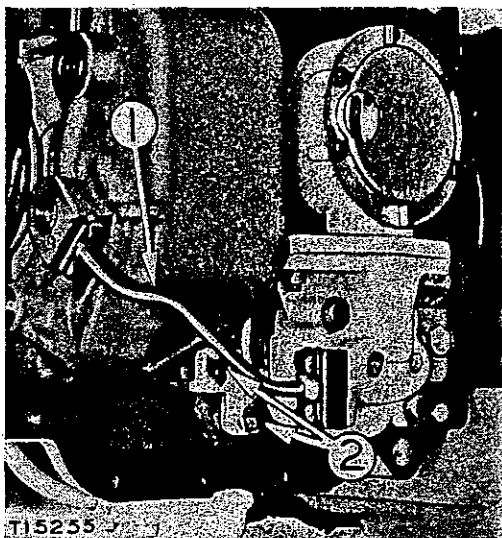


FLOW OF OIL THROUGH OIL PUMP (SCHEMATIC)  
1-Oil manifold. 2-Passage. 3-Inlet. 4-Pressure relief valve. 5-Tube.  
6-Spring-loaded piston.

### Oil Pump Removal

The oil pump can be removed in the following manner:

1. Drain the oil.



#### REMOVING THE OIL PUMP

1-Tube. 2-Capscrews. 3-Oil pump. 4-Capscrews. 5-Oil line.

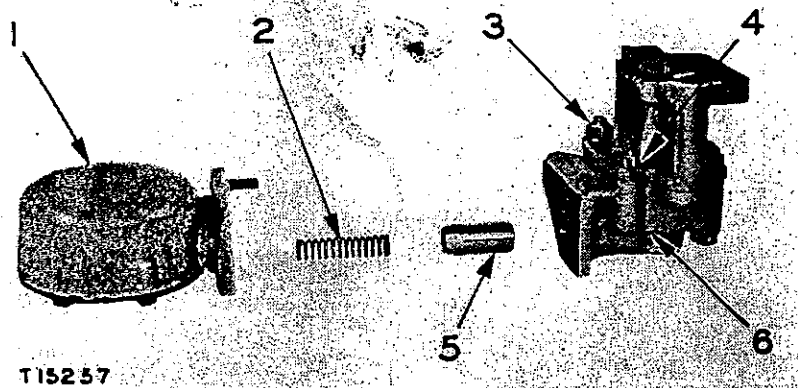
2. Remove the oil pan. See the topic, OIL PAN REMOVAL AND INSTALLATION (ALL MODELS).
3. Remove the oil tube (1) on all models so equipped and disconnect the front suction bell tube on tractor models.
4. Remove the oil line (5).
5. Remove the capscrews (2) and (4).
6. Pull the oil pump (3) off the oil pump drive.

#### Oil Pump Disassembly (All Models except D4 Tractors)

1. Remove the suction bell (1) from the oil pump case (6).
2. Remove the spring (2) and pressure regulating valve (5) from the bore in the oil pump case.
3. Remove the bolts and nuts (3) and the nuts (4).
4. Separate the pump case (6) from the spacer (9).
5. Remove the spring (11), washer (12) and ball (13), which make up the pressure relief valve when installed in the spacer (9).

#### NOTE

The pressure relief valve limits the output of the pump to 90 PSI. This valve functions only when there is excessive oil pressure. Excess oil is returned to the main sump. The pressure relief valve is not adjustable and it does not affect the oil pressure in the system other than to limit the maximum possible pressure to 90 PSI.



#### SUCTION BELL AND PRESSURE REGULATING VALVE REMOVAL

1-Suction bell. 2-Spring. 3-Bolt and nut. 4-Nut.  
5-Pressure regulating valve. 6-Pump case.

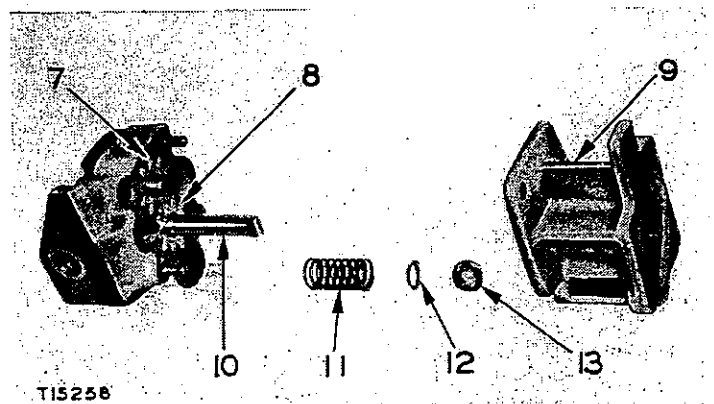
6. Remove the drive shaft (10) and drive gear (8) as a unit.

7. Remove the idler gear (7).

Ordinarily, oil pump gears should not have to be replaced unless they have worn sufficiently to cause a considerable drop in oil pressure or unless they have been damaged. If it is necessary to replace the drive gear (8), it can be removed from the drive shaft (10) in the following manner:

Using a  $\frac{1}{8}$ " drill, clean up the hole (B) that has been peened to retain the pin (C). Drill the gear at point (A) to gain access to pin (C).

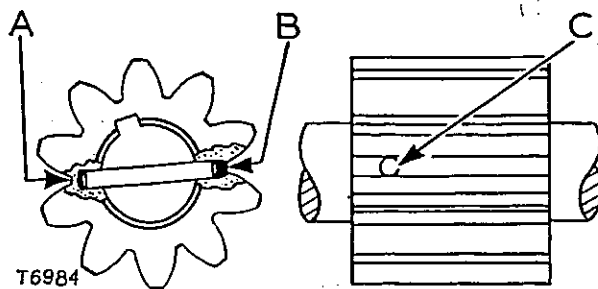
Using a drift pin through the hole drilled at (A), drive out the straight pin (C) from the gear and shaft and remove the gear and the key from the shaft.



#### DISASSEMBLING THE OIL PUMP

7-Idler gear. 8-Drive gear. 9-Spacer. 10-Drive shaft.  
11-Spring. 12-Washer. 13-Ball.





#### REMOVING PIN FROM DRIVE GEAR

A-Point to be drilled. B-Hole to be opened up. C-Pin.

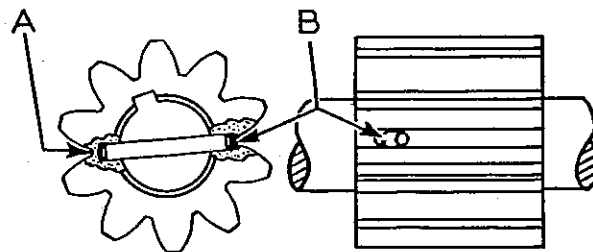
#### Assembling the Oil Pump (All Models except D4 Tractors)

Replace any parts that show excessive wear.

When a new pressure pump drive gear and shaft are to be installed, place the key in the shaft and press the gear on the shaft until the holes in the gear and shaft are in alignment. Using these holes as a guide, drill a  $\frac{1}{8}$ " hole into the gear and shaft to a depth of  $1 \frac{3}{16}$ ". Install a new pin and peen the gear (B) over the end of the pin.

#### INSTALLING DRIVE GEAR PIN

A-Undrilled portion of gear at bottom of hole. B-Portion of gear peened to hold pin in place.



#### CAUTION

The end of the pin should not protrude beyond the surface of the gear. Any roughness at (A) or (B) caused by drilling or peening should be removed.

Any nicks or burrs should be dressed off. Pull the nuts down evenly on the studs which pass through the pump. Check that the shaft turns freely with no binding or drag on the gears. If the gears bind, loosen the nuts slightly and relocate the pump case and spacer by tapping them lightly until the shaft turns freely. Retighten the nuts and bend the locks.

The clearances between the moving and stationary parts of the pump are necessarily small and for this reason, ground joints instead of gaskets are used between the pump case and the spacer. The correct clearance between the gears and these parts is .002"-.004".

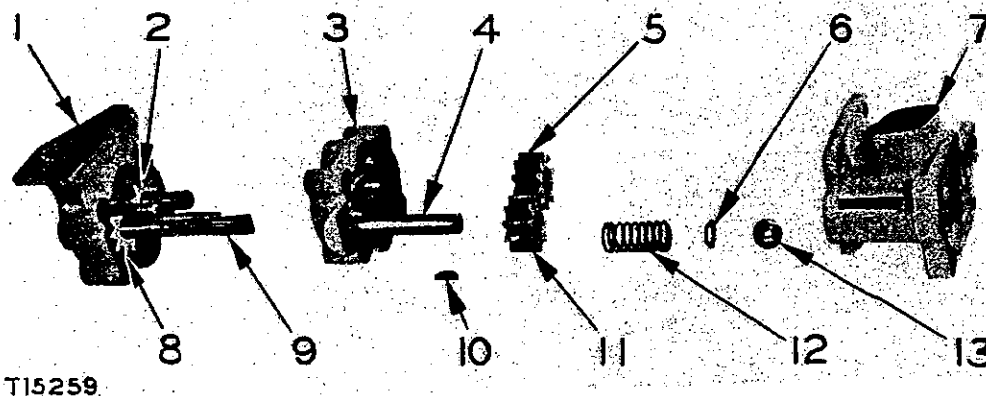
## Oil Pump Disassembly (D4 Tractor)

The oil pump used on the D4 Tractor engine is different than the pump used on other models, since it has an auxiliary pump section in addition to the regular engine oil pump.

The auxiliary section of the pump picks up oil that collects in the oil pan forward sump and returns it to the main sump of the oil pan. This assures a sufficient supply of oil to the main oil pump when the tractor is being operated on an incline.

The pump can be disassembled as follows:

1. Remove the nuts from the studs and bolts which hold the oil pump together.
2. Separate the body (3) and the spacer (7), by tapping gently against the edge of the spacer with a soft hammer or piece of brass. This is necessary due to the pilot tube (4) being a light press fit in the spacer.
3. Remove the spring (12), washer (6) and the ball (13) which make up the pressure relief valve. See the topic, OIL PUMP DISASSEMBLY (ALL MODELS EXCEPT D4 TRACTORS) for information on this valve.
4. Remove the auxiliary idler gear (5).
5. Pull the auxiliary drive gear (11), which is a slip fit on the drive shaft (9) and remove the key (10).
6. Separate the case (1) from the body (3).



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### DISASSEMBLING THE OIL PUMP (D4 TRACTOR)

1-Case. 2-Oil pump idler gear. 3-Body. 4-Pilot tube. 5-Auxiliary idler gear. 6-Washer. 7-Spacer. 8-Main pump drive gear. 9-Drive shaft. 10-Key. 11-Auxiliary drive gear. 12-Spring. 13-Ball.

7. Remove the main oil pump idler gear (2).

8. Pull the drive shaft (9) and the main pump drive gear (8) from the body (3).

If the drive gear (8) is to be removed and a new one installed, use the procedure described in the previously mentioned topic.

Assemble the pump in reverse order of disassembly.

### **Main Suction Bell Disassembly (All Models)**

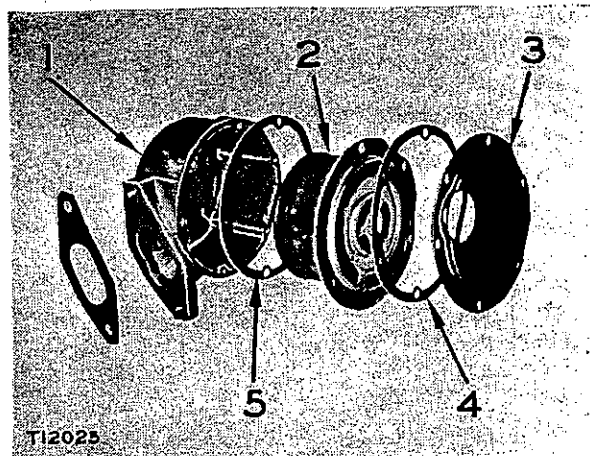
Remove the capscrews and locks which attach the cover (3) to the bell (1) and remove the cover.

Remove the gasket (4), screen assembly (2) and gasket (5).

Clean all parts and inspect the gaskets before assembling the suction bell.

#### **DISASSEMBLING THE MAIN SUCTION BELL**

1-Bell. 2-Screen assembly.  
3-Cover. 4-Gasket.  
5-Gasket.



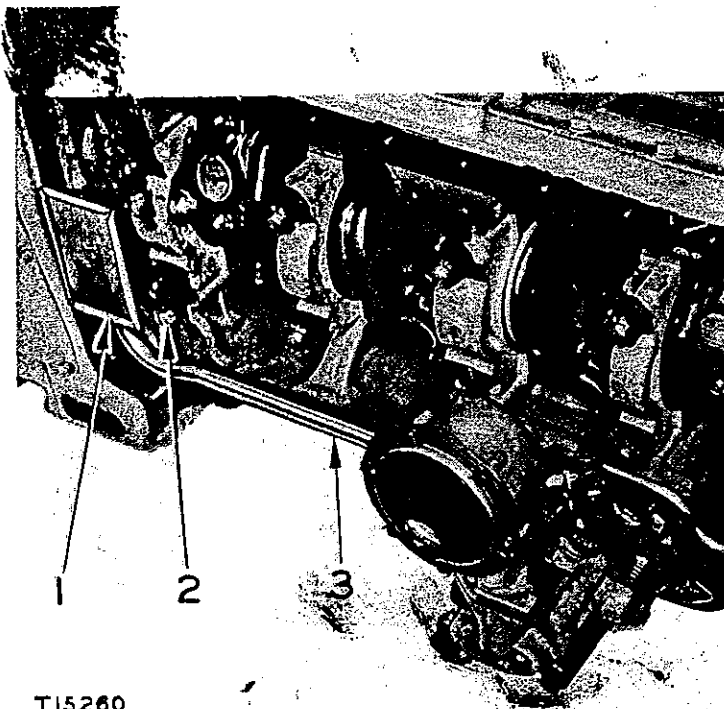
### **Front Suction Bell Removal (D4 Tractor)**

Drain the oil and remove the oil pan. See the topic, OIL PAN REMOVAL AND INSTALLATION (ALL MODELS).

Remove the capscrew (2) which holds the suction bell (1) to the block.

Remove the capscrews which secure the tube (3) to the oil pump.

Remove the tube and the suction bell as a unit.



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#### FRONT SUCTION BELL REMOVAL

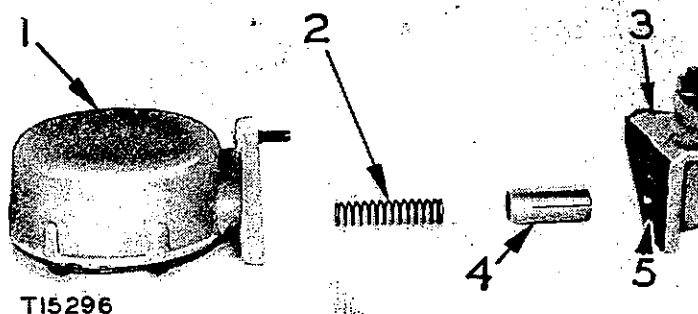
1-Bell. 2-Capscrew. 3-Tube.

#### Pressure Regulating Valve (All Models)

The pressure regulating valve (4) operates within an orifice (5) which is pressed into the pump case (3).

The operation of the pressure regulating valve is described in the topic, OIL PUMP (ALL MODELS).

The valve and the spring (2) are accessible after the main suction bell (1) has been removed.



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#### PRESSURE REGULATING VALVE

1-Main suction bell. 2-Spring. 3-Pump case. 4-Valve. 5-Orifice.

Clean all parts thoroughly before assembling.

Be sure the regulating valve moves freely without binding in the orifice to assure proper pressure.

If the regulating valve or the orifice are worn in excess or damage is apparent, they should be replaced.

### Oil Pump Drive Removal (All Models)

The oil pump drive is located at the right underside of the cylinder block and is driven by a gear cut on the engine camshaft.

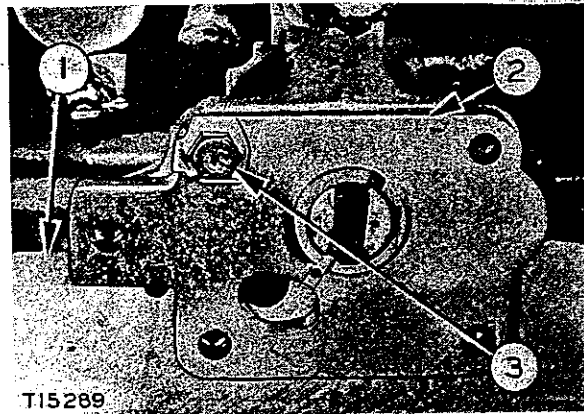
The oil must be drained and the oil pan and oil pump must be removed to permit removal of the pump drive.

The drive (2) is attached to the cylinder block (1) by a single cap-screw (3) and can be removed by removing the capscrew and pulling the drive downward and out of the cylinder block.

Be certain the gasket between the cylinder block and drive is in good condition before installing the drive.

#### OIL PUMP DRIVE REMOVAL

1-Cylinder block. 2-Oil pump drive. 3-Capscrew.



### Oil Pump Drive Disassembly (All Models)

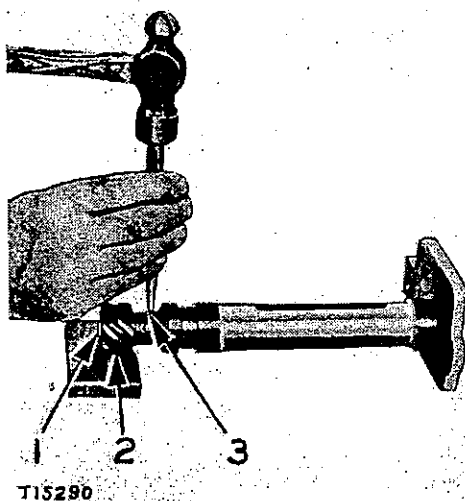
The drive gear (2) is pinned to the drive shaft (1) with a brass shear pin (3).

The pin (3), in case the oil pump should develop a severe bind, which will rarely occur, will shear and prevent damage to the engine camshaft.

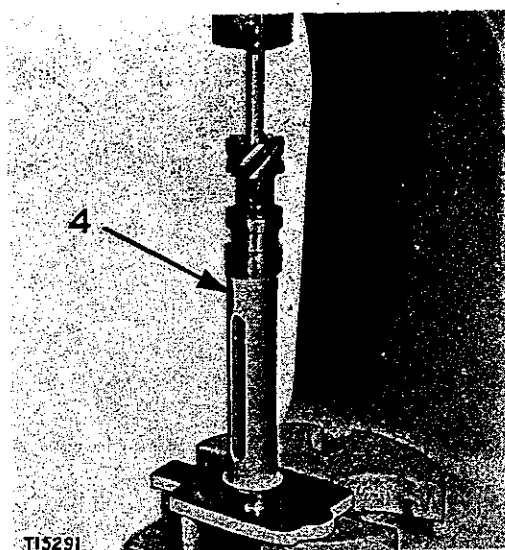
The pin can be removed by filing away the peened portion at one end, placing the drive gear on a brass or hard wood block and driving the pin out with a suitable drift.

When installing a new shear pin, peen over both ends of the pin where it extends through the shoulder of the drive gear (2).

The drive gear and drive shaft can be removed from the drive bracket (4) by pressing the shaft from the gear as illustrated, then pulling the shaft from the bracket at the opposite end.



**REMOVING DRIVE GEAR SHEAR PIN**  
 1-Drive shaft. 2-Drive gear.  
 3-Shear pin.



**PRESSING THE DRIVE SHAFT FROM  
 THE DRIVE GEAR**  
 4-Drive bracket.

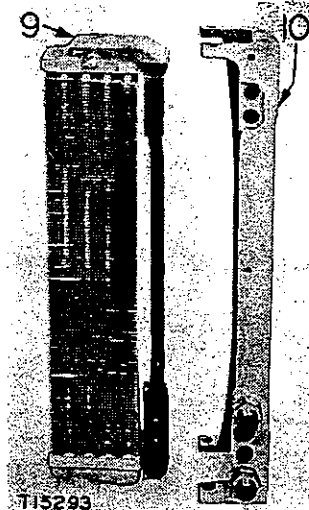
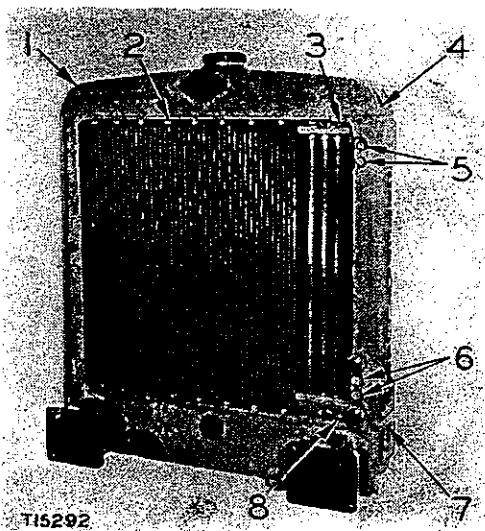
### **OIL COOLER REMOVAL AND INSTALLATION (Radiator-cooled)**

The oil cooler (9) is located in the right side of the radiator assembly and is connected with the base of the oil filter, by two oil tubes.

The oil cooler can be removed without removing the complete radiator assembly from the engine if desired, but for all practical purposes it is advisable to remove the radiator from the engine first. See the topic, RADIATOR REMOVAL.

1. Loosen the capscrews (2) at the front and rear of the radiator top tank (1) slightly.
2. Remove the capscrews (3) and (8) at the front and rear of the oil cooler (9).
3. Remove the capscrews (5) and (6).
4. Remove the capscrews (4) at the right side of the top tank and loosen the corresponding capscrews at the left side of the tank.
5. Remove the two capscrews (7) which hold the right side plate (10) to the radiator bottom tank.
6. Lift the top tank up slightly and remove the right side plate (10) and the oil cooler (9).

When installing the oil cooler and side plate, guide them into place carefully to prevent damage to the extended portions of the radiator water core.



### REMOVING THE OIL COOLER

1-Radiator top tank. 2 thru 8-Capscrews. 9-Oil cooler. 10-Right side plate.

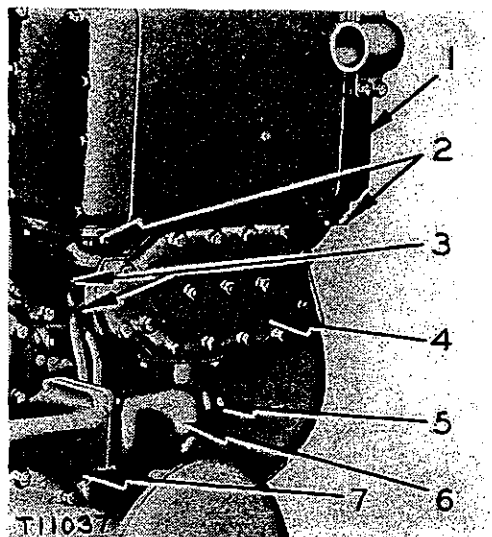
All capscrews should be started before any are tightened, then pull them down evenly until they are tight.

### OIL COOLER REMOVAL AND INSTALLATION (Heat Exchanger-Cooled)

1. Drain the raw water cooling system by removing the plug (5).
2. Drain the lubricating oil from the oil filter base and the oil tubes (3).
3. Disconnect the oil tubes (3) and cover the tubes to prevent dirt from entering the lubricating system.
4. Remove the capscrews holding the water elbow (6) to the oil cooler (4).

### PREPARING FOR OIL COOLER REMOVAL

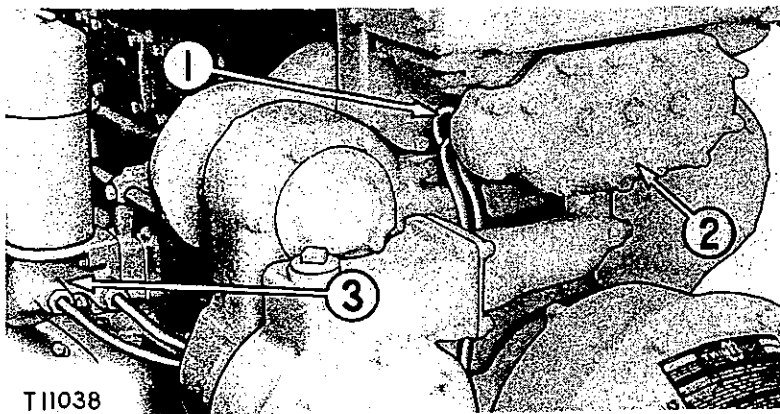
1-Heat exchanger. 2-Capscrews. 3-Oil tubes. 4-Oil cooler. 5-Plug. 6-Water elbow. 7-Raw water pump.



5. Loosen the capscrews holding the water elbow (6) to the raw water pump (7).
6. Remove the capscrews (2) connecting the oil cooler to the heat exchanger (1) and lift off the oil cooler.

### OIL COOLER CORE REMOVAL AND INSTALLATION (Heat Exchanger-Cooled)

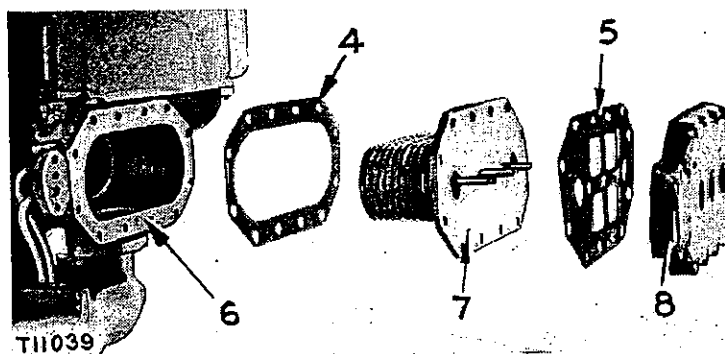
1. The oil cooler core assembly (7) can be removed from an oil cooler on a heat exchanger-cooled engine in the following manner.
2. Drain the lubricating oil from the oil filter base (3) and the oil tubes (1).



#### PREPARING FOR CORE REMOVAL

1-Oil tube. 2-Oil cooler assembly. 3-Oil filter base.

3. Drain the raw water system to a point below the oil cooler.
4. Remove the capscrews holding the oil tubes (1) to the oil cooler assembly (2).



#### OIL COOLER CORE REMOVED

4-Gasket. 5-Gasket. 6-Housing. 7-Oil cooler core assembly. 8-Cover.



5. Remove the capscrews, nuts and lockwashers holding the cover (8) to the housing (6).
6. Remove the cover, the gasket (5), the core assembly (7) and the gasket (4).
7. Clean all parts and inspect the core assembly and install new gaskets at the time of assembly.

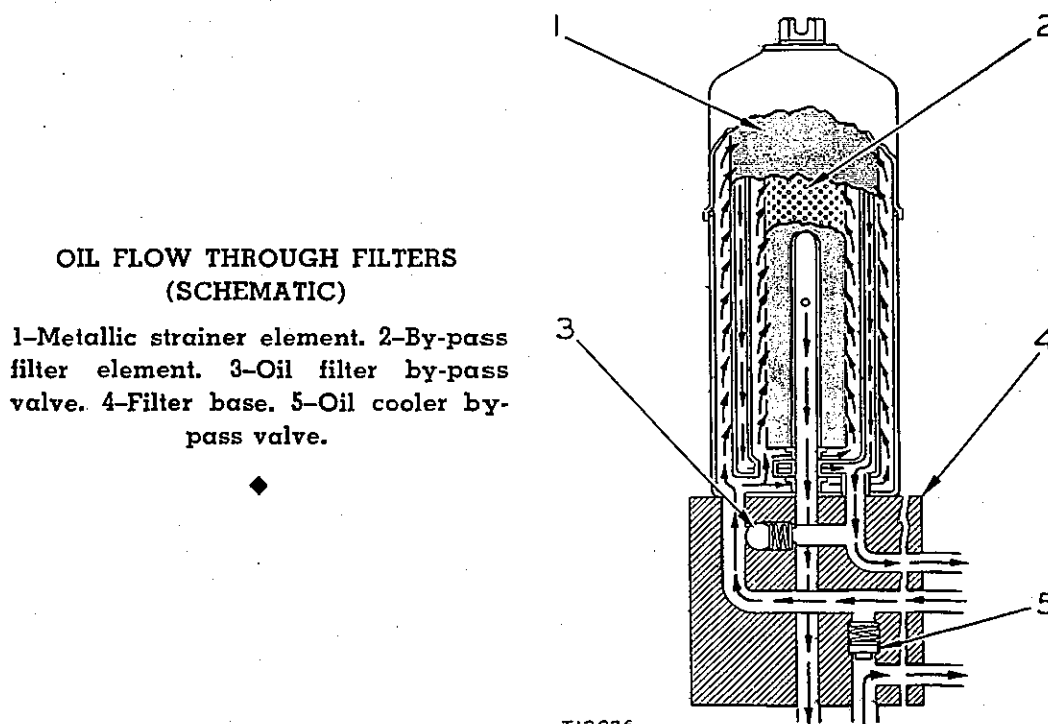
### FLOW OF OIL THROUGH OIL FILTER BASE AND OIL FILTERS (By-Pass Filter System)

The filter has a metallic strainer element (1) surrounding a by-pass filter element (2). As shown in the sketch, the oil filtered by the metallic strainer or outer element goes to the bearings while the oil filtered by the by-pass filter or inner element returns to the sump.

If the oil is too cold to flow readily through the oil cooler, a cooler by-pass valve (5) in the filter base (4) opens to permit the oil to flow directly from the pump to the filter.

Also located in the filter base is a filter by-pass valve (3), which opens if the filters should become clogged, thereby allowing the oil from the cooler to flow directly to the bearings.

The by-pass valves in the filter base should be checked when the engine is reconditioned to insure that they will function if required.



The outer element may be clogged internally even when the outside surface has been carefully cleaned. Occasionally the gums and lacquers that clog the inside of the element cannot be removed with any solvent or cleaner. Under these conditions the element should be discarded.

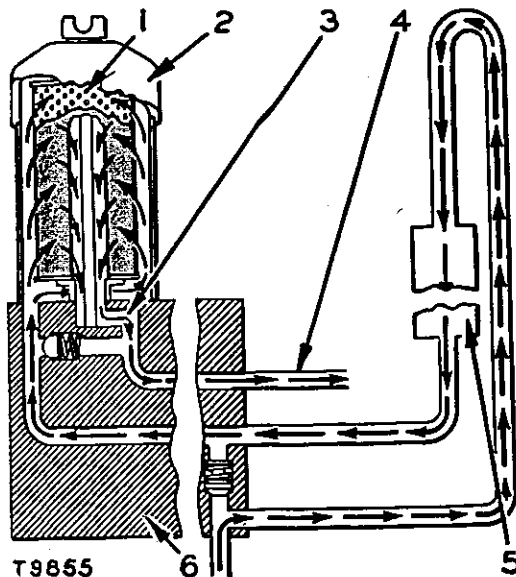
To check the internal condition, plug the holes in the bottom of the element in question and a new element, and then immerse both elements to the top rim in non-inflammable fluid or Diesel fuel. Compare the rate at which the fluid level rises in each element.

If the used element is not at least three-fourths full in the time required to fill a new element, the used element should be discarded.

### FLOW OF OIL THROUGH OIL FILTER BASE AND OIL FILTERS (Full-Flow Filter System)

The lubricating oil flows under pressure into the oil filter base (6) from the oil pump.

The oil is transmitted to the oil cooler (5) where it is cooled and to the filter base from which it goes into the oil filter assembly (2).

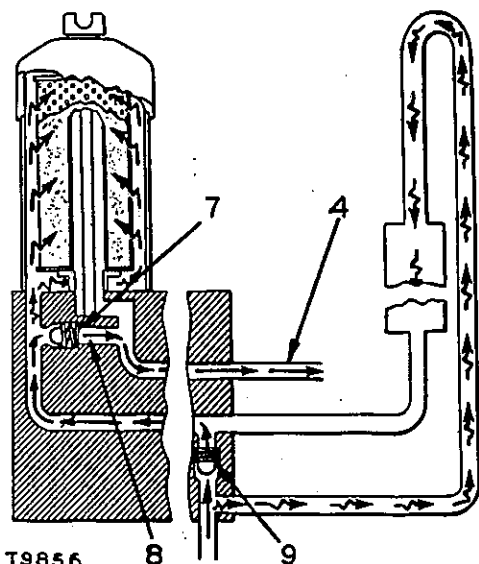


NORMAL FLOW OF OIL THROUGH  
OIL FILTER BASE AND OIL FILTERS  
WITH BY-PASS VALVES CLOSED  
(SCHEMATIC)

1-Full flow oil filter element. 2-Oil filter  
assembly. 3-Passage. 4-Passage. 5-Oil  
cooler. 6-Oil filter base.

The oil passes through the full flow filter element (1) to the passages (3) and (4), which carry the filtered oil to the oil manifold. See the topic, OIL MANIFOLD (ALL MODELS).

If the oil cooler should become clogged or restricted in any manner, the increased oil pressure will unseat the oil cooler by-pass valve (9) and permit the oil to by-pass the oil cooler.



**RESTRICTED FLOW WITH OIL FILTER  
AND OIL COOLER BY-PASS VALVES  
OPEN (SCHEMATIC)**

4-Passage. 7-Oil filter by-pass valve.  
8-Passage. 9-Oil cooler by-pass  
valve.

T9856

If the filter should become clogged or restricted, the increased oil pressure will unseat the oil filter by-pass valve (7) and permit the oil to pass through the passage (8) and then into the passage (4).

The by-pass valves assure passage of a supply of lubricating oil any time the filter or cooler or both, may become clogged.

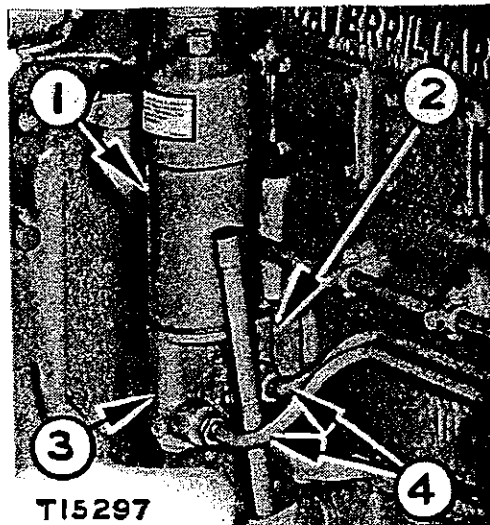
**OIL FILTER AND BASE REMOVAL AND INSTALLATION  
(All Models)**

The oil filter (1) and the oil filter base (3) can be removed as a unit in the following manner:

1. Drain the lubricating oil from the oil filter base.
2. Disconnect and remove the oil tubes (4), which carry the oil to and from the oil cooler.

**REMOVING OIL FILTER AND BASE**

1-Oil filter. 2-Oil manifold. 3-Oil filter  
base. 4-Oil tubes.



T15297

3. Remove the nuts which connect the oil filter base to the oil manifold (2) and the cylinder block.
4. Remove the oil filter and base as a unit.
5. Check all passages to see that they are open and install new gaskets at the time of assembly.

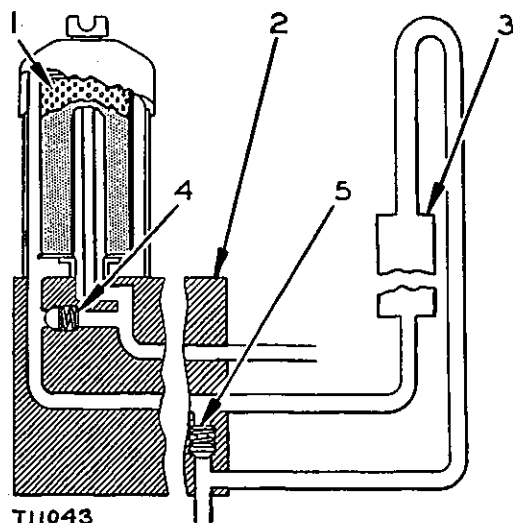
### OIL COOLER AND OIL FILTER BY-PASS VALVES

The oil filter base (2) contains an oil cooler by-pass valve (5) to serve the oil cooler (3) and an oil filter by-pass valve (4) to serve the oil filter assembly (1).

These by-pass valves are installed to assure the engine of lubricating oil even when the oil is heavy or cold or when the oil cooler or the oil filter is restricted or clogged. Therefore, the bearings always receive a supply of oil.

For the removal of these valves, see the topic, DISASSEMBLING AND ASSEMBLING OIL FILTER BASE (ALL MODELS).

The operation of the by-pass valves is described in the topic, FLOW OF OIL THROUGH OIL FILTER BASE AND OIL FILTER (BY-PASS FILTER SYSTEM).

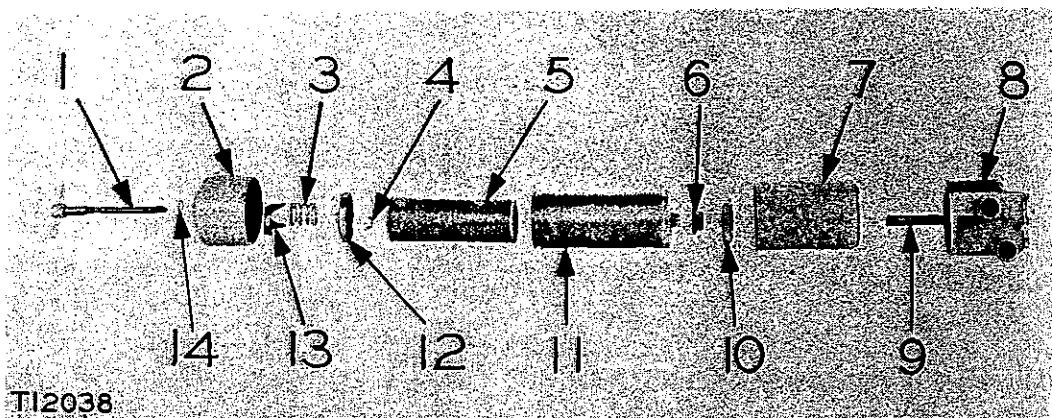


#### OIL COOLER AND OIL FILTER BY-PASS VALVES (SCHEMATIC)

1-Oil filter. 2-Oil filter base. 3-Oil cooler. 4-Oil filter by-pass valve. 5-Oil cooler by-pass valve.

### Oil Filter Disassembly and Assembly (By-pass Filter System)

The screw assembly (1), springs (3) and (13) and plate (12) are held in place in the top cover (2) by a snap ring (4) that fits in a groove in the screw assembly (1). They in turn hold the filter elements (5) and (11) in position. A copper gasket (14) on the screw assembly prevents oil from leaking where the screw passes through the cover.



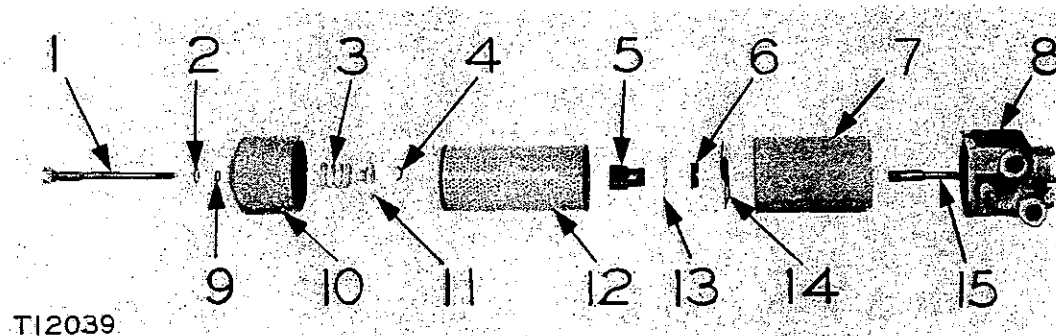
#### DISASSEMBLING THE OIL FILTER (BY-PASS SYSTEM)

1-Screw assembly. 2-Cover. 3-Spring. 4-Ring. 5-By-pass element. 6-Adapter. 7-Case. 8-Filter base. 9-Stud. 10-Clamp. 11-Metallic strainer element. 12-Plate. 13-Spring. 14-Gasket.

With the top cover assembly and filter elements removed, an 8B2444 Socket Wrench can be used to remove the adapter (6) at the bottom of the filter stud (9). This nut holds the retainer clamp (10) that secures the filter element case (7) to the base (8). Remove the stud (9), taking care not to damage the metering hole in the stud.

#### Oil Filter Disassembly and Assembly (Full-flow Filter System)

1. Place a screwdriver or flat piece of metal in the slot of the bar (1) and loosen the bar enough to remove the cover (10).
2. Remove the spring (3) and plate (11) from the bar (1) by removing the ring (4).
3. Do not lose the washer (2) and seal (9) when removing the bar from the cover (10).



#### DISASSEMBLING THE FILTER (FULL-FLOW SYSTEM)

1-Bar. 2-Washer. 3-Spring. 4-Ring. 5-Screw. 6-Sleeve. 7-Case. 8-Filter base. 9-Seal. 10-Cover. 11-Plate. 12-Element. 13-Plate. 14-Clamp. 15-Stud.

4. Remove the element (12) from the case (7).
5. Remove the screw (5) with the 9F9963 Special Socket Wrench.
6. Remove the plate (13), sleeve (6), clamp (14) and the case (7) from the filter base (8).
7. The stud (15) can be removed from the filter base by using a small pipe wrench.

Before assembling the filter, see that the gasket in the cover and filter base are in good condition and are properly positioned in their respective grooves to assure a good oil seal.

#### Disassembling and Assembling Oil Filter Base (All Models)

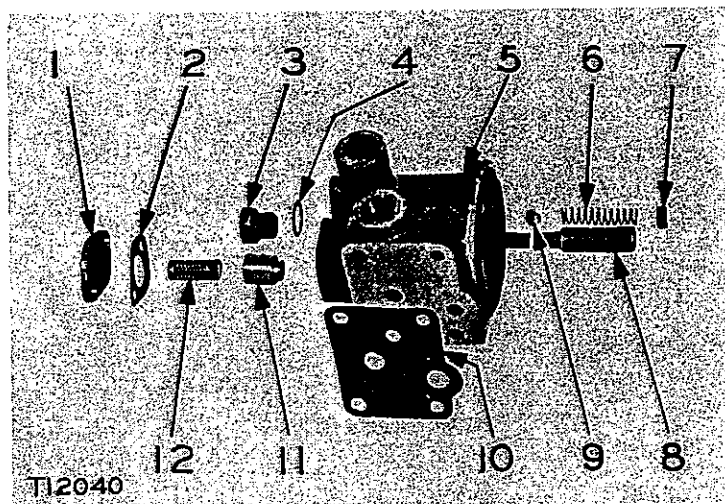
Remove the cover (1) and gasket (2). The spring (12) and plunger (11) which make up the oil cooler by-pass valve can then be removed from the base (5).

Remove the drain plug (3) and gasket (4).

The spring (6) and the ball (9) which form the filter by-pass valve, can be removed from the base by prying the plug (7) out of the base first.

If it becomes necessary to remove the stud (8) from the base (5), a small pipe wrench will serve satisfactorily for the purpose. Remove any burrs raised by the pipe wrench after installing the stud in the base.

Inspect the gaskets (2) and (4) when assembling the base.



#### DISASSEMBLING FILTER BASE

1-Cover. 2-Gasket. 3-Plug. 4-Gasket. 5-Base. 6-Spring. 7-Plug. 8-Stud.  
9-Ball. 10-Gasket. 11-Plunger. 12-Spring.

A new plug (7) will be required in most cases, since the original plug is usually damaged beyond further use at the time of removal.

Check the condition of the gasket (10) before installing the base (5) on the engine.

### **OIL MANIFOLD (All Models)**

The oil manifold is mounted along the right side of the cylinder block.

Unfiltered oil from the oil pump passes through a passage in the manifold and into the filter base. From the filter base the oil is delivered to the oil cooler and returned to the filter base through connecting oil tubes.

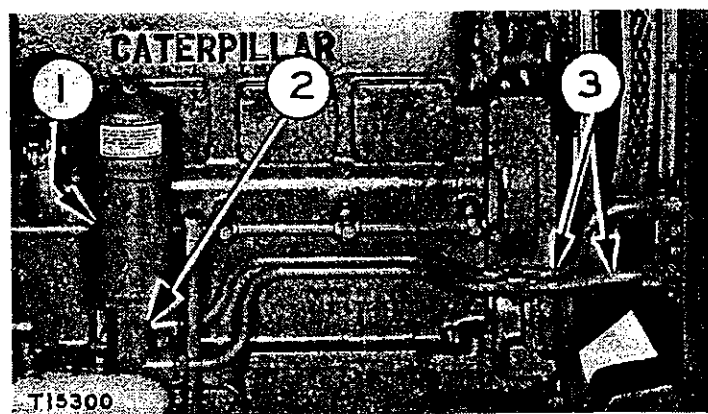
From the filter base the oil enters the oil filter. The oil leaves the filter and is delivered to the oil manifold through a connecting passage in the filter base.

The oil manifold distributes the cooled and cleaned oil to the proper working parts of the engine.

### **Oil Manifold Removal and Installation (All Models)**

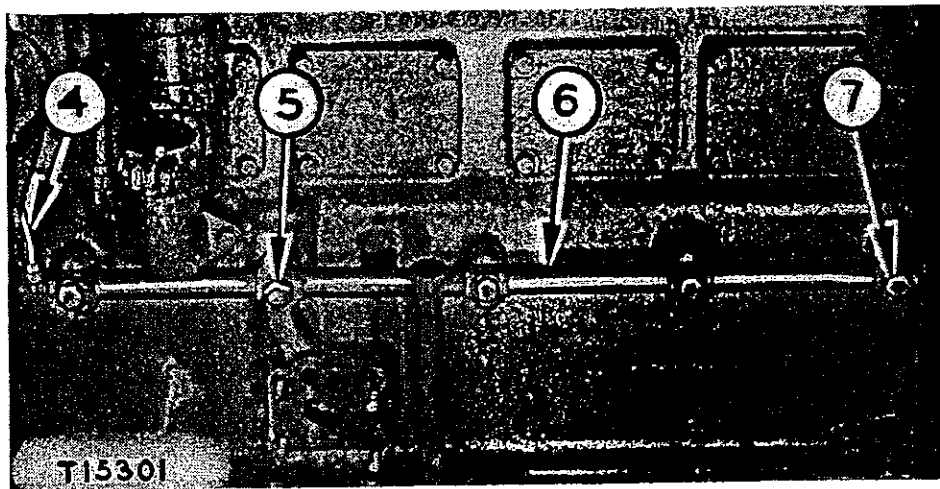
Drain the oil from the filter base (2) and disconnect the oil tubes (3).

Remove the oil filter (1) and the filter base (2) as a unit.



**REMOVING THE FILTER AND FILTER BASE**  
1-Oil filter. 2-Filter base. 3-Oil tubes.

Disconnect the tube (4) and remove the nut (5) and capscrews (7). Do not lose the washers located under the nut and the heads of the capscrews. The washers act as gaskets and oil leakage will occur if the washers are not in place, when installing the oil manifold (6) on the cylinder block.



**REMOVING OIL MANIFOLD**  
4-Tube. 5-Nut. 6-Oil manifold. 7-Capscrew.

Clean and check all passages in the manifold and inspect the gaskets located between the cylinder block and the manifold at time of installation.

### SUMP PUMP

Normally, marine engine installations are made in surroundings that offer only limited clearance around the underside of the engine oil pan. This makes it difficult in most cases, and absolutely impossible in some cases, to drain the oil by removing the drain plug in the bottom of the oil pan.

A sump pump which is mounted at the left side of the oil pan on marine engines, provides a method for removing the oil from the oil pan.

#### Removing the Sump Pump

The sump pump (2) and the cover (3) can be removed together if desired, by removing the capscrews (4). However, it is usually not necessary for the cover to be removed, since only the ball check valve is located in the cover and it requires very little attention. Periodic inspection of the ball check valve is sufficient.

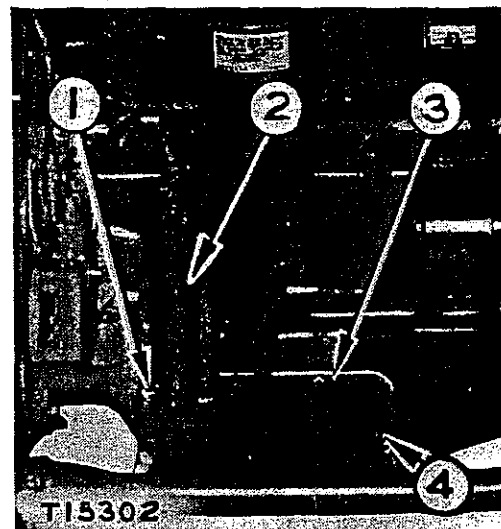
Separate the sump pump from the cover (3) by removing the capscrews (1).

Cover the opening in the cover with tape or cloth to prevent the entry of dirt.



### REMOVING SUMP PUMP

1-Capscrew. 2-Sump pump.  
3-Cover. 4-Capscrew.



### Sump Pump Disassembly

Remove the handle (9) and the packing nut (8).

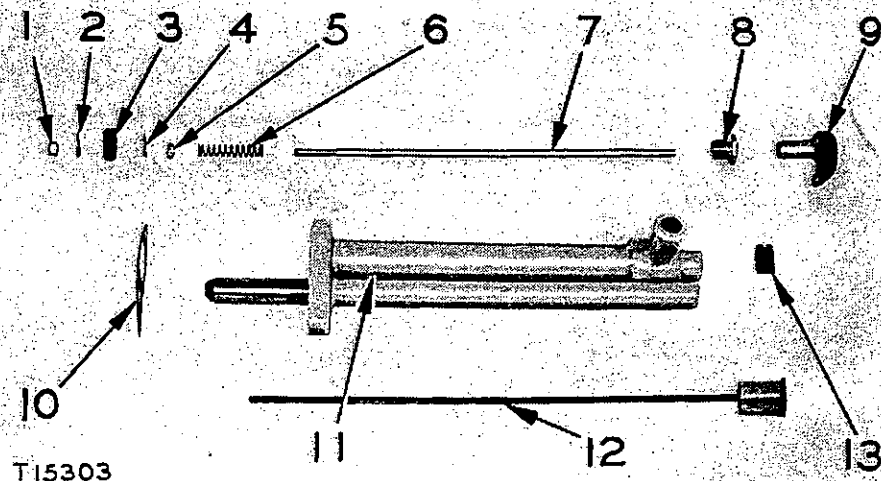
Pull the shaft (7), spring (6), nut (5), washer (4), cup (3), washer (2) and the nut (1) out as an assembly from the lower end of the cylinder (11).

Unless leakage has occurred, it is not necessary to remove the packing (13).

If the spring (6), nut (5), washer (4), cup (3), washer (2) and nut (1) are removed from the shaft (7), care must be observed to place the open side of the cup (3) toward the washer (4), when installing it on the shaft.

The gauge (12) provides a method for checking the engine oil level.

Always inspect the condition of the gasket (10) at time of installation.



### DISASSEMBLING THE SUMP PUMP

1-Nut. 2-Washer. 3-Cup. 4-Washer. 5-Nut. 6-Spring. 7-Shaft. 8-Packing nut.  
9-Handle. 10-Gasket. 11-Cylinder. 12-Gauge. 13-Packing.

# Fuel System

(All Models)

On the supply side of the fuel system, the fuel flows from the Diesel fuel tank to the transfer pump which delivers the fuel into the lower chamber of the fuel filter housing, then through the fuel filter elements and into the upper chamber.

A vertical passage within the housing carries the fuel from the upper chamber down to a short drilled passage near the bottom of the lower chamber, thence to a horizontal manifold in the fuel injection pump housing. From this manifold, the fuel is delivered by separate passages to the individual fuel injection pumps.

A fuel pressure gauge is connected so as to register pressure on the fuel delivered to the injection pumps. It also serves to indicate the condition of the fuel filter elements and transfer pump. The fuel by-pass valve is located in the side of the housing or in the fuel transfer pump adapter to return excess fuel to the tank or into the suction side of the pump. See the topic, FLOW OF FUEL (ALL MODELS).

On the injection side of the system, the fuel injection pumps deliver the fuel to the injection valves. The injection valves control the injection pressure and atomize the fuel delivered to the cylinders.

Lack of pressure on the gauge indicates difficulty in the supply side of the system. This could be caused by an empty Diesel fuel tank, a closed shut-off valve at the tank, clogged filter, dirt under the by-pass valve, open vent valves, a faulty transfer pump or gauge.

If a clogged filter is responsible for the lack of pressure, there should still be pressure in the lower chamber of the fuel filter housing. To check, open the lower chamber vent valve.

Air in the system or water in the fuel can also be responsible for the engine firing irregularly or failing to start.

If, after eliminating the above possibilities, there still seems to be something wrong with the fuel system, check the injection side of the system. Fuel injection pumps and fuel injection valves can be checked as described later.

Many times the fuel system is blamed when the fault lies elsewhere. A smoky exhaust may be caused by faulty fuel injection valves. But it can also be caused by a dirty air cleaner, overloading at high altitudes or badly worn piston rings.

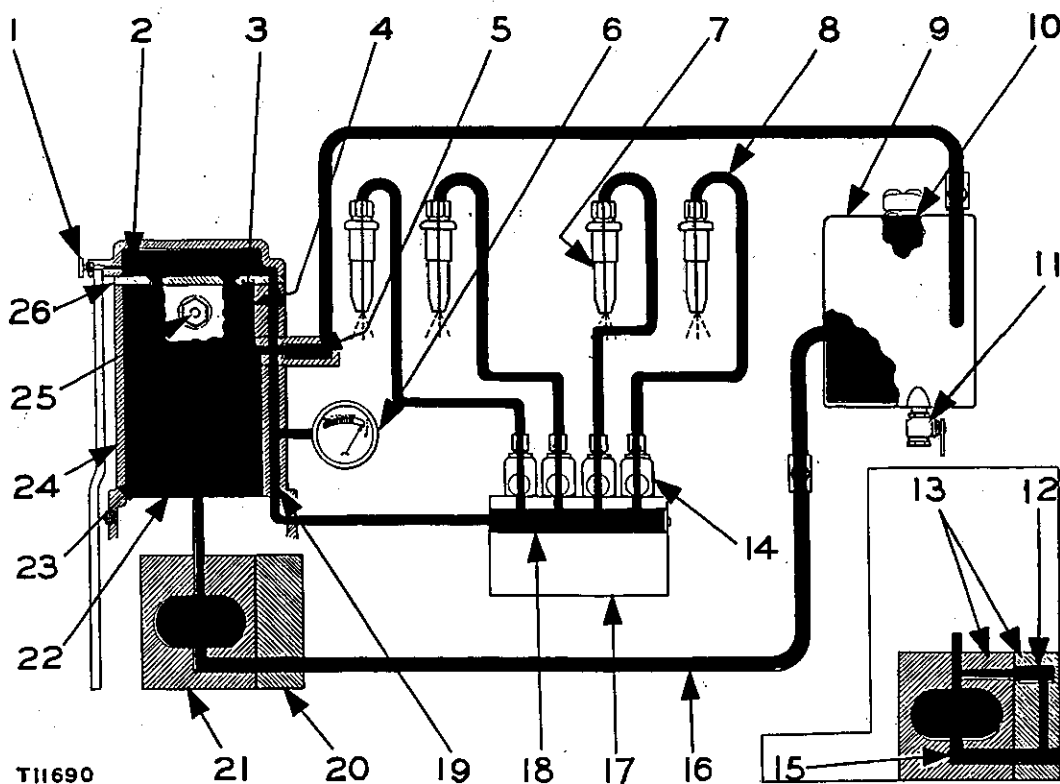
Irregular firing can be caused by faulty fuel injection valves. It can also be caused by the burning of excessive lubricating oil which gets past worn piston rings, or new rings which have not become fully seated.

## FLOW OF FUEL (All Models)

The fuel is supplied to the Diesel engine in the following manner.

Fuel from the fuel tank (9) is carried by the fuel line (16) to the adapter (20) and the fuel transfer pump (21). It is delivered under pressure into the lower chamber (22) of the fuel filter housing (24). The fuel is filtered as it passes through the fuel filter elements (23) into the upper chamber (2) of the fuel filter housing.

The by-pass valve (5) seats in the passage (4) which is connected to the lower chamber (22). This passage is shown schematically and is drilled to the highest point in the lower chamber, an air pocket (3). This permits the air that may collect in the lower chamber to escape with the fuel that is by-passed.



**FUEL SYSTEM (SCHEMATIC)**

1-Upper vent valve. 2-Upper fuel chamber. 3-Air pocket. 4-Drilled passage. 5-By-pass valve. 6-Fuel gauge. 7-Fuel injection valve. 8-Fuel line. 9-Fuel supply tank. 10-Fuel strainer. 11-Drain cock. 12-By-pass valve. 13-Fuel transfer pump and adapter. 14-Fuel injection pump. 15-Fuel passage. 16-Fuel supply line. 17-Fuel injection pump housing. 18-Fuel manifold. 19-Drilled passage. 20-Adapter. 21-Fuel transfer pump. 22-Lower chamber. 23-Fuel filter element. 24-Fuel filter housing. 25-Upper vent valve. 26-Filter element plate.

The D4 Tractor and the No. 112 Motor Grader have the fuel by-pass valve (12) installed in the fuel transfer pump and adapter (13). The by-pass assembly for the D4 Tractor and the No. 112 Motor Grader is shown in the inset.

The transfer pump supplies an amount of fuel in excess of the fuel required for engine operation. The by-pass valve becomes unseated if the pressure becomes too great in the lower chamber. This permits the excess fuel to pass through the fuel return tube and return preferably to the supply tank, (or to the suction side of the fuel transfer pump through passage (15) if the supply tank is above the engine).

The drilled passage (19) in the fuel filter housing delivers the filtered fuel to the fuel manifold (18) in the fuel injection pump housing (17). The fuel pressure gauge (6) is also connected to the drilled passage (19) to register the pressure of filtered fuel in the upper chamber.

From the fuel manifold, the fuel is supplied by separate passages to the individual fuel injection pumps (14).

The fuel injection pumps deliver the fuel to the individual fuel injection valves (7) at the proper time through the fuel lines (8). The fuel is discharged into the precombustion chambers where it starts to burn.

Air can be eliminated from the fuel filter housing by opening the vent valves (1) and (25). The vent valve (25) is connected to the lower chamber, and the vent valve (1) is connected to the upper chamber. When a solid stream of fuel is discharged, it indicates the air has been eliminated. Close the valves after a solid stream of fuel has been obtained.

Air trapped in the fuel injection pump housing can be eliminated by opening the individual vents on each fuel pump. A solid stream of fuel indicates the system is free of air.

The fuel strainer (10) should be cleaned occasionally and sediment can be drained out by opening the drain cock (11).

### **FUEL TRANSFER PUMP (All Models)**

The fuel transfer pump is mounted on the fuel filter housing assembly and is driven by a gear which is cut integrally on the accessory shaft.

The fuel flows from the fuel tank to the suction side of the fuel transfer pump.

The transfer pump delivers the fuel under about 15 PSI through the fuel filter elements and then into the fuel manifold in the fuel injection pump housing.

Fuel is delivered by the individual injection pumps into the fuel injection valves and the precombustion chambers at the proper time.

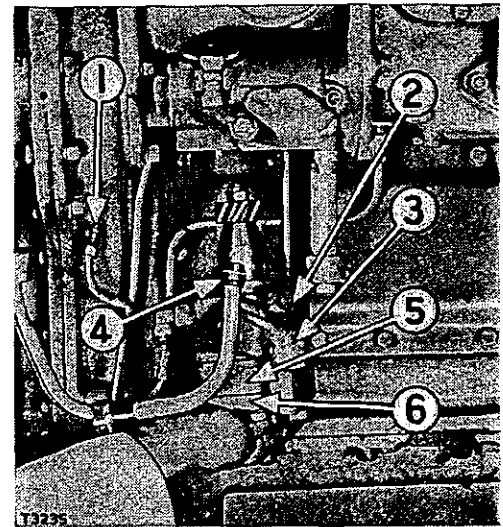
### Fuel Transfer Pump Removal and Installation (All Models)

The transfer pump (2) and adapter (3) can be removed as a unit, or, either the cover (6) or the body (5) and one gear can be removed without taking out the entire unit.

To remove the complete unit, disconnect the main fuel line (4) and the small overflow line (1).

#### FUEL TRANSFER PUMP REMOVAL

- 1-Overflow line. 2-Pump. 3-Adapter.
- 4-Main fuel line. 5-Pump body.
- 6-Cover.



Remove the nuts from the two short studs next to the engine and the nut from the long stud in the outside rear position.

Remove the long capscrew from the outside front position. The unit can then be removed.

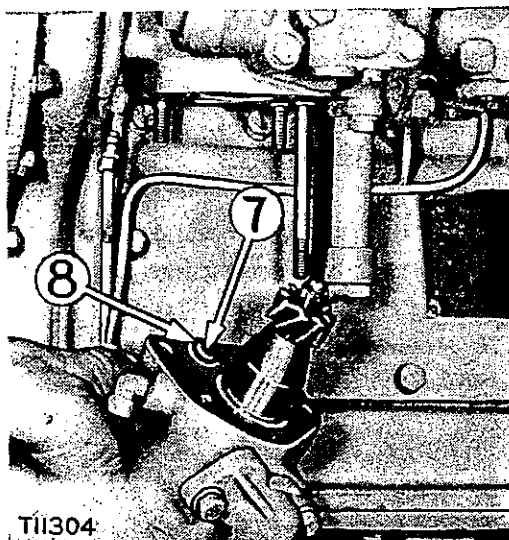
Remove the ferrule (7) and the rubber ring seal (8) from the fuel filter housing, if they did not come out of the housing when the transfer pump was removed.

Inspect the ring seal and the gasket at the time of assembly.

Place the ring seal and the ferrule into its bore in the transfer pump before installing the transfer pump on the engine, for the easiest method of installing the ferrule and ring seal.

Later transfer pumps have a counterbore in alignment with each of the three studs which pass through the housing.

The gasket is cut out to permit the installation of the small rubber seals (9). These seals prevent fuel leakage around the studs.



**INSTALLING TRANSFER PUMP**  
7-Ferrule. 8-Rubber ring seal.



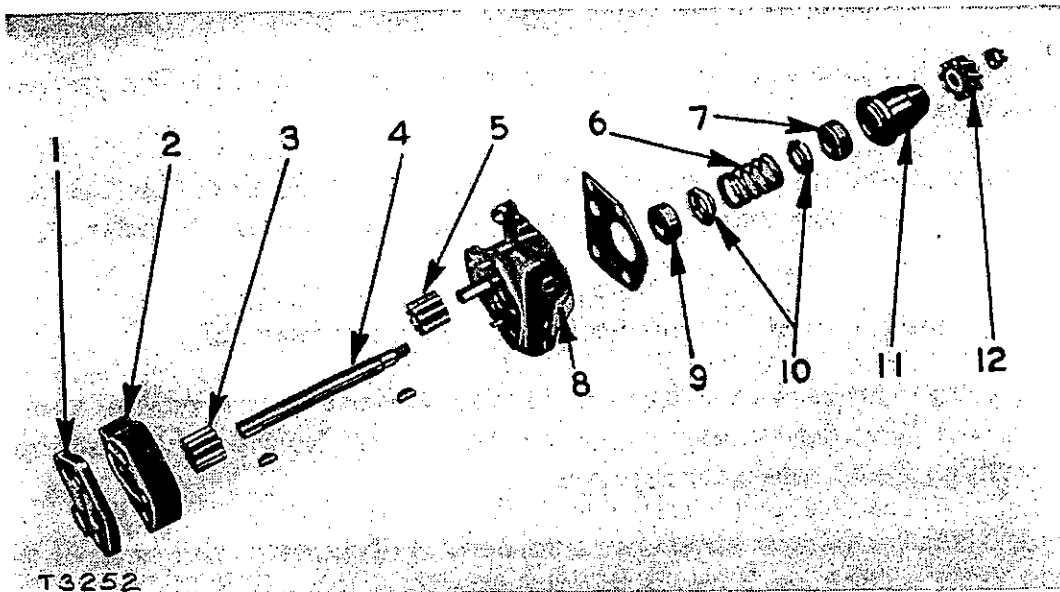
**LATER TRANSFER PUMPS**  
9-Small rubber seals.

