Operation and Maintenance *Instructions*

Four Cylinder Diesels

ZD-129	ED-201	ED-208
GD-157	HD-260	HD-277
GD-193	JD-382	

Continental Motors Corporation
Muskegon, Michigan

Form No. DM 5154-B

Revised 4-15-58

QUICK REFERENCE SECTION INDEX

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FOREWORD

Diesel engines have today assumed a position of importance in the field of power development. Because of their inherent characteristics of high thermal efficiency, they have become the answer to a long standing demand for more economical power. The entry of CONTINENTAL MOTORS CORPORATION into the Diesel field was made only after extensive research had enabled them to produce a Diesel engine which would maintain the reputation earned in over 50 years of leadership in the internal combustion engine industry.

Continental Red Seal Diesel engines are designed for rugged service and are simple to service and maintain; they are capable of producing smooth dependable power, with excellent fuel economy.

Good operation and a **planned** maintenance program as outlined in this manual are of vital importance in obtaining maximum engine performance, and long engine life. The instructions on the following pages have been written with this in mind, to give the operator a better understanding of the various problems which may arise, and the manner in which these problems can best be solved or avoided.

The operator is cautioned against the use of any parts, other than **Genuine Continental Parts** for replacement or repair. Genuine Continental parts have been engineered and tested for their particular job, and the use of any other parts may result in unsatisfactory performance and short engine life. Likewise, Continental distributors and dealers, because of their close factory relations, can render the best and most efficient service.

Continental Motors Corporation
MUSKEGON, MICHIGAN

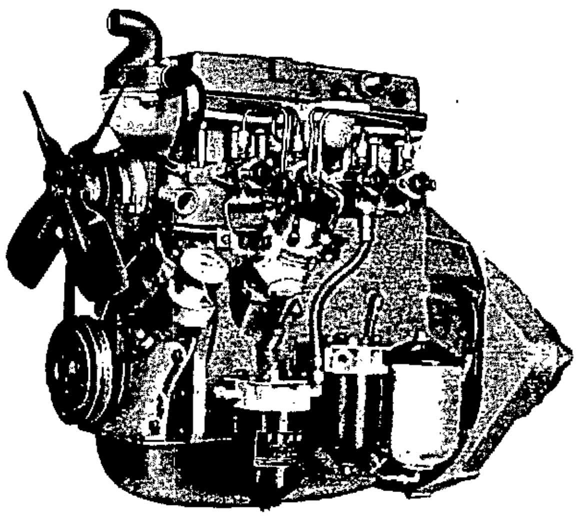


Figure 1 — ZD 129 Diesel

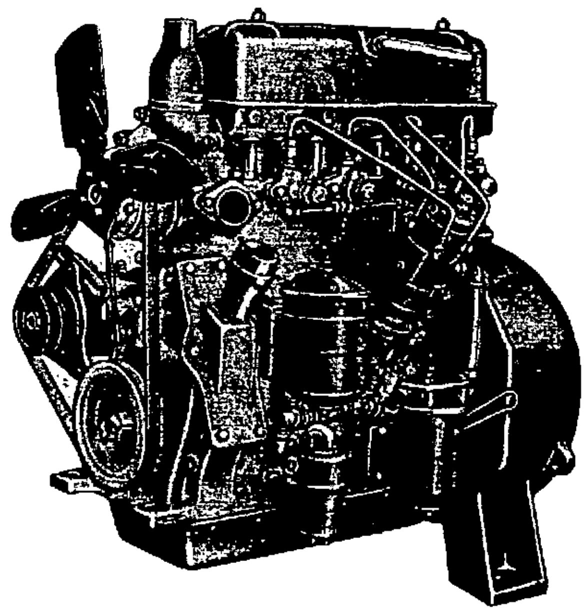


Figure 2 — GD-157 Diesel

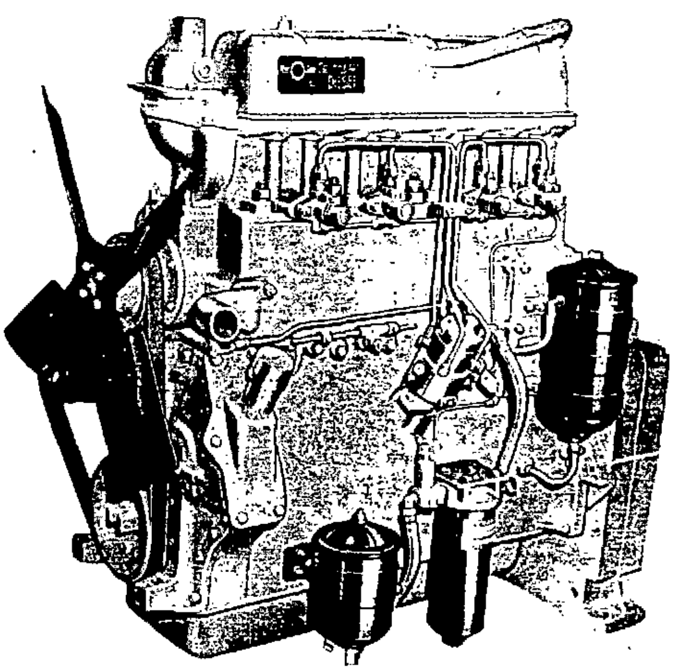


Figure 2A — JD 382 Diesel

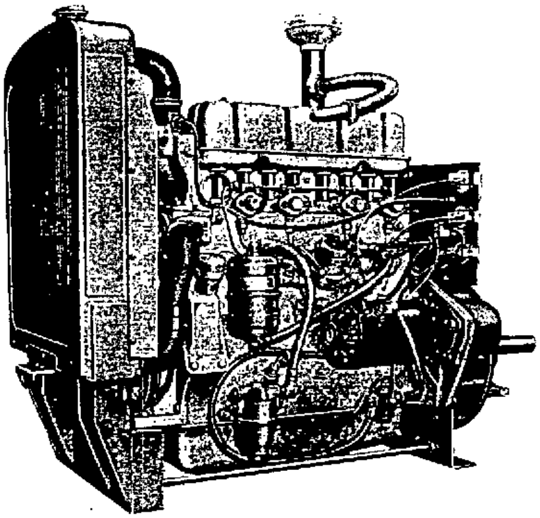


Figure 2B — ED 201 Diesel

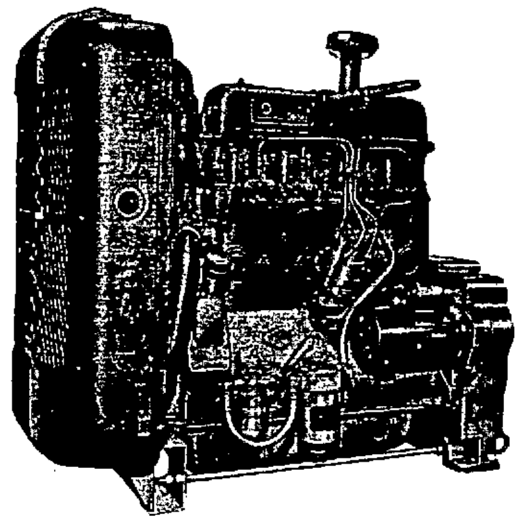


Figure 3 — HD 260 Diesel

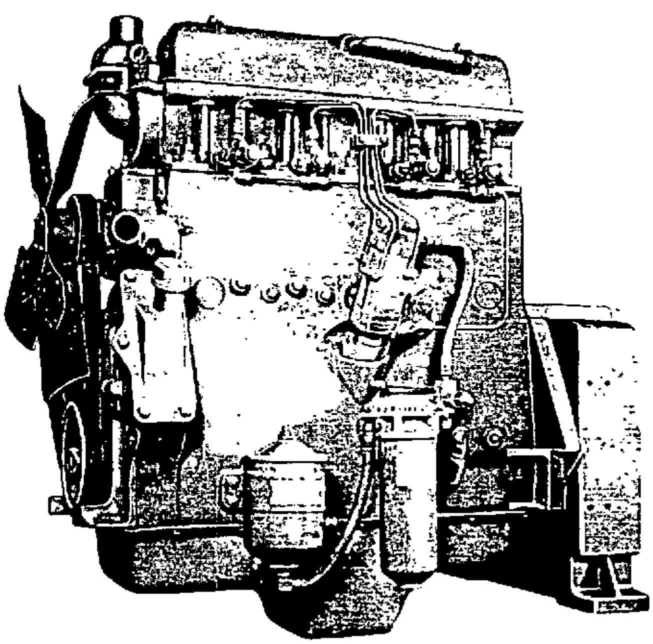


Figure 4 — JD 382 Diesel with a Lanchester Balancer

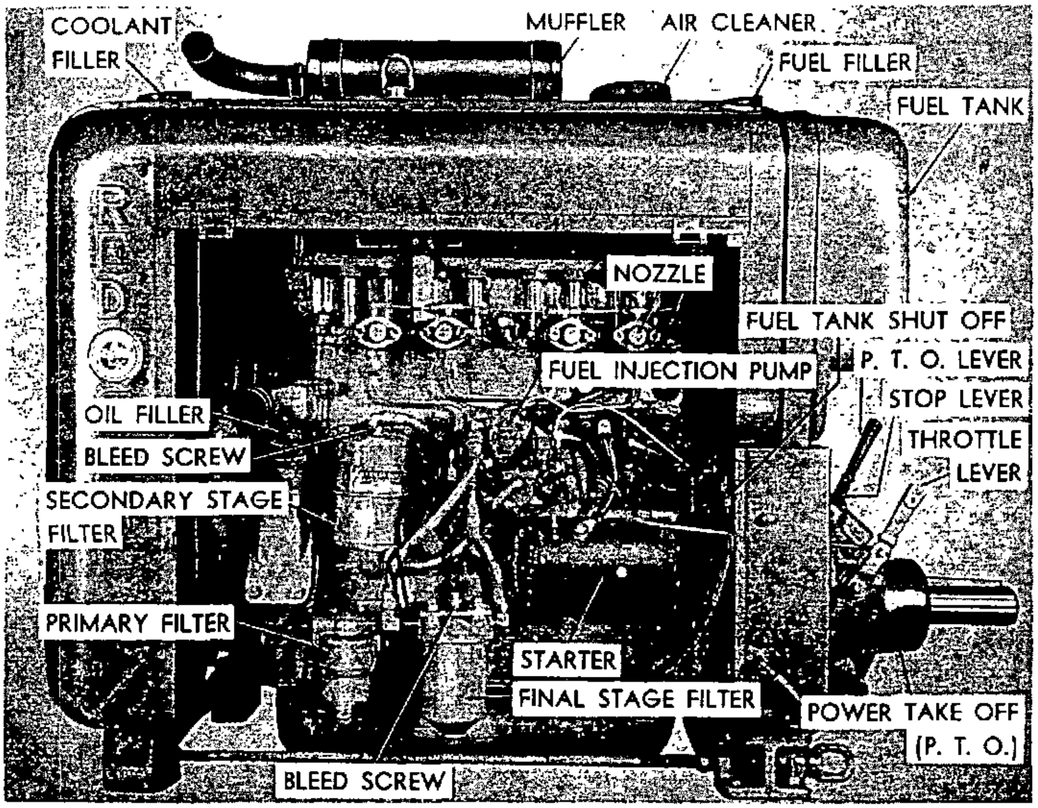


Figure 5—HD260 Diesel, Closed Power Unit (Fuel Injection Side)

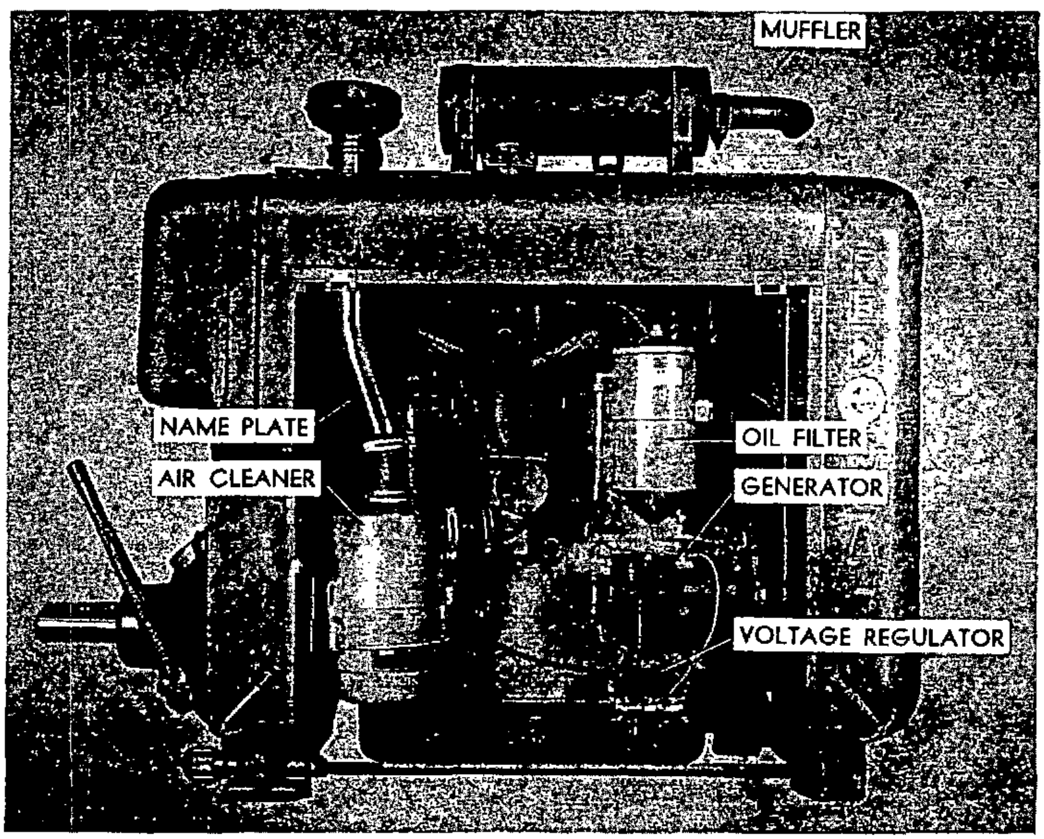


Figure 6—HD260 Diesel, Closed Power Unit (Manifold Side)

FOUR CYLINDER DIESEL ENGINE SPECIFICATIONS

MODEL	ZD-129	GD-157	GD-193	ED-201*	HD-260**	JD-382
No. of cyl.	4	4	4	4	4	4
Bore and stroke	$3\frac{1}{4} \times 3\frac{7}{8}$	$3\frac{3}{8} \times 4\frac{3}{8}$	$3\frac{3}{4} \times 4\frac{3}{8}$	$3\frac{5}{8} \times 4\frac{7}{8}$	$3\frac{7}{8} \times 5\frac{1}{2}$	$4\frac{1}{2} \times 6$
Displacement cu. in.	129	157	193	201	260	382
Comp. ratio	16.25:1	15.54:1	16.8:1	15.5:1	15.0:1	15.0:1
H. P. BHP	34 at 2000	39 at 2000	52.5 at 2000	45.8 at 2000	59.3 at 2000	72.5 at 1600
Max. Torque lb. ft.	95 at 1200	113 at 1200	154 at 1200	145 at 1100	188 at 1100	276 at 1000
Oil Pressure Normal at 1800 RPM	30–40	30–40	30–40	10–20	30–40	30–40
Min. at Idling	7	7	7	7	7	7
Firing order	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2
Main brg. frt.	$2\frac{1}{2} \times$ 1-7/16	$2\frac{3}{8} \times$ 1-19/32	$2\frac{3}{8} \times$ 1-19/32	$2\frac{5}{8} \times 1\frac{5}{8}$	$2\frac{7}{8} \times 1\frac{3}{4}$	$3\frac{1}{4} \times 2\frac{1}{8}$
ctr.	$2\frac{1}{2} \times 1\frac{1}{2}$	$2\frac{3}{8} \times 1\frac{3}{4}$	$2\frac{3}{8} \times 1\frac{3}{4}$	$2\frac{5}{8} \times 2$	$2\frac{7}{8} \times$ 2-5/16	$3\frac{1}{4} \times 2\frac{5}{8}$
rear	$2\frac{1}{2} \times$ 1-17/32	$2\frac{3}{8} \times$ 1-25/32	$2\frac{3}{8} \times$ 1-25/32	$2\frac{5}{8} \times$ 1-15/16	$2\frac{7}{8} \times$ 2-1/16	$3\frac{1}{4} \times$ 2-11/32
Conn. rod brg. Dia. and length	$2\frac{1}{4} \times 1\frac{1}{4}$	2-1/16 x 1-5/16	$2\frac{1}{4} \times$ 1-5/16	$2\frac{1}{4} \times$ 1-9/16	$2\frac{1}{2} \times$ 1-13/16	$2\frac{3}{4} \times$ 1-13/16
Oil Capacity (Qts.) Crankcase only	5	5	5	6	6	11
Oil Filter	1	1	1	1	2	2
Total	6	6	6	7	8	9
Fuel Capacity (Gal.)	13	13	13	15	15	17
Water Capacity (Gal.)	$4\frac{3}{4}$	5	5	5	6	9
Valve clearance (Hot and Idling) Intake	.012 hot	.014 hot	.014 hot	.014 hot	.014 hot	.014 hot
Exhaust	.012 hot	.014 hot	.014 hot	.014 hot	.014 hot	.014 hot
Weight — Bare Engine	395	575	600	650	790	990

NOTE

* Data for ED-208 same as ED-201 except: $3\frac{11}{16}$" Bore — 208 cu. in. Displacement 57.3 H.P. @ 2000 — 154.5 Max. Torque @ 1400

** Data for HD-277 same as HD-260 except: 4" Bore — 277 cu. in. Displacement 72.9 H.P. @ 2000 — 204 Max. Torque @ 1200

INFORMATION FOR ORDERING PARTS

When ordering parts, refer to the **engine name plate** attached to side of the cylinder block, which lists the model and serial number. In most cases a specification number is listed. This data is of vital importance in obtaining the correct parts: **always include this information on your parts order.**

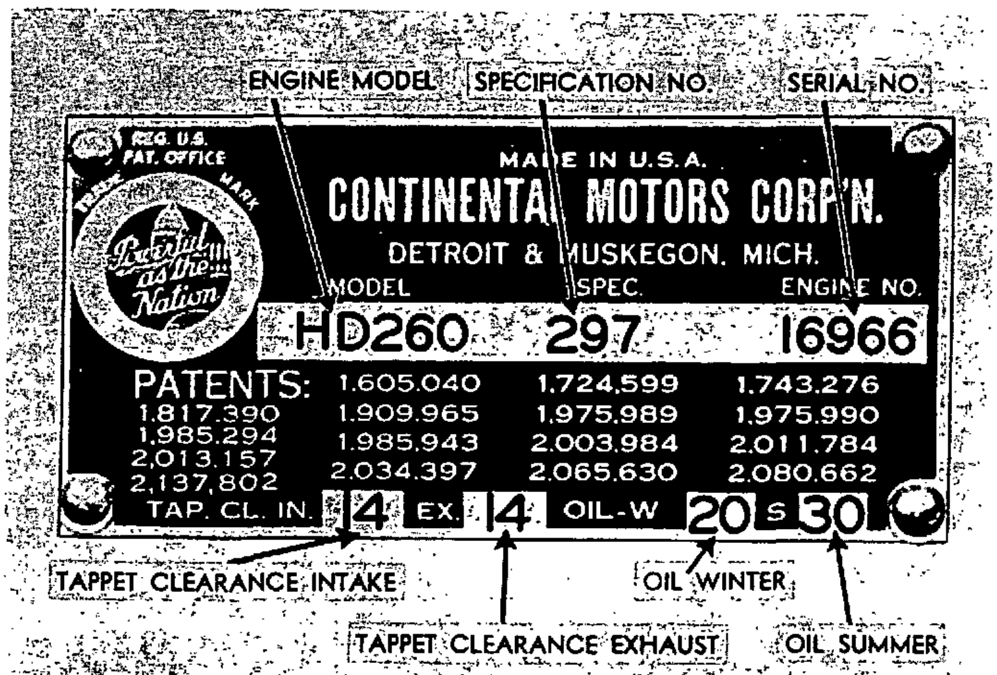


Figure 7—Nameplate

SECTION I
GENERAL INFORMATION

ELEMENTARY PRINCIPLES OF DIESEL ENGINES

In order to dispel any mystery there may be with regard to the diesel engine and how it operates, let us take a moment to compare any one of our Continental Red Seal Diesel Engines with its gasoline counterpart.

Mechanically, the two are alike. Both have pistons moving up and down in cylinders with connecting rods attached to a crankshaft converting the reciprocating motion of the pistons into a rotary motion; valves in the cylinder heads operated by a camshaft and push rods; the intake valve to admit air into the cylinder and the exhaust valve to permit the disposition of burned gases. The camshaft is driven through a train of timing gears so that the opening and closing of the exhaust and intake valves are properly timed with the stroke of the piston and crankshaft.

The engines are so much alike in exterior appearance that the only way most people are able to distinguish between them is to look for the carburetor and distributor on the gasoline engine or injection pump on the diesel.

Both operate on mixtures of liquid fuel and air inside the combustion chambers. The ignition of these mixtures under pressure and the subsequent expansion furnishes the power to drive the piston downward on its power stroke. The one big difference between the two types of engines lies in the way the fuel is handled and combustion brought about.

In a gasoline engine desired proportions of fuel and air are mixed in the carburetor before entering the cylinder through the intake valve. In a diesel engine, air is drawn into the cylinder through the intake valve and is compressed and at the proper time a measured quantity of fuel is injected into this air thus forming a combustible mixture which is self-ignited due to the temperature of the compressed air.

To further illustrate this, on page 8 we show what actually takes place in the gasoline and diesel engines during the four strokes in any one cylinder. In a gasoline engine the suction or downward stroke of the piston draws in a combustible mixture of air and gasoline which is compressed in the upward stroke, then ignited by an electric spark whereupon the expansion of this compressed mixture begins, forcing the piston down on the power stroke and upward on the exhaust stroke which follows.

In the diesel engine, the piston on the down stroke draws in clean pure air which is compressed on the upward stroke. At the proper instant, fuel is injected into this compressed air which then ignites from the heat of compression causing the expansion of the mixture, which forces the piston down on the power stroke and up on the exhaust stroke. The compression ratio of diesel engines is twice that of gasoline engines, and it is the heat generated by the comparatively rapid compression of the air, which ignites the fuel as it is sprayed in under high pressure.

GENERAL INFORMATION

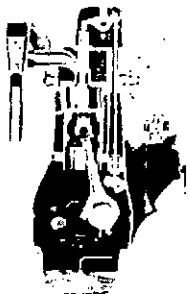
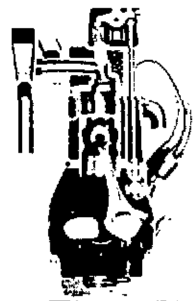
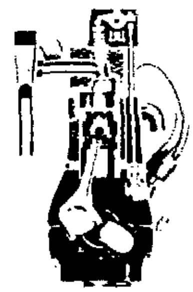
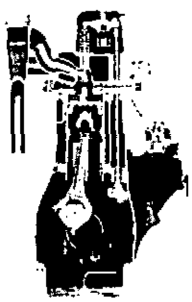
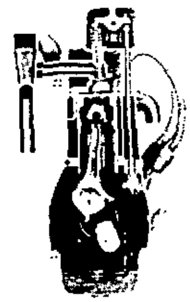
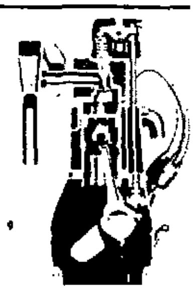
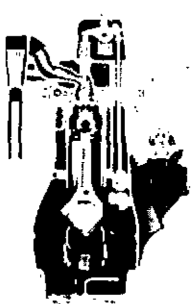
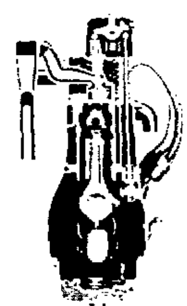
4 CYLINDER DIESEL	STROKE	4 CYLINDER GASOLINE
 **INTAKE** Air only is drawn into the cylinder through the open intake valve by the suction created by the DOWNWARD moving piston.	INTAKE	**INTAKE** The properly proportioned mixture of gasoline and air formed by the carburetor is drawn into the cylinder through the open intake valve by the suction created by the DOWNWARD moving piston. 
 **COMPRESSION** The intake valve is now closed and the air in the cylinder is highly compressed by the UPWARD MOVING piston. This high compression of the air raises the temperature to between 900° and 1000° F.	COMPRESSION	**COMPRESSION** The intake valve is now closed and the mixture of gasoline and air is compressed by the UPWARD moving piston. 
 **INJECTION AND COMBUSTION** At a definite point, shortly before the piston reaches the top of its stroke, fuel is injected into the cylinder by the spray nozzle. The fuel is ignited by the heat of the highly compressed air.	INJECTION / IGNITION	**IGNITION AND COMBUSTION** At a definite point, shortly before the piston reaches the top of its stroke, an electric spark from the spark plug ignites the compressed mixture. 
 **POWER** The expansion of the gases resulting from the burning of the fuel exerts pressure on top of the piston, driving it DOWNWARD.	POWER	**POWER** The expansion resulting from the combustion of the air-fuel mixture exerts pressure on top of the piston, driving it DOWNWARD. 
 **EXHAUST** As the piston passes the bottom of its stroke the exhaust valve opens and the burnt gases are expelled by the now UPWARD moving piston. The intake valve opens about the time the piston reaches the top of its stroke and a similar sequence of events also referred to as "cycle" repeats itself.	EXHAUST	**EXHAUST** As the piston passes the bottom of its stroke the exhaust valve opens and the burnt gases are expelled by the now UPWARD moving piston. The intake valve opens about the time the piston reaches the top of its stroke and a similar sequence of events also referred to as "cycle" repeats itself. 

Figure 8 — Comparison Between Diesel and Gasoline 4 Cycle Operation.

It is a well known fact that the tendency in gasoline engine design is to increase compression ratios in order to obtain more power and greater efficiency out of the engine without increasing the bore and stroke. Compression ratios are however limited by the octane number of fuels available and the desire to keep combustion chamber temperatures down to prevent pre-ignition. A diesel engine is not controlled by these conditions, consequently, compression ratios in the neighborhood of 15 to 1 can be used with entire satisfaction since there is no possibility of the air in this engine igniting until injection of the fuel provides a combustible mixture. This high compression in a diesel causes the temperature of the air to rise under compression to approximately 900° Fahrenheit, which is far above the ignition point of the fuel, thus igniting the mixture.

To summarize, both engines are heat engines of the internal combustion type, the power in each case being developed from the expansion of the mixture of air and fuel after ignition occurs. Since the expansion is directly related to the compression, the diesel is able to deliver a greater amount of work using a given quantity of fuel. This is basically the reason for its superior efficiency, which results in its saving in fuel cost.

THE CONTINENTAL DIESEL ENGINE

Continental Red Seal Diesel Engines are the four-stroke cycle type and developed to operate efficiently on Commercial Diesel Fuels, which, when injected into the combustion spaces, are ignited by the heat of compression, without other ignition aids.

In order to clarify the features of Continental Design, we will go through a complete cycle of events for one cylinder, even though it means repeating, to a certain extent, information given in a previous section.

1. The piston on its downward stroke, draws in a charge of clean fresh air, through the open intake valve and intake manifold which is unrestricted except for the oil bath air cleaner.

2. On the upward or compression stroke, the air is forced into the combustion chamber and energy cell where it is compressed approximately 15 to 1. Compressing it to this high ratio, raises its temperature to between 900° and 1000° F.

3. Near the top of the compression stroke, at a predetermined point, fuel is injected into the combustion chamber under pressure of approximately 1800 pounds per square inch. Fig. 9. This injection takes the form of a solid core passing directly from nozzle "C" across the combustion chamber "B" into the opening of the energy cell "A". This solid core is surrounded by a conical spray which upon entering the heated air in the combustion chamber, ignites and starts the combustion.

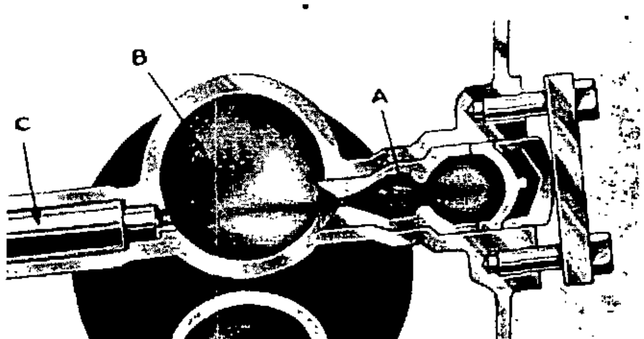


Figure 9—Fuel Injected into Combustion Chamber

The air and fuel trapped in the energy cell likewise ignites, Fig. 10, but due to the design

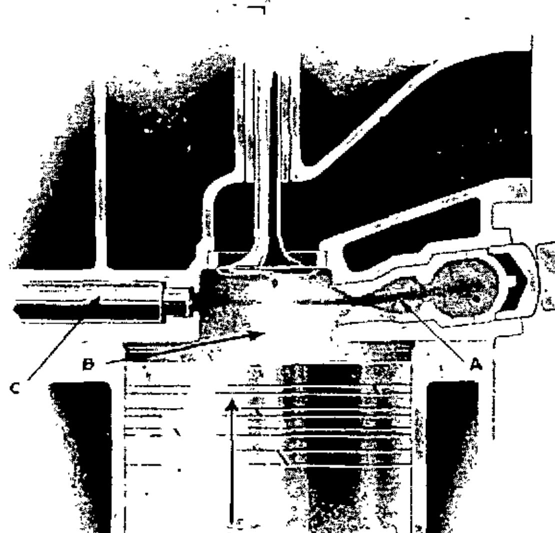


Figure 10—Combustion Starting in Energy Cell

of this assembly, which is made of special steels, the rapidly built up pressure is trapped and is permitted to expand only through the metered opening, back into the combustion chamber where its application against the head of the piston continues well through the power stroke.

THE CONTINENTAL DIESEL ENGINE

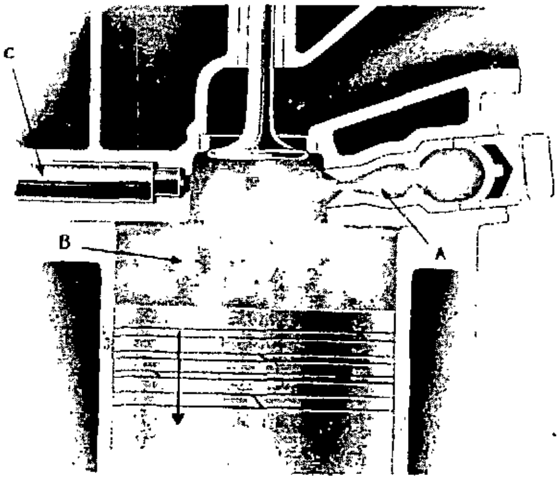


Figure 11
Power Stroke

It is this reaction, wherein the full pressure of combustion is not permitted to reach the piston in one heavy, sharp build up of power, but instead is controlled and extended over a longer portion of the downward stroke, that provides foundation for the name Cushioned Power.

4. Near the end of the power stroke, the exhaust valve opens and as the piston starts up on the fourth and final stroke of the cycle, the burned gases are forced out through the exhaust system.

This design makes it possible to build a Diesel Engine that is comparatively light in weight, without sacrificing power or engine life.

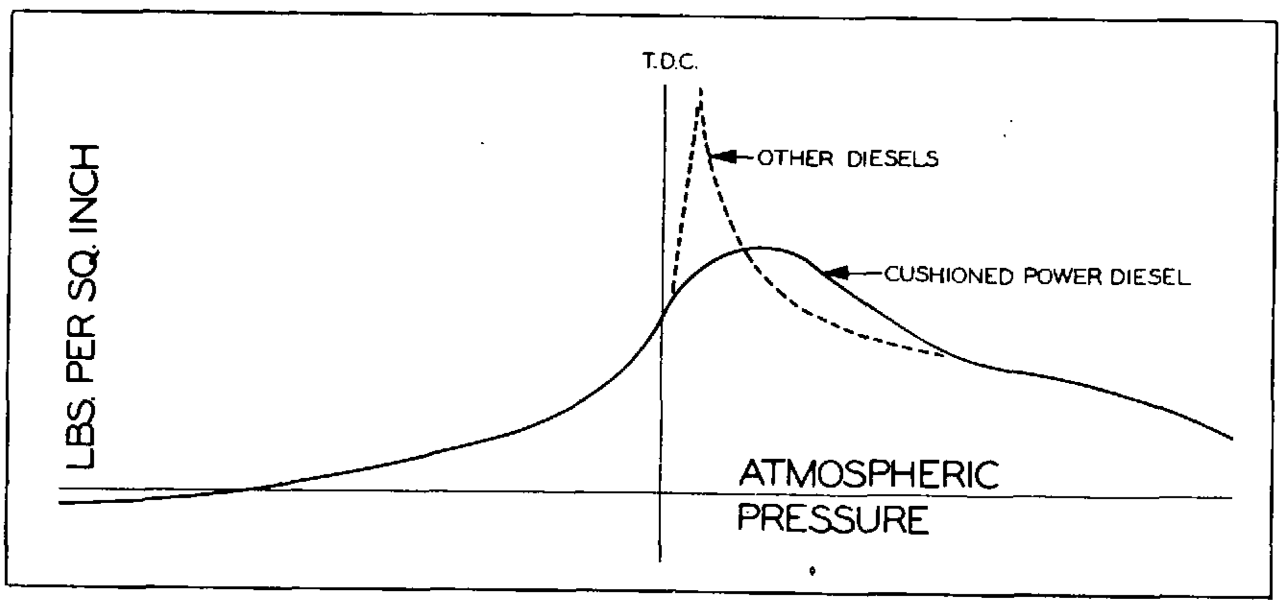


Figure 12
"Cushioned Power" Controlled Combustion pressure

DIRT
IS THE WORST ENEMY
OF A DIESEL ENGINE

SECTION II
FUELS & LUBRICATION

FUEL OIL RECOMMENDATIONS

Diesel fuel oil selection, handling and filtration is of great importance. The fuel not only supplies the energy for all the work done by the engine but it also lubricates the parts of the fuel injection system which operate with very close tolerances. Fuel oil that contains water, abrasives or sulphur in excess of our recommended specifications can cause extensive damage to the engine.

DIESEL FUEL OIL SPECIFICATIONS

Continental Red Seal Diesels have been designed and developed to use Grade #2D Diesel Fuel Oil which can be a cracked residual, a blend or preferably a straight-run distillate having the following fuel characteristics:

Diesel Fuel Characteristics	Effect	Industrial and Agricultural Diesels 1800 RPM Max.
A.P.I. Gravity @ 60° F	Lower Gravity Fuels contain more heat Units/Gal.	30 - 40
Cetane Number	Indicative of Ignition Quality, Higher number — better Starting and Idling.	40 minimum
Volatility: Initial Boiling Point	To prevent premature vaporization during hot weather operation.	320° F Minimum
50% recovery 90% recovery End Point	Less smoke with fuel at low 50% & 90% Recovery Temperatures. Higher end points only partially burn, causing build up of deposits in energy cell and nozzle, causing pintle sticking and smoke.	580°F. maximum 650°F. maximum 700°F. maximum
Distillation Recovery	Lower % recovery indicates heavy oil fractions to cause smoke and poor combustion.	98%
Total Sulphur	Sulphurous acids corrode and increase engine wear.	.5% maximum
Corrosion (Copper) 3 hours @ 212°F.	Discoloration or pitting on polished copper strip shows same effect on engine parts.	pass test
Pour Point	Fuel Oil must be in fluid state to prevent clogging due to congealing wax.	10°F. below lowest anticipated operating temperature.

WARNING: The Grade #2D Diesel Fuel Oil should not be confused with the #2 **Furnace Oil** which has no definite limits on ash content, sulphur content and Cetane value.

FUELS AND LUBRICATION

Grade #1D Diesel Fuel Oil is a distillate fuel oil of higher volatility which may be used in our engines **except those having Bosch APE pumps.**

Buy fuel only from reputable refineries and distributors and **specify fuel for high-speed diesel engine operation** *which meets the above specifications.*

> **WARNING**
>
> Bosch A.P.E. Injection Pumps require #2 Diesel Fuel Oil to insure adequate lubrication of the pump assembly.

HANDLING AND STORAGE

Fuel should always be strained or filtered before being put into the supply tank — **as it is easier and cheaper to remove dirt from the fuel BEFORE it finds its way into the engine fuel system.**

The storage tank should be constructed for fuel oil storage with provision for removal of accumulated sludge and water — which should be done at regular 10-day intervals.

In addition, the fuel should be filtered between the storage tank and the dispensing pump. Double filtering is preferable and the filter equipment should be maintained as recommended by the manufacturer.

The open end of the dispenser funnels, measures and containers should be covered, when not in use, to prevent the entrance of dirt or moisture, and should be kept **scrupulously clean** at all times.

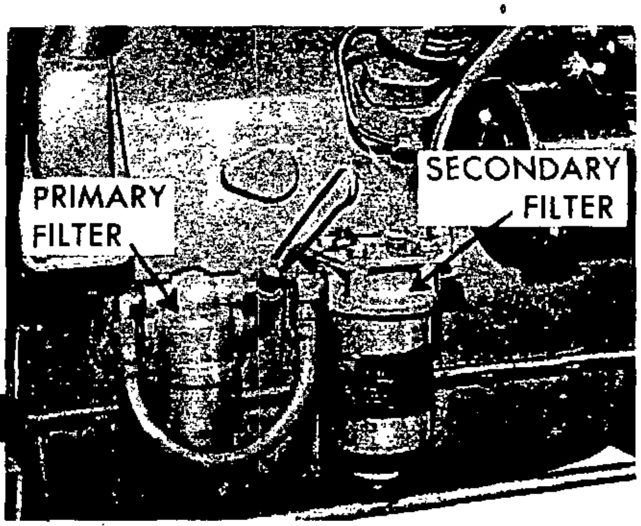


Figure 13—Two Stages of Filtration with the Roosa Pump

FUEL SYSTEM PRECAUTIONS

1. Fill the fuel tank at the end of each day to keep condensation to a minimum. When emptying a drum of fuel oil, agitate it as little as possible and leave about 1" of fuel, which may contain sediment or water, in the bottom of the drum.

2. Shut off fuel supply valve at fuel tank when disconnecting lines—to save needless waste of fuel.

3. Bosch pumps must have 10# minimum fuel pressure delivered to the fuel injection pump inlet through the final-stage filter. Pressure may be determined by using a gage with a tee connection at pump inlet. Roosa pumps must have 10# minimum vacuum at pump inlet.

4. Drain first stage fuel filter daily. This will also prevent ice damage to the filtering element where freezing temperatures are encountered.

5. DO NOT USE WASTE OR LINTY RAGS AROUND FUEL CONTAINERS OR FUEL INJECTION EQUIPMENT.

6. Use of clean fuel and daily care of the first-stage filter will prolong the life of the final-stage filter. For further details see Section VI Fuel Injection.

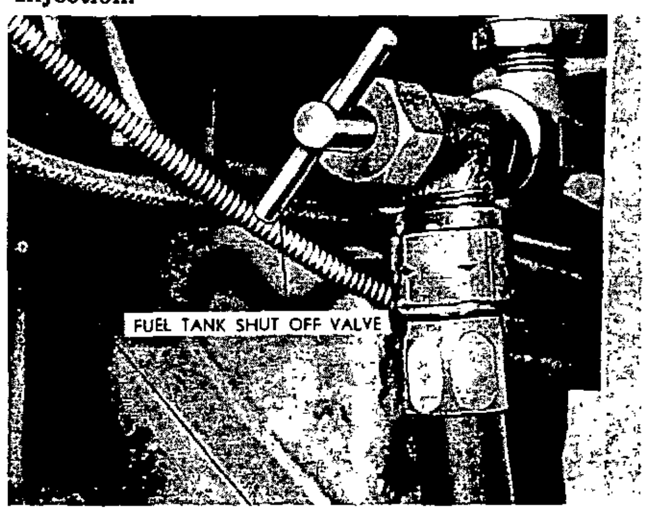


Figure 14—Fuel Tank Shut-Off Valve

LUBRICATION RECOMMENDATIONS

Diesel Engines operate with much higher pressures in the combustion chambers than their gasoline counterparts. Diesel fuels have much higher end points, that is, heavier ends of fuel which do not vaporize readily and burn completely. This results in a tendency to form deposits in the combustion area as well as in the ring grooves which could cause clogging of energy cells, rings sticking in the grooves and poor performance in general with resultant rapid wear and increased maintenance expense.

To counteract these conditions, the choice of fuels and lubricating oils must be made according to the specifications. Fuels and Fuel Specifications have been dealt with on pages 11 and 12.

Oils used in the Lubrication System must have certain qualities to provide a satisfactory oil film on friction surfaces to minimize wear, to protect bearings from corrosion and to keep engines free from harmful deposits.

Lubricating Oils for Diesel Engines are compounded with additives to provide this protection. They are better able to resist oxidation resulting from the higher operating pressures found in the Diesel and at the same time hold combustion by-products in suspension until removed when the oil is drained.

Diesel Engines are generally used in heavy duty operation. The American Petroleum Institute have classified oils for two types of service: DG and DS — General Service and Severe Service depending on the type of operation.

FOR SERVICE DG (DIESEL GENERAL)

As the name indicates, this D.G. oil is for use in General or Ordinary service where diesel fuel oil with less than .4% sulphur is used with normal engine operation and maintenance.

FOR SERVICE DS (DIESEL SEVERE)

This oil is to be used when the diesel fuel oil has over .4% sulphur content coupled with severe operating conditions under heavy loads and high temperature conditions or very light or intermittent operation at low temperatures.

While oils in this category are, by no means, a safeguard against failure to follow proper maintenance procedures, they are absolutely necessary where operating conditions approach those outlined in the preceding paragraph.

LUBRICATING OIL CHART FOR FOUR CYLINDER DIESELS

TEMPERATURE RANGE	OPERATING CONDITIONS		S.A.E. NUMBER
	NORMAL	SEVERE	
Below 10° F	Service DG	Service DS	10W or 5W-20*
10° to 32° F	Service DG	Service DS	20 or 10W-30*
32° to 90° F	Service DG	Service DS	30 or 10W-30*
Above 90° F	Service DG	Service DS	30 or 10W-30*

As in other internal combustion engines, oils must be selected as to S.A.E. number grades in accordance with the atmospheric temperature where the engine is to be operated.

Except for the break-in period, designated elsewhere in this manual as the first 50 hours, select the grade of oil as shown in the above chart.

While we are not in position to recommend any particular brand of oil, there are numerous reputable oils which meet the specifications, such as Socony Mobil Oil Company's Delvac, 900-Series for Service DG and Delvac S200-Series for Service DS.

If oils designated for Service DG or Service DS are not readily available, an "HD" high detergency oil of any reputable brand may be used as a temporary expedient until the desired type is obtained.

*These are called "multi-range viscosity" or "cross graded" oils. An SAE 10W-30 oil such as Mobiloil Special for example, has (1) free flowing characteristics at low temepratures for easy starting (2) the rapid distribution of an SAE 10W oil (3) the necessary body of an SAE 30 oil at operating temperatures.

Since these oils reduce combustion chamber deposits, engine life is lengthened. The greater detergency keeps engine working parts free from harmful deposits under severe operating conditions

ENGINE LUBRICATION SYSTEM

CONTINENTAL DIESEL ENGINES have full pressure lubrication through drilled passages in the cylinder block and crank shaft to all main and connecting rod bearings as well as to the timing gears and overhead valve rocker arms, the overflow from which lubricates the tappets. The oil pressure is automatically regulated by a spring loaded Relief Valve.

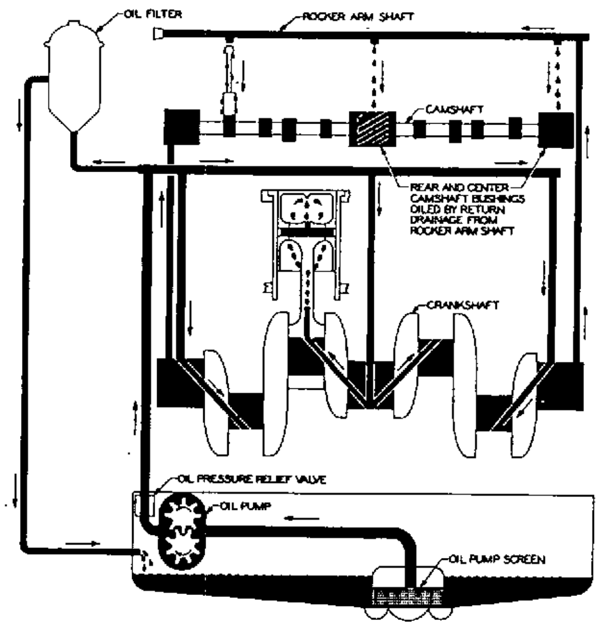


Figure 15—Lubrication Diagram (The camshaft has been moved up in order to simplify the Schematic drawing)

The gear type oil pump is driven off the crankshaft gear and has several times the capacity required by the engine — the excess being by-passed. Oil is supplied the pump by a suction tube with a screened inlet which picks up clean oil without any residue which may have settled in the bottom of the pan.

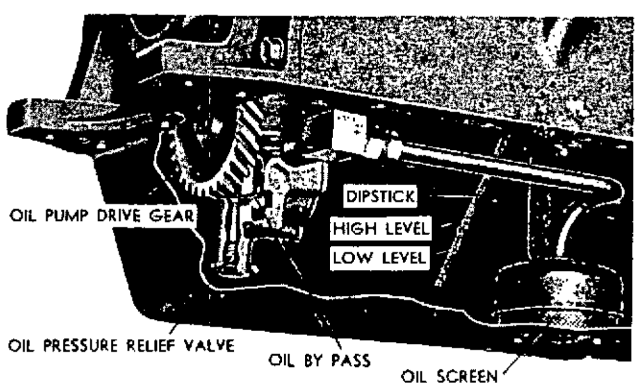


Figure 16—Sectional View of By-Pass Oil Pump

To insure piston pin lubrication and prevent piston scuffing during the warm-up period in cold weather — the large end of the connecting rods have drilled spurt holes pointing toward the

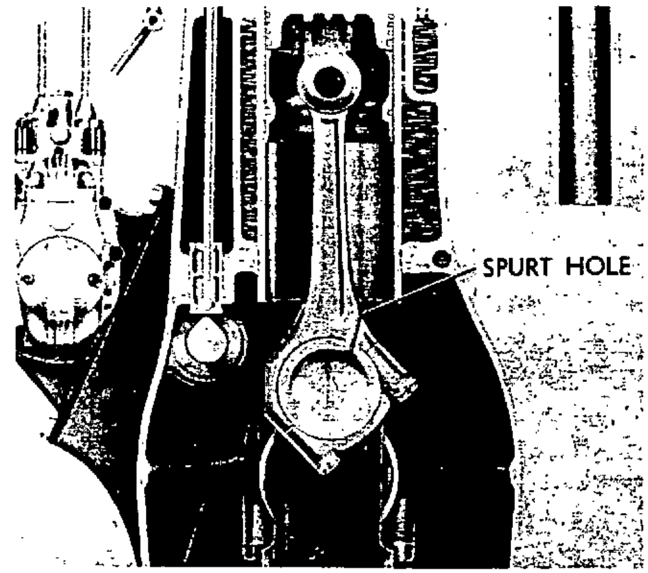


Figure 17—Connecting Rod Spurt Hole (Looking at engine from rear)

thrust side of the pistons. These line up with the oil hole in the crank pin so that once each revolution oil is sprayed on the cylinder wall for lubrication. Rocker arm lubrication is pressure fed from the crankshaft intermittently.

A by-pass type oil filter is provided to remove dirt and foreign elements from the oil, a percen-

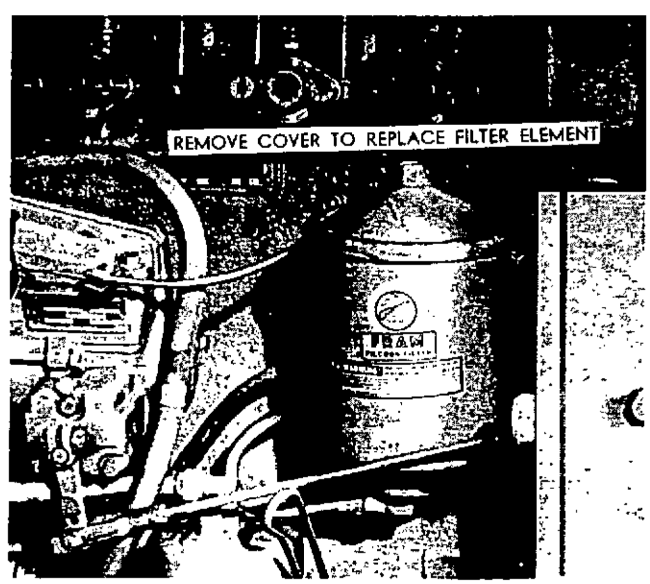


Figure 18—Oil Filter

tage of which is passed through the filter during operating period. The removal of grit, sludge and foreign particles causes filter elements to clog and become ineffective unless they are replaced at regular intervals.

Oil filter elements or cartridges should be replaced at every oil change or approximately every 50 hours of operation.

OIL CHANGE FREQUENCY

Engine oil does not "wear out." However, heavy-duty detergent oil in Diesel engines becomes contaminated from by-products of combustion, dirt, water and unburned fuel entering the crankcase, and the detergents holding the carbon particles in suspension in the crankcase.

In normal industrial operation, the Continental Diesel engines should have the oil and filter element changed after every 50 hours of operation. The oil should be drained when the engine is at normal operating temperature.

OIL PUMP

The oil pump (Fig. 16) on the four cylinder diesels is mounted on the front bearing cap. It is a gear type pump driven by the timing gear on the crankshaft.

This pump rarely gives any trouble; if it does it can be readily removed and either repaired or replaced with a new one.

The normal oil pressure is 30 to 40 lbs.* and at idling speed should not fall below 7 lbs. If the pressure fluctuates or falls below these limits, **STOP THE ENGINE IMMEDIATELY** and find the cause of the trouble. Refer to trouble shooting

AIR CLEANER

Diesel engines, when operating, consume several thousand cubic feet of air per hour. Since dusty air is full of abrasive matter, the engine would soon **wear excessively** if the air cleaner did not collect the dust in the oil cup.

Since air cleaners are not 100% efficient, their efficiency is DECREASED by the lack of proper servicing.

Proper servicing means **cleaning thoroughly** and **refilling with new oil,** and **maintaining air tight connections** between the air cleaner and intake manifold **so that *all* air entering the engine is filtered.**

*On the ED series this is 10-20#.

ENGINE LUBRICATION SYSTEM

The number of hours an engine may be permitted to run before the air cleaner is serviced depends entirely on operating conditions, and no definite interval can be established. In extremely dusty operations, this might be once or twice a day, while in dust protected areas, the air cleaner should be serviced when changing the oil.

Dirt or foreign particles removed from the air settle at the bottom of the air cleaner oil sump. This deposit must not be permitted to build up to any quantity.

The speed at which this builds up indicates how often the air cleaner should be serviced.

IT REQUIRES ONLY A COMPARATIVELY SMALL QUANTITY OF ABRASIVE DUST TO WEAR OUT AN ENGINE. The rapidity with which this occurs depends on the maintenance the engine and its equipment receive. A planned air cleaner servicing program will increase the effective life of your engine.

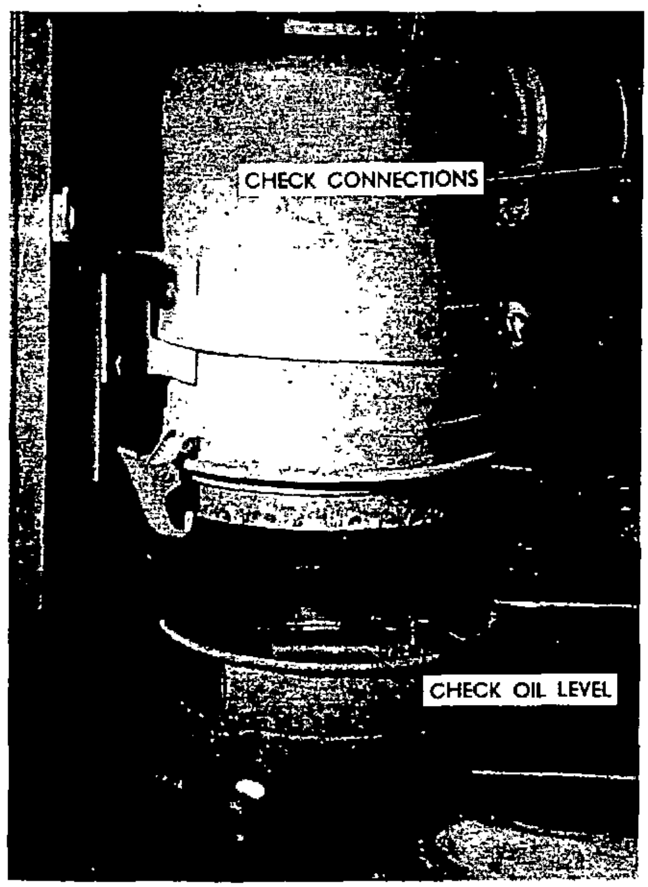


Figure 19—Air Cleaner

"RUNNING-IN" A NEW OR REBUILT DIESEL ENGINE

New or rebuilt Diesel engines should be operated on the following running-in schedule to assure better seating of pistons, rings and bearings before heavy duty service under full operating load.

1. **Fill crankcase with SAE 10W-30 oil to high level mark — regardless of outdoor temperature.**
2. **Start engine and run-in at following schedule:**

   ½ hour warm-up period at 800 RPM (no load). Check for leaks, oil pressure and water temperature.

   ½ hour at 1000 RPM — no load.

   ½ hour at 1200 RPM — ¼ load.

   ½ hour at 1500 RPM — ¼ load.

   ½ hour at 1800 RPM — ½ load.

   During the first 10 hours, do not operate at more than ¾ load and then for only short periods. And for the next 10 hours it may be operated under full load intermittently only, for periods of not more than 10 minutes at a time.

3. **At end of first day's operation** — while warm:
   (1) Torque down cylinder head studs to specifications.
   (2) Adjust intake and exhaust valve clearances.
   (3) Check cooling system hoses and fan belt tension and make needed adjustments from initial settings.
4. **After 50 hours operation**
   (1) Change crankcase oil in accordance with recommendations.
   (2) Make 50 hour preventive maintenance inspection.

TEN "MUSTS" FOR CONTINENTAL DIESEL USERS

1. **Use only #2D Diesel Fuel Oil — that meets specification shown on Page 11.**
2. **Use Lubricating Oil of recommended grade for operation.** Change filter element each time oil is changed.
3. **Maintain 165-185° F operating temperatures** — will pay dividends in economy, performance and engine life.
4. **Check for leaks — fuel — oil — water — air in fuel lines.**
5. **Avoid "Lugging"** — Operating engines in recommended range provides increased performance and reliability.
6. **Governor Setting** — Use accurate hand tachometer and maintain recommended low and high speed settings.
7. **Cleanliness** — of fuel oil and its handling is most important to provide trouble-free operation and the added dividend in long life of the fuel injection system.
8. **Fuel Injection Equipment** — has very close tolerances and should only be repaired or calibrated by trained personnel having proper tools. The injection pump gives long service and is the last thing to suspect, as a source of trouble.
9. **Idling Engine** — Slow engine down to low idle for approximately 5 minutes before stopping engine, but do not allow it to run for prolonged periods at idle.
10. **Follow recommended preventive maintenance program.**

SECTION III
OPERATION

OPERATING INSTRUCTIONS

The person operating the engine naturally assumes responsibility for its care while it is being operated. This is a very important responsibility since the care and attention given the engine goes a long way in determining how long a period it will operate satisfactorily before having to be shut down for repairs.

The several operations established for care and maintenance of a Continental Red Seal Diesel Engine are comparatively simple but instructions set forth in the following paragraphs must be followed without deviation, in order that expensive shut down and repairs will not occur prematurely.

The entire aim in setting forth these instructions is to give you the benefit of knowledge and experience gained over a long period of collaboration between Engineering Research and Field Service.

INSTRUCTIONS FOR STARTING ENGINE

BEFORE ATTEMPTING TO START THE ENGINE, CHECK:

1. Lubricating oil level in crankcase.

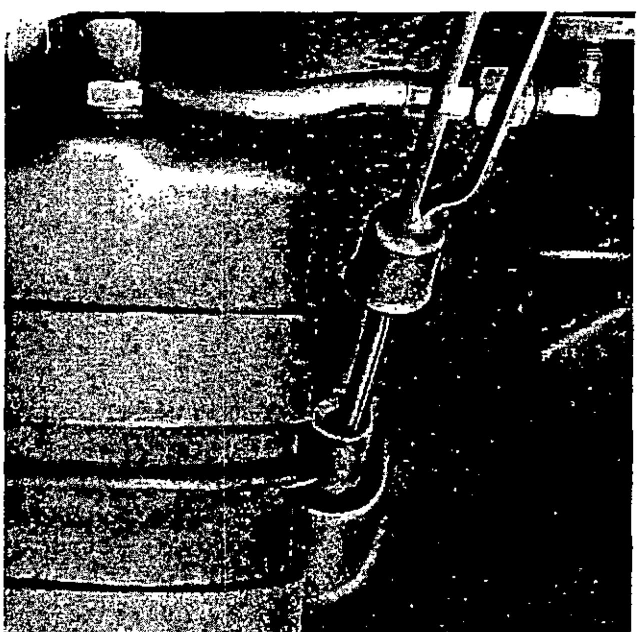


Figure 20—Bayonet Oil Gauge Rod

A dipstick or oil bayonet gauge is located on the left hand side of the engine near the lower flange of the crankcase.

It is marked "H" for high and "L" for low, and oil level must be maintained between these marks at all times.

If the engine is new or rebuilt, the crankcase must be filled to the high level mark. An engine that has been in operation but has been shut down for at least one hour, may require the addition of oil to bring level to the "H" mark, but do not overfill.

CAUTION: When adding oil always use the same make and grade as that in the crankcase. If, in case of emergency, it is necessary to mix oils, run engine only until a new supply can be obtained, then drain crankcase and refill with new oil.

2. Supply of coolant in system.

Cooling system must be filled with water or a solution of water and permanent type anti-freeze in accordance with seasonal requirements.

If water, only, is used or if anti-freeze does not contain rust inhibitor, this must be added

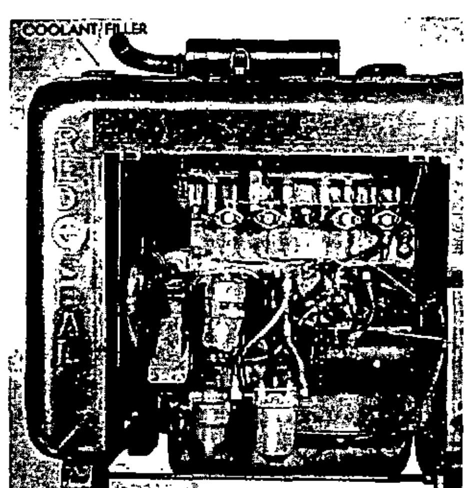


Figure 21—Location of Coolant Filler

OPERATION

to coolant in proportion to capacity of cooling system.

3. Fuel Supply.

Be sure there is a sufficient quantity of good, clean fuel.

Good fuel is that which falls well within the specification listed.

Clean fuel means fuel that has been stored, transported and handled using every possible precaution to keep from picking up dirt or foreign materials.

It is easier to keep dirt out of the fuel than to remove, once it is there.

4. Water, Fuel and Oil Connections.

Examine carefully all connections to be sure there are no leaks or possibility of leaks developing due to loose fittings or worn and chafed lines or hoses.

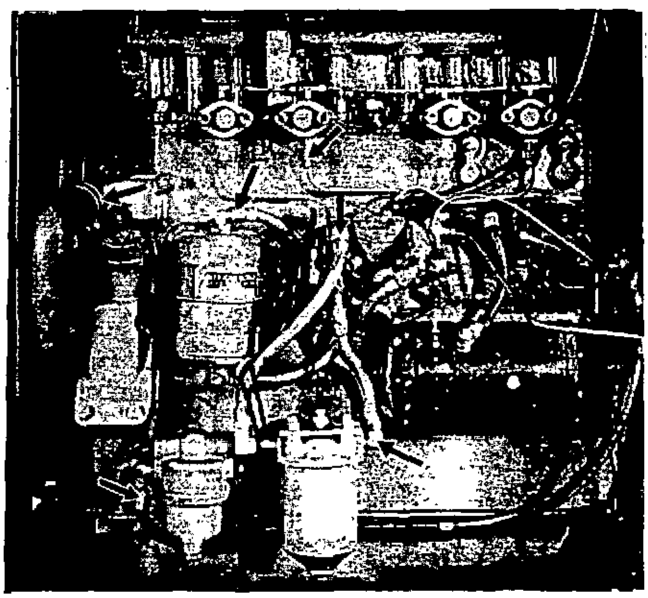


Figure 22—Checking Water, Fuel and Oil Connections

5. Storage Batteries.

Electrolyte or water, as it is more commonly called, must be 3/8" above the plates.

Specific gravity must be 1.250 or higher. Check with hydrometer.

Terminals and cable connections must be tight and clean, free from corrosion. Normally, all batteries are grounded on the positive side.

6. Clutch.

If engine is connected to its load through a clutch, this must be released to lighten load on starter and battery.

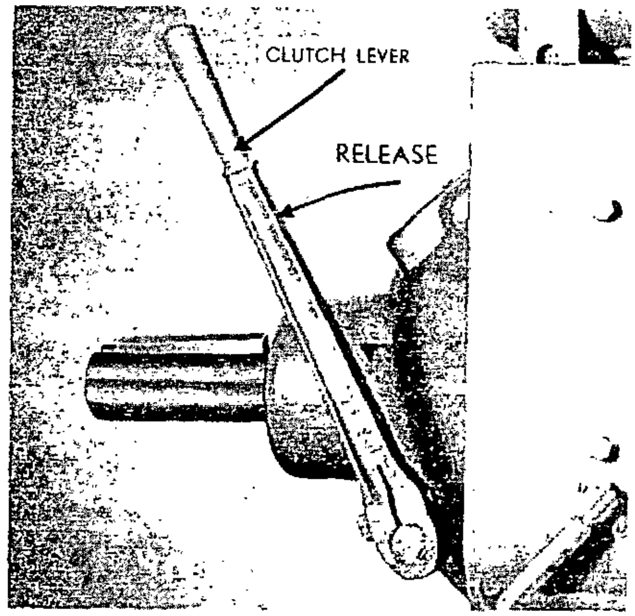


Figure 23—Release Load on Clutch Lever

7. Ability to crank engine with starter.

Crank engine 1 or 2 times with the starter to be sure assembly is free.

STARTING PROCEDURE

1. If the engine is new or rebuilt or if fuel filters have been serviced or any low pressure lines disconnected, fuel system must be bled to remove any air that may have become trapped in the system.

Make sure shut-off valve in bottom of fuel tank is in open position.

2. Bleed the entire Fuel Inlet System. Detailed instructions for bleeding the four types of Injection Systems are given in the following, and, while the basic procedure is the same, they differ just enough that we will take each individually.

Make sure shut-off valve in bottom of fuel tank is in OPEN position.

3. With fuel stop control pulled out in fully closed position crank engine over several times with Starter.

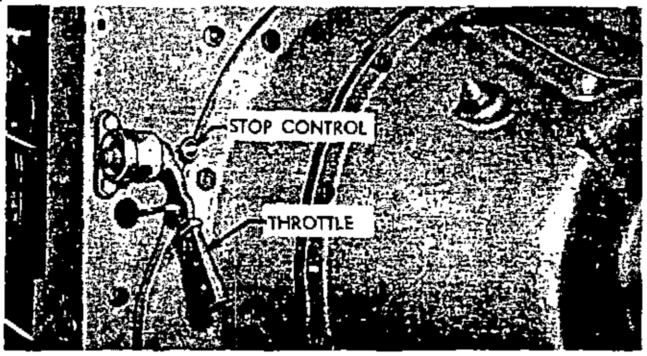


Figure 24—Power Unit Controls

Move fuel stop to wide open position and open throttle approximately 30%.

Turn engine over with starter again and it should start without difficulty. If it fails to start consult trouble shooting section.

Do not keep starter engaged for more than 15 seconds. If engine fails to start in that period, release starter button and wait 20 to 30 seconds before repeating operation.

When engine starts, immediately check oil pressure on gauge. If for any reason pressure fails to register within thirty seconds, pull out stop control and stop engine immediately. Investigate reason for failure.

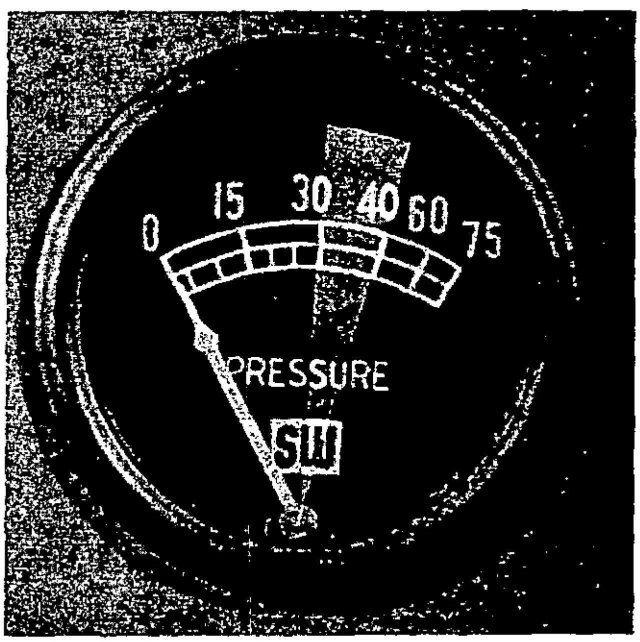


*Figure 25—Correct Operating Oil Pressure Range**

* (On the ED series it is 10-20#)

OPERATION

With satisfactory oil pressure, adjust throttle to control engine speed at approximately 1000 RPM. Always allow it to run until coolant temperature reaches 160° F. before any load is applied.

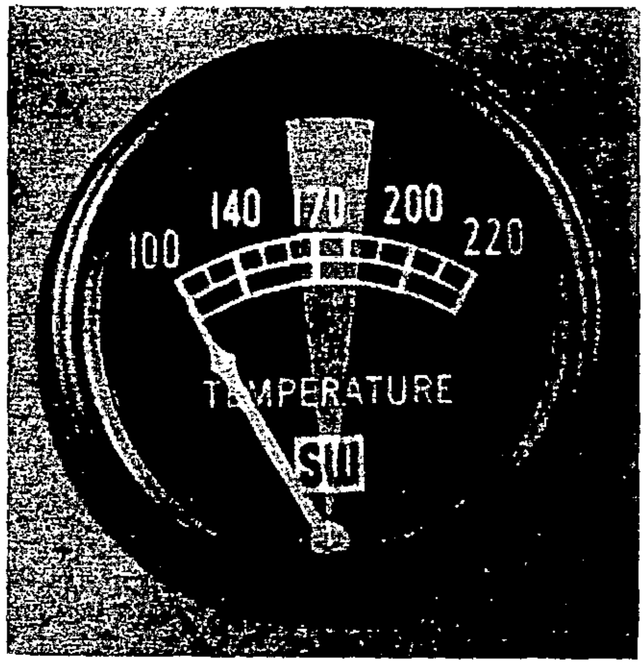


Figure 26—Correct Operating Temperature Range

3. **Check engine or unit after starting.**

While engine is running idle to warm up, inspect carefully for leaks or indications of leaks in fuel lines, oiling system or cooling system. Tighten or make any repairs necessary.

When engine is thoroughly warmed up, slow down to 600 RPM and allow it to idle for approximately 3 minutes then stop by pulling out shutoff control.

Remove cylinder head cover and retorque cylinder head stud nuts, and rocker arm support retainer nuts to specification shown on page 105, section X.

Start engine, allow it to idle at 600 RPM, and check tappet clearance. Adjust, if required, to specification.

Reassemble cylinder head covers and tighten. Engine is now prepared for limited operation under load.

OPERATION

OPERATING "DO'S" AND "DON'TS"

DON'T	DO
Don't permit a Diesel Engine to operate with a cooling water temperature less than 160° F. A cold running engine will smoke and fuel striking cold cylinder walls, condenses and washes oil from surfaces as it travels downward to dilute oil in crankcase.	**Do** maintain water temperature control by using the correct thermostat in the cooling system or shutter to limit air circulation through radiator.
Don't operate a Diesel Engine full throttle at low RPM. Lugging an engine in this manner reduces its efficiency and shortens its life.	**Do** keep the speed up in a desirable operating range. Horsepower increases as the speed, so arrange gear or belt ratio to permit engine to do the work with a minimum of effort.
Don't permit a Diesel Engine to idle for prolonged periods. Idling at low RPM means low temperatures in combustion chamber and poor combustion, causing carbon formation in energy cells and on nozzle tips and the possibility of sticking valves and piston rings.	**Do** idle the engine at approximately 1000 RPM to warm up and at 600 RPM for service checking or cooling down after period of operating under load, otherwise shut engine off when not in use.
Don't stop a Diesel Engine immediately after completing a period of operation under load where temperatures throughout the engine have possibly reached the maximum.	**Do** idle the engine at 600 RPM for 5 minutes to permit engine parts to cool and temperatures to equalize over the engine before stopping.
Don't neglect to change oil at regular intervals and **don't** use inferior grades of oil.	**Do** change the oil as prescribed in service instructions and use only H.D. oils of the correct S.A.E. number that meets specifications.
Don't fail to clean and service the air cleaner as needed. Diesel engines have no throttling control on the air intake consequently it is taking in a full charge at all times.	**Do** clean and service the air cleaner to maintain its efficiency. Deposit must not be permitted to build up, to any quantity, in oil cups. The rapidity with which this builds up, indicates how often the air cleaner should be serviced.
Don't neglect your Diesel by failing to follow the comparatively simple instructions for Operating and Maintenance, as set forth in detail in the pages of this manual.	**Do** follow Operating and Maintenance Procedures and thus obtain the maximum performance and economy with a minimum of repairs and expensive down-time.

OPERATION

CHECK AFTER STARTING NEW OR REBUILT ENGINE

1. While engine is running idle to warm up, inspect carefully for leaks or indications of leaks in fuel lines, oiling system or cooling system. Tighten or make any repairs necessary.

2. When engine is thoroughly warmed up, slow down to 600 RPM and allow it to idle for approximately 3 minutes then stop by pulling out shut-off control.

3. Remove cylinder head cover and retorque cylinder head stud nuts, and rocker arm support retainer nuts to specification shown in section X.

4. Start engine, allow it to idle at 600 RPM, and check tappet clearance. Adjust, if required, to specification.

5. Reassemble cylinder head covers and tighten. Engine is now prepared for limited operation under load.

COLD WEATHER OPERATION

The requirements for satisfactory cold weather operation of Diesel engines differ somewhat from those of gasoline engines. This is brought about, to a large extent, by a difference in the fuels.

The Diesel engine depends on the heat from the air compressed in the combustion chamber to ignite the fuel when it is injected into this air. It requires a temperature of approximately 900° Fahrenheit in the combustion chamber to institute this combustion process.

Sub-zero operations require special #2 Diesel fuel oil of the type MIL-F-896 Class 3 which will permit operation to — 40° F. In emergency, when this fuel is not available, the regular fuel may be diluted with high quality kerosene up to 50%.

With engines standing out in temperatures below freezing, difficulty may be expected in raising the temperature of the air in the combustion chamber to the point where it will ignite the fuel even though compression pressures do meet the required minimum of 325 lbs. per square inch, and the starter will turn the engine over at a desirable minimum of 150 RPM.

To meet this need, we have provided cold starting equipment with which we actually inject a metered quantity of ether base starting-fluid into the air entering the combustion chamber in order to get the engine started, after which it rapidly develops enough internal temperature to continue running on the regular fuel.

LUBRICATING OILS — Special for Cold Weather Starting

The new type multi-grade oils are well suited as aids to cold-starting on Diesels as well as on all Internal Combustion Engines.

These oils are classified as 5W-20 and 10W-30. It means that the first one when cold has viscosity and other characteristics similar to a regular S.A.E. 5W which is ideal for cold starting with its reduced drag and better lubricating possibilities. Then as the engine warms up and the temperature of the oil rises, it assumes the characteristics of an S.A.E. 20 oil, to better withstand the heat and friction of normal operation. The same thing holds true with the 10W-30, so choose your oil with atmospheric temperatures at which the engine is expected to operate in mind and let this indicate the top number grade of oil. For example, if for normal operation, the specification calls for an S.A.E. 30, then choose the 10W-30 for its cold starting characteristics.

COLD WEATHER STARTING — below 32°

Diesel engines in general start well without the use of "aids" above 40°F as the cranking speeds are adequate to generate enough heat by compression to ignite the fuel when injected into a cold combustion chamber.

A fully charged battery @ 0°F has only 40% of its capacity @ 80°F and the stiff engine oil increases the required cranking power 250% — *coupled with the fact that a diesel engine must ignite the fuel from heat of compression* — adequate battery capacity and fully charged condition is a *must* in cold starting.

To meet this need, we have available the following cold starting aids: (1) electric manifold heater which heats the air in the intake manifold or (2) an ether-primer arrangement which injects an ether-base fluid into the intake manifold, which readily ignites to start the engine.

OPERATION

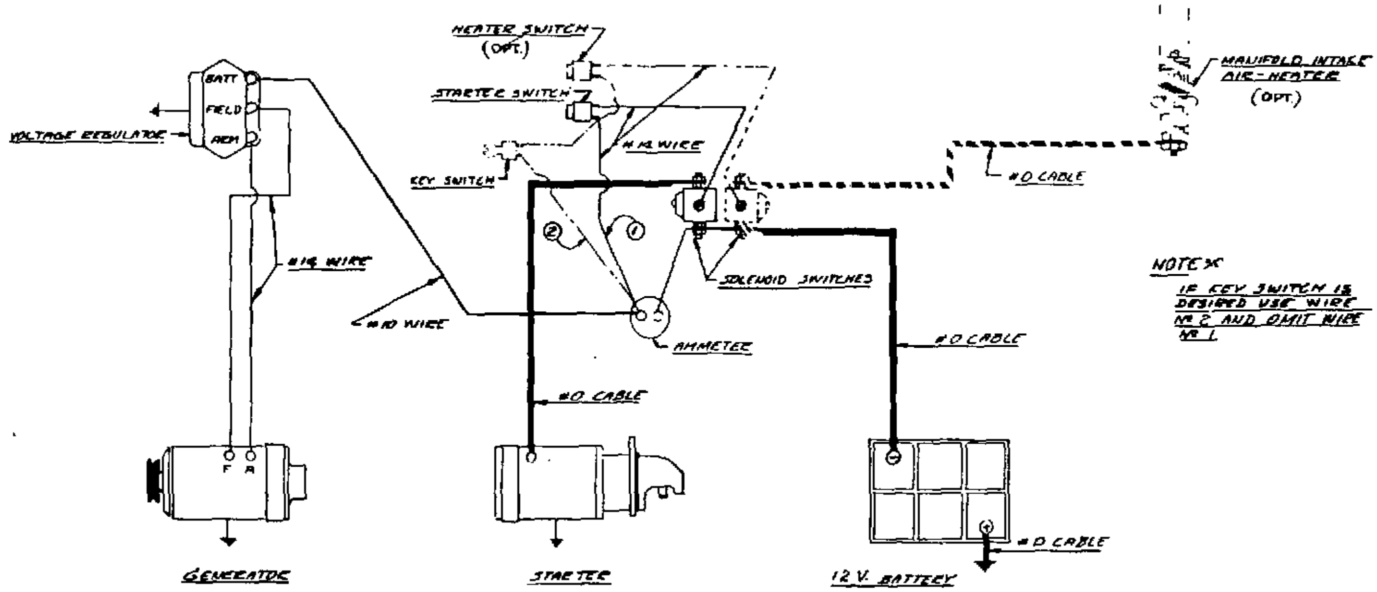


Figure 27
Wiring Diagram including Manifold Heater

ELECTRIC MANIFOLD HEATER (TO 0°F)

This is a 1000 watt, heavy-duty, nichrome wire electric heater — which screws into an adapter elbow connection to the intake manifold inlet.

The starting procedure is to initially energize the heater about 2 minutes — then crank the engine. If the engine does not start in 15 seconds, repeat the operation.

Manifold heaters and solenoid switches are available in 12, 24 and 32 volt systems.

ETHER-PRIMER ARRANGEMENT USE THE FOLLOWING PROCEDURE:

(1)—Unscrew upper chamber B; insert a fluid capsule and screw upper chamber back in place.

(2)—Pull cap A and plunger to top of stroke and then to bottom of stroke, which punctures the capsule and releases the fluid.

(3)—Unlock primer pump plunger by turning knob "D" to the left.

(4)—Crank engine with starter and at the same time pump the primer plunger one full stroke, then a few strokes slowly until engine runs normally on regular fuel and all fluid in the chamber is used up.

(5)—Lock primer pump plunger at bottom of stroke and remove and discard empty capsule from chamber "C", and screw upper chamber "B" tightly in place.

(6)—Unscrew knurled cap "E" to clean puncturing tool and filter screen — removing any particles of broken capsule as they are soluble in moisture and clog orifice.

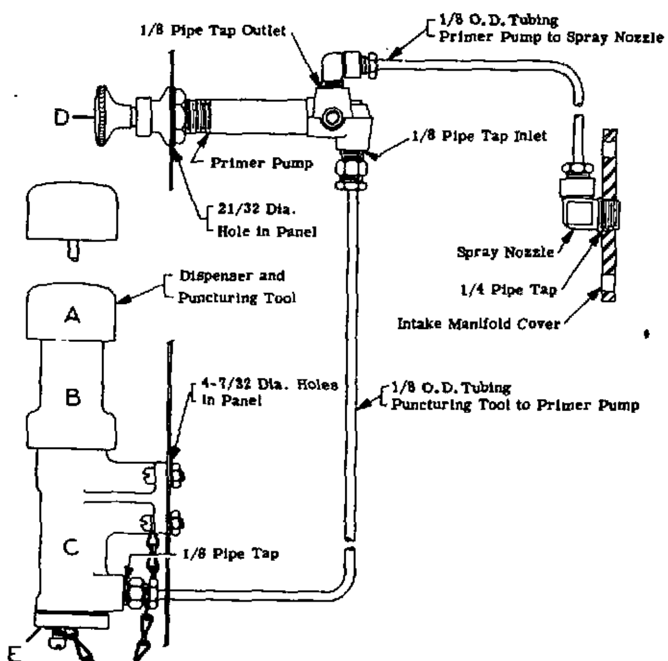


Figure 27A
Ether Cold Weather Starting Equipment

In connection with installation and use of this ether fluid starting equipment, there are certain precautions which should be called to your attention at the same time:

OPERATION

CAUTION!

Starting fluid is highly inflammable, explosive and toxic. Gelatin capsules dissolve in water and soften at high temperatures. Therefore, safe handling of fluid, capsules and plunger requires extreme caution to avoid the following:

(1)—Exposure of fluid and capsules to open flames, sparks or hot surfaces.

(2)—Spillage or leakage of fluid.

(3)—Breathing of fumes from fluid.

(4)—Contact of capsules with water.

(5)—Storage of capsules in temperatures above 120° F.

MAINTENANCE OF EQUIPMENT DURING COLD WEATHER

Certain maintenance operations must be checked more carefully in cold weather, than during the summer operation which includes: the *thermostats and water temperature control* must be maintained so that the engine is warmed up as quickly as possible to 180° and remains at this minimum or above during operation.

Fuel Filters—must be checked more often, particularly the primary stage filter, to remove all the moisture and condensation separated from the fuel, otherwise this may freeze and stop the fuel flow, thus necessitating a roadside repair or a possible service call for help.

Clean fuel—handled by a reliable source having a cetane number of 40 minimum, for Industrial, and 50 minimum for Transportation, is a definite requirement for easy starting and efficient operation. *We cannot caution you too seriously about obtaining fuel from a reliable source.*

The distillation range of fuel has to be controlled as well, otherwise there may be a large quantity of the heavier ends in the higher distillation ranges that do not vaporize readily.

To insure against condensation in the fuel tank, fill to capacity at the end of each operating period.

Drain off about 1 pint of fuel from bottom of fuel tank sump, before starting engine for the day's operation, thus removing any water or sediment that has settled out during the time the engine was not running.

MAINTAIN CRANKCASE ABOVE 135° F.

Sludge formation at low temperatures is a close second to dirt to cause engine damage and wear. This is formed by the piston blow-by gases mixing with the fine oil mist in the crankcase and condensing on a cold surface. This condensation forms both a sulphuric and sulphurous acid which combines with the oil to become a highly injurious sludge.

This dew point is about 135° F. — when crankcase temperatures are higher, the contaminated gases remain in gaseous form and the engine operates clean — however temperatures below this will result in injurious sludge formation.

It is vitally important therefore to maintain oil and crankcase temperatures above 135° F., as shown on the following chart:

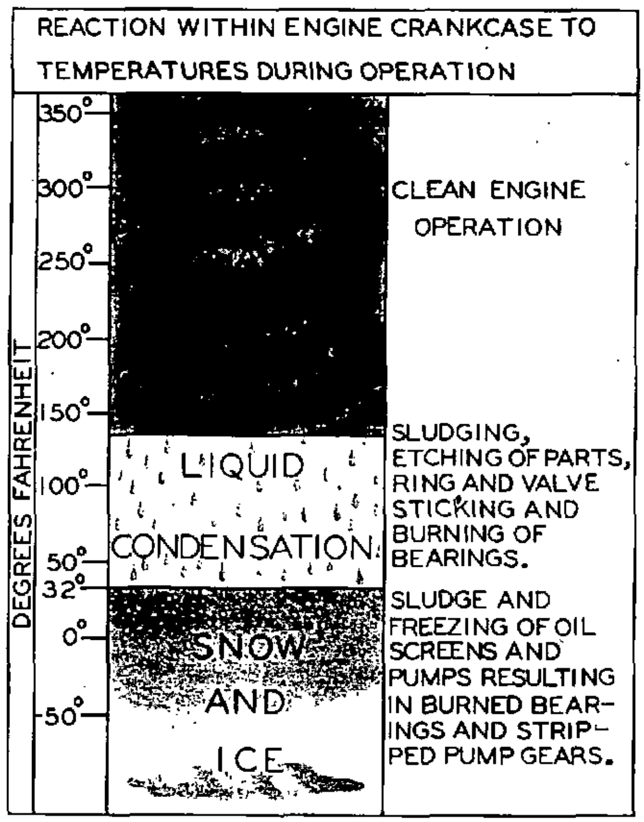


Figure 27B
Crankcase Temperature Reactions

When sludging conditions prevail, the oil should be examined daily and changed as it may freeze, or clog the inlet strainer and cause bearing failures.

SECTION IV
PREVENTIVE MAINTENANCE

In order to obtain maximum efficiency from your diesel engine, a definite maintenance program should be set up and followed. Haphazard maintenance will only lead to faulty engine performance and shortened engine life.

Moving parts in the engine are all subject to wear; however, wear can be retarded by careful operation and a planned maintenance program. The importance of such a program cannot be overemphasized, since it has a direct bearing on the effective life of your engine.

In general, Diesel operation demands careful attention to the cleanliness of air, fuel and oil as well as the maintenance of operating temperatures between 165° - 185° F.

The following pages, covering **DAILY**, 50, 250, and **500 hour** maintenance, have been worked out with our field service division as "minimum requirements" to keep your engine in first-class mechanical condition.

DAILY

PREVENTIVE MAINTENANCE SCHEDULES

❶ Over-all Visual Inspection of Engine

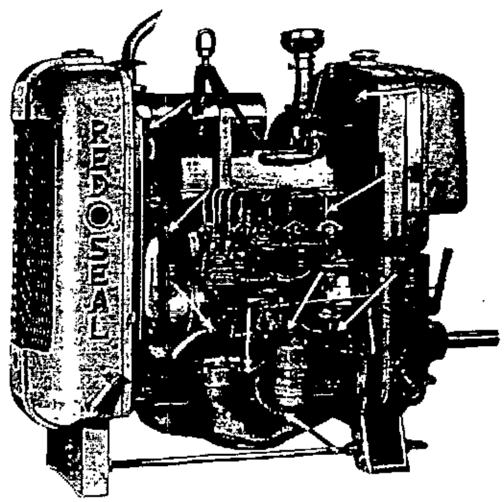


Figure 28—Check Points for Possible Leakage

Look for evidence of fluid leakage on floor, cylinder head and block, indicating loose fuel, oil or water connections — **tighten if found.**

❷ Check Oil Level of Engine

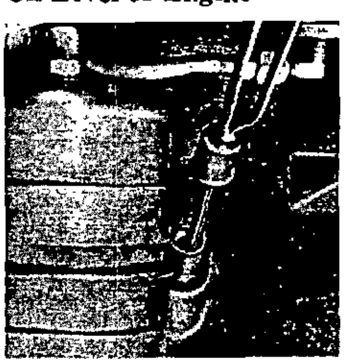


Figure 29

The dipstick indicates the high and low oil level in the crankcase — make allowance for additional oil drainage back into oil pan if engine has not been stopped over one half hour. Since the most efficient oil level is between the two dipstick levels, DO NOT ADD OIL UNTIL OIL LEVEL APPROACHES THE LOW MARK ON DIPSTICK AND THEN ONLY ENOUGH TO BRING IT TO HIGH LEVEL — NEVER ABOVE.

DO NOT OPERATE THE ENGINE WITH OIL BELOW THE LOW OIL LEVEL MARK

Bosch APE fuel injection pumps of the multi-plunger type with integral governor have separate oil sumps that must be filled with oil to the level plugs in both the pump and governor base.

Bosch PSB pumps of the single-plunger type are engine lubricated and require no attention.

Roosa Master Pumps are self-lubricated pumps and also require no special attention as far as lubrication is concerned.