### Fuel Transfer Pump Disassembly (All Models)

Remove the fuel transfer pump adapter, which is connected to the fuel transfer pump and receives the supply of fuel from the main fuel supply line.

#### CAUTION

The adapters for the D4 Tractor and the No. 112 Motor Grader contain the fuel by-pass valve. See the topic, FUEL BY-PASS (ALL MODELS).



### FUEL TRANSFER PUMP

1-Cover. 2-Body. 3-Gear. 4-Shaft. 5-Idler gear. 6-Spring. 7-Seal. 8-Bracket.  
9-Seal. 10-Retainers. 11-Seat assembly. 12-Gear.

The seals (7) and (9) are seated by the pressure of spring (6) acting against them.

When replacing the seals, take off the nut that holds the gear (12) in place and remove the key. Then remove the gear (12), seat assembly (11), spring (6), and retainers (10). The seals (7) and (9) can then be taken out.

When installing gear (12) and tightening the retaining nut, make sure the gasket does not get caught between the seat assembly (11) and the bracket (8). Tighten the nut securely and install a cotter pin.

Worn pump gears are caused by dirty fuel. A worn pump can be made serviceable by installing new gears if the bracket and cover are not worn.

Remove the capscrews that hold together the cover (1), body (2), and bracket (8). Remove the cover (1) and idler gear (5). Remove the body (2) from the dowel pins in the bracket (8).

Remove the shaft (4) and gear (3) as a unit.

The gear (3) is keyed and pinned to the shaft (4). To remove the pin, drill a hole through from the opposite side of the gear so a punch can be inserted to drive out the pin. The gear can then be pressed from the shaft and the key removed. See the topic, OIL PUMP DISASSEMBLY (ALL MODELS except D4 Tractors) for the procedure of removing a pin which is similar.

### **Assembling the Fuel Transfer Pump (All Models)**

When installing a new drive shaft (4) and gear (15), install the key (17) and press the gear on the shaft until the end of the shaft is flush with the lower face of the gear. Using the partly drilled hole in the gear as a guide, drill a  $\frac{1}{8}$ " hole,  $\frac{3}{4}$ " deep through the shaft and into the opposite side of the gear. Install a new pin (16) and peen the gear over the end of the pin.

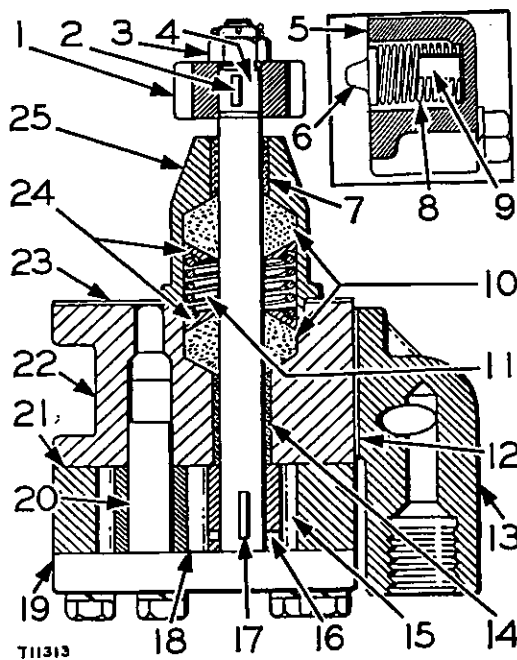
### **CAUTION**

The end of the pin should not protrude beyond the surface of the gear. Any roughness caused by drilling or peening should be removed. See the topic, ASSEMBLING THE OIL PUMP (ALL MODELS except D4 Tractors) for illustration.

Check the bushings (7) and (14) and all other parts for wear. The bushings can be removed and installed by using a press.

Install the drive shaft and gear into the bracket assembly (22).

Slide the body (21) onto the bracket assembly mating the dowels and the dowel holes.



### FUEL TRANSFER PUMP (CROSS-SECTION)

1-Gear. 2-Key. 3-Nut and cotter pin.  
4-Drive shaft. 5-Adapter. 6-Plunger.  
7-Bushing. 8-Spring. 9-Stop. 10-Seals.  
11-Spring. 12-Gasket. 13-Adapter.  
14-Bushing. 15-Gear. 16-Pin. 17-Key.  
18-Idler gear. 19-Cover. 20-Idler gear  
shaft. 21-Body. 22-Bracket. 23-Gasket.  
24-Retainers. 25-Seat.

Install the idler gear (18) on the idler gear shaft (20).

Install the cover (19), and rotate the drive shaft and gears to see they turn freely.

Install the gasket (23), a seal (10), a retainer (24), the spring (11), the remaining retainer (24) and the remaining seal (10). (The gasket (23) must be installed before the seat (25) because of the size of the hole in the gasket).

Install the seat (25), the key (2), the gear (1) the nut and cotter pin (3).

Install the gasket (12) and the adapter (13) for all models that use this type adapter, with the fuel by-pass valve installed in the fuel filter housing. See the topic, FUEL BY-PASS (ALL MODELS).

The D4 Tractor and the No. 112 Motor Grader use the adapter (5) with the by-pass valve assembly installed between the adapter and the bracket assembly.

The by-pass valve assembly consists of the plunger (6), the spring (8) and the stop (9).

### FUEL BY-PASS (All Models)

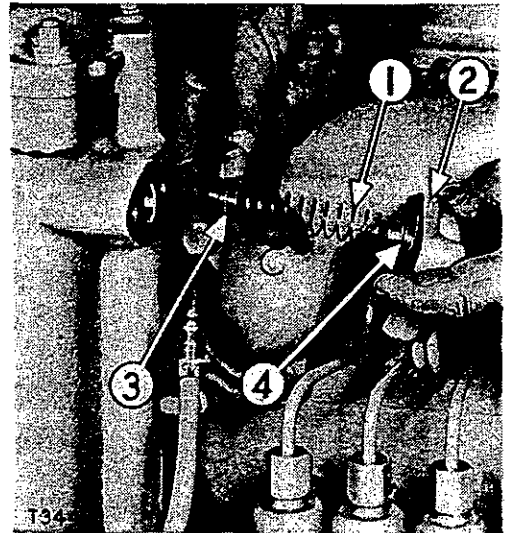
Since the fuel transfer pump normally supplies more fuel than is required by the engine, a by-pass for the excess fuel is provided.

The fuel by-pass assembly on all models except the D4 Tractor and the No. 112 Motor Grader, consisting of the housing (2), spring (1), a stop (4)



### FUEL BY-PASS VALVE

1-Spring. 2-Housing.  
3-Plunger. 4-Stop.

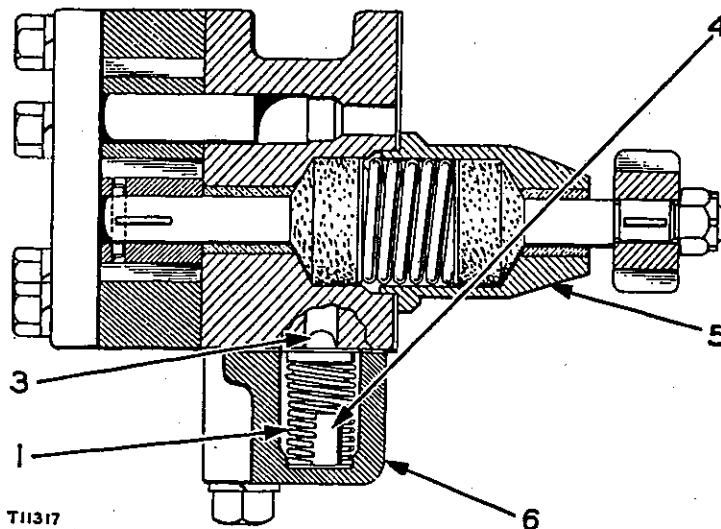


and the plunger (3), is located on the side of the fuel filter housing and returns fuel to the tank or the suction side of the fuel transfer pump.

The fuel by-pass assembly of the D4 Tractor and the No. 112 Motor Grader is located in the adapter (6) and is attached to the fuel transfer pump (5). The assembly also consists of the spring (1), the stop (4) and the plunger (3), and they return the excess fuel to the suction side of the fuel transfer pump.

The fuel by-pass assemblies regulate the fuel pressure to the fuel injection pumps. The plunger opens when the fuel injection pumps do not use all the fuel.

The spring pressure is such that the excess fuel is by-passed to the tank without causing damage to the fuel filter housing or fuel filter pressure gauge mechanism.



### D4 TRACTOR AND NO. 112 MOTOR GRADER FUEL BY-PASS VALVE

1-Spring. 3-Plunger. 4-Stop. 5-Fuel transfer pump. 6-Adapter.

The plunger may fail to function properly if dirt gets between it and the seat. This may cause the fuel filter pressure gauge to show a wide variation between low idle and high idle speed.

After cleaning the contact surfaces, see that the seat is smooth and flat and that the sealing surface of the plunger is in good condition.

If this plunger is functioning properly, the gauge should vary only slightly.

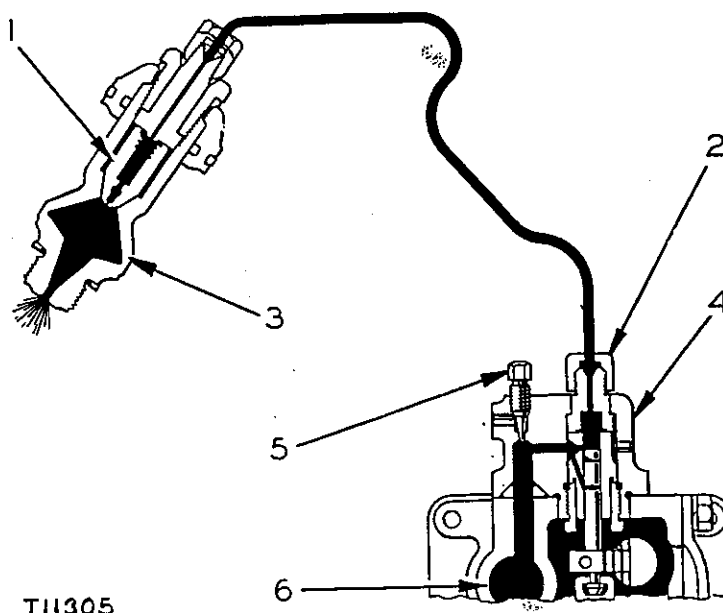
### FUEL INJECTION EQUIPMENT (All Models)

The most likely causes for faulty fuel injection are:

1. Air in the fuel system.
2. Low fuel supply.
3. Water in the fuel.
4. Clogged fuel filters.
5. Insufficient fuel transfer pump pressure.

If these conditions are checked and corrected and the engine still does not operate as it should, it is well to check the fuel injection equipment.

### Checking Fuel Injection Equipment (All Models)



**CHECKING FUEL INJECTION EQUIPMENT**  
1-Fuel injection valve. 2-Fuel line nut. 3-Pre-combustion chamber.  
4-Fuel injection pump. 5-Bleeder screw. 6-Fuel manifold.

Before removing a fuel injection valve (1) or fuel injection pump (4) from an engine that is operating irregularly, a simple check may be made to determine which cylinder is not firing properly.

With the engine running at a speed that makes the irregularity most pronounced, momentarily loosen the fuel line nut (2) just above the fuel injection pump sufficiently to "cut-out" that cylinder. Check each cylinder in the same manner. If one is found where loosening makes no difference in the operation of the engine, probably the valve and pump for that cylinder only need be tested.

Air can be eliminated from the fuel manifold (6) and the fuel pumps by opening the bleed screw (5). See the topic, FLOW OF FUEL (ALL MODELS).

### FUEL INJECTION VALVE (All Models)

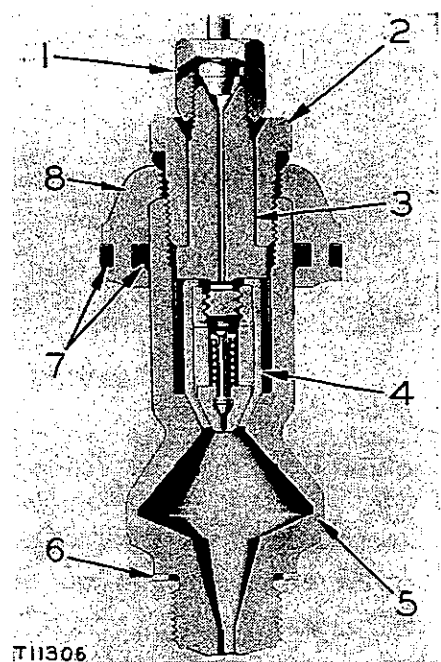
The function of the fuel injection valves is to inject and atomize the fuel from the fuel injection pumps into the precombustion chambers. Irregular engine operation and smoking may be caused by an improperly operating injection valve.

The fuel injection valve is installed in the precombustion chambers (5).

The precombustion chamber is threaded into the cylinder head and torqued to 200 pound feet. Leakage is prevented by the gasket (6) and the rubber ring-type seals (7) which are installed into the retainer (8).

#### FUEL INJECTION VALVE CROSS-SECTION

- 1-Fuel line assembly. 2-Nut.
- 3-Body. 4-Nozzle assembly.
- 5-Pre-combustion chamber.
- 6-Gasket. 7-Seals.
- 8-Retainer.



The fuel injection valve consists of the body (3) and the capsule-type nozzle assembly (4).

Only the nozzle assembly need be replaced whenever the fuel injection valves require reconditioning work.

The fuel injection valve is held in place by the nut (2), and can be removed by loosening the fuel line assembly (1) and removing the nut and seal.

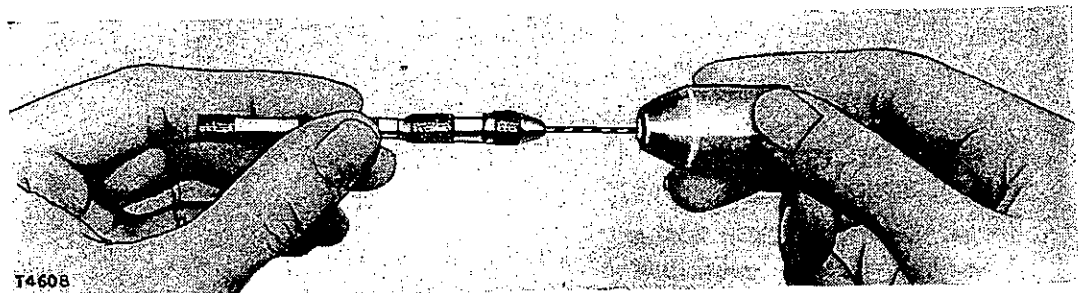
The body and the nozzle assembly can then be lifted out. The nozzle assembly is only finger-tight onto the body.

When installing a fuel injection valve, always check the seats of both the nozzle and the precombustion chamber.

Torque the nut (2), to 100 pound feet to assure proper seating of the nozzle assembly. Excessive tightness will damage the nozzle and excessive looseness will allow the nozzle to leak and in some instances cause the nozzle case to split.

### **Cleaning Fuel Injection Valve (All Models)**

The operation of the engine will be affected if the discharge hole in the nozzle becomes partially filled with carbon. To correct this, remove the nozzle assembly from the valve body and clean the fuel discharge hole using a 5B2178 Drill and 5B1254 Chuck which are part of the 5B1401 Cleaning Tool Group. If after cleaning, the valve does not operate properly the nozzle should be checked for leakage.



**CLEANING FUEL INJECTION VALVE**

### **Checking Fuel Injection Valve (All Models)**

The condition of a capsule type fuel injection valve can be checked out of the engine by the use of the special pressure gauge on the "Caterpillar" Diesel Fuel Injection Test Apparatus. This determines its rate of leakage, which indicates how rapidly the nozzle will carbon up.

## FUEL INJECTION PUMPS (All Models)

Worn fuel injection pumps will result in loss of power and hard starting. These same conditions may be present if the piston rings and cylinder liners are badly worn or if the condition of the engine in general is bad.

However, in the case of worn piston rings and liners, the hard starting and loss of power will be accompanied by a smoky exhaust, excessive blow-by gases from the crankcase breather and high oil consumption.

Ordinarily, if one fuel injection pump is worn and not supplying sufficient fuel, it will be found that all of the injection pumps are worn and need replacing.

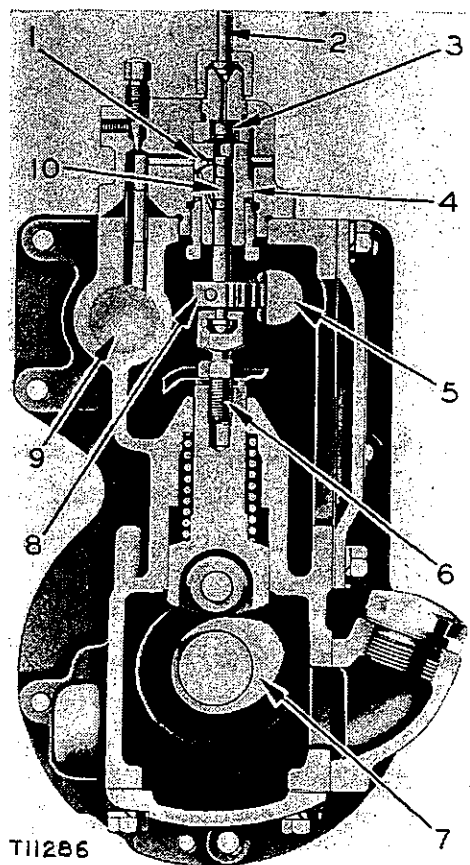
Failure to replace all of the worn injection pumps can result in erratic and irregular engine operation.

### Functions of Fuel Injection Pumps (All Models)

The fuel transfer pump maintains a full supply of fuel in the fuel manifold (9) at all times.

#### FUEL PUMP AND LIFTER ASSEMBLY

1-Inlet port. 2-Fuel line. 3-Check valve. 4-Barrel. 5-Rack. 6-Lifter assembly. 7-Cam. 8-Gear segment. 9-Fuel manifold. 10-Injection pump plunger.



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Each fuel pump measures the amount of fuel to be injected into its particular cylinder and produces the pressure for injection. The injection pump plunger (10) and the lifter assembly (6) are lifted by a cam (7) and always make a full stroke.

The amount of fuel pumped during any one stroke is varied by rotating the plunger in the barrel (4). The plunger is rotated by the governor action through the rack (5) which meshes with a gear segment (8) on the bottom of the pump plunger.

Figures A, B and C illustrate the functioning of an injection pump as the plunger makes a stroke.

In Fig. A, the plunger is down and the inlet port (1) is uncovered. Fuel flows into the space above the plunger through the slot and into the recess around the plunger.

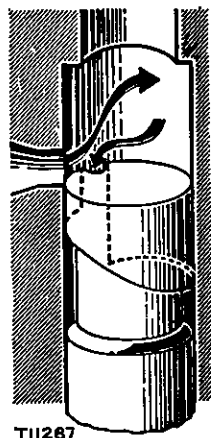


FIG. A  
PORT UNCOVERED  
FUEL ENTERS BARREL

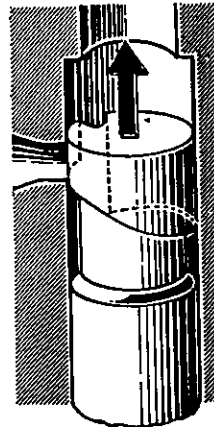


FIG. B  
PORT COVERED  
INJECTION BEGINS

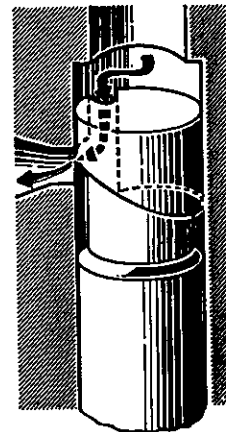


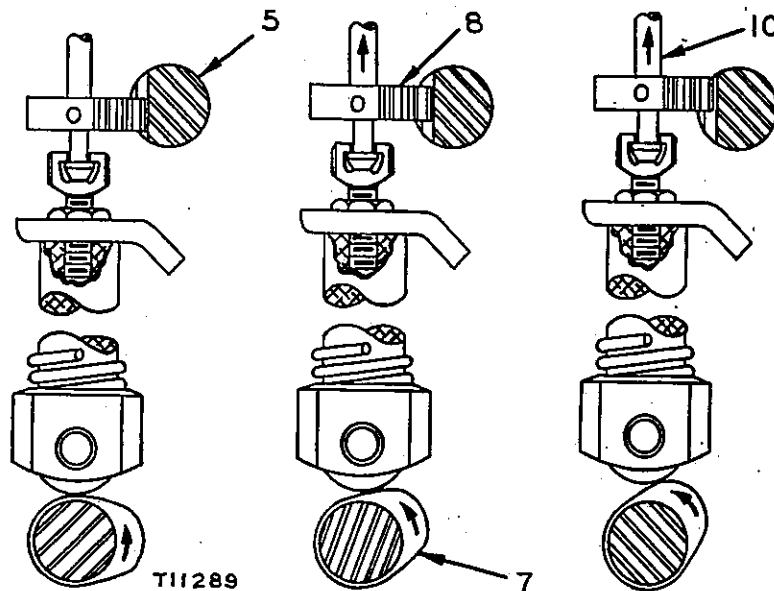
FIG. C  
PORT UNCOVERED  
INJECTION ENDS

#### PUMP PLUNGER STROKE

In Fig. B, the plunger has started up and the port is covered. The fuel is trapped and will be forced through the check valve (3), fuel line (2) and injection valve as the plunger moves upward.

In Fig. C, the plunger has risen until the port is uncovered by the recess in the plunger. The fuel can now escape back through the port into the fuel manifold and injection will cease.

It will be noted that the recess in the pump plunger forms a helix around the upper end of the plunger. Figures D, E and F illustrate how rotating the pump plunger affects the quantity of fuel injected.



**CROSS-SECTION OF FUEL PUMP CAMSHAFT AND LIFTER ASSEMBLY  
(SCHEMATIC)**

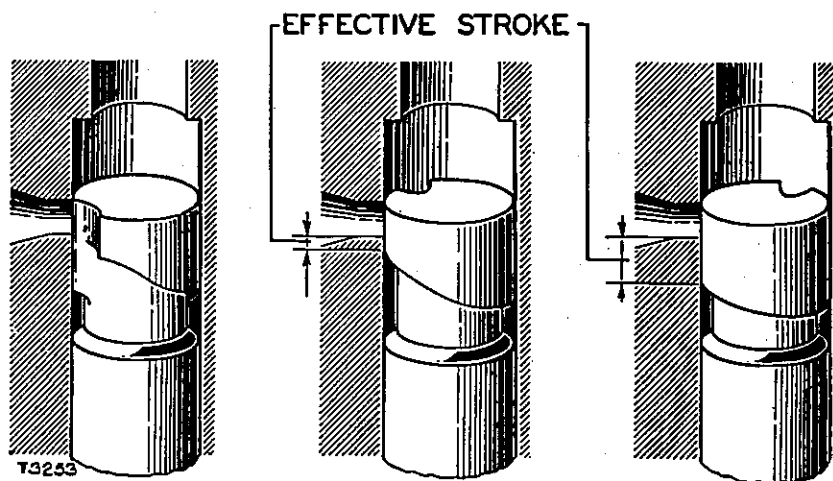
**FIG. A**  
PORT UNCOVERED  
FUEL ENTERS BARREL

**FIG. B**  
PORT COVERED  
INJECTION BEGINS

**FIG. C**  
PORT UNCOVERED  
INJECTION ENDS

5-Rack. 7-Cam. 8-Gear segment. 10-Injection pump plunger.

In Fig. D, the plunger has been rotated into the shut-off position. The slot connecting the top of the plunger with the recess is in line with the port, therefore, no fuel can be trapped and injected.



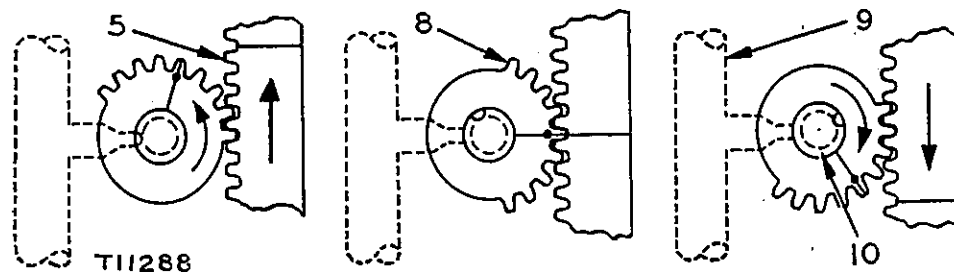
**PLUNGER ROTATION (SIDE VIEW)**

**FIG. D**  
SHUT-OFF  
POSITION

**FIG. E**  
IDLING  
POSITION

**FIG. F**  
FULL LOAD  
POSITION

In Fig. E, the plunger has been rotated into the idling position. The narrow part of the plunger formed by the helix will cover the port for only a short part of the stroke. This permits only a small amount of fuel to be injected per stroke.



CROSS-SECTION SHOWING PLUNGER ROTATION  
(TOP VIEW)

FIG. D  
SHUT-OFF  
POSITION

FIG. E  
IDLING  
POSITION

FIG. F  
FULL LOAD  
POSITION

5-Rack. 8-Gear segment. 9-Fuel manifold. 10-Injection pump plunger.

In Fig. F, the plunger has been rotated into the full load position. The wide part of the plunger formed by the helix covers the port for a longer part of the stroke. This permits a larger amount of fuel to be injected per stroke.

### FUEL INJECTION PUMP HOUSING REMOVAL AND INSTALLATION (All Models)

1. Drain the fuel filter housing and the injection pump housing.
2. Remove the fuel injection lines and disconnect the fuel drain tube (3).
3. Disconnect the control rod from the governor.
4. Plug the lines and put covers (1) on the pumps.
5. Remove the nuts holding the pump housing to the fuel filter housing. The injection pump housing and governor housing can then be removed as a unit by lifting it away from the filter housing.
6. The ring seal (2) which prevents fuel leakage between the filter housing and the pump housing manifold should be replaced if deteriorated or damaged.
7. Remove the governor by disconnecting the linkage and the nuts holding the governor to the fuel injection pump housing.

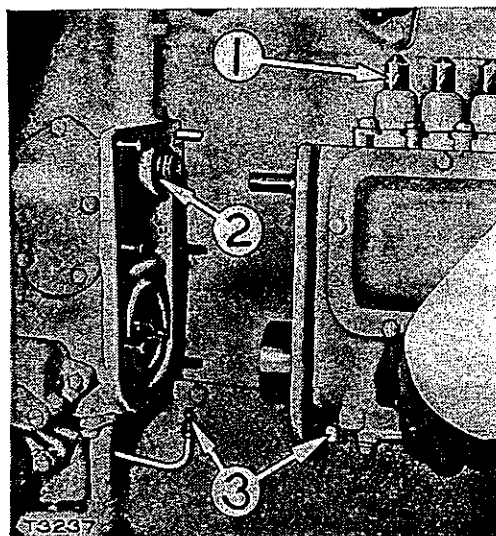
#### NOTE

When installing the fuel injection pump housing on the filter housing, be sure the off-center tang of the accessory shaft fits into the off-center slot in the end of the fuel pump cam-shaft, before tightening the mounting nuts.



## FUEL INJECTION PUMP HOUSING REMOVAL

1-Cover. 2-Seal. 3-Fuel  
drain tube.



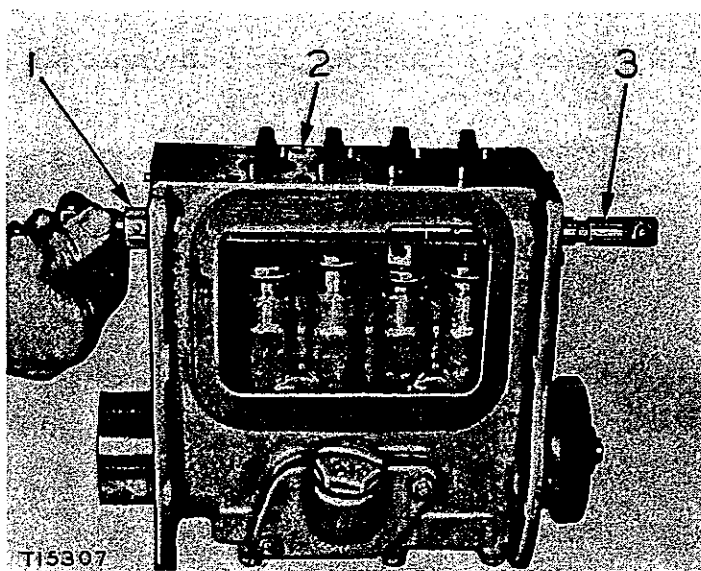
## FUEL PUMP HOUSING DISASSEMBLY (All Models)

### Fuel Rack Removal (All Models)

With the fuel injection pump housing (2) off the engine, remove the fuel pumps. The fuel rack (3) can then be pulled from the forward end of the housing.

The fuel rack has a stop (1) attached near its forward end, which contacts the fuel injection pump housing and prevents the rack from moving beyond the shut-off position.

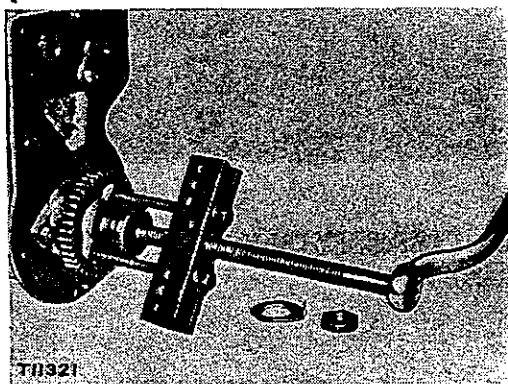
The fuel rack can also be removed without separating the governor from the housing (2), by removing the cover from the rear of the governor and disconnecting the linkage between the rack and governor lever.



REMOVING FUEL INJECTION PUMP RACK  
1-Stop. 2-Fuel injection pump housing. 3-Fuel rack.

## Governor Drive Gear and Camshaft Thrust Washer Removal and Installation (All Models)

The governor drive gear can be pulled as illustrated, after removing the nut and lock from the end of the fuel pump camshaft. Use two suitable capscrews 3" long with the 5F7465 Puller, the 8B7560 Step Plate and two flat metal washers.



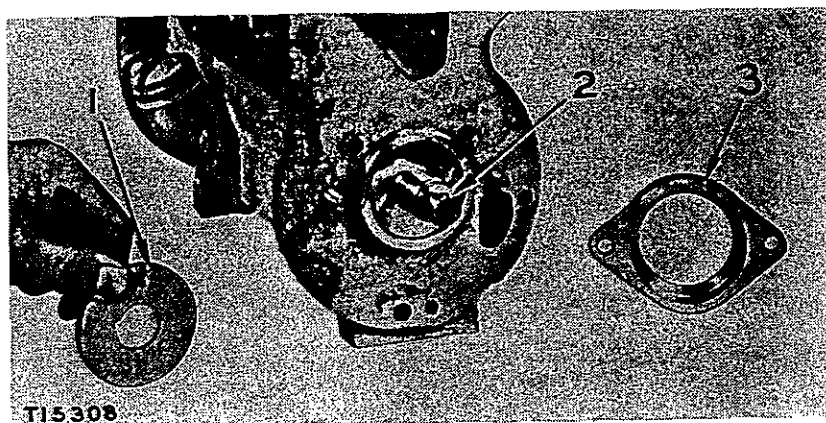
PULLING GOVERNOR DRIVE GEAR

### NOTE

The governor gear has two tapped holes to accommodate puller capscrews. On the gears of earlier models these two holes had a  $\frac{3}{8}$ "-16 (NC) thread. On later models the two holes have a  $\frac{3}{8}$ "-24 (NF) thread.

Remove the nuts holding the thrust plate (3). Remove the thrust plate.

Slide the thrust washer (1) off the fuel pump camshaft (2).



### THRUST WASHER REMOVAL

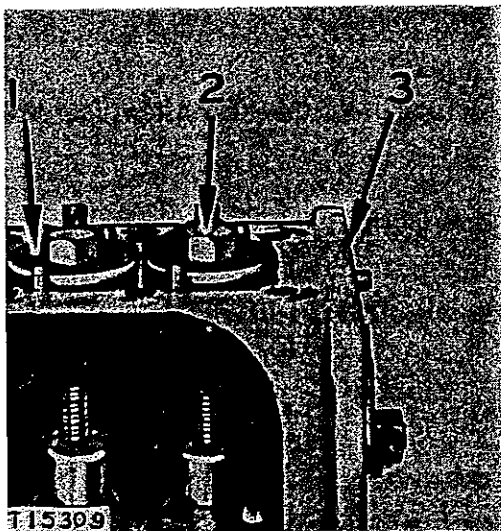
1-Thrust washer. 2-Camshaft. 3-Thrust plate.

The fuel pump camshaft end clearance is controlled by the distance the thrust washer can move between the rear bushing in the fuel pump housing and the inside machined surface of the thrust plate.

Check all surfaces for roughness at the time of assembly. The end clearance should be .003" to .015" with a maximum of .025"...

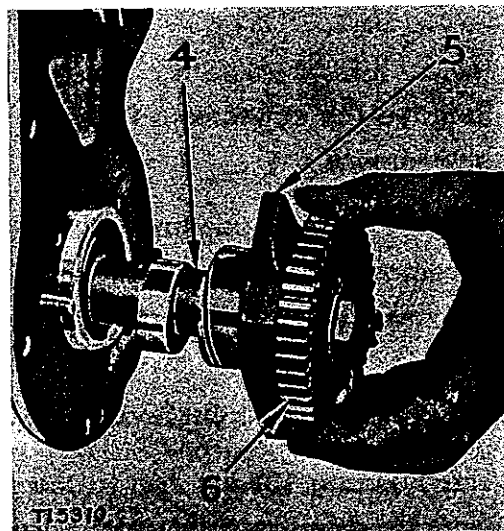
### Fuel Pump Camshaft Removal and Installation (All Models)

The fuel pump camshaft (4) can be removed, with or without the governor drive gear (6) removed.



#### RAISING FUEL PUMP LIFTERS

1-Flat washer. 2-Capscrew.  
3-Fuel pump housing.



#### INSTALLING FUEL PUMP CAMSHAFT

4-Camshaft. 5-Thrust plate.  
6-Governor drive gear.

If the lifter yokes are removed, the lifters can be raised with 6F7031 Capscrews,  $\frac{3}{8}$ "-24 (NF) 3" long (2), and 4F3714 Washers (1).

Remove the nuts holding the thrust plate to the injection pump housing (3).

Slide out the camshaft, the gear, the thrust plate (5) and the thrust washer as a unit.

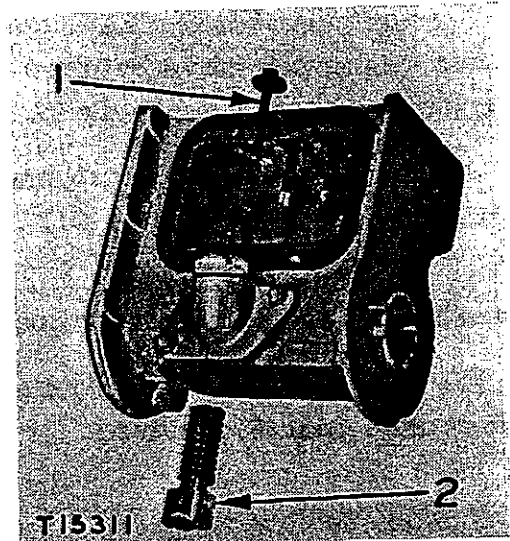
See the topic, GOVERNOR DRIVE GEAR AND CAMSHAFT THRUST WASHER REMOVAL AND INSTALLATION (ALL MODELS).

### Pump Lifter Removal (All Models)

With the camshaft removed, the pump lifters (2), springs and yokes can be removed from the housing.

### REMOVING PUMP LIFTER

1-Capscrew. 2-Lifter.



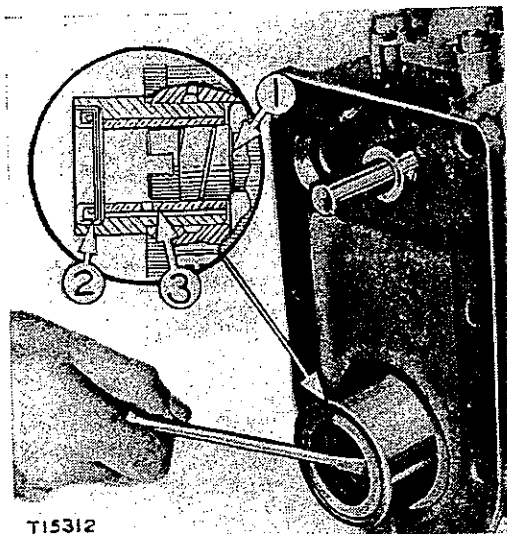
Remove the capscrews (1) which were used to raise the lifters for camshaft removal.

Remove the inspection cover from the bottom of the pump housing and remove the lifter and spring from the bottom of the housing. A new cork gasket should be used between the shield and lifter in reassembly.

### Fuel Pump Housing Oil Seal (All Models)

The bushing (3) located in the forward end of the fuel injection pump housing, serves as a forward bearing for the fuel pump camshaft and as a rear bearing for the engine accessory shaft.

The oil seal (2) is located in the fuel pump housing and prevents leakage of the lubricating oil from the fuel pump housing into the Diesel engine crankcase.



### SEAL REMOVAL

1-Camshaft. 2-Seal. 3-Bushing.



The seal can be removed and installed without removing the fuel pump camshaft (1). A small bar may be used to pry out the seal as illustrated. Care should be taken not to damage the bushing (3).

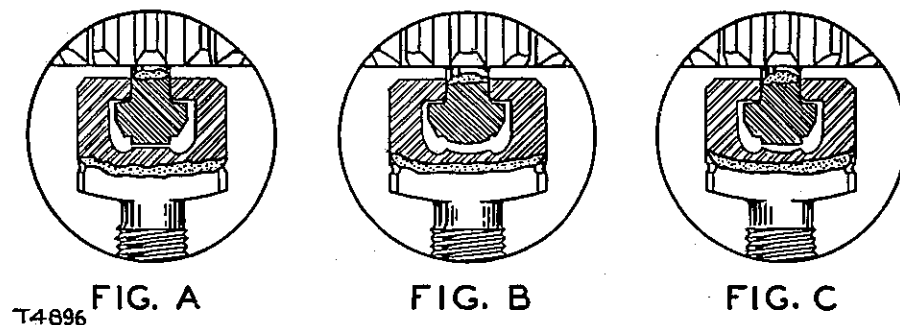
When installing the seal, coat the outside diameter with a sealing compound and install the seal with the sealing edge toward the injection pump housing.

The seal should be tapped into the bushing until the outer face of the seal is flush with the outer end of the bushing.

### Fuel Pump Lifter Yoke and Pump Plunger Inspection (All Models)

Adjusting the fuel pump lifters is necessary whenever they have been removed from the housing. The adjustment should also be checked periodically to compensate for wear in the timing gears, lifters or the ends of the pump plungers to assure that the point of fuel injection is correct. If the lifter is too high, injection will begin early, and, if too low, injection will be late.

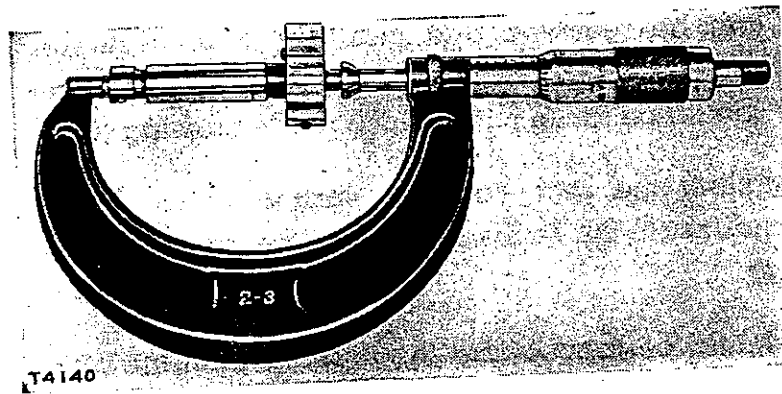
When pump plunger wear becomes excessive, the lifter yoke may also be worn in such a manner that it will not make full contact with the end of a new plunger. To avoid rapid wear on the end of the new plunger, lifter yokes showing visible wear should always be replaced.



WEAR BETWEEN YOKE AND PLUNGER

Fig. A illustrates the contact surfaces of a new pump plunger and a new lifter yoke. In Fig. B, the pump plunger and lifter yoke have worn considerably. Fig. C shows how the flat end of a new plunger makes poor contact with a worn lifter yoke, resulting in rapid wear to both parts.

A pump can maintain a satisfactory discharge rate and yet be unserviceable because of delayed timing resulting from wear on the lower end of the plunger. When testing a pump which has been in use for a long time, the length of the plunger should be checked and the pump



**CHECKING LENGTH OF PLUNGER**

discarded if the plunger wear exceeds .005". The length of new plungers is 2.6575"-2.6577". The length should be checked with a micrometer as shown.

### **Fuel Pump Lifter Setting (All Models)**

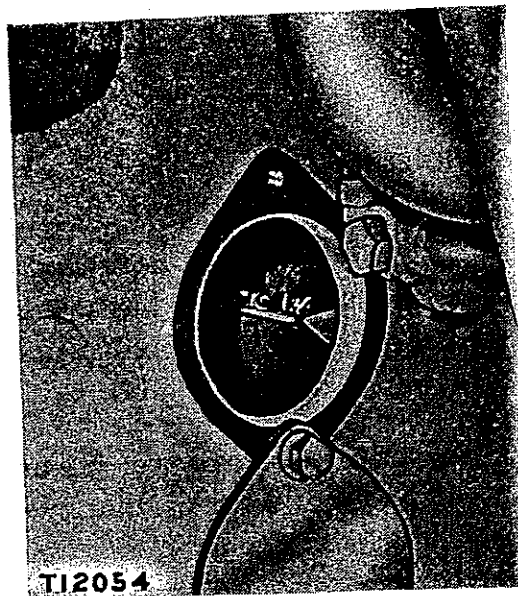
If the injection pump lifters have been removed, or disturbed from their original setting, it is necessary to reset them.

Periodically the lifter setting should be checked and reset if necessary, to compensate for worn timing gears. See the topic, FUEL INJECTION PUMP LIFTER YOKE AND PUMP PLUNGER INSPECTION (ALL MODELS).

Injection pump lifters can be set most accurately with the injection pump housing in place on the engine, since all timing gear wear can be compensated for by this method.

The lifter setting can be made in the following manner:

1. Remove the flywheel pointer cover on the flywheel housing and the injection pump of the respective lifter to be set.

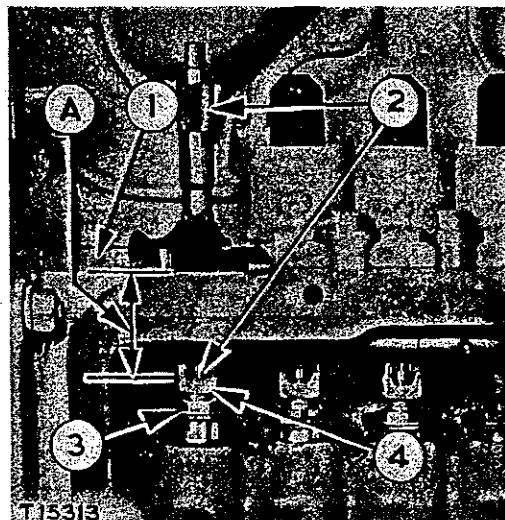


**FLYWHEEL TIMING MARKS**

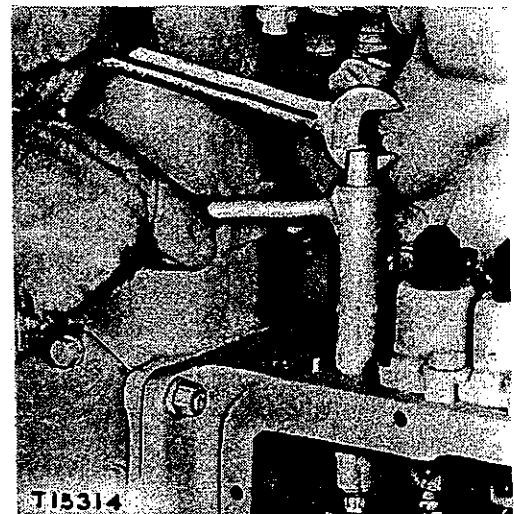
2. Turn the crankshaft in the direction of the engine rotation to "Top Center" (TC) on the compression stroke of the cylinder for which lifter is to be set. See the topic, CHECKING THE FLYWHEEL TOP CENTER MARKS (ALL MODELS), if there is reason to believe that the top center marks on the flywheel are not correct.
3. If the crankshaft is accidentally turned too far, turn it backwards approximately 60°, then repeat step 2.

Check the pump lifter at this crankshaft position (top center of the cylinder for which the lifter is being set). Using the 6F6922 Micrometer Depth Gauge check the distance (A) and reset if necessary, using the 7F4581 Wrench and the 7F4582 Wrench.

The correct setting (A) is 1.736". This is measured from the machined surface (1) at the top of the pump housing to the machined surface of the lifter yoke (4).



**ADJUSTING INJECTION PUMP LIFTERS**  
 A-Setting of 1.736". 1-Machined surface at top of pump housing. 2-Micrometer depth gauge. 3-Lock nut. 4-Lifter yoke.



**ADJUSTING LIFTER SETTING**

The surface (1) must be clean and free of paint. Raise or lower the lifter yoke with the 7F4581 Wrench on lock nut (3) and 7F4582 Wrench on lifter yoke (4).

If all the lifters are to be checked or reset, continue the procedure in the normal firing order of the engine, which is 1-3-4-2. The fuel pumps are numbered 1 through 4 consecutively, with the No. 1 pump located nearest the front of the engine.

As there are two evenly spaced T.C. marks on the flywheel, T.C. 1 & 4, and T.C. 2 & 3, care must be taken to be sure that the proper T.C. mark is lined up with the pointer.

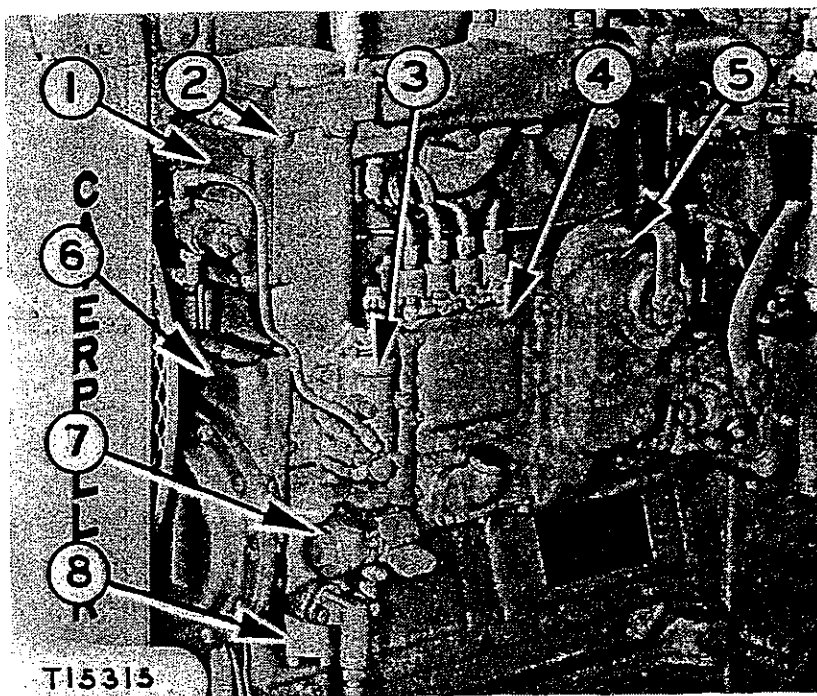
It is important when checking and setting the lifters that the crankshaft be turned in the direction of engine rotation.

After a lifter has been checked or set according to the specifications, turn the crankshaft a few degrees in the direction of engine rotation. Again measure the distance (A). This distance should be less than the measurement when checked with the crankshaft at top center thus indicating the lifter is rising and was checked at the correct position.

### FUEL FILTER HOUSING (All Models)

The fuel filter housing (2) is mounted to the timing gear housing (6) and is located on the forward left side of the engine.

The fuel filter housing has the following assemblies attached to, or mounted on it: the fuel transfer pump (8), the hour meter (7), the fuel injection pump housing (4), the governor housing assembly (5) and the safety shut-off (3).



#### FUEL FILTER HOUSING

- 1-Water elbow. 2-Fuel filter housing. 3-Safety shut-off. 4-Fuel injection pump housing. 5-Governor housing assembly. 6-Timing gear housing. 7-Hour meter. 8-Fuel transfer pump.



In the event that a safety shut-off is not used, a cover can be installed over the opening on the fuel filter housing.

The engine coolant passes through the water elbow (1) and warms the fuel compartment of the fuel filter housing.

The fuel transfer pump delivers the fuel through the fuel filter housing to be filtered and cleaned before the fuel is delivered to the fuel injection pump housing.

### **Fuel Filter Housing Removal and Installation (All Models)**

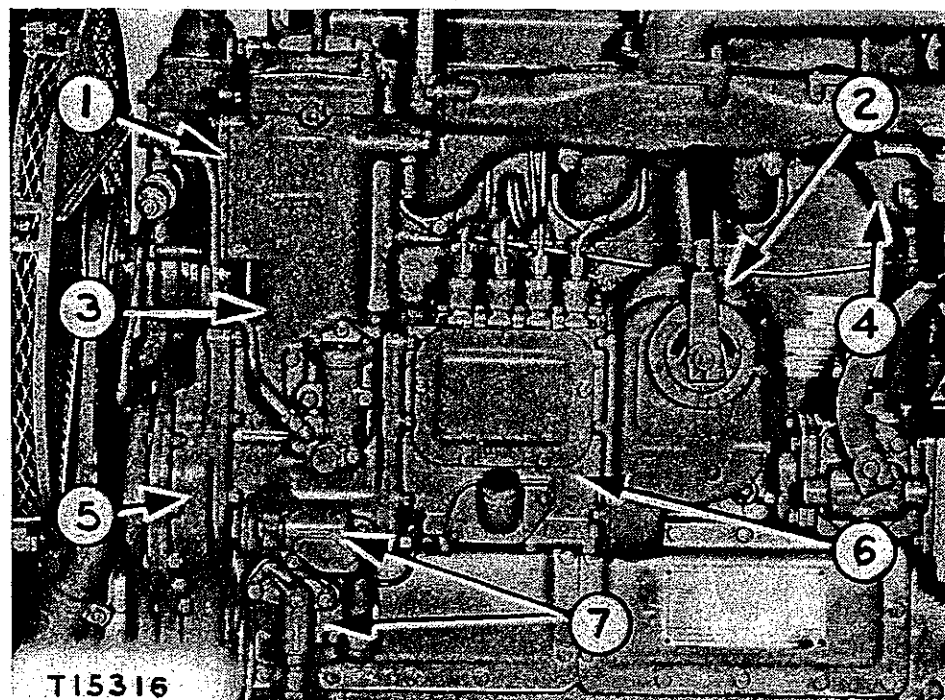
The fuel filter housing (3) can be removed along with the governor housing assembly (2), the fuel injection pump housing (6), the fuel transfer pump and the hour meter (7) as a unit.

When these individual assemblies need to be removed, see the covering topics.

The fuel filter housing can be removed in the following manner:

Drain the fuel from the fuel filter housing and the oil from the fuel injection pump housing.

Drain the cooling system to a point below the water elbow (1) and remove the elbow.



#### **PREPARING TO REMOVE FUEL FILTER HOUSING**

1-Water elbow. 2-Governor housing assembly. 3-Fuel filter housing. 4-Inlet manifold.  
5-Timing gear housing. 6-Fuel injection pump housing. 7-Fuel transfer pump  
and hour meter.

Remove the inlet manifold (4).

Disconnect and remove the various fuel lines and the governor control linkage.

Remove the nuts and lockwashers from the studs connecting the filter housing to the timing gear housing (5), noting the hidden nuts and studs located in back of the housing near the cylinder block.

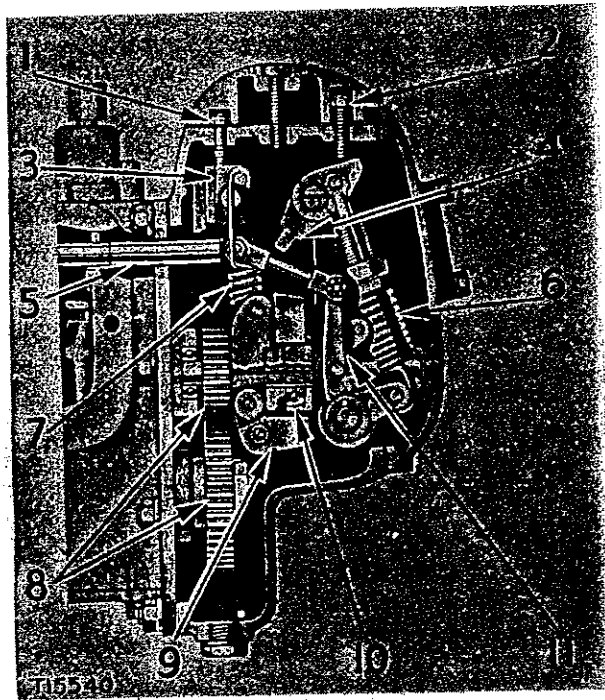
Lift the combined assemblies off with a suitable hoist and sling.

Always install new gaskets. Be sure to align the off-center tang on the end of the accessory shaft with the off-center slot in the fuel pump camshaft at the time of installation.

## Governor

The governor, as used for all versions of the 4½" bore 4-cylinder engines, is similar in appearance and construction.

A basic governor is used with different levers, linkage, gears and governor springs to adapt the governor to the specifications required for each model.



**GOVERNOR CUTAWAY**

1-Low idle adjusting screw. 2-High idle adjusting screw. 3-Spring-loaded stop assembly. 4-Low idle stop lever. 5-Fuel rack. 6-Governor spring. 7-Shut-off spring. 8-Gears. 9-Governor weight. 10-Thrust bearing and sliding sleeve. 11-Terminal lever.

The governor is connected to the fuel rack through levers and linkage. The governor regulates the amount of fuel supplied to the engine during engine operation in the following manner:

The governor spring constantly strives to move the fuel rack in a direction to increase the amount of fuel injected, while the force generated by the rotating governor weights is transmitted to the rack in a direction to decrease the amount of fuel injected. Since the governor weights are rotated by a gear which meshes with a gear that is attached to the fuel injection pump camshaft, any change in engine speed correspondingly results in a change in governor weight force. The opposing force of the governor spring varies accordingly with the governor control setting.

When the engine load is lightened, the engine speed increases, due to the amount of fuel it is receiving at the moment, then the governor moves the fuel rack in the direction to decrease the amount of fuel supplied. As a result the engine speed tends to remain constant even when the load is lightened.

If the engine speed decreases, due to an increase of load, the governor moves the fuel rack in the direction to increase the amount of fuel supplied.

The horizontally mounted governor shaft is driven from the rear end of the fuel injection pump camshaft through the gears (8). The force of the governor weights (9) acting through the thrust bearing and sliding sleeve (10) and the terminal lever (11) opposes the force created by the tension of the governor spring (6) which is controlled by the governor control setting. The terminal lever is connected to the fuel rack (5). The balanced forces hold the fuel rack in position to supply the engine with the correct amount of fuel.

The fuel shut-off mechanism consists of the spring-loaded stop assembly (3), the low idle stop lever (4) and the spring (7).

In low idle position the low idle stop lever is against the stop assembly and can be adjusted by the low idle screw (1). As the governor control is put in the shut-off position the stop lever forces the stop held in place by the spring, over center. This allows the governor control to be positioned and held in the shut-off position.

The high idle speed can be adjusted by the screw (2).

## GOVERNOR OPERATION

(All Models)

### GOVERNOR SPRING VS. GOVERNOR WEIGHTS

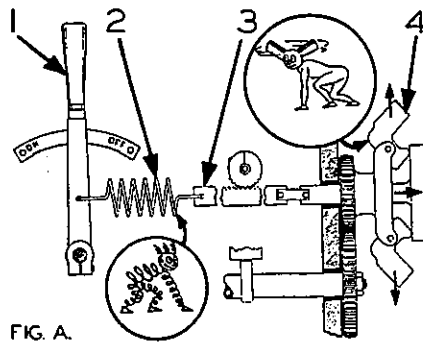


FIG. A.

Fig. A. Two forces act on the fuel rack (3). The governor spring (2) constantly strives to move the rack in the direction to increase fuel. This force is applied by the setting of the governor control lever (1). The force generated by the rotating governor weights (4) strives to move the rack in the opposite direction to decrease fuel.

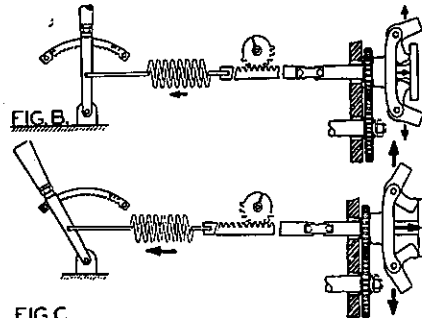


FIG. C.

### GOVERNOR SPRING AND WEIGHT FORCES

Fig. B & C. The force generated by the rotating governor weights is illustrated by the figures B and C. Figure B shows half speed and figure C shows high speed. As the engine speed increases the weight force increases. The spring force varies, depending on how much it is stretched.

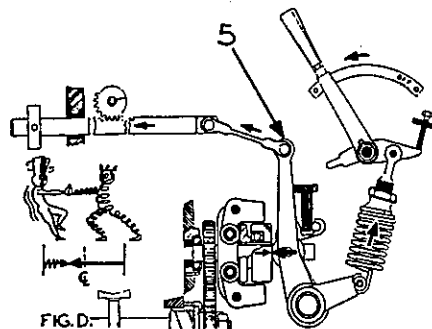


FIG. D.

### FORCES BEFORE STARTING THE ENGINE

Fig. D. When the governor control is moved to the "fuel on" position, the governor spring is stretched, and the lever (5) pushes the fuel rack toward the increased fuel position, since the weights are not rotating. As the engine is started, the speed will increase and the governor weights move outward to supply the opposing force.

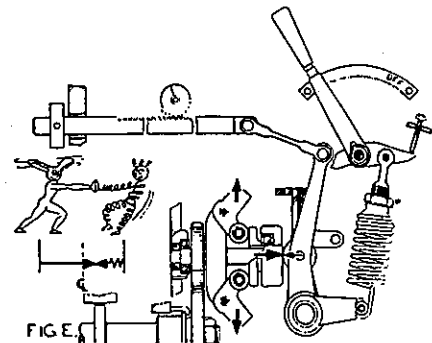


FIG. E.

### FORCES BALANCED AT HIGH IDLE

Fig. E. As the governor spring force moves the fuel rack to increase the fuel, the engine speed increases and the weight force increases. The forces oppose each other and rapidly assume a balance, whereby the correct amount of fuel is injected to balance the forces at high speed.

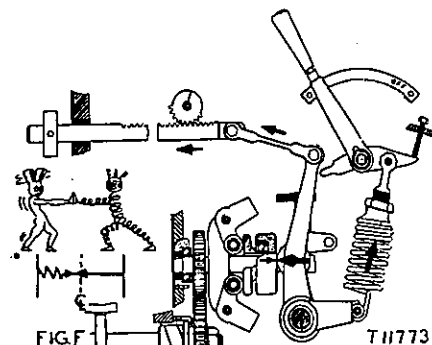


FIG. F.

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### LOAD BEING APPLIED

Fig. F. When the engine is running at high idle speed and a load is applied, the engine speed decreases momentarily, with a corresponding decrease of governor weight force. The governor spring takes immediate advantage of this to move the rack to increase fuel.

## ENGINE UNDER FULL LOAD

Fig. G. A further increase in load results in additional movement of the rack to provide additional fuel. The stop pin (7) is in contact with the torque spring (6) or stop. As long as the load remains constant the fuel remains constant.

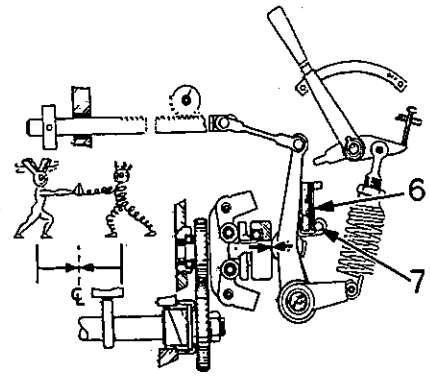


FIG. G.

## ENGINE OVERLOADED

Fig. H. If additional load is imposed, the engine speed will start to drop, reducing the force of the weights, and allowing the governor spring force to compress the torque spring to give a further increase in the amount of fuel being injected.

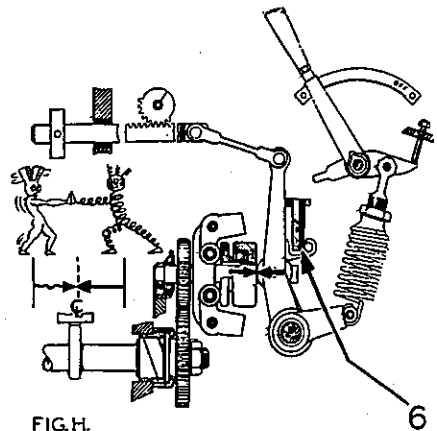


FIG. H.

## HIGH AND LOW IDLE ADJUSTMENTS

Fig. I. When the low idle stop lever (8) is in contact with the spring-loaded stop (9) as illustrated, the engine operates at low idle. The screw assembly (10) controls the low idle setting. When the lever (12) contacts the high idle screw (11) which is also adjustable, the engine operates at the high idle speed.

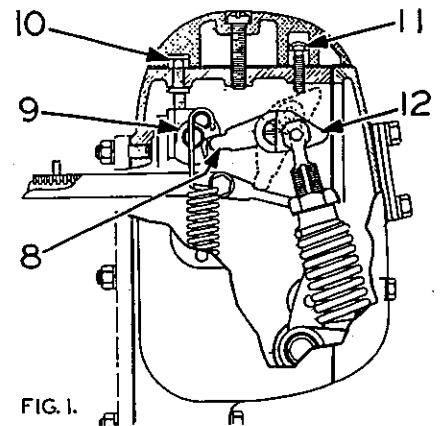


FIG. I.

## GOVERNOR SHUT-OFF POSITION

Fig. J. When the governor control is in the shut-off position, it causes the stop lever (8) to pivot the spring-loaded stop (9) and it will hold the fuel rack in the "fuel off" position.

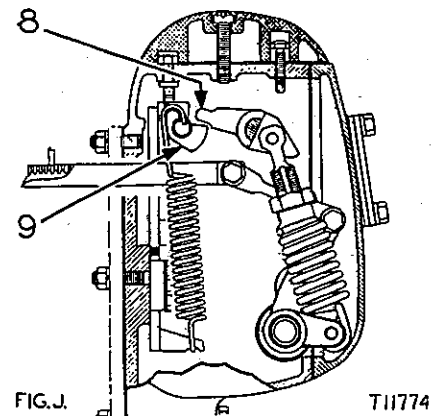


FIG. J.

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## GOVERNOR LUBRICATION (All Models)

The governor for all models is lubricated primarily by a splash system.

The governor and the fuel pump housing assembly (10) have a common lubricating system.

The system can be filled after removing the filler cap located at the side of the fuel pump housing (10) and can be drained by removing the drain plug (11).