❸ Check Coolant

Fill radiator with clear water or recommended anti-freeze solution to normal level maintained due to expansion when heated. Visually inspect fan and belt for condition and adjustment.

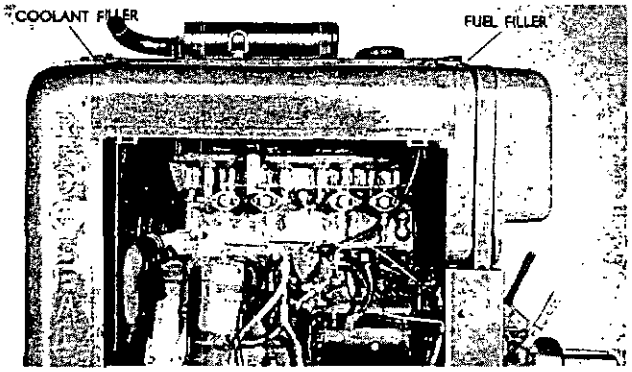


Figure 30

❹ Fill with Clean Fuel Oil

Should be done at end of day's operation to prevent condensation forming in tank. Clean filler cap and area around spout **before** filling to prevent entrance of dust into fuel system — **which is harder to remove than prevent.**

Use only Diesel fuel oil that meets Continental recommended specifications.

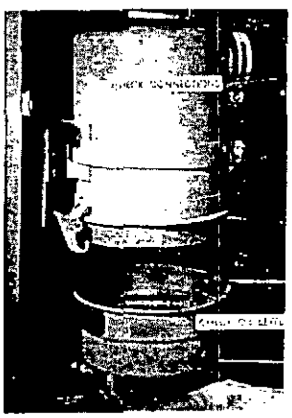


Figure 31—Air Cleaner

❺ Check Air Cleaner

Remove air cleaner oil cup and note quantity of sediment—if required, clean and refill with engine oil to level. Visually inspect air cleaner connections to manifold. The larger volume of air used in Diesel engines emphasizes the importance of clean air entering the cylinder.

❻ Drain water and sediment from primary filter — remove drain plug in bottom of filter and drain out water and sediment until fuel runs clear. Then replace plug and tighten.

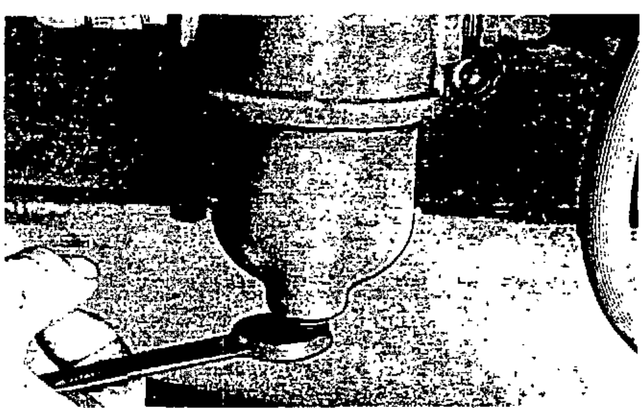


Figure 32—Primary Filter Drain

PREVENTIVE MAINTENANCE SCHEDULES

❼ Check oil pressure

Note oil pressure gauge, which should indicate 30-40 pounds pressure* at full throttle and a minimum of 7 pounds pressure at idling speed. **Shut down engine** if not within this range and follow detailed instructions outlined under lubrication system, Section II.

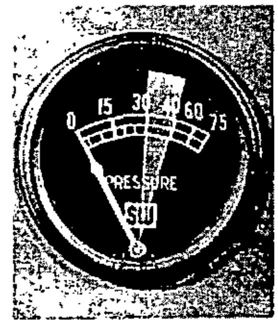


Figure 33

❽ Note any unusual noise

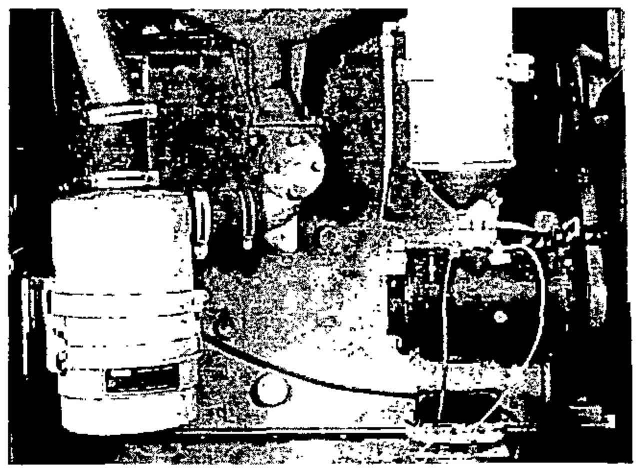


Figure 34

Operators familiar with daily engine operation soon become alert to any noise not normally present. This is very valuable in correcting defects in the early stages and preventing expensive repairs or delays.

Due to the operating pressure on the pistons being approximately three times that of gasoline engines, allowance must be made for increased combustion knock associated with all diesel engines.

EVERY 50 HOURS

❶ Repeat DAILY operations outlined — Follow Previous Instructions

❷ Change Crankcase Oil and Oil Filter Element

Engine life is dependent upon clean oil being circulated to all moving parts; therefore, the frequency of oil changes and oil filter replacement is very important and should be made at regular, scheduled periods.

*ED series is 10-20#.

PREVENTIVE MAINTENANCE SCHEDULES

Figure 35—Oil Pan Drain Plug & Inspection Hole Cover

The crankcase oil must be changed after 50 hours service and when the oil is at running temperatures so that complete drainage will result.

Remove the oil filter element at the same time. Thoroughly clean the filter can, cover and sealing surfaces and replace element and cover gasket.

Check for cover leakage under full oil pressure after replacement.

❸ Clean Primary Fuel Oil Filter

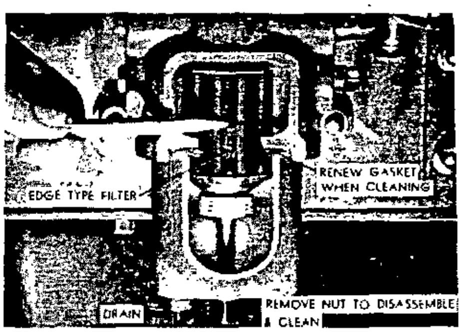


Figure 36—Sectional View of Primary Filter

Remove the cover and element — clean thoroughly in fuel oil or solvent and reassemble, making certain that all connections are tight to prevent leakage of air into fuel system on the suction side, which would affect operation.

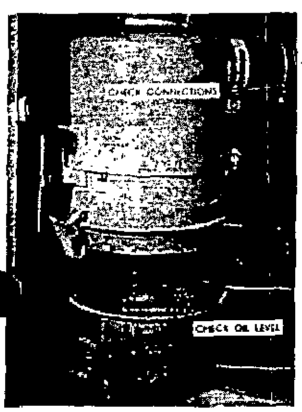


Figure 37

❹ Clean Air Cleaner and replace oil in cup

Remove bottom half of air cleaner — clean thoroughly and fill with new engine oil to oil level shown on cup. Replace cup and check all connections. Be sure that no unfiltered air can enter the engine intake manifold.

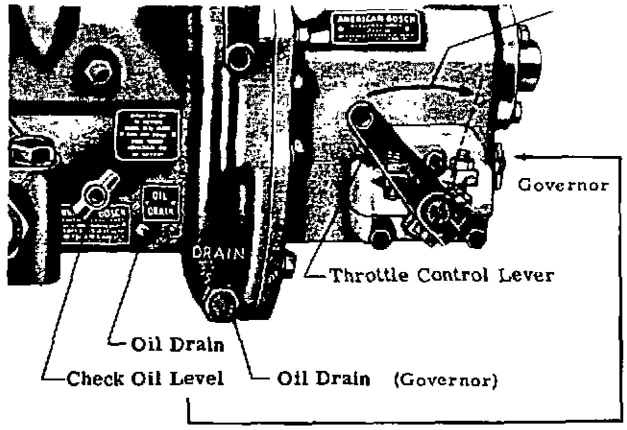


Figure 38

❺ Drain and fill with new oil in Bosch APE (multi-plunger) injection pump

Remove drain plug in side of housing and drain all oil and fuel. Then replace plug and fill housing through the oil gauge rod hole until oil flows out the level plug — then replace level plug.

The Bosch mechanical governor should be drained by means of the drain plug in the side of the housing. Replace plug and add engine oil until oil flows out level plug on side of governor. Allow it to drain down to level before replacing plug. — Too much oil will affect governor operation.

NOTE: Bosch PSB single-plunger type and Roosa-Master injection pumps are self-lubricated.

❻ Check Fan Belt Tension

Check condition of fan belt; note alignment and check belt tension which should allow ¾″ to 1″ deflection on long span.

Figure 39
Fan Belt Tension

❼ Check Battery

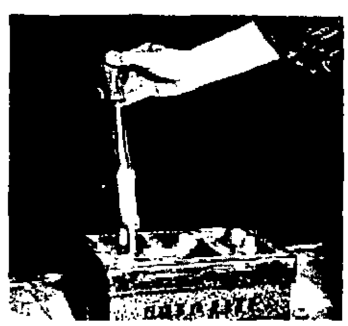


Figure 40—Checking Battery

Check specific gravity of each cell. This should be at least 1.250. Add distilled water, if required, to raise level 3/8" above the separators.

Particular attention should be given battery during cold weather. The cranking power of a fully charged battery @ 80° F is reduced 50% at 0° F; yet the power required to crank the engine is 2½ times greater at 0° F than at 80° F.

8 Lubricate Starter and Generator

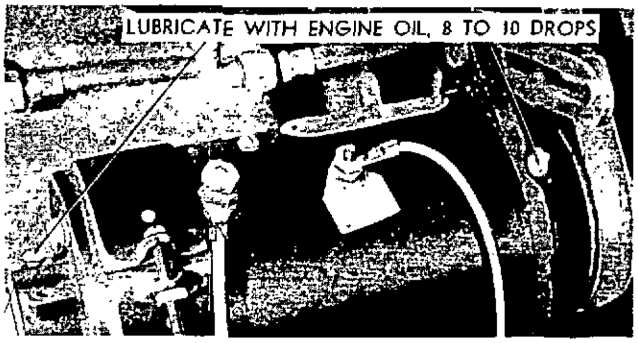


Figure 41—Generator, Lubrication Points

Apply 8 - 10 drops of engine oil to each cup.

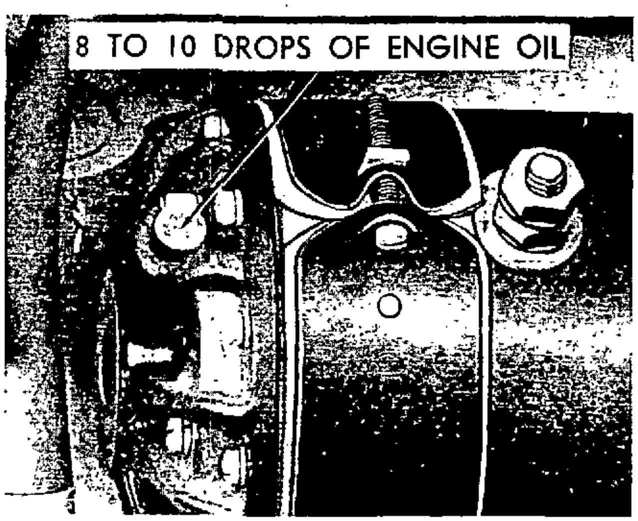


Figure 42—Starter Lubrication Point

9 Lubricate Power Take-off

Figure 43—Power Take-Off Lubrication Points

PREVENTIVE MAINTENANCE SCHEDULES

Lubricate with grease gun the clutch throw-out bearing and output shaft bearing with approved ball bearing grease, such as Mobilgrease No. 5. (On some models, there is a zerk fitting on the end of the shaft).

EVERY 250 HOURS

1 Repeat DAILY and 50-HOUR operations according to previous outlined instructions.

2 Clean Exterior of Engine

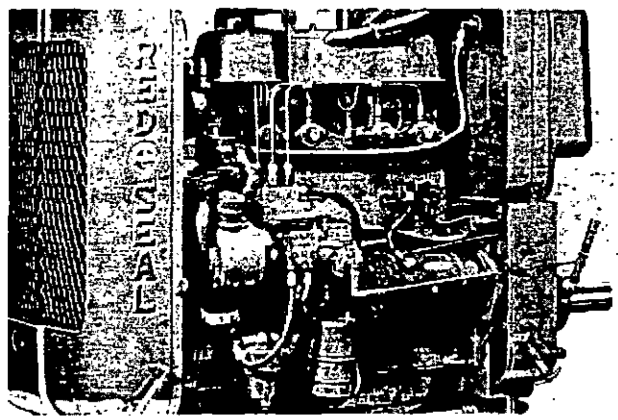


Figure 44—Clean Engine

Use steam if available otherwise some solvent can be used to wash down the engine.

3 Adjust Valve Tappet Clearance

Check and adjust if necessary to specified clearance both intake and exhaust valves after the engine has warmed up to running temperature.

Turn the rocker arm adjusting screws in or out until the correct feeler gauge clearance is obtained. If adjustments are made while the engine is idling use extra caution in judging the correct "feel" for proper clearance.

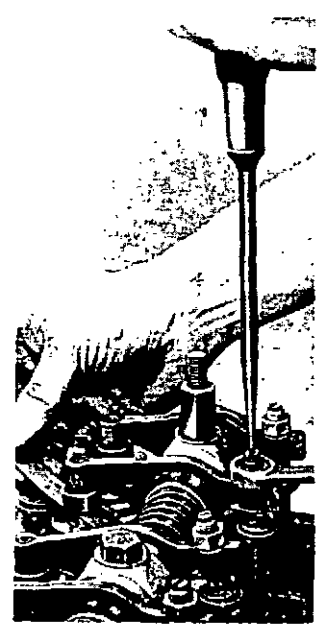


Figure 45—Adjusting Valve Tappet Clearance

PREVENTIVE MAINTENANCE SCHEDULES

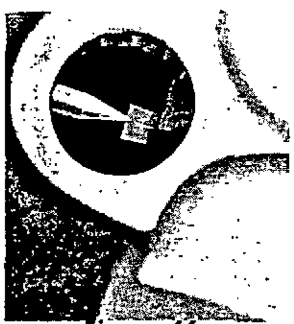


Figure 46
Injection Pump Timing Marks (PSB Pump)

④ Check Injection Pump Timing to Engine

Detailed instructions are given under Section 6 — Fuel Injection System — for the various types of injection pumps used on Continental Red Seal Diesel engines.

⑤ Check Engine for even running and Exhaust Smoke for indication of Poor Combustion

Uneven running is generally due to air in the lines or faulty nozzles and black exhaust smoke can generally be traced to poor or excessive fuel; wrong injection pump timing to engine or the energy cells carboned up. Blue smoke indicates heavy oil consumption and white smoke indicates "missing" cylinders. (Further details are given in Chapter under Fuel Injection.)

* If this smoke is encountered, stop engine and investigate cause.

EXHAUST SMOKE CHART

	Smoke Number	Color	Explanation
ACCEPTABLE RANGE	0	Clear	No smoke visible, only heat distortion of objects through exhaust gas vapor.
ACCEPTABLE RANGE	1	Trace	Very faint smoke
ACCEPTABLE RANGE	2	Light Gray	Definite smoke visible without any doubt
ACCEPTABLE RANGE	3	Dark Gray Haze	Usual maximum considered desirable for continuous operation
	4*	Black	Not desirable for continuous operation
	5*	Heavy Black	Soot color—possible flame or glow present, dependent on length of exhaust line

Figure 47

⑥ Check Governor Setting with Hand Tachometer

An accurate hand tachometer should be used at the front end of the crankshaft to set the governor and to check the accuracy of the tachometer mounted on the engine. The high speed setting should meet the particular requirement of normal operation and under no conditions should it exceed the speed recommended for the engine. The idling speed should not be lower than 600 RPM and for prolonged idling, the speed should be increased to 800 - 1000 RPM.

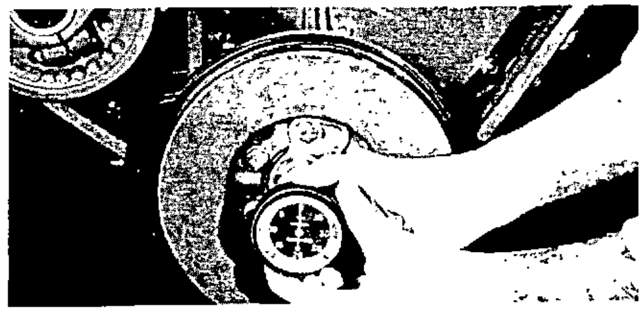


Figure 48—Hand Tachometer in Operation

⑦ Check Safety and Thermal Controls

Diesel engines can only be stopped by shutting off either the fuel or the air — usually the simplest way is to shut off the fuel with a solenoid shut-off valve in the low pressure fuel feed line to the injection pump.

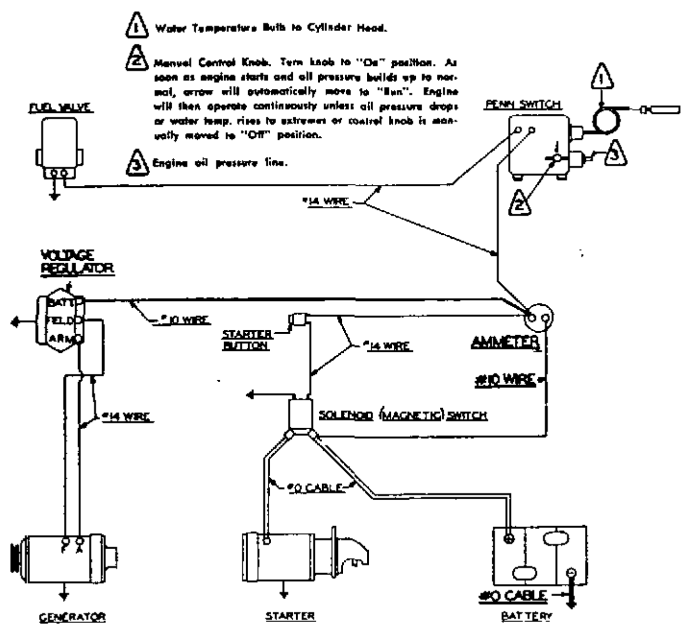


Figure 49—Safety Controls

This valve opens when the knob on the safety switch is turned to START and holds open in the run position unless abnormal high water temperature or low oil pressure breaks the electric circuit and permits the plunger to drop thus shutting off the fuel. This shut-off is so designed that the fuel pressure of the supply pump acts to hold the valve tightly closed.

When fuel does not flow through this valve with the button turned to START position — remove one wire and make and break the circuit, noting whether the plunger rises and falls, indicating that it is free. If you are unable to detect movement, disassemble and clean, after which reassemble it carefully. Holding it in the hand and tipping it first one way and then the other — you should feel the plunger action.

Assemble it to the engine in a vertical position with solenoid up and the mounting screws below or it will not function since the valve must *close by gravity.*

The best engine performance is obtained with water temperatures of 165°-185°F — which can only be obtained with proper operation of the thermostats and shutter control. If temperatures are not in this range check fan belt tension and thermostat opening by heating in water as shown in Section V.

EVERY 500 HOURS

❶ Repeat DAILY, 50 HOUR and 250 HOUR operation outlined.

❷ Clean Oil Pump Screen

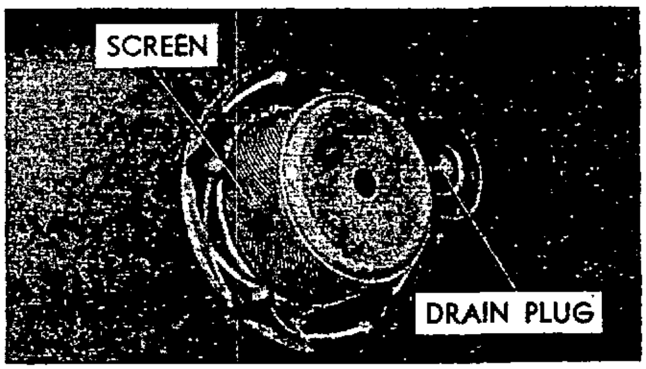
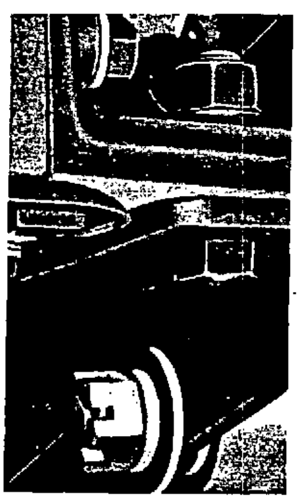


Figure 50—Oil Screen in Pan

Remove hand hole cover from oil pan sump and clean screen — the pump inlet screen can easily be removed from the cover for cleaning. If the oil pressure indicates lower than normal pressure, usually the screen will require cleaning. This is very important as further clogging of the screen would prevent the main and connecting rod bearings from receiving sufficient oil.



❸ Check Engine Mounting

Check engine mountings and bolts — tighten if required — inspect mounting biscuits for condition (if used) and tighten mounting bolts, as they will wear the brackets and supports if left loose. Replace defective mountings or bolts as required.

Figure 51
Check Mounting Bolts

PREVENTIVE MAINTENANCE SCHEDULES

❹ Inspect Manifold Assembly

Figure 52—Manifold

Check and tighten manifold nuts to recommended torque — exhaust, intake and water manifold should be checked for leaks and tighten as required.

❺ Check Cylinder Head Nuts

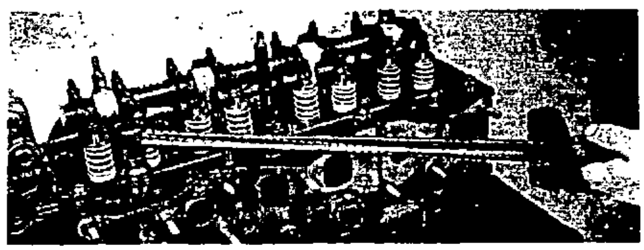


Figure 53—Tightening Cylinder Head Nuts with Torque Wrench

Tighten if necessary in the recommended sequence and to the torque shown in the charts in the Limits and Clearance Section.

❻ Replace Secondary Fuel Filter or Element

The life of the injection pump is entirely dependent upon the cleanliness of the fuel passing through the secondary fuel filter.

In order to assure extreme cleanliness as well as adequate pressure, this filter or element must be replaced as a unit on a scheduled 500-hr. basis or when the minimum pressure at the pump inlet connection is 10 pounds.

This is dependent upon the service conditions and the initial cleanness of the fuel entering the tank.

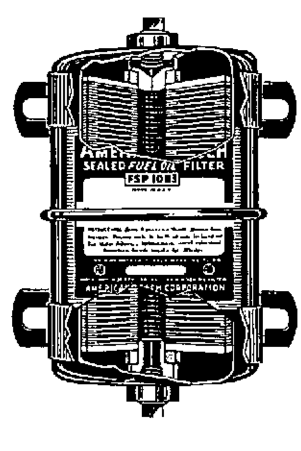


Figure 54
Secondary Fuel Filter
(In some models this is used as a final stage filter)

PREVENTIVE MAINTENANCE SCHEDULES

7 Clean and Check Injector Nozzles

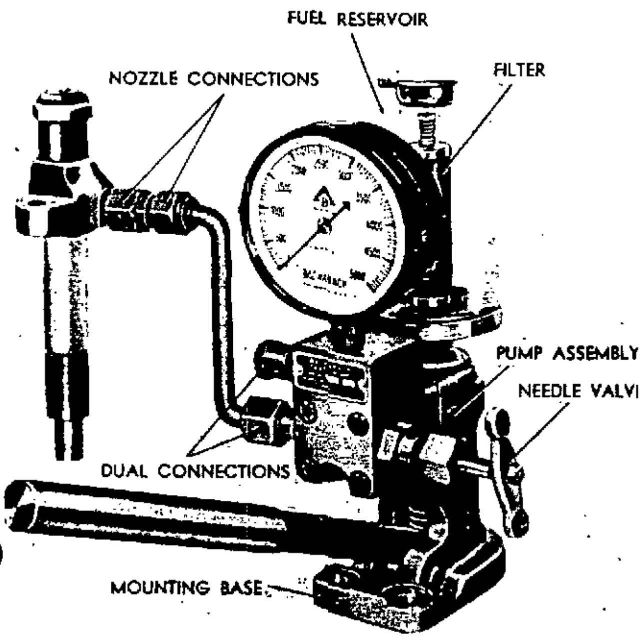


Figure 55—Nozzle Testing Fixture

Remove all nozzles and check for opening pressure (1750-1850 pounds) and spray pattern. Clean thoroughly and adjust if necessary. Clean hands, tools and working conditions are a "must" to do a good job of checking and reconditioning nozzles.

Before removing nozzles wash externally with fuel oil. Disconnect both high pressure and overflow lines and close openings. The nozzles are then to be tested for leakage, opening pressure and spray pattern according to the detailed instructions given under Chapter VI Fuel System.

8 Compression Check

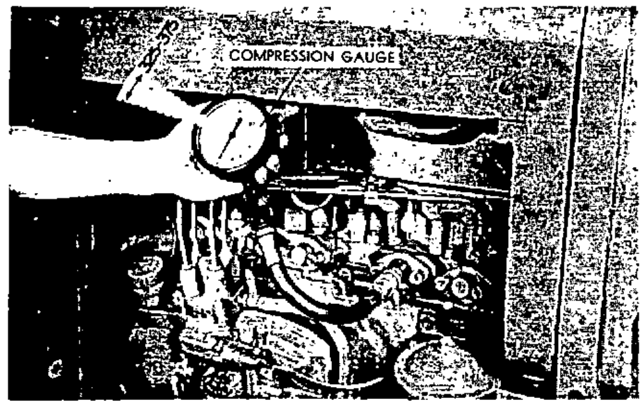


Figure 56—Checking Compression of Cylinders

Check compression of each cylinder using special gauge assembly with adapter to replace nozzle holder.

Pressures obtained should not vary more than 25 pounds between cylinders or fall below 325 pounds to avoid starting difficulty.

9 Check Starter and Generator Brushes and Commutator

Figure 57—Checking Starter & Generator Brushes

Remove cover band of the starter and generator to inspect the commutator and brushes. The commutators should be cleaned with 00 sand paper or stone (*never use emery cloth*) and if worn or found to have high mica — it should be removed, turned and undercut $\frac{1}{32}$". Replace all brushes that have worn approximately $\frac{1}{2}$ the original length.

The starter drive should be cleaned, inspected and lubricated with dry graphite so that full engagement results.

SECTION V
COOLING SYSTEM

The function of the cooling system is to prevent the temperatures in the combustion chamber, which may reach as high as 3500°F, from damaging the engine and at the same time keep the operating temperatures within safe limits.

Maintaining the cooling system efficiency is important, as engine temperatures must be brought up to and maintained within satisfactory range for efficient operation, — but must be kept from overheating, in order to prevent damage to valves, pistons and bearings.

CONTINENTAL DIESEL COOLING SYSTEM

Continental Diesel Engines operate most efficiently with water temperatures of 165° - 185° F. and a thermostat and by-pass system is used to control these temperatures.

The thermostat valve remains closed and only allows the water to recirculate within the engine itself until normal operating temperatures are reached. This provides for both rapid and even temperature increase of all engine parts during the warm up period. When desired temperature is reached, the thermostat valve opens and allows the water to circulate through both the engine and radiator or heat exchanger.

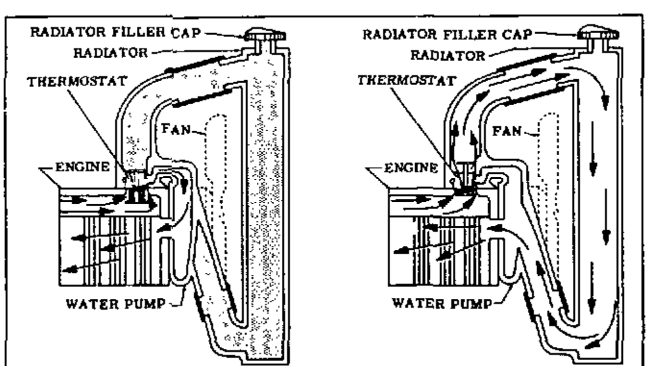


Figure 58—Thermostat Flow Control Thermostat Closed, Water Re-Circulating through Engine ONLY *Thermostat Open, Water Circulating through BOTH Engine and Radiator*

The cooling water is circulated by a water pump located at the front of the engine block. The coolest water enters the pump from the lower or suction opening, then is directed through **integral distribution passages cast in the cylinder** head, to the areas in and around the valve seats

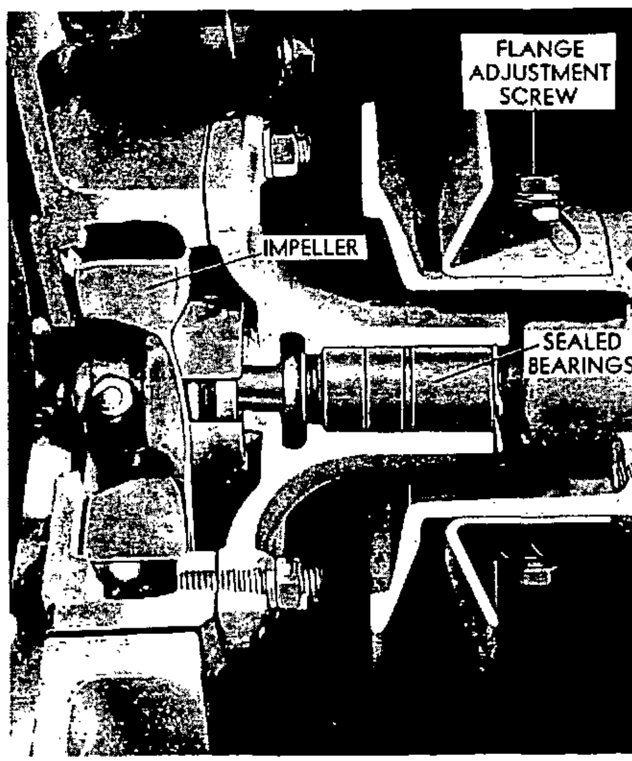


Figure 59—Water Pump

and combustion chamber. This method provides that the coldest water reaches the parts in the **engine subjected to the highest temperatures.**

The cylinder walls, in turn, are cooled by convection currents only, which keeps the cylinder barrels at a more uniform temperature and thereby greatly reduces crankcase oil dilution and sludge formation.

Upon leaving the cylinder head, the water enters the thermostat housing in which is mounted the by-pass type thermostat which controls the opening to the radiator or heat exchanger. Upon being discharged from the thermostat housing, the water enters the radiator or heat exchanger,

COOLING SYSTEM

depending upon the application, where it is cooled before re-entry into the engine.

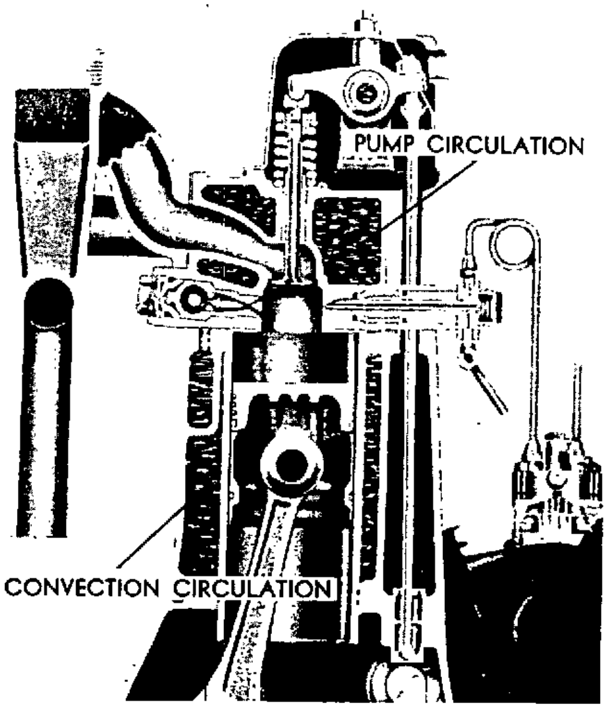


Figure 60—Cooling by Convection and Pump Circulation

EXPANSION OF WATER

Water has always been the most commonly used coolant for internal combustion engines because it has excellent heat transfer ability and is readily obtained everywhere. Like all liquids it expands when heated, the rate of expansion being 1/4 pint per gallon when the temperature is raised from 40° to 180° F.

For example: If a 4 gallon cooling system is filled completely full of water at 40° F, 1 pint will be lost through the radiator overflow pipe by the time the water temperature reaches 180° F.

WATER FILTERS

In some areas, the chemical content of the water is such, that even the best of rust inhibitors will not protect the cooling system from the formation of rust and scale.

There are instances where this corrosive element has eaten holes through cast iron parts such as water pump impellers and bodies. This condition is caused by electrolysis taking place in the parts involved.

Where these conditions exist, water filters, such as those made by the Perry Co. and the Fram Corp., should be incorporated in the assembly to remove these troublesome elements and offset the electrolytic action.

EFFECT OF ALTITUDE ON COOLING

Water boils at 212° F under atmospheric pressure at sea level. This pressure becomes less at higher altitudes and the reduced pressure causes water and other liquids to boil at a lower temperature. The following chart shows the effect on boiling point of water and anti-freeze solution:

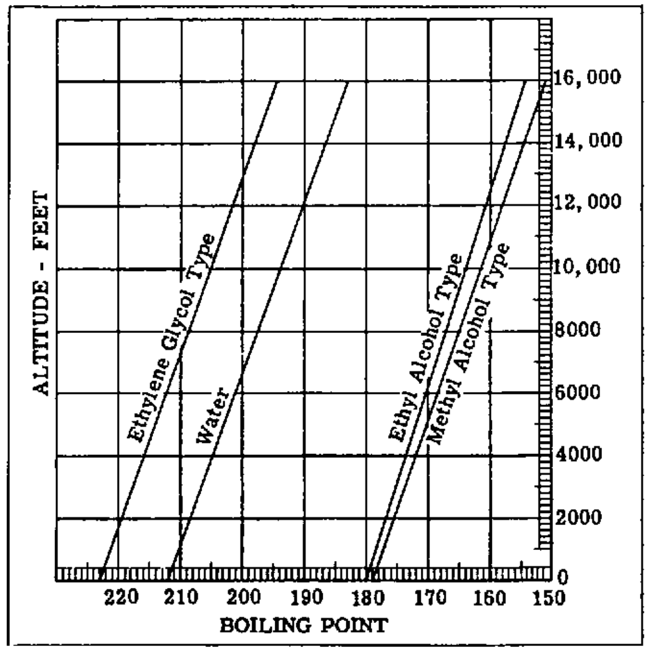


Figure 61—Effect of Altitude on Boiling Point of Coolant

ANTI-FREEZES

Water freezes at 32° F., forms solid ice and expands about 9% in volume — which causes tremendous pressure and serious damage when allowed to freeze inside the cooling system.

When operating temperatures are below 32° F. an anti-freeze liquid must be added which will lower the freezing point a safe margin below the anticipated temperature of outside air.

Anti-freeze solutions come in 3 general types and may be used in the following proportions by volume to withstand the temperatures indicated: For example, 1 quart of alcohol to 3 quarts of water for 10° F.:

TYPES OF ANTI-FREEZE	OPERATING TEMPERATURE RANGE		
	32° to 10°F	+10° to —10°F	—10° to —30°F
PLAIN ALCOHOL — (evaporates easily) — Check with Hydrometer and replenish often. — If spilled on paint wash thoroughly immediately	1 to 3*	4 to 9	5 to 8
METHYL ALCOHOL COMPOUNDS — such as Mobil Freezone, etc., (evaporates less easily) — Check and replenish occasionally.	1 to 4	2 to 5	1 to 1
ETHYLENE GLYCOL — such as Mobil Permazone, (permanent type) — When there are no leaks add water only to make up for evaporation	1 to 4	2 to 5	1 to 1

***NOTE:* While the above list includes information on three types of generally used Anti-Freeze, the Ethylene Glycol or Permanent Type will be found to be the most desirable and likewise the most economical because of the temperatures desirable to maintain for efficient operation.**

CORROSION INHIBITORS

Water forms rust due to its natural tendency to combine chemically with iron and air in the system. Rust inhibitors for water are inexpensive, simple to use and make cleaning and flushing necessary only after long periods of operation.

The most commonly used are either a 3% addition of soluble oil or commercial corrosion inhibitors such as Mobil Hydrotone that are readily available at low cost. The addition of corrosion inhibitors are not necessary if an anti-freeze containing a rust inhibitor is used.

RADIATOR

The radiator or heat exchanger consists of a series of copper tubes through which the cooling water is circulated. In standard radiator design fins are connected to the copper tubes to give an extended surface through which heat can be dissipated. It is important that these tubes be kept clean on the inside and the fins free of dirt on the outside so that maximum heat transfer can take place in the radiator.

Blowing out between the fins of the radiator, using compressed air, in a direction opposite to that of the fan circulated air, will serve to keep the cooling surfaces of the core free of dirt and other particles.

*Example: 1 qt. of alcohol to 3 qts. of water.

Every 500 hours of operation the radiator and cooling system should be well cleaned and flushed with clean water. (See Radiator Drain.)

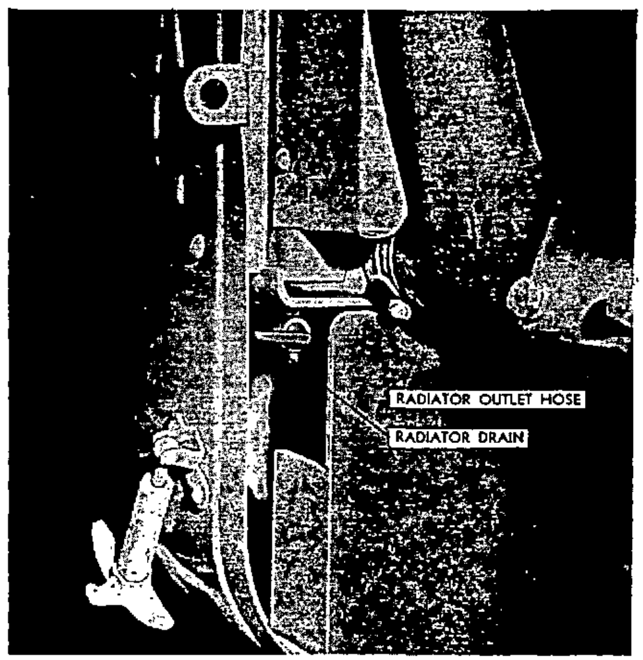


Figure 62—Radiator Drain

Wherever possible, only soft clean water should be used in the cooling system. Hard water will cause scale to form in the radiator and the engine water jackets and cause poor heat transfer. Where the use of hard water cannot be avoided, an approved water softener can be used.

CLEANING COOLING SYSTEM

Deposits of sludge, scale and rust on the cooling surfaces prevent normal heat transfer from the metal surfaces to the water and in time

COOLING SYSTEM

render the cooling system ineffective to properly maintain normal operating temperatures. The appearance of rust in the radiator or coolant is a warning that the corrosion inhibitor has lost its effectiveness and should be cleaned before adding fresh coolant.

Dependable cleaning compounds should be used. Follow the procedure recommended by the supplier. This is of prime importance because different cleaners vary in concentration and chemical compositions. After cleaning and flushing, the system should be filled with an approved anti-freeze compound containing a rust and corrosion inhibitor or water with a corrosion inhibitor.

REVERSE FLOW FLUSHING

Whenever a cooling system is badly rust-clogged as indicated by overflow loss or abnormally high operating temperatures, corrective cleaning by reverse flow flushing will most effectively remove the heavy deposits of sludge, rust and scale. The reverse flow flushing should be performed immediately after draining the cleaning solution and it is advisable to flush the radiator first, allowing the engine to cool as much as possible.

Reverse flush the radiator, as follows:

1. Disconnect the hoses at the engine.
2. Put radiator cap on tight.

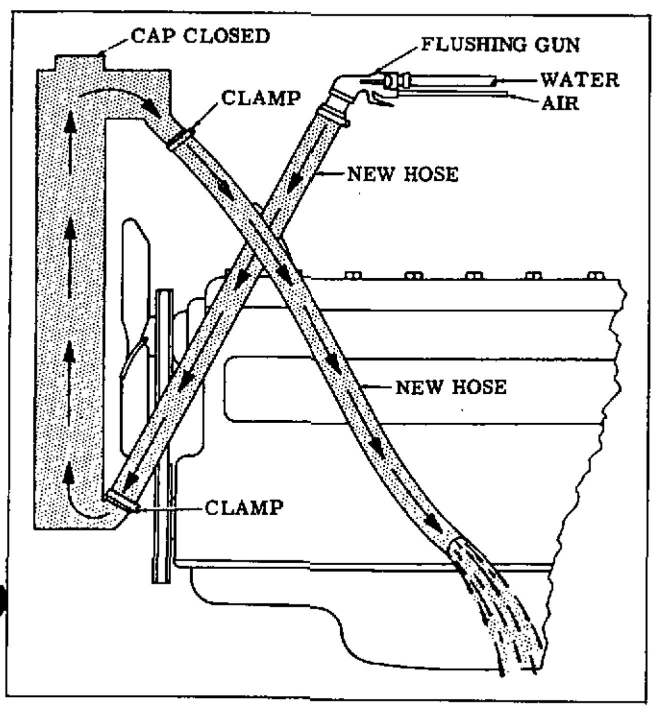


Figure 63—Reverse Flushing Radiator

3. Clamp the flushing gun in the lower hose with a hose clamp.
4. Turn on the water and let it fill the radiator.
5. Apply air pressure gradually, to avoid radiator damage.
6. Shut off the air, again fill the radiator with water and apply air pressure — repeat until the flushing stream runs out clear.
7. Clean and inspect radiator cap.

To Reverse flush the engine water Jacket

1. Remove the thermostat.
2. Clamp the flushing gun in the upper hose.
3. Partly close the water pump opening to fill the engine jacket with water before applying the air.
4. Follow the same procedure outlined above for the radiator by alternately filling the water jacket with water and blowing it out with air (80# pressure) until the flushing stream is clear.

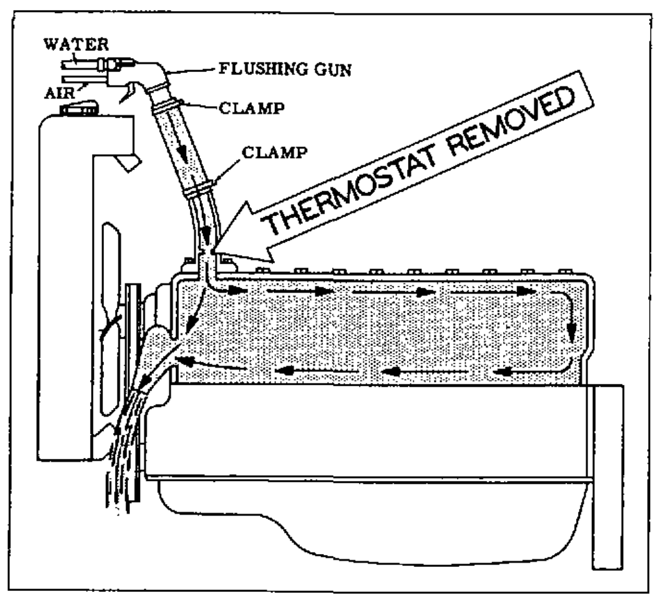


Figure 64—Reverse Flushing Engine

TESTING THERMOSTAT

Remove Water Pump Header as shown in illustration. Before testing clean and examine the bellows for rupture or distortion. If the valve can be pulled or pushed off its seat with only a slight effort when cold or it does not seat properly, the unit is defective and should be replaced.