The fuel pump camshaft gear (8) is attached to the fuel pump camshaft (12) which is driven by the engine timing gears.

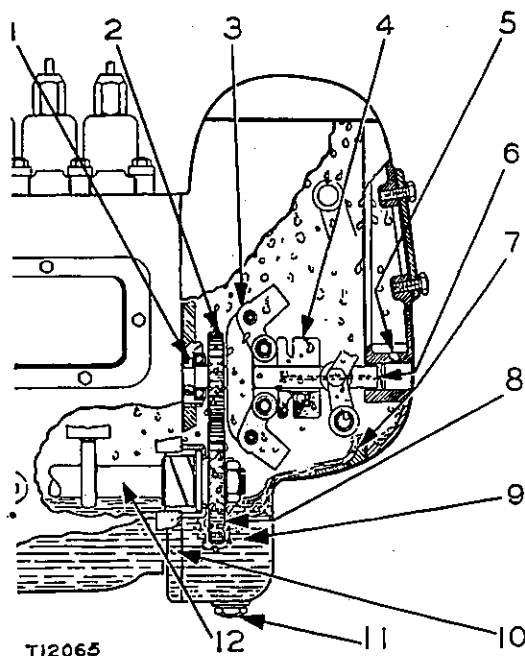
During operation the gear (8) dips into the lubricating oil in the sump (9) of the governor housing (7).

Oil is picked up by the governor gear (2) and is thrown onto the governor weights (3) and to all parts of the governor inside the housing.

Later model governor weights are slotted to supply a larger quantity of lubricant to the bushings in the weights.

A portion of the oil settles into the oil reservoir (5). This reservoir feeds oil into the bushing and into a drilled passage (6) in the spindle and then to the thrust bearing and sliding sleeve (4).

Various other oil holes are drilled in appropriate places to collect oil for lubrication of the remaining working parts of the governor.



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### GOVERNOR LUBRICATION

1-Oil seal. 2-Governor gear. 3-Governor weight. 4-Thrust bearing and sliding sleeve. 5-Oil reservoir. 6-Drilled passage in the spindle. 7-Governor housing. 8-Fuel pump camshaft gear. 9-Sump. 10-Fuel pump housing. 11-Drain plug. 12-Fuel pump camshaft.

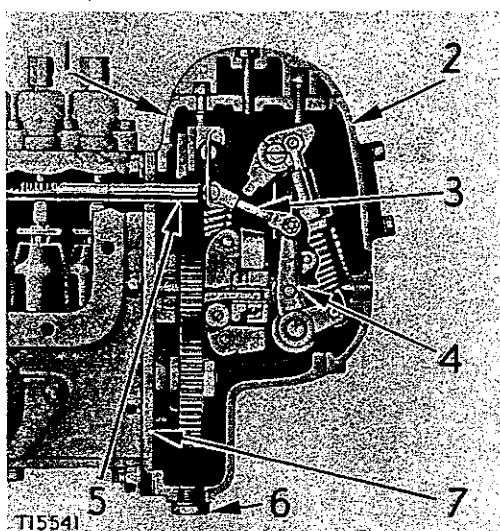
Earlier models used the oil seal (1), because the spindle was drilled from the gear end.

Later models do not use this oil seal.

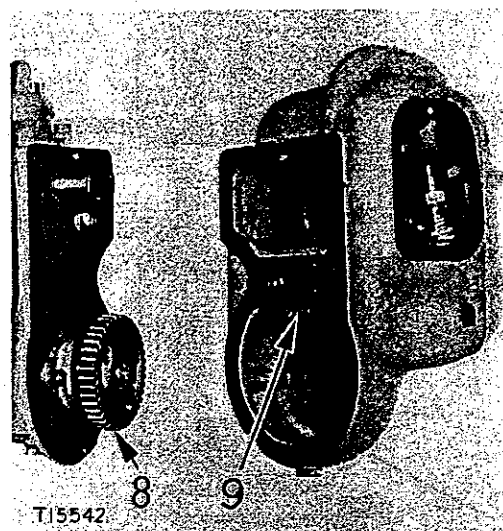
## GOVERNOR REMOVAL AND INSTALLATION (All Models)

The governor (1) can be removed in the following manner:

1. Drain the lubricating oil from the governor by removing drain plug (6). This will also drain the oil from the fuel injection pump housing (7) since they have a common system.
2. Disconnect the governor control linkage.
3. Remove the inspection cover (2).
4. Disconnect the link (3) which serves as a connection between the fuel rack (5) and the terminal lever (4).
5. Remove the series of nuts and capscrews holding the governor housing to the fuel injection pump housing. (One long capscrew goes completely through the governor cover and housing and is threaded into the fuel injection pump housing).
6. Remove the governor.



**PREPARING FOR GOVERNOR REMOVAL**  
1-Governor. 2-Cover. 3-Link. 4-Terminal lever. 5-Fuel rack. 6-Drain plug. 7-Fuel injection pump housing.



**GOVERNOR REMOVED**  
8-Fuel pump camshaft gear.  
9-Governor gear.

## NOTE

The governor and the fuel injection pump housing can be removed as a unit. See the topic, FUEL INJECTION PUMP HOUSING REMOVAL AND INSTALLATION (ALL MODELS).

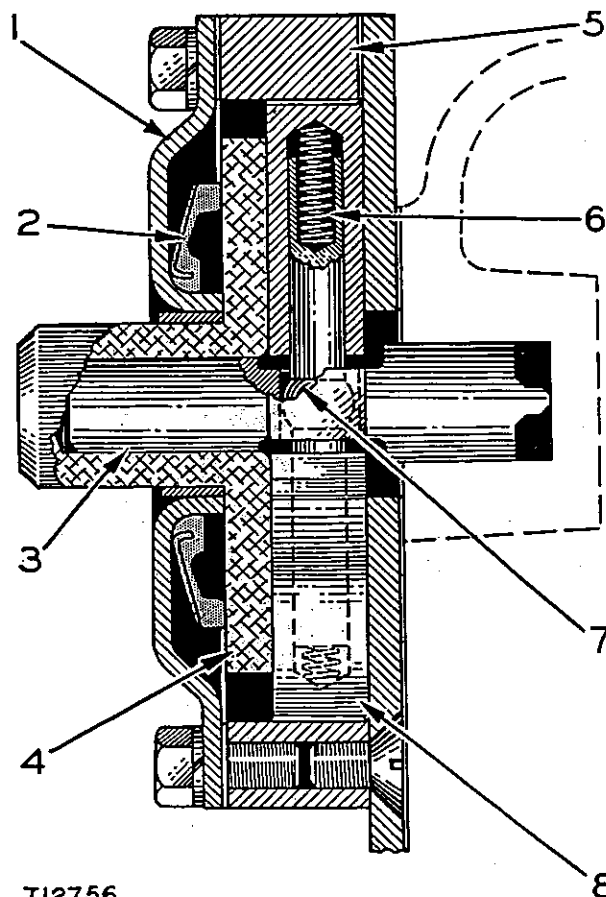
7. Use new gaskets at the time of installation and engage the teeth of the governor gear (9) with the teeth of the fuel pump camshaft gear (8) before tightening down the governor housing.

## GOVERNOR LOCKING CONTROL

### Operation

The governor locking control consists of the following parts: The cover (1), ring (5), seal (2), hub (4), shaft (3), guide (7), springs (6) and the pawls (8).

The hub (4) is rotated by the external control lever. When the hub is rotated in the ring (5), the bosses on the hub apply pressure inward on the pawls (8). This action compresses the springs (6), thus reducing the contact pressure between the serrated ends of the pawls and the serrated inner face of the ring (5), permitting the pawls to travel around the inner surface of the ring.



### GOVERNOR LOCKING CONTROL

- 1-Cover. 2-Seal. 3-Shaft. 4-Hub.  
5-Ring. 6-Spring. 7-Guide.  
8-Pawl.



The rotating motion of the pawls is transferred to the governor mechanism through the guide (7) and the shaft (3).

When the locking control has been moved to the desired position and the hub (4) is no longer being moved, the springs (6) force the pawls (8) out against the serrated inner surface of the ring (5), with sufficient pressure to hold the hub at that position.

Governor action being applied to the shaft (3) tends to pivot the shaft between the pawls, forcing the pawls outward. This increases the contact pressure between the pawls and the serrated inner surface of the ring (5), providing a more positive lock between the ring and the pawls.

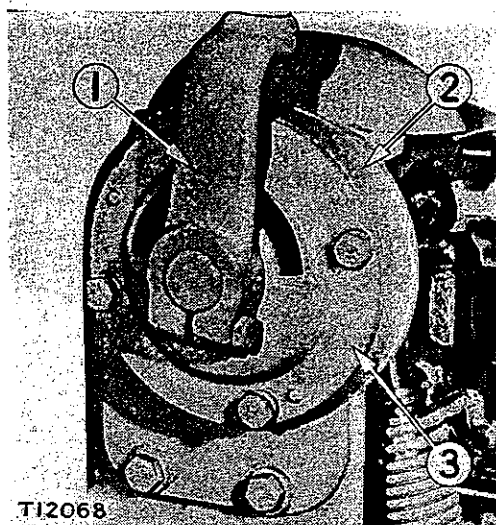
If the governor control lever is moved to a desired position and fails to stay fixed at that position, it is advisable to inspect the serrated surfaces of the pawls and ring for wear.

### GOVERNOR DISASSEMBLY (All Models)

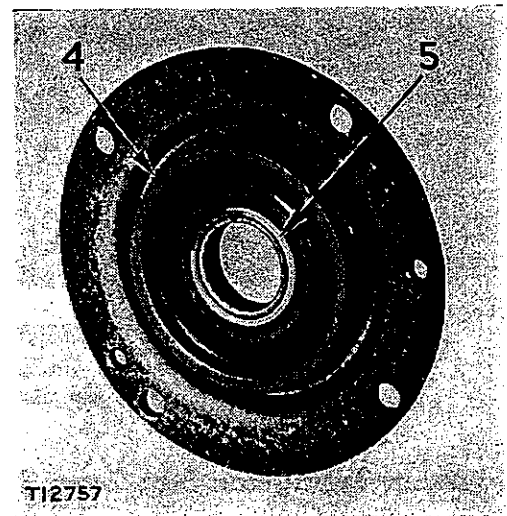
Several parts and assemblies can be removed from the governor, without removing the governor from the engine. However, for extensive disassembly, it is more practical and advisable to remove the governor from the engine first. See the topic, GOVERNOR REMOVAL AND INSTALLATION.

#### Removal and Disassembly

Remove the lever (1).



REMOVING THE CONTROL COVER  
1-Lever. 2-Ring. 3-Cover.



COVER SEAL  
4-Cup-type seal. 5-Projecting  
shoulder on cover.

Take out the capscrews which secure the cover (3) to the ring (2) and remove the cover.

The cover has a cup-type oil seal (4), which fits over the projecting shoulder (5) on the inner surface of the cover.

When the cover is in place on the ring, the seal is held with sufficient pressure against the outer face of the hub (6) to form an oil seal. This prevents oil from escaping through the cover around the shaft (9).

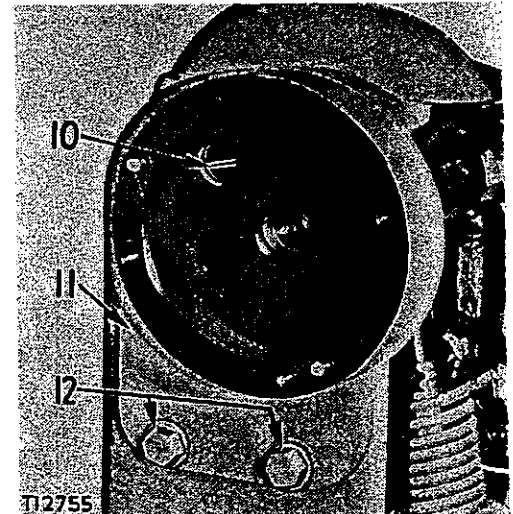
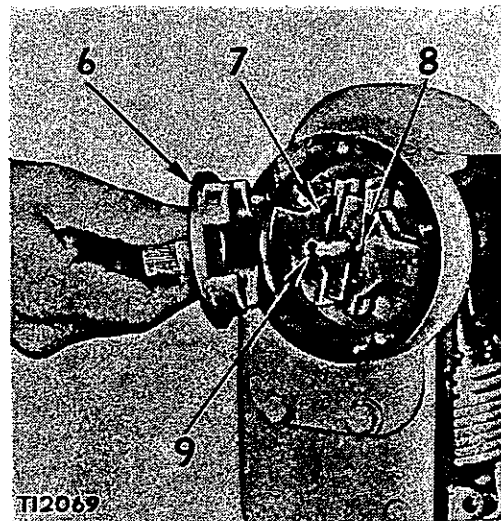
When installing the seal (4) on the projecting shoulder of the cover, coat the shoulder with a good grade of cement, such as Goodrich No. A-178-B, Armstrong No. N-171 or equivalent.

The sealing on earlier models at this point was accomplished by a ring seal fitted into a recess in the cover (3).

Pull the hub (6), pawls (7), shaft (9), guide (8) and the springs (not visible in the illustration) from the ring (2).

Remove the capscrews (12) and the machine screw (10), then pull the side plate (11) and the ring (2) from the governor housing as a unit.

The ring can be separated from the side plate by removing the machine screws at the back of the plate.

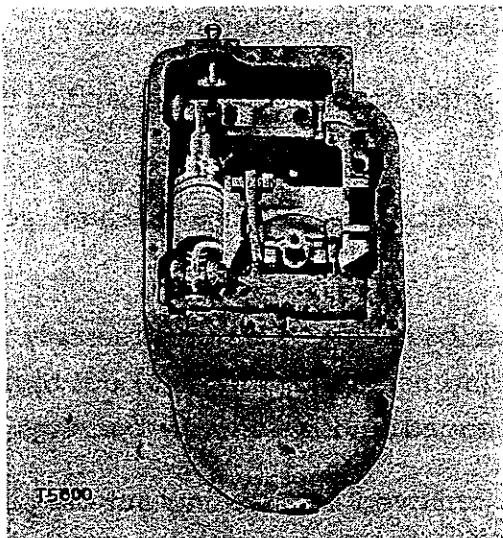


#### REMOVING SIDE PLATE AND RING

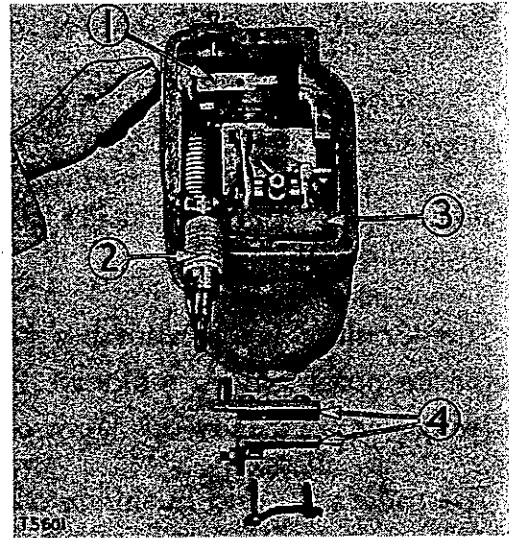
6-Hub. 7-Pawl. 8-Guide. 9-Shaft. 10-Machine screw.  
11-Side plate. 12-Capscrews.

#### Governor Spring and Stop Lever Removal

Remove the rear cover from the governor, which will expose the working parts of the governor. Remove the capscrews holding the low idle stop lever assembly (4) to the shaft (1).



**GOVERNOR REAR COVER REMOVED**



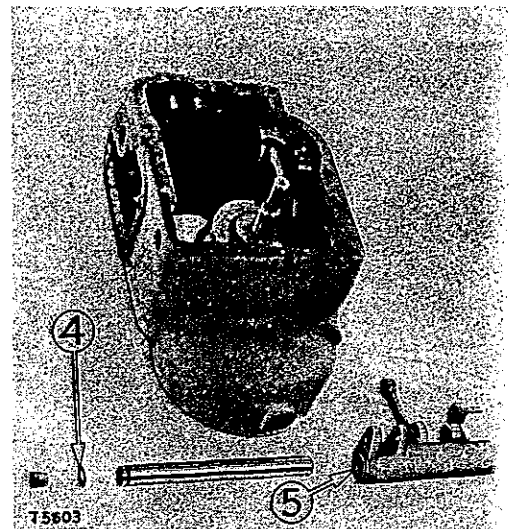
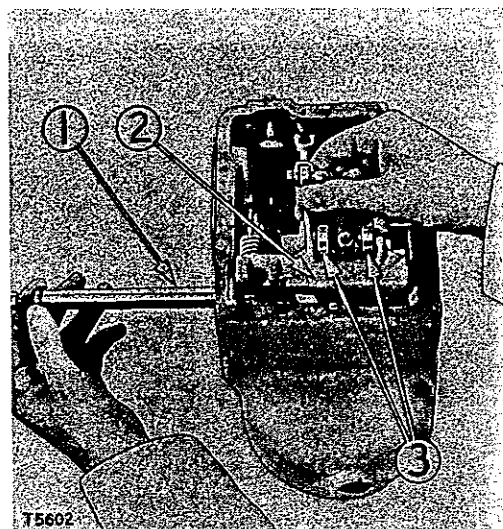
**GOVERNOR SPRING REMOVAL**  
1-Shaft. 2-Spring. 3-Terminal lever assembly. 4-Stop lever assembly.

Remove the lever assembly and shaft from the housing being careful not to lose the spacer located between the upper end of the governor spring (2) and the governor housing.

Take out the capscrew and remove the spring (2) from the terminal lever assembly (3).

### Terminal Lever Removal

Pull the shaft (1) and remove the terminal lever assembly (2). The end of the shaft is drilled and tapped for a 5/16"-18 (NC) capscrew to assist in removal.



**REMOVING TERMINAL LEVER ASSEMBLY**  
1-Shaft. 2-Terminal lever assembly. 3-Rollers. 4-Rubber seal. 5-Needle bearings.

Examine the shaft for wear or roughness and replace if necessary.

This shaft is a free fit in the outside of the housing but a press fit in the engine side of the housing.

Remove the rubber seal (4) from the shaft and replace it when reassembling the unit.

The terminal lever assembly (2) can be serviced as an assembly or separate parts can be replaced. Press the needle bearings (5) out of the lever assembly if they are worn or damaged and install new bearings.

The rollers (3) and bushings can be removed by pressing out the pins with a small diameter punch.

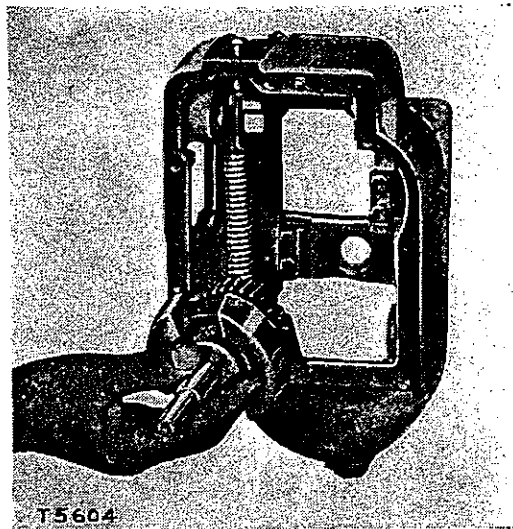
### Governor Spindle Group Removal

After the terminal lever assembly has been removed, the governor spindle group is easily removed from the housing.

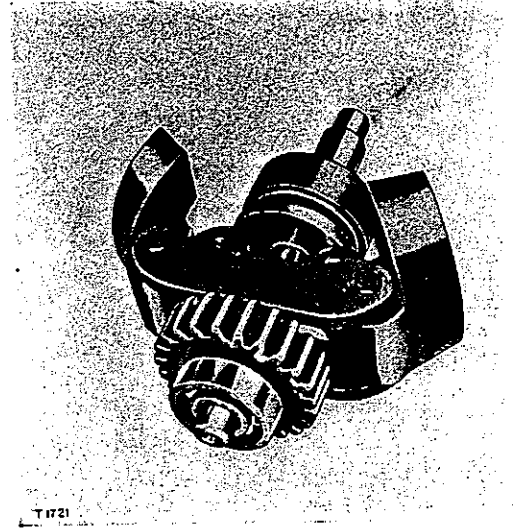
The bearing (1) and gear (2) are removed together, using the 8B7547 Puller.

Slide the sleeve assembly (10) and bearing assembly (11) from the spindle. The sleeve assembly fits in the bearing assembly with a light press fit and can be removed by tapping it lightly.

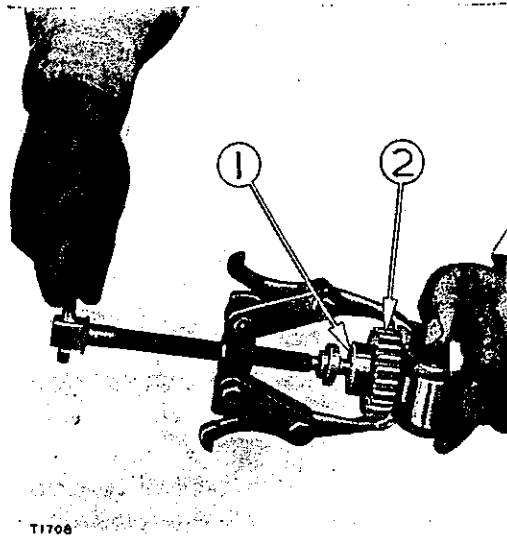
Both the sleeve assembly and the bearing assembly are serviced as separate assemblies.



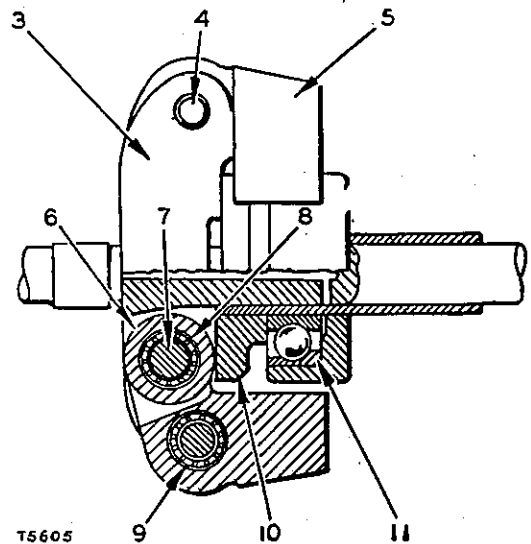
REMOVING SPINDLE GROUP



SPINDLE GROUP



**PULLING GEAR AND BEARING**  
1-Bearing. 2-Gear.



**SPINDLE CROSS SECTION**  
(Earlier model illustrated)

3-Spindle. 4-Pin. 5-Governor weight.  
6-Roller. 7-Pin. 8-Needle bearing.  
9-Needle bearing. 10-Sleeve assembly.  
11-Bearing assembly.

The spindle assembly is made up of the spindle (3), governor weights (5), needle bearings (8) and (9), rollers (6) and pins (4). These parts can be serviced individually or as a unit.

On later D4 and No. 112 governor spindle assemblies, the needle bearings (9) are replaced by bushings. The needle bearings (8) are omitted and the thrust rollers turn directly on the hardened steel pins (7).

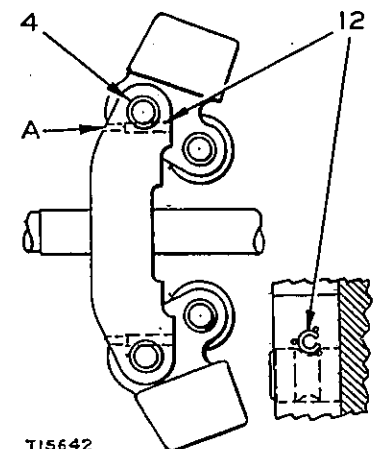
Press the pins (4) and (7) out to replace the bearings and pins.

The needle bearings in the rollers and governor weights can be pressed out using a suitable punch.

On later models, the pins (4) are secured by the roll pins (12). The holes into which the roll pins are installed are counterbored.

**SPINDLE ASSEMBLY (LATER MODEL)**

4-Pin. 12-Roll pin. A-Opening.



To remove the pins, insert a suitable punch into the opening at (A) and drive them out.

When installing the roll pins (12), center punch the spindle in three places around each pin as shown.

### Fuel Injection Pump Stop Removal

A spring-loaded stop arrangement, which has a positive action to hold the governor in the shut-off position, is incorporated. The upper face of the notch in the stop (5) is the low idle stop.

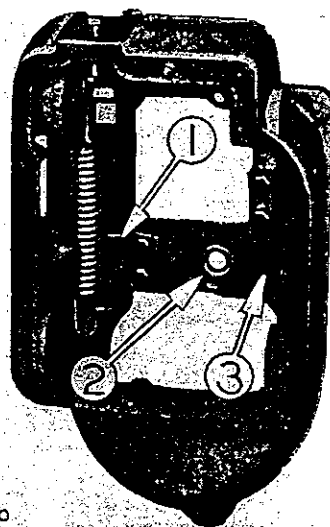
Moving the governor control past the low idle position forces the stop to rotate until the shut-off spring moves over center, at which time the spring tension brings the lower face of the notch against the stop lever with sufficient force to hold the lever and the fuel rack in the shut-off position.

Remove the two capscrews holding the slide retainer (1) to the housing. Unscrew the low idle adjusting screw counting the number of turns required until the assembly is free for removal. This will be helpful at the time of assembly as a primary adjustment.

Remove the spring (7). The stop assembly can then be serviced as a unit or the parts serviced separately.

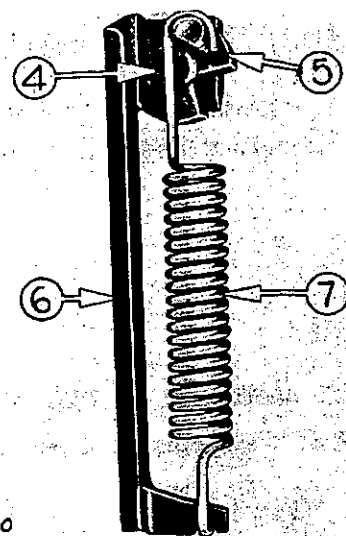
Press out the pin (4) and remove the stop (5) from the slide assembly (6).

The torque spring (3) can be removed by taking out two capscrews.



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**SHUT-OFF REMOVAL**  
1-Slide retainer. 2-Oil seal.  
3-Torque spring.



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**SHUT-OFF ASSEMBLY**  
4-Pin. 5-Stop. 6-Slide assembly.  
7-Spring.

The seal (2) is used on earlier models only.

Do not lose any spacers or shims that are part of the torque spring assembly. These should be kept intact.

### KNIFE EDGE BEARINGS (LATER 3% REGULATING GOVERNOR)

The spindle assembly on later 3% regulating governors is equipped with knife edge bearings to support the governor weights. Each weight has two hardened notches or seats which bear against a hard wedge or knife edge. Centrifugal force keeps the bearing surfaces in contact and the weights pivot through a small arc directly on the knife edge.

The thrust rollers turn directly on hardened steel pins.

#### CAUTION

If the spindle assembly is accidentally dropped, it is possible that the very hard knife edge will be broken or damaged and require replacing.

#### Removing Knife Edge Bearings

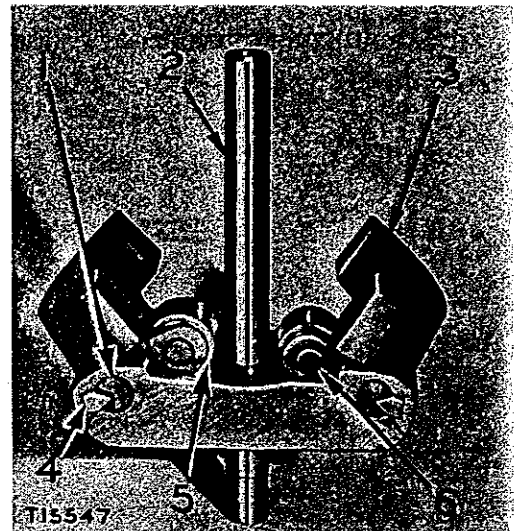
Press the seats (1) from the spindle (2) and the governor weights (3).

Press the knife edges (4) from the spindle.

The thrust rollers (5) can be removed by pressing out the pins (6).

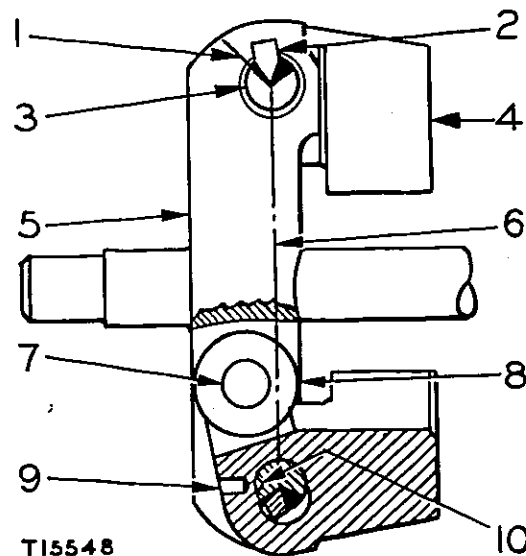
#### REMOVING KNIFE EDGE BEARING

1-Seat. 2-Spindle. 3-Governor weight.  
4-Knife edge. 5-Thrust roller. 6-Pin.



#### Assembling Knife Edge Bearings

Press the pins (7) through the weights (4) and the thrust rollers (8). The rollers must turn freely on the pins.



#### ASSEMBLING KNIFE EDGE BEARINGS

1-Mark. 2-Knife edge. 3-Seat. 4-Governor weight. 5-Spindle. 6-Centerline. 7-Pin. 8-Thrust roller. 9-Stake hole. 10-Pocket.

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When assembling the weight assemblies to the spindle (5), the knife edge (2) must be carefully and completely seated in the slot in the spindle as illustrated, before the seat (3) is pressed into the spindle and weights.

Be sure the pocket (10), which is drilled into the seat is turned toward the stake hole (9) in the governor weight.

Align the seat with the mark (1) as shown; and, with the face of the weights in a plane perpendicular to the centerline (6) of the spindle, press the seats into the spindle and weights.

With a suitable punch, force the remaining metal at the bottom of the stake hole (9) into the pocket (10) in the seat.

#### ASSEMBLING THE GOVERNOR (All Models)

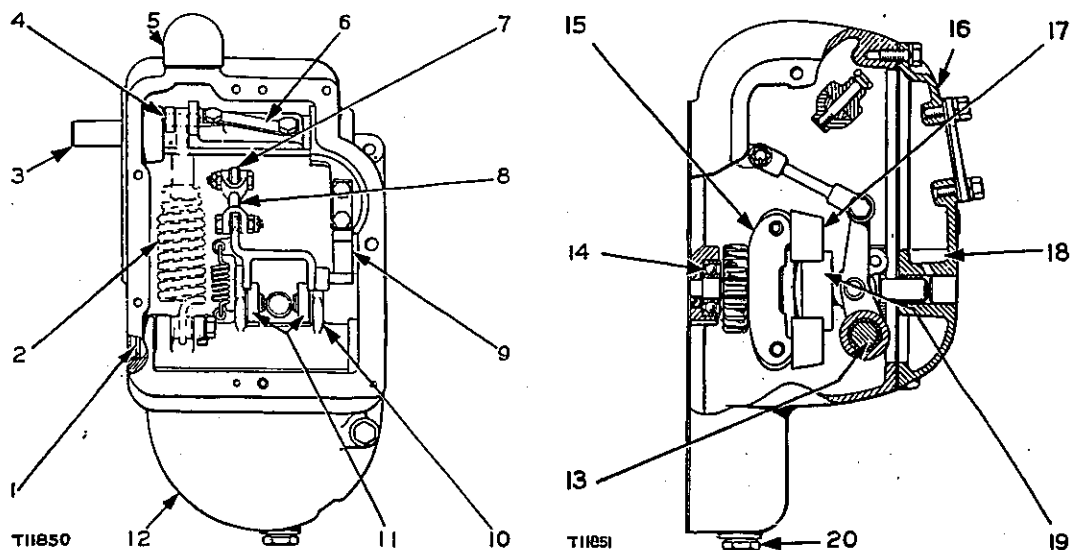
Assemble the governor in the reverse order of disassembly. Replace all seals and gaskets to insure against oil leaks.

All parts which are worn to the extent that motion is lost through the linkage, should be replaced.

#### CAUTION

Make sure that all parts move freely before the governor is put into operation. Make the adjustments given in the topic, GOVERNOR ADJUSTMENTS (ALL MODELS).





### CROSS-SECTION OF GOVERNOR

(All Models)

1-Seal. 2-Governor spring. 3-Stop lever shaft. 4-Spacer. 5-Top cover. 6-Stop lever assembly. 7-Fuel rack. 8-Link. 9-Torque spring assembly. 10-Terminal lever assembly. 11-Rollers. 12-Governor housing. 13-Shaft. 14-Bearing. 15-Spindle assembly. 16-Cover. 17-Governor weight. 18-Oil reservoir. 19-Thrust bearing and sliding sleeve. 20-Drain plug.

### GOVERNOR ADJUSTMENTS

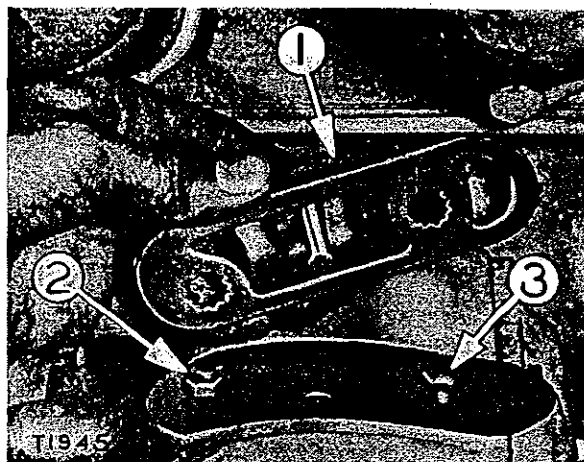
(All Models)

Check the engine speed with a hand tachometer at the tachometer drive, located on the hour meter. If the engine is not equipped with a tachometer drive, one can be obtained and installed on the engine long enough to make the correct governor high and low idle adjustments. The tachometer drive registers actual engine speed.

The low idle and full engine speeds can be adjusted by removing the cover (1) from the top of the governor.

### GOVERNOR ADJUSTMENTS

1-Cover. 2-Low idle adjusting screw. 3-High idle adjusting screw.



Remove the cover and turn the low idle adjusting screw (2) clockwise to decrease the low idle speed or counterclockwise to increase the speed.

Place the governor control lever in the low idle position and check the speed at the tachometer drive. The low idle speed is 550 RPM.

The high idle speed adjustment can be made by turning the high idle adjusting screw (3) clockwise to decrease the speed or counterclockwise to increase the speed. Push the control lever forward and then pull it back and recheck the engine speed.

The proper full load speed will result from the correct high idle speed. After the correct speed is obtained, install the cover making sure the adjusting screws (2) and (3) are seated properly in the cover (1).

When making the governor adjustments with the top cover removed, the adjusting screws may turn because of engine vibration. After an adjustment is made on one or the other adjusting screws, the housing should be prick punched near the screw threads. This will hold the adjusting screw while the second adjustment is made.

## Air Cleaners

### AIR CLEANER AND PRE-CLEANER (All Models)

All models except the D315 Marine Engine use a pre-cleaner (1) and an oil-bath type air cleaner (6).

Air enters the engine through the vanes (2) of the pre-cleaner, which give it a swirling motion, throwing out the heavier particles into the jar (7).

After passing down the inlet pipe (4) to the center oil cup (5), the air is deflected upward through a series of screens, carrying drops of oil up onto the screens (3).

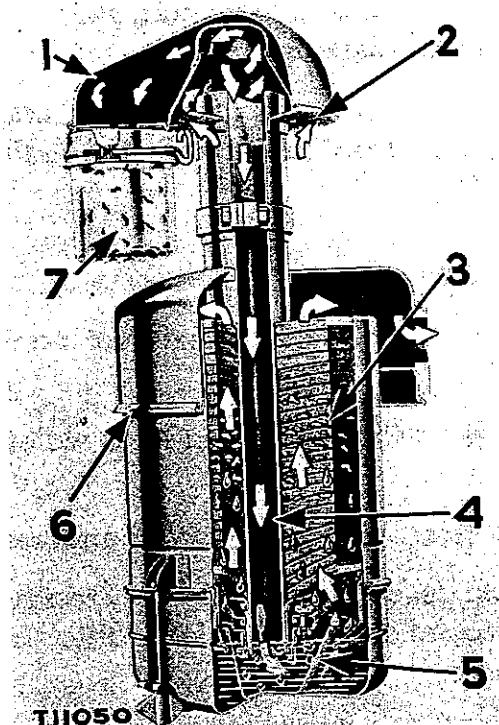
The oil absorbs dirt from the air as it passes through these screens. The screens are sloped so that the air sweeps the dirt-laden oil toward the outside of the cleaner where it falls down into the outside or settling cup.

The oil re-enters the center cup through small holes.

The air inlet pipe can be cleaned without removing the air cleaner.

The lower screens are removable and can be serviced and cleaned, without removing the air cleaner from the engine.

To service the upper or fixed screens, the air cleaner should be removed from the engine.



#### AIR CLEANER

- 1-Pre-cleaner. 2-Vanes. 3-Screens.  
4-Inlet pipe. 5-Center oil cup.  
6-Air cleaner assembly.  
7-Jar.



#### AIR SILENCER (D315M)

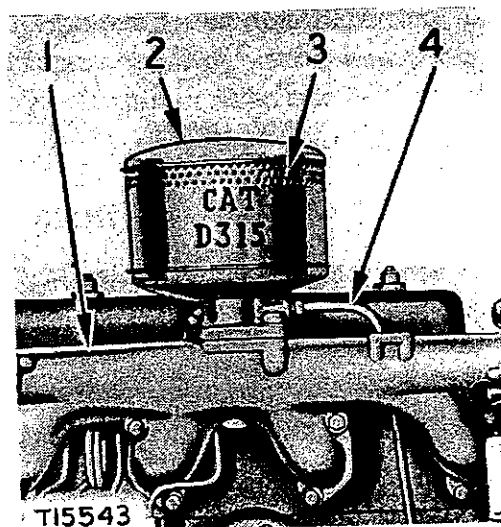
In most cases, the marine engine does not require an oil-bath type air cleaner, as used on other models, since these engines do not usually operate under dusty conditions.

A silencer (2) is used on marine engines as standard equipment.

The inlet holes (3) should be checked occasionally to assure there is no restriction. They can be cleaned after the silencer has been removed.

#### AIR SILENCER

- 1-Inlet manifold. 2-Silencer. 3-Inlet holes.  
4-Fumes disposal tube.



The silencer can be removed by removing the nuts holding it to the inlet manifold (1) and disconnecting the fumes disposal tube (4).

Earlier engines had the fumes disposal tube connected to the inlet manifold, whereas later engines have the disposal tube connected to the silencer.

## Manifolds

All engines are equipped with an inlet manifold and an exhaust manifold.

Two types of exhaust manifolds are used and are referred to as water-cooled and dry manifolds.

The water-cooled manifold is used on heat exchanger-cooled engines.

Cooling for the water-cooled manifold is accomplished by directing the engine coolant through cored passages in the manifold, after the coolant is cooled within the heat exchanger.

The dry manifold is used on radiator-cooled engines.

The exhaust manifold is mounted along the right side of the engine cylinder head.

The inlet manifold is mounted along the left side of the cylinder head.

Later engines have inlet manifolds which have a pipe assembly installed through the center of the manifold, through which the starting engine exhaust gases pass.

The exhaust gases heat the pipe and bellows assembly, which in turn pre-heats the incoming air from the air cleaner, before the air enters the cylinders.

Earlier engines have manifolds which do not contain the pipe and bellows assembly, but which had an air inlet pipe assembly between the inlet manifold and the air cleaner through which the starting engine exhaust gases pass. On these engines the incoming air for the Diesel engine was pre-heated within the air inlet pipe, before reaching the inlet manifold.

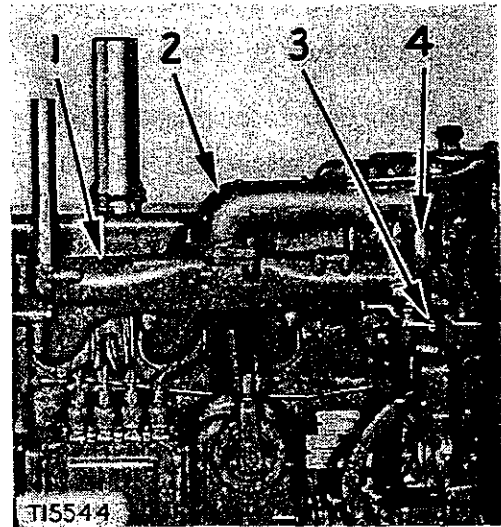
### INLET MANIFOLD

#### Inlet Manifold Removal (Later Models)

1. Disconnect the air inlet pipe (2) at the manifold (1).
2. Loosen the air inlet pipe supporting capscrews at the starting engine end slightly, just enough to permit slight movement of the pipe.
3. Disconnect the starting engine exhaust pipe (4) at the rear end of the manifold.

### REMOVING INLET MANIFOLD (Later Models)

1-Inlet manifold. 2-Air inlet pipe. 3-Compression release control rod. 4-Starting engine exhaust pipe.

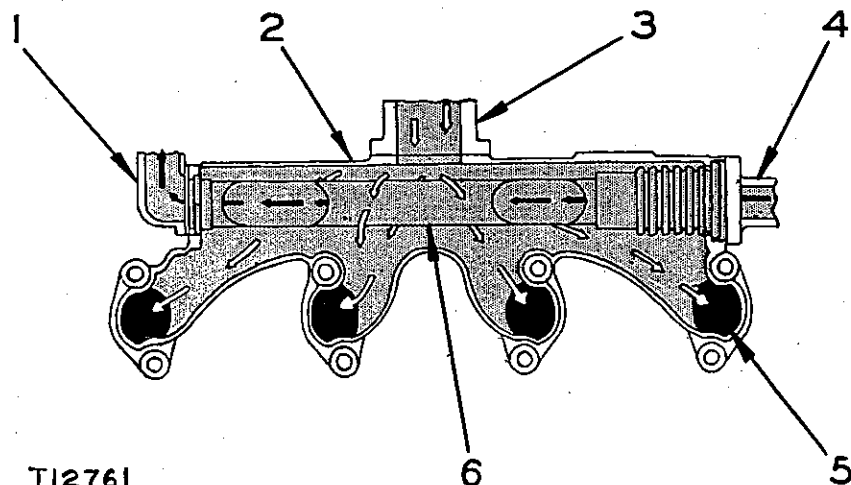


4. Disconnect the compression release control rod at (3).
5. Remove the capscrews which secure the manifold to the cylinder head and remove the manifold. New gaskets should be used at the time of installation.

### Flow of Air and Exhaust Gases through the Inlet Manifold (Later Models)

Starting engine exhaust gases enter the bellows end of the pipe assembly (6) located within the inlet manifold (2), through the starting engine exhaust pipe (4).

The exhaust gases which pass through the pipe assembly (6), heat the pipe assembly and are then expelled through the pipe (1) at the forward end of the manifold.



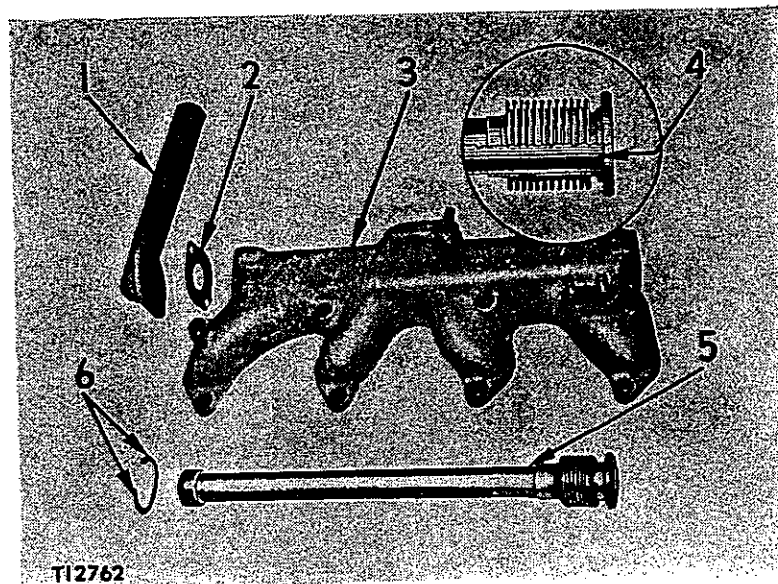
**FLOW OF AIR AND GASES THROUGH THE INLET MANIFOLD**  
1-Pipe. 2-Inlet manifold. 3-Air inlet pipe. 4-Starting engine exhaust pipe.  
5-Air inlet port. 6-Pipe assembly.

The bellows which is a part of the pipe assembly (6) permits the pipe to expand when heated.

Incoming air from the air cleaner for initial starting of the Diesel engine, enters the manifold at the air inlet pipe (3). The air flows around the tube assembly (6) where it is warmed before entering the air inlet ports (5) of the cylinder head.

#### Inlet Manifold Disassembly (Later Models)

1. To remove the pipe assembly (5) from the inlet manifold (3), the manifold must be removed from the engine.
2. Remove the exhaust pipe (1) and gasket (2), at the forward end of the manifold.
3. Observing the manifold from the rear, place a blunt instrument (which will just fit inside the bellows) against the end of the pipe assembly (5) at point (4) shown in inset of illustration.
4. Push the pipe forward in the manifold just enough to permit removal of the retainer rings (6). Never push the tube farther than absolutely necessary, otherwise the bellows will be damaged.
5. After the rings have been removed, pull the tube assembly from the rear end of the manifold.
6. Inspect the condition of the pipe and bellows.



#### REMOVING PIPE AND BELLOWS ASSEMBLY

1-Exhaust pipe. 2-Gasket. 3-Inlet manifold. 4-Point on pipe. 5-Pipe assembly.  
6-Retainer rings.

7. Install the pipe assembly in the reverse order of removal, using the blunt instrument against the end of the pipe to assist in retainer ring installation.

### EXHAUST MANIFOLD (DRY)

The dry-type exhaust manifold is used on all radiator-cooled engines and is mounted along the right side of the engine cylinder head.

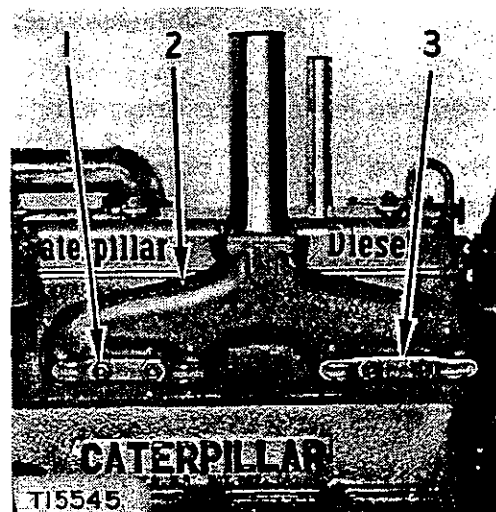
#### Manifold Removal

The exhaust manifold (2) can be removed after removing the nuts (1) and the clamps (3).

New gaskets should be used at time of installation and should be centrally located over the exhaust ports in the cylinder head.

#### REMOVING THE EXHAUST MANIFOLD (DRY)

1-Nut. 2-Exhaust manifold. 3-Clamp.



### EXHAUST MANIFOLD (WATER-COOLED)

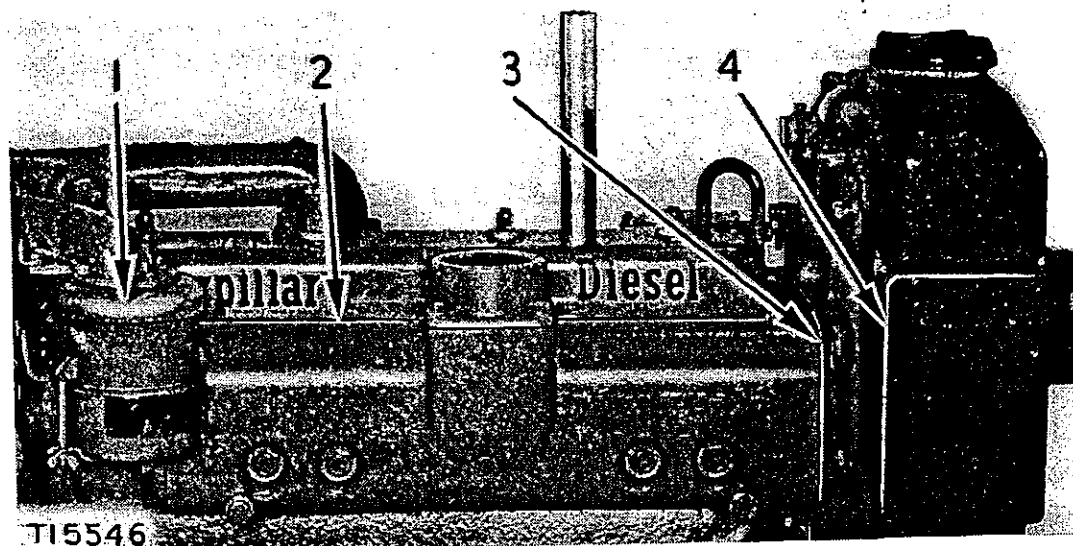
The water-cooled manifold is used on heat exchanger-cooled engines, or on engines equipped with an expansion tank, usually marine installations.

The manifold is mounted along the right side of the cylinder head and receives its coolant from the fresh water cooling system.

The fresh water coolant passes around the integrally cast passages, within the manifold and this cools the Diesel engine exhaust gases as they are expelled.

#### Exhaust Manifold Removal (Water-cooled)

Drain the fresh water coolant from the manifold (2), then remove the nuts holding the manifold to the cylinder head.



#### EXHAUST MANIFOLD REMOVAL (WATER-COOLED)

1-Starting engine air cleaner. 2-Water-cooled exhaust manifold.  
3-Adapter housing. 4-Heat exchanger.

Remove the starting engine air cleaner (1).

Remove the four capscrews connecting the manifold to the adapter housing (3).

#### NOTE

Two of these capscrews are partly hidden from view and they are located between the adapter housing and the heat exchanger (4).

Remove the manifold.

At the time of assembly it would be advisable to start these capscrews first.

### Cylinder Head

(All Models)

A one-piece cylinder head is used on this engine. Copper water directors direct the flow of coolant toward the valve ports and pre-combustion chambers.

Rubber seals and ferrules seal the water passages between the cylinder head and cylinder block.

The inlet and exhaust valves and the valve rocker arm mechanism are a part of the cylinder head and valve mechanism.

Properly adjusted valves will operate for many hours before they need to be reconditioned. Eventually, however, the valve faces and seats may



become pitted which ultimately allows compression pressure losses. Valve leakage can often be heard distinctly in the manifolds.

Worn piston rings, improperly adjusted valves or a damaged cylinder head gasket will result in loss of compression; therefore, these items should be checked before concluding that the valves are at fault.

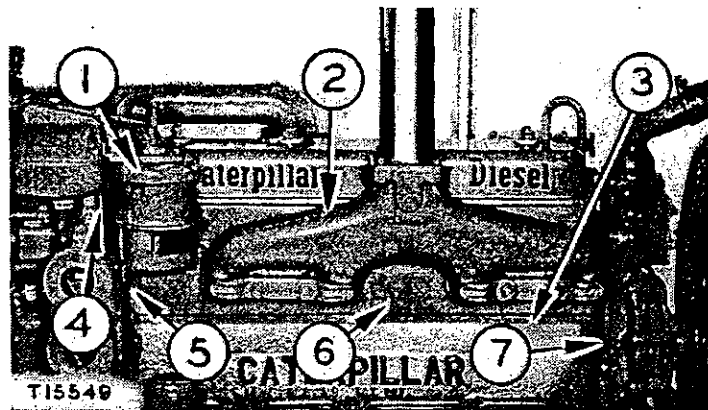
The cylinder head can be removed separately or with the inlet and exhaust manifolds installed.

At the time of removal, if possible it should first be determined what work is to be done and which method of removal is best suited for the work to be done.

Remove or disconnect any parts that are attached to the cylinder head that would restrict its removal or installation. See the topic, CYLINDER HEAD REMOVAL.

### CYLINDER HEAD REMOVAL (All Models)

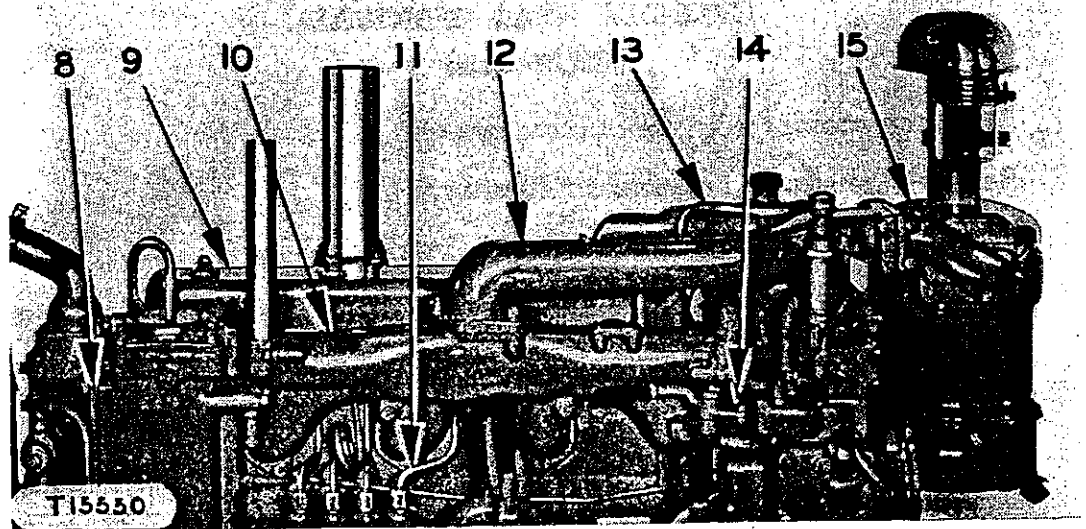
1. Drain the coolant from the cooling system.
2. Remove the starting engine air cleaner (1).
3. Remove the starting engine fuel tank bracket (4).
4. Remove the water elbow which connects the starting engine cooling system to the Diesel head (6).
5. Remove the heat indicator cable (5) from the head.
6. Remove the exhaust manifold (2).
7. Remove the capscrews which secure the regulator housing (7) to the cylinder head.



### CYLINDER HEAD REMOVAL

1-Starting engine air cleaner. 2-Exhaust manifold. 3-Diesel cylinder block. 4-Fuel tank bracket. 5-Heat indicator cable. 6-Cylinder head. 7-Regulator housing.

8. Loosen the capscrews which secure the regulator housing to the Diesel cylinder block (3).
9. Remove the capscrews which secure the fuel filter heater elbow (8) to the regulator housing.
10. Remove the compression release control rod (14).
11. Disconnect the fumes disposal tube (13) at the air inlet pipe (12).
12. Remove the air inlet pipe (12) and air cleaner (15) as a unit.
13. Remove the air inlet manifold (10).
14. Remove the valve cover (9).
15. Remove the fuel injection lines (11). Install plugs at the ends of the lines and cap the openings to the pumps and valves.



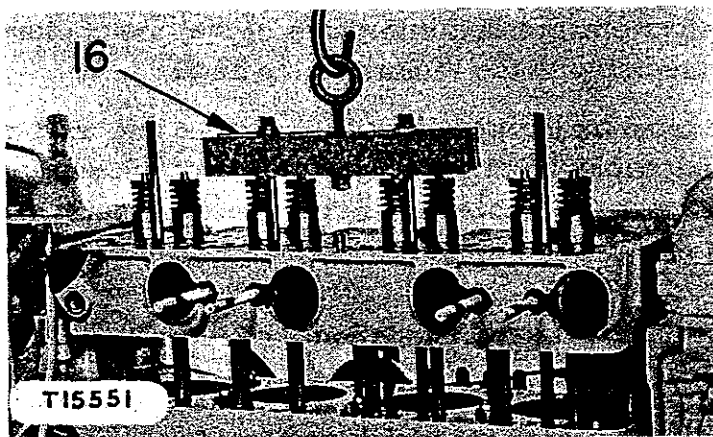
#### CYLINDER HEAD REMOVAL

- 8-Elbow. 9-Valve cover. 10-Inlet manifold. 11-Fuel lines. 12-Air inlet pipe. 13-Tube.  
14-Compression release control rod. 15-Air cleaner.

16. Remove the valve rocker assembly. See the topic, VALVE ROCKER-ARM REMOVAL (ALL MODELS).
17. Remove the push rods.
18. Remove all the nuts and washers which hold the head to the cylinder block.

#### NOTE

The cylinder head can be removed by using the cross-bar (16), which is part of the 8B7548 Push Puller, with washers, nuts and a suitable eye-bolt, as illustrated.



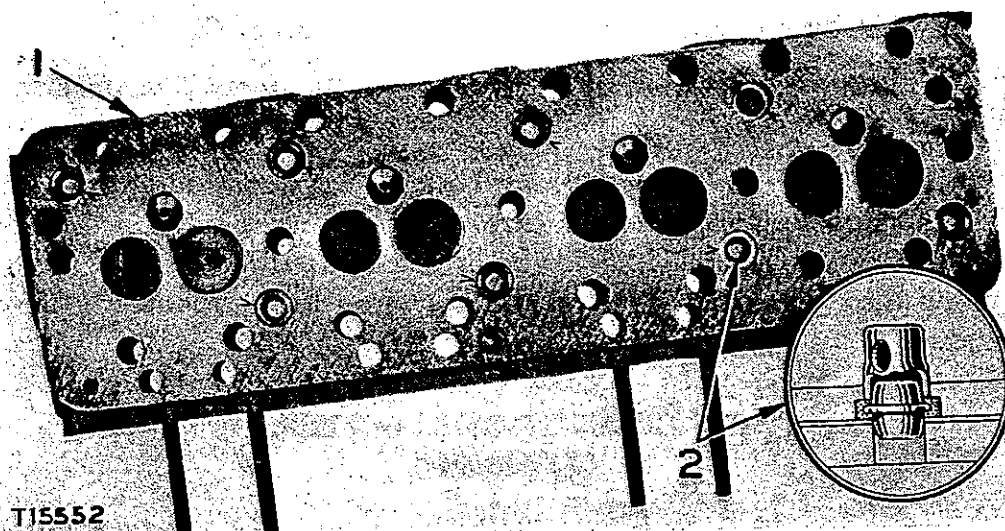
**CYLINDER HEAD REMOVAL**  
16-Cross-bar.

19. With a pry bar positioned so not to damage the head, pry the head up and away from the cylinder block, as a final check to see that everything has been disconnected, before lifting off the head.
20. Using a suitable hoist, remove the head and place it on a clean work bench.

### **WATER DIRECTORS, SEALS AND FERRULES** (All Models)

There are eight water directors (2) pressed into the head (1) to direct the flow of coolant to certain points.

On the inlet side, coolant is directed toward the pre-combustion chambers; and on the exhaust side, toward the exhaust valve ports, as indicated by the V-marks.



**WATER DIRECTORS**  
1-Cylinder head. 2-Water director.

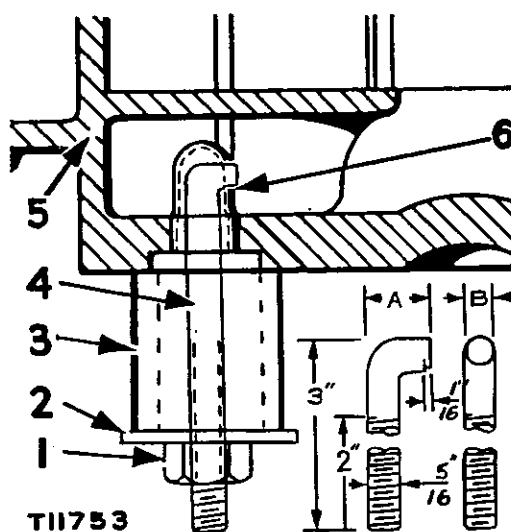
Water directors are pressed into place in the heads after aligning the notch on the director with the V-mark on the head.

The rubber seals and copper ferrules between the head and top of the block are replaceable. Coat the inner surface of the seal with soap and place the groove in the rubber seal over the ridge on the ferrule before installing.

### Water Director Removal and Installation

The water directors can be removed from the cylinder head (5) as follows, using a tool similar to the tool illustrated.

1. Place the hook end of the rod (4) into the water director discharge hole (6).



#### WATER DIRECTOR REMOVAL

A-Inside diameter of water director plus  $\frac{1}{16}$ ". B-Director water discharge hole diameter minus approximately  $\frac{1}{32}$ ". 1-Nut. 2-Flat washer. 3-Spacer. 4-Rod. 5-Cylinder head. 6-Water discharge hole.

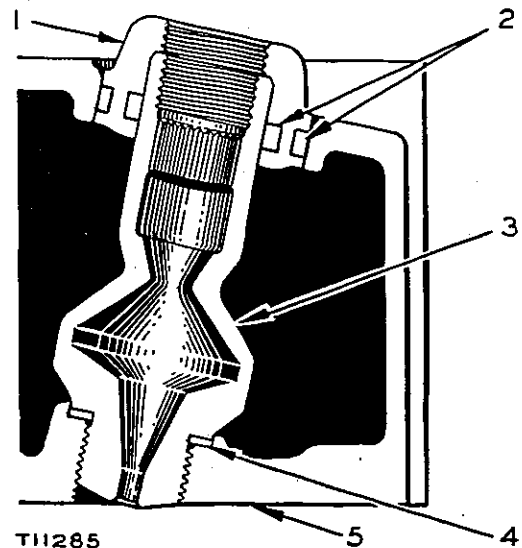
2. Place a piece of  $\frac{3}{4}$ " pipe approximately  $1\frac{1}{2}$ " long as a spacer (3) between the cylinder head (5) and the flat washer (2).
3. Install and tighten the nut (1) to remove the water director from the head.
4. To install the water directors in the cylinder head, align the notches in the directors with the V-marks stamped on the cylinder head and with a suitable tool either drive or press the directors into the head, until they are flush with the counterbored face around the director holes.

### PRE-COMBUSTION CHAMBERS (All Models)

The pre-combustion chamber (3) is threaded and screwed into the cylinder head (5) and sealed in place with a retainer (1) in which rubber ring-type seals (2) are used.

### PRE-COMBUSTION CHAMBER

1-Retainer. 2-Rubber seals. 3-Pre-combustion chamber. 4-Gasket. 5-Cylinder head.



The rubber seals prevent the leakage of coolant past the retainer.

The gasket (4) prevents combustion gases from entering the cooling system as well as preventing the leakage of coolant into the cylinder.

For installing pre-combustion chambers equipped with glow plugs see the topic, REMOVAL AND INSTALLATION OF PRE-COMBUSTION CHAMBERS EQUIPPED WITH GLOW PLUGS.

### Pre-combustion Chamber Removal and Installation (All Models)

The 5F9217 Tool Group is available for removal and installation of the pre-combustion chambers. After removing the fuel injection valve assembly, remove the retainer (3) in the following manner:

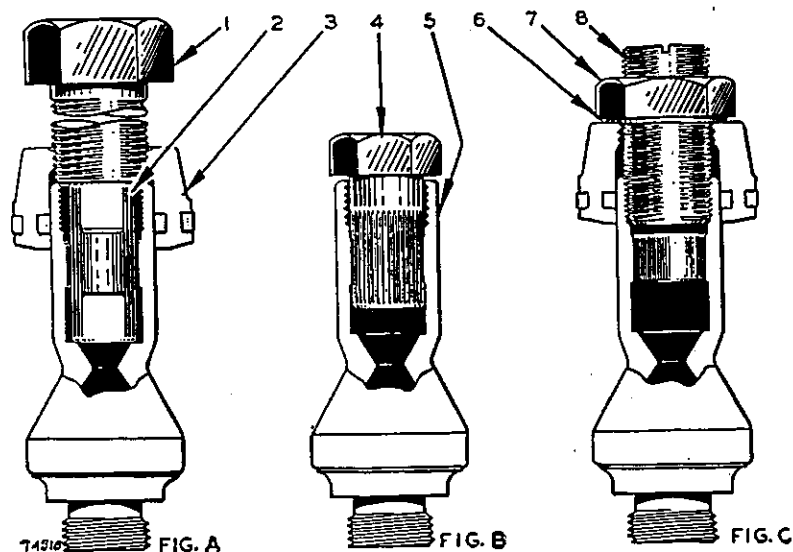
Place the 5F9072 Spacer (2) in the pre-combustion chamber and turn the 1A2208 Screw (1) in the retainer (3) and against the spacer until the retainer comes out of the cylinder head. See Fig. A.