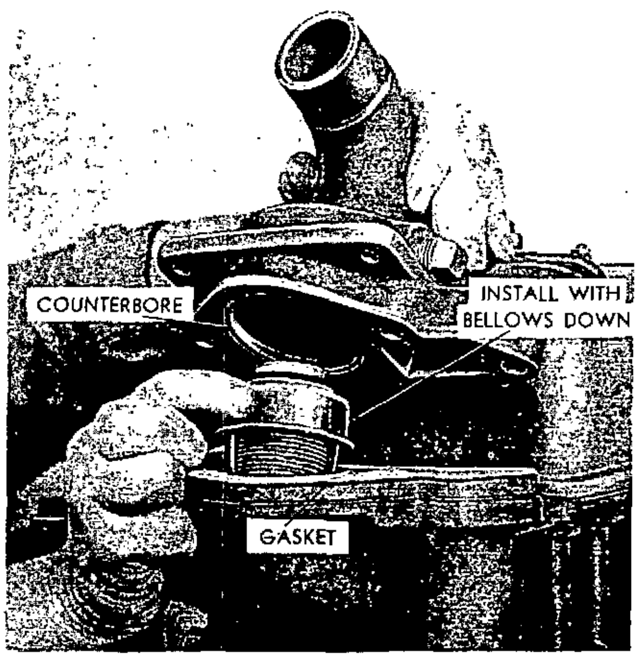


Figure 65—Installing Thermostat

The thermostatic operation can be checked in the following method:

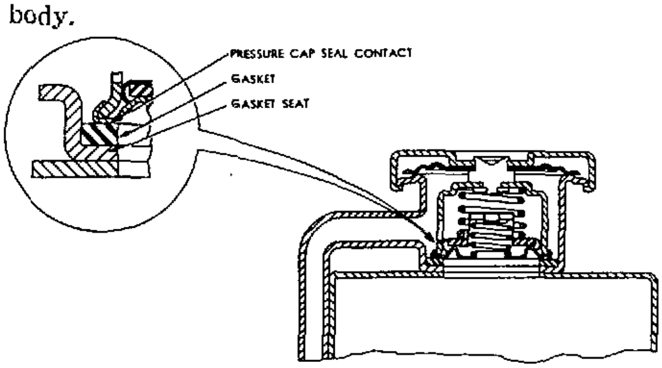
1. Hang thermostat by its frame in a container of water so that it does not touch the bottom.

2. Heat the water and check temperature with a thermometer.

3. If the valve does not start to open at temperatures of 165-175°F or if it opens well before the 165° point is reached the thermostat should be replaced.

When replacing the thermostat in the water outlet elbow, be sure seal is in place, and seal seat as well as the **counterbore** is clean.

Assemble new gasket to pump body or spacer. Thermostat flange must seat in counterbore with gasket sealing contact between it and the pump body.



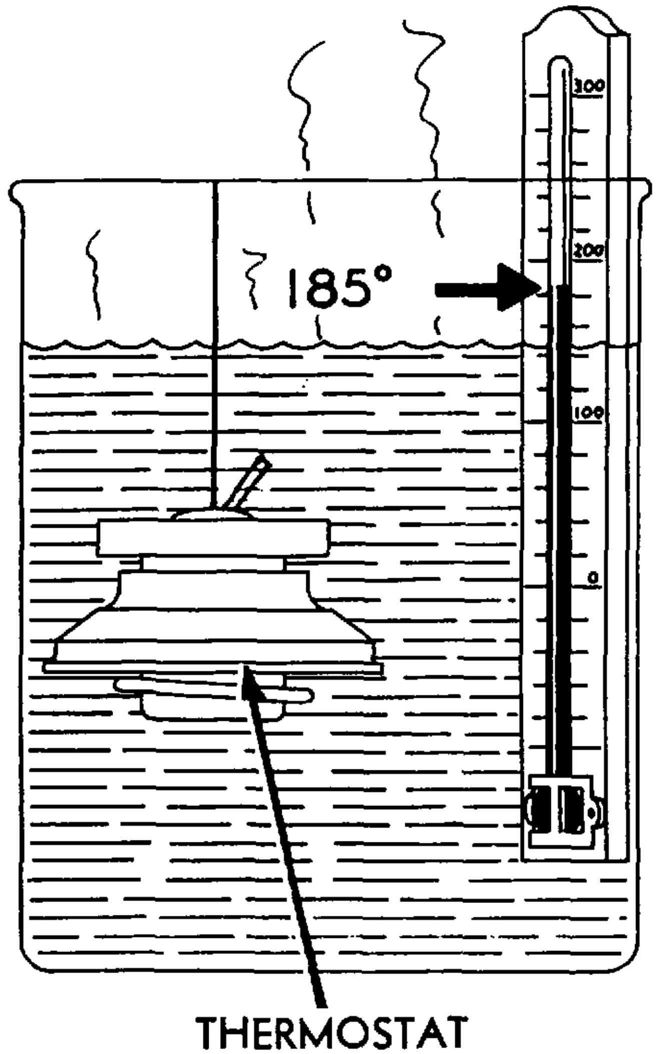


Figure 66—Checking Thermostat

RADIATOR PRESSURE CAP

Many operations use a pressure cap on the radiator to prevent overflow loss of water during normal operation. This spring loaded valve in the cap closes the outlet to the overflow pipe of the radiator and thus seals the system, so that pressure developing within the system raises the boiling point of the coolant and allows higher temperatures without overflow loss from boiling. Most pressure valves open at 4 pounds, allowing steam and water to pass out the overflow pipe, however, the boiling point of the coolant at this pressure is 225°F at sea level. When a pressure cap is used

COOLING SYSTEM

an air tight cooling system is necessary with particular attention to tight connections and a radiator designed to withstand the extra pressure.

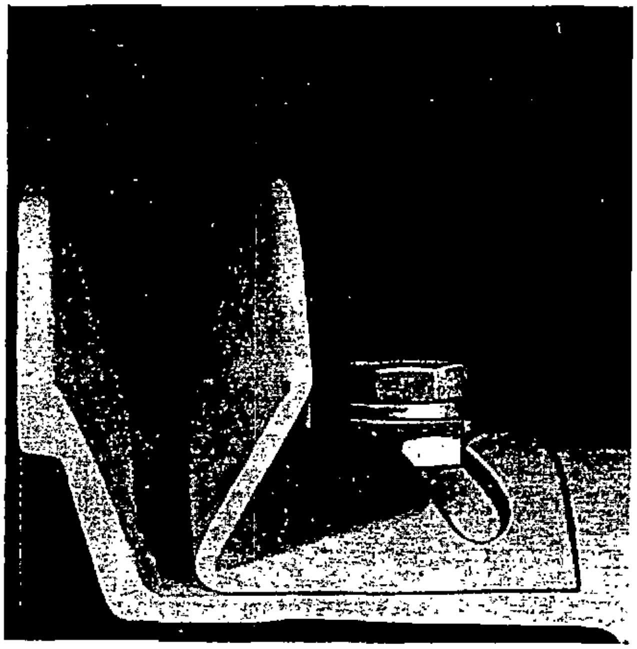


Figure 67—Fan Belt Adjusting Flange

FAN BELT TENSION

When tightening fan belts, loosen the generator adjusting bolts and pull out on the generator by hand until the belt is just snug. **Under no consideration should a pry bar be used on the generator to obtain fan belt tension** or damage to the bearings will result.

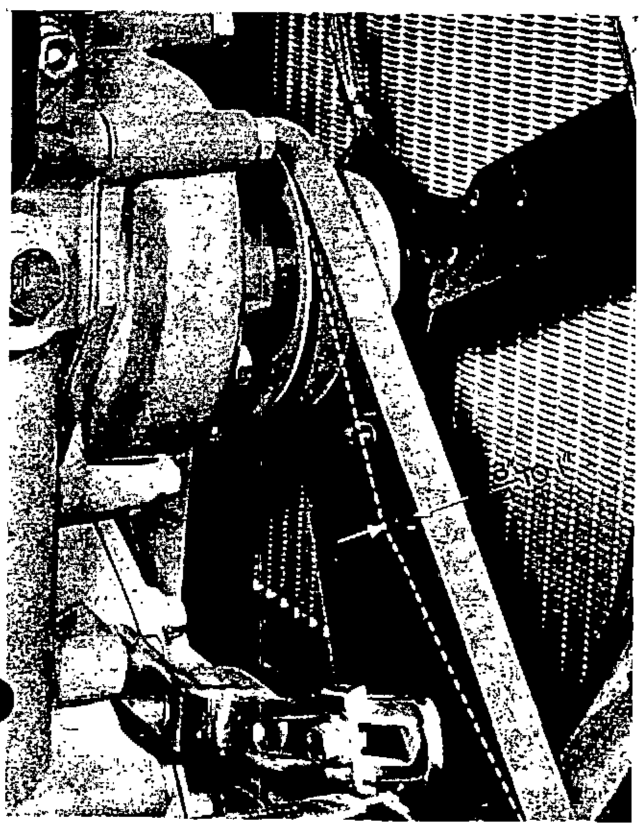


Figure 68—Fan Belt Tension

When adjusted correctly the fan belt should have between ¾″ to 1″ deflection on the long side.

CYLINDER BLOCK WATER DRAINS

When the cooling system is to be completely drained, there are one or two drain plugs on the right hand side of the cylinder block depending upon engine models, which drain all cooling water which might be trapped in the base of the block.

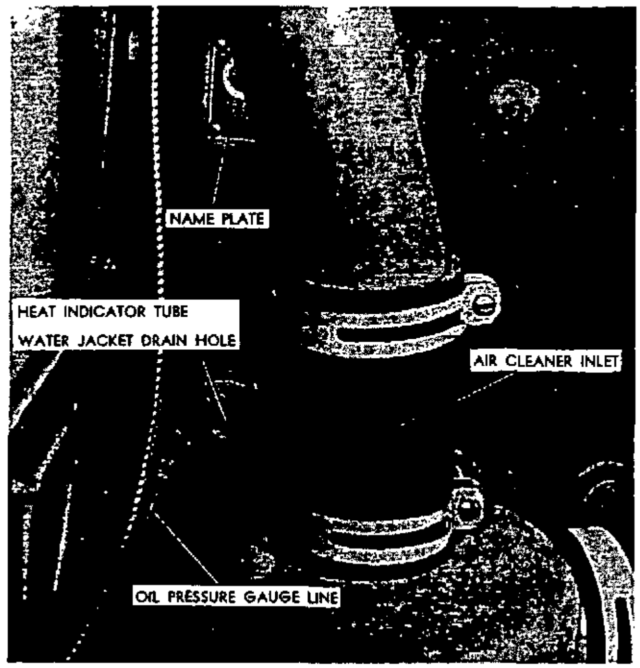


Figure 69—Cylinder Drain Plug

> **CAUTION: OVERHEATED ENGINE**
> **Never pour cold water or cold anti-freeze into the radiator of an over-heated engine. Allow the engine to cool and avoid the danger of cracking the cylinder head or block. Keep engine running while adding water.**

OVERCOOLING

Continuously low operating temperature wastes fuel, increases engine wear and causes oil sludge and corrosion of engine parts.

Over-cooling may be caused by operating conditions such as excessive idling, low speeds and light loads during cold weather. Partly covering the radiator or use of a thermostatic or manually controlled shutter will improve this condition. Improper thermostat or shutter operation can also result in over-cooling. Temperatures should be regulated to maintain 165° - 185° operating temperature.

WATER PUMP

The water pump is located in the front of the cylinder block and is driven by the fan belt from the crankshaft pulley. The inlet of the water pump is connected to the lower radiator connection and the outlet flow from the pump is through integral passages cast in the cylinder head.

No lubrication of the pump is required as the bearings are of the permanently sealed type and are packed with special lubricant for the life of the bearing.

The water pump requires no attention other than bearing replacement when they show excessive looseness or if a water leak develops which shows a damaged or badly worn seal that needs replacement.

REMOVING WATER PUMP

The water pump assembly can be removed from the engine as a unit for service or repair in the following manner:

1. Remove fan by taking out four cap screws.

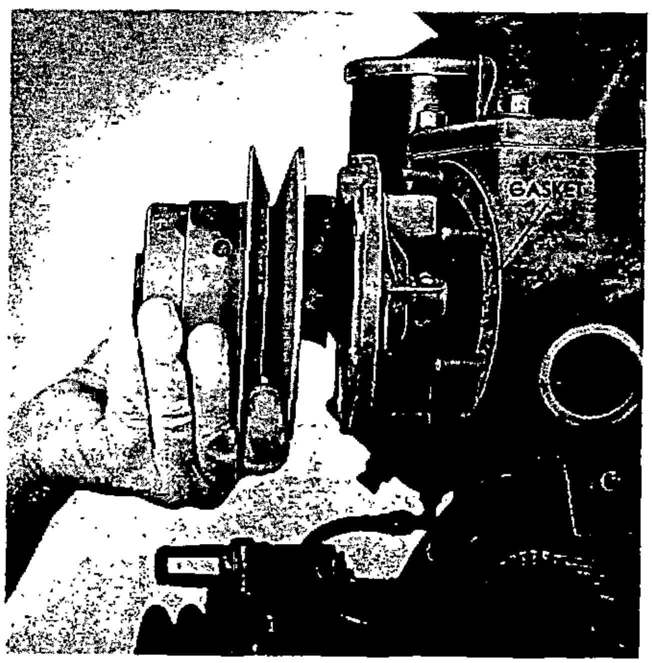


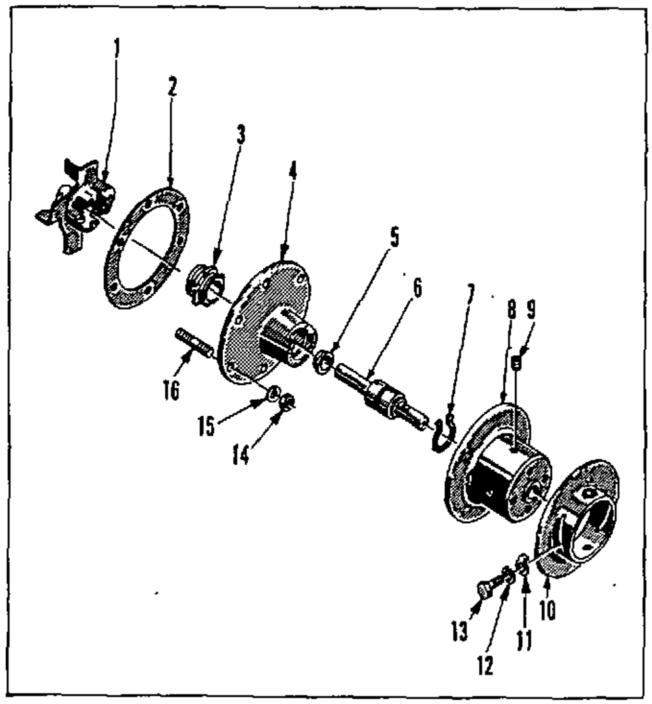
Figure 70—Water Pump Removal

2. Loosen generator so that fan belt can be slacked off enough to slide over pulley.

3. Remove nuts (14) and lockwashers (15) holding the pump support (4) to the front of the block and remove the pump assembly.

DISASSEMBLY OF WATER PUMP

1. Remove the bolt from the impeller hub and using a puller, remove the impeller from the shaft. Do not pound or drive on the pump shaft or the carbon seal on shaft will be damaged.



1. Impeller
2. Gasket
3. Seal Assembly
4. Support
5. Bushing
6. Shaft & Bearing Assembly
7. Snap Ring
8. Fan Hub
9. Screw
10. Adjusting flange
11. Locknut
12. Lockwasher
13. Screw
14. Nut
15. Lockwasher
16. Stud

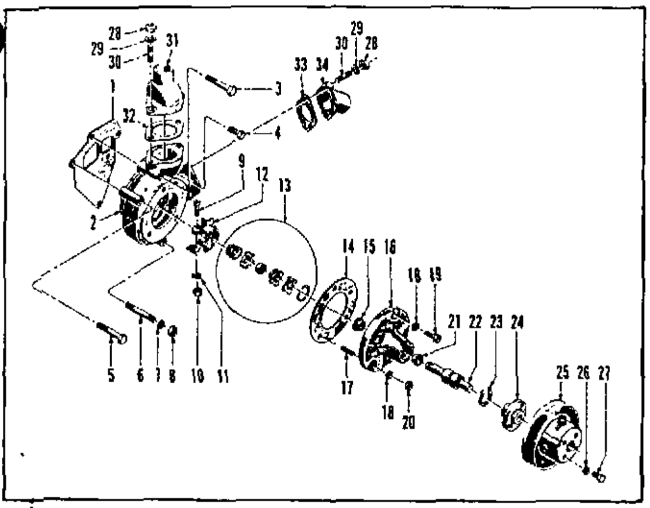
Figure 71—Water Pump Disassembly (HD & JD Series)

2. Remove the impeller snap ring and the seal assembly (3) can be lifted from the impeller hub.

3. Where removal of the shaft (6) is required for inspection, loosen the Allen set screw (9) and pull the fan hub (8) from the shaft using a puller.

4. Remove the snap ring (7), then the shaft and bearing assembly (6) can be pressed out of the pump body toward the front end.

COOLING SYSTEM



1. Gasket
2. Body
3. Screw
4. Screw
5. Screw
6. Stud
7. Lockwasher
8. Nut
9. Screw
10. Lockwasher
11. Nut
12. Impeller Assembly
13. Seal Assembly
14. Gasket
15. Bushing
16. Support Assembly
17. Stud
18. Lockwasher
19. Screw
20. Nut
21. Slinger
22. Shaft & Bearing Assembly
23. Snap Ring
24. Fan Hub
25. Fan pulley assembly
26. Lockwasher
27. Screw
28. Nut
29. Lockwasher
30. Stud
31. Outlet Elbow
32. Gasket
33. Gasket
34. Inlet Elbow

Figure 72—Water Pump Disassembly (GD157)

REASSEMBLY AND INSTALLATION

1. Reassemble pump, replacing worn or failed parts and reverse above instructions.

Seal contact surface must be smooth and flat, regardless of whether it is on a replaceable bushing or machined directly in the iron of the support. The bushing may be replaced, if scored or cut, but either of them may be refaced and polished for further use.

A light film of lubricant applied to the face of the seal will facilitate seating and sealing.

2. Use thick soapsuds on both the seal and shaft when assembling in order to prevent damage to the seal.

3. Mount pump assembly on block using a new housing gasket.

4. Install fan belt and adjust belt tension to have ¾" to 1" deflection on long side. Pull out the generator by hand, as bearing damage will result with a pry bar.

SECTION VI
FUEL INJECTION SYSTEM

The fuel injection system of a Diesel engine is of paramount importance in the functioning of that type of engine. There is no carburetion system and there is no ignition system; the injection system takes the place of both in one way or another.

It draws the fuel from the supply tank, forces it through the filters, places it under the high-pressure required for mechanical atomization, meters it with great accuracy, distributes it in the proper sequence to the various cylinders, commences the individual injections with fine precision in timing, and produces uniformly through the nozzles the correct pattern of spray for the combustion chamber.

The injection system of a Diesel engine includes (a) an injection pump assembly complete with fuel supply pump and speed governor, (b) fuel filters, (c) high-pressure steel lines connecting the pump discharge outlets to the nozzles, and (d) nozzle holder and nozzle assemblies, one for each cylinder. Not the least of these are the filtration elements, as fine particles of dirt in the fuel are extremely destructive to high-pressure pumps of any description, and a final-stage filter capable of stopping particles down to 2 microns prevents premature wear.

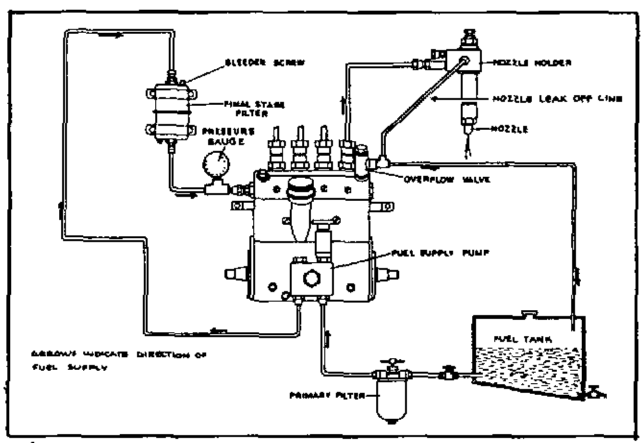


Figure 73A
Schematic View of Fuel Supply System with APE Pump

Careless or too frequent removal of elements of the fuel injection system for "inspection" or "cleaning" is generally far more harmful than beneficial, due to the danger that dirt will enter the exposed connections and the possibility of mishandling the equipment through lack of knowledge of its design and construction. Various of its components are made with the utmost precision and may be easily damaged when removed.

CAUTION: **There should be no tampering with the injection pump assembly, or removal of it for inspection, unless engine operation is seriously impaired and the cause of the difficulty is directly traceable to the pump unit.**

It should be borne in mind that **minor troubles**, such as suction leaks at joints in the supply line to the transfer pump, can cause erratic engine behavior. ***It is unlikely that the injection pump itself would require overhaul before it has several thousand hours of operation.***

All injection pumps should be calibrated and repaired at authorized service stations, unless factory trained personnel are available with the proper tools and test equipment.

FUEL INJECTION SYSTEM

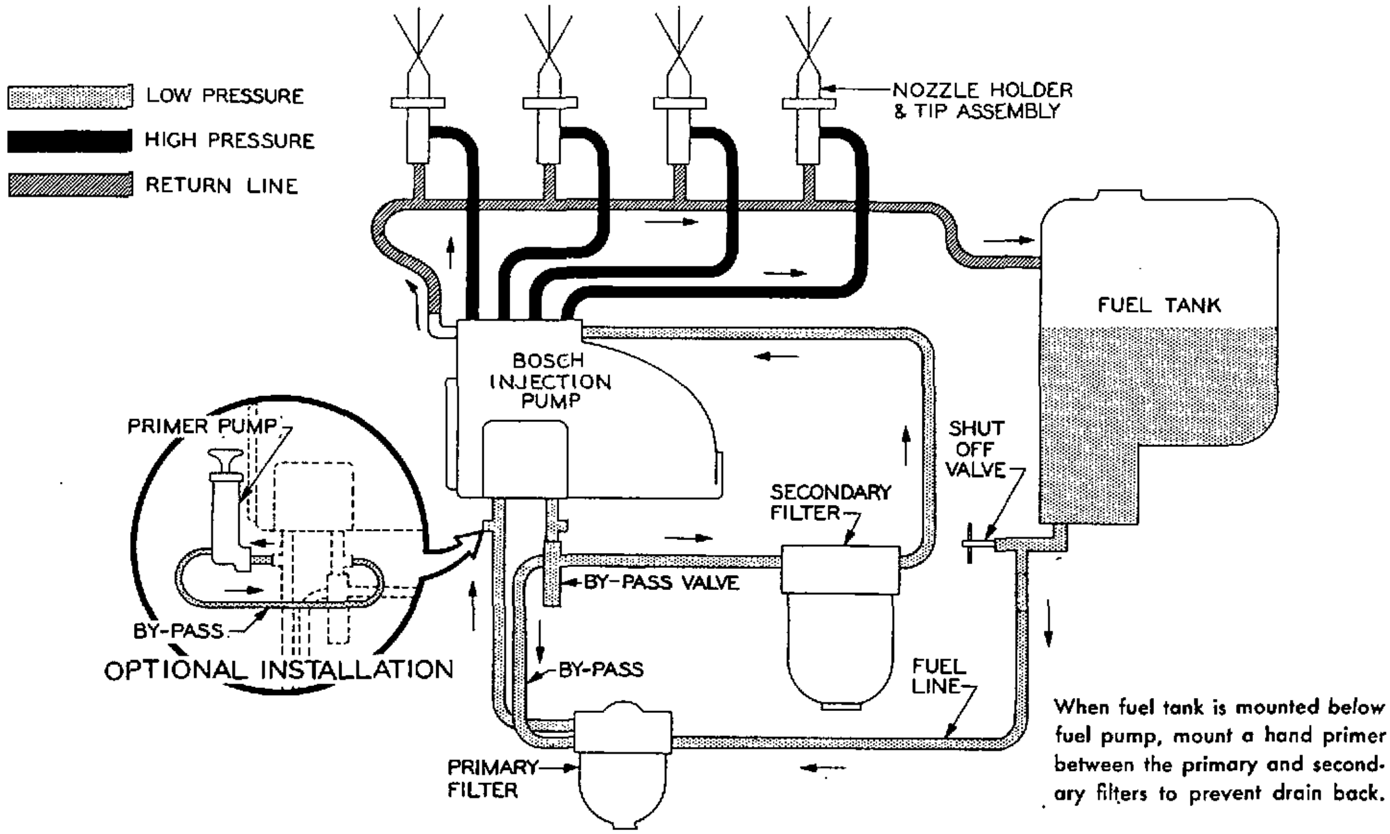


Figure 73B—Schematic View of Fuel System with PSB Pump

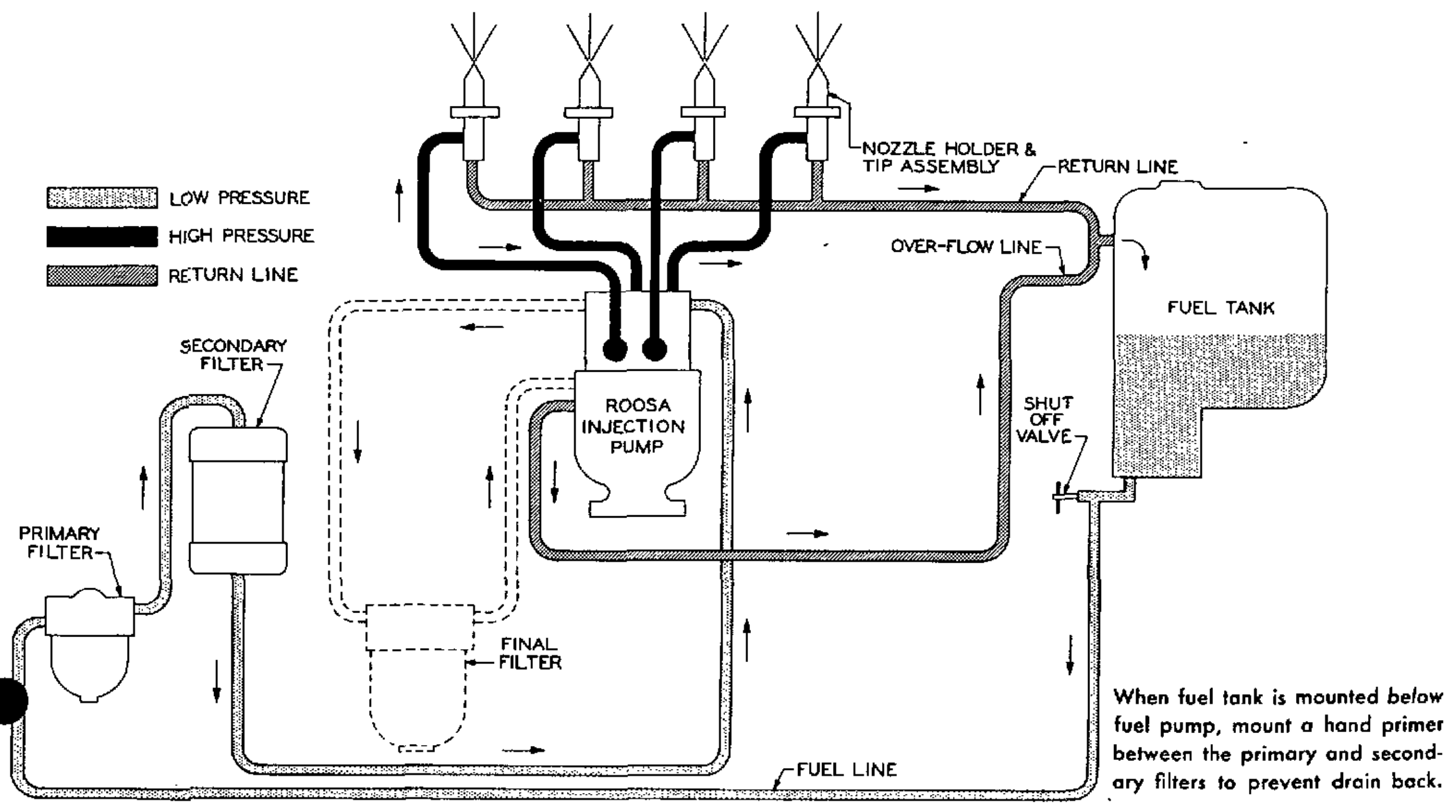


Figure 73C—Schematic View of Fuel System with Roosa-Master Fuel Injection Pump

BOSCH *APE* MULTI-PLUNGER TYPE INJECTION PUMPS

Bosch APE Fuel Injection Pumps are of the constant-stroke, cam-actuated, lapped-multi-plunger type and are driven at half engine speed. Their purpose is to meter the fuel accurately and to deliver it precisely at a definite time under 1800 pounds pressure to the spray nozzles by which it is injected into the respective cylinder of the engine.

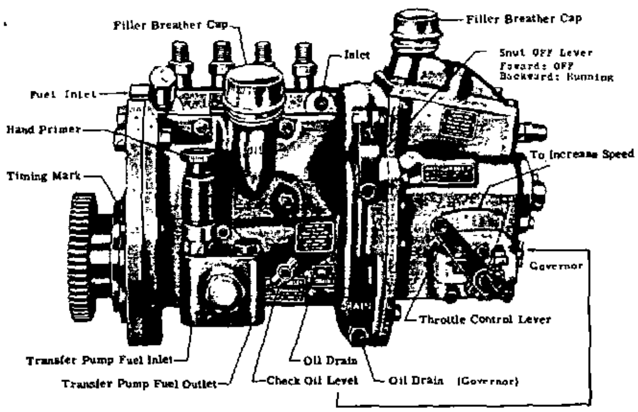


Figure 74—Bosch APE Pump

PUMP LUBRICATION

The lower or cam compartment of this pump should be filled initially with a good grade of engine lubricating oil to the height of the oil level plug, and this compartment should be drained and refilled whenever the engine crankcase oil is changed. A drain plug is provided on the front of the housing and is clearly indicated.

Presence of fuel oil in the camshaft compartment of the APE pump is to be expected and should not be a source of worry. The lubricating properties of the fuel are ample to meet requirements, and slight leakage of it down past the lapped fits of the plungers is quite normal. The purpose of filling the cam compartment initially with lube oil is to insure the presence of an oil supply there at the outset. The purpose of draining and refilling the cam compartment at the time of engine crankcase oil change is to clear away any accumulations of sludge or moisture.

On Continental Diesels, the APE pumps are fitted with cam compartment overflow tubes in order that the surplus leakage fuel may be conveyed automatically to some convenient point of collection or disposal.

When such overflow tubes are not provided, it will be necessary for the operator periodically to open the oil level plug and allow the surplus oil to drain off. The frequency with which this service must be performed can be determined only by experience.

Erratic engine performance, attributed to the injection pump, only after all other factors have been eliminated, may often be caused by a sludging condition within the injection pump. Thoroughly clean the pump externally with fuel oil to prevent entrance of dirt during subsequent operations. Open oil drains on both governor (if used) and pump housing and allow the oil to drain.

Carefully remove the inspection cover from the pump and the top cover from the governor housing and examine internal condition of both units. If reddish-brown sludge deposits or gummy oil conditions are noted, the units should be flushed, employing a pressure or squirt gun using fuel oil, or other solvents.

Actuate the control rack while flushing to assure complete removal of all deposits from the gear segments within the pump and governor linkages. After flushing allow units to drain, then refill with clean engine oil to the proper level. Lightly spray springs and gear segments with oil and replace covers.

The injection pump and governor are provided with breather caps. These should be tightly covered when engines are cleaned with pressure type cleaners to prevent the entrance of steam or water into the injection pump.

FUEL SUPPLY PUMP

In the conventional multi-plunger injection pump of the APE type, the fuel supply pump (Type SPA) is of the self-regulating, plunger type pump capable of building pressure up to a predetermined point controlled by the plunger return spring. The pump is not normally required to self-regulate, however, because fuel is ordinarily circulated back to the supply tank through an overflow valve on the injection pump which is set at a lower pressure.

It is preferable to employ a fuel supply system of the return-flow type, in which the pressure is limited by a spring-loaded overflow valve, usually placed on the injection pump opposite its fuel inlet connection. Such an overflow valve **adjusted to about 15 pounds per square inch,** per-

FUEL INJECTION SYSTEM

mits the fuel to pass entirely through the injection pump gallery and back into the supply tank.

Thus any air or gas which may have entered the system will be carried away. An accumulation of air or gas within the gallery can easily become troublesome.

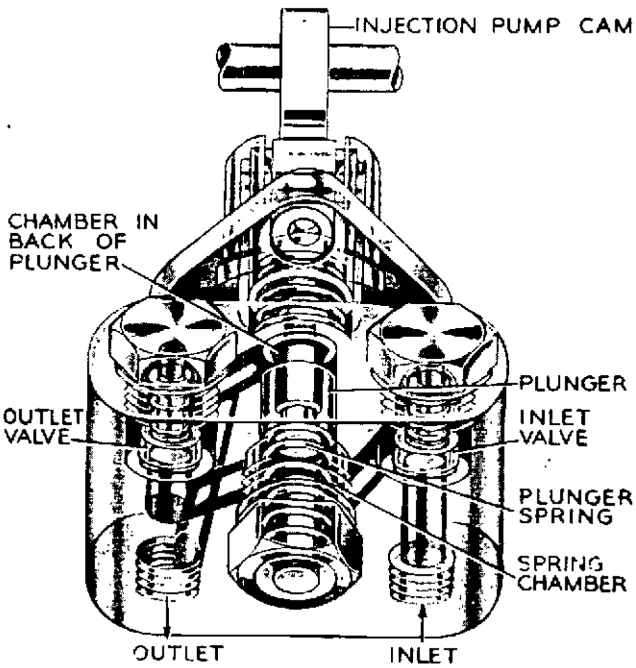


Figure 75—Bosch Fuel Supply Pump (SPA)

The direction of fuel flow is always indicated by an arrow inscribed on the supply pump housing. Some fuel supply pumps are provided with a hand-prime feature for manually filling the low pressure fuel lines between the supply pump and the injection pump before the engine is started.

Difficulties with the fuel supply system, often laid to the supply pump, may often be traced to such causes as clogged fuel filters or air leaks into the fuel lines as a result of loose connections at the various line fittings. Dented, badly crimped or spongy supply lines cause high fuel flow restrictions. Defective overflow valves may also contribute to impaired engine operation. In some isolated cases, dirt may be lodged under supply pump valves. This can readily be checked by removing spring retaining nuts and examining valves and seats.

Insertion of a 30 pound pressure gauge at outlet side of supply pump with engine running will further aid to isolate troubles. Satisfactory supply pump operation will be obtained with a minimum pressure reading of 10 lbs. By inserting gauge between secondary and final stage filter, a clogged unit can easily be determined.

BOSCH MECHANICAL GV TYPE GOVERNOR (APE PUMP)

The prime purpose of the governor is to serve as a means for presetting and maintaining within close limits any desired engine speed regulation within the idling and maximum speed range, irrespective of engine load.

In addition, the governor controls the engine idling speed to prevent stalling and the maximum speed to prevent racing.

In the event that minor changes in engine speed are necessary, ready adjustments by means of stop screws are provided on the side of the governor as shown below. This adjustment should be made by competent personnel only and with accurate hand tachometer.

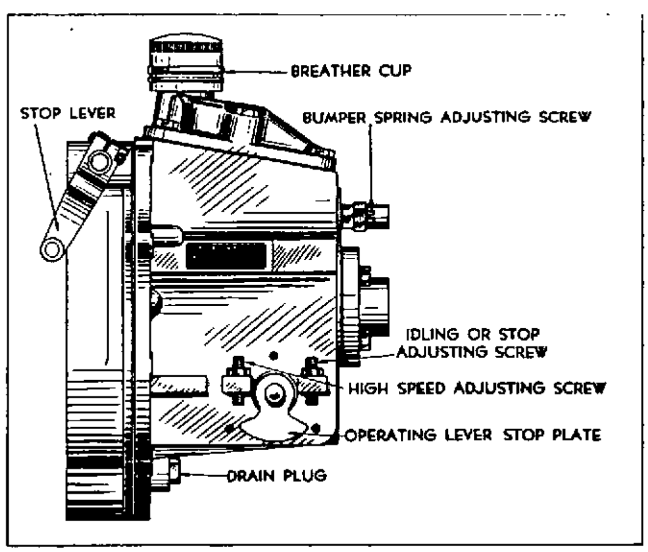


Figure 76—GV Type Mechanical Governor

ADJUSTING THE TYPE GV GOVERNOR ON THE ENGINE

HIGH-SPEED ADJUSTMENT

Changes in engine speeds should be made only when necessary to conform with speeds given in your engine manufacturers operating manual. The adjustments are originally set and sealed by the engine manufacturer for your protection.

Warm up the engine thoroughly before attempting to make any governor adjustments.

The illustration shows a governor being adjusted for high idle speed. The bumper spring has been withdrawn and the operating lever, in this case at the rear of the pump and not showing in the illustration, has been moved clockwise toward full load position until the stop plate on the lever shaft has contacted the high speed adjusting

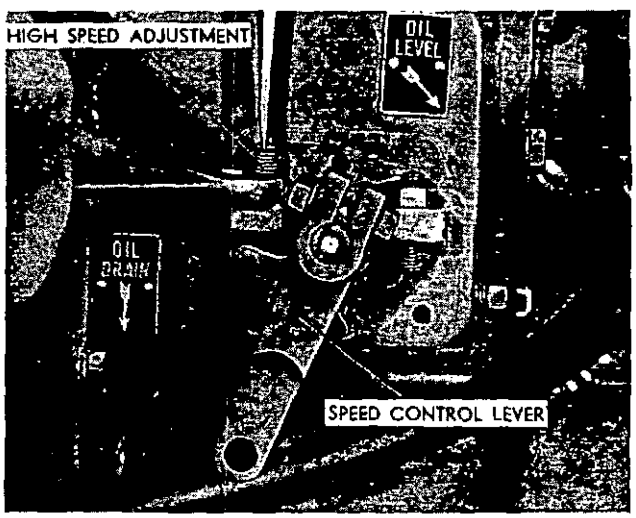


Figure 77—High Speed Adjustment

screw. This screw is always the one nearer to the injection pump regardless of the governor mounting.

When the engine reaches its maximum speed, check by means of a tachometer whether this is the high idling speed as specified in your instruction manual. If the speed is too low, raise the high speed adjusting screw and, if the speed is too high, lower the screw.

After the correct speed is obtained, secure the adjusting screw by means of the lock nut and re-check the speed, making sure that the stop plate on the governor operating lever shaft is in contact with the adjusting screw.

HIGH IDLE BUMPER SPRING ADJUSTMENT

This illustration shows the adjustment of the high idle bumper spring. With the engine still operating at the high idle speed, the bumper

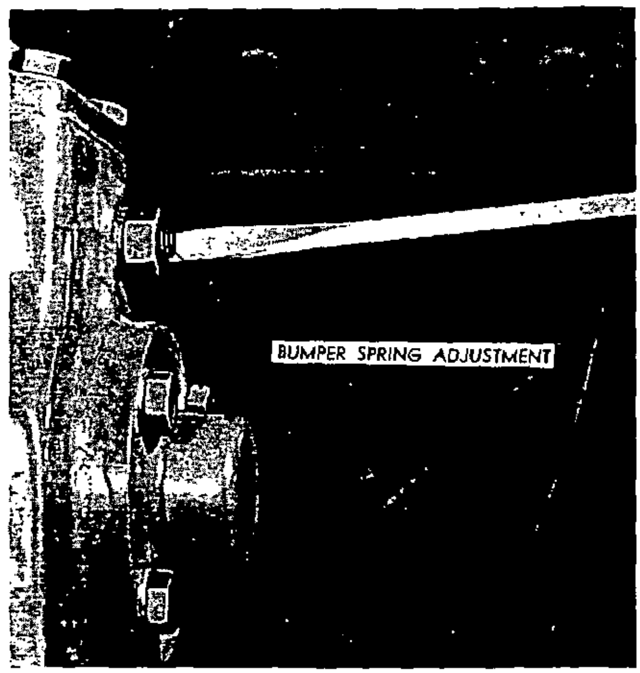


Figure 78—High Idle Bumper Spring Adjustment

spring adjusting screw should be turned in until the spring just touches the fulcrum yoke assembly without any appreciable increase in engine speed.

If the pump control rack oscillates rapidly back and forth at high idle speeds, screw in the bumper spring slightly further until the control rack is reasonably steady. Re-check the engine speed with a tachometer and be sure that no excessive speeds have resulted from the bumper spring adjustments. It may be necessary to lower the high speed adjusting screw slightly.

LOW IDLING SPEED ADJUSTMENT

Illustrated below is a governor being adjusted for low idle speed. Move the operating lever in the direction of less speed until the engine reaches the correct idle speed. Hold the operating lever in this position and screw in the idle speed adjusting screw until its lower end touches the stop plate on the operating lever.

FUEL INJECTION SYSTEM

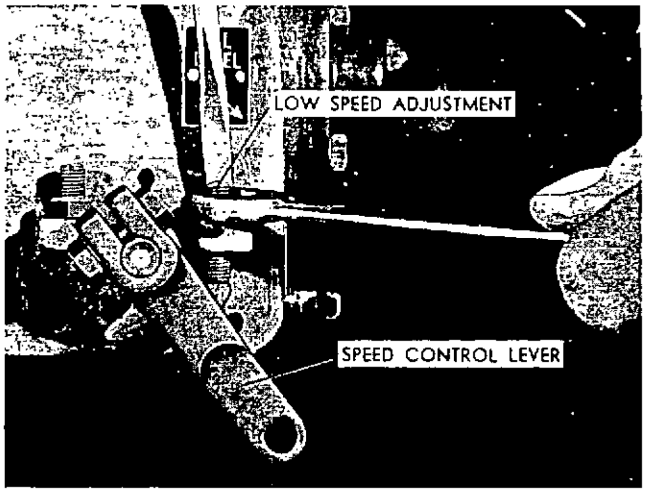


Figure 79—Low Speed Adjustment

The nominal idling and maximum speeds controlled by the governor cannot be varied to any great extent because they depend entirely upon the characteristics of the spring combination contained in the governor unit. If the governor adjustments are not sufficient to obtain the desired speeds, an American Bosch authorized service station should be consulted.