The pre-combustion chamber (5) is then removed by placing the 5F8353 Wrench Adapter (4) in the serrations of the pre-combustion chamber and turning it out of the cylinder head in a counterclockwise rotation, see Fig. B.

If the pre-combustion chamber has been removed while the cylinder head is removed from the engine, clean out the water jacket of the head thoroughly.

If the pre-combustion chamber is removed while the cylinder head is still on the engine, carefully clean the water jacket of the head so as not to drop anything into the cylinder.

This can be done by using a long screw driver with a coating of heavy grease. The dirt will adhere to the grease and can be removed out through the pre-combustion chamber bore at the top of the head.



#### PRE-COMBUSTION CHAMBER TOOLS

1-1A2208 Screw. 2-5F9072 Spacer. 3-Retainer. 4-5F8353 Wrench Adapter. 5-Pre-combustion chamber. 6-4B4285 Washer. 7-L1017 Nut. 8-6F5515 Screw.

If a cylinder head has collected an excessive amount of scale or rust within the water jacket, remove the cylinder head and clean it thoroughly. This is also an indication that the entire cooling system should be cleaned. See the covering topic.

Use a new gasket, coat it with a thin layer of grease on the bottom side of the gasket and place the gasket into the gasket seat bore of the cylinder head. The grease will help retain the gasket in place while installing the pre-combustion chamber.

Insert the pre-combustion chamber in the cylinder head and tighten with the 5F8353 Wrench Adapter (4) to 200 pound feet.

Coat the chamfered portion of the cylinder head and the new rubber seals with soap.

Place the retainer over the pre-combustion chamber and start it into the cylinder head and on the pre-combustion chamber. Using the 4B4285 Washer (6), the 6F5515 Screw (8) and the L1017 Nut (7) as illustrated in Fig. C, turn the nut clockwise until the retainer bottoms.

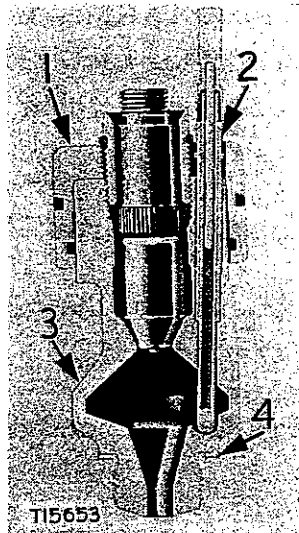
#### Removal and Installation of Pre-combustion Chambers Equipped with Glow Plugs

Disconnect the electrical leads to the glow plugs (2).

Remove the glow plugs.

#### NOTE

The pre-combustion chambers (3) and the gasket (4) must be marked so that they can be installed in their original locations unless new gaskets are to be installed.



### PRE-COMBUSTION CHAMBER EQUIPPED WITH GLOW PLUG

1-Retainer. 2-Glow plug. 3-Pre-combustion  
chamber. 4-Gasket.

Remove the retainers (1) and pre-combustion chambers as explained in the topic, "PRE-COMBUSTION CHAMBER REMOVAL AND INSTALLATION" (All Models).

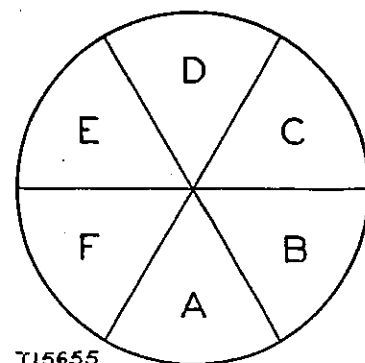
The gasket (4) is supplied in six different thicknesses which are marked "A" thru "F". With the proper thickness gasket and the recommended torque of 200 pound feet to tighten the pre-combustion chambers into the head, the glow plugs and the electrical connections will be positioned clear of the fuel lines or other points of interference.

The following chart can be used to properly position the pre-combustion chambers, if new gaskets are installed.

The segment (A) of the circle is the position on which the glow plug will clear any points of interference, when installed in the pre-combustion chamber.

Install the pre-combustion chamber, using one of the gaskets marked for the segment (A) and tighten to a torque of 200 pound feet.

PRECOMBUSTION CHAMBER  
POSITIONING CHART  
A thru F-Segments.



TI5655

If the glow plug opening is not within the segment (A), note the segment on the chart that corresponds to the position of the glow plug opening. For instruction purpose, assume that the opening is within the segment (D).

Remove the pre-combustion chamber and discard the gasket "A".

Select a gasket that is marked for the segment that the glow plug opening stopped within (In this case select a gasket marked D).

Using this gasket, reinstall the pre-combustion chamber and tighten to 200 pound feet torque.

The glow plug opening will now be within the segment (A).

The retainer is installed as described in the topic, "PRE-COMBUSTION CHAMBER REMOVAL AND INSTALLATION" (All Models) except that a 2H4649 Guide Screw is inserted into the recess for the glow plug in the pre-combustion chamber. This will correctly position the retainer over the hole for the glow plug.

Install the glow plugs and tighten to 10 to 12 pound feet torque.

## CYLINDER HEAD INSTALLATION

(All Models)

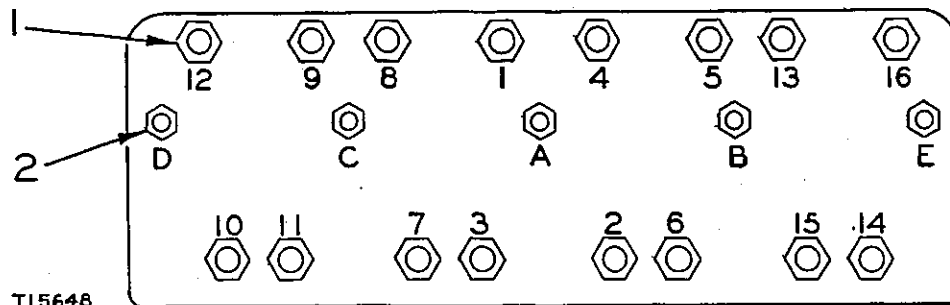
A cylinder head gasket can be used more than once if it is not damaged. If the gasket shows cracks or blow-by marks, a new gasket should be installed.

Install the head gasket, the ferrules and new rubber seals. There are eight large and two small ferrules and seals to transmit the coolant from the cylinder block to the head. There is also one small ferrule and seal located on the lifter side, which transmits oil from the block to the rocker arm assembly.

When installing the head on the cylinder block, see that the ferrules and rubber seals start properly in the head. Rock the head gently until it seats flat on the head gasket.

Install the cylinder head and the hold-down nuts (1) and (2) and tighten. See the topic, SPECIFICATIONS.





#### CYLINDER HEAD NUT TIGHTENING PROCEDURE

1- $\frac{5}{8}$ " nut. 2- $\frac{1}{2}$ " nut.

Install the push rods and valve rocker arm mechanism. Securely tighten the nuts which hold the valve rocker arm mechanism in place. Set the valve clearances to .010" hot.

### Valves and Valve Mechanism (All Models)

The valves (7), which operate in valve bushings (5), admit and release the air and gases to and from the cylinders.

This engine is of the four-stroke cycle, having four separate strokes required for each cylinder to complete one cycle.

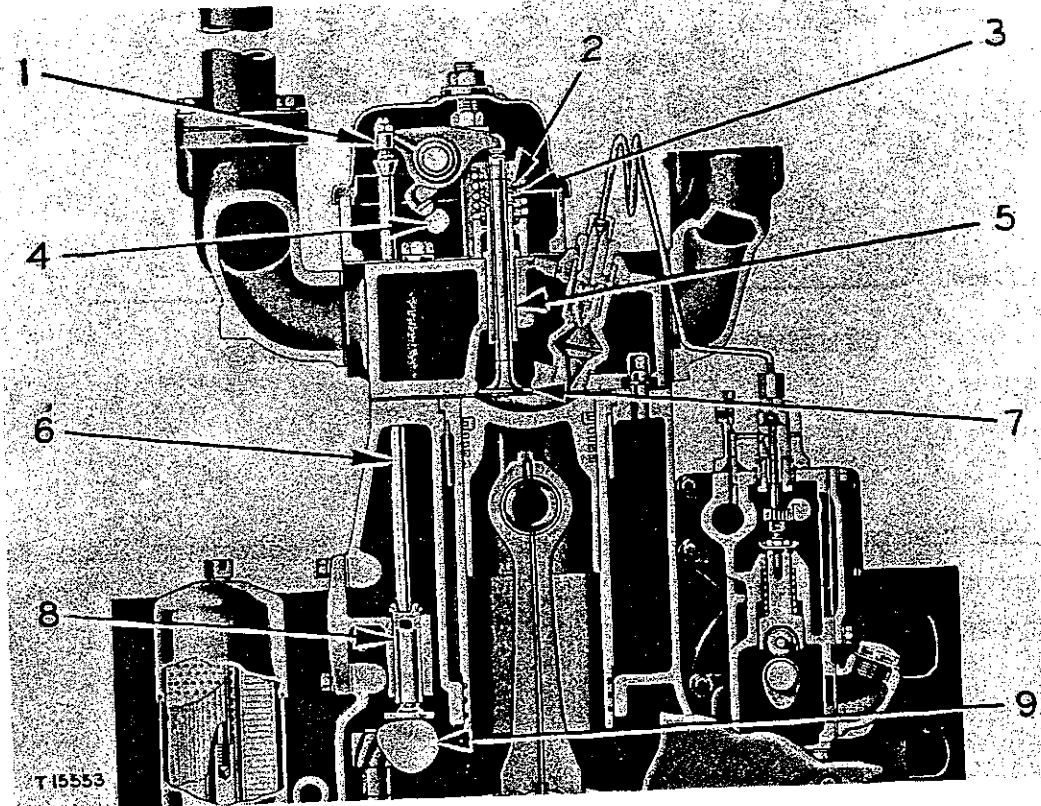
The camshaft (9) is timed to the crankshaft by the engine timing gears and turns one-half crankshaft speed. See the topic, TIMING GEARS AND TIMING MARKS (ALL MODELS).

The operation of the valves and the valve mechanism is as follows.

The compression release for starting is accomplished by a lever-operated cam (4) which contacts the inlet valve rocker arm (1) and holds the valve open. A spring-loaded plunger holds the cam in the "start" or "run" position.

When the compression release mechanism is positioned to "run", the inlet valves are permitted to seat in the head, thus permitting compression to build up within the cylinder.

As the camshaft turns in time with the crankshaft, the camshaft operates the valve lifters (8), which in turn move the push rods (6) upward at the correct time.



#### VALVE MECHANISM

1-Rocker arm. 2-Valve inner spring. 3-Valve outer spring. 4-Compression release cam. 5-Valve bushing (earlier type). 6-Push rod. 7-Valve. 8-Valve lifter (earlier type). 9-Engine camshaft.

The push rods and the rocker arms open the inlet and exhaust valves and the valve springs (2) and (3) close the valves as the valve lifters come in contact with the base circle of the camshaft.

#### INLET STROKE

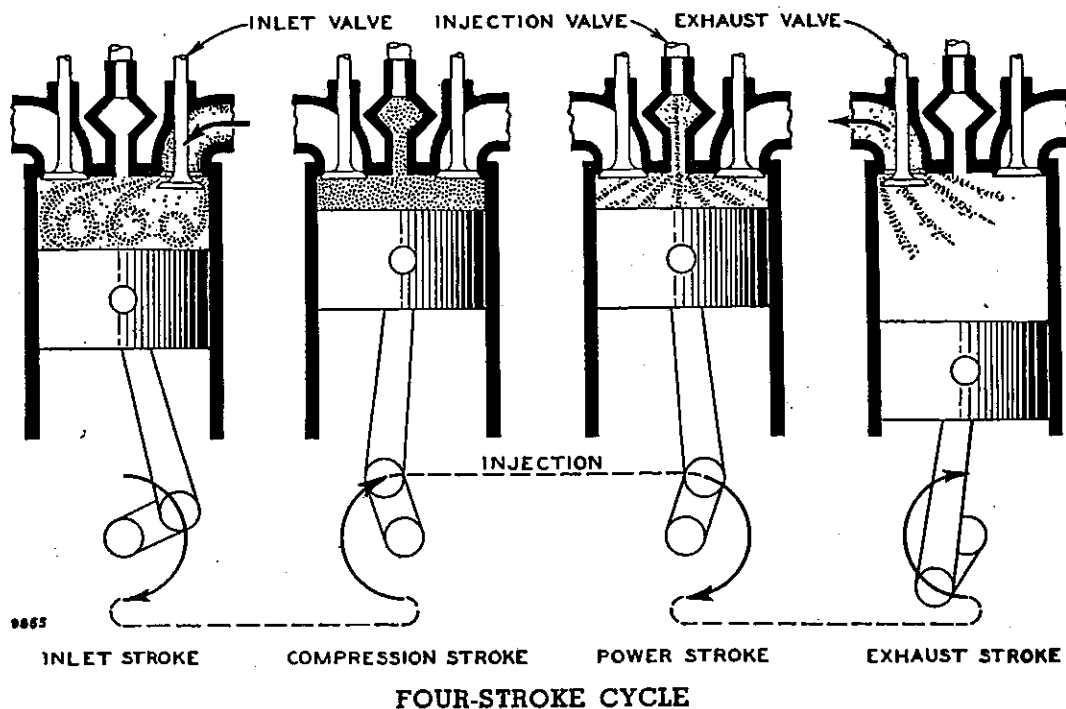
The inlet valve opens when the crankshaft is ahead of its top center position. The valve remains open until the crankshaft is past its bottom center position. As the piston moves downward air is drawn into the cylinder.

#### COMPRESSION STROKE

As the piston moves upward, the trapped air becomes greatly heated. At a specified point before the crankshaft is again at its top center position, fuel is injected into the cylinder and ignited by the heat of air compression.

#### POWER STROKE

The combustion of fuel creates a greatly increased pressure above that of compression which moves the piston downward for the power stroke. The engine firing order is 1-3-4-2 and the crankshaft turns in a counterclockwise rotation when facing the flywheel.



### EXHAUST STROKE

The exhaust valve opens before the crankshaft reaches its bottom center position, allowing the exhaust gases to be expelled on the exhaust stroke. The exhaust valve closes after the crankshaft reaches its top center position. The cycle is now completed.

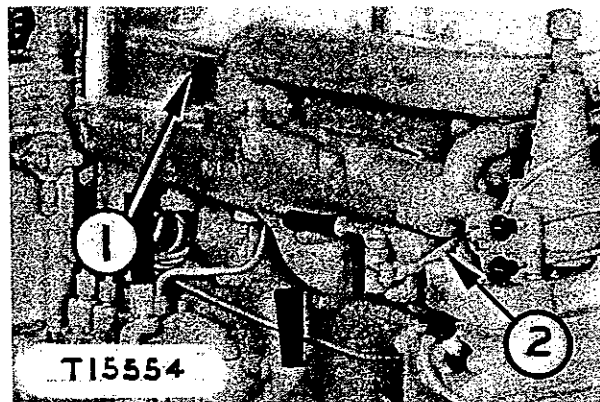
For the proper method of checking valve timing, see the topic, CHECKING VALVE TIMING (ALL MODELS).

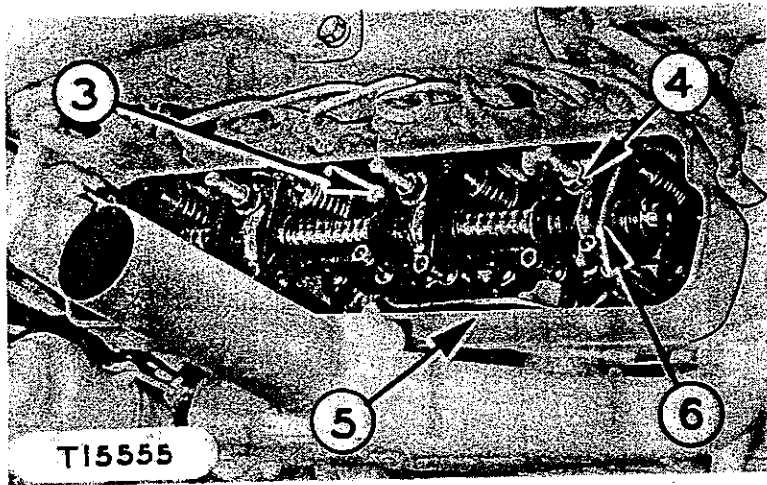
### REMOVING ROCKER ARM ASSEMBLY AND VALVE COVER BASE

1. Remove the valve cover (1).
2. Disconnect the inner end of the compression release control rod (2).

#### REMOVING VALVE COVER

1-Valve cover. 2-Compression release control rod.

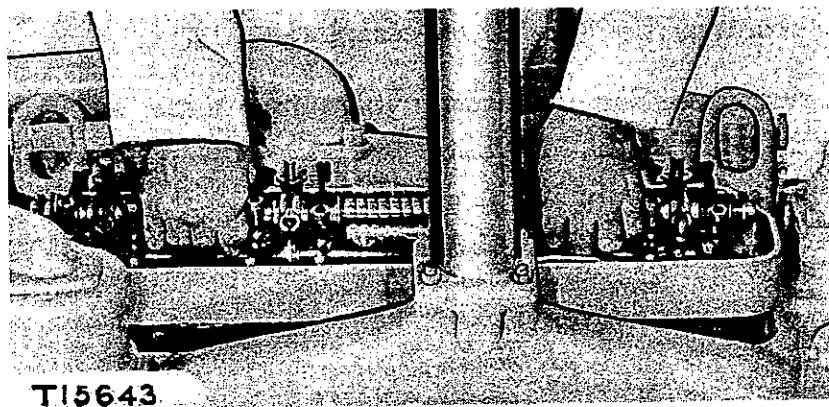




#### PREPARING FOR REMOVAL OF VALVE COVER BASE AND ROCKER ARM ASSEMBLY

3-Capscrew. 4-Nut. 5-Valve cover base. 6-Rocker arm assembly.

3. Disconnect the oil supply tube at the head.
4. Remove the capscrews (3) and the nuts (4) which hold the valve cover base (5) and the rocker arm assembly (6) to the cylinder head.
5. Lift the valve cover base and rocker arm assembly from the engine as a unit as illustrated.



#### LIFTING VALVE COVER BASE AND ROCKER ARM ASSEMBLY FROM ENGINE

#### VALVE ROCKER ARM AND BRACKET REMOVAL AND INSTALLATION

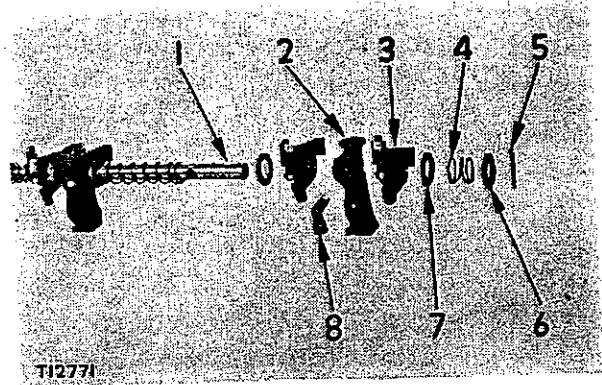
Remove the compression release shaft. See the topic, COMPRESSION RELEASE MECHANISM.

Lift the rocker arm assembly from the valve cover base.

Remove the oil line fitting (8) from the bracket (2) and shaft (1).

### REMOVING ROCKER ARM AND BRACKET

- 1-Shaft. 2-Bracket. 3-Rocker arm.  
4-Spring. 5-Cotter pin. 6-Washer.  
7-Washer. 8-Fitting.



Remove the cotter pin (5), then pull the washer (6), spring (4), washer (7), rocker arm (3) and the bracket (2) off the shaft (1).

When installing the rocker arms, brackets and other parts on the shaft (1), be certain the rocker arms which are equipped with compression release cam contact buttons, are placed on the shaft so they will operate the inlet valves.

This is important, otherwise the compression release mechanism will not operate as it should.

Install all parts in the reverse order of disassembly.

### COMPRESSION RELEASE MECHANISM (All Models)

The compression release opens the inlet valves for all cylinders allowing the Diesel engine to be easily cranked.

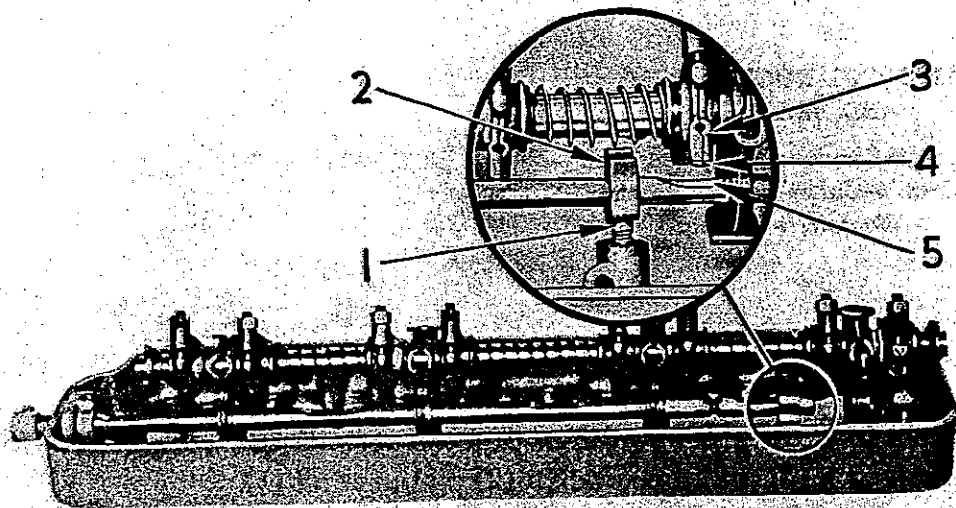
The compression release shaft is locked in the "RUN" and "START" positions by a spring-loaded plunger (1), which engages in a cam (2) on the shaft. Each inlet valve rocker arm is fitted with a button (4) which rides on the shaft.

When the compression release is in the "RUN" position, flat sections (5) on the shaft allow normal operation of the inlet valves.

When the shaft is turned to the "START" position, the high portions of the shaft contact the inlet valve rocker arm buttons and hold them open. The normal clearance between the inlet valve rocker arm button and flat of the shaft is about .125".

Remove the capscrew holding the compression release lock cam (2) and move the lock cam off the key.

Remove the key from the shaft and the retaining screw from the lever end of the cover base. The shaft will now slide out. Care should be taken not to damage the lip-type seal at the lever end of the valve cover base. This seal is installed with the lip inward.



TI2770

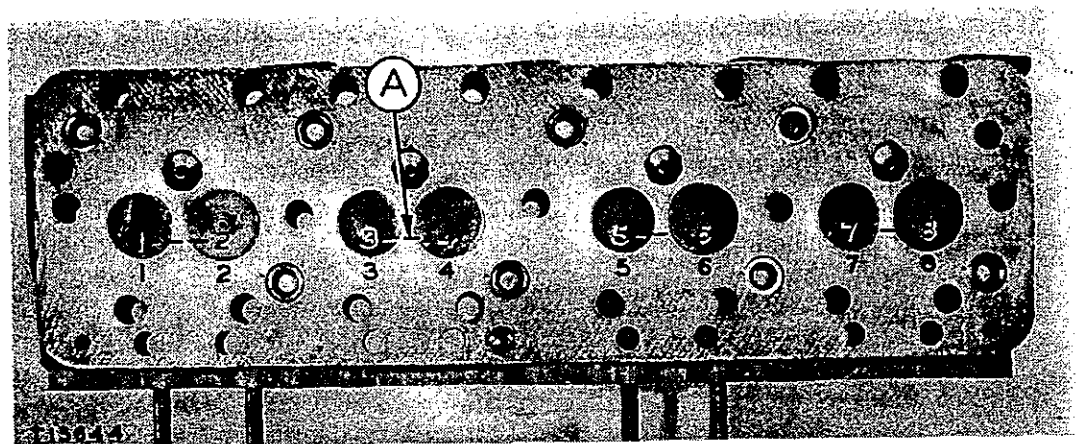
#### COMPRESSION RELEASE MECHANISM

1-Plunger. 2-Cam. 3-Inlet valve rocker arm. 4-Button. 5-Flat section on shaft.

#### INLET AND EXHAUST VALVE REMOVAL AND INSTALLATION (All Models)

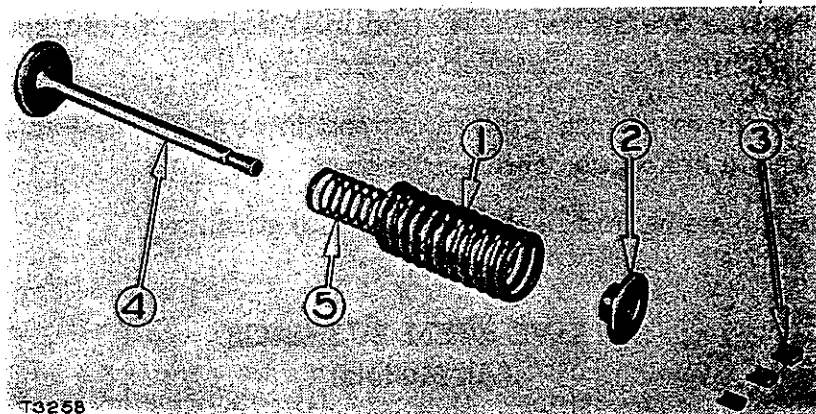
Two springs are used on each valve. The smaller or inner spring (5) prevents a valve (4) from dropping onto the piston should the heavier spring (1) break. Valves are held in the cylinder head by a retainer (2) and locks (3).

Intermediate and later engines have shorter, stiffer valve springs which provide longer service life for the valves and valve seats. A spacer (9) is used below the shorter valve spring and a different retainer is required. Later engines have the spacer and bushing integral.



#### IDENTIFICATION MARKS

A-Chalk marks used for identification and location of valves.



#### VALVE GROUP (EARLIER ENGINES)

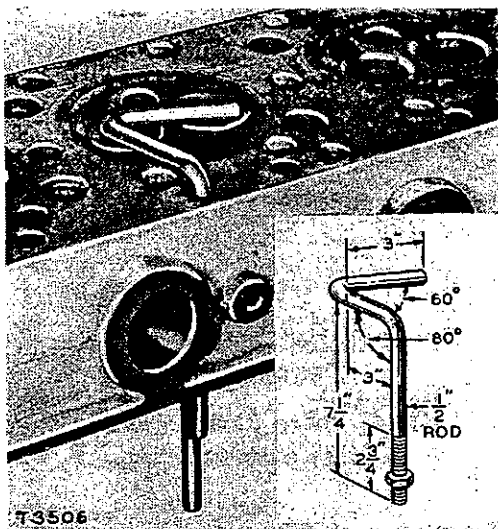
1-Outer valve spring. 2-Valve spring retainer. 3-Valve locks.  
4-Valve. 5-Inner valve spring.

After removing the cylinder head from the engine, make identification marks (A) on the face of the head and the valves. This will be helpful if the valves are inspected only and not reconditioned. Then the valves can be installed in their original positions.

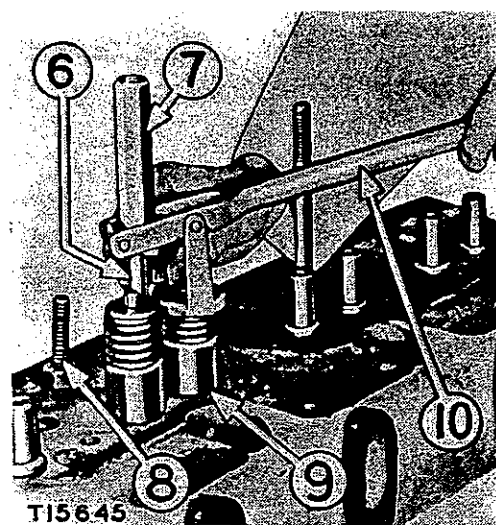
The illustration shows the 7F4292 Valve Spring Compressor Group (7) and (10) being used. The adapter (7) threads onto a rocker arm stud (6).

Also shown is a simple tool (8) which can be made to hold valves in place while installing valve springs.

If the valves were removed for inspection only, make sure they are installed in the same positions from which they were removed.



VALVE HOLDING TOOL



COMPRESSING VALVE SPRING  
6-Rocker arm stud. 7-Adapter. 8-Valve holding tool. 9-Spacer (intermediate type, bushing later type). 10-Valve compressor tool.

Exhaust valves are marked "EX" and inlet valves are marked "IN" for identification and must be installed accordingly.

Inlet valves have a small groove around the top of the stem for identification after the head has been installed.

Lubricate the stems and bushings for initial starting.

### VALVE STEM BUSHINGS (All Models)

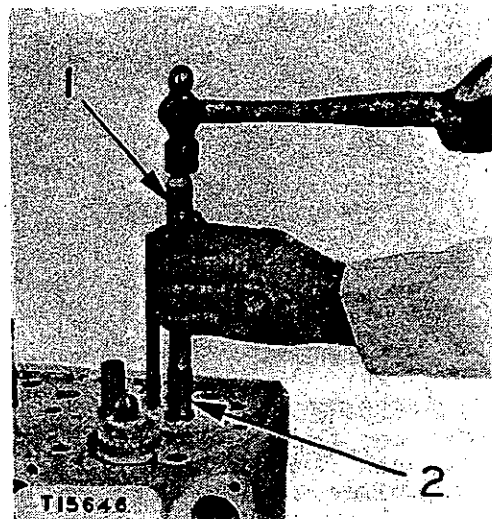
The inlet and exhaust valves operate in replaceable valve stem bushings. On later engines the valve stem bushing and the spacer under the valve springs are integral. After the valves have been removed, clean the valve stems and the valve stem bushings.

The valve stem bushing wear should be checked with a gauge or by using the pilots furnished with some makes of valve seat regrinding equipment. Generally the pilots are supplied in graduated sizes. Use a micrometer to measure the diameter of the largest pilot that will pass through the bushing. This dimension will indicate the wear in the bushing, excluding possible out-of-roundness.

Normal valve stem clearance in the valve stem bushings is from .004" to .006" for inlet valves and .005" to .007" for exhaust valves. Maximum permissible clearance is .012".

The wear of the valve stems can be checked by the use of a 0" to 1" micrometer. The valve stem should be measured in three places. Use the measurement near the top of the valve stem where the valve stem does not touch the bushing as the original valve stem diameter.

The valve stem bushing (2) can be pressed or driven out by the use of the 4H445 Valve Bushing Driver (1) from the inside of the head.



#### INSTALLING VALVE STEM BUSHING

- 1-4H445 Valve Bushing Driver.
- 2-Valve stem bushing.



The bushings should be pressed or driven into place carefully with the 4H445 Valve Bushing Driver shown in the accompanying illustration to prevent damage to the bushing. A .440"-.441" reamer run through the bushings after they are installed will insure correct valve stem clearance.

### Valve Inspection and Reconditioning (All Models)

The valves should always be carefully inspected. If the valve faces are pitted or making poor contact with the valve seat, they can be renewed in a valve refacing machine. If the valves are deeply pitted, badly warped or worn, they should be replaced.

The 45° valve seats can be ground with a valve seat grinding tool. Care should be exercised in its use as too much material may be removed quickly and unknowingly.

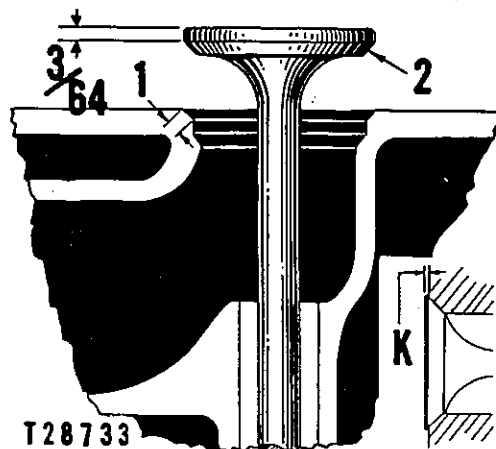
After the valve seats have been ground until they are smooth and concentric with the valve guides, all parts should be cleaned thoroughly.

### Checking Valve Seats (All Models)

Coat the valve face (2) with Prussian blue and rotate the valve in the valve seat. Remove the valve and examine the contact pattern on both valve and seat. The entire circumference of the valve seat (1) should indicate contact with the valve.

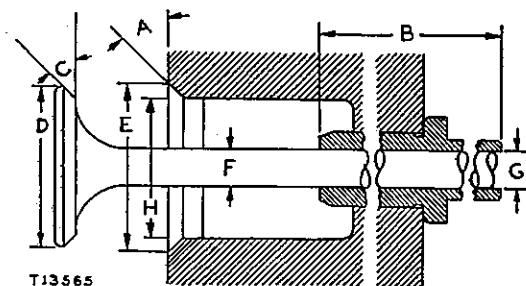
A valve seat (1) width of .106"-.110" should be maintained. To narrow the seat use a 30° stone or fly cutter.

The maximum depth a valve seat should be cut into the cylinder head is 5/64". The measurement should be taken after (E) has been restored. This measurement is taken from the face of the cylinder head to the top of the valve seat at (E).



VALVE FACE AND SEAT WIDTH

1-Valve seat. 2-Valve face. K-Distance from machined surface of head to top of valve.



VALVE SEAT SPECIFICATIONS

Complete valve seat specifications are also given.

INLET		EXHAUST	INLET		EXHAUST
A	45°	45°	E	1.9625 - 1.9685	1.775 - 1.778
B	4 1/4	4 1/4	F	.435 - .436	.434 - .435
C	44 1/4°	44 1/4°	G	.440 - .441	.440 - .441
D	2.023 - 2.033	1.835 - 1.845	H	1.8125	1.625
			K	.0937	.0937

When grinding the valve face (2), do not remove any more material than necessary. The measurement between the top of the valve and the top of the valve face should never be less than 3/64", to prevent "dishing out" of the top of the valve.

Valves can be checked for "dishing out" by placing a straight-edge on the top of the valve. Valves that are dished out should be replaced.

After the valve seats have been ground until they are smooth and concentric with the valve guides, all parts should be cleaned thoroughly.

### VALVE TIMING (All Models)

The inlet and exhaust valves are lifted off their seats by the rocker arms which are operated by the push rods and the valve lifters.

The valve lifters in turn are moved upwards in the valve lifter guides as the camshaft lobes come in contact with the valve lifters.

After the valves have been fully opened and the valves begin to return to their seats, the valve springs supply the force to seat the valves in the cylinder head and the valve lifters are then returned to the base circle of the camshaft and the cam lobes no longer touch the valve lifters.

The camshaft and the camshaft gears are timed together by a key and keyway.

The camshaft gear is timed to the crankshaft gear as described in the topic, TIMING GEARS AND TIMING MARKS (ALL MODELS).

The camshaft turns one-half crankshaft speed, thus requiring the crankshaft gear to rotate 720° in order to permit the camshaft and the camshaft gear to rotate 360°.

See the topic, VALVES AND VALVE MECHANISM (ALL MODELS), for the firing order and the description of the four-stroke cycle of the engine.

Seldom if ever will it be necessary to check the valve timing as there is little chance that the timing gears or the flywheel are marked incorrectly or installed incorrectly. However, if for any reason it is desired to do so, it can be done as described in the topic, CHECKING VALVE TIMING (ALL MODELS).

## CHECKING VALVE TIMING (All Models)

### Checking Valve Timing with Dial Indicator

Adjust the valves to the correct clearance. It is important that the valves be set in the correct firing order. Reset to .010" hot after checking valve timing.

The inlet valve of No. 1 cylinder must be adjusted to .010" cold, to produce the following timing data.

Refer to, SPECIFICATIONS, for the correct firing order and illustration of the cylinder numbering.

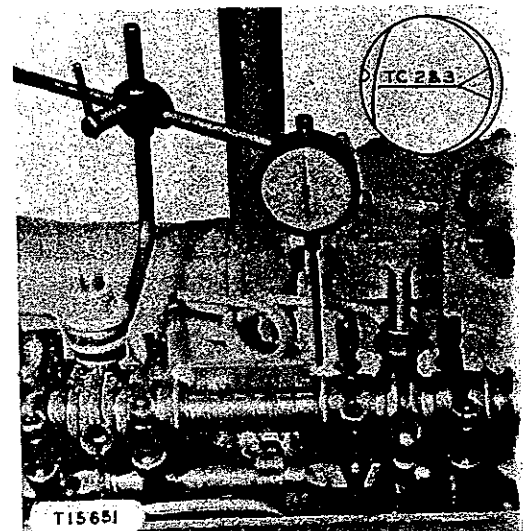
#### STEP 1

Rotate the crankshaft in the direction of engine rotation until the top center mark for No. 2 and 3 cylinders which is stamped on the flywheel, appear in alignment with the flywheel pointer when No. 3 cylinder is on its compression stroke. At this point the No. 1 piston should be coming upward on its exhaust stroke and the exhaust valve should be open, with the inlet valve closed.

Install a dial indicator as illustrated on the inlet valve retainer of No. 1 cylinder.

#### STEP 1

Dial indicator mounted on the inlet valve retainer of No. 1 cylinder. Dial indicator to read "0" with T.C. 2 and 3 in alignment with the flywheel pointer, with No. 3 cylinder on its compression stroke.



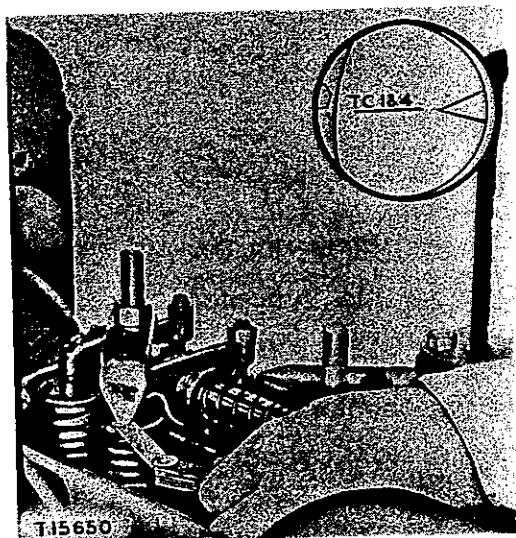
There must be clearance between the checking tool and the valve spring retainer after the tool is in place. Measure this clearance with a thickness gauge and record the amount of clearance.

## STEP 2

Rotate the crankshaft in the **direction of engine rotation** until the top center mark for cylinders 1 and 4 on the flywheel are aligned with the flywheel pointer.

With the crankshaft at this position, check the clearance between the checking tool and the inlet valve spring retainer. From this measurement, deduct the amount of clearance measured in Step 1. The difference between the two measurements should be  $.043'' \pm .010''$  if the engine timing is correct.

Readings obtained by using the thickness gauge checking method, should provide readings that will correspond favorably with those obtained when checking is done with a dial indicator.



## STEP 2

Thickness gauge measurement minus original amount of checking tool clearance to be  $.043'' \pm .010''$ , when the top center mark on the flywheel for cylinders 1 and 4 are aligned with the flywheel pointer.



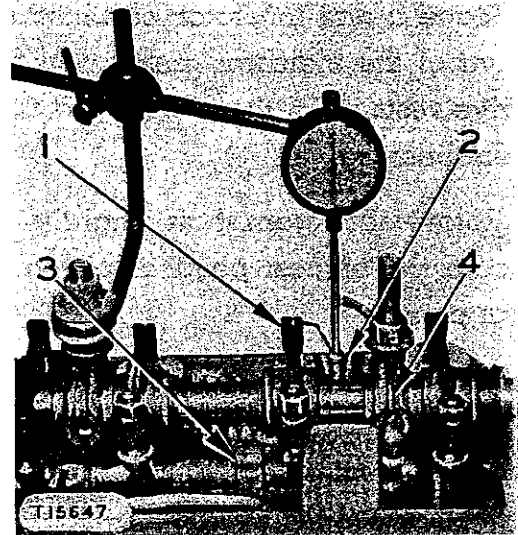
## CHECKING THE FLYWHEEL TOP CENTER MARKS (All Models)

Top center marks can be checked if it is suspected that the flywheel pointer is not located correctly, if no mark is legible on the flywheel through the inspection opening when No. 1 piston is at top center or if the pointer has been removed from the housing. In the latter case, install the pointer.

To check the top center mark for No. 1 cylinder, be sure the piston is at the top, on the compression stroke. This can be determined by removing the valve cover and rotating the crankshaft in the direction of engine

### CHECKING FLYWHEEL TOP CENTER MARKS

1-Rocker arm. 2-Wire. 3-Locking cam.  
4-Support.



rotation until the inlet valve starts to close. This piston will then be going up on the compression stroke. Remove the front inspection cover from the left side of the engine block and continue turning the crankshaft until the No. 1 connecting rod is at its uppermost point. The piston will then be at approximately top center.

1. Remove the cover over the flywheel pointer.
2. Loosen the No. 1 cylinder inlet valve adjusting screw enough to permit removal of the push rod and remove the rod.
3. Loosen the capscrew which secures the compression release shaft locking cam (3) to the shaft.
4. Slide the cam toward the rear of the engine about one half the width of the cam.
5. Move the inlet valve rocker arm (1) toward the rear of the engine far enough to clear the valve and springs.
6. Block the rocker arm at this position by placing a suitable spacer between the rocker arm and the rocker arm shaft support (4) as illustrated.
7. Compress the valve springs and remove the locks, spring retainer and springs from the inlet valve.

### CAUTION

Wrap a piece of wire (2) several times around the valve stem in the groove which accommodates the valve locks, to prevent the valve from falling out of the cylinder head in event the crankshaft is turned too far.

Place a dial indicator as illustrated, above the valve stem so that the anvil of the indicator rests upon the end of the valve stem. Be sure the valve rests upon the piston and that the valve moves freely in the valve stem bushing.

Rotate the crankshaft slightly clockwise and counterclockwise and locate the highest point of piston travel and set the indicator at "0" at that point.

Be sure that the indicator deviates from "0" reading when the flywheel is slightly rotated in either direction. With the indicator in the position which indicates the No. 1 piston is at top center, check whether the TC 1 & 4 mark on the flywheel is even with the pointer.

At this point, the pointer should be in line with the top center mark on the flywheel. If the pointer is not even with the mark on the flywheel, establish a mark on the flywheel in line with the pointer.

With the mark lined up with the pointer, both valves for No. 1 cylinder should be closed and the fuel injection pump lifter should be 1.736" when checked with a depth gauge. Some engines built to special arrangements have special lifter settings. See the information plate on the engine.

If the valves are not closed or the lifter setting is not correct, it may be that the marks on the timing gears are not matched correctly or were marked in error.

For other information on timing, see the topics, FUEL PUMP LIFTER SETTING (ALL MODELS) and TIMING GEARS AND TIMING MARKS (ALL MODELS).

### **VALVE LIFTER REMOVAL AND INSTALLATION (All Models)**

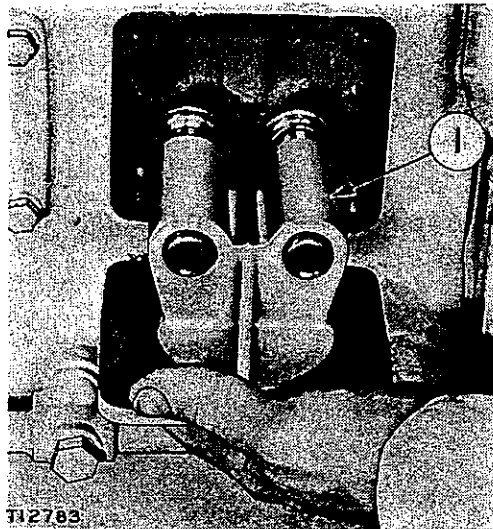
The valve lifters operate in guides which are attached to the right side of the cylinder block.

Remove the valve cover, loosen the rocker arm assembly and lift out the push rods.

Remove the crankcase filler and breather assemblies whenever necessary and the oil filter case from the filter base.

After four capscrews, two of which are ground-finished for aligning purposes, are removed, each valve lifter guide assembly (1) can be tilted out at the top and lifted out of the cylinder block.

The valve lifters (3) can be slipped out of the guides after the snap rings (2) at the top are taken off. If the snap rings are weakened or distorted, new ones should be installed.



#### REMOVING VALVE LIFTERS AND GUIDE

1-Valve lifter guide assembly.



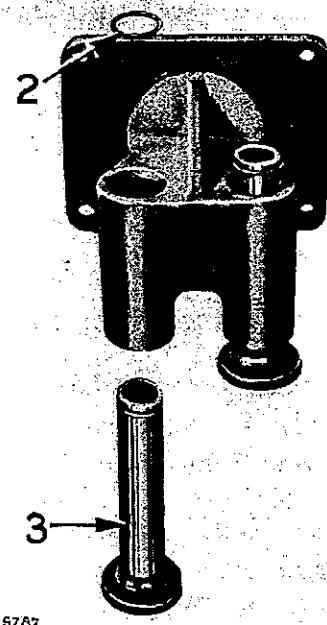
The clearance between new guides and lifters should be from .0015" to .003".

Replace the valve lifters or guide if the clearance exceeds .008".

Install in reverse order of removal making sure all parts are working freely.

#### VALVE LIFTERS AND GUIDE

2-Snap ring. 3-Valve lifter.



# Timing Gears

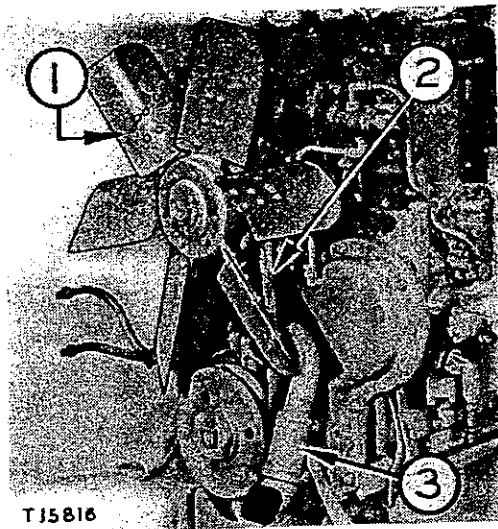
(All Models)

## TIMING GEAR COVER REMOVAL AND INSTALLATION

(All Models)

Timing gear cover removal (with the exception of the removal of different types of accessories and attachments located at the front of the engine) is similar for all models.

See the covering topics, for method of removing and installing these parts.



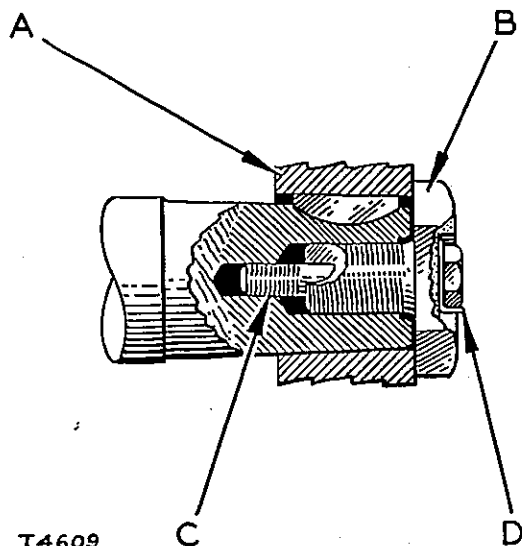
### PREPARING TO REMOVE TIMING GEAR COVER

1-Fan assembly. 2-Fan belt.  
3-Water line.

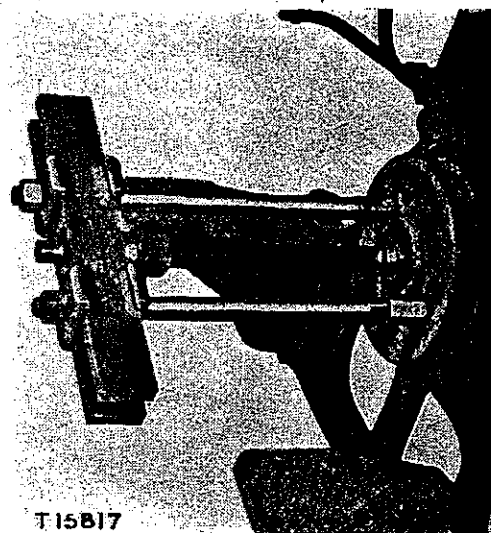
The following procedure describes the removal of the timing gear cover from a D315 Industrial Engine:

1. Drain the lubricant from the oil pan.
2. Remove the cover from the left side of the oil pan.
3. Remove the radiator assembly, the fan assembly (1), and the fan belt (2).
4. Remove the water elbow, pipe and hose connection (3) as a unit.
5. A hollow screw (B) retains the crankshaft pulley (A) on the crankshaft. A capscrew (C) having left-hand threads secures this hollow screw. Remove the lock (D) and the capscrew (C).
6. The 1B4657 Special Socket Wrench can be used for removing the large screw. Use the puller holes provided and the 8B7548 Puller with two 8B7557 Adapters as shown and remove the pulley from the crankshaft. Remove the key.





T4609

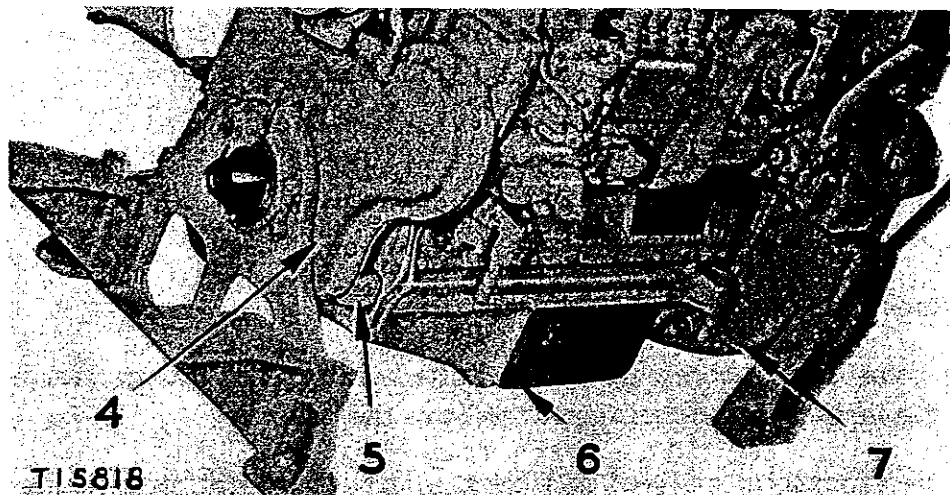


T15817

### CRANKSHAFT PULLEY REMOVAL

A-Pulley. B-Screw. C-Capscrew. D-Lock.

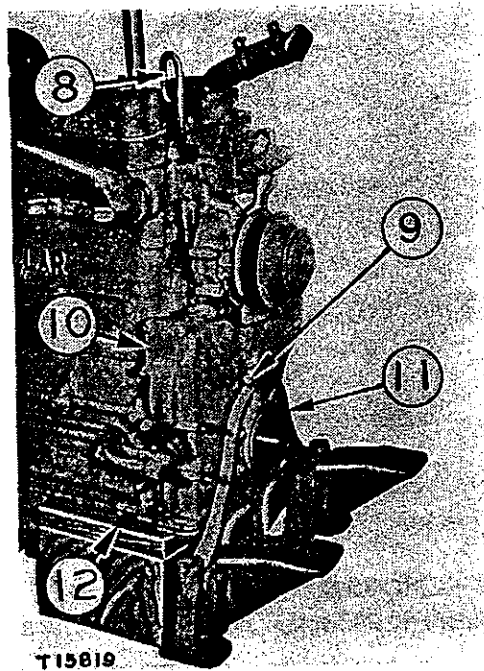
7. Loosen all the capscrews holding the oil pan (6) to the cylinder block, the timing gear housing, the timing gear cover (4) and the flywheel housing (7).
8. Remove the capscrews holding the oil pan to the timing gear housing (5) and the timing gear cover. Carefully lower the pan about 1/4 inch. Use a putty knife to pull the pan gasket away from the timing gear cover.
9. Install a heavy shim stock spacer (12) between the pan and the cylinder block on both sides of the engine. This will hold the pan away from the timing gear cover and avoid damage to the pan gasket when the cover is removed.



T15818

### LOOSENING THE OIL PAN

4-Timing gear cover. 5-Timing gear housing. 6-Oil pan. 7-Flywheel housing.



### REMOVING THE TIMING GEAR COVER

8-Lifting eye. 9-Clamp screw. 10-Cover.  
11-Support. 12-Spacer.

10. Raise the front of the engine just enough to take the weight from the front support (11) and place a wooden block under the front of the oil pan. A suitable hoist attached to a 4F9660 Lifting Eye (8) can be used to raise the engine. Be sure the engine is blocked securely if the hoist is removed.
11. Loosen the clamp screw (9) on the front support.
12. Remove the capscrews holding the front support to the timing gear cover. Remove the support.

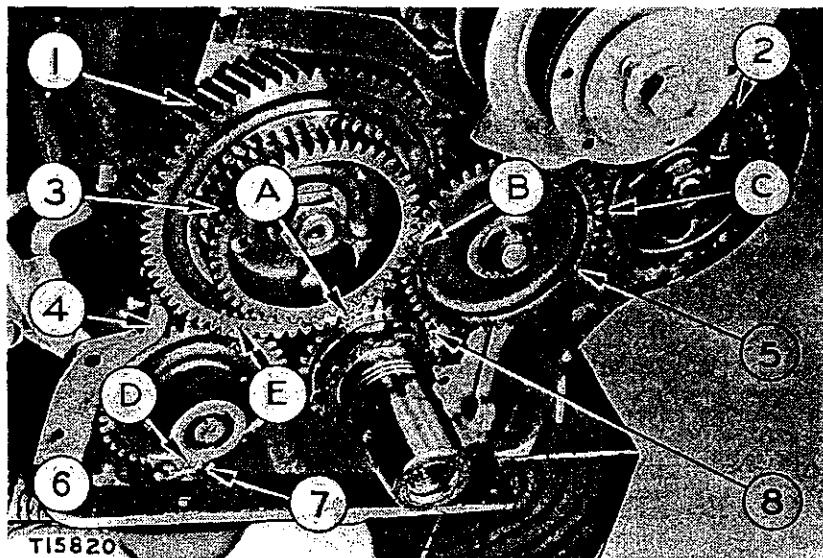
### NOTE

When reinstalling the front support, leave the clamping screw loose until the engine has been placed back in its permanent installation, leveled and lined up. Then tighten the clamping capscrew.

13. Remove the tube which connects the safety shut-off to the timing gear cover, if so equipped.
14. Remove the auxiliary drive cover (10).
15. Remove the capscrews and the bolts holding the timing gear cover to the timing gear housing and remove the cover.
16. If the crankshaft oil seal has been removed, do not replace the seal until the cover has been installed on the engine. Install the seal with the wiping edge out. A 7B7918 Driver can be used for this.

## TIMING GEARS AND TIMING MARKS (All Models)

The engine timing gears are located within the timing gear housing (4). See the topic, TIMING GEAR COVER REMOVAL AND INSTALLATION (ALL MODELS), for the procedure of removing the timing gear cover.



### TIMING GEARS

A-Timing marks for large camshaft gear to crankshaft gear. B-Timing marks for accessory idler gear to camshaft gear. C-Timing marks for accessory shaft gear to idler gear. D-Timing marks for balancer drive gear to idler gear. E-Timing marks for camshaft gear to balancer idler gear. 1-Large camshaft gear. 2-Accessory shaft gear. 3-Small camshaft gear. 4-Timing gear housing. 5-Accessory idler gear. 6-Balancer idler gear. 7-Balancer drive gear. 8-Crankshaft gear.

The camshaft gear consists of two gears made integral. For reference purposes we refer to the large gear as gear (1) and the small gear as gear (3).

The large camshaft gear (1) is driven by the crankshaft gear (8). These gears are timed by the mating teeth at (A).

The small camshaft gear (3) in turn drives the accessory idler gear (5) and is timed by the mating teeth at (B).

The accessory shaft gear (2) is timed to the accessory idler gear at (C).

The balancer idler gear (6) is driven by the large camshaft gear (1) and it is timed at (E).

The balancer drive gear (7) is driven by the idler gear (6) and it is timed at (D). See the topic, TIMING THE BALANCER.

The auxiliary drive housing (when installed) is attached to the timing gear housing (4) and the timing gear cover.

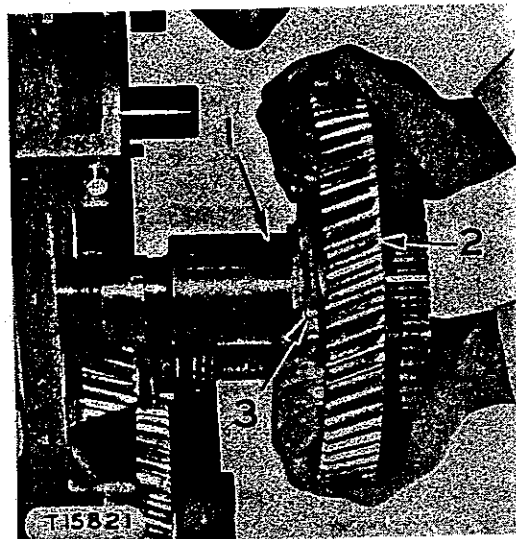
The attachments that are installed to the timing gear housing and the timing gear cover are driven by the large camshaft gear (1).

## Camshaft (All Models)

The camshaft is driven by the camshaft gear which meshes with the crankshaft gear. The cams which actuate the inlet and exhaust valves are forged integrally with the shaft.

### CAMSHAFT AND CAMSHAFT GEAR REMOVAL AS A UNIT (All Models)

1. Remove the valve lifter assemblies as described in the topic, VALVE LIFTER REMOVAL AND INSTALLATION (ALL MODELS).
2. Take off the timing gear cover as described in the topic, TIMING GEAR COVER REMOVAL AND INSTALLATION (ALL MODELS).
3. Slide off the accessory idler gear.
4. Bend down the locks on the capscrews which hold the thrust plate (3) to the timing gear housing and remove the capscrews by using a wrench through the hole in the camshaft gear.
5. Withdraw the camshaft (1) and gear (2) carefully to avoid damaging the camshaft bearings and the oil pump drive gear. The maximum permissible clearance between the bushings and shaft is .010".



#### CAMSHAFT REMOVAL

- 1-Camshaft. 2-Camshaft gear.  
3-Thrust plate.

The camshaft gear can be removed separately without removing the camshaft. See the topic, CAMSHAFT GEAR REMOVAL AND INSTALLATION (ALL MODELS).

Before installing the camshaft, see the topic, CHECKING CAMSHAFT END CLEARANCE (ALL MODELS).

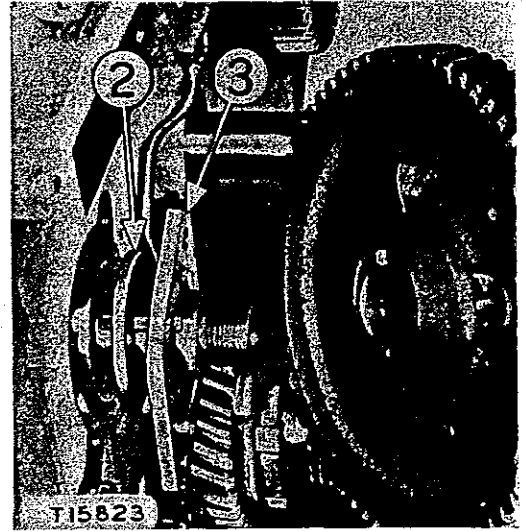
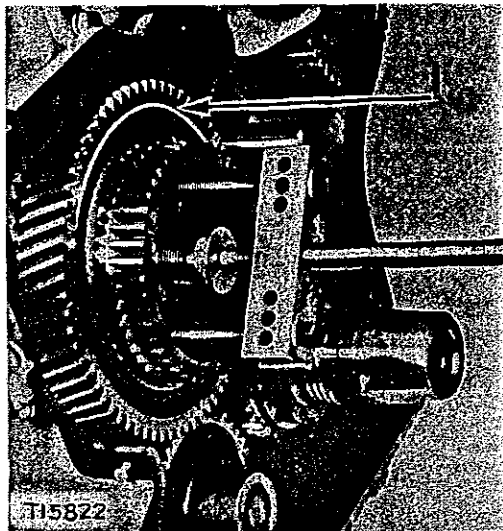
### CAMSHAFT GEAR REMOVAL AND INSTALLATION (All Models)

The camshaft gear (1) can be pulled from the camshaft with the camshaft in the engine.

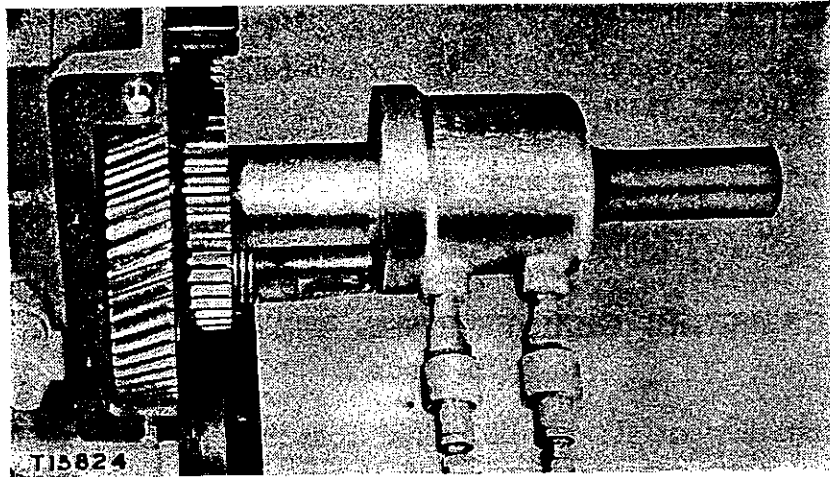
1. Remove the nut and lock. Use the 5F7465 Puller with two  $\frac{1}{2}$ " - 13 (NC) capscrews  $4\frac{1}{2}$ " long as shown.
2. Camshaft end thrust is taken by a thrust plate (3) between the camshaft gear and thrust washer (2). Remove these parts for inspection, noting the inside chamfer on the thrust washer.
3. Install the thrust washer with the chamfer toward the camshaft.
4. Install the thrust plate and check the camshaft end clearance.

#### NOTE

Before installing the camshaft gear on the camshaft, be certain the key is properly positioned in the shaft and that the gear surface on the shaft is smooth and free of burrs.



CAMSHAFT GEAR REMOVAL  
1-Camshaft gear. 2-Thrust washer. 3-Thrust plate.



### INSTALLING CAMSHAFT GEAR

5. Start the camshaft gear on the shaft aligning the key and keyway.
6. Attach the 8F3671 Pusher Assembly and the 7F9540 Hydraulic Puller as shown.
7. Align the marked teeth on the camshaft gear with the crankshaft gear and with the balancer idler gear, if so equipped as the gears start to mesh.

### NOTE

On engines equipped with a balancer, see the topic, **TIMING THE BALANCER (ALL MODELS)**.

8. Push the gear onto the shaft until it becomes bottomed.
9. When the gear is firmly seated against the thrust washer, install the lock and retaining nut.