BOSCH *PSB* INJECTION PUMP

The American Bosch type PSB Fuel Injection Pumps are of the constant-stroke, single distributing-plunger, sleeve-control type, the plunger being actuated by a cam and tappet arrangement which also carries gearing for the distribution function.

The purpose of the pump is to deliver accurately metered quantities of fuel oil under high pressure to the spray nozzles thru which the fuel is injected into the engine cylinders, at a definite timing in relation to the engine firing cycle and within the required injection period. This pump is designed to reduce initial cost and to simplify servicing, both objectives being reached thru a substantial reduction in the number of required parts. PSB type pumps are driven at engine speed.

An integral governor, of the mechanical-centrifugal type, is used with this pump to control fuel delivery as a function of speed. It is driven directly off the rear of the pump camshaft without gearing.

A gear-type fuel supply pump is provided for direct attachment to the pump at the front, driven from the distributor drive gear on the camshaft.

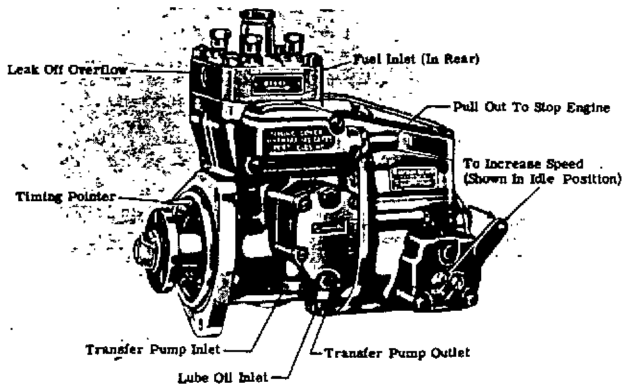


Figure 80—Bosch PSB Fuel Injection Pump & Governor

This type PSB pump is a self-contained unit and requires no periodic lubrication check because lubrication is provided from the engine lube oil system; strict adherence to manufacturer's specifications regarding engine oil change and maintenance of engine oil filters is therefore of special importance.

A small lube oil filter is provided within the pump itself but solely for the protection of the lower lapped section of the plunger. This little filter requires no servicing unless the entire pump is to be subjected to a major overhaul and should otherwise not be disturbed. Re-

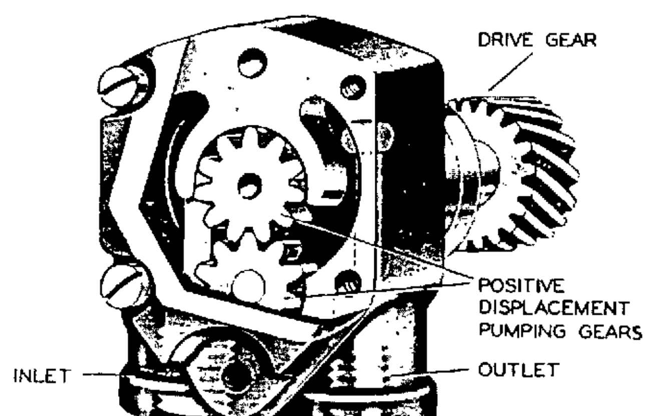


Figure 81—Fuel Supply Pump

moval of the filter without completely dismantling the injection pump would invariably prove harmful because any deposits around the filter could be dislodged and trapped in the lubrication oil passage.

PSB injection pumps use SGB type positive displacement gear type fuel supply pumps. **It is essential that in an installation of this type a permanent bleed or spring-loaded overflow valve be used to allow fuel circulation and prevent damage to the low-pressure system.**

To accomplish manual priming the fuel system with this gear type of pump when no hand primer is provided, it is suggested that the fuel supply pump with its inlet and outlet lines in place be removed from the injection pump. Then by manually rotating the driven gear in the normal direction of rotation, the fuel system can be primed. The following illustration shows the use of the hand primer which is available to provide easy priming of the fuel system.

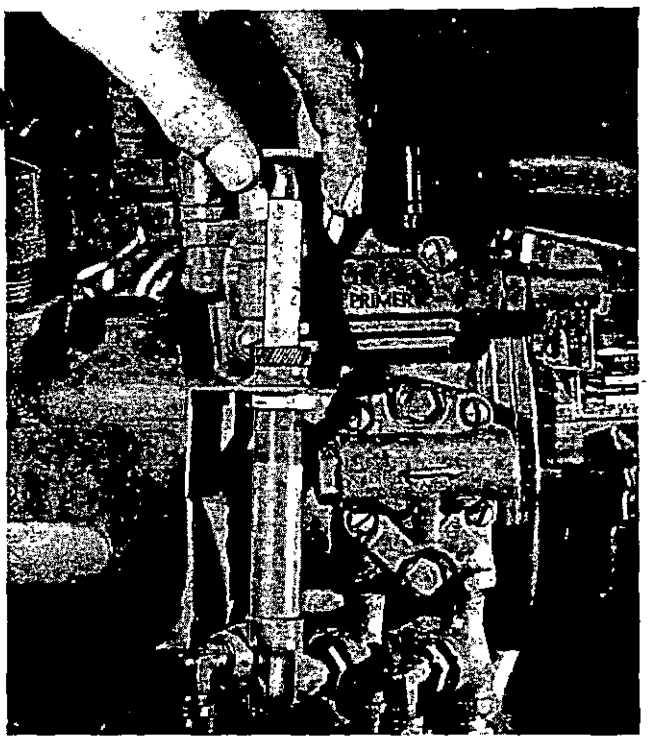


Figure 82—Hand Primer in Operation

Difficulties with the fuel supply system, often laid to the supply pump, may sometimes be traced to such causes as clogged fuel filters or air leaks into the fuel lines as a result of loose connections at the various line fittings. Dented, badly crimped or spongy supply lines cause high fuel flow restrictions. Defective overflow valves may also contribute to impaired engine operation.

The SGB type fuel supply pump used with PSB pumps can be checked for proper operational efficiency by inserting a gauge in the fuel inlet line to the injection pump gallery. The supply pump must be capable of producing a minimum gauge reading of 10 lbs. with the engine running.

In either case, by inserting a gauge between secondary and final stage filter, the clogged unit can easily be determined.

BOSCH PSB PUMP BY-PASS SYSTEM

It is essential in this installation that a permanent bleed or spring-loaded overflow valve be used to allow fuel circulation and prevent damage to the low-pressure system.

There is a safety by-pass in the system between the fuel supply pump and the secondary filter. When the secondary filter becomes inoperative due to being blocked by dirt and other foreign material it has filtered from the fuel, it will cause the fuel to recirculate through the primary filter. In the meantime, the engine will stop for lack of fuel.

The use of this safety by-pass and recirculating tube in the fuel supply system is for the protection of the fuel injection pump and its very accurately machined working parts. If the final stage filter were to break down and allow passage of fuel containing pieces or particles of dirt into the injection pump, the life of this latter equipment would be definitely shortened.

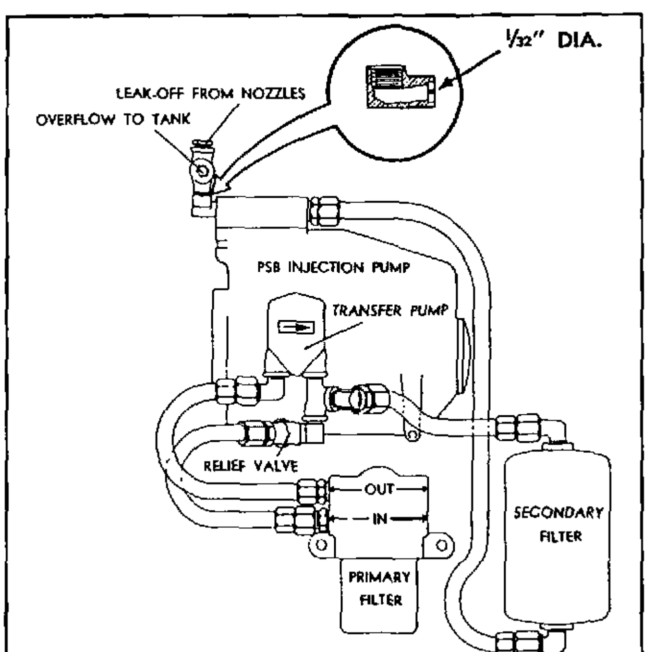


Figure 83—Bosch PSB Pump By-Pass System

FUEL INJECTION SYSTEM

INTERNAL SPRING GOVERNOR FOR USE WITH PSB PUMP

The governor, whose weight assembly is attached to the camshaft, is considered an integral part of the pump. This governor is of the variable speed, mechanical, centrifugal type. The governor action is accomplished thru flyweights acting against a movable sleeve which is backed up by springs loaded in the opposite direction.

The assembly consists of an aluminum housing (A), attached to the rear of the pump housing with cap screws, containing a shaft and weight assembly, sliding sleeve, control springs, fulcrum lever, operating shaft assembly and stop plate.

The shaft and weight assembly comprises a spider pressed onto an extension of the camshaft (B) and two movable weights (C) pinned on opposite sides of the spider. The weights swing freely about their pins.

The sliding sleeve (D) moves freely on the governor shaft and has a ball thrust bearing (E) on the front against which the fingers of the weights bear. There is a slot on each side of the sleeve to receive the pivot pins of the fulcrum lever; counterbores at the rear receive the two governor springs.

The fulcrum lever (F) has two pivot pins which slide in the slots on the sleeve. These pins may be located in an alternative set of holes to vary the closeness of governor regulation. The control rod extension (G) is connected to the top of the fulcrum lever and transmits the governor movement to the control sleeve in the hydraulic head. The stop plate (H) is screwed into the top of the housing; the smoke limit cam (I) at the top of the fulcrum lever bears against this in operation.

The two governor springs (J) (outer for low speed control, inner and outer for high speed control) are held into the sliding sleeve by an easily removable cover (K) which screws onto the back of the housing.

The operating shaft assembly extends thru the governor housing and is intended for connection to the engine control thru linkages.

Easily accessible on the outside are a stop plate and limiting screws for adjusting idling and full-load speeds. Inside the governor, the shaft is connected to a yoke (L) thru a torsion spring acting on an ear on the shaft and an ear on the fulcrum lever, these being loaded towards each other. The yoke is in turn pinned to the fulcrum lever and serves as a second fulcrum point.

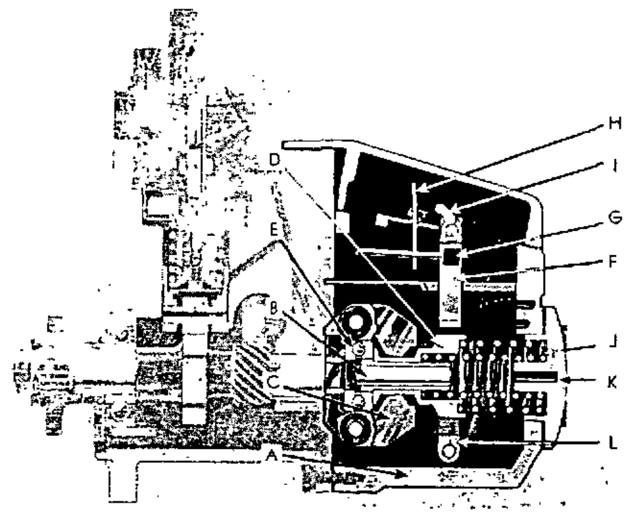


Figure 84—Internal Spring Governor—PSB Pump

ADJUSTING THE PSB GOVERNOR ON THE ENGINE

HIGH SPEED ADJUSTMENT

Changes in engine speeds should be made only when necessary to conform with speeds given in your engine manufacturers operating manual. The adjustments are originally set and sealed by the engine manufacturer for your protection.

Warm up the engine thoroughly before attempting to make any governor adjustments.

Illustrated below is a governor being adjusted for high idle speed. The speed control lever, has been moved *counterclockwise* toward full load

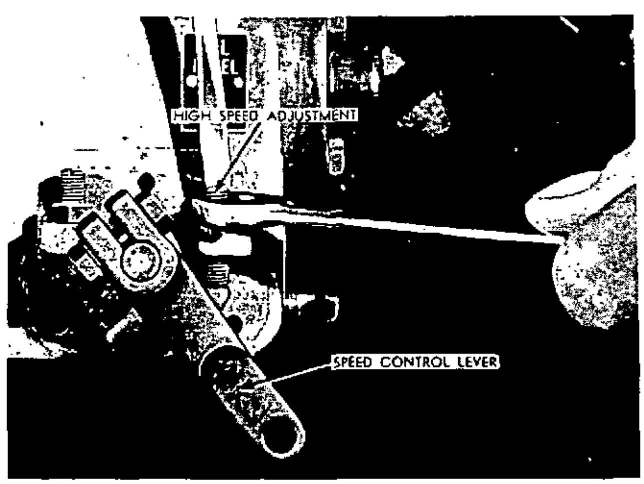


Figure 85—High Speed Adjustment

position until the stop plate on the lever shaft has contacted the high speed adjusting screw.

When the engine reaches its maximum speed, check by means of a tachometer whether this is the high idling speed as specified in your instruction manual. If the speed is too low, raise the high speed adjusting screw and, if the speed is too high, lower the screw. After the correct speed is obtained, secure the adjusting screw by means of the lock nut and re-check the speed, making sure that the stop plate on the governor operating lever shaft is in contact with the adjusting screw.

LOW IDLE SPEED ADJUSTMENT

Illustrated below is a governor being adjusted for low idle speed. Move the speed control lever *clockwise* in the direction of less speed until the engine reaches the correct idle speed. Hold in this position and turn the adjusting screw until its lower end touches the stop plate on the operating lever.

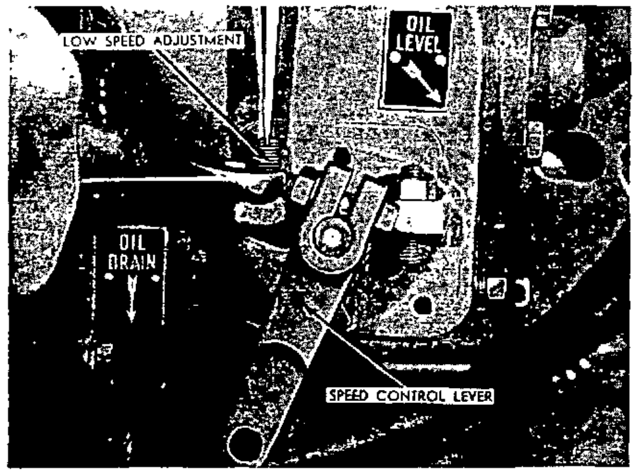


Figure 86—Low Speed Adjustment

> The nominal idling and maximum speeds controlled by the governor *cannot be varied to any great extent* because they depend entirely upon the characteristics of the spring combination contained in the governor unit.

ROOSA-MASTER FUEL INJECTION PUMP

GENERAL INFORMATION:

Roosa-Master Fuel Injection Pumps are a single cylinder, opposed plunger, inlet metering, distributor type and operate equally well in a vertical or horizontal position.

The pump is extremely simple, having no ball bearings, no lapped surfaces, no gears and no complicated springs. The basic model has about

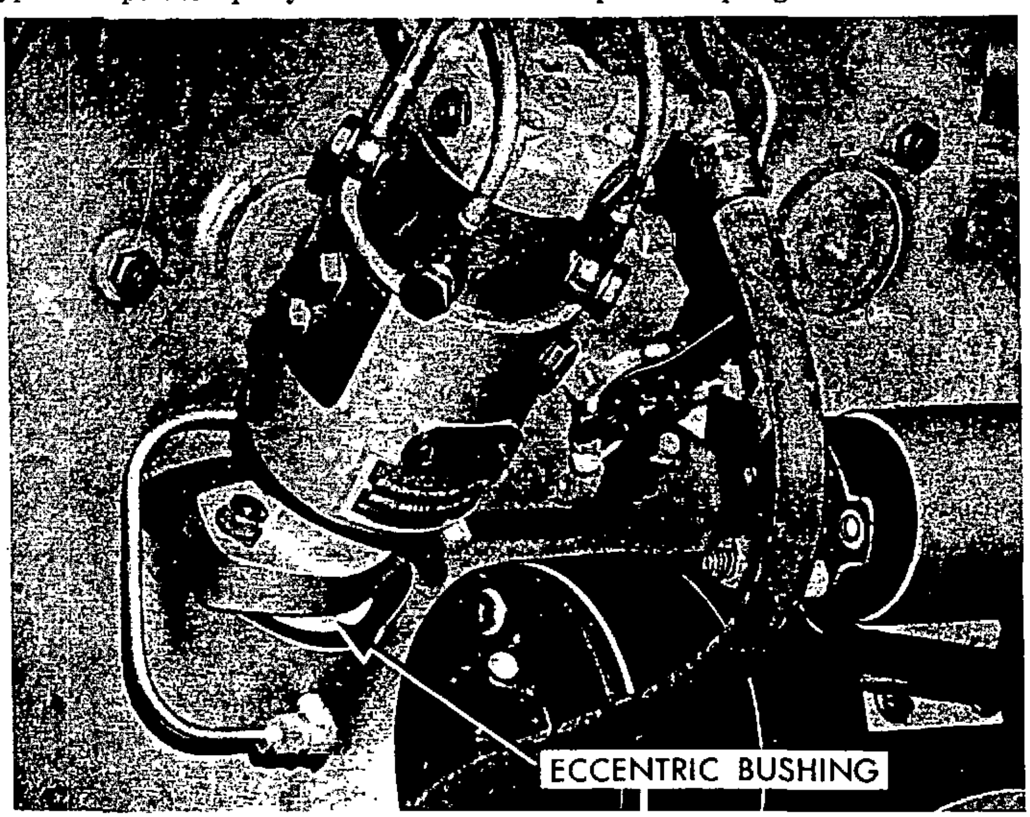


Figure 87
Roosa "D" Pump Installation

FUEL INJECTION SYSTEM

30 parts and only 3 main rotating members, which revolve on a common axis and include the drive shaft, distributor rotor and transfer pump.

The Roosa-Master Pump is self-lubricated as well as cooled by the filtered fuel oil flowing through the pump assembly and operates on either No. 1 or No. 2 Diesel fuel oil. The pump and its accessories are enclosed in an oil-tight compartment in which slight pressure is maintained, thus preventing the entrance of dust, water or any foreign matter.

The transfer pump supplies an excess of fuel, which is returned to the fuel tank along with any air that is trapped in the pump body. The design of the pump makes engine reversal impossible, since there would be no transfer pump pressure.

There are the following two types of Roosa-Master Injection Pumps:

Model "D" Pumps — Having integral mechanical governors which are normally used on all 4 cylinder Continental Diesels.

Model "E" Pumps — Are controlled by external governors independent of the pump to meet special conditions.

All 4 cylinder Continental Diesels drive the Roosa-Master Pumps in a vertical position from the timing gears at one-half engine speed.

Model "D" Pumps have the one piece shaft adapter drive or the two-piece shaft with tang drive and eccentric bushing — which provides micrometer adjustment of backlash.

The Roosa-Master Pumps have the following special equipment available to further improve operation and control.

Automatic Advance — Provides variable injection timing to aid cold starting and performance during accelerating loads.

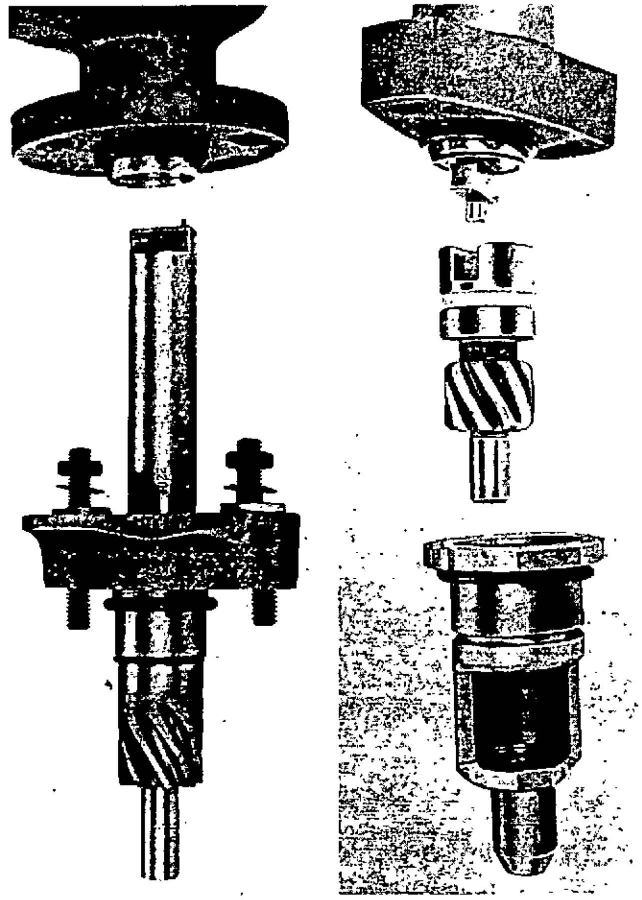


Figure 88

One Piece Drive *Two Piece Drive*

Electric Fuel Shut-Off — Can be furnished with 12- 24 or 32 volt electric solenoid fuel shut-off on all "D" pumps. They are furnished to be "Energized to Shut-off" or "Energized to Run".

Speed Droop Device — Provides an external adjustment screw at the rear of the pump housing to control the governor spring sensitivity and improve close regulation.

The above accessories are further explained in detail later.

COMPONENTS AND FUNCTIONS

The Model "D" pump with integral mechanical governor consists of the following eight main parts, which function as follows and are shown below:

(1) **DRIVE SHAFT** which is retained in pump drive assembly, engages the distributor rotor (2) and revolves this rotor in the hydraulic head (6).

(2) **DISTRIBUTOR ROTOR** — the major rotating assembly; contains the drilled fuel passages and at the drive end has a diametric bore containing two plungers (4). Its other end drives the rotor of the transfer pump.

(3) **TRANSFER PUMP** — is the 4-vane positive displacement type which supplies fuel to the metering device at an even and predetermined pressure.

(4) **PUMP PLUNGERS** — The plungers are closely fitted in the bore and are actuated toward each other simultaneously by an internal cam ring (5) through rollers and shoes which are carried in guide slots in the flanged end of the rotor.

FUEL INJECTION SYSTEM

(5) INTERNAL CAM RING — is a stationary ring located in the housing. As the *entire rotor (incorporating the plungers)* turns in the hydraulic head (6) opposing lobes in this cam ring force the plungers inward and causes the fuel between the rollers to be ejected from the pump.

(6) HYDRAULIC HEAD—contains the bore in which the rotor revolves; the metering valve (12) bore and the outlet ports for connecting the nozzle lines. The rotor shaft is very closely fitted to its central bore and **must remain a mated assembly.**

(7) END PLATE — This assembly houses the fuel inlet connection, fuel strainer, the transfer pump pressure regulating valve, and acts as a cover for the transfer pump.

(8) GOVERNOR — of the flyweight or mechanical type — is built in the pump assembly and is capable of close speed regulation. The centrifugal action of the weights in their retainer (9) is transmitted through a sleeve (10) to the governor arm (11) and through a positive linkage to the metering valve (12).

The metering valve (12) is positively closed to shut off fuel through a solid linkage by the independently operated shut-off lever (13).

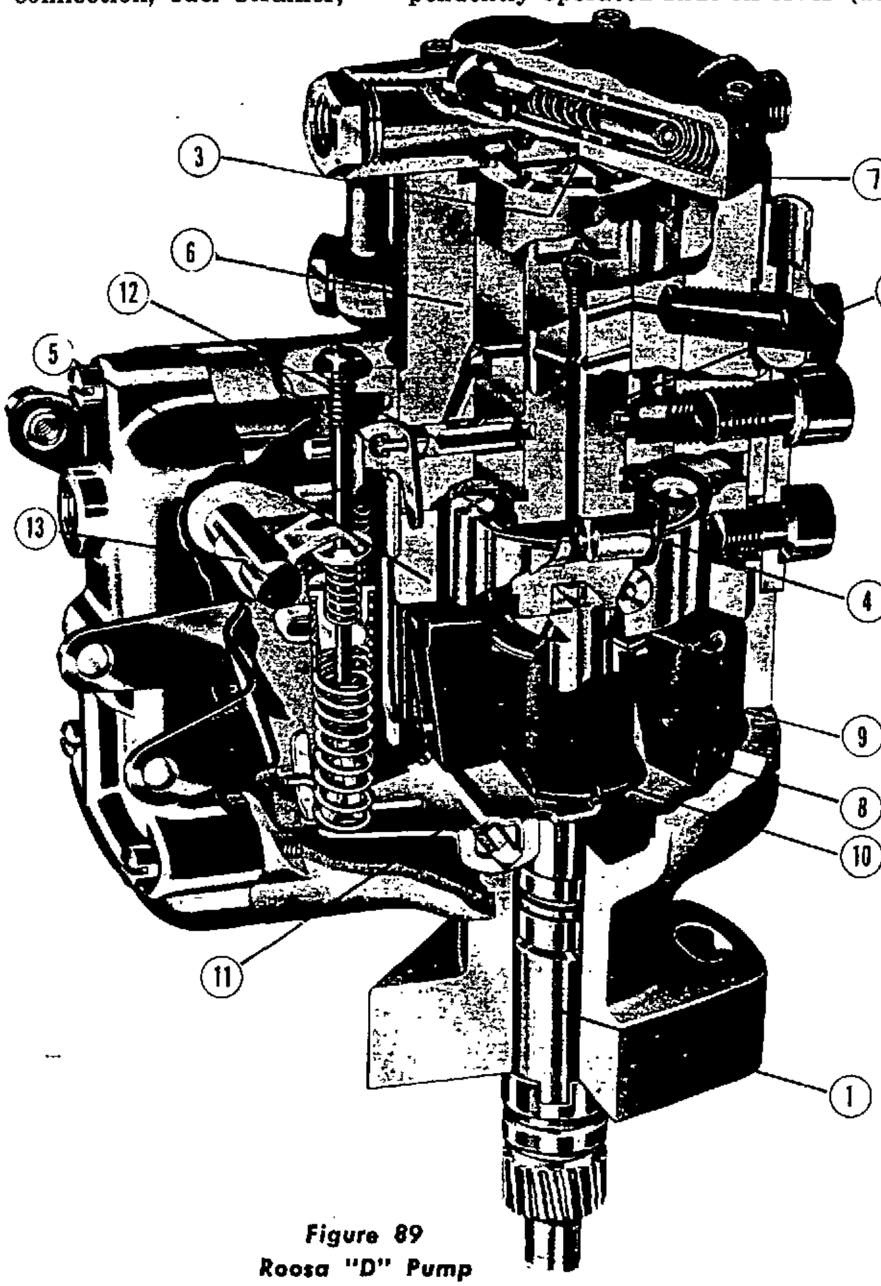


Figure 89
Roosa "D" Pump

FUEL INJECTION SYSTEM

FUEL FLOW

Fuel is drawn from the supply tank into the pump through the inlet strainer (1) by the transfer pump (2).

The transfer pump output greatly exceeds the injection requirements so a large percentage of fuel is by-passed through the regulating valve (3) back to the inlet side.

The transfer pump pressure then forces fuel through the axial passage (4) into an annular groove (5), milled around the rotor shank, and through the metering valve (6) in a quantity determined by engine demands.

As the rotor revolves, one of its charging ports (7) comes into registry with passage (8), permitting the fuel to enter the axial passage to the pumping cylinder (9). The in-flowing fuel forces the plungers (10) outward, a distance proportionate to the quantity to be injected on the following stroke.

If only a small amount of fuel is admitted into the pumping cylinder, as at idling, the plungers move out very little. As additional fuel is admitted, the plunger stroke increases to the maximum quantity as limited by the leaf spring arrangement (11).

At this point (charging) of the cycle, the rollers (12) are in the "valley" or relieved part of the cam ring, between lobes. The fuel is trapped in the cylinder for a very slight interval after charging is complete. This is caused by the fact that the charging port has passed out of registry with passage (8) and the rotor discharge port (13) has not yet come into registry with an outlet port (14) in the hydraulic head.

Further rotation of the rotor brings its discharge port into registry with an outlet port at which point the rollers simultaneously contact the opposing cam lobes and the plungers are forced towards each other. The fuel trapped between the plungers is forced from the pump through one of the outlet ports to a high pressure injection line.

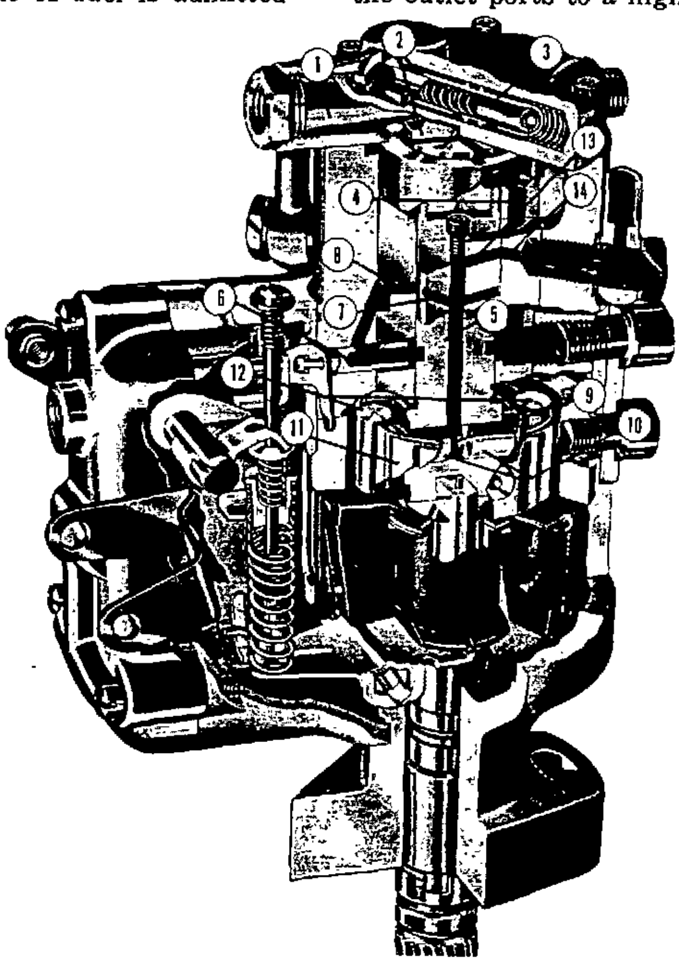


Figure 90
Roosa Fuel Flow Diagram

CENTRIFUGAL GOVERNOR

In the centrifugal governor, shown below, the movement of the flyweights against the governor thrust sleeve rotates the metering valve. This rotation varies the registry of the metering valve slot with the passage to the rotor, thus controlling the flow of fuel to the engine.

This type of governor derives its energy from the centrifugal action of the flyweights pivoting on their outer edge in the retainer. Centrifugal force tips them outward, moving the governor thrust sleeve against the governor arm, which pivots on the knife edge of the pivot shaft, and is connected through a simple positive linkage to the metering valve.

The force on the governor arm caused by the centrifugal action of the flyweights is balanced by the compression type governor spring, which is manually controlled by the throttle shaft linkage in regulating engine speed.

A light idle spring is provided for more sensitive regulation at the low speed range. The limits of throttle travel are set by adjusting screws for proper idling and high speed positions.

A light tension spring allows the stopping mechanism to close the metering valve without overcoming the governor spring force. Only a very light force is required to rotate the metering valve to the closed position.

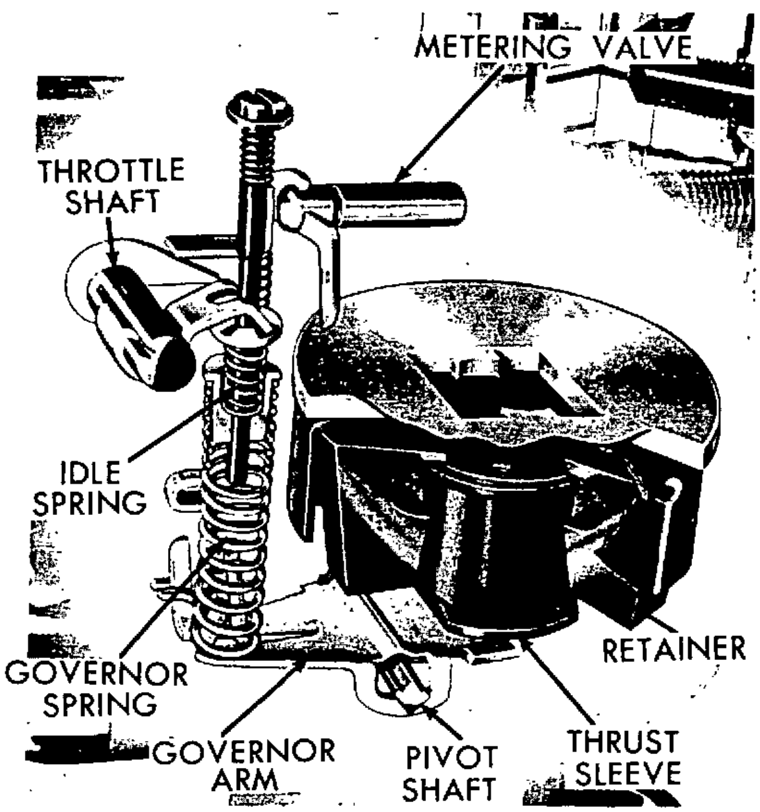


Figure 91
Roosa Centrifugal Governor

GOVERNOR AND THROTTLE ADJUSTMENTS

There are no internal adjustments of the governor. Since the centrifugal force of the flyweights increases with engine speed, the desired governed speed is obtained by balancing this force with the correct governor spring combination. For this reason, close governor regulation can only be obtained within ± 100 RPM of the existing governed speed. If changes greater than this are required — new, correct springs must be used.

The idling (7) and high speed (2) screws shown on Fig. 92 provide the idling and governed speed adjustments.

The engine speed is increased to the governed speed by moving the throttle lever in a clockwise direction. The throttle lever is held in place by the 2 Allen head screws and may be moved to any position desired.

FUEL INJECTION SYSTEM

1. Fuel inlet
2. High Speed Adj.
3. Torque Screw
4. Automatic Advance
5. Nozzle line connection
6. Throttle lever
7. Idling Screw
8. Fuel Oil Return to Tank
9. Stop Lever

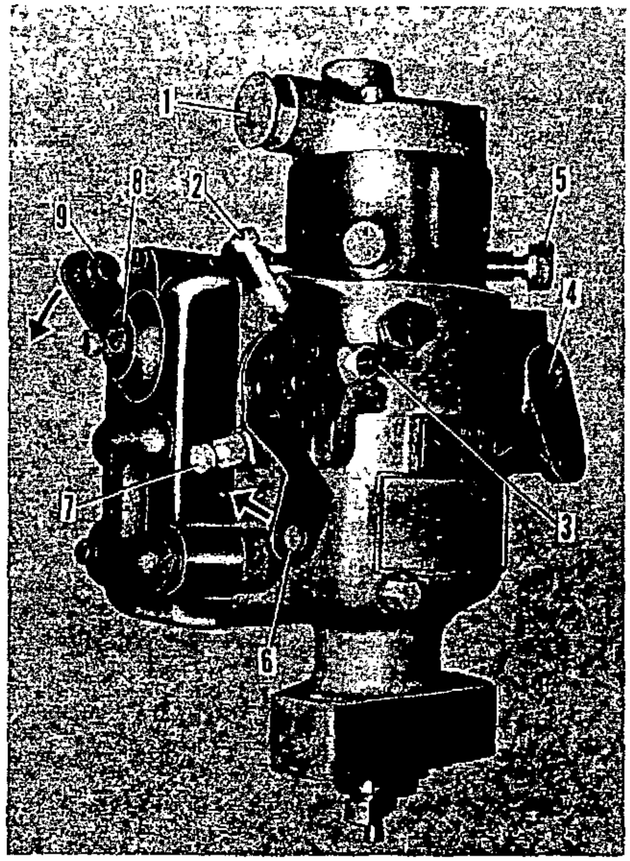


Figure 92
Roosa "D" Pump

TORQUE CONTROL

Torque is commonly defined as the "lugging ability" of an engine. The engine can burn more fuel at the lower speeds while still maintaining the combustion chamber efficiency it had at higher speed — which would result in higher torque in the intermediate speed range.

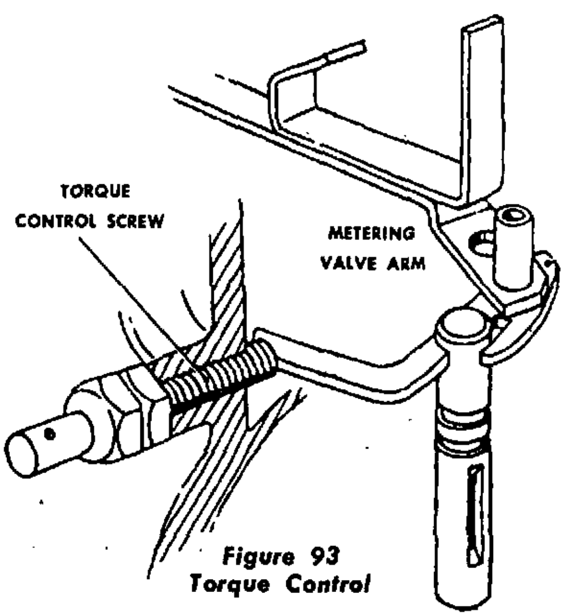


Figure 93
Torque Control

For example, consider a crawler tractor being used as a bulldozer to level land on a construction job. The operator, being busy with clutches and blade controls, sets the engine throttle for the desired travel speed. As the blade picks up its load, the demand on the engine increases and engine speed slows. If the torque tends to increase at reduced speed due to a greater amount of fuel being injected into the cylinder, then the engine can handle the greater load easily without the operator "jockeying" the throttle. This desirable feature is called "torque back-up" and is incorporated in the Roosa Master Pump.

This adjustment is made during the factory dynamometer power test by carefully adjusting the torque control screw so that the power output follows the engine curve and provides the torque back-up desired for the application.

The torque screw contacts the metering valve arm and rotates the metering valve which changes the quantity of fuel delivery.

Turning the torque-screw in, or clockwise (Fig. 92) will reduce the fuel; turning out or counter-clockwise, will increase the fuel. The adjustment is factory-sealed and should not be tampered with except in emergency field work to compensate for fuel viscosity variations which would be indicated by low power or too heavy exhaust smoke. Any adjustments in the field should be made in increments of 1/16 turns as it is very sensitive.

CAUTION: In general, torque adjustments should be made only during a dynamometer or bench test so actual fuel delivery can be determined.

AUTOMATIC ADVANCE

The Roosa Master design permits the use of a simple hydraulic servo-mechanism, powered by oil from the transfer pump, to rotate the normally stationary cam ring to advance injection timing. Transfer pump pressure, increasing with speed, operates the servo-advance piston against spring pressure as required along a predetermined timing curve.

OPERATION

Controlled movement of the cam in the pump housing is induced and limited by the action of the hydraulic and spring loaded pistons of the automatic advance against the cam advance screw.

During cranking, the cam is in the retard position, since the force of the spring is greater than transfer pump pressure. As the engine RPM and transfer pump pressure increases, oil entering the advance housing behind the hydraulic piston moves the cam. Any amount of advance may be provided up to 10 pump degrees. A ball-check valve is provided to offset the normal tendency of the cam to return to the retard position during injection.

There are no adjustments required on this unit, other than correct assembly of parts.

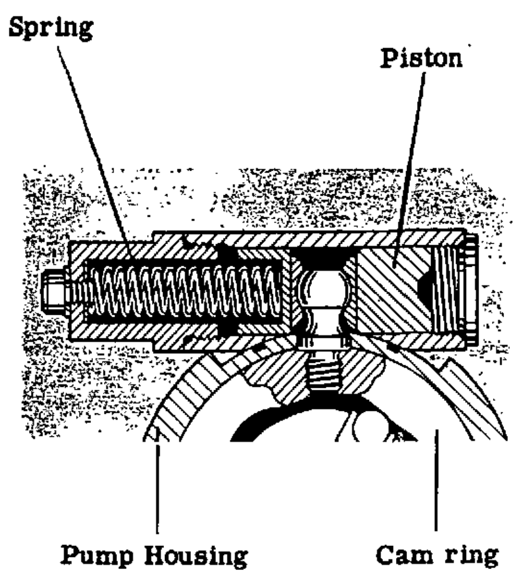


Figure 94
Roosa Automatic Advance

ELECTRICAL SHUT-OFF

The Electrical Shut-Off may be furnished for "energized to run" operation or "energized to shut-off". This device is housed within the governor control cover; the external dimensions of the pump do not change. Solenoids are available for 12 - 24 or 32-volt operation.

CAUTION — Use Solenoid for correct operating voltage.

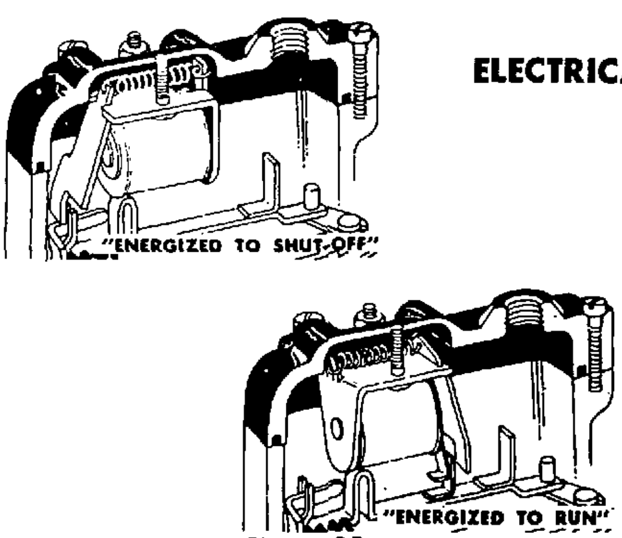


Figure 95
Solenoid Fuel Shut-Off

FUEL INJECTION SYSTEM

OPERATION

Energized to run: De-energizing the coil allows the shut-down coil spring to open the shut-down arm. The lower end of the arm moves the governor linkage hook, rotating the metering valve to the closed position cutting off the fuel. Generally we use "energized to run" in order to insure more protection.

Energized to shut-off: Energizing the coil overcomes the force of the shut-down coil spring, pulling the shut-down arm in and causing the tab on its lower end to contact the governor linkage hook. This moves the linkage hook against the governor linkage spring tension, rotating the metering valve to its closed position and cutting off the fuel.

VARIABLE SPEED DROOP DEVICE

In generator set applications an external adjustment screw at the rear of the pump housing controls regulation by controlling governor spring sensitivity. This device decreases or increases the effective length of the governor control spring.

OPERATION

Turning the adjustment screw clockwise decreases the speed droop by shortening the effective length of the control spring. This increases the spring rate and lessens governor sensitivity. Turning the adjustment screw counterclockwise has the opposite effect.

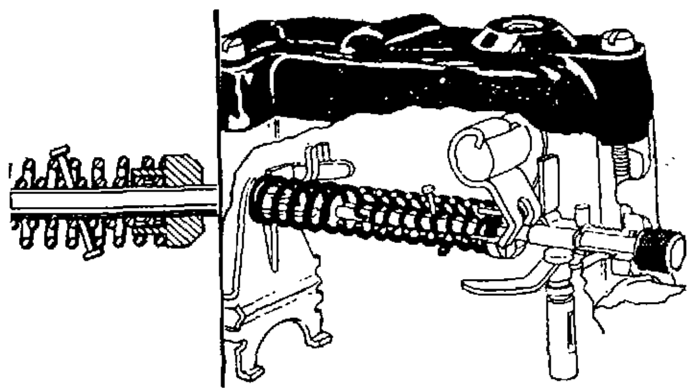


Figure 96
Speed Droop Device

HAND PRIMER PUMP

The hand primer pump is used primarily for filling the fuel supply system completely after it has been opened for changing filters or servicing the pump. Its secondary function is to prevent fuel from draining out of the system while the engine is not in operation. It is always mounted on the inlet side of the system between the primary and the secondary filters.

OPERATION

Operation of the plunger knob with the connection at the pump inlet fitting loosened, purges air from the system. The arrangement of check valves in the primer body prevents fuel from draining out of the system when not in operation.

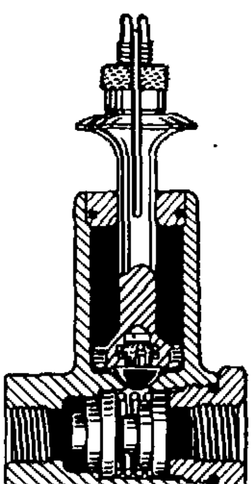


Figure 97
Roosa Hand Primer

CAUTION: Do not mount primer on pressure side under any circumstances.

NOZZLE ASSEMBLIES

Nozzle holder assemblies are located in the cylinder head of a Diesel engine, one per cylinder,

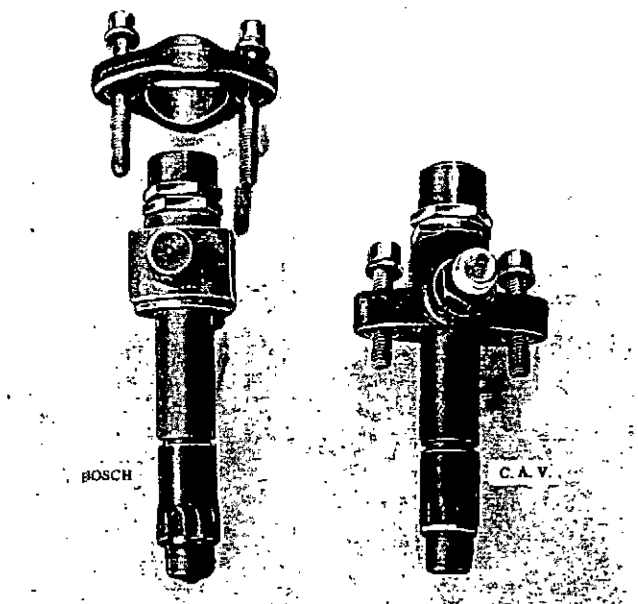


Figure 98
Bosch and C. A. V. Nozzles

very much as spark plugs in a gasoline engine. The function of these assemblies is to receive the metered quantity of fuel from the injection pump, atomize it mechanically, and direct it into the engine combustion chamber in a definite spray pattern and in such manner as to produce the most efficient engine performance.

The unnecessary removal of nozzle and holder assemblies is inadvisable for a number of reasons. Nozzle and holder assemblies should be allowed to operate undisturbed until such time as faulty engine performance is encountered and is directly traceable to these assemblies. Servicing then should be performed only by competent personnel, with proper equipment.

NOZZLE HOLDERS

The nozzle holder is used to hold the nozzle in its correct position in the cylinder head and provide a means of conducting fuel oil to the nozzle. The holder also contains the spring and necessary means of pressure adjustment to provide proper action of the nozzle valve.

Two types of nozzle holders are used, American Bosch and C.A.V. The American Bosch holder is secured to the cylinder head by two round head slotted cap screws and a hold-down yoke.

The CAV holder is secured to the cylinder head by (2) round head slotted cap screws.

The component parts of the nozzle holder, as shown in Fig. 99, consist of a steel holder body with drilled passages for conducting the fuel from the inlet connection to the nozzle.

The lower end of the body is provided with an accurately ground and lapped surface which makes a leak-proof and pressure-tight seal with the corresponding lapped surface at the upper end of the nozzle.

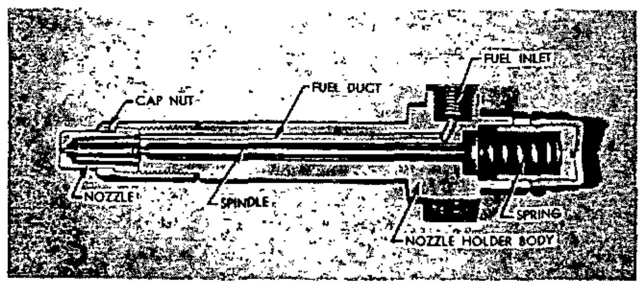


Figure 99
Sectional View of Nozzle and Nozzle Holder

Nozzle opening pressure for Continental Diesels is 1750-1850 pounds. This is adjustable by turning screw under the cap.

Operation of the nozzle and holder assembly is simple and positive. The metered quantity of fuel from the injection pump enters the holder through the inlet connection and passes through ducts to the pressure chamber just above the nozzle valve.

At the instant the pressure of fuel acting on the differential area of the valve exceeds the predetermined spring load, it will lift the valve from its seat and fuel will flow from the nozzle until delivery from the pump ceases. Then, a positive, instantaneous cut-off of fuel occurs as the valve is snapped to its seat by the spring force. This action eliminates the possibility of after dripping or dribbling.

A certain amount of seepage of fuel between

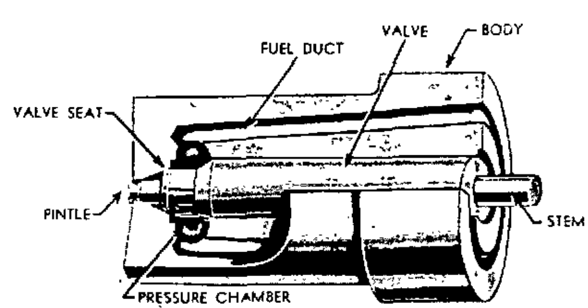


Figure 100
Section of Pintle Type Nozzle

FUEL INJECTION SYSTEM

the lapped guide surfaces of the nozzle valve and its body is necessary for lubrication. This leakage accumulates around the spindle and in the spring compartment, from which it drains back to the tank through the leak-off connections.

PINTLE TYPE NOZZLES

Continental Diesels use Pintle type nozzles as shown in figure 100.

The nozzle valve has an extension at its lower end called the Pintle, which protrudes through the close fitting hole in the nozzle body. This causes the injected fuel to pass through an annular orifice or pressure chamber, which produces a cone-shaped spray having a solid core. The nominal included angle of the spray is 12 degrees.

The projection of the pintle through the orifice induces a self-cleaning effect and increases the service life without attention.

C.A.V. and American Bosch nozzles may be used on either nozzle holder.

NOZZLE SERVICING AND TESTING

Nozzle trouble is caused by dirt, water and fuel impurities which corrode or clog the small orifice and cause sticking of the needle valve and damage to the lapped surfaces — again emphasizing the need of clean fuel to the nozzles.

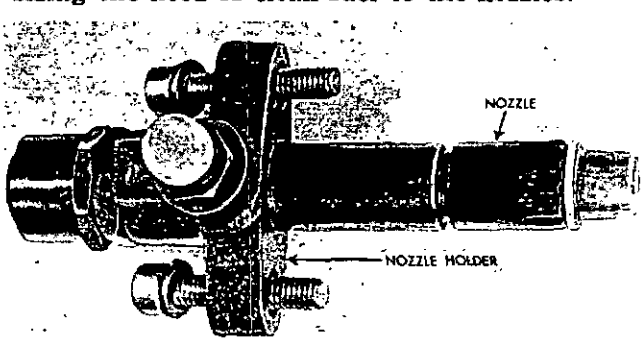


Figure 101
Side View of Nozzle Holder and Nozzle

Misfiring of a cylinder is usually due to a faulty nozzle — which can be located by loosening the high pressure line fitting, on each nozzle in turn, which allows the fuel to escape and not enter the cylinder. **The nozzle least affecting the engine performance is the one with the faulty nozzle.** Use two wrenches: one to hold the fitting in the nozzle holder and one to loosen the nut, since the assembly of the fitting must not be disturbed.

REMOVAL

Clean the side of the engine before disconnecting the injection pipes. Use clean fuel to flush the injection pipe fittings so that there is no possibility of dirt entering the injection system. Proceed as follows to remove the injection nozzles:

1. Disconnect the fuel injection lines from the pump and nozzles. As each pipe is removed plug the pump opening and cap the nozzle.

Important: Both the plugs and caps must be clean. Tape the ends of the injection tube.

Note: Plastic plugs and caps are recommended for keeping nozzle and pump openings clean. (Kit No. HD260T-195.)

Figure 102
Removing Nozzle Holder Assembly

2. Remove No. 1 nozzle holder assembly first. Remove the two screws securing it to the cylinder head. Remove the nuts from the leak-off fitting on No. 1 and No. 2 nozzles. Rotate the No. 1 nozzle clockwise and remove the leak-off tube. Remove the nozzle assembly.

> **CAUTION: Do not strike nozzle tips against hard surface or damage will result.**

3. Remove remaining nozzles in the same manner.

TESTING

Nozzles and holders should not be disassembled unless testing shows that cleaning or other service is needed. Adjustment of the opening pressure may be made without removing the nozzle from the holder by adjusting the screw shown in Figure 99.

Use a special hydraulic nozzle tester, bolted to a bench and include a small fuel oil supply tank with filter so that only clean oil enters the nozzle. (Fig. 103.)

A high pressure injection line is used to connect the outlet of the nozzle tester to the nozzle.

> **CAUTION: Keep hands away from nozzle spray: the high velocity may puncture the skin and cause blood poisoning.**
>
> **The nozzle test gage should not be subjected to shock pressures so keep the gage valve open only when reading pressure.**

1. Close gage valve and work pump handle several sharp strokes to dislodge any carbon or dirt particles in nozzle cavities.

2. Open gage valve, work pump slowly and observe opening pressure. If not between 1750-1850 pounds/sq. inch, remove holder cap, loosen locknut and turn adjusting screw — IN to raise or OUT to lower the opening pressure. (Fig. 103). (New springs should be set 1900-1950 pounds/sq. inch to allow for set.) It is desirable to have all nozzles set as nearly alike as possible in the same engine.

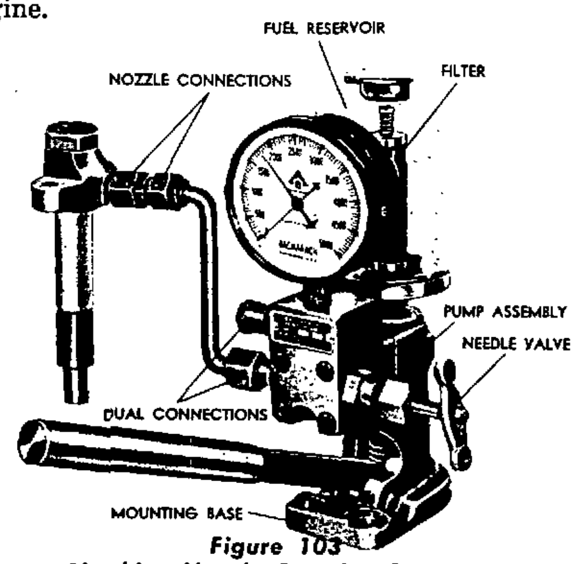


Figure 103
Checking Nozzle Opening Pressure

3. Maintain a pressure of 1450-1500 pounds and watch for dribble from spray orifice, indicating a bad seat, or "weeping" around cap nut, indicating a leak between the holder and valve body lapped surfaces.

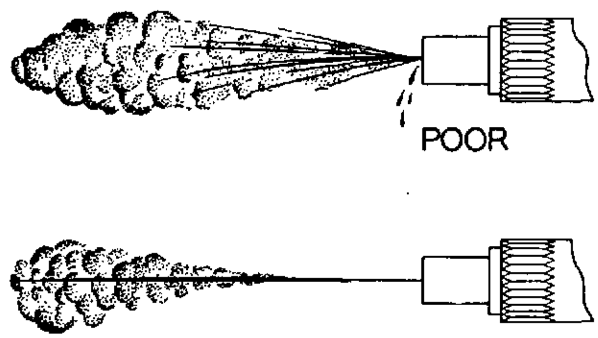


Figure 104
Nozzle Spray Patterns

4. Close gage valve and observe spray characteristics while working the tester about 100 strokes per minute. "Flags", heavy ends, deflected core, or spray pattern that is not symmetrical are undesirable and require repair or replacement of faulty parts. A target 12" from the nozzle end, with bullseye level with pintle — will show any deflection of spray pattern.

DISASSEMBLY AND CLEANING NOZZLE

1. Clamp holder in a soft-jowed vise, remove nozzle cap nut and remove nozzle assembly. If the valve cannot be pulled from the body with the fingers, heat in water or soak in solvent until it can be easily removed.

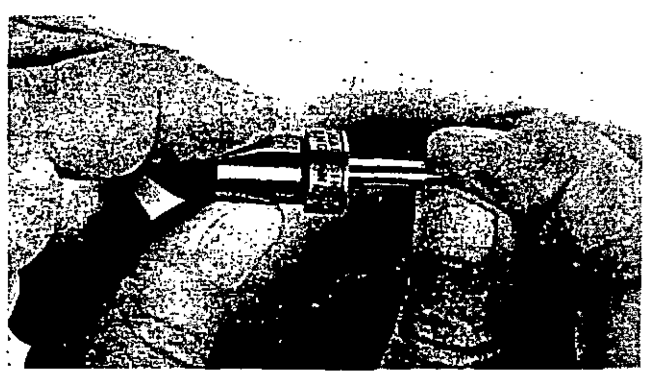


Figure 105
Removing the Nozzle Valve From Nozzle Body

> **CAUTION: Do not permit the polished nozzle surfaces to contact any hard substance.**

EL INJECTION SYSTEM

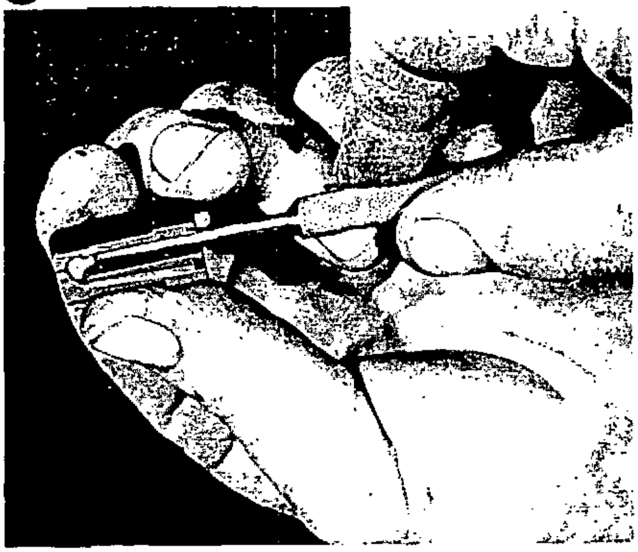


Figure 106
Cleaning Nozzle Cavity

2. The nozzle valve can be cleaned with mutton tallow used on a soft cloth or a felt pad. The valve may be held by its stem in a revolving chuck during this operation. A piece of soft wood well soaked in oil, or a brass wire brush, will be help- in removing carbon from the valve.

Hard or sharp tools, emery cloth, crocus cloth, grinding compounds, or abrasives of any kind must never be used in the cleaning of nozzles.

3. The inside of the nozzle body can be cleaned with brass scrapers included in the cleaning kit or if these tools are not available, by forming a piece of soft wood, soaked in oil, with a point corresponding to the nozzle valve seat angle. Clean the nozzles with a wood splinter. Figures 106 and 107.

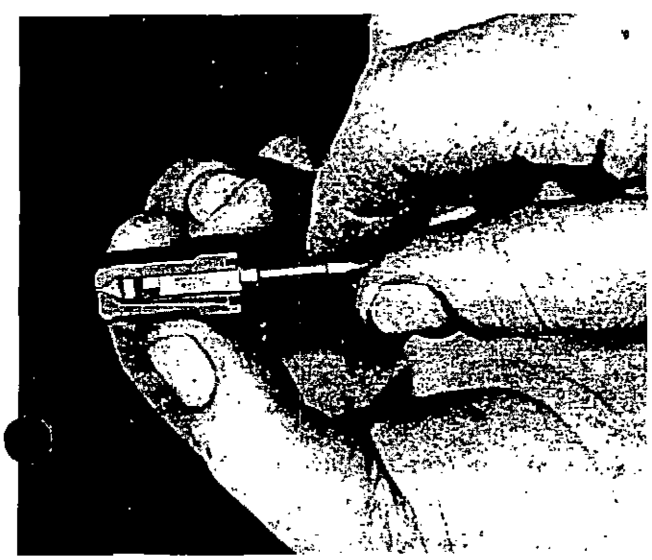


Figure 107
Cleaning Nozzle Orifice

4. Clean the outer surfaces (except the area which contacts the holder) of the nozzle body with a fine brass wire brush. Do not use any hard tool to scrape carbon from the area around the orifice.

5. Clean the lapped surface of the nozzle body on a lapping plate as follows: (See Fig. 108).

Figure 108
Cleaning the Lapped Surface of the Nozzle Holder

DO NOT use abrasives of any kind!

a. Clean the lapping plate with a clean cloth.

b. Coat the lapping plate surface with clean mutton tallow. Be sure the entire surface is coated.

c. Wipe the nozzle body with a clean soft cloth and coat the lapped surface with clean mutton tallow.

d. Place the lapped surface of the nozzle body on the lapping plate as shown in Fig. 108, and move in a circular motion being careful to hold even pressure on the nozzle body so that the entire surface will make contact. This cleaning operation will remove carbon or discoloration and leave a mirror finish. Scratches, nicks or pitting cannot be removed and may cause leakage.

6. Clean the exterior of the nozzle holder, with the nozzle cap nut in place to protect the lapped surface. (Fig. 108A.)

7. Clean the lapped surface of the nozzle by the same procedure used to clean the lapped surface of the nozzle body.

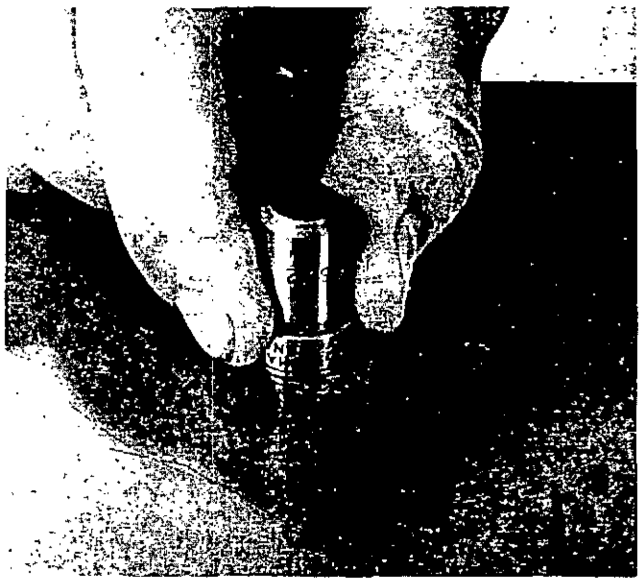


Figure 108A
Cleaning the Lapped Surface of the Nozzle Body

8. Clean the nozzle cap nut, being sure that all carbon is removed from the flange contacting the nozzle body.

9. Inspect the spindle and spring for damage or wear. If any pitting or corrosion is found on the spring, it must be discarded. Figure 109.

Figure 109
Removing Spring and Spindle From the Nozzle Holder

REASSEMBLY

1. Flush the holder, being sure all passages are clean. Clamp the holder in a vise as shown in Fig. 110.

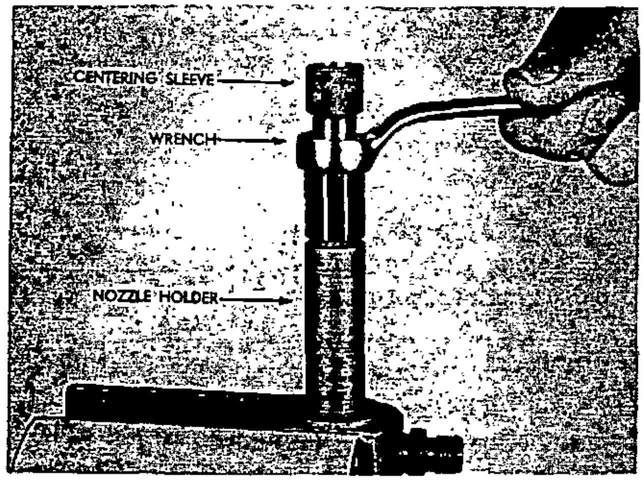


Figure 110
Nozzle Assembly, Using Centering Sleeve

Important: Each part of the nozzle assembly must be flushed with clean diesel fuel before it is assembled; cleanliness is of utmost importance.

> **CAUTION: Do not touch any polished (lapped) surface with the fingers after flushing. Moisture from the fingers is very corrosive.**

2. Flush the valve and nozzle body and test for freeness of valve in body. If both parts are clean the valve should slide in the body from its own weight if it does not reclean both parts.

3. Place the nozzle in the nozzle cap nut and install on the holder. While the nut is still loose place the nozzle centering sleeve (Fig. 110) in position and use a box end wrench to partially tighten the nozzle cap nut. Finish tightening the nut with a deep socket and torque wrench. Torque to 60 to 65 ft. lbs. Be very careful not to damage the pintle.

4. Place the spindle in position, being sure it is properly sealed on the valve stem. Hold the holder with the nozzle end down, place the spring in position and screw the spring cap nut into place finger tight. Place the lock nut gasket in position and install the lock nut. Do not tighten.

5. Adjust nozzle for opening pressure; check for spray pattern and leaking. (Fig. 104.)

FUEL INJECTION SYSTEM

INSTALLING NOZZLE

1. Clean carbon and dirt from counterbore and gasket seat in the cylinder head before installing nozzle holder assembly — as small carbon particles on seating surfaces will cock assembly and permit blow-by. A special reaming tool or round piece of wood or brass, properly shaped may be used.

2. Crank engine with starting motor to blow out particles.

3. Place a new soft copper washer over the nozzle body and carefully insert nozzle so that the tip does not strike the wall.

IMPORTANT

4. Tighten hold-down screws *evenly* so as not to bind or cock and tighten to 14-16 ft. lbs. torque.

5. Reassemble high-pressure and leak-off connections and tighten, always holding the fitting with a wrench to keep it from turning while tightening the nut.

NOZZLE MAINTENANCE PRECAUTIONS:

1 — Do not remove nozzles if operating satisfactorily except at unit overhaul periods.

2 — Do not change nozzle opening pressures from manufacturer's standard.

3 — Use clean, filtered #2 Diesel Fuel Oil.

4 — Operate engine within 165°-185° F range and avoid overheating due to faulty cooling system or excessive loads.

FUEL FILTERS

Clean Fuel is a *Must* in Diesel operation and the fuel oil passes through two and in some installations three stages of filtration before entering the fuel injection pump. Extreme conditions may require even a parallel bank arrangement of filters to provide longer filter change periods — when clean fuel is not available.

Continental Diesels equipped with Roosa-Master injection pumps have both the primary and secondary filters installed between the fuel tank and the transfer pump inlet — so that all the filters are on the suction side.

Engines equipped with Bosch injection systems have the primary filter installed between the fuel tank and fuel supply pump inlet and the secondary filter in the fuel line between the supply pump outlet and the injection pump inlet.

PRIMARY FILTERS

Two types of primary filters are used which include the metal "Edge-Type" filter having .002 spacing and the cotton-waste type—both of which remove water and the solid particles from the fuel oil.

The metal-edge filter has a drain plug, which should be drained daily and after 50 hours operation, the filter should be disassembled and thoroughly cleaned in fuel oil or solvent.

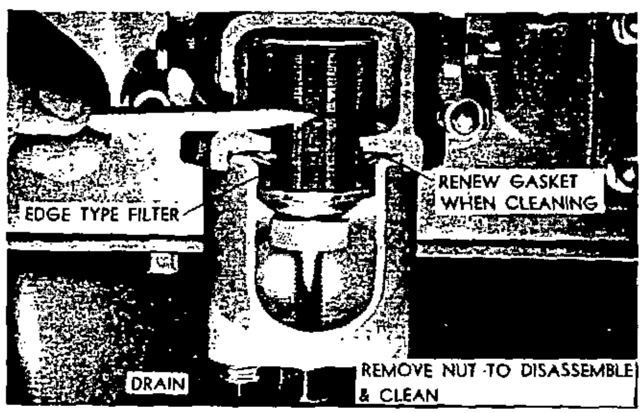


Figure 111A
Edge Type Primary Filter

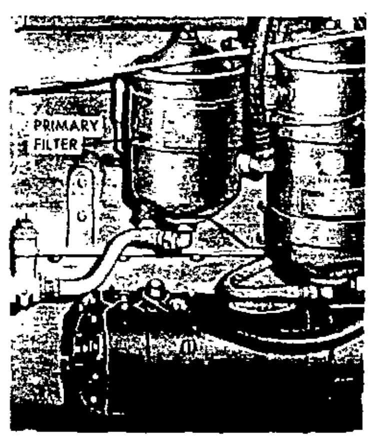


Figure 111B
Replaceable Primary Filter

When reassembling the filters, use a new gasket to prevent air leaks into the fuel system as filters located on the suction side of the pump have leaks that are very hard to locate.

Suction leaks may be detected by pressurizing the lines and noting leaks or coating all connections with aniline dye and noting any coloring of the return line flow to the tank. Another method is to install a vacuum gauge in a tee at the pump inlet and with the engine running, close the fuel supply valve at the tank (tight) and note over 15″ vacuum — which should hold; any sudden drop indicates a bad suction leak, which should be checked until found.

The cotton-waste type primary filter is very effective in filtering water, gums and solid particles. This filter has a replaceable element, which is serviced by removing the top and renewing the gasket with reassembling.

SECONDARY FILTERS

Two types of secondary filters are used: one which is sealed and non-cleanable and the other has a replaceable element or cartridge. Both are capable of removing particles of 2 microns (.000078″).

Figure 111C
Sealed Secondary Fuel Filter

The frequency of secondary filter replacements is dependent upon operating conditions and the quality and cleanliness of the fuel. Clogging or excessive deposits of contaminents on the filter element restricts the fuel flow and necessitates periodic replacement.

The secondary filter should normally be serviced every 500 hours or when the following restriction check indicates the following:

Roosa Injection Pump — Vacuum gauge located in tee at pump *inlet* is below 10″.

Bosch Injection Pump — Pressure gauge located in tee at pump *inlet* is below 10 psi.

Various types and sizes of filters are available for special conditions. Only filters recommended by Continental should be used on their engines to insure that they are adequate and also capable of withstanding the required suction or pressures without damage to the filter element.

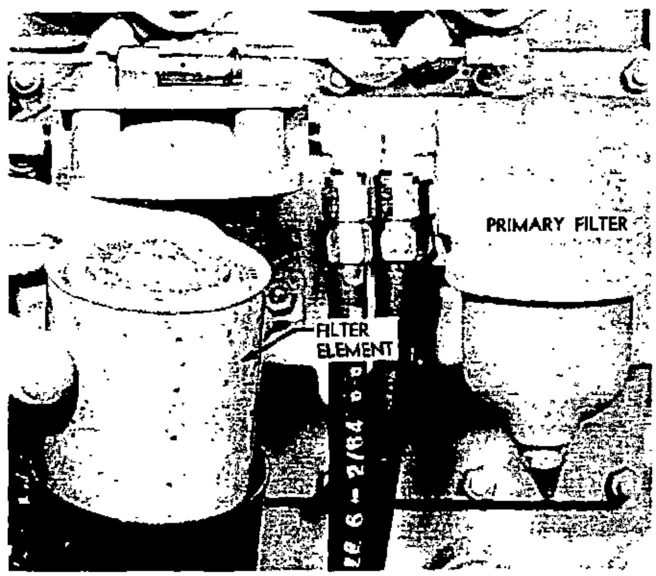


Figure 111D
Replaceable Secondary Fuel Filter

REMEMBER — IT IS BOTH EASIER AND LESS EXPENSIVE TO KEEP DIRT OUT OF THE FUEL OIL THAN TO REMOVE IT.

FUEL PIPING ARRANGEMENTS

The best fuel supply arrangement is with the fuel tank mounted higher than the injection pump and filters — which provides gravity feed to the filters and pump.

When the fuel supply tank is lower than the filters and injection pump an auxiliary electric supply pump is generally recommended, and in addition a hand primer, located between the primary and secondary filter to prevent drain-back to the tank when the unit is not operating.

FUEL INJECTION SYSTEM

The fuel supply lines should be ⅜" copper tubing minimum when under 10 feet and ½" copper tubing for lines over 10 feet. The return lines should be 5/16" minimum tubing. It must also be piped to the *tank* and never back to the inlet, as its fuel flow cools, lubricates and purges air from the pump.

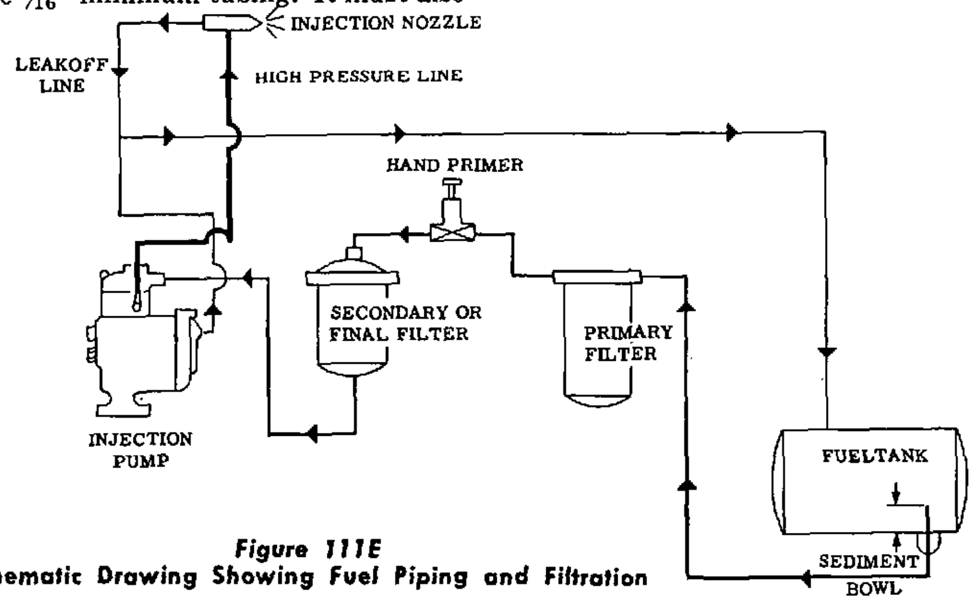


Figure 111E
Schematic Drawing Showing Fuel Piping and Filtration

TIMING OF INJECTION PUMP TO THE ENGINE

Injection pumps must be installed on the engine in accurate alignment and timed to correct relation with the crankshaft for proper engine operation with maximum power and economy and to prevent complaints of hard starting, overheating, uneven running and excessive smoking.

Timing a fuel injection pump to a Diesel engine is similar to and even more simple in operation than timing a gasoline engine ignition system — yet both require precision to insure the correct timing as recommended by the engine manufacturer.

TIMING BOSCH APE TYPE PUMP TO ENGINE

The simple steps required to correctly time the Bosch APE injection pumps to the Continental four-cylinder Diesels follow:

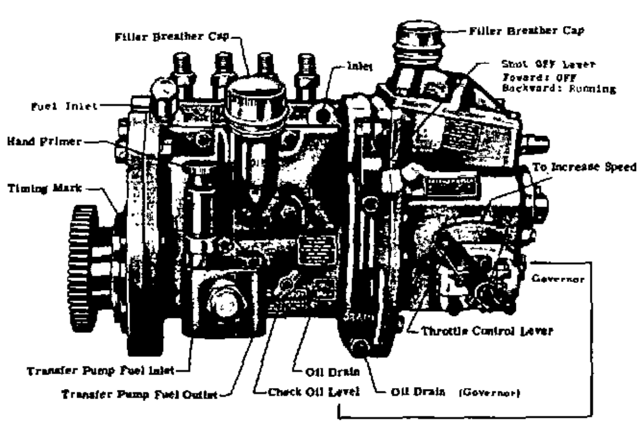


Figure 112
APE Pump

1. Turn engine until #1 piston is on compression stroke and pointer seen through the flywheel housing timing hole, Fig. 113, is at the following mark on the flywheel rim corresponding to maximum governed speed operated:

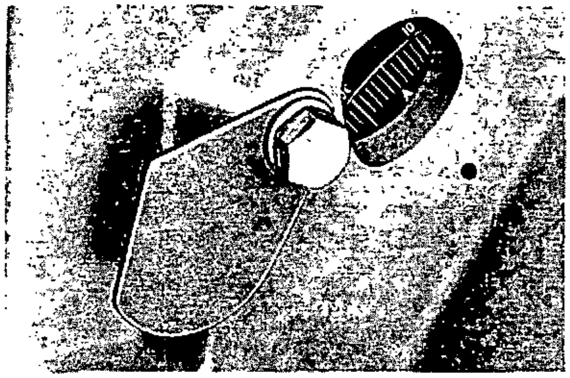
Bosch APE Type Pump Timing to Engine

Industrial Engines			
RPM	GD-157	HD-260 *	JD-382
800	24° BTDC	25° BTDC	32½° at 1350
1000	26° BTDC	27° BTDC	
1200	28° BTDC	29° BTDC	
1400	30° BTDC	31° BTDC	
1600	32° BTDC	33° BTDC	
1800	34° BTDC	35° BTDC	
2000	36° BTDC		

NOTE: Make certain that #1 Piston is on compression stroke by turning both Push Rods by hand — indicating both valves are closed.

*Also HD277

Figure 113—Flywheel Timing Marks



2. Remove pipe plug or inspection plate in the injection pump drive adapter. The **mark,** or pointer, (late models) on the front end of pump should line up with **mark** on driven gear flange with the correct flywheel setting for governed speed. If it doesn't, remove

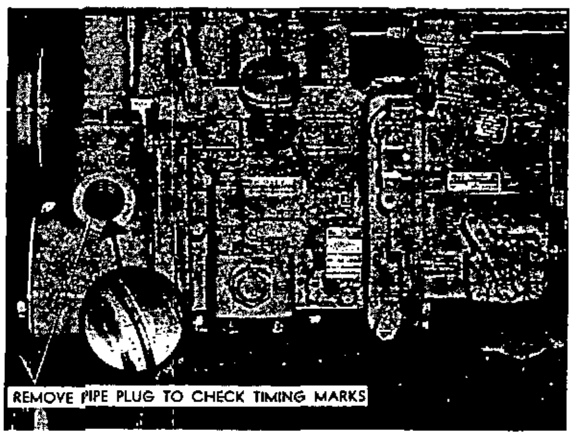


Figure 114—Timing Marks — Injection Pump to Adapter

front adapter plate, loosen screws which hold gear to the flange, turn shaft so marks line up — then tighten screws securely.

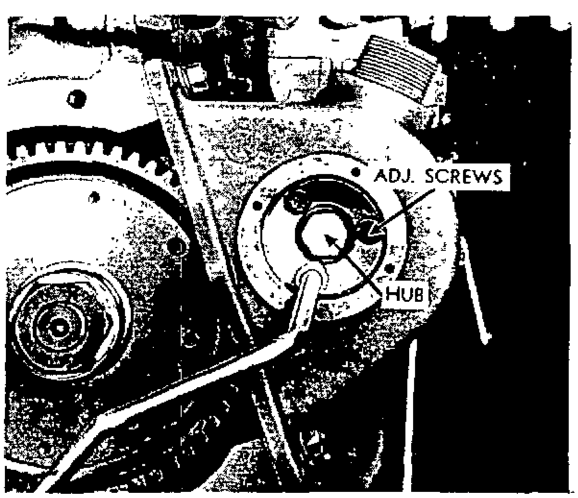


Figure 115—Adjusting Pump Timing to Engine

TIMING BOSCH PSB TYPE FUEL PUMP TO ENGINE

1. Remove rocker arm cover and turn engine over until the #1 Piston is on compression stroke and the pointer seen through the opening in the flywheel housing is aligned with the mark on the flywheel rim corresponding to the maximum **Engine Governed Speed** Operated:

DEGREES B.T.D.C.

800	GD-157	ED-201*	HD-260**	JD-382
RPM	16°		18°	21°
1000	18°		20°	24°
1200	20°		22°	26°
1400	22°		24°	
1500		24°		28°
1600	24°		26°	
1800	26°		28°	
2000	28°			

*Also ED-208.
**Also HD-277.

NOTE: Make certain that #1 Piston is on Compression stroke by turning #1 Valve Push Rods by hand indicating both valves of #1 cylinder are closed.

2. Remove control cover by removing (2) retaining screws. Check Pump Plunger Drive Gear for tooth which has a beveled top face and painted red which should be visible in window opening. (If not visible disconnect pump and turn pump drive gear to relocate).

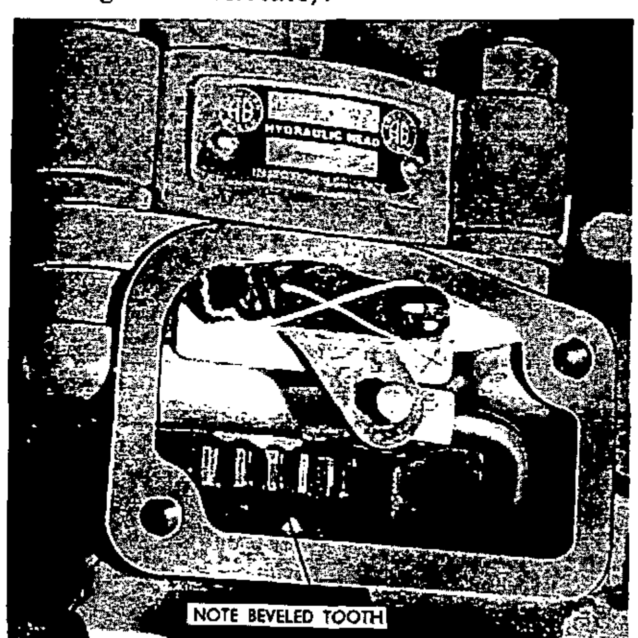


Figure 116 — Bosch PSB Pump Timing

FUEL INJECTION SYSTEM

3. Remove timing hole plug or inspection plate on top of pump drive housing and check if line on hub of pump drive gear is in alignment with pump timing pointer. If not — loosen adjusting screws; turn hub with ¾" socket to complete alignment and tighten adjusting studs securely.

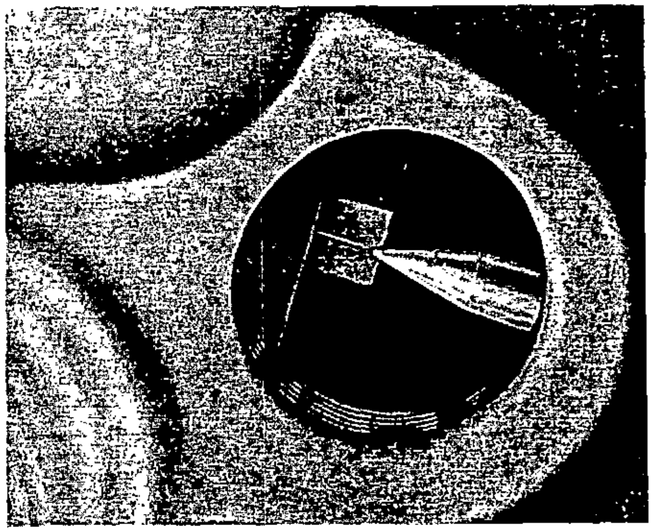


Figure 117—Pump Timing Mark and Pointer

INSTALLING AND TIMING ROOSA-MASTER INJECTION PUMPS TO ENGINE

TIMING ROOSA-MASTER PUMP TO ENGINE (WITHOUT REMOVAL)

1. Turn engine until #1 Piston is on **compression** stroke and pointer seen through flywheel housing hole is at the following mark on the flywheel rim corresponding to maximum governed speed operated:

NOTE: Make certain that #1 Piston is on Compression stroke by turning both Push Rods BY HAND indicating that both valves are closed.

2. Remove timing hole cover in pump housing and check if the timing line on the drive plate lines up with the timing line on the cam ring. Fig. 118.

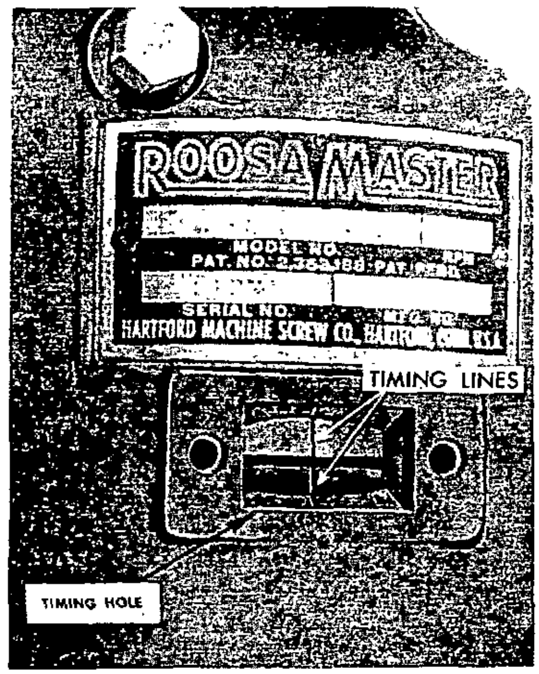


Figure 118 — Roosa-Master Pump Timing

If adjustment is required, loosen mounting nuts and turn assembly by hand so that timing marks line up.

Turn engine over two revolutions and recheck to make sure all backlash is eliminated in gear train.

ROOSA TIMING CHART

ENGINE R. P. M.	ZD-129		GD-157		GD-193		ED201 & ED208		HD260 & HD277	
	Standard	Automatic Advance	Standard	Automatic Advance	Standard	Automatic Advance	Standard	Automatic Advance	Standard	Advance Automatic
1000	18°		17°				18°		19°	
1200	20°		19°				20°		21°	
1400	22°		21°				22°		23°	
1600	24°		23°		29°		24°		25°	
1800	26°	17°	25°	19°	30°	20°	26°		27°	
2000	28°	19°	27°		31°	22°	28°		29°	
2200			29°						31°	25°

TIMING PROCEDURE AND INSTALLATION INSTRUCTIONS WHEN 2-PIECE DRIVE IS USED WITH ECCENTRIC BUSHING

This improved drive with eccentric bushing permits pump removal without disturbing timing and micrometer backlash adjustment.