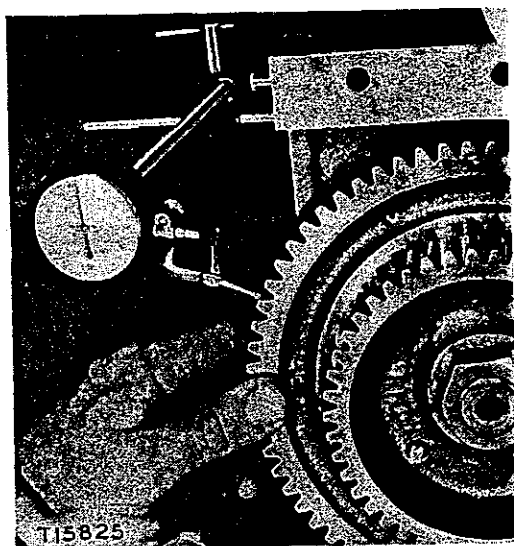
### Checking Camshaft Gear Backlash (All Models)

The backlash between the camshaft gear and the crankshaft gear can be checked in the following manner:

Install a dial indicator as illustrated. The backlash between the camshaft gear and the crankshaft gear should be .003"-.004"

The backlash is pre-determined through machining, and cannot be adjusted.

When a dial indicator reading of .010" or more is shown, a further check must be made to determine the cause. Excessive backlash indicates that either the timing gears, the main bearings or the camshaft bearings are badly worn.



## CHECKING CAMSHAFT GEAR BACKLASH



Timing gear wear can be compensated for, by adjusting the fuel injection pump lifters. See the topic, FUEL PUMP LIFTER SETTING (ALL MODELS).

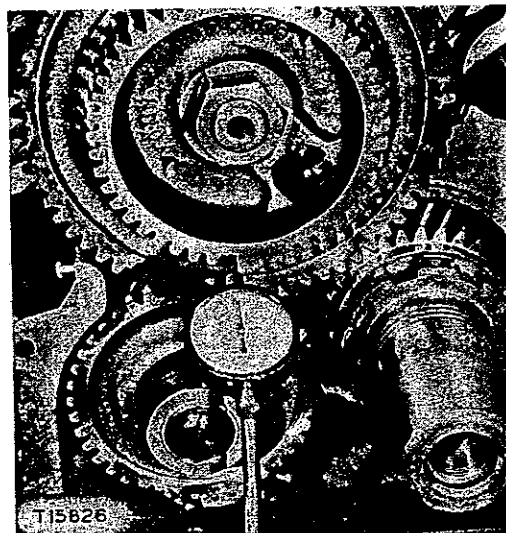
If either the main bearings or the camshaft bearings are badly worn, they should be replaced with new ones.

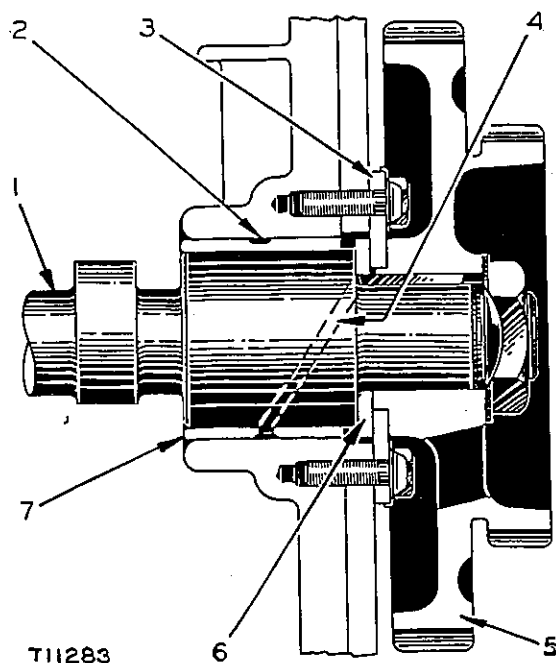
If a reading of less than .003" backlash is shown, it is an indication of incorrect assembly, or a burr or rough spot on one of the gears. In this case, take readings every 90° around the camshaft gear to determine the cause. A burr can be removed from a gear tooth, by using a gear file or fine stone, without removing the gear from the camshaft. When removing a burr, cover the remaining exposed parts to keep them clean.

## Checking Camshaft End Clearance (All Models)

The end thrust of the camshaft is taken by the thrust plate (3) and thrust washer (6).

## CHECKING END CLEARANCE





### CAMSHAFT END CLEARANCE

1-Camshaft. 2-Undercut (in back of camshaft bearing). 3-Thrust plate. 4-Drilled passage. 5-Camshaft gear. 6-Thrust washer. 7-Camshaft bearing.

The correct end clearance is .006"-.010". The washer and plate should be replaced if the end clearance exceeds .025".

The end clearance can be checked by installing a dial indicator as illustrated. After checking the end clearance, if it is necessary to replace the thrust washer or thrust plate, they can be removed as described in the topic, CAMSHAFT GEAR REMOVAL AND INSTALLATION (ALL MODELS).

If the camshaft (1) and camshaft gear (5) were removed as a unit, the thrust washer and thrust plate should be inspected for wear. The end clearance can be checked in the following manner. Push the thrust plate against the gear; and using a thickness gauge, measure the clearance between the thrust washer and thrust plate.

The camshaft bearing (7) receives a supply of oil from the manifold through a passage in the cylinder block.

An undercut (2) delivers the oil through the bearing into a drilled passage (4) in the camshaft (1). This passage transmits the oil to the thrust washer and plate.

### ACCESSORY SHAFT AND GEAR (All Models)

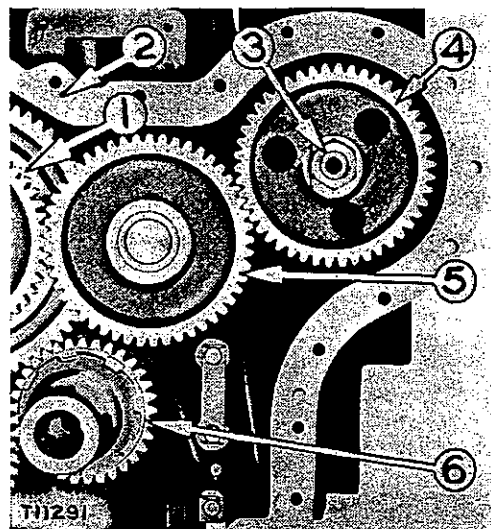
The accessory shaft (3) and the accessory gear (4) are located within the timing gear housing (2) and the timing gear cover (7).

The accessory shaft and gear are driven through the crankshaft gear (6), the camshaft gear (1) and the accessory idler gear (5).



### LOCATION OF ACCESSORY SHAFT AND GEAR

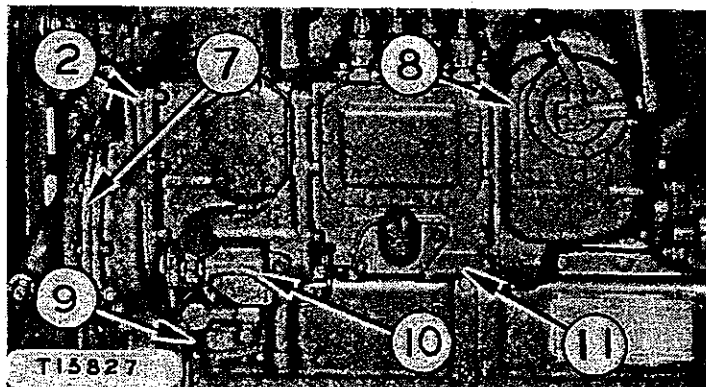
1-Camshaft gear. 2-Timing gear housing.  
3-Accessory shaft. 4-Accessory  
shaft gear. 5-Accessory idler gear.  
6-Crankshaft gear.



The accessory shaft, in turn, drives the fuel transfer pump (9) and the hour meter (10). It also drives the fuel injection pump camshaft which is located in the fuel pump housing (11) and the governor which is located in the governor housing (8).

The rear end of the accessory shaft is supported by the front bushing in the fuel injection pump housing. Endwise movement of this shaft is controlled by a thrust washer and plate secured to the front bearing assembly. The correct end clearance is .006"-.010". If this clearance should exceed .025", the thrust washer and plate should be replaced.

The backlash between the accessory shaft idler gear (5) and the camshaft gear (1), and between the idler gear and the accessory shaft gear (4), is .003"-.004", with a maximum of .010". The backlash can be checked in a similar manner to that described in the topic, CHECKING CAM-SHAFT GEAR BACKLASH (ALL MODELS).



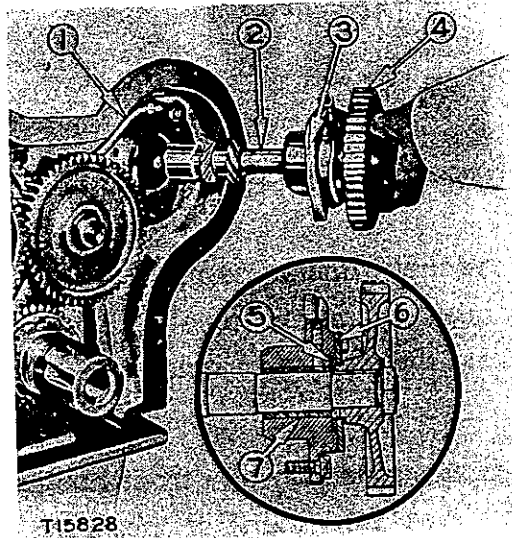
### ASSEMBLIES DRIVEN BY ACCESSORY SHAFT

2-Timing gear housing. 7-Timing gear cover. 8-Governor housing. 9-Fuel transfer pump. 10-Hour meter. 11-Fuel pump housing.

## Accessory Shaft and Gear Removal (All Models)

Remove the hour meter and the fuel transfer pump.

With the timing gear cover removed, disconnect the oil line (1) and remove the capscrews which hold the bearing assembly (3) to the timing gear housing.



**ACCESSORY DRIVE GEAR AND SHAFT**  
1-Oil line. 2-Accessory shaft. 3-Bearing assembly. 4-Accessory shaft gear. 5-Thrust washer. 6-Thrust plate. 7-Bushing.

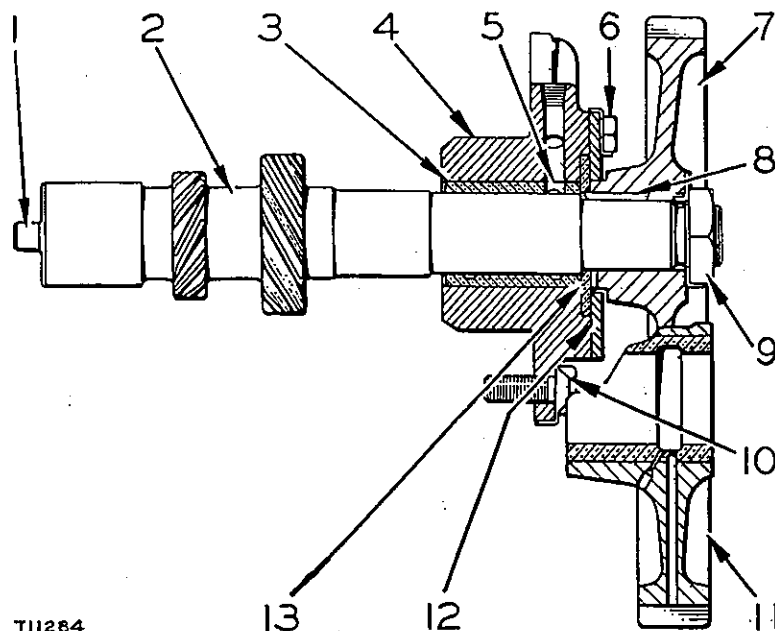
The capscrews may be reached with a socket wrench through the holes in the gear. The entire assembly may then be removed.

Unlock and remove the nut from the end of the shaft. Pull the gear, using an 8B7546 Puller. Take out the capscrews and remove the thrust plate (6) and washer (5).

Remove the key from the shaft. Withdraw the shaft from the bearing assembly. Press the bushing (7) from the bearing assembly if it is damaged or if the clearance exceeds .010".

## Accessory Shaft and Gear Installation (All Models)

1. Press the bushing (3) into the bearing assembly (4), being careful to line up the oil holes (5).
2. Place the bearing assembly on the shaft (2) and install the key (8).
3. Install the thrust washer (13) on the shaft with the chamfered edge of the bore toward the tang (1) on the shaft.
4. Install the thrust plate (12), locks and capscrews (6). Tighten the capscrews and bend locks.



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#### INSTALLING ACCESSORY SHAFT AND GEAR

1-Off-center tang. 2-Accessory shaft. 3-Bushing. 4-Bearing assembly. 5-Oil holes.  
6-Capscrew. 7-Accessory gear. 8-Key. 9-Nut. 10-Capscrew. 11-Accessory  
idler gear. 12-Thrust plate. 13-Thrust washer.

5. Press the gear (7) on the shaft. Install the lock and nut (9). Tighten the nut securely and bend the lock.
6. Install the complete assembly, turning the shaft until the off-center tang (1) is engaged with the off-center slot in the fuel pump camshaft.
7. Install the locks and capscrews (10) which hold the bearing assembly in place. Tighten the capscrews and bend the locks.
8. Connect the oil line to the fittings in the top of the bearing assembly.
9. Install the accessory idler gear (11), mating the timing marks, and assemble the remaining parts.

### Gear-type Balancer

The balancer is positioned in a housing fastened to the underside of the block at the center of the engine.

The balancer has two balance weights, timed to each other and to the crankshaft. The balancer is driven from the camshaft through an idler. The balance weights rotate in opposite directions at twice engine speed and counteract vertical inertia forces of the connecting rod and piston.

When replacing the balancer, it must be correctly timed in itself and also correctly timed to the engine.

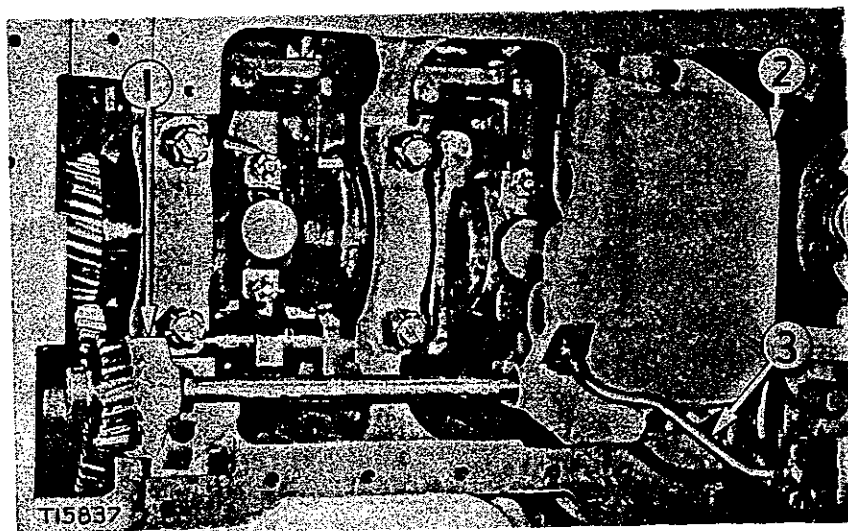
## BALANCER REMOVAL

The balancer can be removed in the following manner:

1. Remove the oil pan. See the topic, OIL PAN REMOVAL AND INSTALLATION (ALL MODELS).
2. Remove the oil line (3).
3. Remove the capscrews and the locks which secure the shaft support bracket (1) to the cylinder block.
4. Remove the capscrews and the locks which secure the balancer bracket assembly (2) to the cylinder block.

### NOTE

Dowels are driven into the balancer bracket assembly and the shaft support bracket to properly locate the brackets on the cylinder block.

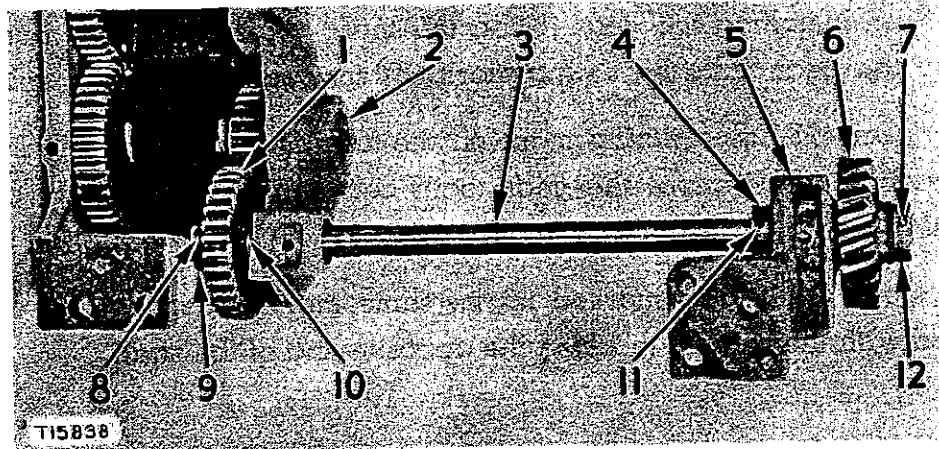


### BALANCER REMOVAL

1-Shaft support bracket. 2-Balancer bracket assembly. 3-Oil line.

## BALANCER DRIVE SHAFT REMOVAL AND INSTALLATION

1. Remove the taper pin (8) which secures the collar (9) to the shaft (3).
2. Move the collar and the gear (1) as far as possible toward the end of the shaft.
3. Work the ring (10) out of the groove in the shaft and slide it against the gear.



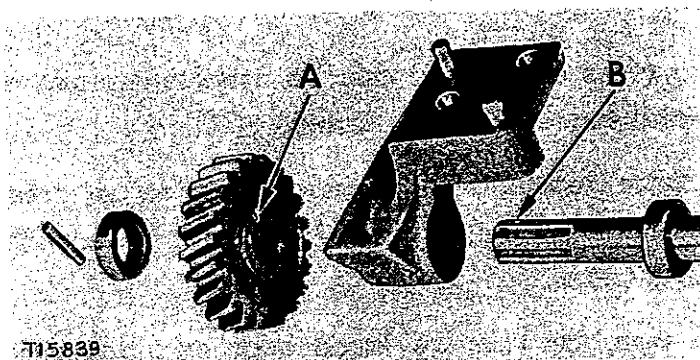
#### DRIVE SHAFT REMOVAL AND DISASSEMBLY

1-Gear. 2-Bracket. 3-Shaft. 4-Collar. 5-Bracket. 6-Gear. 7-Taper pin. 8-Taper pin.  
9-Collar. 10-Ring. 11-Taper pin. 12-Collar.

4. Pull the shaft out of the collar, the gear, the ring and the bracket (2), removing each part as it comes free from the shaft.
5. Remove the taper pin (7) from the collar (12).
6. Remove the collar, the gear (6) and the support bracket (5) from the shaft.
7. If necessary, the collar (4) can be removed from the shaft after removing the taper pin (11).
8. When replacing the bushings in the brackets (2) and (5), align the oil holes in the bushings with the oil holes in the brackets.

#### NOTE

If the balance weights are to be removed, do not install the gear (1) and the shaft (3) in the bracket (2). The additional clearance provided with the gear removed is needed to remove the weight nearer the gear.



#### ASSEMBLING THE DRIVE SHAFT AND GEARS

A-Timing mark. B-Timing mark.

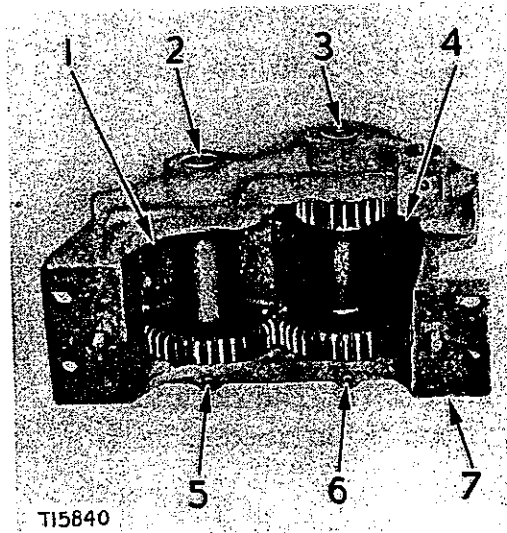
9. When installing the gear (6) on the shaft, align the timing mark (A) on the gear with the timing mark (B) scribed on the shaft spline.

The gear (1) has a timing mark on the face of one of the teeth. Align the mark on the face of the gear tooth between the two marks on the face of the teeth on the mating gear of the balance drive weight.

The gear (1) is also marked in the same manner as gear (6) and is aligned with the scribed mark on the opposite end of the shaft.

### REMOVING THE BALANCE WEIGHTS

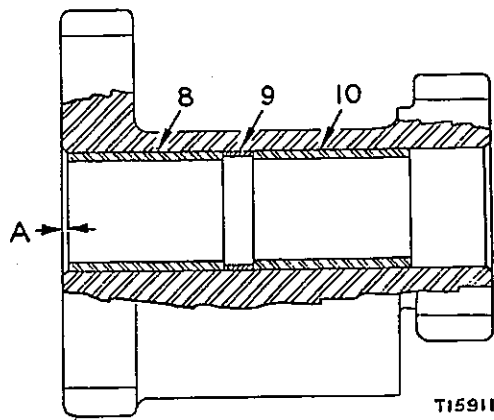
1. Remove the taper pins (5) and (6) which secure the shafts (2) and (3).
2. Place the balancer bracket (7) in a suitable press with the plugged ends of the shafts up.
3. Press out the shafts and remove the weights (1) and (4).



### REMOVING THE BALANCE WEIGHTS

1-Weight. 2-Shaft. 3-Shaft. 4-Weight.  
5-Taper pin. 6-Taper pin. 7-Balancer bracket.

4. A suitable press and driver can be used to remove and install the bushings and spacers in the weights.
5. With the large gear end of the weights turned up, press the bushing (8) into the bore of the weights  $1/32''$  past flush of the face of the large gear at (A).
6. Place the weights with the large gear end down and install the spacer (9) in each weight. Then press the remaining bushings (10) into the weights until the bushings bottom against the spacers.



### INSTALLING THE BUSHINGS AND SPACERS IN THE BALANCE WEIGHTS

A-Dimension of  $\frac{1}{32}$ ". 8-Bushing.  
9-Spacer. 10-Bushing.

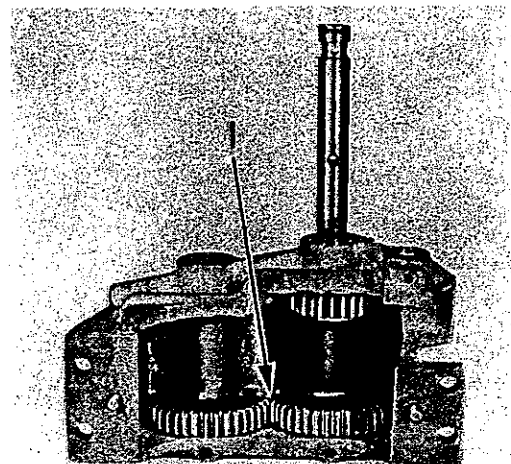


### INSTALLING THE BALANCE WEIGHTS

1. Place the weights in the bracket, aligning the timing marks (1) on the weight gears. These marks are represented by the letter W.
2. Align the bore in the weights with the bores in the bracket.
3. Line up the holes in the shafts for the taper pins with the holes in the bracket.
4. Press the shafts into the bracket and weights until the taper holes in the shafts align with the taper holes in the bracket.
5. Install the taper pins.

### INSTALLING THE BALANCE WEIGHTS

1-Timing marks.



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6. If new shafts are used, install as described, then drill a  $\frac{15}{64}$ " hole through the housing and shaft. Ream the hole from the top side of the bracket with a number 5 taper reamer and install the taper pin.

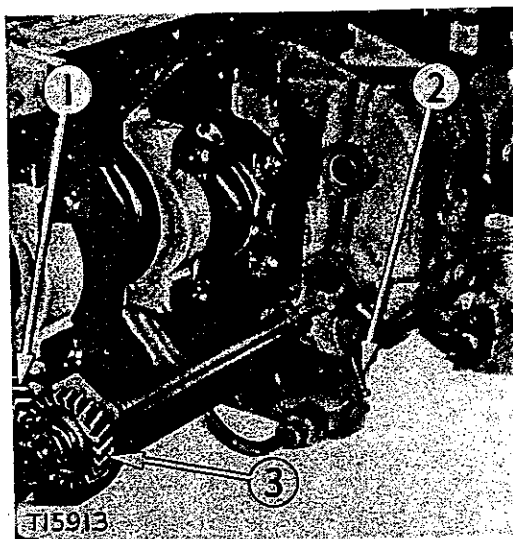
## TIMING THE BALANCER

1. Before installing the balancer on the engine, rotate the crankshaft to position any of the pistons at top center.
2. With the W-marks on the weights aligned and the timing marks on the drive shaft gear mating with the small gear on the balance drive weight, install a 5/16"-18 (NC) capscrew (2) to finger tightness in the tapped hole provided in the bracket. The capscrew will prevent the weights from rotating out of position during installation of the balancer.
3. Install the balancer, meshing the teeth on the drive gear (3) with the teeth on the balancer idler gear (1).

### NOTE

The timing marks on gear (3) can be disregarded in this instance. They are intended primarily for use during the installation of all the timing gears. See the topic, TIMING GEARS AND TIMING MARKS.

4. Remove the capscrew (2) from the bracket.
5. Install the remaining parts.



### TIMING THE BALANCER

1-Balancer idler gear. 2-Capscrew.  
3-Drive gear.

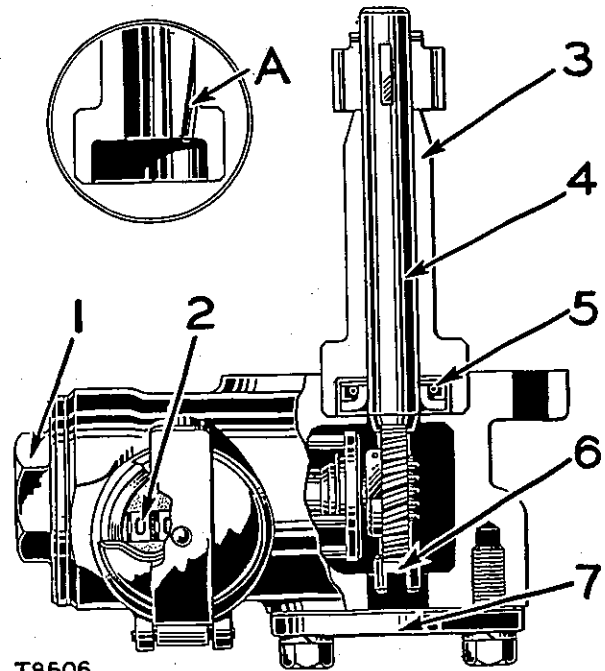
## Hour Meter (All Models)

The hour meter is mounted on the fuel filter housing and is driven by the accessory shaft. Remove the nuts from the studs holding the hour meter to the housing and lift it off.



#### HOUR METER (TOP VIEW)

1-Retainer assembly. 2-Counter assembly. 3-Bearing assembly. 4-Drive shaft. 5-Oil seal. 6-Grooved end of drive shaft. 7-Cover. A-Oil return passage on under side of bearing (3).



The hour meter can be disassembled in the following manner:

1. Remove the retainer assembly (1) and the counter retaining spring.
2. Remove the counter assembly (2).
3. Remove the cover (7) or the tachometer drive assembly if installed in place of the cover. When installed, the tachometer is driven by the grooved end (6) of the shaft (4).
4. Slide out the drive shaft (4). The gear can be removed from the shaft, by first removing the pin which retains the gear to the shaft. Pull the gear using the 8B7547 Puller.
5. Place the bearing (3) in a vise, gripping the bearing lightly. Tap the hour meter housing gently to separate the housing and the bearing.
6. When installing the counter assembly, lubricate the drive gear with a suitable ball and roller bearing grease.

An oil seal (5) keeps oil out of the hour meter assembly. If this seal is replaced, the wiping edge should be installed toward the bearing (3). The bearing should be replaced if the clearance between the shaft and the bearing exceeds .012".

The bearing (3) is lubricated through holes (not shown) in the bearing and the oil is returned through a drilled passage (A) just behind the seal. This drilled passage should be on the bottom when the bearing is installed, to permit the oil to drain away from the oil seal.

## Connecting Rods

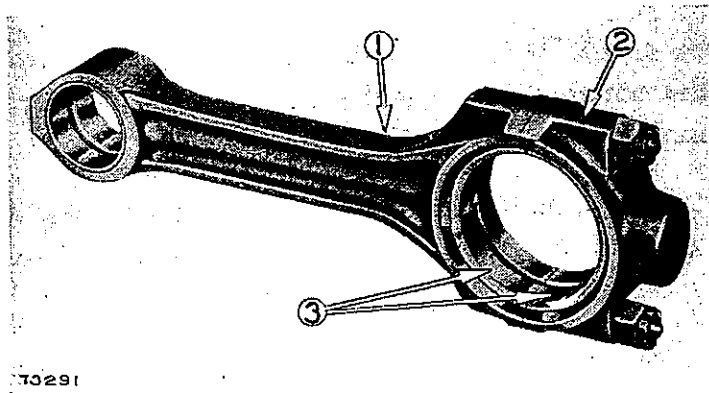
(All Models)

The bearing caps and rods are numbered consecutively, 1 to 4, from the front end of the engine on the left side so that the numbers can be seen through the inspection openings on the left side of the cylinder block. The rods and caps should be reassembled with the numbers in this position.

In order to remove the connecting rods first remove the cylinder head; remove the carbon from the top of the cylinder liner, then remove the connecting rod caps and remove the connecting rods and pistons from the top of the cylinder liner.

### CONNECTING ROD BEARING REMOVAL AND INSTALLATION (All Models)

Connecting rod bearings are of the precision-type, aluminum alloy, and are to be installed without fitting, reaming or scraping the rod (1), cap (2) or the bearing halves (3).



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#### CONNECTING ROD ASSEMBLY

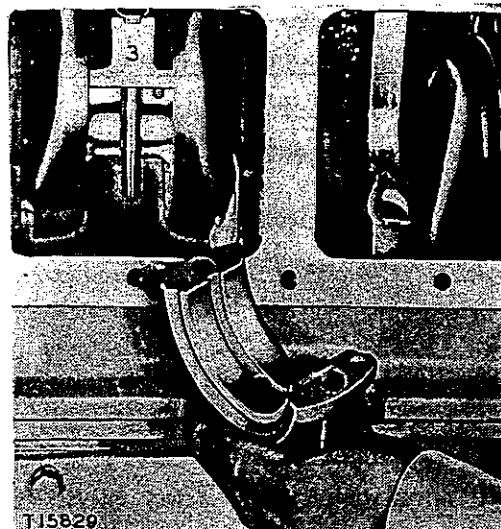
1-Connecting rod. 2-Connecting rod cap. 3-Bearing halves (earlier type).

The bearing halves can be removed, inspected and replaced through the inspection openings without removing the rod from the engine.

To remove a connecting rod bearing through the inspection opening, remove the inspection cover and turn the crankshaft until the bearing to be removed is in the position shown in the illustration.

Remove the nuts from the connecting rod bolts and take out the cap and lower bearing half. To remove the upper bearing half, turn the crankshaft or push the rod up slightly.

**REMOVING CONNECTING ROD  
BEARING CAP LEFT SIDE  
OF ENGINE**



Two hollow dowels prevent the bearings from turning in the connecting rod. One dowel is located in the cap and the other dowel in the drilled connecting rod oil passage. A pin in the connecting rod assures correct reassembly of the cap and connecting rod.

A torque of 58 pound feet should be used to tighten the nuts. It is permissible to exceed this value by the amount necessary to turn the nut to the next slot for alignment with the cotter pin hole.

**Connecting Rod Bearing Inspection (All Models)**

All the connecting rod bearings should be inspected for wear and possible damage any time they are removed from the engine.

Larger particles of dirt and abrasives in the oil do not tend to embed in aluminum bearings. Such particles roll around between the bearing and crankshaft journal causing scratches in the aluminum bearing without actually becoming embedded in the aluminum. Such scratches are not necessarily harmful and do not indicate that the bearings should be replaced.

Bearings having over .013" clearance should be replaced with new ones.

A new standard connecting rod bearing has a clearance of .005"-.0075" for aluminum bearings and .0035"-.0055" for the steel-backed aluminum bearings between the bearing and new crankshaft.

The correct connecting rod bearing crankshaft journal diameter is 2.999"-3.000", and the maximum permissible journal wear is .007". When the wear exceeds this, the crankshaft should be reground or replaced. Bearings .030" undersize are serviced for reground crankshafts.

If there is any question about the surface of a bearing, wash it with cleaning solvent to remove oil. Then, if the surface feels rough and abrasive to the touch, replace the bearing. Another indication of dirt in the bearing is excessive crankshaft wear.

Bent rods should be discarded. Do not attempt to align connecting rods by bending them.

### **PISTON PIN BUSHING** (All Models)

It is not always necessary to replace piston pin bushings at each engine reconditioning. They may last many thousands of hours if the oil has been kept clean.

After the oil has been cleaned from the pin and bushing, it is possible to feel the clearance between them. This normal oil clearance must not be mistaken for wear.

A new bushing, a pin or both, should be installed only when the clearance between the bushing and pin exceeds .006".

New connecting rods have the piston pin bushing bored in a special machine which maintains the proper center-to-center distance and parallelism of the connecting rod bearing and piston pin bore. Reconditioned rods should be machined in the same manner. A new connecting rod makes a good templet. The center-to-center distance is 10.249"-10.251".

After pressing a new bushing into place, it should be machined accurately to 1.8135"-1.8140", inside diameter. A 2H6782 Rod Boring Machine is available for this.

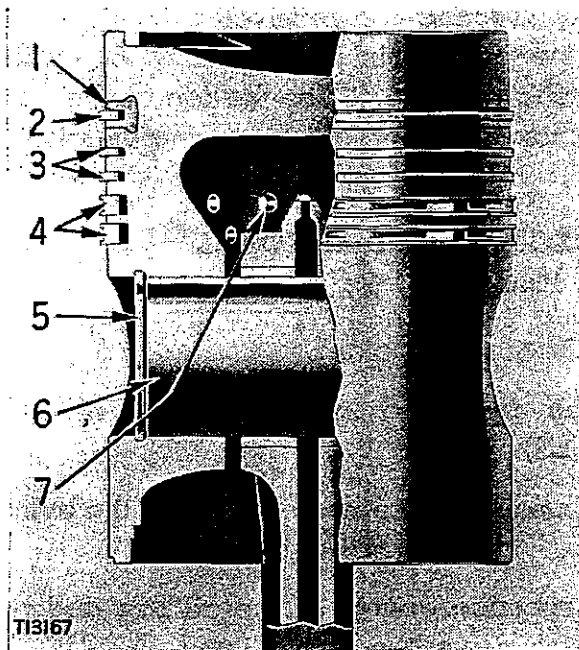
### **Pistons and Rings** (All Models)

The first noticeable symptoms of worn piston rings and cylinder liners are increased oil consumption and excessive vapor from the crankcase breather. Extreme wear will result in poor compression, loss of power and hard starting. See the topic, CYLINDER LINERS (ALL MODELS).

The aluminum alloy pistons have a cast iron insert (1) for the top ring.

Three compression rings (2) and (3) and two oil rings (4) are used and all rings are above the pin bore.

The piston pins (6) are full floating and held in place by snap rings (5) fitting into recesses in the pin bores.



#### PISTON ASSEMBLY

- 1-Insert. 2-Top compression ring.
- 3-Compression rings. 4-Oil rings.
- 5-Retainer. 6-Piston pin.
- 7-Oil return hole.

Holes (7) in the piston oil ring grooves provide for a return of oil to the crankcase.

The top compression ring (2) is chromium plated to provide longer service life.

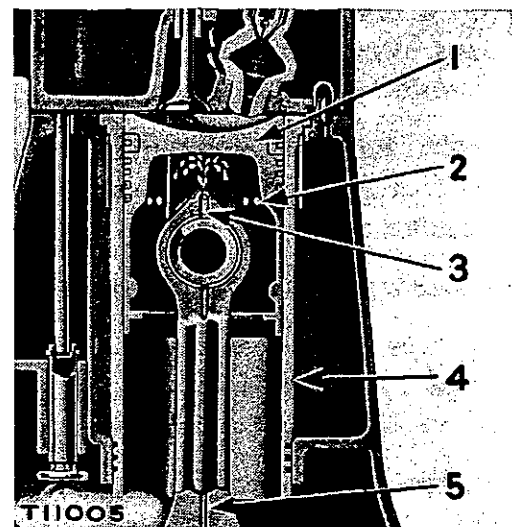
#### PISTON AND RING LUBRICATION (All Models)

The pistons (1) and the cylinder liners (4) are primarily lubricated by the oil that is splashed or thrown by the crankshaft while the engine is in operation.

Oil return holes (2) in the piston oil ring groove provide for the return of oil to the crankcase.

#### PISTON AND RING LUBRICATION

- 1-Piston. 2-Oil return hole. 3-Oil discharge holes at top of connecting rod.
- 4-Cylinder liner. 5-Drilled oil passage in connecting rod.



The drilled passage (5) in the connecting rod receives a supply of oil from the crankshaft to lubricate the piston pin and bushing. A portion of the oil is sprayed from the discharge hole (3) at the top of the connecting rod on the bottom of the piston crown to aid in cooling the piston.

## **PISTON AND CONNECTING ROD REMOVAL** (All Models)

1. Drain the lubricating oil and the engine coolant.
2. Remove the cylinder head as described in the topic, CYLINDER HEAD REMOVAL (ALL MODELS).
3. Remove the carbon from the inside surface near the top of the cylinder liner.
4. Remove the cylinder block inspection covers or the oil pan and remove the connecting rod cap as described in the topic, CONNECTING ROD BEARING REMOVAL AND INSTALLATION (ALL MODELS).
5. Rotate the crankshaft until the piston to be removed is at the top dead center. Carefully push the connecting rod upward in the cylinder liner until the piston rings are out of the liner.
6. Lift out the piston and the connecting rod assembly, being careful not to drop the connecting rod upper bearing, if it has not already been removed from below.

### **Cleaning and Inspecting Pistons (All Models)**

Pistons which are not worn excessively or scored badly should be cleaned and used again. The ring grooves should be square and smooth. The side clearance between a new ring and the top ring groove should not exceed .010".

There are a number of good carbon solvents available for cleaning pistons. Also a carbon softener for use on Diesel engine pistons is fresh, cold water.

Soak pistons in cold water overnight, let them dry (preferably in sunlight) and most of the carbon including that in the ring lands can be easily rubbed off.

Water works well only on aluminum pistons.

The use of broken rings or carbon scrapers on ring lands should in general be avoided, as lands can be cut. A stick of hard wood does a good job and won't scratch the piston.

The bottom of each ring groove must be clean and the oil return hole in the oil ring grooves must be open before the installation of new rings.

Never scrape the sides of the ring grooves or the contact surfaces of the piston. The area above the top ring can be filed smooth but pistons badly scored below the top ring groove should be replaced.

### **PISTONS RINGS (All Models)**

Piston rings seal compression and control the amount of oil on the cylinder walls. If oil consumption is not excessive and compression is satisfactory, pistons should not be removed nor new rings installed when the engine is dismantled for some other reason.

To avoid damage to the piston and rings, remove and replace the rings with a 5F9059 Ring Expander.



**INSTALLING PISTON RINGS**

There are three types of rings used. The top ring is chromium plated. The next two compression rings are identical. In later engines and in replacement sets, the second and third compression rings have a  $\frac{1}{2}^\circ$  taper face and have a TOP side marked. Be sure to install these rings correctly. The two lower or oil rings are interchangeable. See the topic, PISTONS AND RINGS (ALL MODELS).

When installing new piston rings, it is not necessary to check the gaps because new rings are supplied only in standard size. New rings in the standard size may be used in cylinder liners worn as much as .015". Oversize rings are unnecessary.

When new piston rings are to be used in worn cylinder liners, the ridge at the top of the liner should be raised and the liner etched as recommended in the topics, RAISING THE RIDGE IN WORN CYLINDER LINERS (ALL MODELS) and ETCHING CYLINDER LINERS (ALL MODELS).

## PISTON AND CONNECTING ROD INSTALLATION (All Models)

Be sure the carbon has been removed from the inside surface at the top of the cylinder liner.



PISTON INSTALLATION

Place the 5F6502 Ring Compressor on the top of the liner in which the piston is to be installed.

Space the ring gaps evenly around the piston and thoroughly oil the piston and the rings. Center the rings on the piston so they will not protrude more on one side of the piston than on the other.

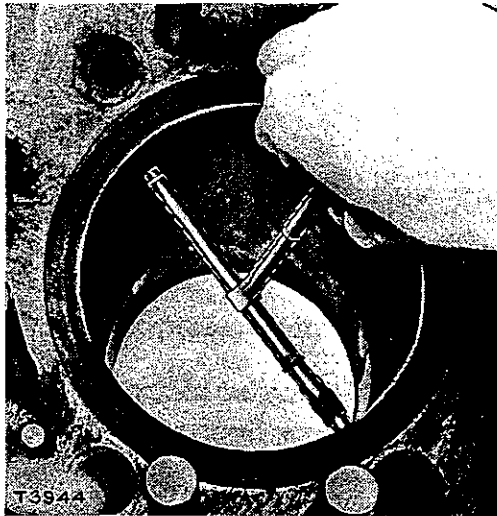
Place the piston and connecting rod into the ring compressor and the liner and position the V-mark on top of the piston in alignment with the V-mark on top of the cylinder block. This will place the crater of the piston directly under the opening of the pre-combustion chamber and the cutout portions of the piston in the correct location in relationship to the inlet and exhaust valves. The identification number on the connecting rod should be toward the inspection opening of the cylinder block.

Apply a gentle downward pressure on the piston. If the piston and rings do not pass into the liner freely, check the rings. It is possible that a ring can be positioned so it is protruding farther out on one side of the piston than the other, thus causing the piston ring to bind and preventing it from being compressed.



## Cylinder Liners (All Models)

Cylinder liner surfaces are machined, hardened, ground and finally honed to a mirror finish and chemically treated to assure proper break-in. The resultant surface is so hard that ordinary boring tools will not machine it.

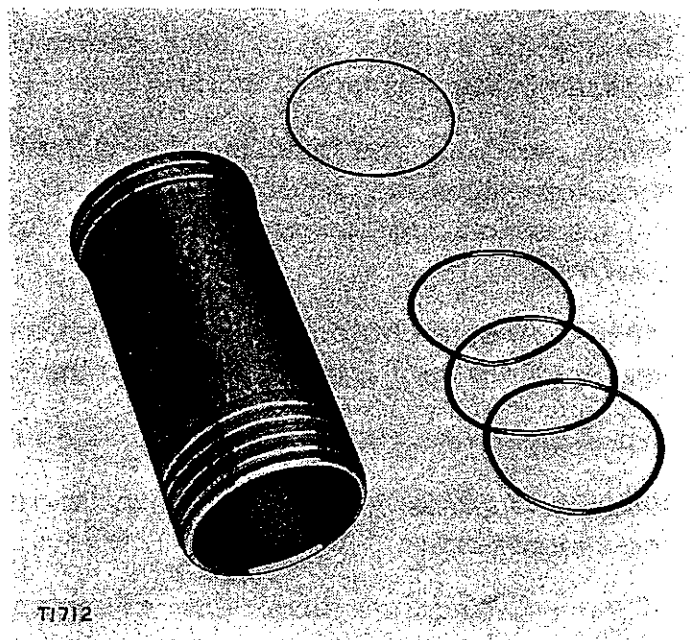


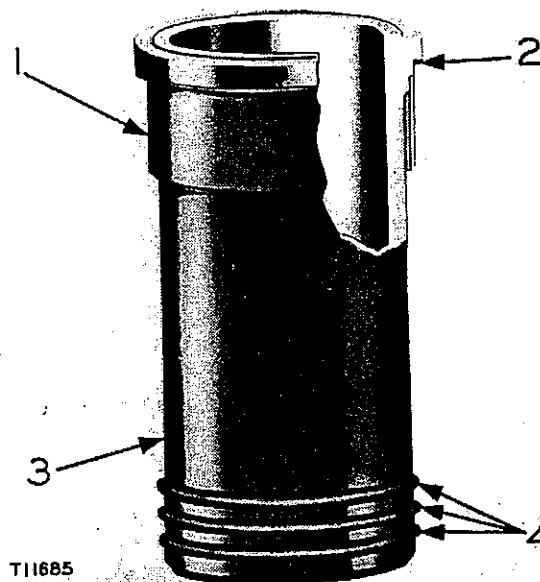
CHECKING LINER WEAR

Liners, pistons and rings are available from the factory in standard sizes only and require no fitting when they are installed.

Cylinder liners should be replaced when they are worn at the top of the ring travel more than .015" or when they are scratched or scored.

CYLINDER LINER  
(Earlier and later type not  
having a sleeve).





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**CYLINDER LINER**  
(Intermediate type which was equipped with a sleeve).

- 1-Sleeve. 2-Gasket.
- 3-Cylinder liner.
- 4-Seals.

Liner wear should be checked with an inside micrometer, as shown.

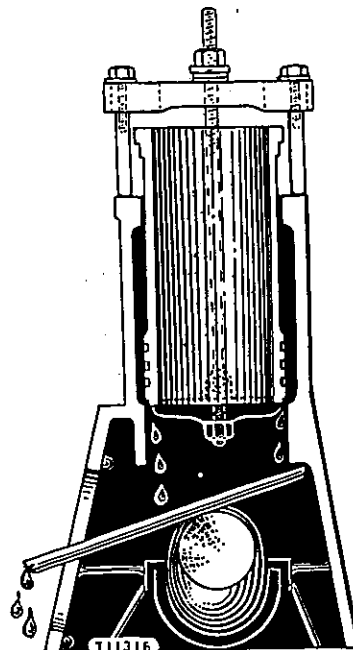
When installing a cylinder liner (3), be sure the cylinder block and liner are clean and always use a new gasket (2) and new liner seals (4). See the topic, CYLINDER LINER SEALS (ALL MODELS).

Earlier and later liners did not use the sleeve (1) while intermediate liners used the sleeve.

### REMOVING AND INSTALLING CYLINDER LINERS (All Models)

1. Drain the cooling system.
2. Remove the cylinder head, the connecting rods and the pistons as outlined in their respective topics.
3. When removing and installing the cylinder liners, rotate the crankshaft to position the crankshaft journal as far away as possible from the inspection opening for the cylinder from which the liner is being removed.
4. Place a piece of cardboard or heavy gasket material into the inspection openings as illustrated, to protect the inside of the engine.
5. Install the 5F7346 Puller and the 5F7362 Adapter Plate.
6. Remove the cylinder liner and clean the water jacket sediment from the cylinder block.
7. When installing the cylinder liner, always use a new gasket and rubber seals. Coat the rubber seals with liquid soap to ease installation.

**PROTECTING THE CRANKSHAFT  
AT TIME OF LINER REMOVAL**



8. Lower the cylinder liner carefully into the block. The liners can be driven into place by using a suitable driver, or by placing the puller adapter on the top of the liner. A block of hard wood to be used as a driving block is then placed on the puller adapter.
9. Drive the liner into the cylinder block until it bottoms. Then hit the block of wood several light taps, to assure that the liner is in. Occasionally the liner may bounce back out a trifle, if the last blow bottoms the liner too hard.

**NOTE**

Properly installed liners should extend slightly above the face of the cylinder block. This insures proper holding and sealing of the cylinder liner against the cylinder head gasket when the cylinder head is drawn down. Some liners may feel slightly loose in the cylinder block, yet serve satisfactorily without water or anti-freeze leaking past the rubber seals.

10. Remove the cardboard and assemble the parts in the reverse order of removal.

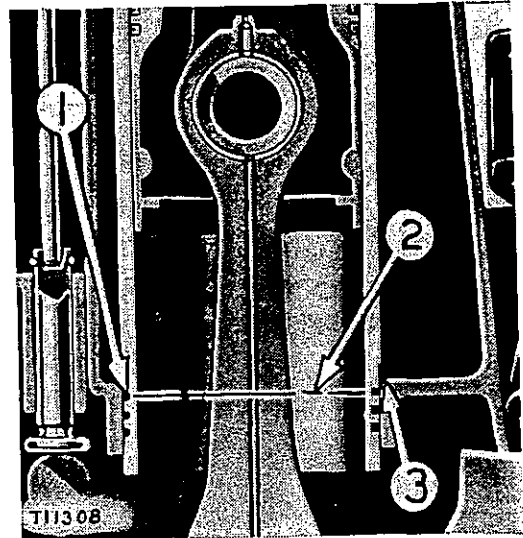
**Cylinder Liner Seals (All Models)**

When installing liners, use a new copper gasket and new rubber seals. Coat the rubber seals with liquid soap to ease installation.

When three liner seals are used, the top seal (1) protects the cylinder bore chamfer (3) from the rust and scale. The cylinder bore chamfer is

### THREE SEAL LINER

1-Top seal. 2-Center line of the top seal ring groove. 3-Cylinder bore chamfer.



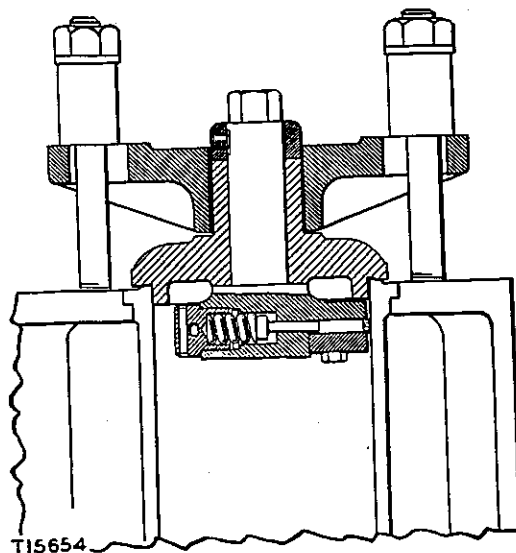
machined to permit the lower edge of the chamfer to align with the center line (2) of the top seal ring groove as illustrated.

Earlier models used two liner seals and the location of the cylinder bore chamfer did not meet the top seal.

If an old liner had only two liner seals, use only two seals in the two bottom grooves of the replacement liner.

### RAISING THE RIDGE IN WORN CYLINDER LINERS (All Models)

When new piston rings are to be used in worn cylinder liners, the ridge in the liner at the top of the ring travel should be raised to provide clearance for the new top ring.



LINER RIDGE BORING TOOL

Since the liners are too hard for ordinary tools, the 3F960 Cylinder Liner Ridge Boring Tool is available for this purpose. Use this with the 5F9581 Body and the 5F9582 Tool Bit. The illustration shows how the tool appears when installed.

The tungsten carbide tool bit is spring loaded and specially ground so it will follow the worn contour of the liner and will not cut deeper than the worn surface. Instructions for its use accompany the tool.

#### **CAUTION**

Be careful not to rotate the tool counterclockwise when the tool bit is against the liner wall. Doing so will break the cutting edge.

The worn liners should be etched or honed to remove the highly glazed surface. Either of these processes will shorten the running-in period and improve the performance of the rings. If the engine still does not break in properly, see the topic, BREAK-IN POWDER (ALL MODELS).

#### **ETCHING CYLINDER LINERS (All Models)**

An inexpensive etching tool can be made similar to the one shown.

Use an etching solution composed of:

Oxalic Acid (commercial grade)—10 ounces

Acetic Acid (Glacial)— $\frac{3}{4}$  fluid ounce

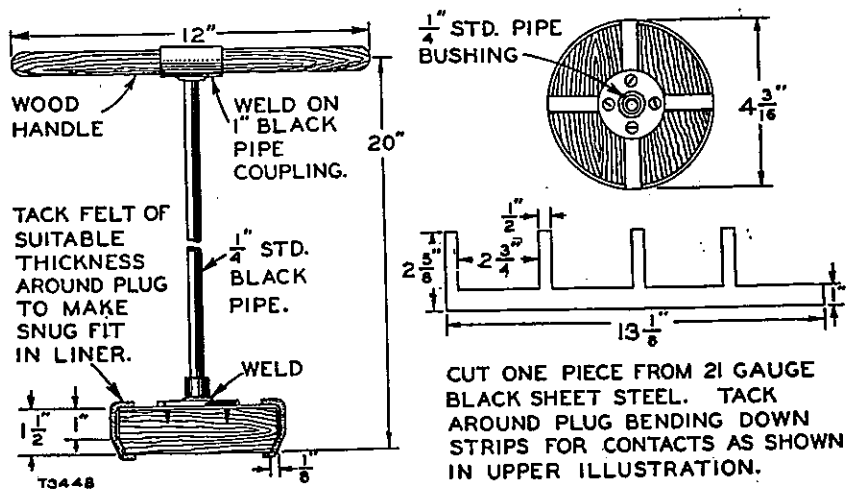
Denatured Alcohol (Industrial)—7 fluid ounces

Add sufficient water to make one gallon.

To prepare the etching solution, dissolve the oxalic acid crystals in approximately one-half gallon of water in a glass container. Add the acetic acid and stir until well mixed. Add the denatured alcohol and water to make one gallon. The solution can be kept indefinitely in a tightly closed glass container.

Clean the liner with cleaning solvent and flush with carbon tetrachloride to remove all traces of oil. Cover the crankshaft beneath the liner to protect it from the etching solution, by using a similar method as illustrated.

Saturate the felt on the tool with the etching solution and place the tool in the liner bore and force it to the bottom.

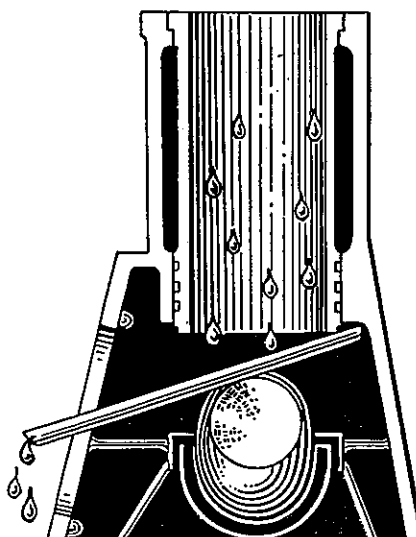


**CYLINDER LINER ETCHING TOOL**

Connect the positive (+) terminal of a 6 volt storage battery to one of the cylinder block studs and the negative (—) terminal to the shank of the tool using wires and battery clips. Move the tool up and down the liner bore with a spiral movement for eight or ten minutes with the current at 15 to 20 amperes. Etching solution should be added while the tool is in the liner to keep the felt well saturated.

Care should be taken to see that the tool is kept in motion while the electrical circuit is complete.

After the etching process, remove the tool from the liner, wipe the liner clean and dry and coat it with oil. Flush out the crankcase before assembling the engine.



**PROTECTING CRANKSHAFT  
DURING ETCHING PROCESS**

T8625

## Running-in Schedule (All Models)

The following is a reproduction of the label that accompanies pistons and rings sent out from the "Caterpillar" Parts Department.

CAUTION		
Whenever new rings, piston assemblies or liners are installed be sure to run-in the engine on at least a 4-hour conditioning schedule before operating at normal load and speed. Avoid operating the engine at high speed idle at any time during the conditioning process. The following schedules are indicated as safe procedures to follow:		
	DIESEL TRACTOR	DIESEL POWER UNITS
Period 1: 1/2 hour	Operate the engine at low idle speed.	Operate the engine at low idle speed.
Period 2: 1/2 hour	Operate the tractor in 4th gear without load at 3/4 rated speed.	Operate the engine on work approximating 1/4 maximum load at 3/4 rated speed.
Period 3: 2 hours	Operate the tractor at 3/4 rated speed on light work.	Operate the engine on work approximating 1/2 maximum load at 3/4 rated speed.
Period 4: 1 hour	Operate the tractor at full rated speed on medium work.	Operate the engine on work approximating 3/4 maximum load at full rated speed.
These periods may be impractical to maintain in all cases; however, at least three hours should be accumulated before operating at full rated speed. Do not run the engine idle for a long period after installing new rings or liners. <b>Rings will not seat during idle operation.</b> Place some load on the engine after 1/2 hour of operation and put a full load on the engine if at all possible, after 4 hours of operation.		
T11370		

## Break-in Powder (All Models)

Besides honing or etching the cylinder liners, a third method has frequently been used to hasten the seating of new rings. This method uses 7F5225 Bon Ami Powder. The procedure is as follows:

After assembling and starting the engine, loosen the air cleaner to allow a gap between the air cleaner flange and the air inlet pipe, (or on a marine engine, loosen the silencer to provide a gap between it and the inlet manifold.) Run the engine at about 800 RPM and allow the powder to be sucked slowly through the gap and into the engine. Use 3/4 of a teaspoonful of powder per cylinder and then tighten the air cleaner. Run the engine idle at 800 RPM for thirty minutes, and it is then ready for service.

This method of break-in has been used successfully when facilities were not available for honing or etching the liners. It has also been successful when, for some unknown reason, new rings and liners have failed

to break-in in a reasonable length of time. If the first powder treatment is not effective, a second one may be. However, if the second treatment is not effective, a thorough investigation should be made to determine the cause of oil consumption.

## Main Bearings (All Models)

The main bearings support the crankshaft in place in the cylinder block.

The main bearings are precision type, aluminum alloy for earlier engines, and steel-backed aluminum for later engines. The upper halves are located in ribs in the cylinder block.

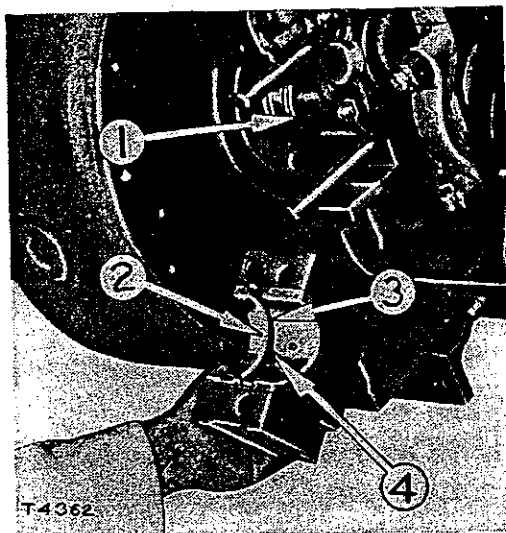
The lower halves are located in the main bearing caps which are secured to the block by studs and nuts.

The lower halves are held in position by dowels in the bearing caps and the upper halves are doweled to the lower halves. This construction makes it possible to remove and replace the main bearings with the crankshaft in place.

Oil under pressure enters the drilled passages in the cylinder block from the oil manifold. See the topic, OIL MANIFOLD (ALL MODELS).

The main bearings are lubricated by this supply of oil. The oil is then carried through the drilled passages in the crankshaft to lubricate the connecting rod bearings.

The center main bearing takes the end thrusts of the crankshaft. The normal end clearance is .009"-.015" and the maximum permissible end clearance is .025".



### REAR MAIN BEARING

1-Oil return threads. 2-Larger diameter section of rear main bearing. 3-Oil groove. 4-Drilled passage.



The flywheel end of the rear main bearing is bored .003" to .005" larger in diameter at (2) and consequently, the crankshaft does not touch this part of the bearing. This section of the bearing provides for oil control by permitting the oil return threads (1) on the crankshaft to deliver oil to the oil groove (3). From the groove, the oil returns to the oil pan through the drilled passage (4).

### REMOVING MAIN BEARINGS (All Models)

Remove only one bearing at a time unless the crankshaft is to be taken out. The bearing caps are identified by numbers stamped on the sides of the caps and block as shown.

Always return the bearing caps to their proper locations, using the numbers as a guide.

To remove the main bearings drain the oil and remove the oil pan.

Remove the oil line or lines attached to the oil pump.

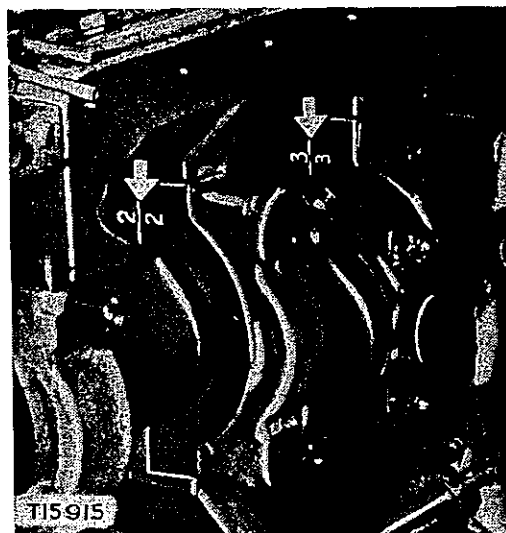
Remove the oil pump and main suction bell. On the D4 Tractor the front suction bell and tube assembly must also be removed.

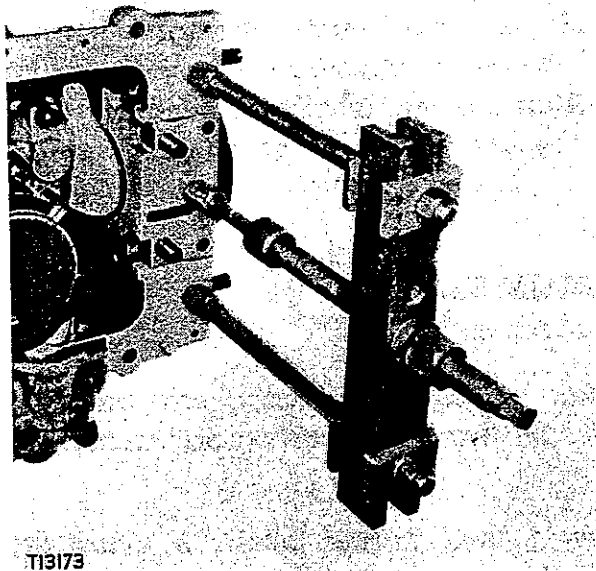
Remove the balancer if so equipped.

All the main bearing caps (with the exception of the rear main bearing) are held in place by two studs and two nuts.

The rear main bearing is also held in place by two studs and nuts, plus two additional hollow head capscrews. The rear bearing cap also has a packing groove cut along each side, which must be filled with packing at the time of installation. The packing prevents engine oil from entering the flywheel housing.

#### MAIN BEARING CAP IDENTIFICATION





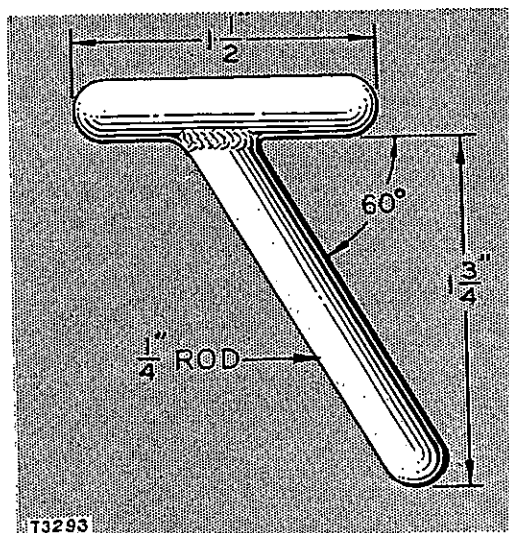
PULLING REAR MAIN  
BEARING CAP

To remove the rear main bearing, remove the two nuts and hollow head capscrews.

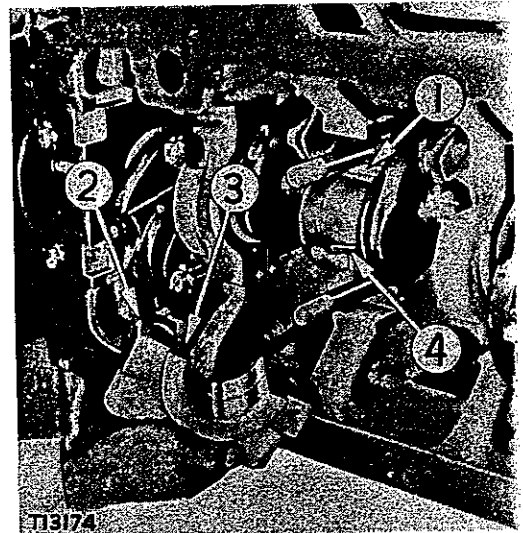
Install the 8B7559 Adapter, 8B7553 Reducing Adapter and the 8B7548 Push Puller as illustrated and pull the cap.