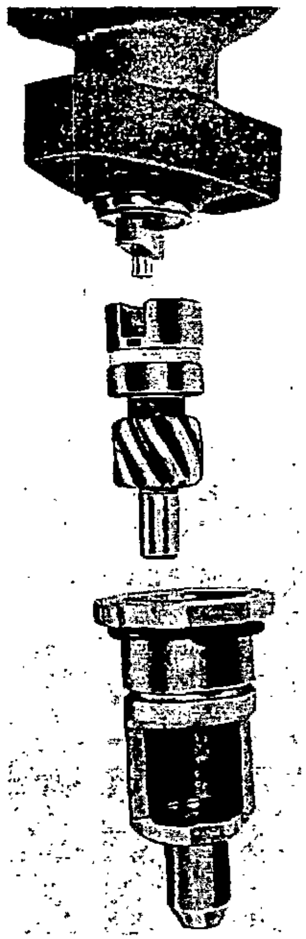


Figure 119—Roosa Model "D" Pump with two-piece drive shaft and eccentric bushing

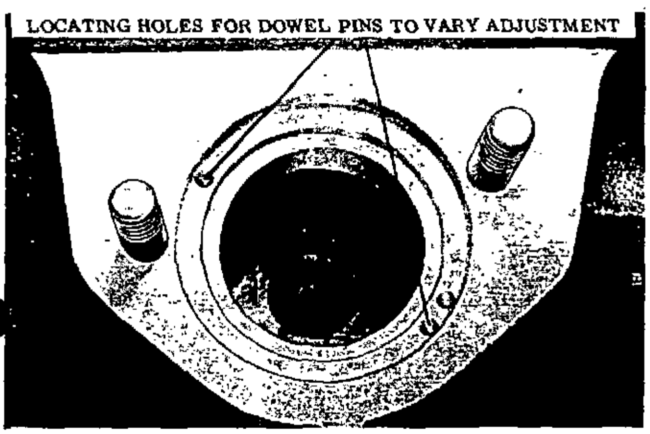


Figure 120—Dowel locating holes in block

1. Turn engine until No. 1 piston is on the compression stroke and pointer seen thru flywheel housing hole is at the correct degree mark on the flywheel rim. Check timing chart for standard timing information; for special applications, — refer to customer's specification.

2. Install the drive gear in the eccentric bushing adapter with the adapter seal.

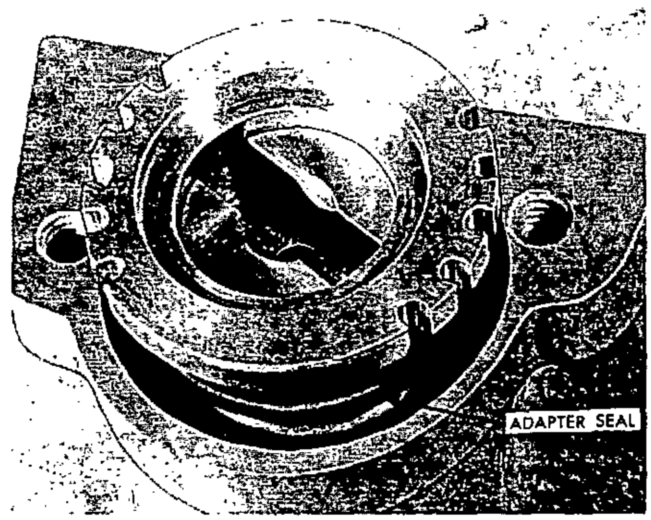


Figure 121—Installing Bushing

3. Use a dial indicator gage to check backlash of the pump drive gear. Measure at the drive slot with the gage positioned approximately at the pitch diameter of the gear. Backlash should be .004 to .006 inch. (Fig. 122.)

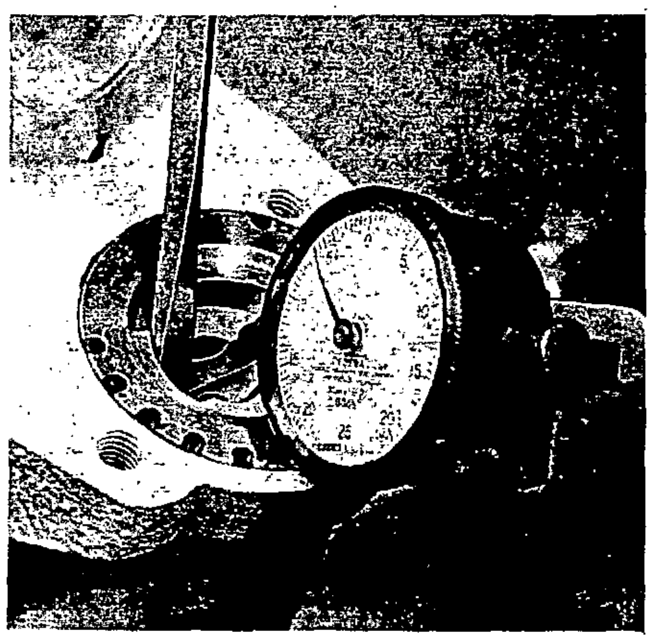


Figure 122—Checking backlash of pump drive gear

FUEL INJECTION SYSTEM

4. Remove the timing line cover from the pump and turn the drive shaft so that the timing line on the governor weight retainer is in alignment with the timing line on the cam. (Fig. 123.)

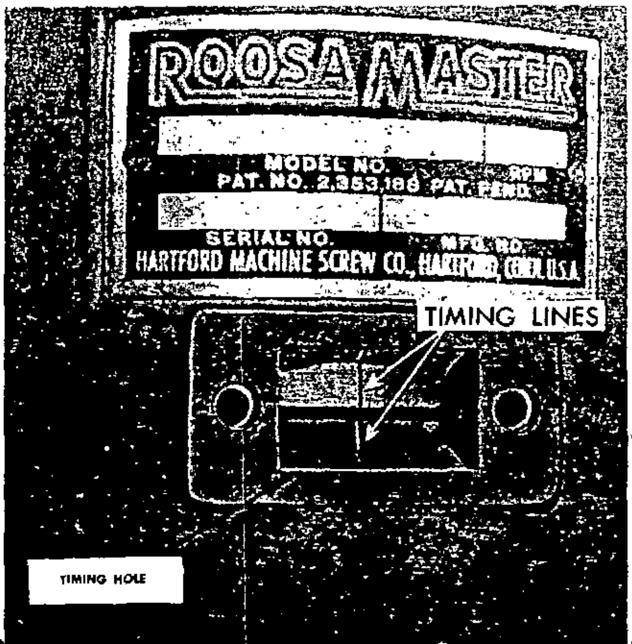


Figure 123—Timing marks aligned

5. Install the seal ring on the eccentric bushing adapter and place the pump in position on the engine. (Fig. 124.)

Figure 124—Eccentric bushing, showing pump seal and shaft

> Note: To reduce backlash, lift the eccentric bushing adapter off the locating pin and turn it clockwise to next locating hole. (Fig. 124A.) If this does not provide correct adjustment, move the locating pin to one of the other holes provided in the crankcase. There must be a minimum of .004 backlash.

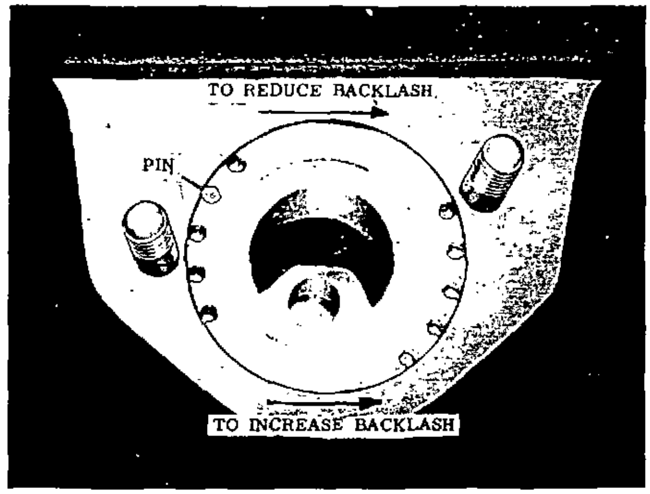


Figure 124A—Eccentric bushing for control of pump gear backlash

Note: The Model "D" pump drive shaft using the eccentric bushing and drive gear has an off-center tang and slot which prevents installation of the pump 180 degrees out of time.

6. Turn the pump as necessary to bring the pump timing lines into perfect alignment, then install and tighten the mounting nuts.

7. Turn the crankshaft 2 revolutions, turning up to the timing marks specified, and recheck the pump timing marks. Adjust if necessary and replace the timing cover on the pump.

STORAGE OF FUEL INJECTION EQUIPMENT

When an engine is to be out of service for a long period, protect the fuel injection equipment as follows:

1 — Before final shut-down — empty fuel tank and fill tank with a 5 gallon mixture of 50% high grade SAE 10 lube oil and pure white kerosene.

2 — Run engine on this mixture about 30 minutes or until blue exhaust smoke indicates complete filling of the fuel system with this mixture.

3 — Drain and completely refill camshaft, spring and governor compartments of the APE type pump with the same oil. Tag engine with notice that the system has been filled with storage oil.

MODEL "E" ROOSA PUMP WITH ENGINE GOVERNOR

The Model "E" Pump is basically the same as the Model "D" Pump except that it does not have a built-in governor — it uses an engine cam gear governor with linkage as shown in Fig. 125 to actuate the pump throttle arm.

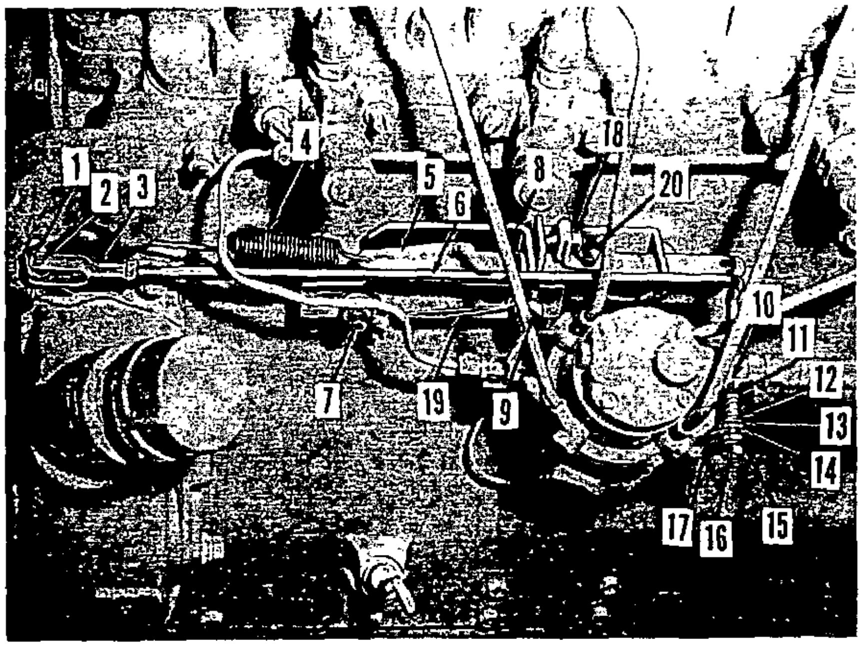


Figure 125 — Engine Cam Gear Governor

The Cam Gear Governor is adjusted as follows:

(a) With governor spring (4) hooked to the governor lever (1) pull sliding variable speed control (5) wide open until it hits the stop bracket (8) (Fig. 125).

(b) Connect the governor rod (6) to the pump throttle arm (17) with the cotter pin (10), washer (11), spring (12), washer (13) in place on the rod; and the rubber grommet (14), steel bushing, and nut (16) in place. (Screw nut down until flush with head.)

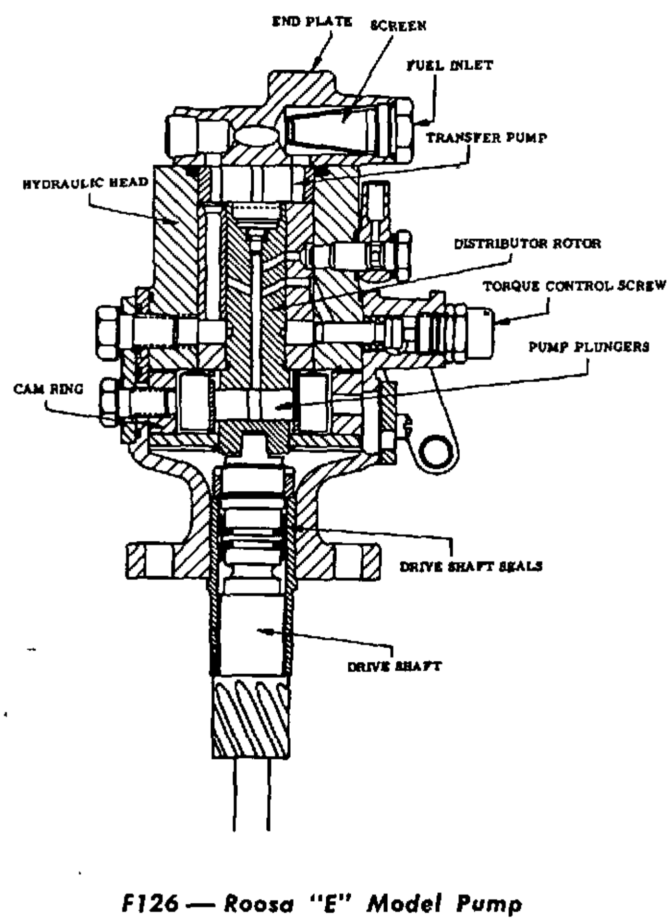
(c) Move pump throttle arm (17) until it barely contacts the spring loaded metering valve — holding in this position, check hole alignment in clevis (3). Adjust so pin (2) will drop freely — then increase rod length 1½ turns of the yoke. Insert pin and cotter pin and tighten clevis lock nut.

(d) Disconnect the governor spring from governor lever and check linkage for free movement or excessive play.

(e) Reconnect governor spring (4).

(f) Check operation and if desired speed range is not obtained, loosen nuts (7) and (9). Stop bracket (8) may then be moved to rear to **increase** speed and forward to reduce speed. When checking — keep variable speed control (5) **tightly against stop,** maintaining full spring tension.

(g) Idle speed adjustment (18) — turn set screw clockwise to **increase** idling speed and counterclockwise to **decrease** idling speed.



F126 — Roosa "E" Model Pump

SECTION VII
ENGINE REPAIR AND OVERHAUL

This section includes instructions for repairs and overhaul of the component units of Continental Red Seal four cylinder Diesel engines.

Provide a clean place to work and clean the engine exterior before you start disassembling — dirt causes engine failures.

Many special tools have been developed to save time and assure good workmanship—which are shown in Section XI and are available at your Continental distributor.

Use only genuine Red Seal parts in Continental Diesel engines as years of development and testing have gone into these specifications to assure maximum life and performance.

CYLINDER HEAD

The cylinder head is the most important part the engine assembly since it contains the complete combustion chamber including valves, fuel injection nozzles, energy cells and cored passages for air, exhaust and water flow.

REMOVING THE CYLINDER HEAD

1. Drain water from engine and disconnect radiator or heat exchanger outlet hose.

2. Remove cylinder cover by taking out the screws holding it to the rocker arm supports.

3. Remove rocker arm shaft assembly and push rods. Grip the push rods and snap them sideways out of the tappet sockets as shown in the illustration. This method serves to break the hydraulic connection and permits lifting the push rods out and leaving the tappets in place. (If tappets are lifted out of the guides they will have to be reassembled through the opening in the block if only the cylinder head is removed for servicing.)

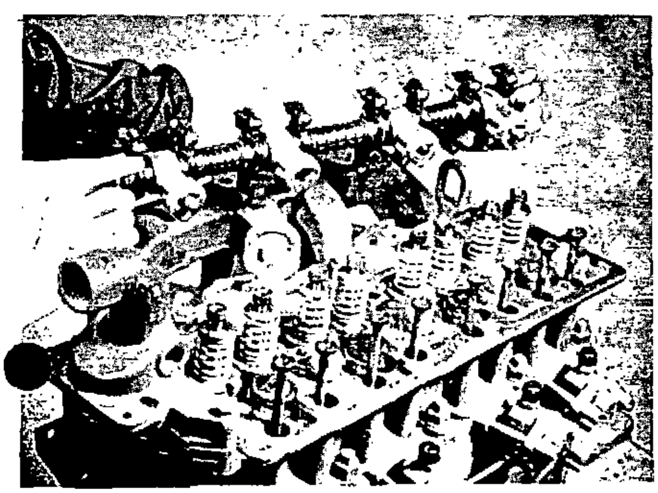


Figure 127—Removing Rocker Arm Shaft Assembly

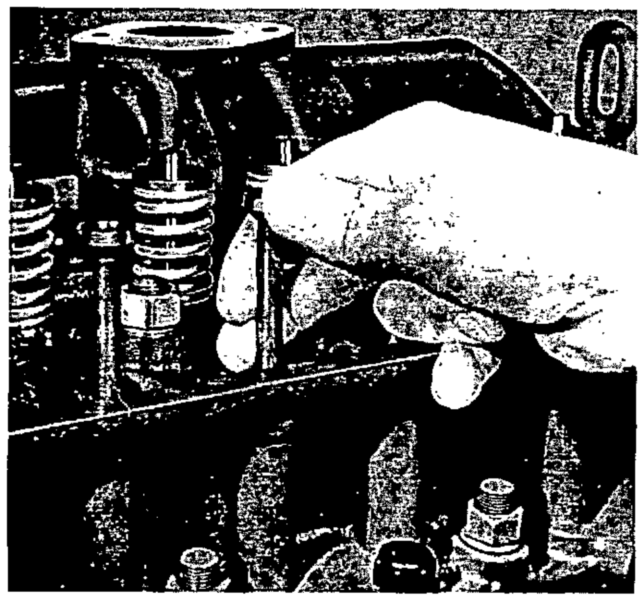


Figure 128—Snapping Push Rod out of Ball Socket of Tappet

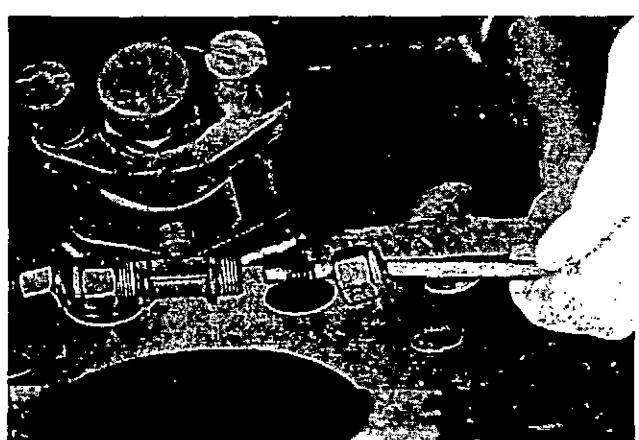


Figure 129—Disconnecting Nozzle Leak-Off Line

4. Disconnect the injection and leak-off lines at both the nozzle and pump connections and im-

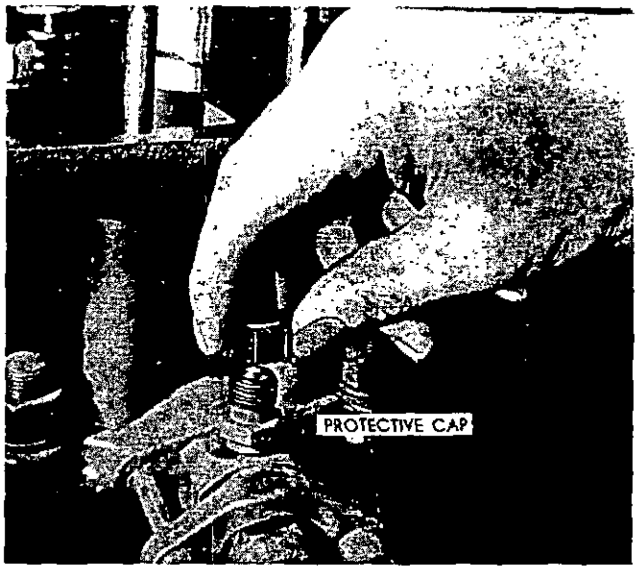


Figure 130—Capping Nozzle Connection

ALWAYS COVER OPENINGS WITH PROTECTIVE CAPS AT ANY TIME WHEN LINES ARE DISCONNECTED. THIS WILL PREVENT ANY DIRT OR FOREIGN MATTER FROM ENTERING

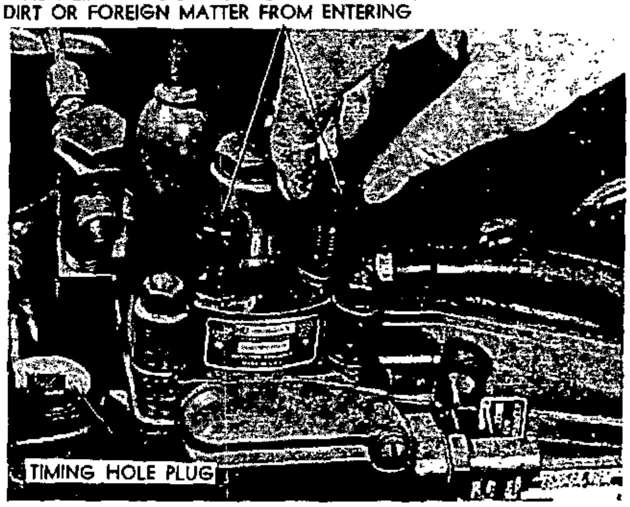


Figure 131—Capping Injection Pump High Pressure Connections

mediately cap the fittings to prevent dirt entering.

5. Loosen and remove the nuts holding the cylinder head to the block.

6. Lift the cylinder head off the engine and carry to a clean bench for further disassembly.

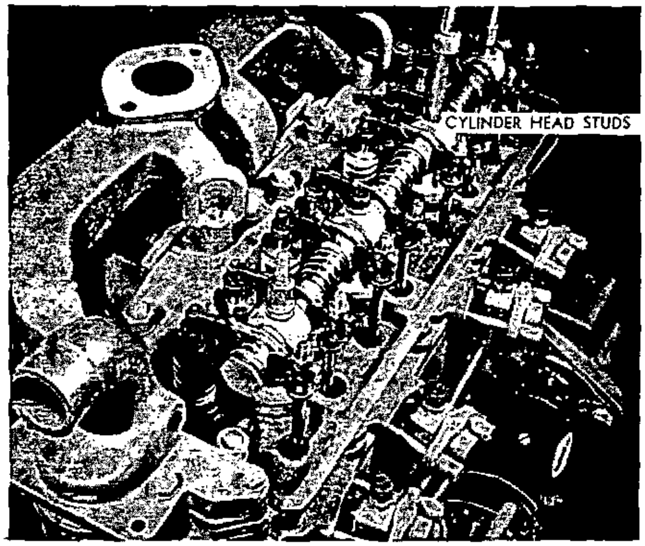


Figure 132—Cylinder Head Assembly Showing Studs

DISASSEMBLY OF CYLINDER HEAD

1. Remove all carbon from combustion areas using scraper and wire brush.

2. Using a C type valve spring compressor, remove the valve spring retainer locks, retainers

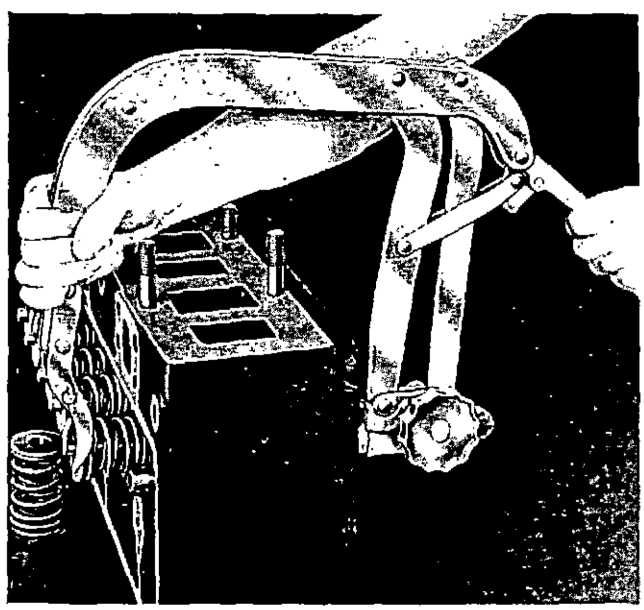


Figure 133—Removing Valve Springs with "C" Type Valve Spring Compressor

and springs and placing all parts in a container of solvent.

ENGINE REPAIR AND OVERHAUL

3. Remove the valves in order and place them in a rack with holes numbered for both intake and exhaust so they will not be mixed in handling.

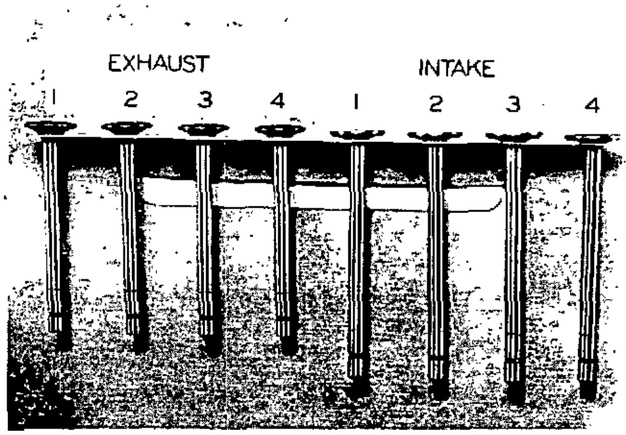


Figure 134—Valves in Rack

4. Clean the cylinder head thoroughly with a solvent or degreasing solution and blow it off with air pressure. Inspect carefully for cracks.

5. Remove hex-head plug holding the energy cell retainer against the cap and the energy cell firmly against the seat — then remove the cap.

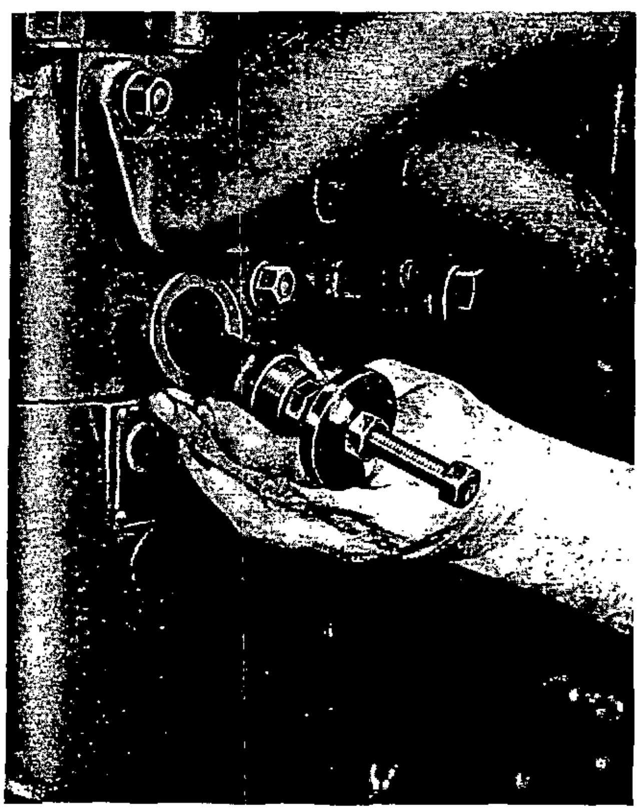


Figure 135—Pulling Energy Cell with Special Tool

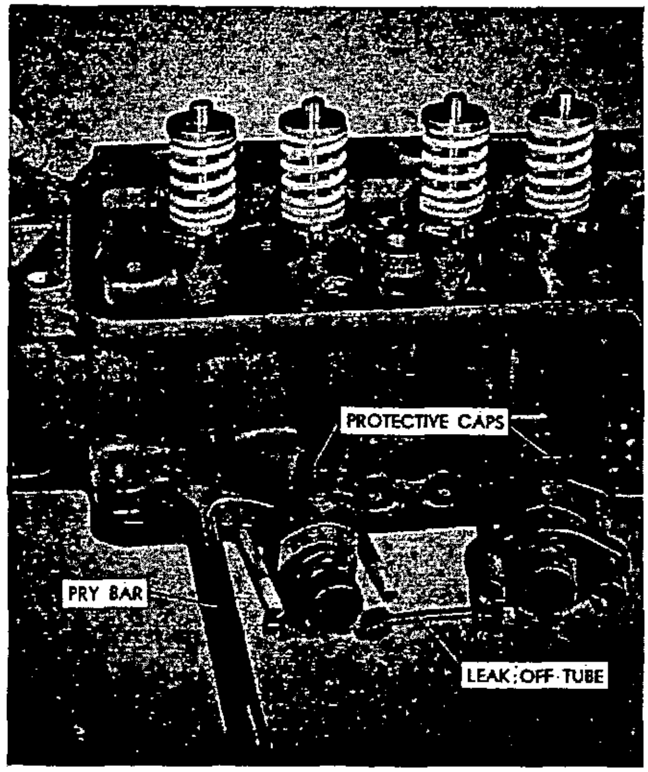


Figure 136

6. Remove the injection nozzle assemblies by removing the slotted nuts and clamps and pull the nozzle holder as instructed in the fuel injection section.

7. Pull the energy cells with special tool as shown in illustration.

> **NOTE: Should difficulty be experienced in pulling the energy cell due to being firmly embedded in the counterbore and held there by carbon — use a brass drift with a spherical head inserted through the nozzle opening and give it a sharp rap with a hammer while tension is applied with the puller. Never use a steel or similar metal drift or one without a spherical nose as damage will result to the conical entrance of the metered opening.**

VALVE GUIDES

1. Clean the valve stem guides, removing lacquer or other deposits by running a valve guide cleaner or wire brush through the guides.

2. Check guides for wear by using "Go and No-Go" plug gauge or a telescope gage and 1" micrometer. Replace all guides that are worn bell-mouthed and have increased .0015 in diameter. See Limits and Clearance Section for maximum diameter permissible to determine actual amount the diameter has increased. Remove all valve guides when necessary by pressing them out from the combustion chamber side.

	INT. "A"	EXH. "B"
ZD-129	$2\frac{5}{32}$	$2\frac{5}{32}$
GD-157	$2\frac{15}{32}$	$2\frac{15}{32}$
GD-193	$2\frac{15}{32}$	$2\frac{15}{32}$
ED-201, ED-208	$2\frac{25}{32}$	$2\frac{25}{32}$
HD-260, HD-277	$2\frac{17}{64}$	$2\frac{19}{32}$
JD-382	$2\frac{25}{32}$	$3\frac{1}{8}$

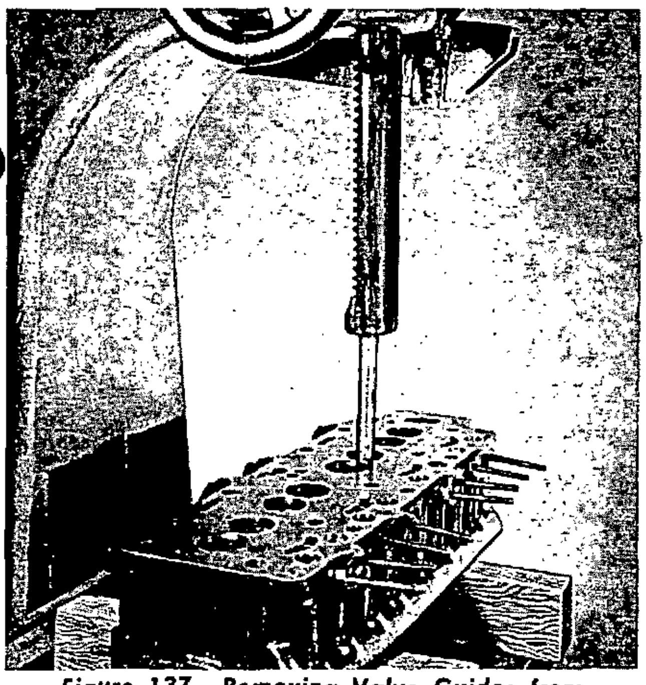


Figure 137—Removing Valve Guides from Combustion Chamber Side

3. Replace worn guides as required by pressing in new guides from the combustion side to the correct depth below the cylinder head contact surface as given in the Limits & Clearance Chart.

4. Ream new valve stem guides to size given in Limits and Clearance Chart, using a straight reamer ground to correct size and having a pilot which will properly locate it and keep it from wandering from the original reamed hole.

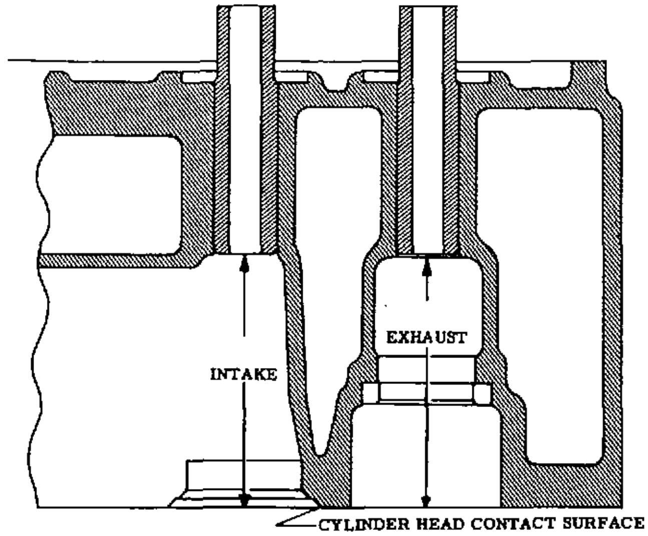


Figure 138—Diagram showing Valve Guide Location

CAUTION

Ferrox coated guides are now used on some models; these are pre-reamed and do **NOT** require reaming after installation.

VALVE SEAT INSERTS

1. The exhaust valve seat insert is held in place by a shrink fit.

Inspect all exhaust valve inserts in the head and replace any that are loose, cracked or otherwise damaged. Use puller for removing faulty insert as shown in illustration.

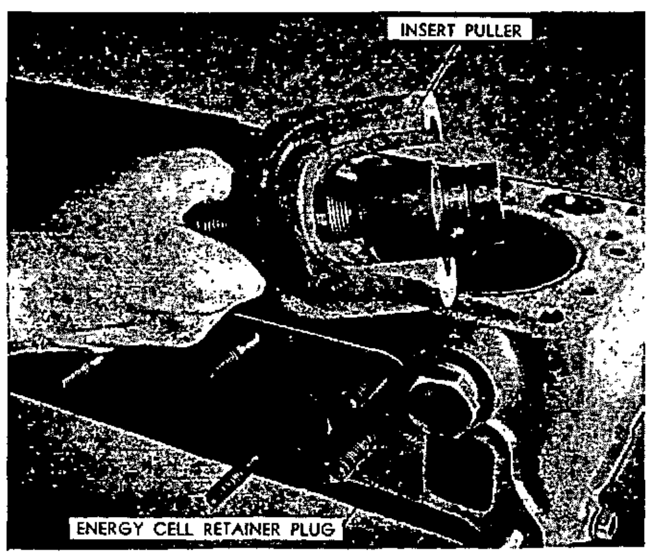


Figure 139—Exhaust Valve Seat Insert Removal Tool

2. When required to replace with new insert, clean and counterbore for .010 larger insert using counterbore tool with correct fitting pilot.

ENGINE REPAIR AND OVERHAUL

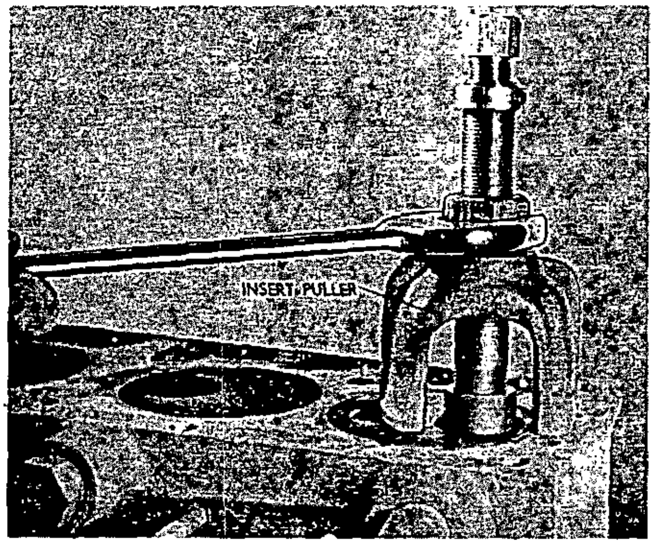


Figure 140—Removing Exhaust Valve Seat Insert

When machining the counterbore, be sure to go deep enough with the tool to clean up the bottom so that the insert will have full contact to carry away the heat.

Continental does not recommend installing new inserts having the same outside diameter as the one removed. The following chart shows the dimensions of Standard Inserts and counterbores:

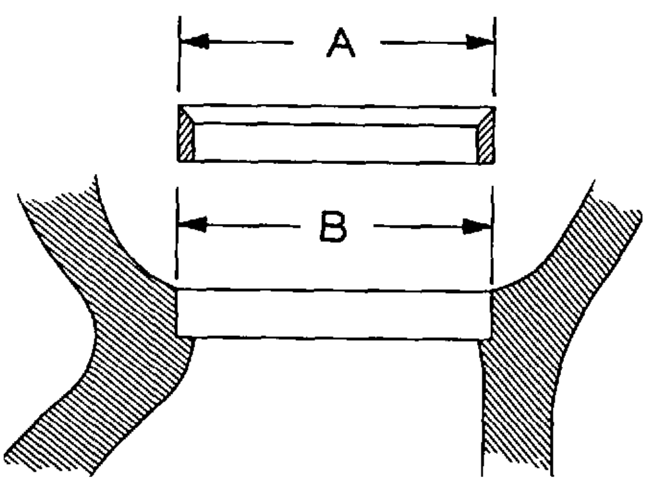


Figure 141—Insert and Counterbore

DIMENSIONS OF STANDARD INSERTS AND COUNTERBORES

When OVERSIZE inserts are used, dimensions of the insert and counterbore increase proportionately (.010, .020, .030 — depending on the oversize.

New insert installation should have .002-.004 press fit. Chill insert in container with dry ice for 20 minutes before assembling.

	Engine Model	Inside Diameter of Counterbore (B)	Outside Diameter of Insert (A)	Press Fit
	ZD-129	1.187/1.186	1.190/1.189	.004/.002
	GD-157	1.3245/1.3235	1.3285/1.3275	.005/.003
	GD-193	1.3245/1.3235	1.3285/1.3275	.005/.003
*	ED-201	1.438/1.437	1.442/1.441	.005/.003
**	HD-260	1.5545/1.5535	1.5585/1.5575	.005/.003
	JD-382	1.688/1.687	1.692/1.691	.005/.003

* Also ED-208
** Also HD-277

Insert may then be installed in the counterbore using a piloted driver, tapping in place with very light hammer blows, without the possibility of shearing the side walls. This assures it being seated firmly on the bottom of the counterbore after which it should be rolled or peened in place.

VALVES

1. Inspect valves for condition and replace any that are "necked", cracked or burned, also any on which valve stems are bent or worn more than .002. Reface or replace all valves.

2. All valves having less than 50% margin thickness (outer edge of valve head) after refacing has been completed must be replaced. To check this dimension, compare the refaced valve with a new valve.

3. Check all refaced or new valves in V-blocks with indicator to determine if the contact face is true with the stem within .002. If not, repeat the refacing operation.

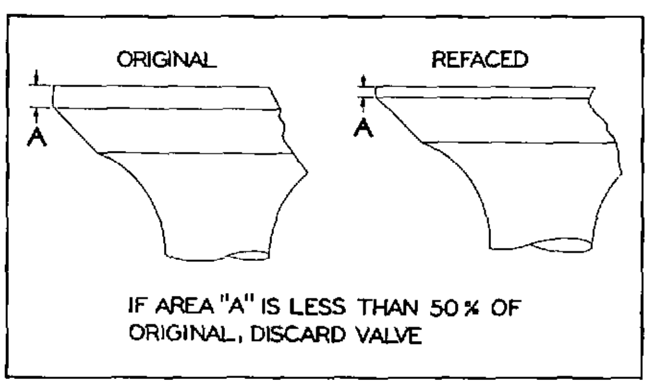


Figure 142—Allowable Head Thickness of Refaced Valves

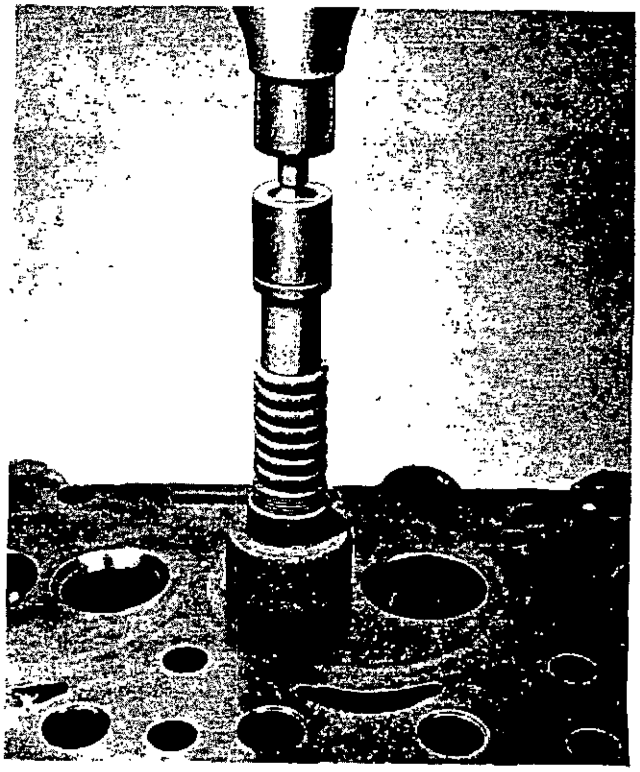


Figure 143—Grinding Intake Valve Seats

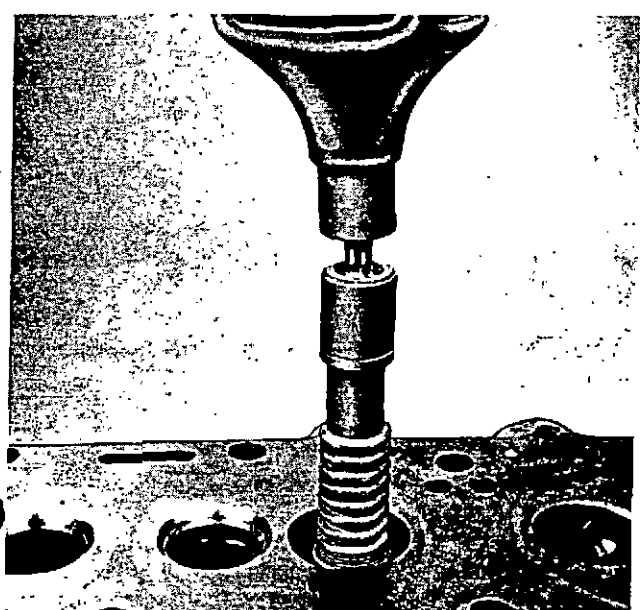


Figure 144—Grinding Exhaust Valve Seat

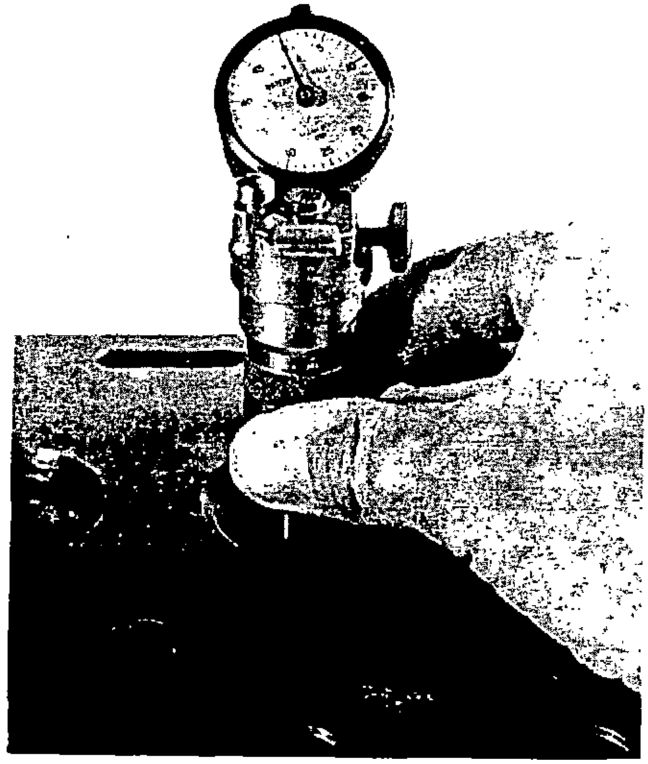


Figure 145—Checking Intake Valve Seat Run-Out

4. Grind the intake and exhaust valve seats in the head in accordance with instructions in your limits and clearance chart and before removing the arbor, indicate the seat. Total indicator reading must not be more than .002". Use a pilot having a solid stem with a long taper, as all valve seats must be ground concentric and square with either new or worn valve stem guide holes.