The remaining main bearing caps have recesses cast in the sides with which to assist in their removal.

Grasp the bearing cap (2) at the recessed portion, then pull outward and tap the cap gently with a soft hammer to remove it. A bar can also



TOOL FOR REMOVING AND  
INSTALLING MAIN  
BEARINGS



REMOVING UPPER HALF OF  
MAIN BEARING

1-Upper half of bearing. 2-Bearing cap.  
3-Lower half of bearing. 4-Bearing  
removing and installing tool.

be used to remove the cap by placing the end of the bar in the recess of the cap and applying pressure.

To remove the lower half (3) of the main bearing from the main bearing cap, hold the cap at one end so the bearing portion of the cap is down. Tip the cap at a slight angle and bump it lightly on a hard wood block.

The upper bearing half (1) can be removed by using a bearing removing and installing tool, made to the dimensions shown in the illustration.

Turn the crankshaft to the position where the drilled oil hole in the shaft is accessible for the bearing to be removed.

Insert the angled part of the bearing removing tool (4) in the drilled passage and remove the bearing half by rotating the crankshaft slowly.

### **MAIN BEARING INSPECTION** (All Models)

Although fine dirt and abrasives in the oil affect aluminum and babbitt bearings somewhat alike, coarser particles act quite differently. While the softer babbitt bearing may permit large particles to become embedded in the bearing, these same size particles may merely roll around between the bearing and the crankshaft journal causing scratches in the aluminum bearing without actually becoming embedded in the aluminum. Such scratches are not necessarily harmful and do not indicate that the bearing should be replaced.

If there is any question about the surface of a bearing, wash it with cleaning solvent to remove the oil. Then, if the surface feels rough and abrasive to the touch, replace the bearing with a new one. Another indication of dirt in the bearing is excessive crankshaft wear.

### **REPLACEMENT MAIN BEARING** (All Models)

Precision main bearings, machined to provide proper clearance, are obtainable in complete sets and should be installed without fitting, scraping, filing or boring.

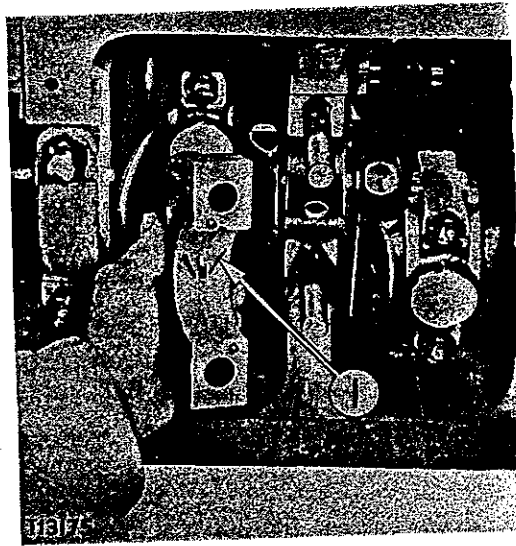
Single replacement bearings can also be obtained and installed without special fitting. As a rule, however, it is good practice to replace the complete set if any one of the bearings needs to be replaced because of wear. If only one new bearing is installed and the other bearings are worn to any extent, the new bearing will carry more than its normal share of load and damage to it or the crankshaft can result.

Precision main bearings are also obtainable for use with crankshafts reground to .030" undersize.

### Checking Main Bearing Clearance (All Models)

The clearances of the main bearings can be measured without removing the crankshaft if the engine is in an upright position. However, the crankshaft must be held against the upper halves of the main bearings, otherwise the weight of the crankshaft can compress the lead wire slightly and indicate a lesser clearance than really exists.

The crankshaft can be held against the upper halves by placing paper, approximately .025" thick, between the lower half and the crankshaft journal of at least two bearings not being checked and tightening those bearing caps. Torque the nuts on those caps to 120 pound feet.



#### CHECKING BEARING CLEARANCE

1-Soft lead wire.

The bearing clearance can be checked by placing soft lead wire (1) between the lower bearing half and the crankshaft. Lead wire for this purpose can be obtained from the Parts Department by ordering part number 5B1161.

Coat two one-inch lengths of the wire with soft grease and place them diagonally on the bearing surface as shown. The soft grease will keep the wires in position while installing and tightening the cap.

Tighten the main bearing stud nuts to 120 pound feet torque. Turn the crankshaft one complete revolution during the final tightening.

Remove the bearing cap and lower bearing half and check the thickness of the lead wire with a 0" to 1" micrometer to determine the bearing clearance.

The main bearing clearance is .006"-.0085" with a maximum permissible clearance of .015".

## NOTE

If the engine is disassembled to a point where it can be placed upside down, the bearing clearance can be checked without the use of paper shims to hold the crankshaft against the upper halves of the bearings. The weight of the crankshaft will be sufficient to seat it in the upper halves of the bearing. Do not check bearing clearances with the engine lying on its side, since the crankshaft will shift to one side of the bearing bores in this position and an accurate check will not be obtained.

### Installing Main Bearings and Bearing Caps (All Models)

The upper halves of the main bearings can be installed with the crankshaft in place, by starting them into their proper locations and pulling them into place by inserting the tool used for bearing removal. See the topic, REMOVING MAIN BEARINGS (ALL MODELS) for description of and method of using the bearing removing and installing tool.

Install the lower halves of the bearings in their respective bearing caps. Be certain the bearing half is properly positioned on the locating dowel in the cap.

Push the bearing caps into their proper locations. Each cap is numbered and must be located in the cylinder block accordingly.

After all the bearing caps are in place, start the two hollow head cap-screws in the rear main bearing. Start and tighten the nuts to 120 pound feet on all but the center main bearing cap.

Before tightening this cap, pry the crankshaft as far forward as possible. This is absolutely necessary to align the thrust faces of the center main bearing in order to obtain proper crankshaft end clearance.

#### PACKING REAR MAIN BEARING CAP

1-Packing.



After the bearing faces have been aligned, the nuts for this bearing cap should also be tightened to 120 pound feet.

It is permissible to exceed the 120 pound feet by the amount required to align the next cotter pin hole in the stud and nut. Tighten the hollow head capscrews in the rear main bearing cap.

After tightening the nuts and hollow head capscrews in the rear main bearing cap, seal the cap by installing new 2B2414 Packing (1) in the grooves.

Work the packing into the grooves as shown, tamping it in tightly with a hammer and long thin punch until the grooves are filled.

Check the crankshaft end clearance. See the topic, CHECKING CRANK-SHAFT END CLEARANCE (ALL MODELS).

## **Flywheel and Flywheel Housing**

The flywheel housing is attached to the rear of the Diesel engine cylinder block. The housing provides an enclosure for the engine flywheel and a mounting surface for the starting engine.

The flywheel is mounted on the flange at the rear end of the engine crankshaft by the use of ground capscrews.

The flywheel is equipped with a ring gear into which the starting engine clutch pinion engages to make Diesel engine starting possible.

### **FLYWHEEL REMOVAL AND INSTALLATION (All Models)**

To facilitate the flywheel removal, first disconnect whatever attachment is connected to and driven by the flywheel. Since there are many different models, they are not illustrated here.

Remove the capscrews holding the flywheel (1) to the crankshaft and remove the flywheel.

When installing the flywheel, clean the mating surfaces of both the crankshaft bolting flange and the flywheel.

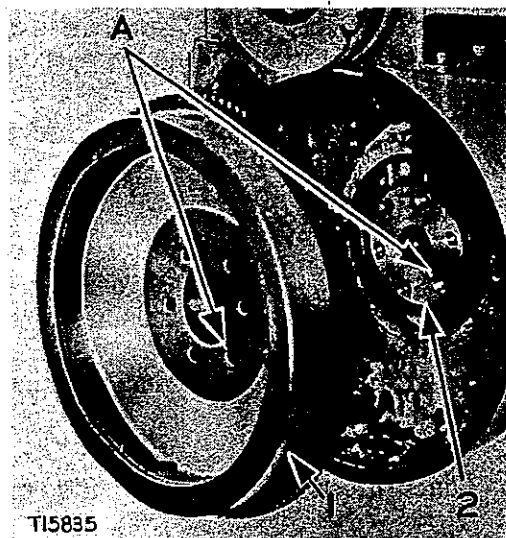
Remove any burrs on the mating surfaces.

Using a capscrew that is used to attach the flywheel, check all the capscrew holes in the flywheel, to see that they are free of roughness and burrs.

Install the flywheel (1) to the crankshaft flange (2) matching the timing marks (A).

## FLYWHEEL INSTALLATION

A—Timing marks. 1—Flywheel.  
2—Crankshaft flange.



Using a soft brass bar, bump the flywheel to assure its being flat against the mating surface of the crankshaft flange.

Install the locks and capscrews through the holes in the flywheel, and start each capscrew before tightening any of them.

After it has been determined that all capscrews have been started correctly, tighten them evenly and diametrically.

If for some reason it is suspected the flywheel mating surface is not in true alignment with the crankshaft flange, the flywheel run-out should be checked with a dial indicator. The indicator reading should not exceed .006" for both the bore and the face.

## RING GEAR

To remove the ring gear, remove the capscrews around it, apply heat to the ring gear and press or drive it off the flywheel.

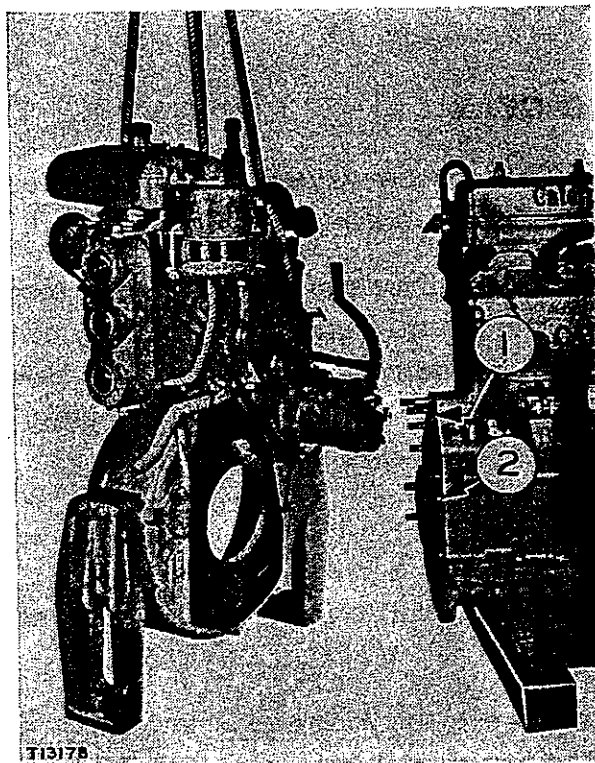
Before installing a new ring gear, carefully clean the contact surfaces of the ring gear and flywheel, and remove all burrs. Heat the ring gear in oil and install it with the chamfer to the rear. Install the capscrews while the ring gear is still hot and pull them down evenly and tightly. After the ring gear cools, retighten the capscrews and lock securely.

## Flywheel Housing Removal and Installation

The flywheel housing can be removed either with or without the starting engine in place.

The following describes the procedure to be followed when removing the flywheel housing with the starting engine in place.

1. Remove the Diesel engine flywheel. See the topic, FLYWHEEL REMOVAL AND INSTALLATION (ALL MODELS).
2. Drain the cooling system and disconnect the water return connection between the starting engine manifold and the Diesel engine cylinder head.
3. Disconnect the fumes disposal tube and remove the Diesel engine air inlet pipe and air cleaner.
4. Disconnect the starting engine exhaust pipe at the Diesel engine inlet manifold.
5. Disconnect the heat indicator and the oil and fuel gauges.
6. Place suitable cables around the starting engine and attach the cables to a hoist.
7. Raise the hoist enough to support the weight of the starting engine and the flywheel housing.
8. Block under the oil pan of the Diesel engine to support the weight of the engine.
9. Remove the nuts and locks that secure the flywheel housing to the Diesel engine cylinder block.
10. Bump the housing off the dowels with a brass bar or block of wood.



**INSTALLING FLYWHEEL  
HOUSING**

**1-Ring seal. 2-Dowel.**



11. Remove the housing and starting engine together as illustrated.
12. Block the housing and starting engine in an upright position during the time it is removed.
13. Before installing the flywheel housing, see that the mating surfaces of the flywheel housing and the cylinder block are clean and free of burrs.
14. Check the dowels (2) for any burrs or roughness that might cause difficulty at installation.
15. Be sure the ring seal (1) is in good condition and is in place in the cylinder block.
16. Install the flywheel housing.
17. Seat the housing against the cylinder block by bumping it with a heavy object, preferably a brass bar.
18. Install the locks and nuts.
19. Tighten the nuts to 150 pound feet and bend the locks against the nuts.
20. Check the flywheel housing face and bore run-out as described in the covering topics.
21. Complete the assembly of the engine.

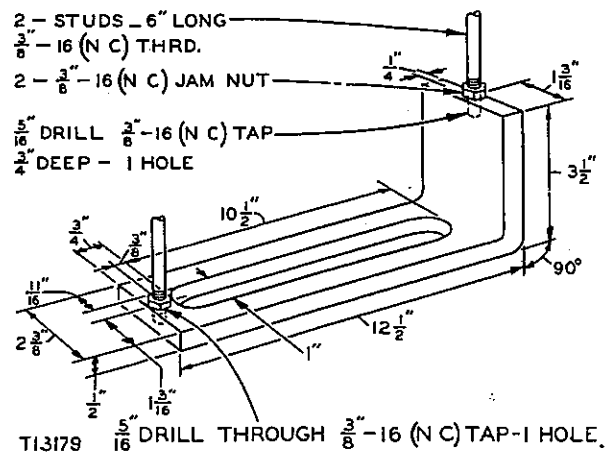
### Checking Flywheel Housing Bore Run-out (All Models)

To assure accurate results, always have the flywheel removed when checking flywheel housing run-out.

Clean the face and counterbore surfaces of the flywheel housing, where the dial indicator anvil will be in contact, to assure a correct reading.

Install a dial indicator to the crankshaft flange using a rigid support bracket for the indicator as illustrated.

INDICATOR MOUNTING  
BRACKET



An indicator mounting bracket made to the dimensions given in the accompanying illustration, is recommended for making the runout check.

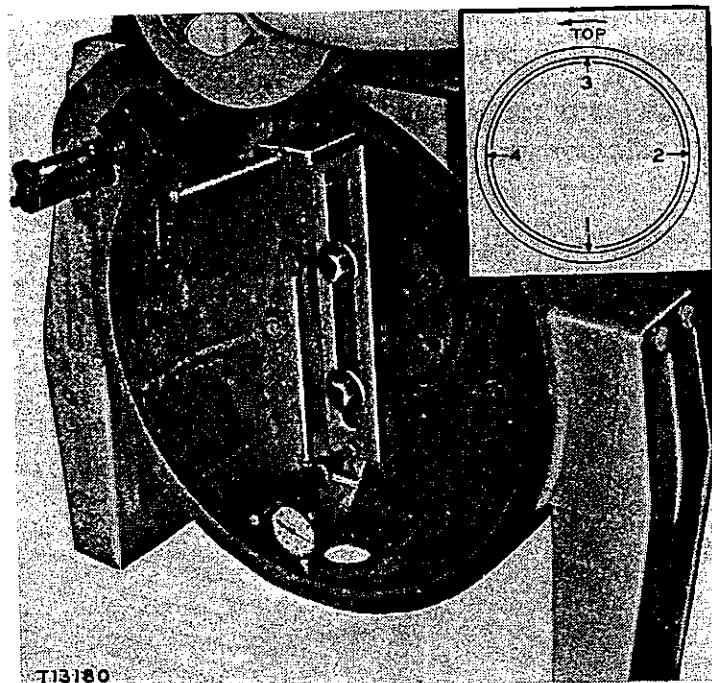
Turn the crankshaft to position the dial indicator at the starting point (1).

Adjust the dial indicator to read .000". (Since the crankshaft is resting on the lower halves of the main bearing shells, this is used as a starting point.)

Turn the crankshaft 90° to position the dial indicator at (2). Carefully pry the crankshaft toward the location (2) to permit the crankshaft to touch the halves of the main bearings. Take the indicator reading.

Turn the crankshaft to position the dial indicator at point (3). Pry the crankshaft upward to permit the crankshaft to touch the upper halves of the main bearings and take the indicator reading at this point.

Turn the crankshaft to position the dial indicator at point (4). Take indicator readings at point (4) as described for point (2). On flywheel housings that have the starting engine starter pinion mechanism installed, the crankshaft must be turned in the opposite direction to avoid bumping the dial indicator.



CHECKING FLYWHEEL HOUSING BORE RUN-OUT  
1-Bottom. 2-Right side. 3-Top. 4-Left side.

The indicator readings should not exceed .007" total run-out for the flywheel housing bore, for single-bearing generator installations, and .010" for other models.

#### NOTE

If any method is used other than the method described here for checking the run-out, always allow for bearing clearances in order to obtain correct readings.

#### Checking Flywheel Housing Face Run-out (All Models)

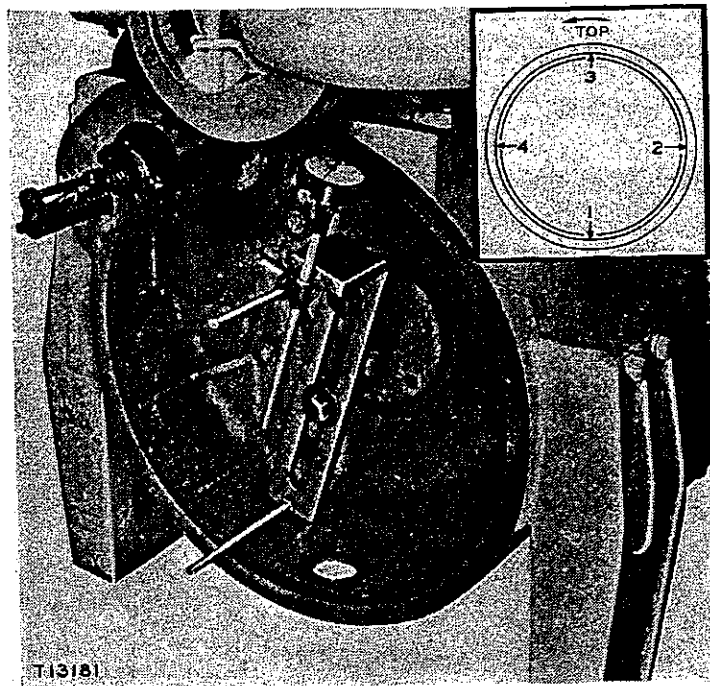
Install a dial indicator as illustrated and turn the crankshaft to position the dial indicator at point (1). See the topic, CHECKING FLYWHEEL HOUSING BORE RUN-OUT (ALL MODELS), for dimensional illustration of indicator mounting bracket.

Pry the crankshaft forward and adjust the indicator to read .000".

Turn the crankshaft and take readings at points (2), (3) and (4). Always pry the crankshaft forward before taking readings to be sure the end clearance is always in the same direction.

The readings should not exceed .007" total run-out for the flywheel housing face on single-bearing generator installations.

On other installations the total run-out for the flywheel housing should not exceed .010".



CHECKING FLYWHEEL HOUSING FACE RUN-OUT  
1-Bottom. 2-Right side. 3-Top. 4-Left side.

## Crankshaft

(All Models)

The crankshaft is of the forged-steel type, having five main bearing journals (7), (8), (9), (10), and (11), and four connecting rod bearing journals (2), (3), (4), and (5).

The main bearings receive their supply of lubricant from the engine oil manifold, through drilled passages in the cylinder block.

Oil is transmitted to the connecting rod bearings from the main bearings, through drilled passages (6) in the crankshaft.

The main bearing journals are numbered consecutively 1 through 5 from the front of the engine.

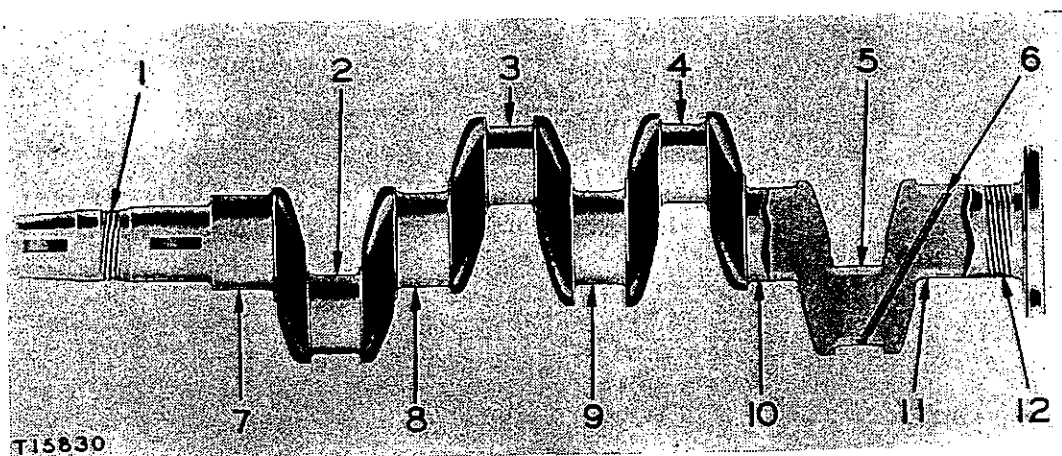
Connecting rod journals are located consecutively 1 through 4, from the forward end of the crankshaft.

The oil threads (1) and (12) return excess oil to the engine oil pan.

The front, center and rear main bearing journals (7), (9) and (11) are wider and therefore, have more bearing surface than the intermediate main bearing journals (8) and (10).

All new crankshaft main bearing journals should be 3.499"-3.500" in diameter and all connecting rod bearing journals should be 2.999"-3.000" in diameter.

A crankshaft is considered unfit for service if the wear on the main bearing or connecting rod bearing journals exceeds .006", if the con-



CRANKSHAFT

1-Oil thread. 2-No. 1 connecting rod journal. 3-No. 2 connecting rod journal. 4-No. 3 connecting rod journal. 5-No. 4 connecting rod journal. 6-Drilled passage. 7-Front main journal. 8-Intermediate main journal. 9-Center main journal. 10-Intermediate main journal. 11-Rear main journal. 12-Oil thread.

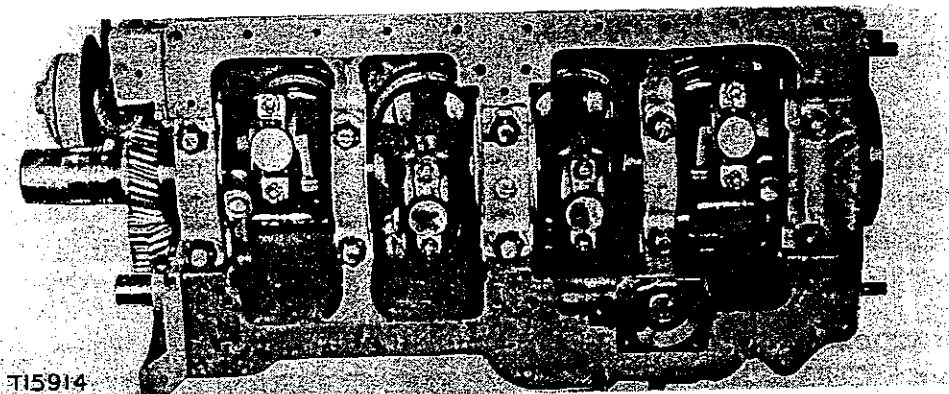
necting rod bearing journals are more than .006" out-of-round, or if the journals are scored.

If a crankshaft is not worn or scored too badly, it can be reground to .030" undersize on both the main and connecting rod journals, for which bearings are available. Make sure to maintain the same radii at the ends of the journals. This will reduce the possibilities of failures at these points.

The crankshaft end thrust is taken by the center main bearing. See the topic, CHECKING CRANKSHAFT END CLEARANCE (ALL MODELS).

### CRANKSHAFT REMOVAL AND INSTALLATION

1. Drain the cooling system.
2. Drain the oil and remove the oil pan.
3. Remove the flywheel, starting engine and flywheel housing. See the covering topics.
4. Remove the radiator if so equipped and remove the timing gear housing cover.
5. Position the engine on its side as shown.
6. Remove the oil pump and suction bell or bells.
7. Remove the balancer and balancer idler gear, if so equipped.
8. Remove the front, center and rear main bearing caps and bearing lower halves.
9. Wrap pieces of clean cloth around the No. 1 and the No. 4 connecting rod journals on the crankshaft.
10. Loop a rope sling at least twice around each of the two rod journals that are covered by cloths.
11. Attach the rope sling to a suitable hoist and take the slack out of the sling.
12. Cover the main bearing studs to prevent marring the crankshaft journals in the event they should accidentally contact the studs.
13. Remove the nuts from the remaining two main bearing caps.
14. Place hand pressure against the center main bearing journal to hold the crankshaft in place, then remove the caps and cover the studs.
15. Carefully roll the crankshaft out of the bearing upper halves and lift it from the engine.
16. When installing the crankshaft, coat the upper and lower halves of the main and connecting rod bearings with oil.



### REMOVING CRANKSHAFT

17. Use the rope sling used at the time of removal to lift the crankshaft into place in the cylinder block.
18. Install the main and connecting rod bearing caps, nuts and the two hollow head capscrews in the rear main bearing cap. Tighten the main bearing cap nuts to 120 pound feet and the connecting rod cap nuts to 58 pound feet. Each of the torque values may be exceeded by the amount necessary to align the cotter pin holes.
19. Tighten the hollow head capscrews and lock all nuts with cotter pins.
20. Pack the rear main bearing as described in the topic, INSTALLING MAIN BEARINGS AND BEARING CAPS (ALL MODELS).

### Checking Crankshaft End Clearance (All Models)

The crankshaft end thrust is taken by a thrust face on the center main bearing.

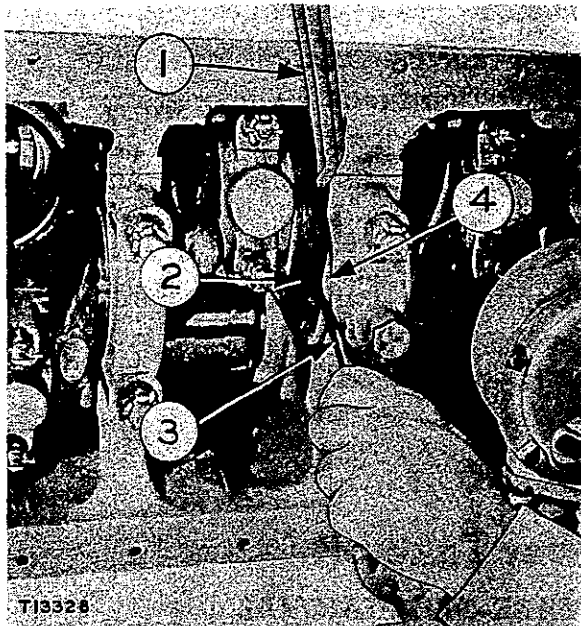
The end clearance can be checked by removing the crankcase inspection covers or when the oil pan is removed. The oil pan is shown removed for better illustration.

Place a bar (1) in the position shown and force the crankshaft as far forward as it will go.

Check the clearance between the crankshaft flange (2) and the thrust face of the center main bearing (4), with a thickness gauge (3).

The clearance should be from .009"-.015", with a maximum permissible end clearance of .030".

If the end clearance measures less than .009", it may be due to misalignment of the center main bearing thrust faces.



### CHECKING CRANKSHAFT END CLEARANCE

1-Bar. 2-Crankshaft flange.  
3-Thickness gauge. 4-Center main bearing.



Loosen the center main bearing cap nuts and pry the crankshaft all the way toward either the front or rear of the engine and retighten the nuts. Check the end clearance again and if the clearance is not corrected, the crankshaft and bearing should be removed and thoroughly inspected to determine the cause.

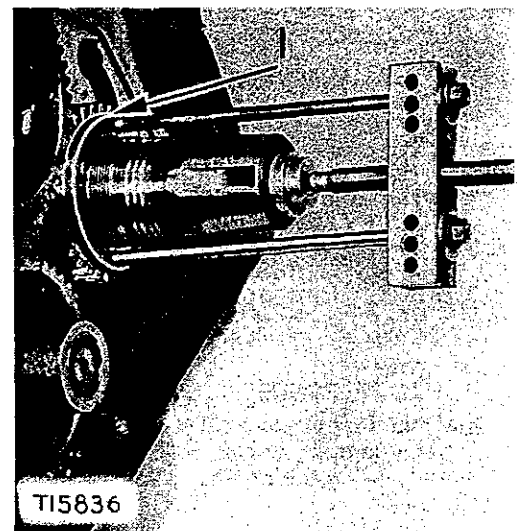
### CRANKSHAFT GEAR REMOVAL AND INSTALLATION (All Models)

To remove the crankshaft gear (1), remove the nut and lock. Then pull the gear using a 5F7465 Puller with two  $\frac{3}{8}$ "-24 (NF) capscrews  $8\frac{1}{2}$ " long as shown.

Heat the gear, preferably in an oil bath, and place it on the crankshaft, lining up the key and keyway. Turn the camshaft until the marked teeth on the camshaft gear and crankshaft gear are in alignment.

### REMOVING CRANKSHAFT GEAR

1-Crankshaft gear.



### CAUTION

When turning either the crankshaft or camshaft independently, do not force it if it binds. There may be interference between the pistons and valves. Turn the crankshaft a few degrees in the opposite direction if interference is encountered.

Push the crankshaft gear into position, making sure it is tight against the shoulder before it cools. If necessary, drive the gear into position, using a hammer and soft metal drift. Install and lock the retaining nut.

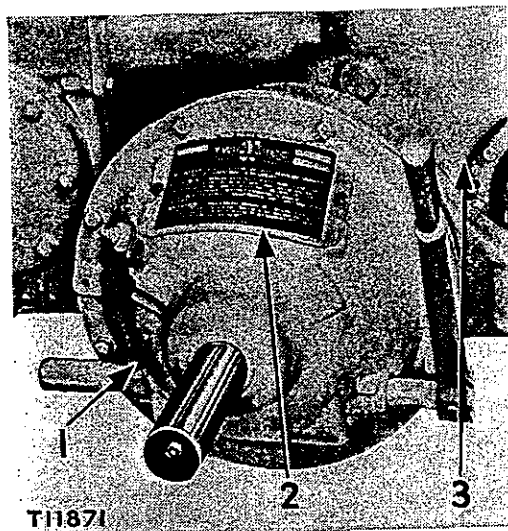
## Front Power Take-off

### FRONT POWER TAKE-OFF REMOVAL (D315M)

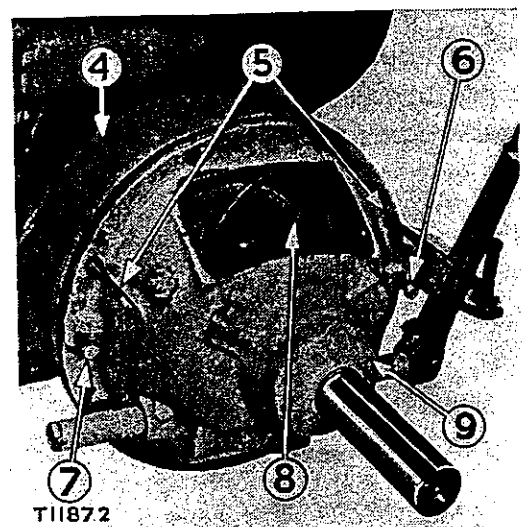
The front power take-off assembly (1) is mounted to the timing gear cover (3), and is attached to and driven by the crankshaft.

The front power take-off can be removed in the following manner:

1. Remove the inspection cover (2).
2. Engage the clutch to lock the driving plates (8) in place. This will be helpful if the clutch assembly is not disassembled, and will keep the plates aligned.

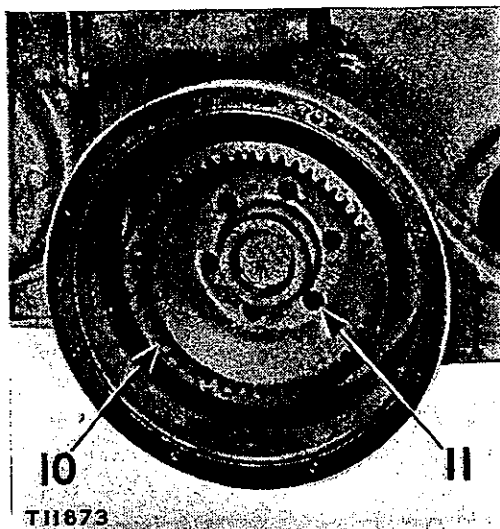


**FRONT POWER TAKE-OFF**  
1-Front power take-off assembly.  
2-Inspection cover. 3-Timing gear cover.

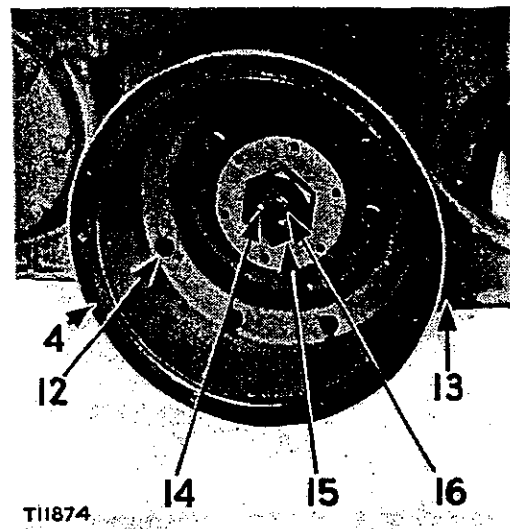


**REMOVING CLUTCH COVER ASSEMBLY**  
4-Adapter. 5-Guide pins. 6-Puller capscrow. 7-Puller capscrow. 8-Driving plates. 9-Clutch cover assembly.





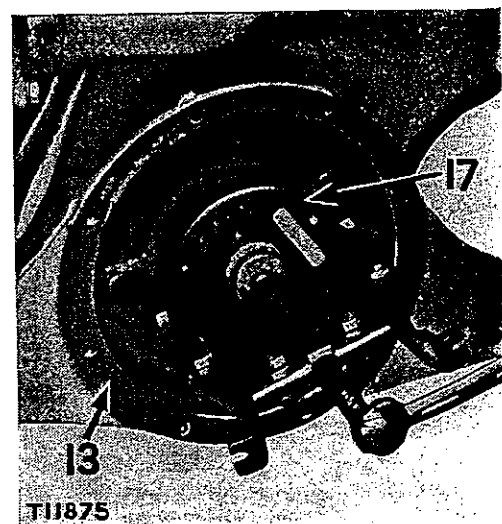
**REMOVING COUPLING**  
10-Coupling. 11-Capscrew.



**REMOVING ADAPTER AND  
CRANKSHAFT NUT**  
4-Adapter. 12-Capscrew. 13-Support.  
14-Lock. 15-Crankshaft nut. 16-Cap-  
screw with left-hand threads.

3. Remove two of the capscrews holding the clutch cover assembly (9) to the adapter (4) and install two  $\frac{3}{8}$ "-16 (NC) guide pins (5).
4. Remove the remaining capscrews holding the cover assembly (9).
5. Install two  $\frac{3}{8}$ "-16 (NC) capscrews (6) and (7) as illustrated and pull the cover assembly. The guide pins (5) will support the cover assembly while pulling is being done.
6. Remove the capscrews (11) holding the coupling (10) and remove the coupling.
7. Remove the capscrews (12) holding the adapter (4) to the support (13) and remove the adapter.

**PULLING HUB**  
13-Support. 17-Hub.



8. Bend the lock (14) and remove the capscrew (16) which has left-hand threads.
9. Remove the crankshaft nut (15).
10. Remove the hub (17) using the 8B7546 Puller and a step plate as illustrated. Remove the crankshaft key.
11. Block the engine and remove the support (13).

### FRONT POWER TAKE-OFF INSTALLATION (D315M)

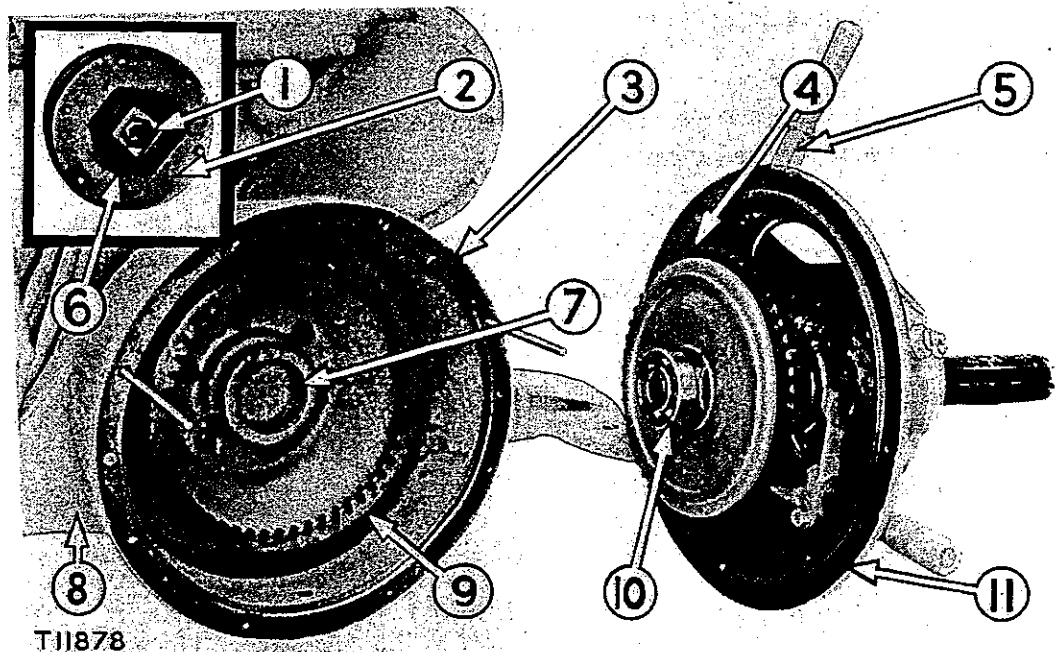
The procedure for installing the front power take-off is as follows:

Be sure the driving plates (4) are aligned properly in order to be a slip-fit into the mating splines of the coupling (9).

If the coupling will not slide easily over the plates, disengage the clutch. Align the mating splines, slide the coupling on and engage the clutch by operating the lever (5) to lock the plates in place. Slide off the coupling.

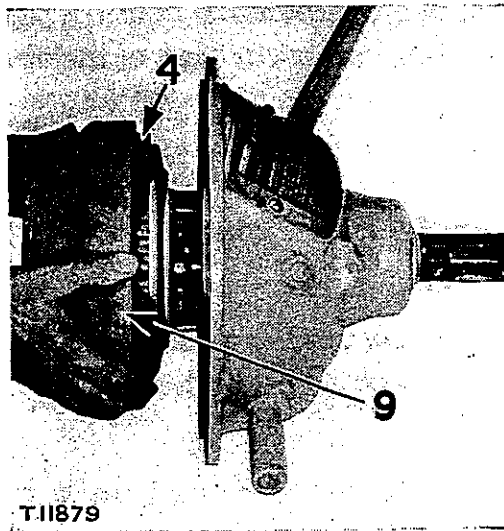
Install the support (8).

Install the crankshaft key, the hub (2), the crankshaft nut (6), the lock and the left-hand threaded capscrew (1).



#### INSTALLING FRONT POWER TAKE-OFF

- 1-Capscrew with left-hand threads. 2-Hub. 3-Adapter. 4-Driving plates.  
5-Lever. 6-Crankshaft nut. 7-Bore. 8-Support. 9-Coupling. 10-Bearing.  
11-Clutch cover assembly.



#### ALIGNING DRIVING PLATES

4-Driving plates. 9-Coupling.

Install the adapter (3) and the coupling (9).

Using two guide pins as illustrated, install the clutch cover assembly (11), mating the driving plates with the splines of the coupling and the bearing (10) in the bore (7) of the coupling.

## Flywheel Clutch

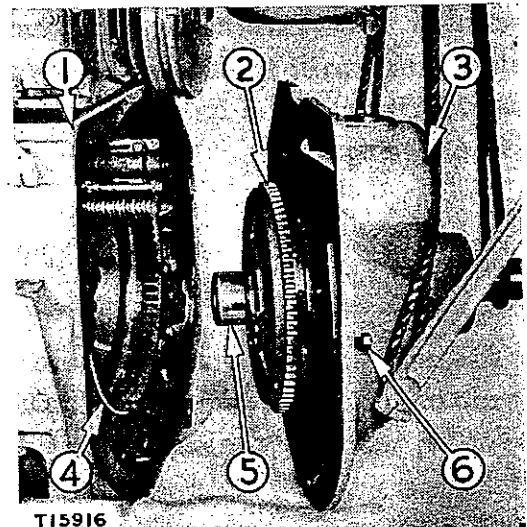
### FLYWHEEL CLUTCH REMOVAL AND INSTALLATION

The flywheel clutch (3) is mounted on the Diesel engine flywheel housing (1) and is attached to and driven by the engine flywheel.

1. Engage the clutch to hold the clutch plates in place and keep them aligned. This will be particularly helpful if the clutch is not to be disassembled.

#### FLYWHEEL CLUTCH

1-Flywheel housing. 2-Plate. 3-Flywheel clutch. 4-Ring. 5-Pilot bearing. 6-Capscrew.



2. Remove the inspection cover from the top of the clutch housing. This is not necessary for removal, but will be helpful at time of installation.
3. Attach a suitable hoist as illustrated.
4. Remove the capscrews which secure the clutch housing to the flywheel housing.
5. Install two of the capscrews (6) which secured the clutch housing to the flywheel housing, into the tapped holes on both sides of the clutch housing flange.
6. Separate the flywheel clutch from the flywheel housing, using the capscrews installed into the tapped holes of the clutch housing flange as puller screws.
7. Remove the capscrews (6) used as puller screws.

#### NOTE

When installing the flywheel clutch, align the pilot bearing (5) with the bore in the flywheel and the teeth on the plate (2) with the teeth on the ring (4).

8. Install the capscrews which secure the clutch housing to the flywheel housing and tighten them evenly and diametrically.

### Aligning Attachments to Flywheel (All Models)

Attachments that are connected to the flywheel can be classified into two general types: the self-aligning coupling, which needs only to be installed with no check necessary to determine the alignment of the attachment with the flywheel; and the flexible drive coupling, which is not rigidly attached to the engine and which must be aligned in relationship to the flywheel.

#### SELF-ALIGNING COUPLING (All Models)

The self-aligning coupling incorporates a pilot bearing or pilot, which is installed into a bore and rigidly connected to the flywheel, the flywheel housing or both. This automatically aligns the drive shaft of the attachment to the crankshaft, and allows the rear main bearing of the engine to serve as a front bearing for the attachment.

Examples of the self-aligning couplings which need only to be installed to the engine are as follows: the marine reverse and reduction gear unit, generator, the enclosed type clutch (for use without pillow blocks) and the multiple disc clutch.

## **FLEXIBLE DRIVE COUPLING**

### **(All Models)**

The flexible drive coupling type does not have a rigid connection between either the flywheel or the flywheel housing and the attachment. The open face clutch (for use with pillow blocks) is of this type, and it must be aligned with the engine.

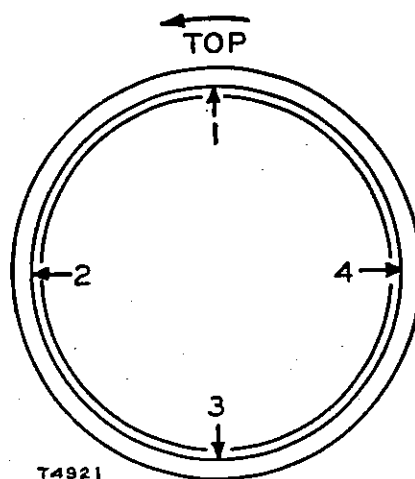
A flexible drive coupling can be aligned to the engine by removing or adding shims, and the alignment can be checked as described in the following topics, BORE ALIGNMENT (ALL MODELS) and FACE ALIGNMENT (ALL MODELS).

### **Bore Alignment (All Models)**

When checking the bore alignment, install a dial indicator (**A**) as illustrated. Rotate the crankshaft to locate the indicator at position No. 1 and adjust it to read .000".

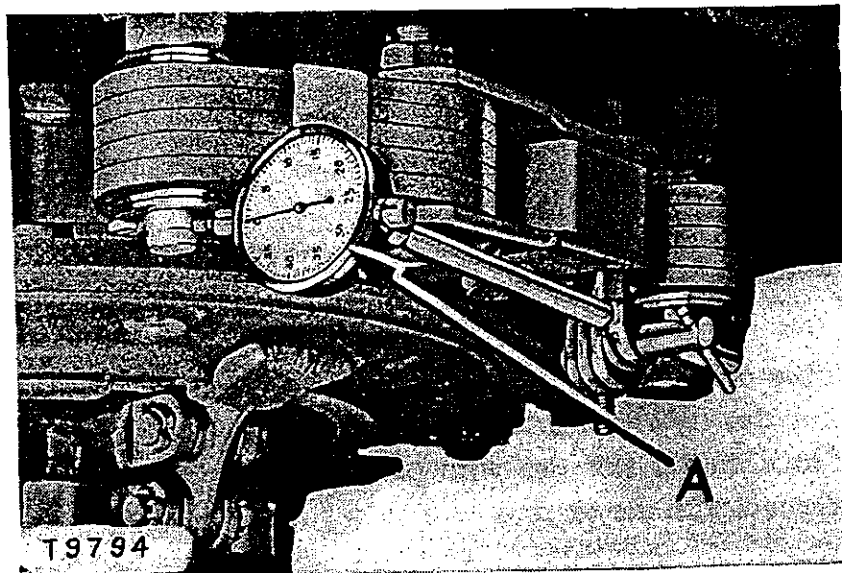
Rotate the crankshaft to check the readings at the positions 2, 3 and 4.

#### **CHECKING POINTS**



The difference in readings between positions No. 1 and 3 and positions No. 2 and 4, should not be more than .010" total indicator movement.

If shims are inserted or removed or if the attachment has been shifted, the hold-down bolts should be tightened firmly before taking further readings.

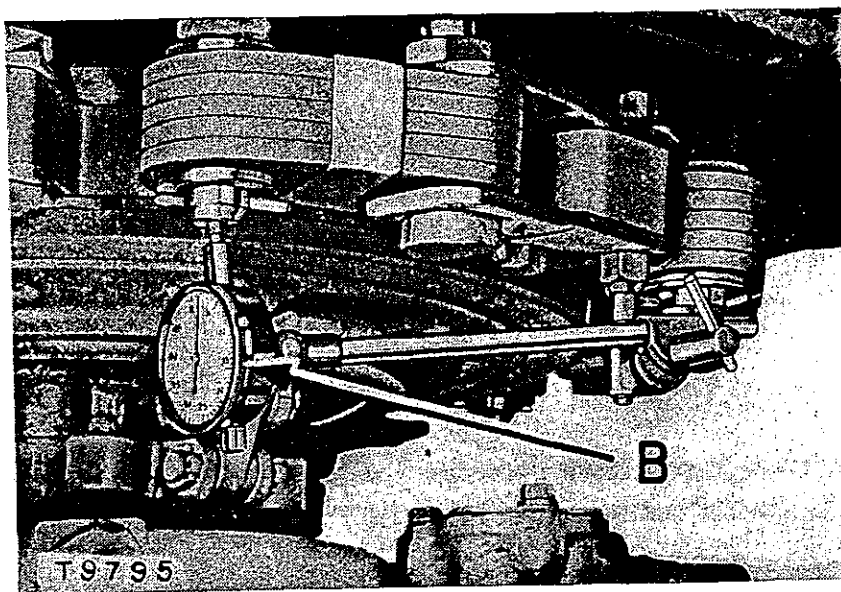


**CHECKING BORE RUN-OUT**  
A-Dial indicator used for checking bore alignment.

### Face Alignment (All Models)

When checking the face alignment install a dial indicator (B) as illustrated.

Start at position No. 1 with the dial indicator adjusted to zero, take readings at No. 2, 3 and 4. Always pry the crankshaft either forward or backward when taking readings so the end clearance will always be in the same direction.



**CHECKING FACE RUN-OUT**  
B-Dial indicator used for checking face alignment.

Face alignment should not exceed .010" total indicator movement.

Repeat bore and face alignment operations until the desired results are obtained. Never take for granted that the face alignment is satisfactory after bore alignment is correct, or that bore alignment is satisfactory after re-aligning the face. A finished alignment is only established when satisfactory readings on both face and bore may be obtained without further movement of the attachment.

## Auxiliary Drive Housing

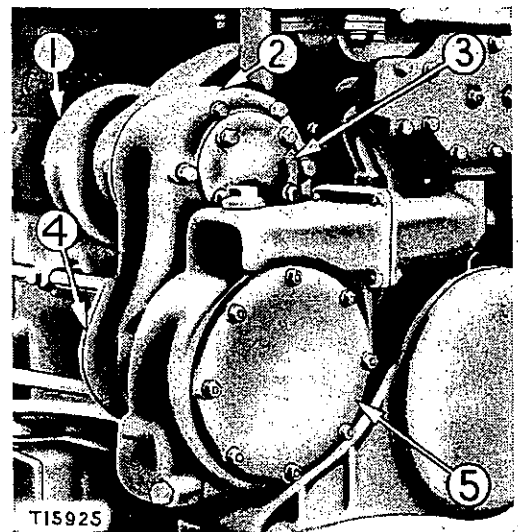
The auxiliary drive housing provides a means for mounting and driving many engine attachments.

The auxiliary drive housing (2) can be mounted on the right side of the timing gear housing and timing gear cover. Engines that do not require an auxiliary drive housing have a cover installed in its place.

An idler gear in the auxiliary drive housing is in mesh with the camshaft gear and is driven by the camshaft gear.

### AUXILIARY DRIVE HOUSING (D315M)

1-Fresh water pump. 2-Auxiliary drive housing. 3-Cover. 4-Cover. 5-Raw water pump.



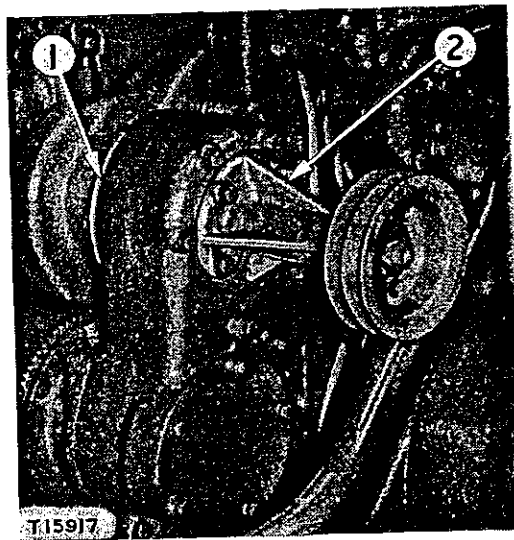
The drive housing and the idler gear for a D315 Marine Engine are used to drive the fresh water pump (1) and the raw water pump (5). The covers (3) and (4) can be removed to facilitate the installation of other attachments which can be driven from the fresh water and raw water pumps.

## Auxiliary Power Take-off

The auxiliary power take-off is mounted on the upper front side of the auxiliary drive housing and can be used to drive various attachments.

### AUXILIARY POWER TAKE-OFF REMOVAL

1. Remove the capscrews which secure the auxiliary power take-off (2) to the auxiliary drive housing (1).
2. Move the auxiliary power take-off forward and remove it.



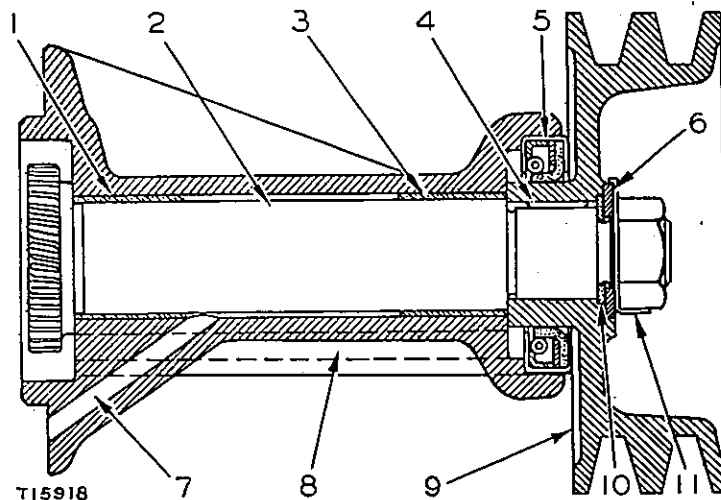
### AUXILIARY POWER TAKE-OFF REMOVAL

1-Auxiliary drive housing. 2-Auxiliary  
power take-off.

### DISASSEMBLY AND ASSEMBLY

1. Bend the lock (11) and remove the nut which secures the pulley (9) to the shaft (2).
2. Remove the lock, washer (6), gasket (10) and the pulley.
3. Remove the key (4).
4. The shaft and gear are integral and must be removed from the bracket at the gear end.
5. The bushings (1) and (3) can be removed or installed with the aid of a suitable press and driver.
6. Clean the oil passages (7) and (8).





#### AUXILIARY POWER TAKE-OFF

1-Bushing. 2-Shaft. 3-Bushing. 4-Key. 5-Seal. 6-Washer. 7-Passage. 8-Passage.  
9-Pulley. 10-Gasket. 11-Lock.

#### NOTE

If the oil seal (5) is replaced, press the new seal into the bore in the bracket with the lip of the seal pointing away from the pulley.

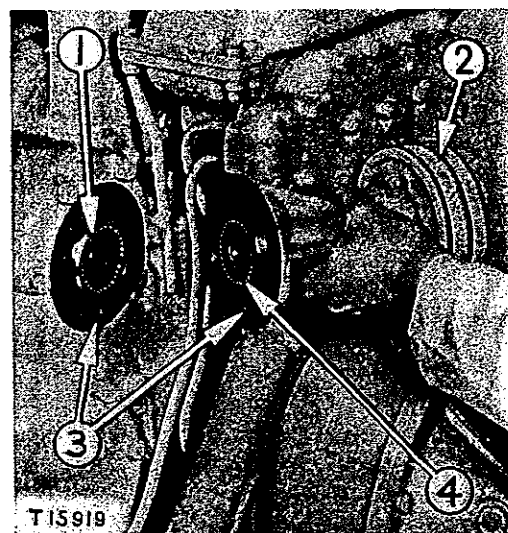
7. Inspect the outer surface of the pulley hub which contacts the oil seal and remove all roughness before reinstalling the pulley.
8. Replace the gasket (10) with a new one.

#### INSTALLING THE AUXILIARY POWER TAKE-OFF

Clean the mating surfaces of the auxiliary power take-off and the auxiliary drive housing.

#### INSTALLING AUXILIARY POWER TAKE-OFF

1-Gear. 2-Pulley. 3-Oil holes.  
4-Gear.



Install the gasket on the flange of the auxiliary power take-off, aligning the holes in the gasket with the oil holes (3) and the capscrew holes.

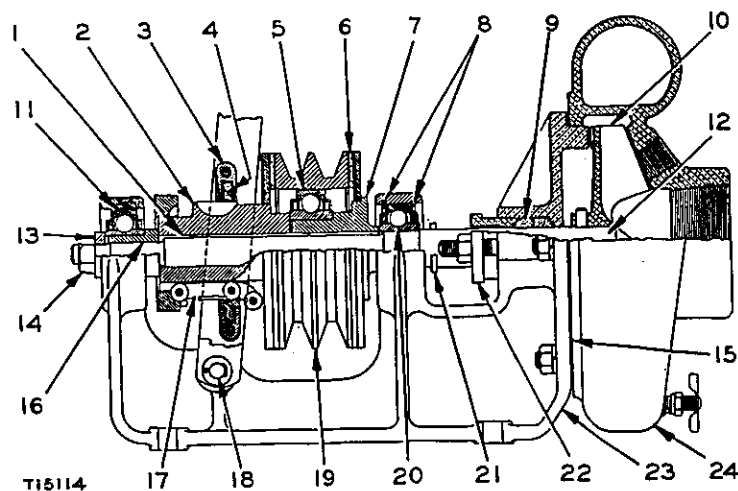
Turn the pulley (2) to mesh the teeth of the mating gears (1) and (4).

Install the capscrews and tighten them evenly and diametrically.

## Bilge Pump and Drive

### DISASSEMBLY AND ASSEMBLY

1. Remove the nuts and washers which secure the pump housing (24) to the body (23).
2. Remove the pump housing by tapping it lightly with a hammer.
3. Disengage the clutch.
4. Remove the cotter pin and washer which secure the shaft (18) and remove the shaft.
5. Remove the nut (14) and washer (13).
6. Loosen the nuts which secure the packing gland (22) and move the gland away from the packing (9).
7. Press the shaft (12) out of the bearings (11) and (20) and from the body (23).
8. Remove the clutch assembly as a unit.



BILGE PUMP AND DRIVE

1-Key. 2-Hub. 3-Collar. 4-Sleeve. 5-Bearing. 6-Clutch facing. 7-Hub. 8-Retainers. 9-Packing. 10-Impeller. 11-Bearing. 12-Shaft. 13-Washer. 14-Nut. 15-Gaskets. 16-Spacer. 17-Lever. 18-Shaft. 19-Pulley. 20-Bearing. 21-Slinger. 22-Packing gland. 23-Body. 24-Pump housing.

9. Press out the bearing (11) and spacer (16). The spacer can then be pressed from the bearing.
10. Remove the retainer rings (8) from both sides of the bearing (20) and press the bearing from the body.

#### NOTE

It is not necessary to remove the packing gland and packing unless the packing is to be replaced.

11. To replace the clutch facing (6), slide the pulley (19) off of the bearing (5), and remove the bearing from the hub (7).

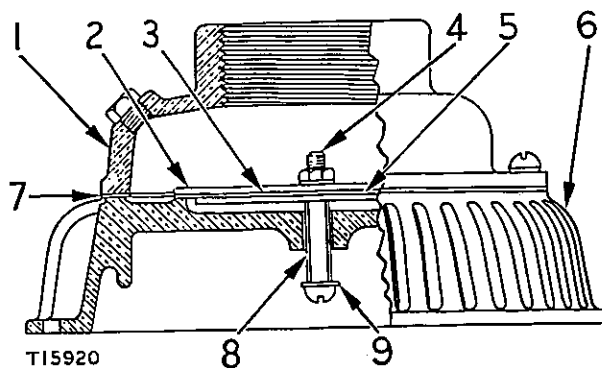
#### CAUTION

When the collar (3) and the sleeve (4) are removed from the hub (2), the levers (17) and the rollers will fall out.

12. Remove the bolts from the collar to remove it from the sleeve. Do not lose the shims which are located between the two halves of the collar.
13. When assembling the pump and drive, install the bearing (20) and the retainers (8).
14. Place the clutch assembly in position in the body and insert the shaft through the packing, packing gland, slinger (21), bearing and clutch.
15. Line up the keyway in the shaft with the keyway in the hubs and install the key (1) through the bore for the bearing (11).
16. Install the bearing (11), washer (13), and nut (14).
17. Place the gaskets (15) on the studs of the housing (24) and install the housing, making sure there is clearance between the impeller (10) and the housing. Add gaskets, if necessary, to obtain more clearance.

#### FOOT VALVE AND STRAINER DISASSEMBLY AND ASSEMBLY

1. Remove the screws which secure the base (6) to the cap (1).
2. Remove the screws or bolts if the base is secured to a mount, then remove the base.
3. Remove the nut and lockwasher which secures the screw (4).
4. Remove the screw, bushing (8) and washer (9).

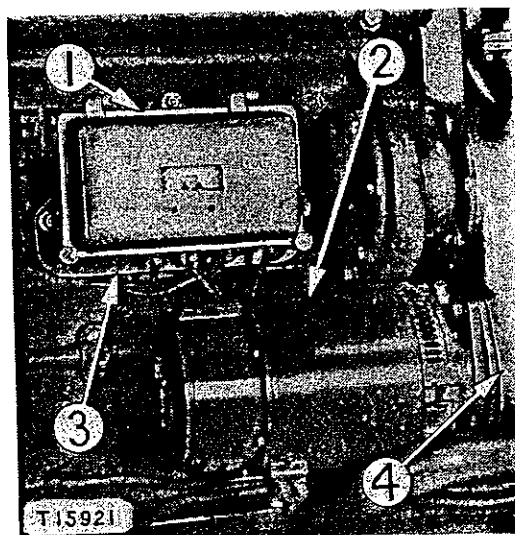


**FOOT VALVE AND STRAINER**  
 1-Cap. 2-Plate. 3-Seal. 4-Screw.  
 5-Washer. 6-Base. 7-Gasket.  
 8-Bushing. 9-Washer.

5. Remove the plate (2), seal (3) and the washer (5).
6. Remove all deposits of rust and scale, making sure all mating surfaces are smooth and clean.
7. Install a new seal (3) and gasket (7) at the time of assembly.

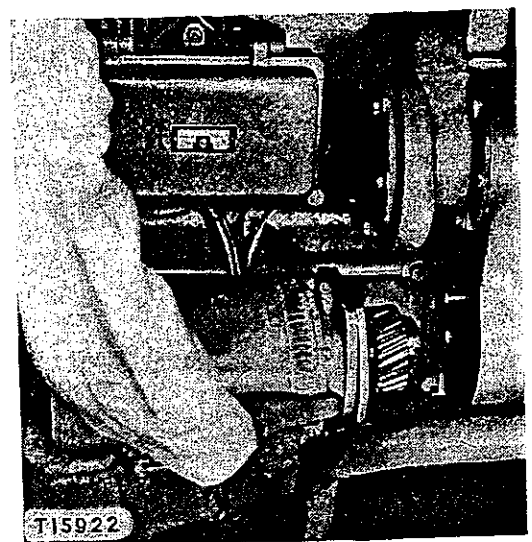
## Electric Generator and Voltage Regulator Removal and Installation

1. Remove the leads attached to the generator (2).
2. Remove the nuts and lockwashers which secure the generator to the auxiliary drive housing (4).
3. Remove the generator as shown.



**PREPARING TO REMOVE  
GENERATOR**

1-Regulator. 2-Generator. 3-Bracket.  
 4-Auxiliary drive housing.



**REMOVING GENERATOR**

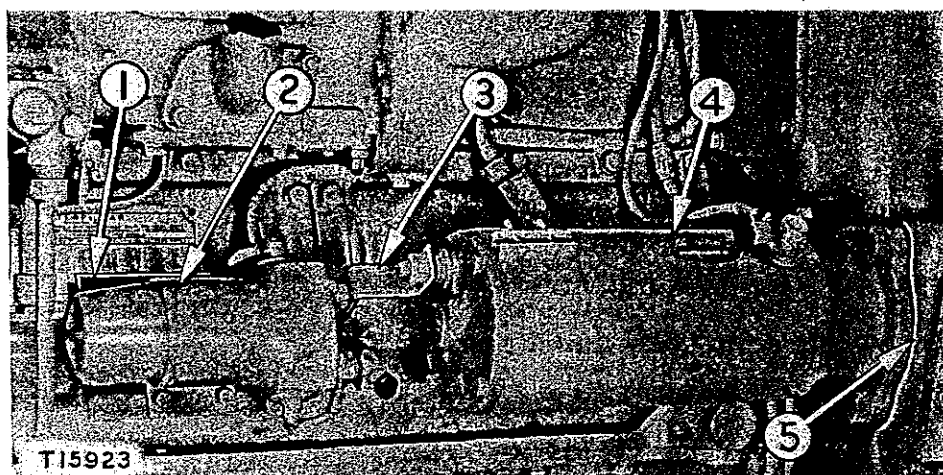
4. Clean the mating surfaces and install new gaskets at time of installation.
5. Install the leads in their proper places.
6. Remove the leads attached to the regulator (1).
7. Remove the nuts which secure the regulator to the bracket (3).
8. Remove the regulator.

## Electric Starting Motor

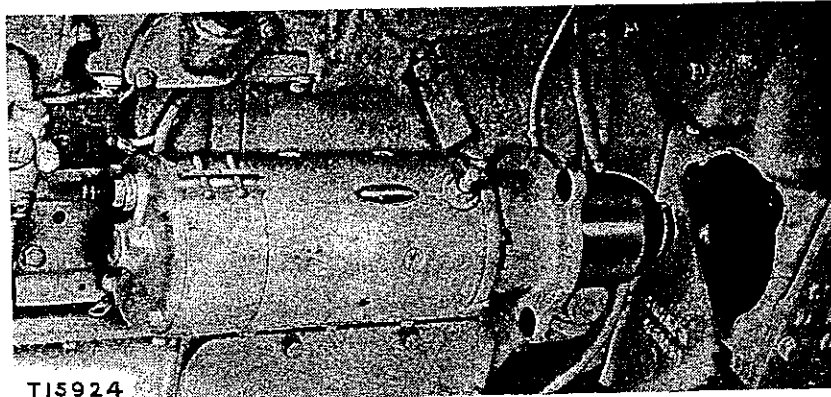
The electric starting motor is mounted on the left, front side of the flywheel housing. A solenoid switch is used with the starting motor.

### REMOVAL AND INSTALLATION OF THE STARTING MOTOR AND SWITCH

1. Remove the leads from the solenoid switch (2).
2. Remove the connector (3).
3. Remove the capscrews which secure the switch to the bracket (1) and remove the switch.
4. Remove the leads from the starting motor (4).
5. Remove the capscrews which secure the starting motor to the flywheel housing (5).
6. Move the starting motor away from the flywheel housing and remove it.



**STARTING MOTOR AND SWITCH REMOVAL**  
1-Bracket. 2-Solenoid switch. 3-Connector. 4-Starting motor.  
5-Flywheel housing.

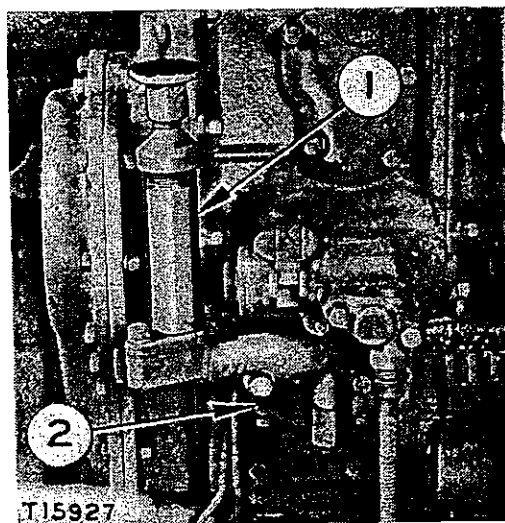


STARTING MOTOR REMOVED

## Fuel Priming Pump REMOVAL

Remove the capscrews which secure the fuel priming pump (1) to the fuel transfer pump (2).

Remove the fuel priming pump.



FUEL PRIMING PUMP REMOVAL

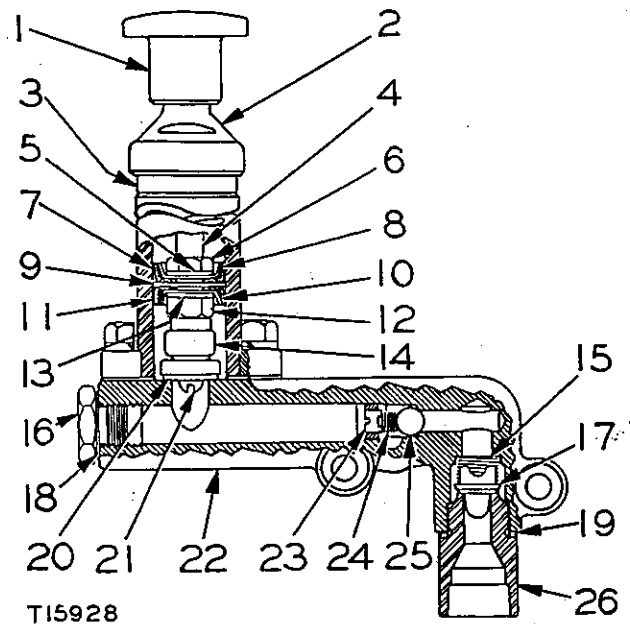
1-Fuel priming pump. 2-Fuel transfer pump.

## DISASSEMBLY AND ASSEMBLY

1. Unscrew the cap (2) from the barrel (3) and remove the rod (4) and attached parts as a unit, from the barrel.
2. Remove the screw (21) and the washer (20).
3. Insert a  $\frac{1}{8}$ " hollow head screw wrench through the opening in the bearing assembly (14) and into the hex seat. Turn the wrench counterclockwise to remove the bearing.
4. Remove the nut (12) washer (13), spring (10), cup (11), washer (9), cup (7), and spring (8). The washer (5), and nut (6) can be removed

### FUEL PRIMING PUMP

- 1-Handle. 2-Cap. 3-Barrel. 4-Rod.  
5-Washer. 6-Nut. 7-Cup. 8-Spring.  
9-Washer. 10-Spring. 11-Cup.  
12-Nut. 13-Washer. 14-Bearing.  
15-Spring. 16-Plug. 17-Plunger.  
18-Gasket. 19-Gasket. 20-Washer.  
21-Screw. 22-Base. 23-Retainer.  
24-Spring. 25-Ball. 26-Fitting.



if necessary. The handle (1) and rod (4) can then be withdrawn from the cap.

5. Inspect the cups (7) and (11) and the washer (20). If they are worn or damaged, install new ones.

### CAUTION

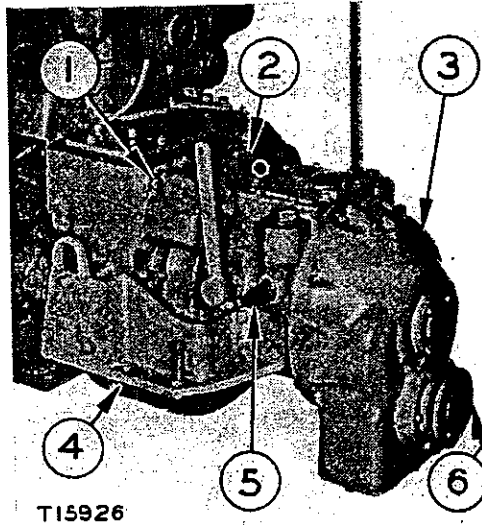
Care should be taken when starting the cups into the barrel to prevent damaging them.

6. Remove the capscrews which secure the barrel (3) to the base (22). Separate the barrel from the base.
7. Remove the plug (16) and gasket (18). Insert a screwdriver of suitable size and remove the retainer (23), spring (24) and ball (25).
8. Remove the remaining retainer, spring and ball from the side of the base which mates with the transfer pump.
9. Remove the fitting (26) and gasket (19) to remove the plunger (17) and spring (15). If the seat on the plunger is worn or rough, install a new plunger.
10. Clean all parts and passages and replace damaged gaskets at time of assembly.

# Reverse and Reduction Gear

## REVERSE AND REDUCTION GEAR REMOVAL AND INSTALLATION (D315M)

1. Close the sea valve.
2. Drain the coolant from the reverse and reduction gear by removing the drain plug at the bottom.
3. Remove the pipe (5) and the pipe (3).



DISCONNECTIONS FOR REMOVAL  
1-Capscrew. 2-Inspection cover. 3-Pipe.  
4-Support. 5-Pipe. 6-Flange.

4. Disconnect and remove the coupling between the propeller shaft and flange (6).
5. Disconnect or remove the supports (4), depending on the type of installation.
6. Remove the top inspection cover (2).
7. Remove the capscrews which connect the unit to the flywheel.
8. Attach a suitable hoist to the unit.
9. Remove the capscrews (1) holding the unit to the flywheel housing
10. Remove the unit from the flywheel and the flywheel housing and lift it out.

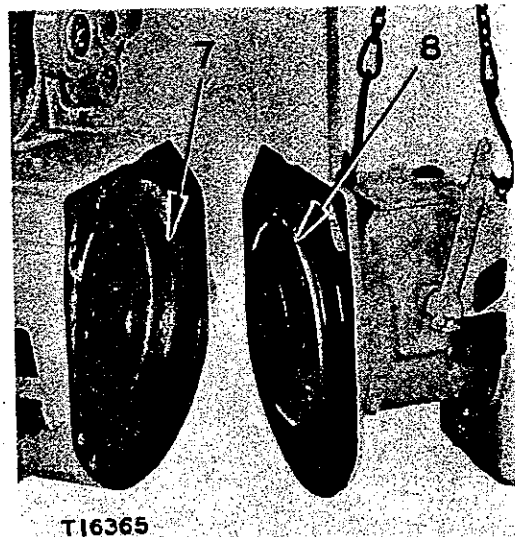
### NOTE

Before installing the unit, always clean the flywheel to be sure it is free of dirt and grease.



### PILOT FLANGE AND BORE

7-Pilot flange bore. 8-Pilot flange.



11. When installing the unit, guide the pilot flange (8) into the pilot flange bore (7) of the flywheel.
12. Start all the capscrews connecting the unit to the flywheel as well as those holding the unit to the flywheel housing before any are tightened.
13. Tighten all capscrews diametrically and evenly. See the topic, ALIGNING ATTACHMENTS TO FLYWHEEL.
14. Install the inspection cover.



# STARTING ENGINE

(All Models so Equipped)

The starting engine is mounted at the rear of the Diesel engine on top of the flywheel housing. The starter pinion mechanism is mounted on the flywheel housing and is driven by the starting engine. When the pinion is in the engaged position, it meshes with the ring gear on the flywheel and turns the Diesel engine in correct engine rotation.

The starting engine contains a lubricating system which is separate from the Diesel engine. See the topic, LUBRICATING SYSTEM.

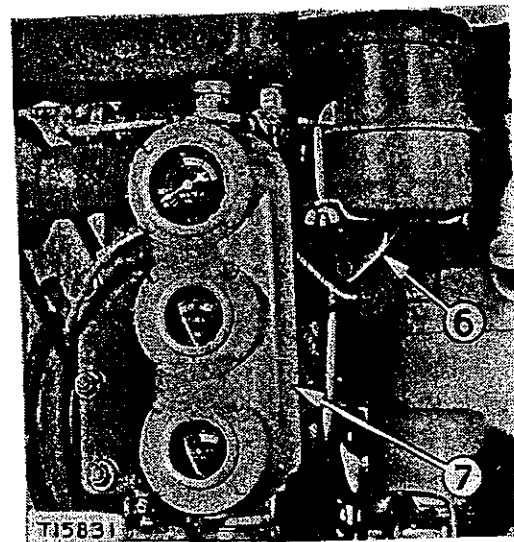
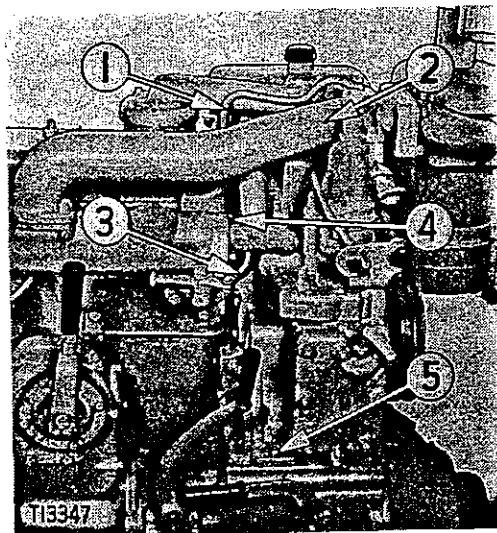
The cooling system is interconnected with the cooling system of the Diesel engine. See the topic, COOLING SYSTEMS, in the Diesel engine section for the flow diagram and description of the combined cooling of the engines.

Most reconditioning work can be done more readily by first removing the starting engine. See the topic, STARTING ENGINE REMOVAL. However, an inspection can be made to determine the general condition of the engine by removing the manifold. See the topic, MANIFOLD REMOVAL.

## Starting Engine Removal

The starting engine can be removed from the Diesel engine flywheel housing in the following manner:

1. Drain the cooling system.
2. Drain the oil from the starting engine crankcase.
3. Remove the fumes disposal tube (1).
4. Remove the Diesel engine air cleaner and the air inlet pipe (2).
5. Remove the compression release rod (3).
6. Remove the water elbow (6) and disconnect the gauge panel (7).
7. Remove the capscrews (4).
8. Remove all the capscrews, nuts (5) and lockwashers holding the starting engine to the Diesel engine flywheel housing.
9. Using a suitable cable and hoist, lift the starting engine off the Diesel engine flywheel housing.

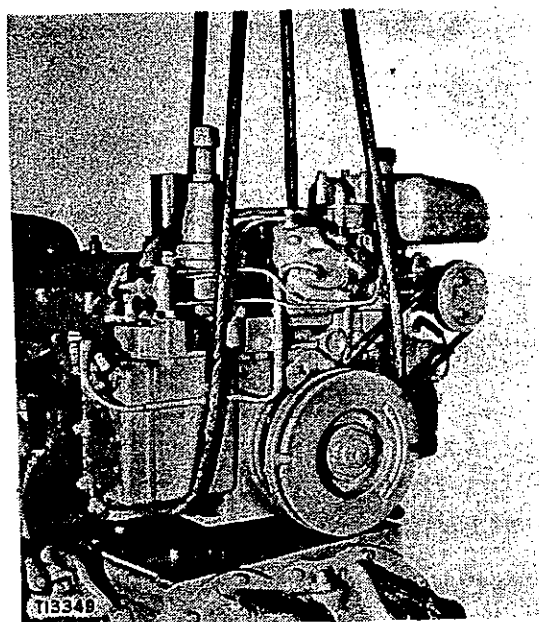


**DISCONNECTIONS FOR STARTING ENGINE REMOVAL**  
 1-Fumes disposal tube. 2-Air inlet pipe. 3-Compression release rod.  
 4-Capscrew. 5-Nut. 6-Elbow. 7-Gauge panel.

## Starting Engine Installation

Before installing the starting engine, clean the gasket surfaces on the top of the Diesel engine flywheel housing and on the bottom of the starting engine block. Cement a new gasket in place on the flywheel housing and allow it to set. Coat the top of the gasket with heavy grease.

Attach cables to the starting engine in a manner to balance the engine, to permit it to be lowered into place so as not to damage the gasket. Guide the starting engine down over the dowels in the flywheel housing and also engage the teeth of the clutch idler gear with the starter pinion



**LIFTING STARTING ENGINE FROM  
 THE FLYWHEEL HOUSING**

gear teeth. (The starter pinion assembly is mounted on the Diesel engine flywheel housing). A rocking motion will assist the gear teeth to become engaged and will permit the starting engine to settle down into place. When the engine is fully seated by its own weight, install the capscrews and nuts at the base of the starting engine and tighten evenly and securely. The remaining connections are made in the reverse order of removal.

## Cooling System

The cooling systems of the Diesel engine and the starting engine are interconnected.

Operation of the starting engine creates enough heat to warm the coolant in both the Diesel and starting engines. The warm coolant assists the initial starting of the Diesel engine.

After the Diesel engine is started, the coolant in the combined cooling systems is circulated through the two engines by the Diesel engine fresh water pump.

## Lubricating System

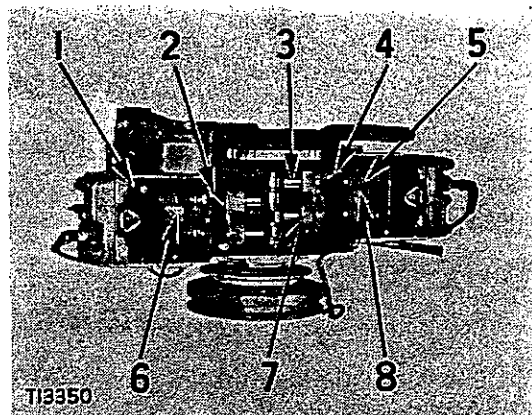
The pistons, pins, rings, connecting rod bearings and main bearings are lubricated by oil in the crankcase being splashed by the engine crankshaft.

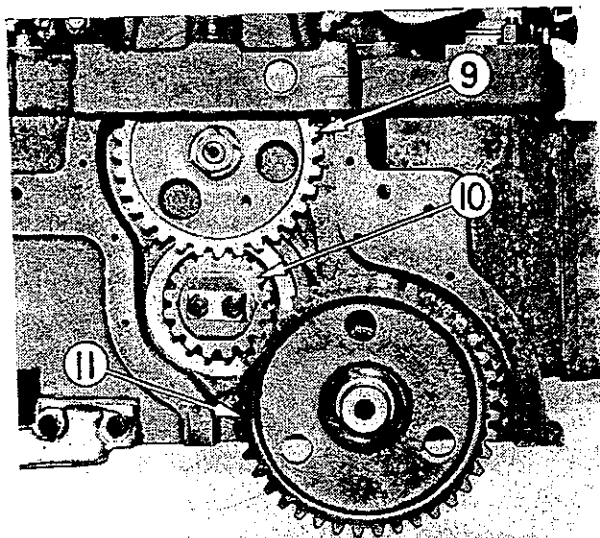
Oil splashed by the crankshaft and connecting rods also lubricates the camshaft bearings (7) and the valve lifters (3).

Oil splashed through the two slots (2) and (4) in the gasket (1) enters the valve compartments (6) and (8) to lubricate the valve mechanism (5). The oil in the valve compartments is returned to the crankcase through oil return tubes.

### LUBRICATING SYSTEM

1-Gasket. 2-Slot in gasket. 3-Valve lifter. 4-Slot in gasket. 5-Valve mechanism. 6-Valve compartment. 7-Camshaft bearing. 8-Valve compartment.





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#### LUBRICATION OF THE TIMING GEARS

9-Camshaft gear. 10-Crankshaft gear. 11-Idler gear.

An oil return thread on the camshaft and a lip-type oil seal on the crankshaft prevent oil in the crankcase from entering the timing gear compartment of the engine.

The camshaft gear (9), crankshaft gear (10) and the idler gear (11) receive their supply of lubricant from the starting engine clutch compartment.

The oil is picked up from the supply in the clutch compartment by the idler gear and is transferred to the crankshaft and camshaft gears by the teeth on the gears.

Surplus oil on the gears drips back into the source of supply.

### Governor

The governor is mounted on top of the starting engine under the fuel tank. It is driven from the starting engine flywheel by a V-belt.

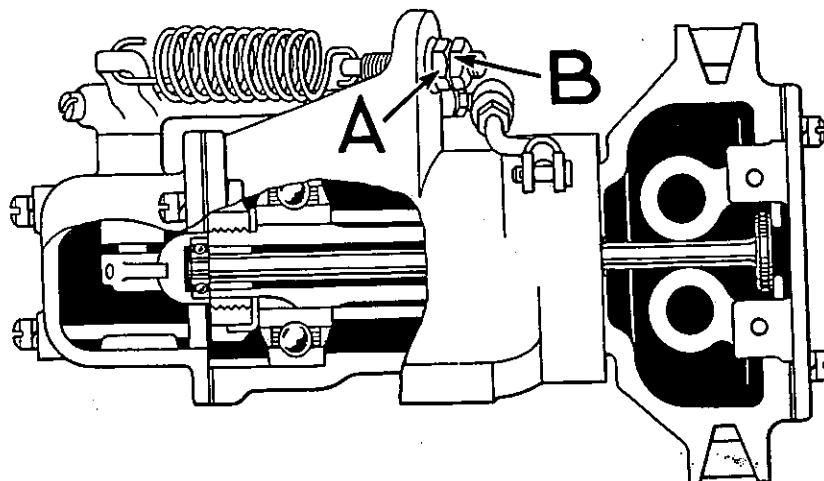
Through linkage operated by the governor control lever, the forces of the governor weights and spring act upon the carburetor throttle valve to govern the speed of the engine.

#### LOW IDLE SPEED

The low idle speed is controlled by an adjusting screw on the carburetor throttle shaft lever assembly. This screw should be set to give a low idle speed of 800 to 900 RPM.

#### HIGH IDLE SPEED

The high idle speed is controlled by the governor spring. Increasing the tension on the spring increases the high idle speed and decreasing



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#### GOVERNOR CROSS-SECTION

A-Adjusting nut. B-Lock nut.

the tension decreases the speed. Loosen lock nut (B) and turn the adjusting nut (A) until the correct high idle speed of 3350 RPM is obtained.

If the starter pinion latches disengage before the Diesel engine starts, adjust the starter pinion latches as outlined in the topic, CLUTCH ASSEMBLY AND PINION LATCH ADJUSTMENT.

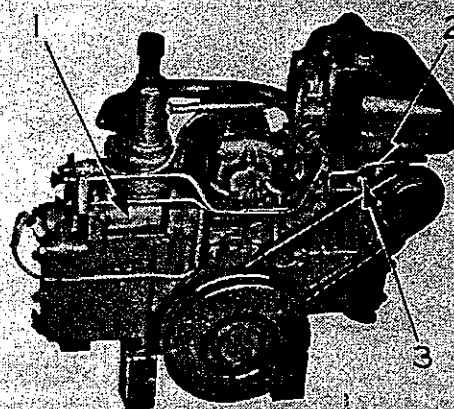
#### GOVERNOR REMOVAL

Disconnect the control rod (2) and remove the nuts (3) that secure the governor to the manifold (1).

Remove the V-belt from the governor drive pulley and lift the governor off the manifold.

#### REMOVING GOVERNOR

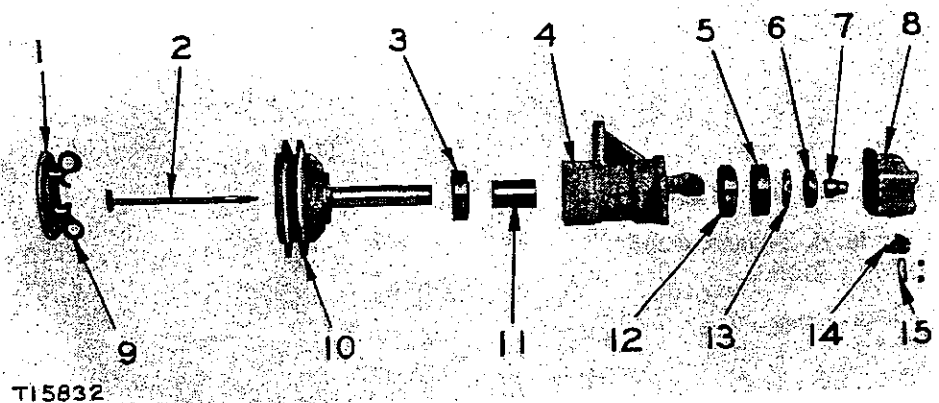
1-Manifold. 2-Control rod.  
3-Nut.



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## GOVERNOR DISASSEMBLY

1. Remove the governor spring and spring adjusting screw.
2. Remove the governor control lever and rod.
3. Remove the body (8) from the bracket (4).
4. Remove the nut (6) and lock (13).
5. Take off the cap (1) and the governor weights (9).
6. Press or tap the pulley (10), plunger (2), bearing (3) and the cap and bearing assembly from the bracket as an assembly.
7. Remove the spacer (11).
8. Press or drive the bearing (12) and the spacer (5) from the opposite end of the bracket.
9. The plunger (2) can be removed from the pulley (10) if necessary by removing the cap and bearing assembly from the end of the plunger.
10. The bearing (3) can be pulled or pressed from the shaft portion of the pulley if desired.
11. To remove the lever (14) from the body (8), loosen the lever clamping screw, then move the lever to one side and remove the key. The shaft (15) can then be removed and the lever lifted out of the body.
12. When installing the body (8) on the bracket, be sure the lever (14) inside the body fits into the slot in the end of the cap and bearing assembly (7).



**DISASSEMBLING THE GOVERNOR**  
 1-Cap. 2-Plunger. 3-Bearing. 4-Bracket. 5-Spacer. 6-Nut. 7-Cap and bearing assembly. 8-Body. 9-Governor weight. 10-Pulley. 11-Spacer. 12-Bearing. 13-Lock. 14-Lever. 15-Shaft.



13. To lubricate the governor, remove the retaining screws and pull the cap (1) away from the pulley (10) approximately  $\frac{1}{2}$ ". Keep the governor weights in a vertical position to keep the weight pins from falling out.
14. Using an oil can, put approximately two tablespoonfuls of oil into the lower portion of the pulley.
15. Push the cap back into place, install and tighten the capscrews.
16. When installing the governor on the engine manifold, position the governor to provide approximately  $\frac{1}{2}$ " slack in the governor drive pulley belt.

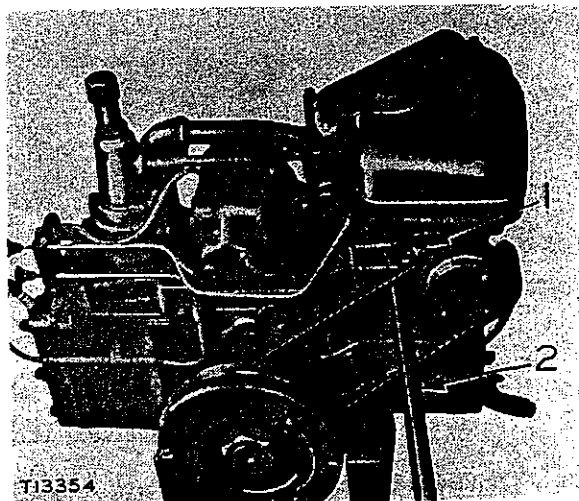
### GOVERNOR DRIVE PULLEY BELT ADJUSTMENT

To adjust the slack in the governor drive pulley belt, loosen the governor bracket mounting nuts (1) enough to permit the bracket to move under pressure.

Insert a bar (2) as illustrated and pry the governor bracket outward until only approximately  $\frac{1}{2}$ " slack remains in the belt. Hold the bracket at this position and tighten the nuts (1).

#### BELT ADJUSTMENT

1-Nut. 2-Bar.



The belt can be removed and replaced on most engines by loosening the bracket mounting nuts and moving the bracket inward far enough to permit removing the old belt and installing a new one.

On starting engines equipped with an electric starting motor, the starting motor drive belt must be removed first to make possible the removal of the governor drive pulley belt. See the topic, ELECTRIC STARTING MOTOR DRIVE BELT ADJUSTMENT AND REPLACEMENT.

## Electric Starting Motor

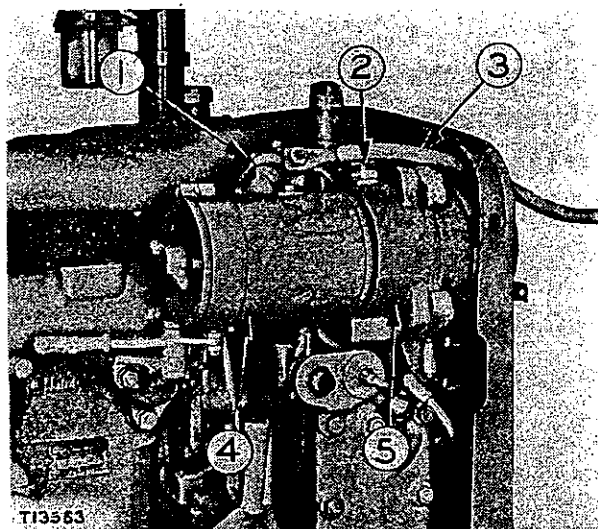
The electric starting motor is mounted at the top left forward side of the starting engine in a supporting bracket. The starting motor drives the starting engine flywheel for initial starting, through a drive mechanism and belt arrangement.

### REMOVING STARTING MOTOR

Disconnect the battery cable (3) at the battery.

Disconnect the cable (3) and the starting switch and magneto wires from the magnetic switch (1).

Loosen the lock nut and back the setscrew (2) out of the mounting bracket (5) enough to permit removal of the starting motor (4) from the bracket.



### REMOVING STARTING MOTOR

1-Magnetic switch. 2-Setscrew.  
3-Battery cable. 4-Starting motor.  
5-Mounting bracket.

### ELECTRIC STARTING MOTOR DRIVE BELT ADJUSTMENT AND REPLACEMENT

The electric starting motor drive belt can be adjusted as follows:

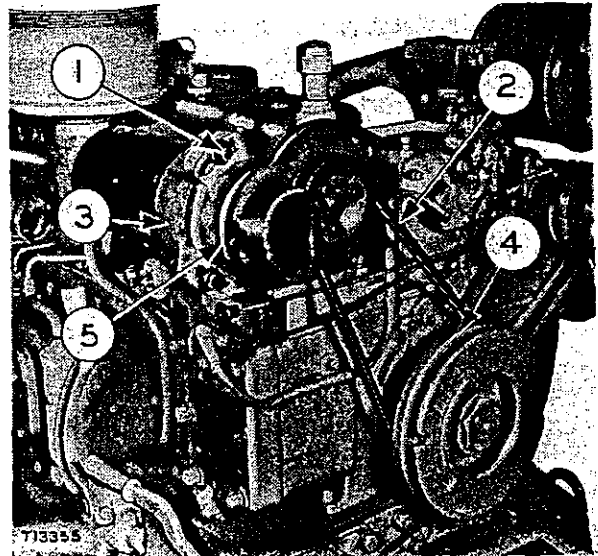
1. Loosen the bracket capscrews (1) and pivot the drive assembly (5) by hand pressure until the belt (2) is as tight as the hand can pull it, then tighten the capscrews.

### NOTE

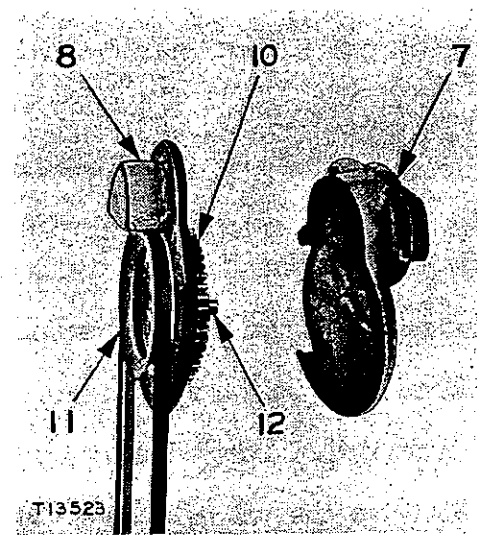
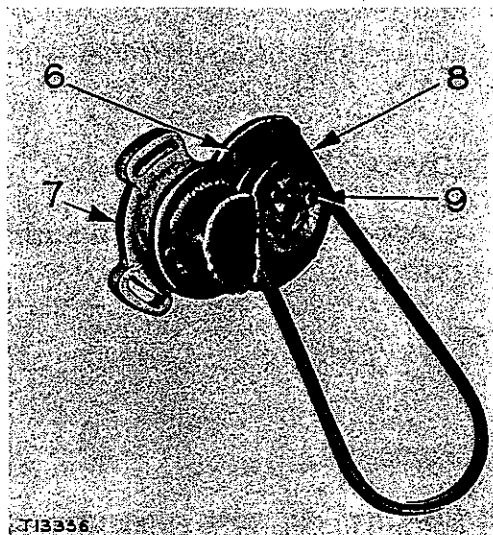
To remove the belt on earlier engines, separate the drive assembly (5) from the starting motor mounting bracket (3).

### ADJUSTING DRIVE BELT

1-Capscrew. 2-Belt. 3-Mounting bracket. 4-Flywheel. 5-Drive assembly.



2. Slip the belt off the starting engine flywheel (4) and remove the belt and drive together.
3. Remove the capscrews (6) which attach the shield (8) to the drive housing (7).
4. Remove the drive pulley retaining capscrews (9).
5. Place the drive assembly under a press, supporting it on blocks placed under the edges of the shield and having the back face of the drive housing up.



### REMOVING AND DISASSEMBLING DRIVE FOR BELT REMOVAL

6-Capscrew. 7-Drive housing. 8-Shield. 9-Capscrew. 10-Gear. 11-Pulley. 12-Shaft.

6. Use a drift, slightly smaller than the drive shaft, as a pressing tool and press the shaft downward just enough to permit the shield (8) to be turned on the drive housing (7).
7. Turn the shield to a position that will permit supporting the assembly by the housing instead of the shield. Place the drift against the shaft and finish pressing the shaft from the drive housing (7).
8. With a suitable puller, remove the gear (10) from the shaft (12) and remove the pulley (11) and shaft (12) from the shield (8) as a unit. The belt can then be removed and a new one installed.

The shaft can be pressed from the pulley if desired.

The governor drive pulley belt should be inspected and replaced at this time if not in good condition.

On later engines it is not necessary to remove the starting motor drive assembly to replace the drive belt. The belt can be changed simply by removing the drive pulley retaining nut and pulley from the drive gear shaft.

## Manifold

The starting engine manifold has ports cast into it which form a portion of the engine inlet and exhaust manifold system.

The manifold also has water passages cast into it which form a part of the engine cooling system.

On an engine which is completely assembled, the following parts and assemblies are mounted on the manifold. The fuel tank, carburetor, governor, magneto, choke and throttle controls, oil filler assembly, air cleaner and air inlet pipe and the exhaust pipe.

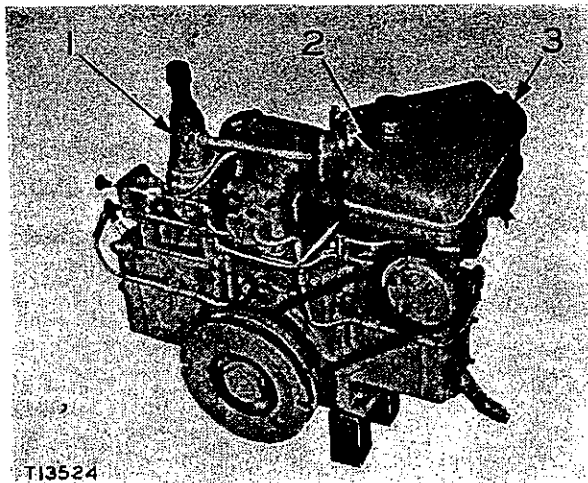
All the parts mentioned can be removed without removing the manifold.

## MANIFOLD REMOVAL

The manifold must be removed to make inspection and reconditioning of the internal parts of the starting engine possible.

The manifold can be removed as follows:

1. Drain the cooling system.
2. Drain the oil from the starting engine crankcase.
3. Remove the oil filler (1), fuel tank (2) and air inlet pipe and air cleaner (3).
4. Remove the fuel tank mounting bracket and air cleaner brace.



#### OIL FILLER, FUEL TANK AND AIR CLEANER REMOVAL

1-Oil filler. 2-Fuel tank. 3-Air inlet  
pipe and air cleaner.

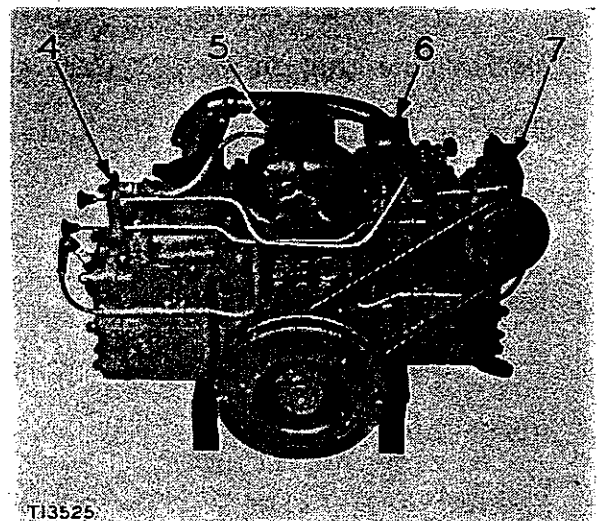
#### NOTE

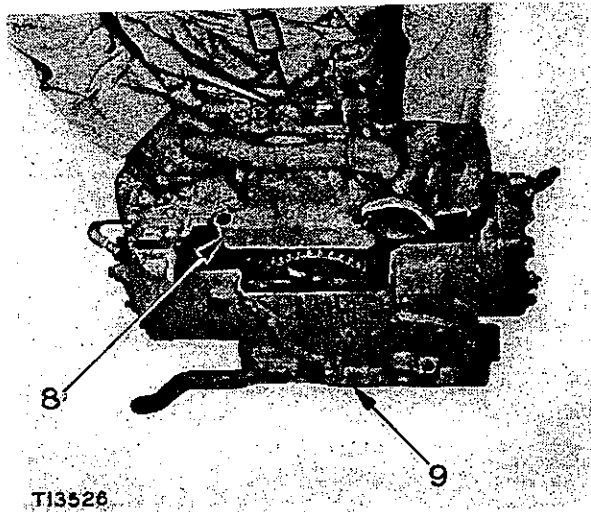
Do not lose the shims located between the brace and the manifold, since they are the correct thickness and will be used again.

5. Remove the switch bracket (4) and the choke and throttle control rods.
6. Remove the magneto (5).
7. Remove the carburetor (6) and the governor (7).
8. Disconnect the magneto to spark plug wire clips from the rear side of the manifold.
9. Remove all the capscrews, nuts and washers that secure the manifold (8) to the starting engine cylinder block and timing gear cover (9).
10. Lift the manifold off the cylinder block as illustrated.

#### REMOVING THE MAGNETO, CARBURETOR AND GOVERNOR

4-Switch bracket. 5-Magneto.  
6-Carburetor. 7-Governor.





**REMOVING THE MANIFOLD**  
8-Manifold. 9-Starting engine timing gear cover.

The top of the cylinder block should be covered except when work is being done inside the case, to prevent the entry of dirt.

When installing the manifold, be certain the gasket is in good condition and properly located.

When installing the air cleaner brace, be sure the correct thickness of shims is installed between the brace and manifold. A strain will be placed on the air inlet pipe if the shims are not in place.

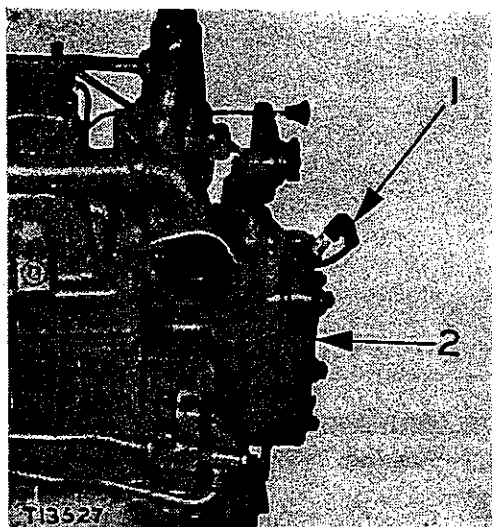
The magneto must be properly timed to the camshaft gear when installing the magneto on the engine manifold.

To time the magneto, remove the pipe plug from the forward side of the manifold and align the letters "M" stamped on the magneto gear and camshaft gear. See the topic, TIMING GEARS.

## Cylinder Heads

### CYLINDER HEAD REMOVAL AND INSTALLATION

1. Remove the ignition wire (1) from the spark plug.
2. Remove the cylinder head hold-down nuts and remove the cylinder head (2).
3. Before installing a cylinder head, remove the carbon from the head.
4. Inspect the gasket for damage.
5. Position the gasket on the studs properly.
6. Install the cylinder head.
7. Install the head hold-down nuts and tighten them evenly to 35 pound feet.



#### REMOVING CYLINDER HEAD

1-Ignition wire. 2-Cylinder head.



## Valves and Valve Mechanism

Compression pressure losses occur when the valve faces and seats become pitted. Valves should be checked occasionally for seating properly. This can be done by rocking the starting engine against compression. If the cylinder head gaskets and piston rings are in good condition and the engine does not "rock back" against compression, it is likely that the valves and seats should be refaced and reground.

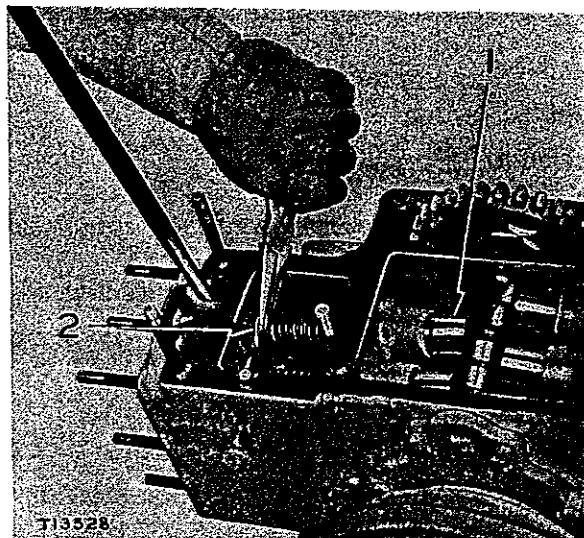
### VALVE AND VALVE MECHANISM REMOVAL

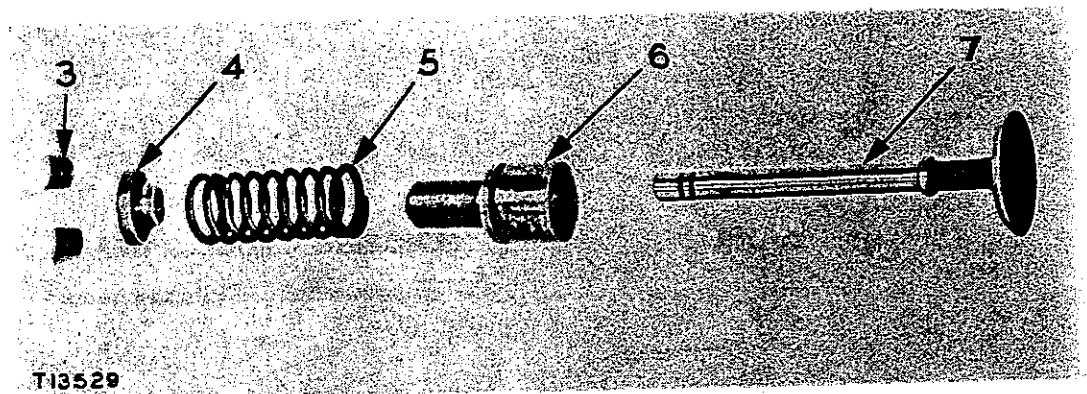
The valve ports, valves and all parts of each valve mechanism should be marked at the time of removal, so they can be returned to their original position when being installed.

1. Drain the cooling system.

#### REMOVING VALVE AND VALVE MECHANISM

1-Valve lifter. 2-Retainer.





**DISASSEMBLING VALVE MECHANISM**  
 3-Lock. 4-Retainer. 5-Spring. 6-Bushing. 7-Valve.

2. Remove the engine manifold. See the topic, MANIFOLD REMOVAL.
3. Remove the cylinder head.
4. Place a bar or screwdriver into the valve port as illustrated and by prying against the valve bushing, compress the valve spring and remove the bushing retainer (2).
5. Remove the valve, bushing, spring and valve locks as an assembly.
6. The valve lifter (1) can also be removed by sliding it out through the bushing bore and valve port in the crankcase.
7. Compress the valve spring (5) and remove the locks (3), spring retainer (4), spring (5) and the bushing (6) from the valve (7).

### INSPECTION AND INSTALLATION

Inspect the valve stems and bushings for wear.

Valve stem to bushing clearances are:

	New Clearance	Wear Limits
Inlet . . . . .	.0015"-.003"	.005"
Exhaust . . . . .	.003"-.005"	.007"

These clearances are obtained with a new valve.

The faces of the valves should always be inspected and refaced if necessary. If the faces are pitted or warped, the valves may need to be replaced.

The valve seats in the cylinder block and faces of the valves should be inspected, reconditioned if necessary, and checked as outlined in the Diesel engine section.



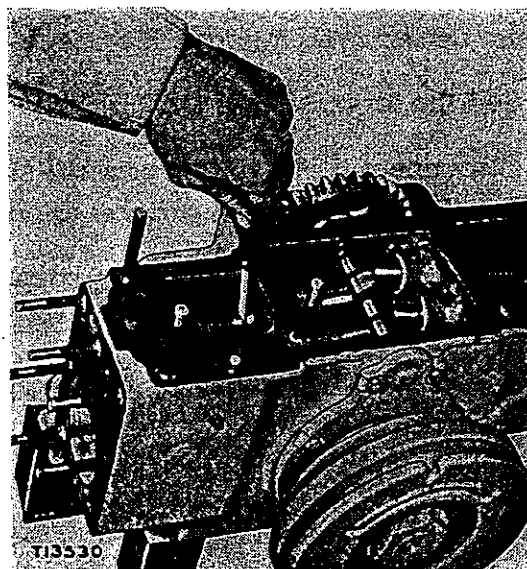
Carefully clean the parts of the valve mechanism and reassemble in the reverse order of disassembly. Be sure the locks are correctly installed in the lock retainer. Installation can be facilitated by coating the inside of the locks with heavy grease.

### VALVE CLEARANCE ADJUSTMENT

The clearance between the inlet and exhaust valve lifters and the camshaft should be .007" to .010" when the engine is cold.

The adjustment is made by grinding the end of the valve stem as required to obtain the proper clearance. Check the clearance with a thickness gauge as shown.

#### CHECKING VALVE CLEARANCE



### VALVE LIFTERS

The valve lifters operate in bores in the engine crankcase, being raised and lowered by lobes on the camshaft when the engine is in operation.

The lifters contact the valve stems, opening and closing the valves at the proper time.

The engine manifold and the cylinder heads must be removed to make lifter removal possible.

After these parts have been removed, follow the process outlined in the topic, VALVE AND VALVE MECHANISM REMOVAL, which explains how to remove a valve lifter.

## Timing Gear Cover

The timing gear cover is attached to the forward side of the starting engine cylinder block.

The cover along with a section of the cylinder block forms a compartment in which the engine crankshaft, camshaft and idler gears are located.

### TIMING GEAR COVER REMOVAL AND INSTALLATION

To remove the timing gear cover, remove the starting engine from the Diesel engine flywheel housing.

It is possible to remove the timing gear cover without removing the engine manifold (1). However, it is advisable to remove the manifold, since the camshaft end clearance should be checked and the manifold must be removed to make the check.

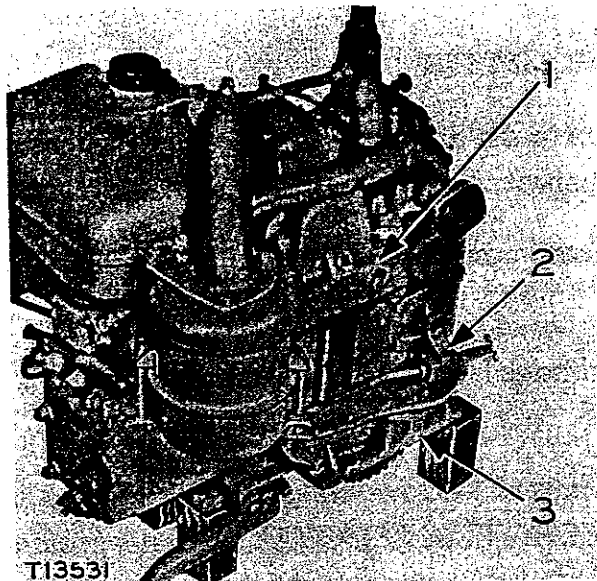
See the topic, MANIFOLD REMOVAL.

Disconnect the fuel line bracket (2) from the engine cylinder block and move the fuel lines and bracket to one side.

Remove the cover retaining capscrews and lift the timing gear cover (3) off the cylinder block.

The camshaft gear (4), crankshaft gear (5) and the idler gear (6) are accessible when the timing gear cover is off the engine.

The bushing in the idler gear should be inspected and a new one installed if badly worn.



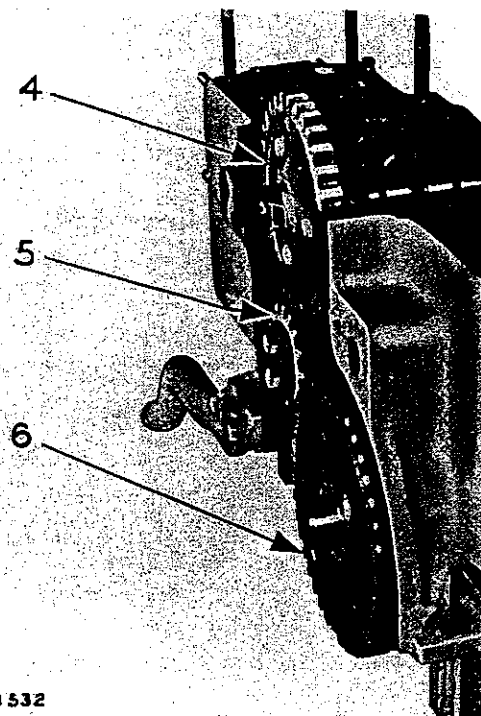
#### REMOVING TIMING GEAR COVER

- 1-Manifold. 2-Fuel line bracket.
- 3-Timing gear cover.



### TIMING GEARS

4-Camshaft gear. 5-Crankshaft gear.  
6-Idler gear.



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The camshaft and crankshaft bearing clearances and end clearances should also be checked. See the covering topics for clearances and methods of checking.

If any of the timing gears are removed, be certain the timing marks are aligned when they are again installed. See the topic, TIMING GEARS.

## Timing Gears

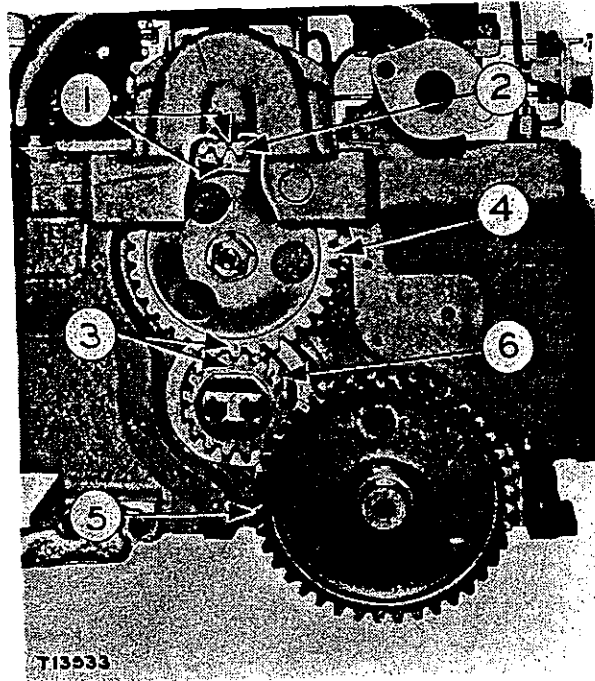
The timing gears, with the exception of the idler gear, have timing marks stamped on them to make visual engine timing possible.

If at any time the magneto gear (2), camshaft gear (4) and crankshaft gear (6) are removed, it will be necessary to retime the engine.

To time the engine, be certain first that the crankshaft gear is on the crankshaft correctly.

Since the gear is positioned on the crankshaft by two keys, located 180° apart, it is possible to install the gear incorrectly. To correctly install the gear, align the "C" mark on the gear with the corresponding "C" mark on the end of the crankshaft.

When installing the camshaft gear, align the "C" marks (3) on the crankshaft and camshaft gears.



#### TIMING MARKS

1—"M" marks on camshaft and magneto gears. 2-Magneto gear. 3—"C" marks on the camshaft and crankshaft gears. 4-Camshaft gear. 5-Idler gear. 6-Crankshaft gear.

When installing the magneto, align the "M" marks (1) on the camshaft and magneto gears.

The idler gear (5) requires no timing.

## Camshaft and Gear

### REMOVAL AND INSTALLATION

To remove the camshaft, remove the engine manifold, cylinder heads, valve mechanisms and the timing gear cover. See the covering topics.

It is possible, but not advisable in most cases, to remove the camshaft with the valves and valve mechanism in place.

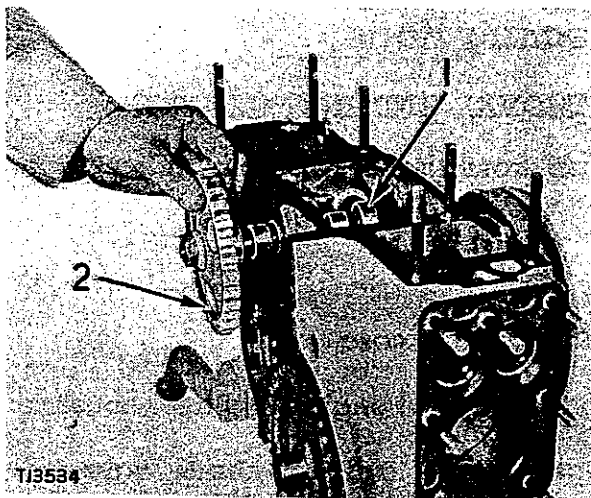
Pull the camshaft (1) and the camshaft gear (2) from the crankcase as illustrated.

The camshaft can be pressed from the gear, if the gear is to be removed.

Before installing the camshaft, measure the bearing journals on the shaft and the bores in the cylinder block into which the camshaft fits.

A new camshaft should have a bearing journal diameter of 1.496"-1.497".

The clearance between the camshaft journals and the bearing bores in the cylinder block should be .0025"-.004".



## REMOVING CAMSHAFT AND GEAR

1-Camshaft. 2-Gear.



When installing the camshaft and gear in the cylinder block, be sure to align the timing marks stamped on the faces of the camshaft, crankshaft and magneto gears. See the topic, TIMING GEARS.

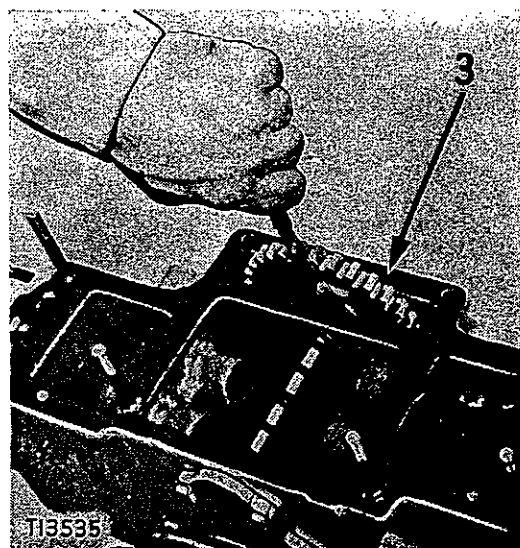
After the timing gear cover (3) is installed on the cylinder block, check the camshaft end clearance.

Check the end clearance, by moving the camshaft forward against the boss located in the cover (3) and measuring the distance between the back of the gear hub and the cylinder block with a thickness gauge as illustrated.

The correct end clearance is .007"-.015" with a maximum permissible end clearance of .025".

## CHECKING CAMSHAFT END CLEARANCE

3-Timing gear cover.



# Connecting Rods

## CONNECTING ROD REMOVAL AND INSTALLATION

To remove the connecting rods from the engine, the following procedure should be followed:

Drain the cooling system.

Drain the oil from the starting engine crankcase.

Remove the starting engine from the Diesel engine flywheel housing.

Remove the manifold, timing gear cover, cylinder heads, valves and valve mechanism, and the camshaft and gear, as described in their respective topics.

The No. 1 cylinder is the one nearer the flywheel.

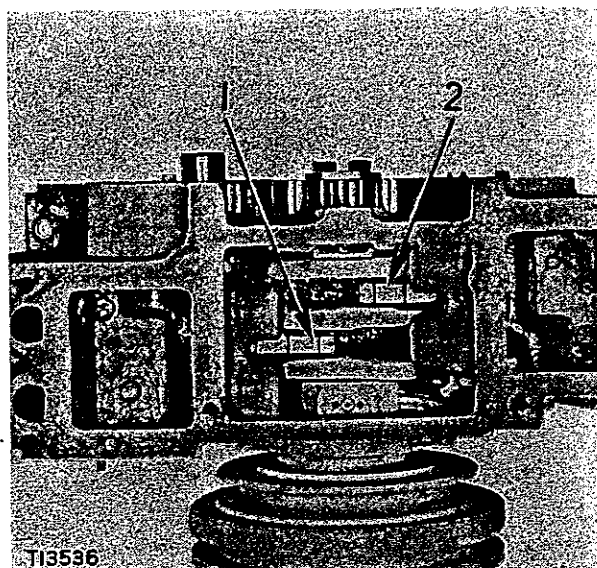
This should be kept in mind when removing the pistons and rods, so they can be returned to the proper places when being installed.

The rods and rod bearing caps are numbered for the cylinder into which they are installed. Always be careful to install the proper rod cap on its corresponding connecting rod.

Each connecting rod and rod cap have an aligning mark in the form of a raised ridge located on the face of the rod and cap bolt boss. The rods and caps are machined with these marks aligned; therefore, they must also be aligned when installing them in the engine.

Remove the carbon from the top portion of the cylinder bore.

Remove the nuts from the connecting rod cap bolts.



### REMOVING CONNECTING RODS

- 1-Connecting rod bearing cap.
- 2-Connecting rod bearing cap.

Remove the connecting rod bearing caps (1) and (2).

Push the rods and pistons upward in the cylinder bore and remove them from the head end of the bore.

If at the time the pistons and rods are removed and new rings are to be installed on the pistons, the ring ridge near the top of the cylinder bore should be removed.

Always inspect the connecting rod bearings when the rods are removed from the engine. For information on the rod bearings, see the topic, 'CONNECTING ROD BEARINGS.

Install the pistons and rods into the bores of the cylinder block according to the numbers stamped on the rod and cap. These numbers should be toward the top of the cylinder block when installed correctly.

Use a suitable ring compressor at time of installation, to prevent ring damage.

Tighten the connecting rod bolt nuts to 14 pound feet. This value can be exceeded by the amount required to align the next cotter pin hole in the bolt and nut.

Lock the nuts with cotter pins.

### CONNECTING ROD BEARINGS

Precision babbitt-lined bearings, machined to provide proper clearance, are used. These bearings do not require fitting, scraping, filing or reaming, and can be put into the engine without removing the piston assembly or the connecting rod.

The cap half of the old bearing can be lifted out and the rod half rotated out.

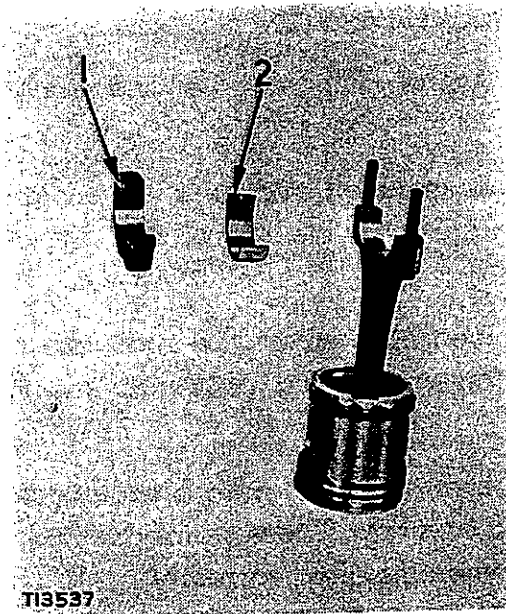
Clean and inspect all parts. Check them in accordance with information contained in the topic, SPECIFICATIONS.

Always check the crankshaft bearing surface to see that it is not scored or damaged before putting in a new bearing.

The connecting rods and connecting rod caps come in mated pairs and are marked on the top side with matching numbers.

Oil the bearings on assembly to protect them until the engine is started.

When replacing the bearings, see that the protruding tangs (2) on the back of each bearing half lines up with its corresponding recesses (1) in the connecting rod and bearing cap. This locks the bearing in place and keeps it from rotating.



### CONNECTING ROD BEARINGS

1-Recess in bearing cap. 2-Tang on back of bearing half.

The rod and cap have raised aligning marks. Replacement rods should be installed with these two marks lined up on the same side, and marked with the number of the rod replaced.

The connecting rod bearing clearance should always be checked.

The proper clearance is .005"-.008" with a maximum permissible clearance of .013".

Connecting rod bearings .020" undersize are available if desired.

### PISTON PIN BUSHING

To remove the piston pins, remove the pin retainers from the grooves in the pin bore of the piston. The pin can then be pushed from the piston and connecting rod bushing.

The clearance between the piston pin and the connecting rod bushing should be .0008"-.0013" with a maximum permissible clearance of .003".

The pin clearance in the piston should be .0004"-.001" with a maximum permissible clearance of .0025".

If a new piston pin bushing is required, one must be obtained from stock, pressed into place and reamed or honed to the proper dimensions. The center-to-center distance is 5.748"-5.750". The oil hole must also be drilled in the bushing after the bushing has been pressed into the rod.

The piston pin should be a thumb push fit in the connecting rod bushing and piston at normal room temperature (70°F.). The piston pin must not be forced into the piston or a connecting rod.



## CHECKING PISTON PIN FIT



## Pistons and Rings

The aluminum alloy pistons have two compression rings and two oil rings. One oil ring is located beneath the piston pin.

The piston and connecting rod assembly can be removed as described in the topic, CONNECTING ROD REMOVAL AND INSTALLATION.

While the piston is removed, it is good practice to gauge the cylinder bore for possible out-of-round (eccentricity) and wall taper as shown. To obtain a true reading, the bore must be checked below the piston ring ridge. If the cylinder bore shows an out-of-round of more than .004" or a taper of .006", the cylinder bore should be reconditioned and new pistons and rings installed.

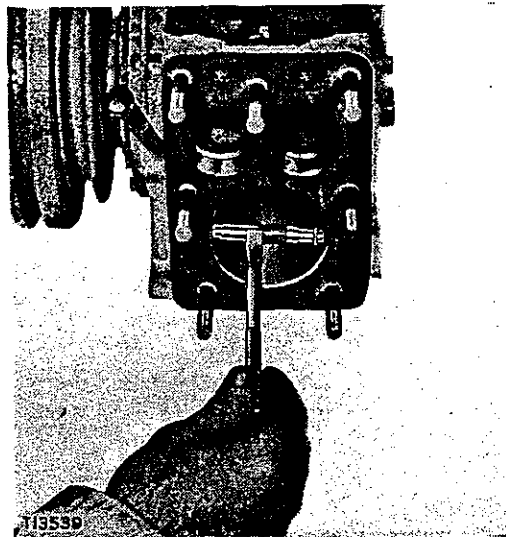
Semi-finished pistons can be obtained that can be finish-turned up to .060" over standard, according to the following chart:

**CYLINDER AND PISTON DIAMETERS FOR REBORING THE STARTING ENGINE**

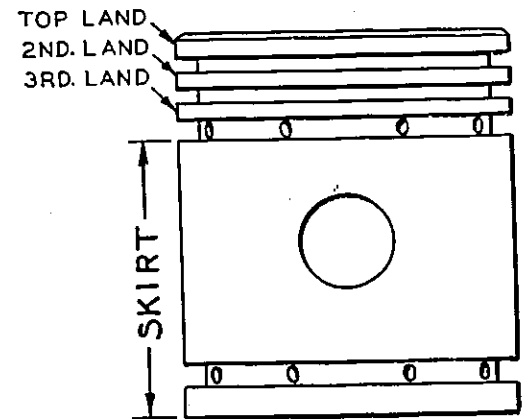
.020" Oversize				.040" Oversize				.060" Oversize			
Cylinder Diameter	Piston Diameter			Cylinder Diameter	Piston Diameter			Cylinder Diameter	Piston Diameter		
	Skirt	Lands			Skirt	Lands			Skirt	Lands	
		Top	2nd & 3rd			Top	2nd & 3rd			Top	2nd & 3rd
2.771"	2.766"	2.749"	2.755"	2.791"	2.786"	2.769"	2.775"	2.811"	2.806"	2.789"	2.795"
2.772"	2.767"	2.752"	2.758"	2.792"	2.787"	2.772"	2.778"	2.812"	2.807"	2.792"	2.798"

### NOTE

The skirt is that portion of the piston from the lower end up to the first ring groove above the piston pin bore. The piston lands are from the upper end of the piston down to the first ring groove above the piston pin bore.



**CHECKING CYLINDER BORE**



**PISTON NOMENCLATURE**

## **PISTONS**

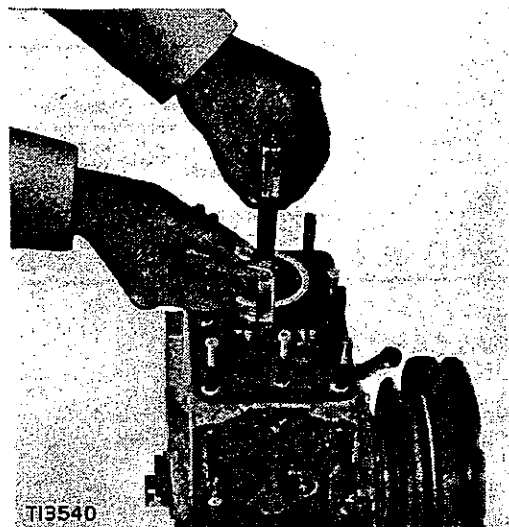
Piston clearance should be measured by a thickness gauge on the thrust side of the piston. The piston skirt clearance of a new piston should be .004" to .006".

The piston surfaces and ring grooves should be thoroughly cleaned before installing rings or replacing pistons in the cylinder.

The most satisfactory method of cleaning pistons is to follow the same recommendations as outlined for cleaning the Diesel engine pistons.

Piston assemblies should be replaced in the same cylinders from which they were removed.

The connecting rods are marked on the camshaft side to assure correct assembly.



**CHECKING PISTON CLEARANCE**

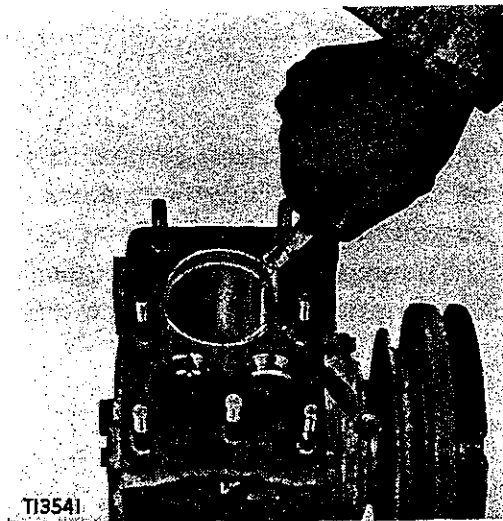
## RINGS

Remove the ridge around the top of the cylinder bore with a ridge remover before attempting to install new rings.

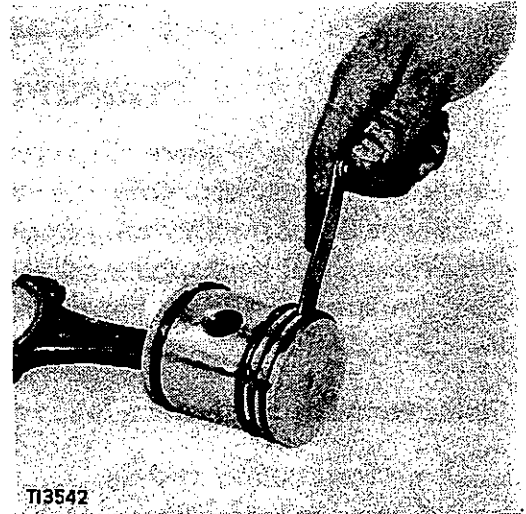
The ring gap for both the compression rings and the oil control rings should be .012" to .020". This measurement should be taken at the smallest diameter of the cylinder bore.

New compression rings should have .0015" to .003" side clearance in the ring groove and oil rings should have .001" to .0025".

After the rings have been installed on the pistons, it should be possible to rotate the rings around the piston without binding.



CHECKING RING GAP



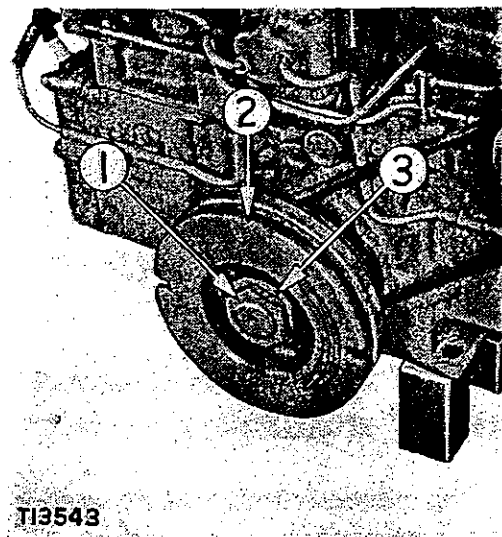
CHECKING RING GROOVE  
CLEARANCE

## Flywheel

### FLYWHEEL REMOVAL

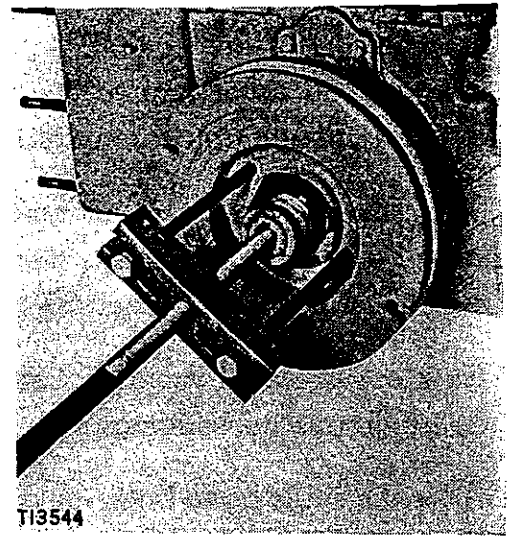
Remove the nut (1) and lock (3).

The flywheel (2) can then be pulled from the crankshaft by using the 5F7465 Puller, 8B7560 Step Plate, two flat washers and two  $\frac{3}{8}$ "-16 (NC) capscrews, 7" long as illustrated.



**PREPARING FOR FLYWHEEL  
REMOVAL**

1-Nut. 2-Flywheel. 3-Lock.



**PULLING FLYWHEEL**

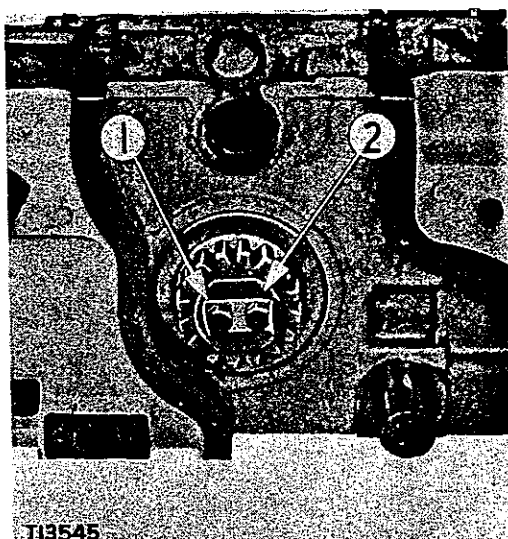
## Crankshaft

### CRANKSHAFT REMOVAL

It is possible to remove the crankshaft from the starting engine crankcase without first removing the flywheel if desired. However, since the flywheel will normally be removed sometime during the process of reconditioning, it is recommended that it be removed from the crankshaft while the shaft is still in the engine. Crankshaft removal is much easier with the flywheel off.

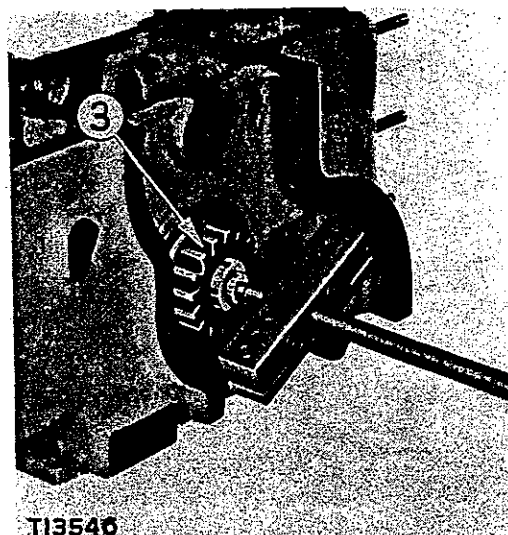
Remove the crankshaft as follows:

1. Drain the cooling system.
2. Drain the oil from the starting engine crankcase.
3. Remove the starting engine from the Diesel engine flywheel housing.
4. Remove the manifold, cylinder heads, timing gear cover, valves and valve mechanism, camshaft and gear, pistons and connecting rods and the flywheel. See the covering topics for the removal of these parts and assemblies.
5. Remove the capscrews, the lock (1) and the retaining washer (2).
6. Pull the gear (3) as illustrated, using the 5F7465 Puller, two  $\frac{1}{4}$ "-20 (NC) capscrews, approximately  $4\frac{1}{2}$ " long and two flat metal washers.
7. Place a suitable spacer between the end of the crankshaft and the puller screw to prevent damage to the end of the crankshaft.



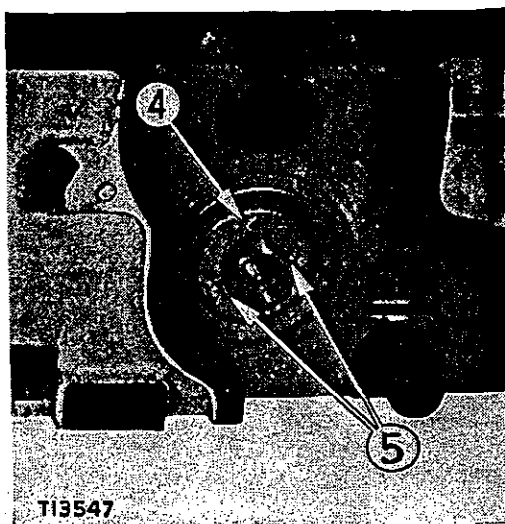
**PREPARING FOR CRANKSHAFT  
GEAR REMOVAL**

1-Lock. 2-Retaining washer.



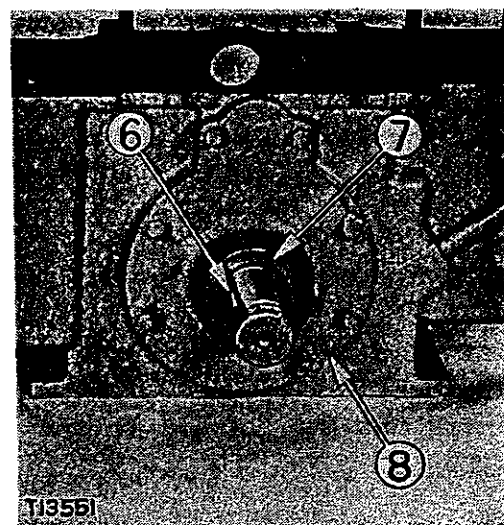
**PULLING CRANKSHAFT GEAR**  
3-Crankshaft gear.

8. Remove the keys (5) and the seal washer (4). If the crankshaft seal in the crankcase is to be replaced, install the new one with the lip of the seal in.
9. Remove the key (6) and the flange (8).
10. Pull the flange off the end of the crankshaft, supporting the crankshaft as the flange is removed to prevent damage to the seal (7) and the bearing surfaces on the crankshaft.
11. Press the seal out of the flange and install a new one if not in good condition. The seal must be installed in the flange with the lip of the seal in.

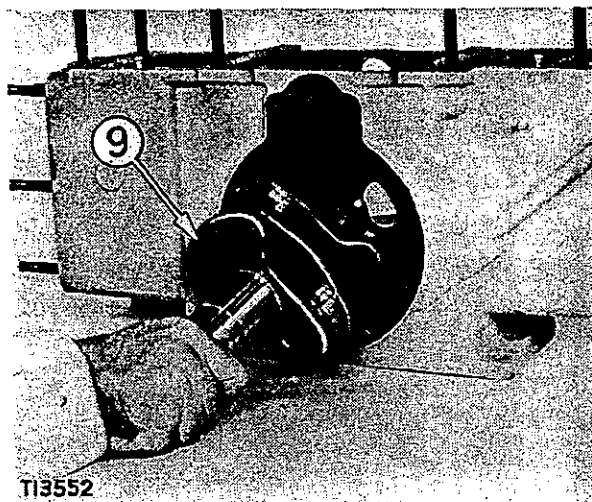


**REMOVING KEYS AND  
SEAL WASHER**

4-Seal washer. 5-Keys.



**REMOVING FLANGE**  
6-Key. 7-Seal. 8-Flange.



## REMOVING THE CRANKSHAFT

9-Crankshaft.

After the flange has been removed from the rear side of the cylinder block, slide the crankshaft (9) from the forward bearing of the block and remove the crankshaft as illustrated. Be careful not to damage the bearing surfaces of the crankshaft by permitting them to strike the edges of the cylinder block.

If the crankshaft is to be out of the block for an extended period of time, lubricate and wrap the bearing surfaces to prevent rusting and nicking.

## CRANKSHAFT INSPECTION AND INSTALLATION

Always inspect the crankshaft bearing surfaces for wear.

The crankshaft main bearing journals should measure 1.8120"-1.8125" and the connecting rod bearing journals 1.7495"-1.7500".

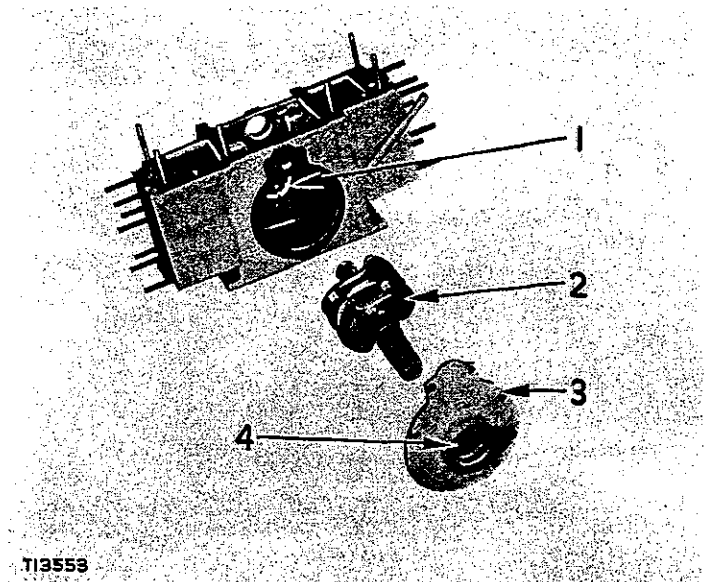
A new crankshaft should be installed or the old one reground to .020" undersize, if the bearing journals show wear in excess of .005" or the connecting rod bearing journals are more than .003" out-of-round.

Main and connecting rod bearings .020" undersize are available to accommodate reground crankshafts.

Before installing the crankshaft, inspect the main bearings for wear. The bearings should be replaced if the clearance between the crankshaft journal and the bearing exceeds .015". See the topic, REMOVING AND INSTALLING MAIN BEARINGS.

To install the crankshaft (2), place it through the flange opening in the cylinder block and insert the forward end into the front main bearing (1).

Push the crankshaft into the bearing as far as possible.



**INSTALLING CRANKSHAFT**  
 1-Front main bearing. 2-Crankshaft. 3-Flange. 4-Seal.

Install a new gasket on the flange (3).

Guide the flange onto the crankshaft taking care not to damage the rear main bearing or the seal (4) when doing so.

Position the flange on the cylinder block and install the locks and capscrews. Lock the capscrews after tightening.

### **INSTALLING CRANKSHAFT GEAR AND CHECKING CRANKSHAFT END CLEARANCE**

The crankshaft end clearance is controlled through machining and new parts must be installed when excessive end clearance is found.

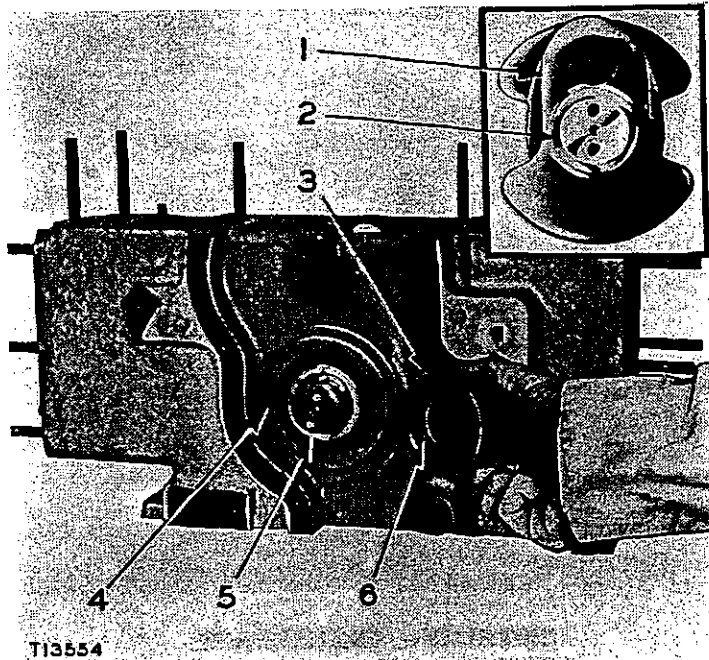
The crankshaft end thrust is taken by the inner surface (6) of the washer (3) and the forward end surface of the front main bearing (5).

The outer surface on the shoulder of the washer (3) also serves as a seal surface for the seal (4).

The amount of end clearance will be the amount of space between the inner surface (6) of the washer and the ground face (2) on the forward face of the crankshaft flange (1), minus the length of the front main bearing.

Install the washer (3) on the crankshaft with the surface (6) toward the front main bearing.

Wedge the crankshaft all the way forward in the cylinder block.



#### INSTALLING CRANKSHAFT GEAR

1-Crankshaft flange. 2-Ground face on flange. 3-Washer. 4-Seal.  
5-Front main bearing. 6-Inner surface of washer.

Install the two crankshaft gear locating keys and the crankshaft gear.

Heat the gear (preferably in hot oil) to ease installation.

Align the timing marks "C" on the end of the crankshaft and the face of the crankshaft gear and install the gear.

Be certain the washer (3) is tight against the shoulder on the crankshaft and the gear is tight against the washer.

After installing the crankshaft gear, the end clearance should be checked as follows:

Install a dial indicator as illustrated.

Move the crankshaft all the way forward in the cylinder block.

Adjust the indicator dial to read "0".

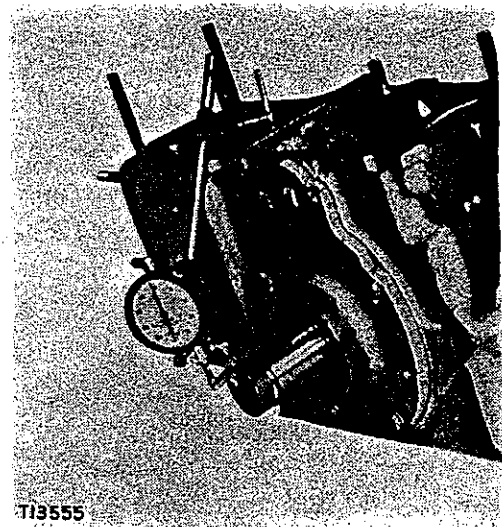
Push the crankshaft all the way toward the rear of the cylinder block, observing the amount of travel registered on the indicator as the crankshaft is moved.

The correct end clearance should be .010"-.015" with a maximum permissible end clearance of .025".

After the end clearance has been checked and found to be satisfactory install the flywheel and all other parts of the engine in the reverse order of which they were removed.



## CHECKING CRANKSHAFT END CLEARANCE



## Main Bearings

The main bearings are of the aluminum alloy bushing-type and are not adjustable.

Each of the two main bearings are located and prevented from rotating by a dowel pin.

The dowel for the front main bearing is located in the cylinder block and the one for the rear main bearing is located in the flange bolted to the rear side of the cylinder block.

It is possible to remove the rear main bearing without removing the crankshaft if desired. This can be accomplished by pulling the flywheel and removing the flange which contains the bearing, from the rear side of the cylinder block. However, the front and rear main bearings should be replaced at the same time if either is badly worn. Therefore, the crankshaft should be removed unless perhaps, only the flange is to be replaced and the original rear bearing is to be removed and installed in the new flange.

## REMOVING AND INSTALLING MAIN BEARINGS

To remove the rear main bearing, remove the flywheel and key from the crankshaft.

Remove the flange (3) from the cylinder block.

Remove the bearing locating dowel (2), by using a punch of the proper size as illustrated.

Press out the bearing (1) and the seal located in the back face of the flange.



## REMOVING MAIN BEARING DOWEL

1-Main bearing. 2-Dowel. 3-Flange.

When installing new bearings, line up the drilled hole in the bearing as closely as possible with the drilled hole in the flange and press the bearing flush with the inner face of the bearing bore.

Use the hole in the flange as a guide and drill through the bearing with a  $15/64$ " drill. Finish ream the dowel hole to  $.249$ "-. $.250$ " and install the dowel.

Precision main bearings machined to provide proper clearance, are obtainable in complete sets and should be installed without fitting, scraping, filing or reaming.

Install the seal in the flange assembly with the wiping edge toward the bearing.

Press the seal in until it is flush with the outer face of the flange.

Protect the seal with shim stock when installing the flange assembly.

To remove the front main bearing, the crankshaft must be removed. See the topic, CRANKSHAFT REMOVAL.

Remove the bearing locating dowel from the cylinder block and bearing in the same manner as that used in removing the dowel from the rear main bearing.

Press the bearing from the cylinder block, align the dowel hole in the new bearing with the dowel hole in the cylinder block and press the bearing in until it is flush with the inner face of the bearing bore.

Use the dowel hole in the cylinder block as a pilot and drill through the dowel hole in the bearing with a  $15/64$ " drill. Finish ream the hole with a  $.249$ "-. $.250$ " reamer.

Install the dowel.

Complete the assembly of the engine.

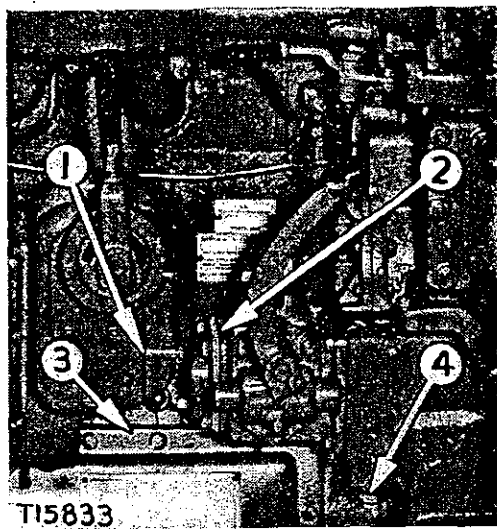
## Clutch and Starter Pinion

The starting engine transmits its power through a multiple disc clutch to a sliding pinion which is engaged with the Diesel engine flywheel gear by means of a hand lever. The pinion is automatically released by centrifugal force acting on the pinion latches when the Diesel engine starts.

### REMOVING THE CLUTCH AND STARTER PINION

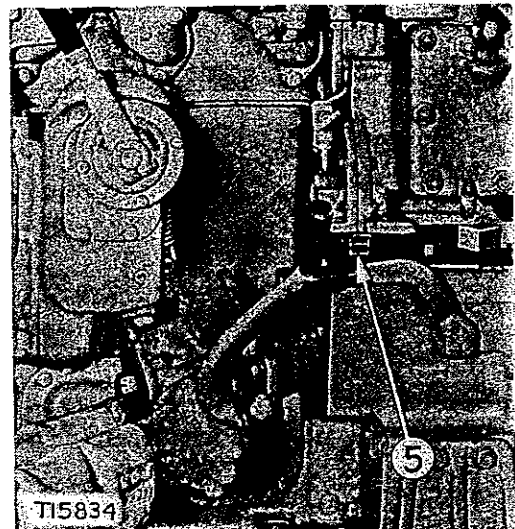
Remove the clutch and starter pinion from the Diesel engine flywheel housing as follows:

1. Follow the procedure for preparing the starting engine for removal described in the topic, STARTING ENGINE REMOVAL, to the point where the engine is to be lifted off.
2. Instead of lifting the starting engine off the flywheel housing, raise it only high enough to place supporting blocks approximately 2" thick, between the starting engine and the flywheel housing as shown. This will permit the starter pinion to pass by the idler gear (5).
3. Drain the oil from the clutch housing by removing the drain plug (4).
4. Remove the cover (1) from the governor housing.
5. Engage the clutch pinion. This will mesh the teeth on the pinion with the teeth on the flywheel gear and make removal of the clutch and pinion possible.



PREPARATION FOR CLUTCH  
REMOVAL

1-Governor cover. 2-Clutch cover.  
3-Inspection cover. 4-Drain plug.



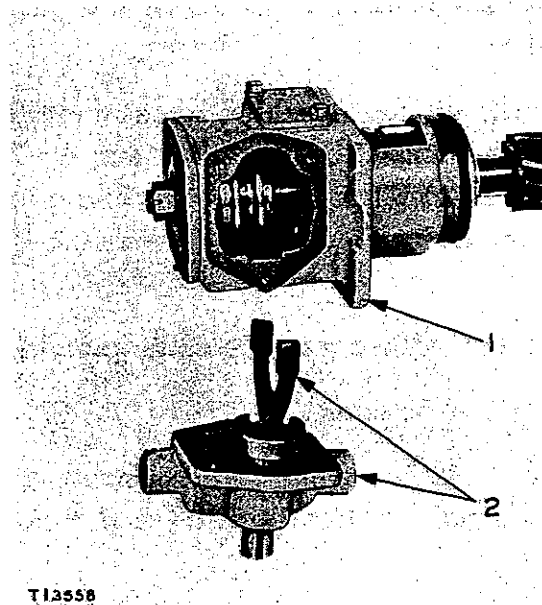
REMOVING CLUTCH AND  
STARTER PINION

5-Idler gear.

6. Remove the cover (2) to provide clearance.
7. Remove the upper rear capscrew from the inspection cover (3).
8. Remove all the clutch to flywheel housing capscrews and lift the clutch from the flywheel housing as illustrated.

### CLUTCH AND STARTER PINION DISASSEMBLY

1. Remove the clutch engaging yoke and cover (2) from the side of the clutch housing (1).



REMOVING ENGAGING YOKE AND COVER

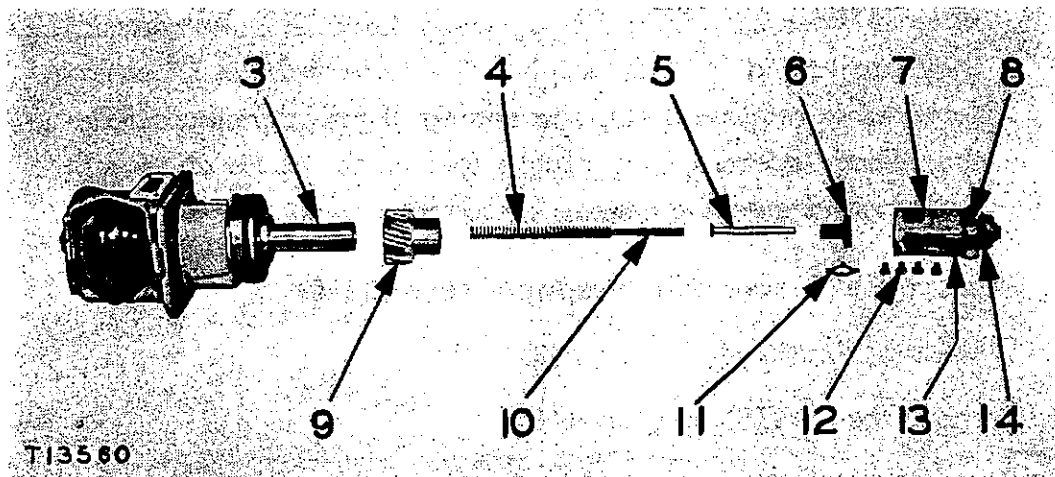
1-Clutch housing. 2-Engaging yoke and cover.

2. Remove the capscrews (12) which secure the sleeve (7) to the pinion (9).
3. If the latches (13) of the sleeve are engaged with the stop (6), they should be released.

#### NOTE

To release the latches, apply hand pressure against the button end of the sleeve and release the latches, by pressing inward on the upper end of each latch simultaneously.

4. Remove the sleeve from the pinion.
5. To remove the latches from the sleeve, press out the pins (8).



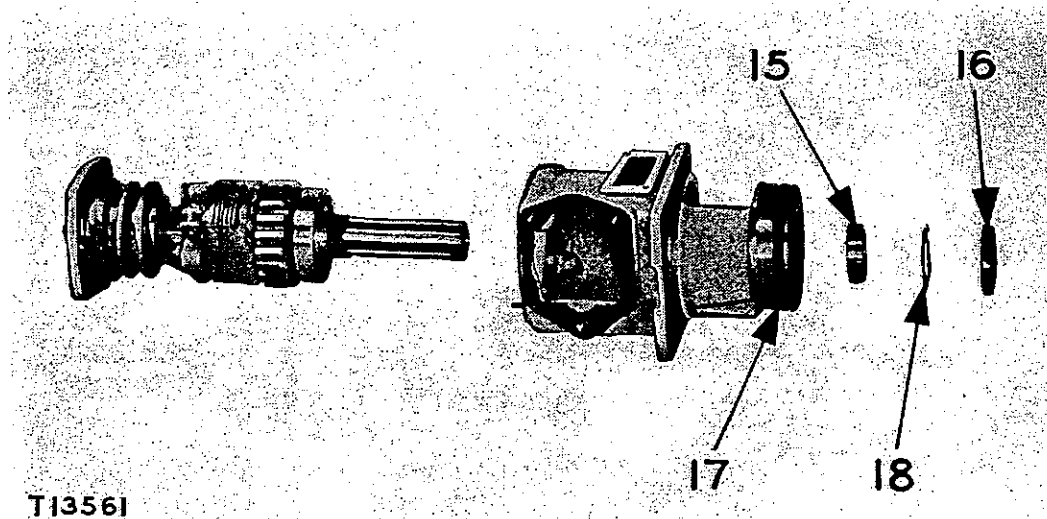
#### REMOVING PINION AND SLEEVE

3-Shaft. 4-Spring. 5-Plunger. 6-Stop. 7-Sleeve. 8-Pin. 9-Pinion. 10-Spring. 11-Lock. 12-Capscrew. 13-Latch. 14-Adjusting screw.

6. Remove the stop (6) and lock (11). Apply hand pressure downward on the plunger (5) when removing the stop to relieve spring pressure on the stop.

#### NOTE

If the adjusting screws (14) are to be removed from the latches (13), make match marks on the latch and adjusting screws before backing the screws out. Count the number of turns required to remove each screw and record the infor-

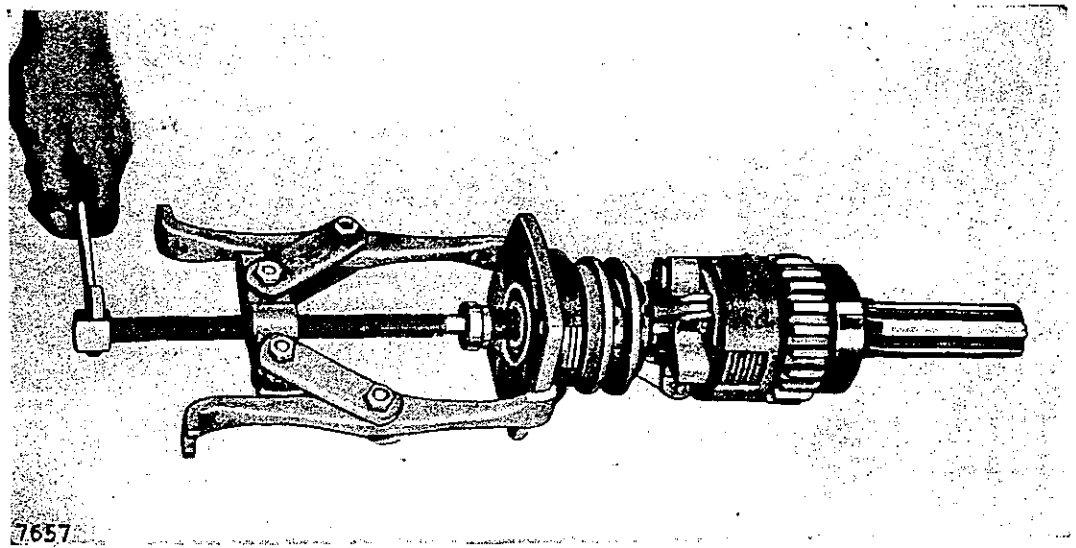


#### REMOVING CLUTCH AND ASSEMBLY FROM THE HOUSING

15-Seal. 16-Nut. 17-Seal. 18-Lock.

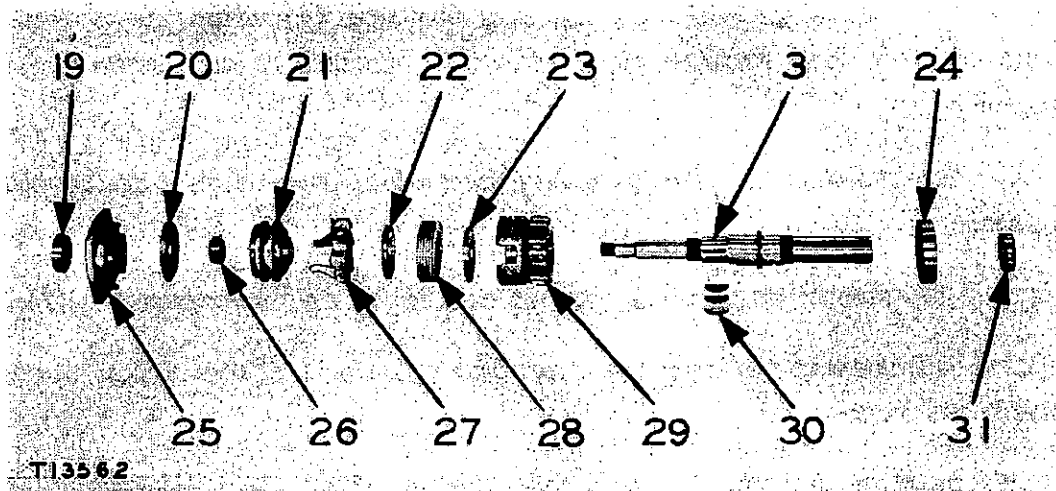
mation. When installing the screws in the latches, be certain they are turned into the latches the same number of turns required to remove them. The setting of the latches controls the release speed of the pinion and must not be changed unless adjustment becomes necessary.

7. Remove the plunger and the springs (4) and (10).
8. Pull the pinion (9) off the shaft (3).
9. Remove the nut (16) and lock (18).
10. Bump the end of the clutch shaft with a block of wood or brass bar to loosen the bearing in the clutch housing.
11. Remove the clutch assembly from the clutch housing as shown.
12. Inspect and if not in good condition, replace the seals (15) and (17).
13. Remove the seal (15) by inserting a suitable driver through the clutch housing and either press or drive the seal out.
14. When installing a new seal, press the seal into the clutch housing with the lip of the seal in.
15. Remove the retaining nut and pull the bearing and bearing cage from the clutch shaft with the 8B7546 Puller and the 8B7560 Step Plate.
16. Press the bearing (19) from the bearing cage (25).
17. Remove the clutch brake discs (20).



PULLING BEARING AND BEARING CAGE

18. Remove the sleeve (26) and the key which prevents the sleeve from turning on the shaft.
19. Slide the collar (21) off the clutch shaft.
20. Pull out on the plunger knob and back the spider assembly (27) off the threads and remove it from the shaft.



#### DISASSEMBLING THE CLUTCH

3-Shaft. 19-Bearing. 20-Brake discs. 21-Collar. 22-Adjusting plate. 23-Plate. 24-Bearing. 25-Bearing cage. 26-Sleeve. 27-Spider assembly. 28-Clutch discs. 29-Gear. 30-Keys. 31-Ring.

21. Inspect the dogs on the spider assembly and replace any that show excessive wear.
22. Remove the adjusting plate (22), clutch discs (28), plate (23) and the gear (29).

#### NOTE

There are twelve clutch discs, six steel and six brass. The six brass discs have three projections on their outer edge which fit into corresponding slots cut into the gear (29). The brass discs must, therefore, turn with the gear. The steel discs are keyed to the clutch shaft by the keys (30) and drive the shaft when the clutch is engaged.

23. Remove the bearing (24) and ring (31) from the shaft by either pressing or pulling them off the shaft.

## CLUTCH ASSEMBLY AND PINION LATCH ADJUSTMENT

The clutch can be assembled in reverse order of disassembly. Be certain when installing the steel and brass clutch discs that one of the brass discs is installed first. The remaining discs should then be alternated, installing a steel then a brass disc until all are in place.

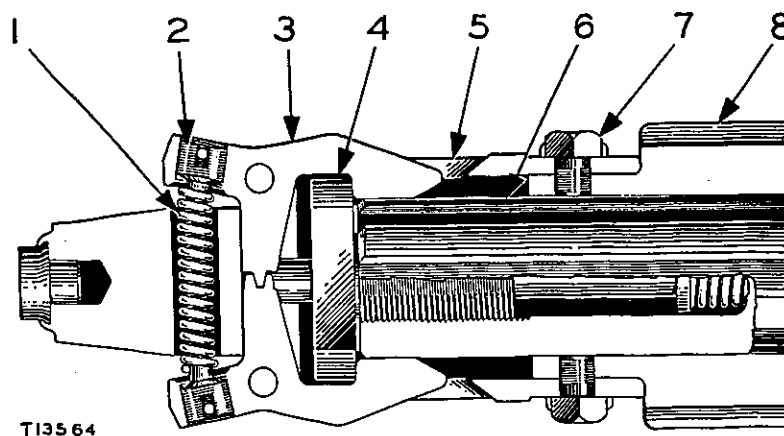
When installing the pinion (8) and the sleeve (5), the pinion must be positioned on the splines of the clutch shaft (6) so that the latches (3) will snap over the projecting portion of the stop (4) when the pinion is engaged. This may require more than one attempt to locate the pinion properly.

After the pinion has been properly located on the shaft, lock the stop in place.

Install the sleeve and install, tighten and lockwire the capscrews (7).

Latch adjustment controls the disengaging speed of the pinion due to centrifugal force.

Care must be observed not to raise the disengaging speed too high, since damage to the starting engine will result if the engine is overspeeded.



### INSTALLING THE PINION AND ADJUSTING THE LATCHES

1-Latch spring. 2-Latch adjusting screw. 3-Latch. 4-Stop. 5-Sleeve.  
6-Clutch shaft. 7-Capscrew. 8-Pinion.

The disengaging speed is controlled by the amount of tension placed on the latch spring (1), by turning the latch adjusting screws (2) in or out the required amount.



One complete turn of the adjusting screw (2) will increase or decrease (depending upon the direction in which it is turned) the disengaging speed of the pinion from 100 to 150 RPM.

Turn both latch adjusting screws an equal amount.

The latches are set at the factory to permit disengagement of the pinion at a clutch shaft speed of 3515 RPM.

When this setting has been obtained, lock the adjusting screws with cotter pins.

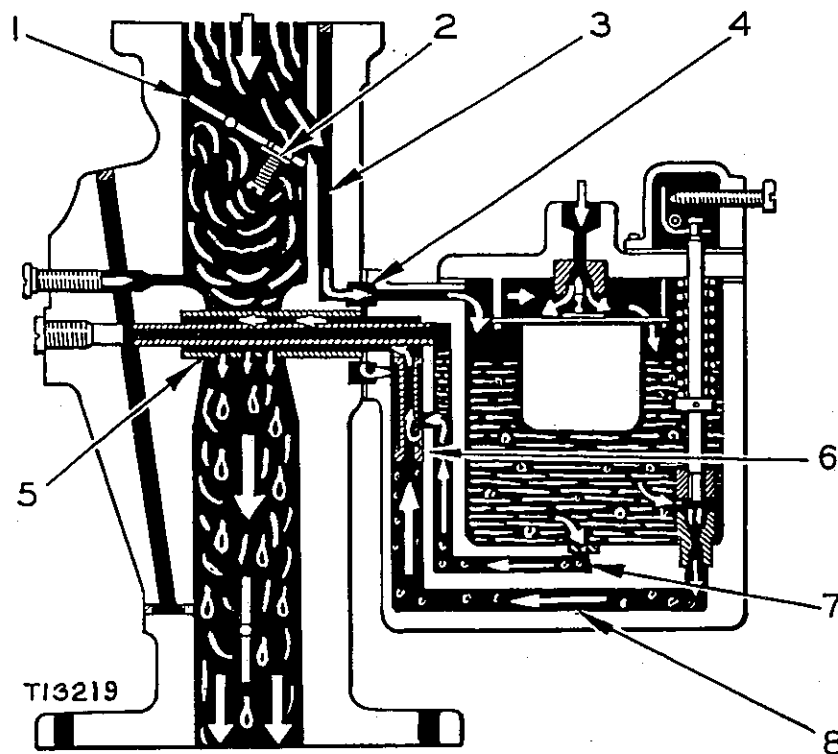
## Carburetor

A Zenith TU-4C Series Carburetor of the down draft type is used.

### OPERATION

This carburetor is sealed, protecting all internal parts from dirt and moisture. All air for the jet system, idling and ventilation of the fuel bowl is drawn through the air cleaner.

### Carburetor Starting Action



### CARBURETOR STARTING ACTION

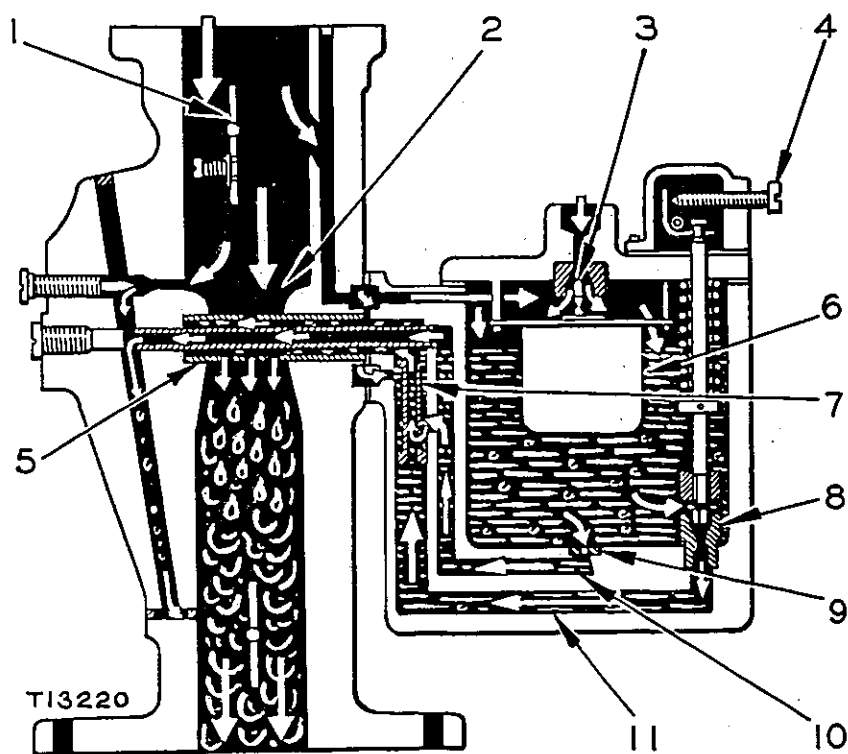
1-Choke plate. 2-Poppet valve. 3-Air passage. 4-Circular chamber. 5-Main discharge nozzle. 6-High speed metering well. 7-Compensating passage. 8-Main passage.

With the choke plate (1) closed, air is drawn into passage (3). The air divides at the circular chamber (4). One stream of air enters the float chamber and causes the fuel to rise in the main passage (8) and the compensating passage (7). The other stream of air flows around the jacket of the high speed metering well (6) and mixes with the fuel in the main passage (8). The low pressure area created under the choke plate and around the main discharge nozzle (5) siphons the fuel-air mixture out of the six discharge holes in the main discharge nozzle and into the carburetor throat.

After the engine starts, the suction of the engine inlet manifold opens the poppet valve (2) located in the choke plate. This permits the engine to continue running until the choke control rod can be pushed in.

### Carburetor High Speed Action

Once the engine has started and the choke plate (1) has been opened, the low pressure area at the bottom of the venturi (2) siphons the fuel from the main jet (8). The fuel passes through the main passage (11) to the high speed metering well (7) and is discharged into the air stream from the main discharge nozzle (5).



#### CARBURETOR HIGH SPEED ACTION

1-Choke plate. 2-Venturi. 3-Needle valve. 4-Main jet adjusting screw. 5-Main discharge nozzle. 6-Float. 7-High speed metering well. 8-Main jet. 9-Compensator jet. 10-Compensating passage. 11-Main passage.

Compensation fuel flows through the compensator jet (9) into the compensator fuel passage (10). From the compensator fuel passage it flows through a cross drilled passage and into the high speed metering well jacket. The fuel enters the high speed metering well through a small hole in the side of the metering well and mixes with the fuel in the main discharge nozzle.

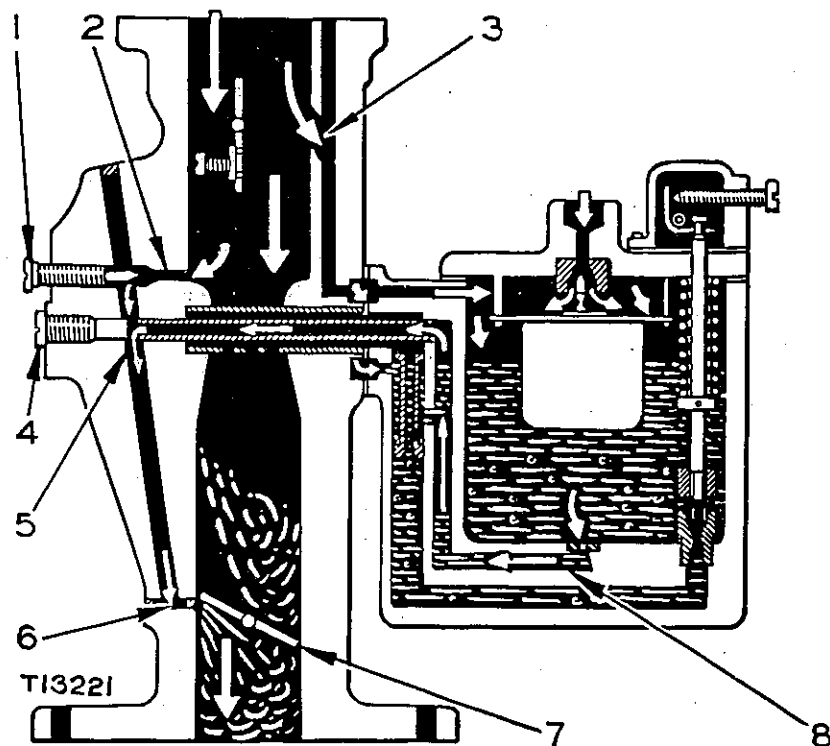
This extra fuel also provides a reserve for good recovery when the throttle is opened quickly.

The main jet adjusting screw (4) provides a means of controlling the flow of fuel from the fuel bowl to the main fuel passage way leading to the main discharge nozzle.

The float (6) controls the amount of fuel in the fuel bowl by opening and closing the needle valve (3).

### Carburetor Idling Action

When the engine is idling with the throttle plate (7) closed, air enters the passage (3) causing the fuel to rise in the compensator passage (8).



### CARBURETOR IDLING ACTION

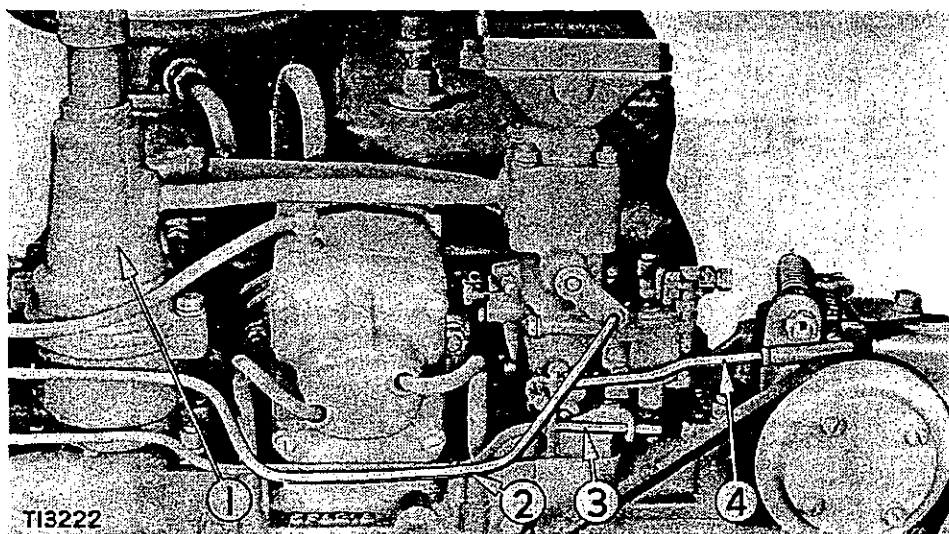
1-Idle adjusting screw. 2-Passage. 3-Passage. 4-Idle discharge jet. 5-Hole in idle discharge jet. 6-Idle discharge port. 7-Throttle plate. 8-Compensator passage.

Air passing through passage (2) and across the idle discharge jet (4) siphons fuel from a hole (5) in the idle discharge jet and discharges it through the idle discharge port (6) into the carburetor throat.

The idle adjusting screw (1) does not meter fuel, but adjusts the amount of air allowed to enter and mix with the fuel at idling speeds.

## REMOVAL

1. Remove the flame arrester or air cleaner if so equipped.
2. Disconnect the throttle control rod (3) and the choke control rod (2).
3. Disconnect the governor control rod (4).
4. Remove the starting engine oil filler (1).
5. Disconnect the fuel inlet line.
6. Remove the nuts holding the carburetor in place and remove the carburetor.



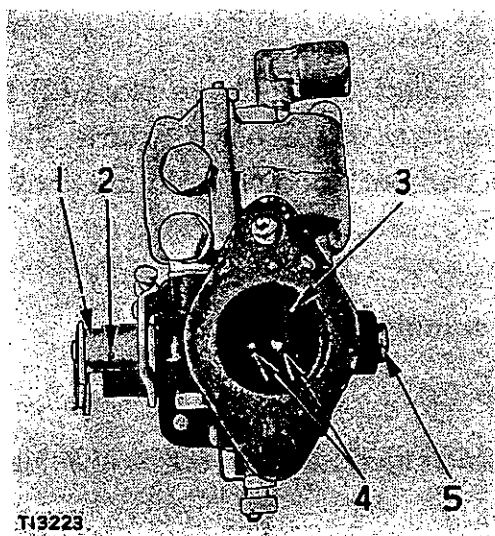
### REMOVING CARBURETOR (D311 Marine Illustrated)

- 1-Starting engine oil filler. 2-Choke control rod. 3-Throttle control rod.  
4-Governor control rod.

## DISASSEMBLY

### Throttle Valve

1. Melt the solder around the screws (4) and remove them.
2. Remove the throttle plate (3).



#### REMOVING THROTTLE VALVE

1-Stop assembly. 2-Tapered pin. 3-Throttle plate. 4-Screws. 5-Cap.



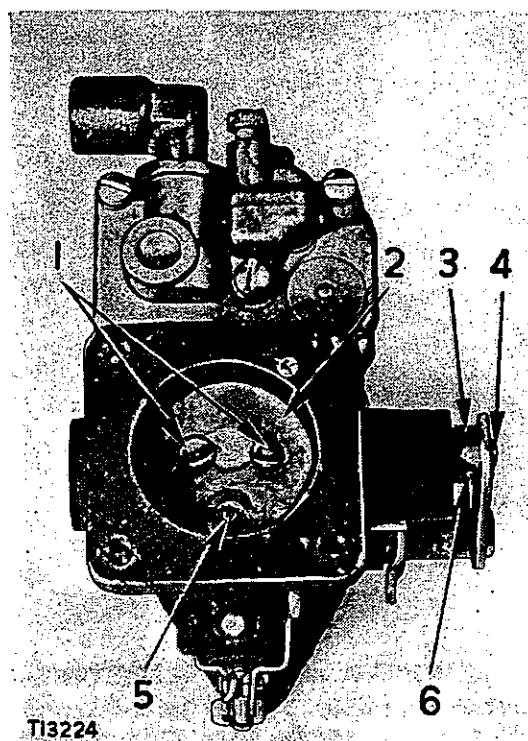
3. Drive the tapered pin (2) out of the stop assembly (1).
4. Remove the stop assembly (1).
5. Remove the cap (5) and drive the shaft out of the retaining ring.

#### Choke Control

1. Melt the solder around the two screws (1) and remove them.
2. Remove the choke plate (2).
3. Drive out the taper pin (6) and remove the lever assembly (3).

#### REMOVING CHOKE PLATE

1-Screws. 2-Choke plate. 3-Lever assembly. 4-Shaft assembly. 5-Pop-pet valve. 6-Taper pin.



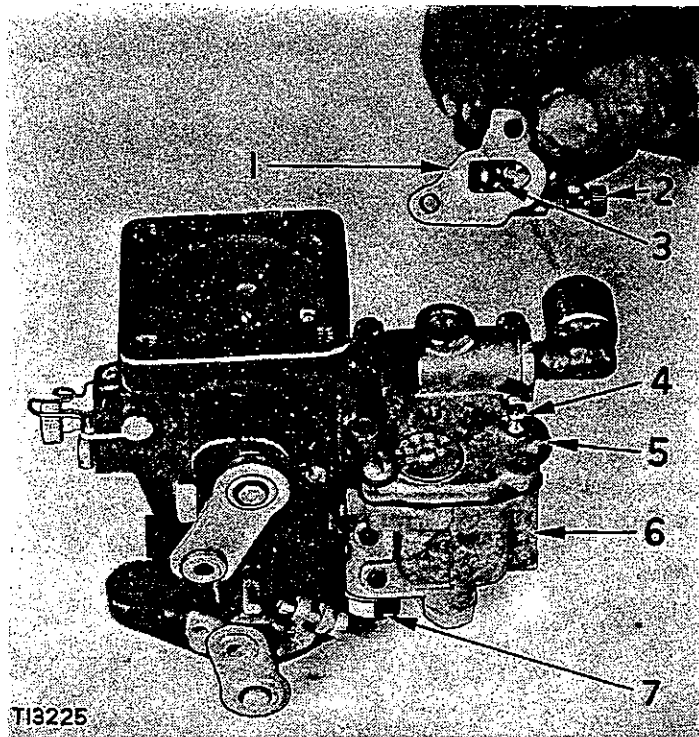
4. Drive out the shaft assembly (4).

The spring loaded poppet valve (5) located in the choke plate (2) is opened by the force of the air stream as soon as the engine starts. This permits the engine to continue running without flooding until the choke control rod can be pushed in.

### Main Jet Adjusting Screw and Needle Assembly

1. Unscrew the main jet adjusting screw (2).
2. Remove the screws securing the housing assembly (1) to the fuel bowl cover (5).
3. Unhook the hinge (3) from around the needle assembly (4) and remove the housing assembly (1).
4. Remove the fuel bowl cover (5) from the fuel bowl (6) and remove the needle assembly (4).

The main jet adjusting screw (2) raises and lowers the spring-loaded needle assembly (4) which regulates the amount of fuel in excess of the fuel from the compensator jet (10).



### REMOVING MAIN JET ADJUSTING SCREW AND NEEDLE ASSEMBLY

1-Housing assembly. 2-Main jet adjusting screw. 3-Hinge that permits raising and lowering of the needle assembly. 4-Needle assembly. 5-Fuel bowl cover. 6-Fuel bowl. 7-Plug covering high speed metering well.

The amount of fuel is changed by screwing the main adjusting screw clockwise to increase and counterclockwise to decrease.

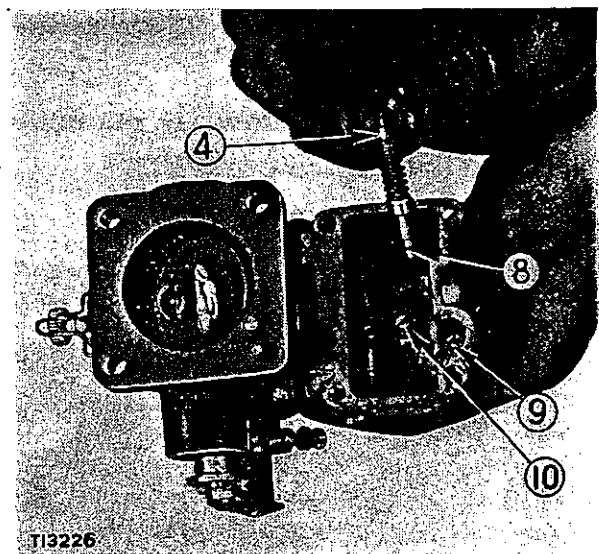
The head of the main jet (9) is specially shaped to accommodate the tapered end of the main adjusting needle. When the adjusting needle is seated in the main jet, the fuel must pass through the orifice (8) to reach the main jet, thus the minimum fuel limit is accomplished.

Screwing the main jet adjusting screw (2) clockwise raises the adjusting needle up from the main jet and permits extra fuel to move around the needle to reach the main jet. When fully open, the size of the main jet calibration becomes the maximum limit.

The maximum limit is the size of the main jet and the minimum limit is the size of the orifice in the main adjusting needle.

#### REMOVING NEEDLE ASSEMBLY AND JETS

4-Needle assembly. 8-Orifice in  
needle assembly. 9-Main jet.  
10-Compensator jet.

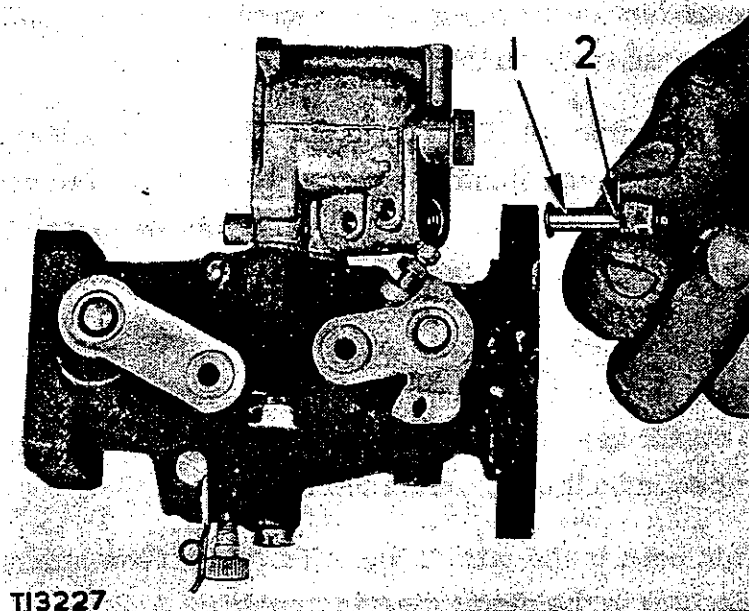


The main jet (9) and the compensator jet (10) can be removed with a screwdriver.

The high speed metering well is located under the plug (7).

#### High Speed Metering Well

After removing the plug over the high speed metering well (1), remove the well. The fuel flow through the metering well is regulated by the size of the orifice (2).

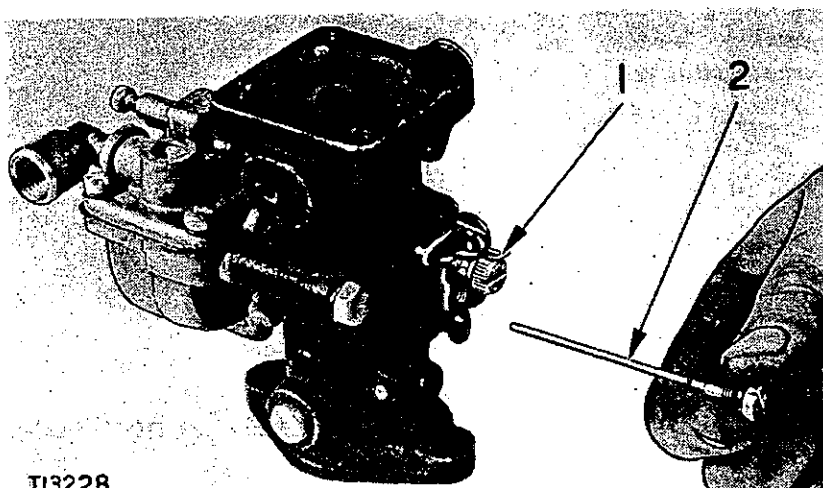


TI3227

**REMOVING HIGH SPEED METERING WELL**  
1-High speed metering well. 2-Orifice.

### Removing Idling Jet

The idle adjusting screw (1) regulates the amount of air to be mixed with the fuel at the idling jet (2).



TI3228

**REMOVING IDLING JET**  
1-Idle adjusting screw. 2-Idling jet.

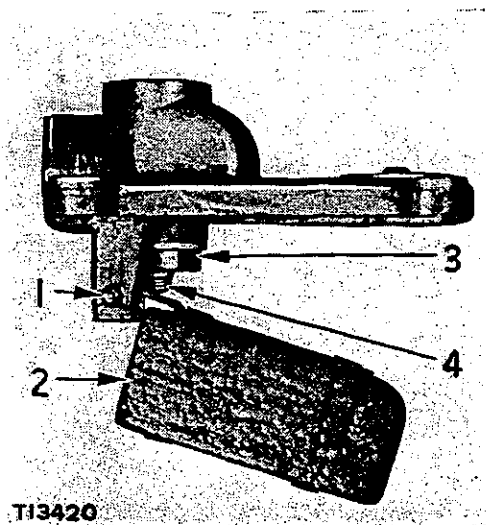
The idling jet (2) can be removed with a screwdriver. The jet controls the amount of fuel taken from the high speed metering well.

The fuel and air pass through the priming plug located in the carburetor throat adjacent to the idling position of the throttle valve.



## Float Assembly

If the float needle valve (4) leaks or the engine performance does not respond to normal carburetor adjustment, inspect the seat of the valve assembly after removing the pin (1) and the float assembly (2).



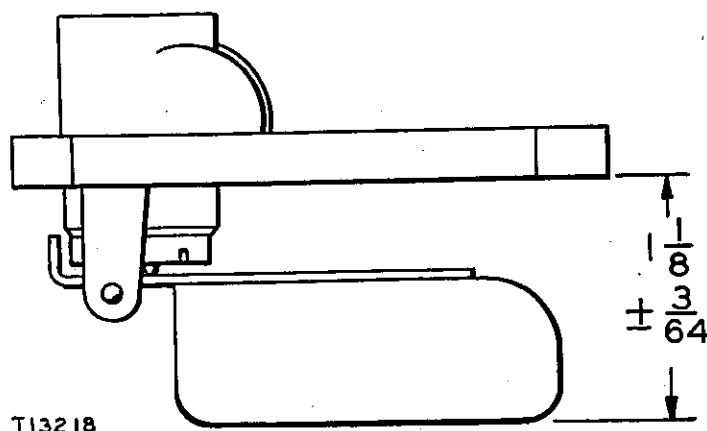
### NEEDLE VALVE AND FLOAT ASSEMBLY

1-Pin. 2-Float assembly. 3-Needle valve seat. 4-Needle valve.

Clean any foreign materials from the seat (3), or if worn, replace the needle valve (4) and the seat (3).

The float level is correct when a measurement of  $1\frac{1}{8}$ " plus or minus  $\frac{3}{64}$ " exists between the face of the cover of the fuel bowl (without gasket) and the float as shown.

### FLOAT ASSEMBLY LEVEL





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