5. After the valves and seats have been refaced and reground, coat the seat lightly with Prussian blue and drop the valve into position, oscillating it slightly to transfer the blue pattern to the valve face. This should show a contact width of 1/16" to 3/32" and should fall well within

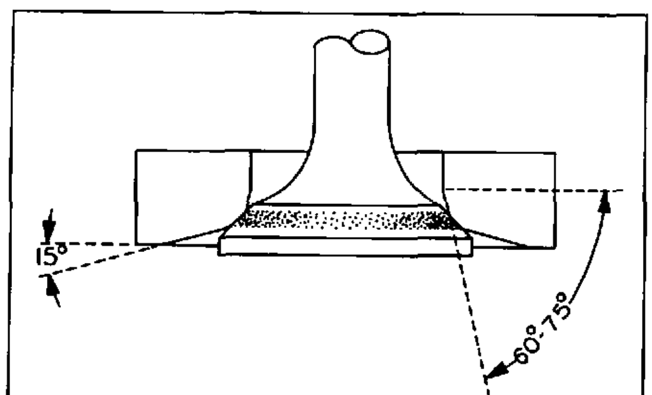


Figure 146—Method of Narrowing Valve Seats

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the width of the valve face, leaving at least 1/64" on either side where the blue does not show. If the contact is over 3/32" wide, the seat in the head may be narrowed by using a 15° stone to reduce the outside diameter or using a 60° or 75° stone to increase the inside diameter.

Never allow valves to set down inside the seat.

After the narrowed-down seat is brought within specifications, the seat should be retouched lightly with the original stone to remove burrs or feathered edge.

> **"A poor valve grinding job cannot be corrected by valve lapping."**

6. Coat the valve stem with a light film of engine oil.

VALVE SPRINGS

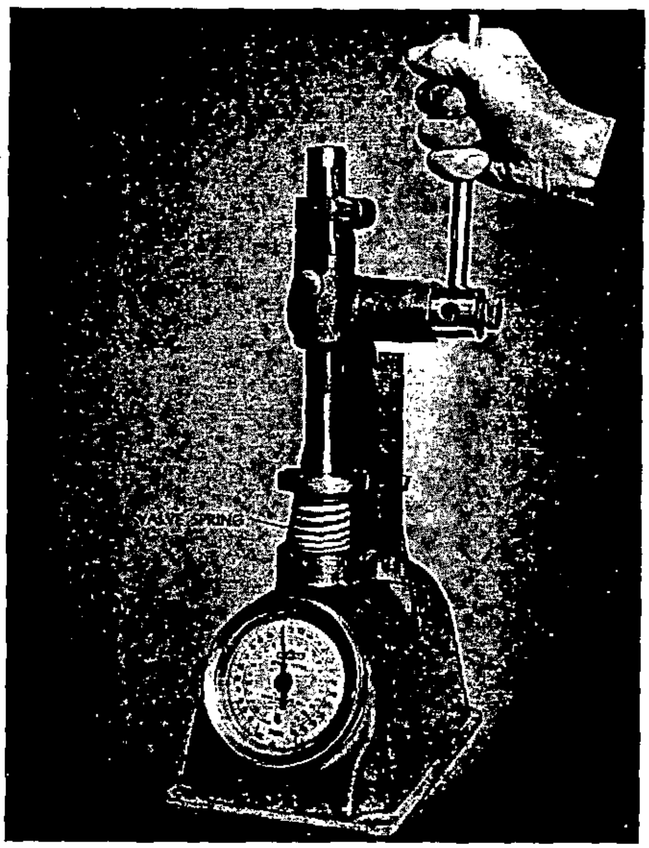

Figure 147—Valve Spring Tester

1. Check all valve springs on a spring tester to make sure they meet specifications regarding weight and length. Springs, when compressed to the "valve open" or "valve closed" length, must fall within the specifications shown on the chart when new, and must not show more than 10% loss to re-use.

2. Reassemble the valves and springs in the head with the retainer and retainer lock. The close wound coils of the valve spring should contact the cylinder head.

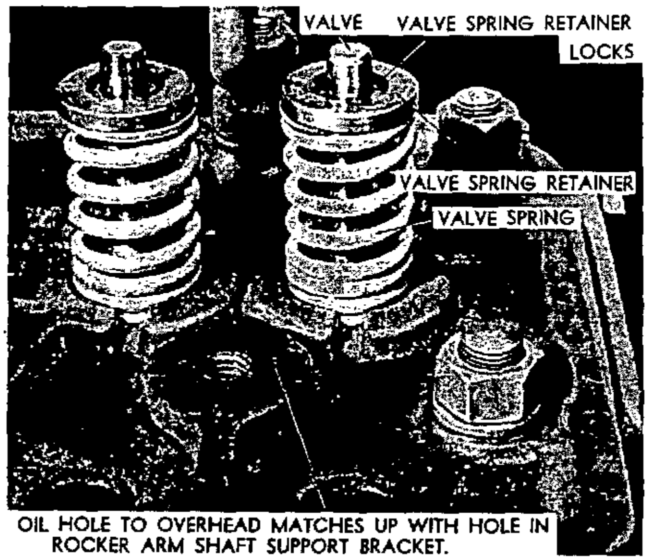

Figure 148—Valve Assembly (Note Close Wound Coils Contact Head)

ENERGY CELLS

1. Clean all carbon and any other deposit from the energy cell counterbore being careful not to damage the large diameter angular seat on which the energy cell body makes contact.

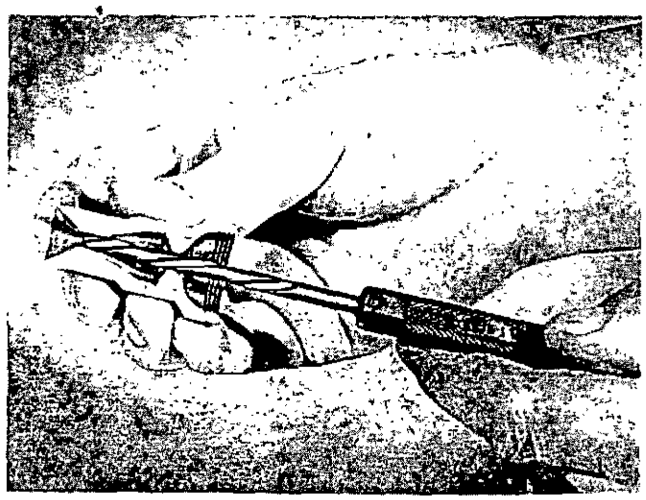

Figure 149—Cleaning Energy Cell Metering Holes with Special Reamer

2. Clean the energy cell body exterior as you would an exhaust or intake valve on the outside. Clean the inside chambers and passages using the scraper and drill provided in the tool kit to restore it as nearly as possible to new condition.

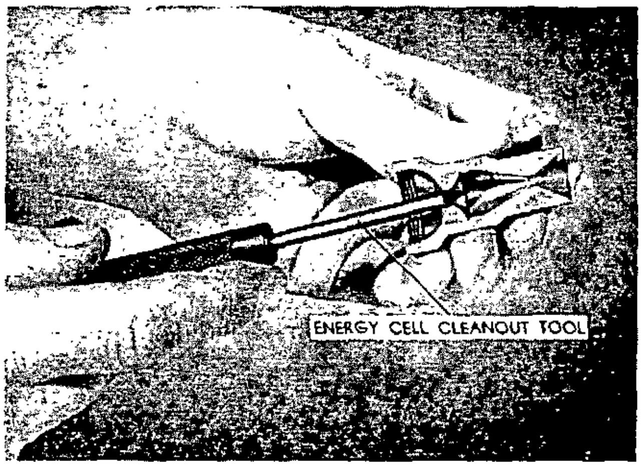

Figure 150—Cleaning Energy Cell with Special Scraper

3. The contact surface where the cap seats on the body must be clean and free from any dirt or scratches. Then lap, with valve grinding compound, the cap to the body so that it will make an air tight seat.

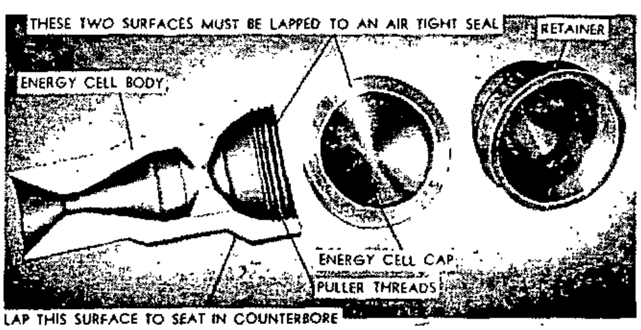

Figure 151—Sectional View of Energy Cell Parts

4. Lap the energy cell body into the head with valve grinding compound using the puller or a piece of wood of such size that it can be screwed into the thread in the energy cell, — and lap in same manner as you would lap a valve in a cylinder head.

> **Important** — This must be an airtight seat, since it is a point at which the energy cell is sealed into the head and any leakage will cause burning of the surrounding metal in a short time.

5. Reassemble the energy cell in the cylinder head, first the body and cap, the retainer and finally the screwed-in cap or plug with a hex-head. Tighten and torque to specifications since there must be no possibility of any leak from the combustion chamber at either the seat where the body contacts the head or the contact surface between the cap and the body.

INJECTION NOZZLES

The injection nozzles inject the metered amount of fuel received from the injection pump into the combustion chamber. For efficient performance and maximum economy the injection nozzles must inject the fuel in a definite spray pattern—at 1750-1850 pounds pressure and without the nozzle dribbling due to leaking of the nozzle valve.

1. All the nozzles previously removed during head disassembly should be cleaned, tested and repaired under clean conditions by competent workman following the procedure outlined in the Fuel Injection Section VI before assembling them into the head.

2. Clean the nozzle recess in the cylinder head with the special reaming tool before insert-

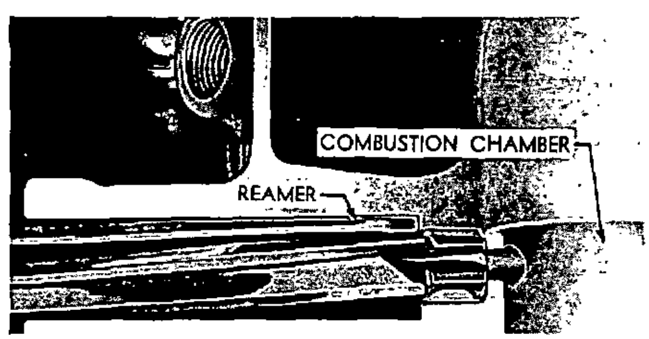

Figure 152—Cleaning Nozzle Recess in Cylinder Head

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ing the nozzle holder assembly. There must be no carbon particles on seating surface which will tilt the assembly or permit blow-by. No hard or sharp tools should be used — a round piece of wood or brass properly shaped can be used if special reamer is not available.

3. Always use new injector gaskets and insert the nozzle tip carefully so that it does not strike the wall.

4. Tighten the holder clamp nuts evenly to prevent binding the nozzle valve and torque down to 14-16 ft. lbs. Use special "T" handle tool provided in kit for this purpose if torque wrench is not available.

ROCKER ARMS

1. Inspect the rocker arm shaft for wear. If the shaft has "shoulders" on it due to wear, replace. Blow out oil holes with air.

2. Examine rocker arms for cracks, condition of valve contact surface and worn bushings. Replace all defective rocker arms or any having over .005 clearance between shaft and arm.

3. Inspect the rocker arm brackets for cracks or other damage.

VALVE PUSH RODS

1. Inspect push rods for bends or twists and examine the ball and cup ends for excessive wear. Replace rods that are faulty or excessively worn.

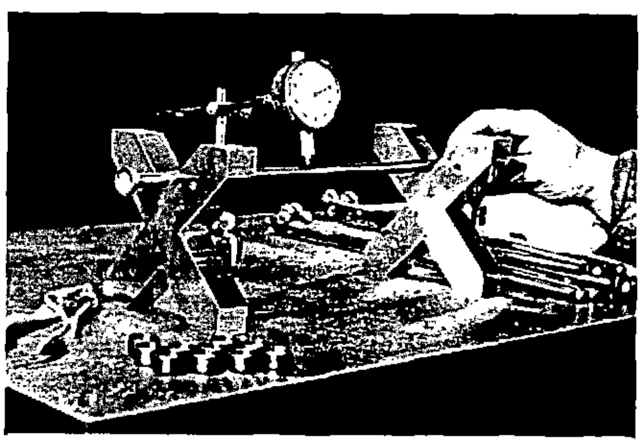

Figure 153—Push Rod Inspection for Bends

2. To prevent damage to push rods, replace after the cylinder head is installed.

INSTALLING HEAD

1. Make sure that gasket contact surfaces on the head and block are clean, smooth and flat.

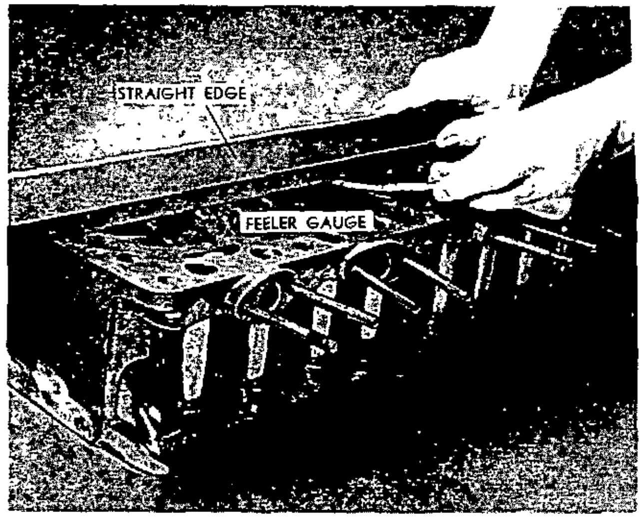

Figure 154—Checking Cylinder Head Flatness (.004 maximum) Lengthwise

Check flatness with straight edge and feeler gauge in three positions lengthwise and five crosswise. The maximum permissible is .004 low in the center lengthwise, gradually decreasing towards the ends, or .003 crosswise or in localized low spots. Cylinder head or block must be resurfaced if these limits are exceeded.

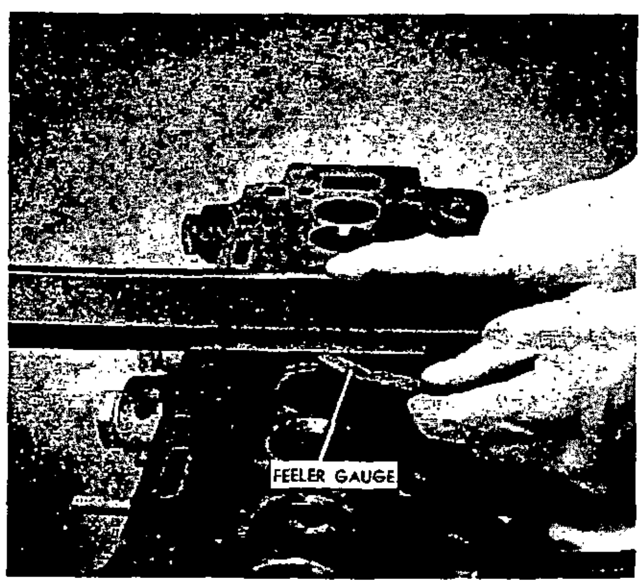

Figure 155—Checking Cylinder Head Flatness (.003 maximum) Crosswise

Use new cylinder head gasket which is precoated, thus no cement is required.

When difficulties are encountered with gasket sealing, coat both sides of gasket with heat resisting aluminum paint and assemble immediately.

2. Using a chain hoist, lower the cylinder head assembly evenly over the studs, then pull all cylinder head cap screws up snug with speed wrench.

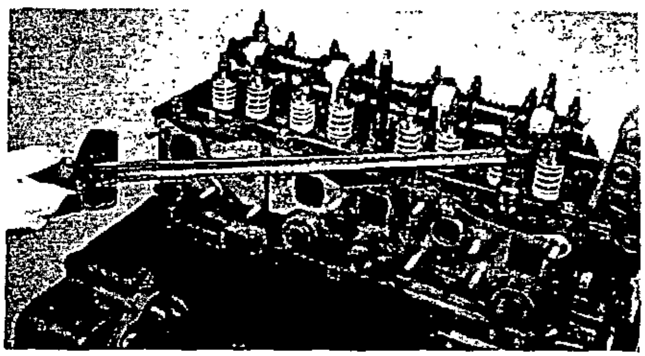

Figure 156—Tightening Cylinder Head Studs with a Torque Wrench

3. Tighten with torque wrench in recommended sequence to the correct torque shown in Limits & Clearance Chart by going over them

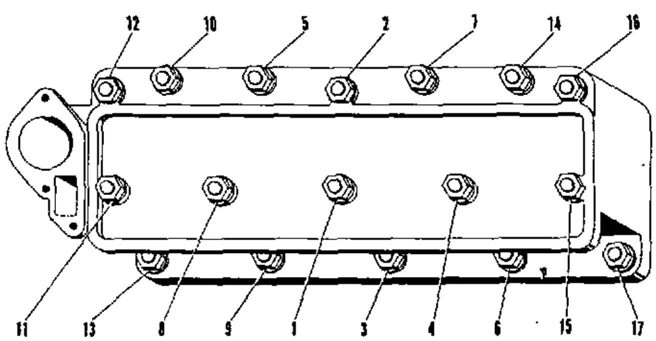

Figure 157—Cylinder Head Tightening Sequence

two times before pulling them down to the final torque specification on the third round.

CYLINDER BLOCK

In all of the 4 cylinder Diesel engines except the GD-193 model, the cylinder barrels are replaceable sleeves, commonly termed the "wet-type", meaning that they complete the water jacket of the cylinder block when they are assembled in place. The GD-193 has dry sleeves.

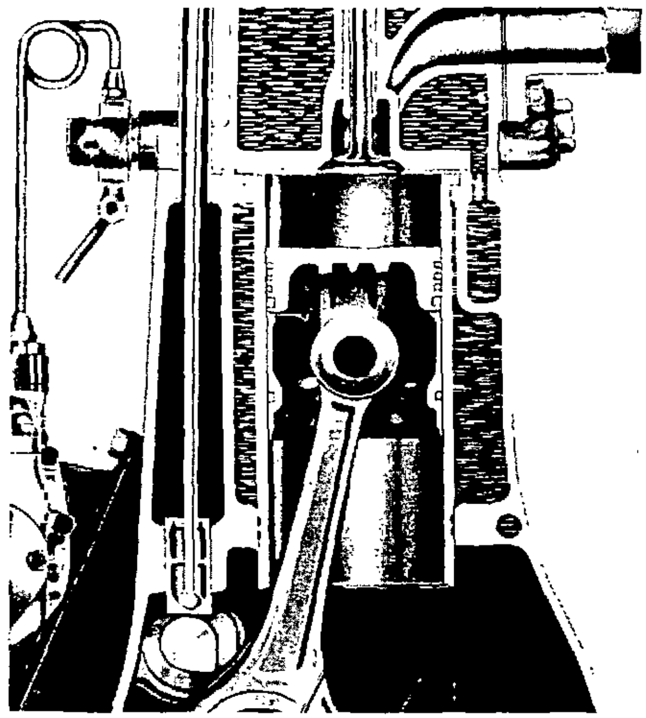

Figure 158—Sectional View of Cylinder

When cylinder bores of wet-sleeve engines are worn more than .008 it is more economical to replace the sleeve and use a standard piston and ring assembly instead of reboring the cylinder and assembling an oversize piston. When worn less than .008, a set of service rings may be used to restore the engine to satisfactory operating condition.

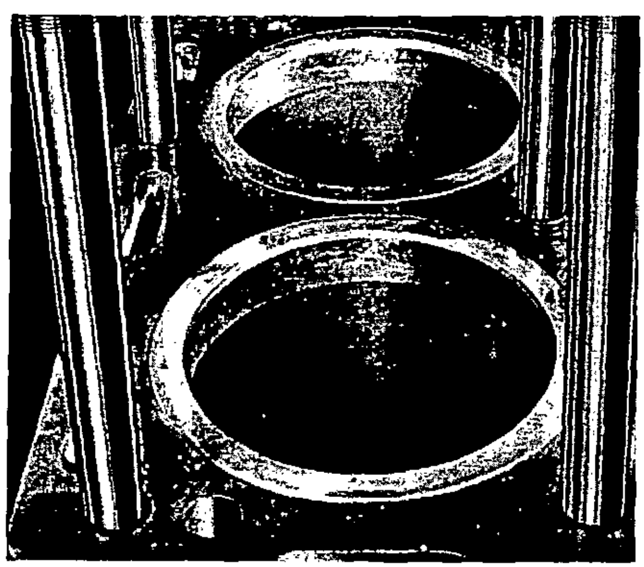

Figure 159—Deposits on Cylinder Sleeve before Cleaning

ENGINE REPAIR AND OVERHAUL

CHECKING BORE WEAR

1. Clean the ring of carbon from around the top of the cylinder bore formed above the travel of the top ring.

2. Determine the original diameter of the cylinder barrel by checking this unworn area with a pair of inside micrometers at intervals of approximately 45°.

Figure 160—Measuring Original Diameter of Sleeve

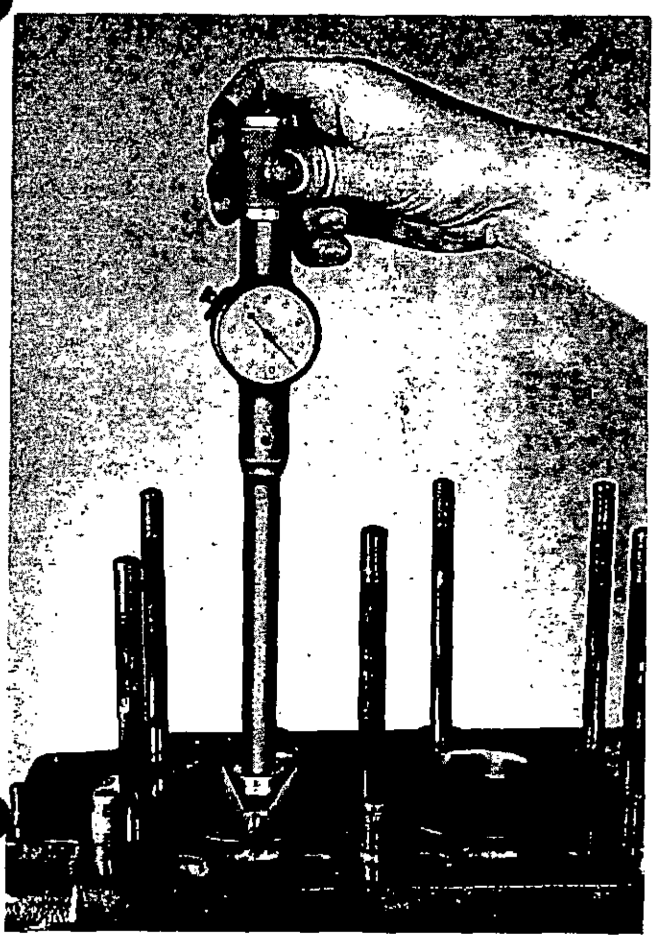

Figure 161—Measuring Original Diameter of Sleeve with Bore Gauge

3. Check in same manner the top of the ring travel area approximately 1/4" below the shoulder.

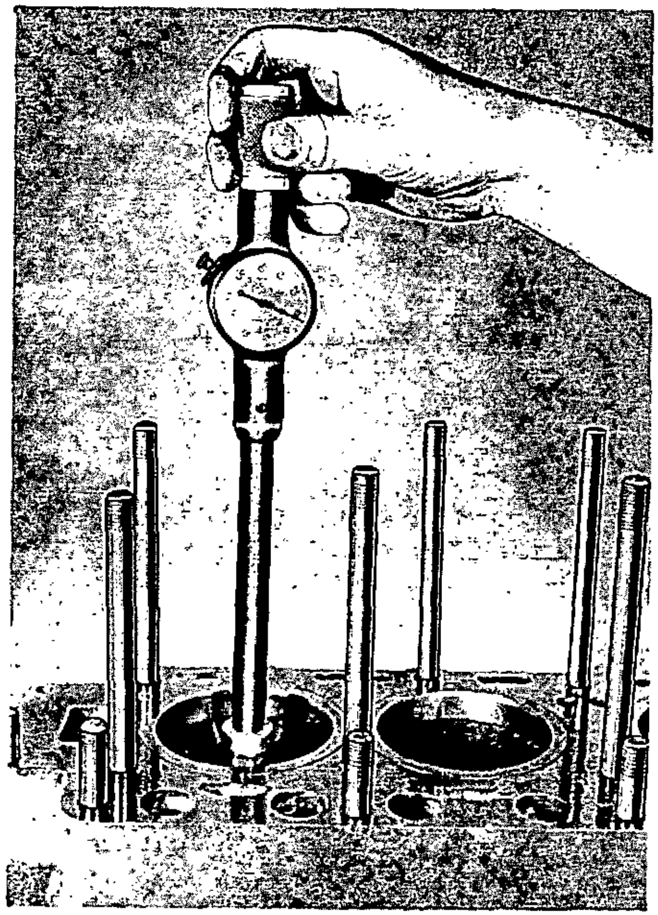

Figure 162—Measuring Bore Wear 1/4" Below Shoulder

4. The maximum difference in the above checks, indicates the amount of cylinder bore wear. If less than .008, reringing will be suitable and if over .008 resleeving is recommended.

RE-RINGING (For bore wear less than .008)

1. Ridge ream the cylinders to remove the unworn area at the top so that the new rings when assembled will not bump and distort both themselves and the piston lands.

Several good makes of ridge reamers are available which will ream the top of the bore in direct relation to the worn area so that should the worn area be off center slightly there will be no partial ridge remaining.

With the head removed, there is no compression on the sleeves to keep them from turning and it may be necessary to make some form of clamp to hold them in place while ridge reaming.

A flat piece of steel with a slot can be slipped over one of the cylinder head studs and

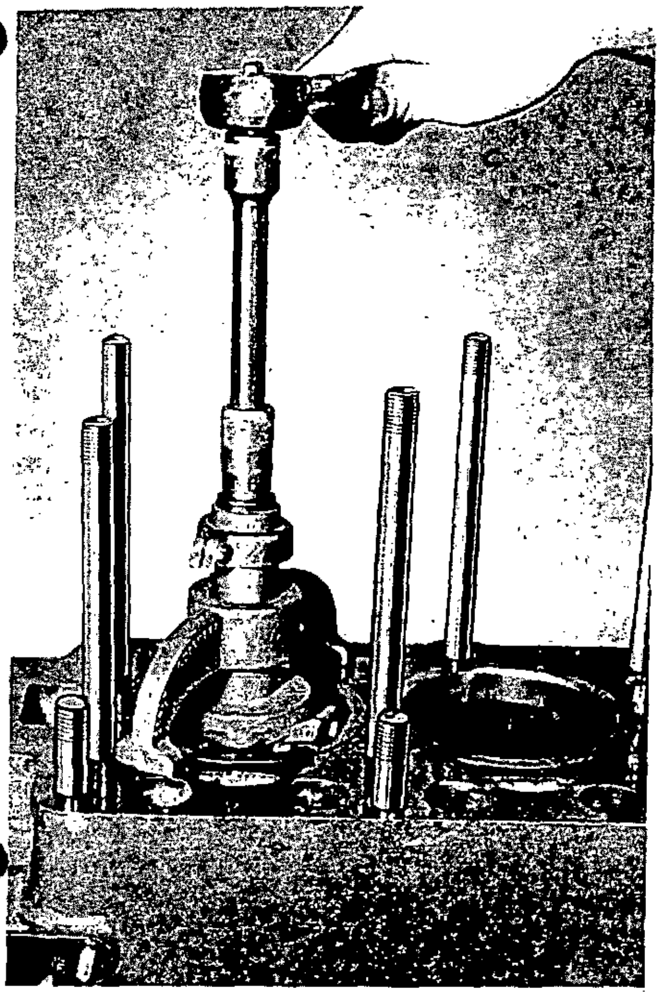

Figure 163—Ridge Reaming Top of Cylinders

with the outer end resting on the milled surface of the block, it can be drawn down on the flange of the sleeve to hold it firmly in position.

2. Drain the crankcase and remove the oil pan.

Figure 164—Removing Connecting Rod Cap

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3. Remove the cap screws holding the connecting rod caps to the rod. Keep the caps and bolts in numerical order so that when the pistons and rods are removed from the engine, the cap can be reassembled and kept with its mating part.

4. Push the pistons and connecting rods up through the top of the cylinder, carrying with them all the carbon and metal chips left from the cleaning and ridge reaming operation. When doing this, every precaution must be taken to prevent damage to cylinder bores by the sharp corners and rough edges of the connecting rods and bolts.

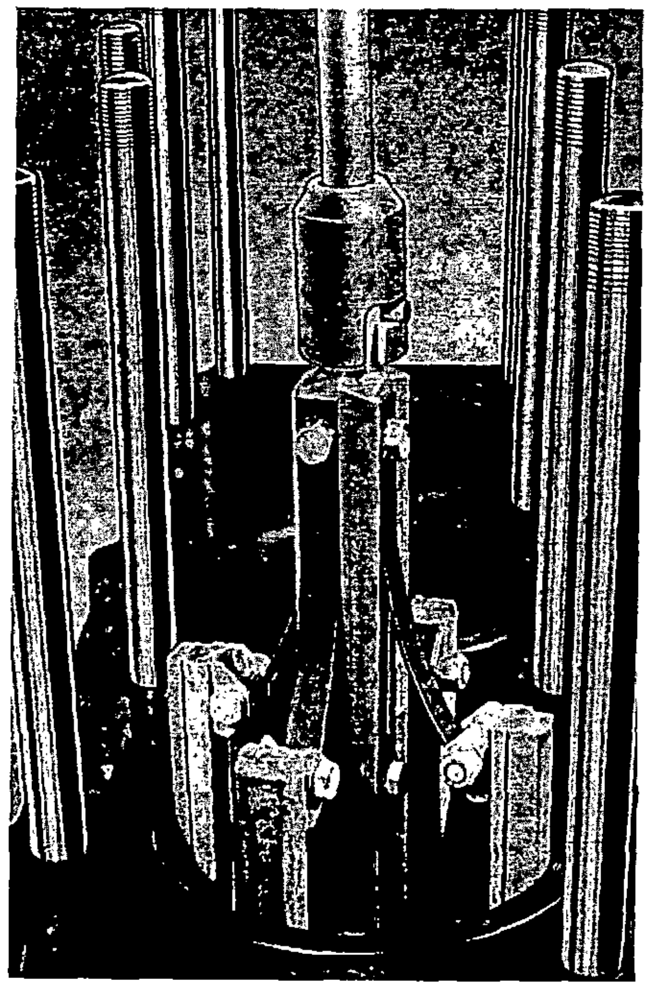


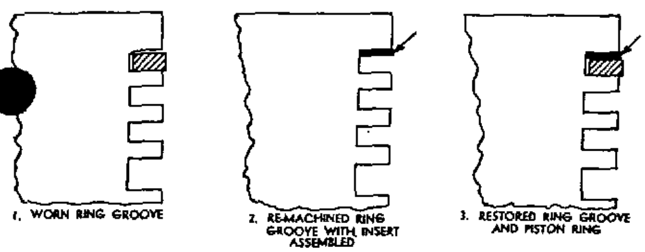
Figure 165—Breaking the Cylinder Wall Glaze

5. Break the glaze on the cylinder bores by using a glaze-breaker or other means in order to assure quick seating of the new piston rings — protect the crankshaft with oily (not dirty) rags during the glaze breaking operation.

The glaze breaker may be run up and down the cylinder bore while turned with an electric drill until the shiny surface is removed, after which these surfaces must be thoroughly cleaned by wiping with a clean oiled rag which will pick up the small particles of dust that are embedded in the pores of the iron.

Failure to do this cleaning carefully, raises one of the big objections to using a glaze breaker or other means for roughing up the cylinder bores so the new rings will seat. If the glaze is not removed, we have no assurance as to when the rings will begin to function properly and control the oil; therefore, we must recommend that this be done — but done with care — and the bores thoroughly cleaned afterwards.

6. Check the pistons for excessive ring groove wear usually found in the top groove, which can be salvaged by installing a ring groove insert as furnished by several piston ring manufacturers. Some of them provide tools so that this job can be done manually in a shop not equipped with machines for this purpose.



RE-SLEEVING BLOCK (Wet-Sleeve Type)

When the bore wear measures over .008 or bores are badly scored or damaged, re-sleeving is recommended, using standard piston and ring assemblies, which are available in complete kits including sleeves, pistons, piston pins, rings and piston pin retaining rings.

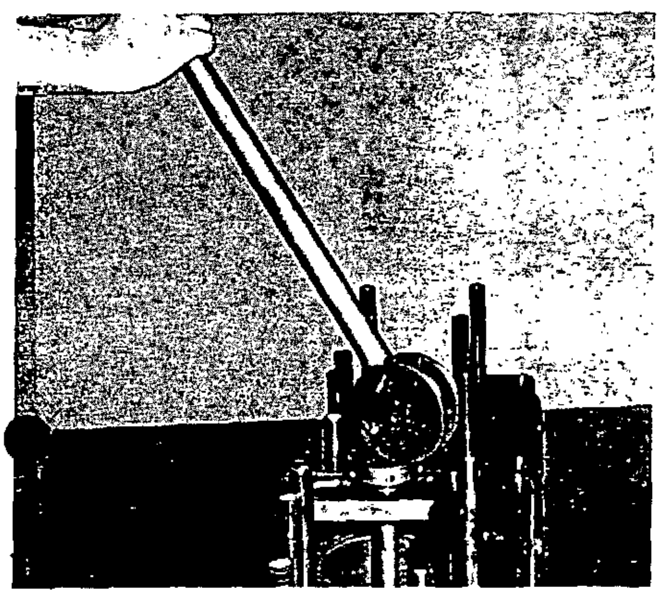


Figure 166—Cam-Action Sleeve Puller

1. Pull the sleeves, using a puller of the type shown in the illustration which makes this a simple, easy operation.

2. Clean out the counterbore thoroughly, removing all rust and scale to permit metal to metal contact of the new sleeve with the block.

3. Clean the lower seal contact so that the new seals when assembled will not be torn or damaged by particles of rust or corrosion protruding from the machined surfaces.

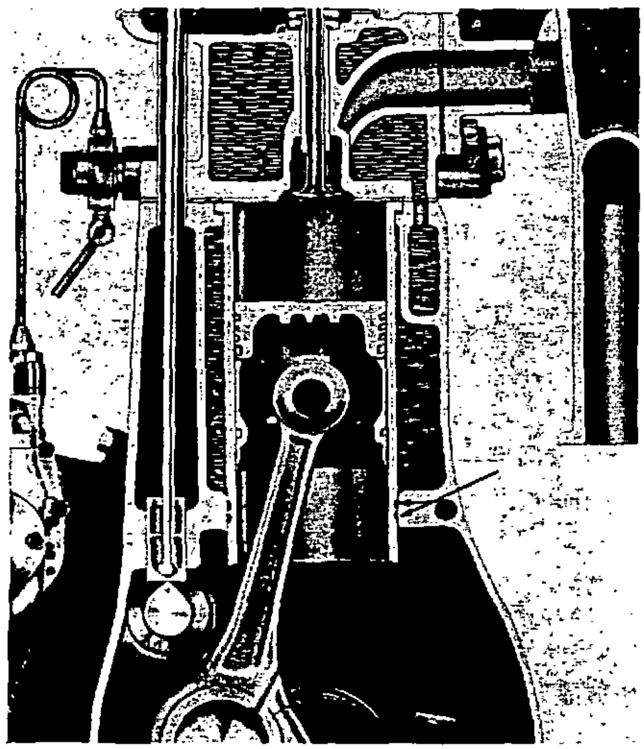


Figure 167—Cylinder Section Showing Seals

4. A new sleeve should first be dropped in place in the cylinder block, without the seals, to determine the amount it protrudes above the top of the block.

Lay a straight edge across the top of the sleeve and use a feeler gauge to measure the height. This amount should be from .001 - .004, thus permitting a slight pressure build-up where the gasket contacts the sleeve, assuring a good seal at this point.

It may be necessary to shift the sleeve from one bore to another until the desired projection is obtained or shims of .0015 and .003" thickness are

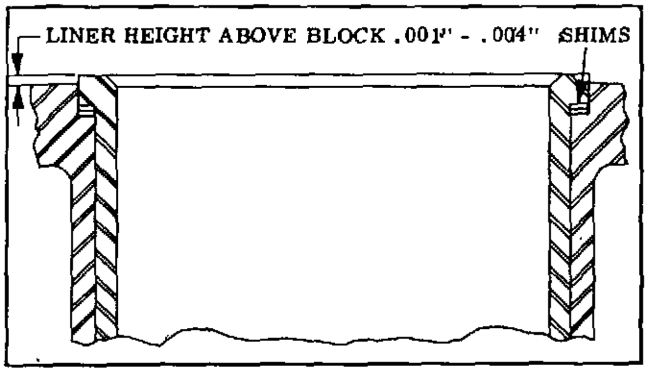


Figure 168—Height of Sleeve Above Block

available which, when assembled around the sleeve, will raise it the desired amount.

5. Remove the sleeve, selected for each bore, and assemble new seals in the grooves provided for them.

Figure 169—Assembling Seals on Sleeve

The seals must not be twisted during assembly; otherwise they are very likely to leak. To prevent any possibility of twist slip the fingers under the seals, sliding them out of the grooves in the cast iron sleeve and running the finger around inside two or three times, allowing the seal to slide back in place without a twist.

Figure 170—Installing Sleeve in Block

6. Thoroughly lubricate the seal with either petroleum jelly or hydraulic brake fluid, after which the sleeve may be dropped back into the bore to a point where it is resting on the seal.

7. Press the sleeve in place with the palm of the hand, a simple operation, when the seal con-

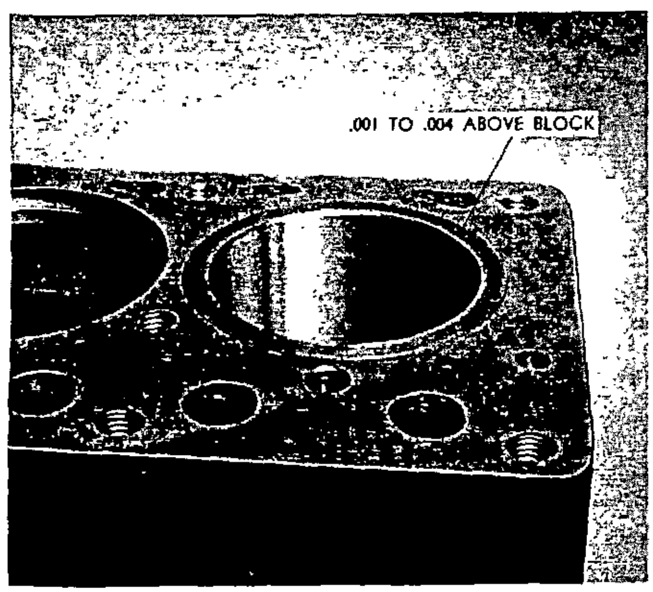


Figure 171—Sleeve Pressed in Place

ENGINE REPAIR AND OVERHAUL

tact bore in the block and the chamfer on the upper corner of the bore is thoroughly cleaned.

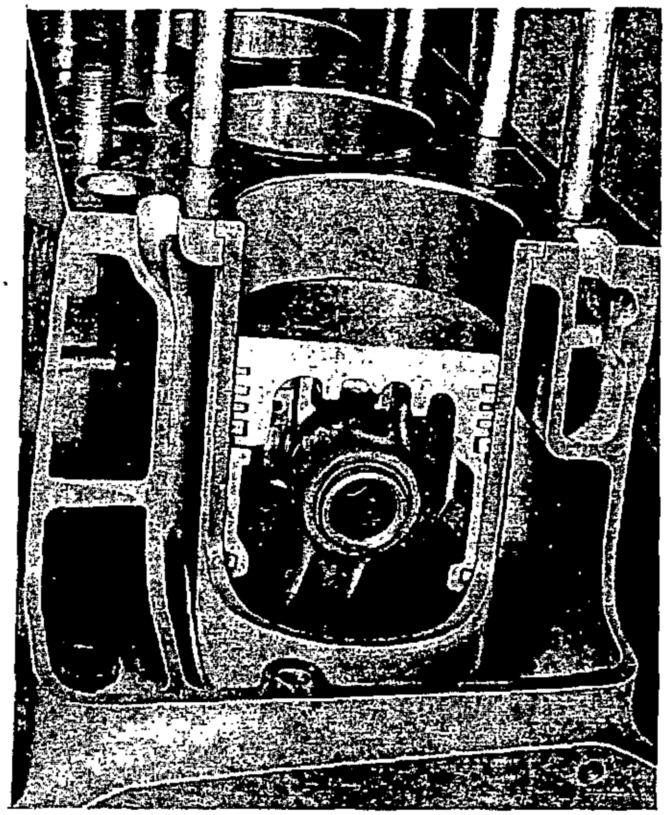


Figure 172—Section Showing Sleeve Installed

PISTONS

Check the piston fit in the bore using a half-inch wide strip of feeler stock, of the thickness specified in the Limits and Clearance Chart, the feeler being attached to a small scale of approximately 15 lbs. capacity.

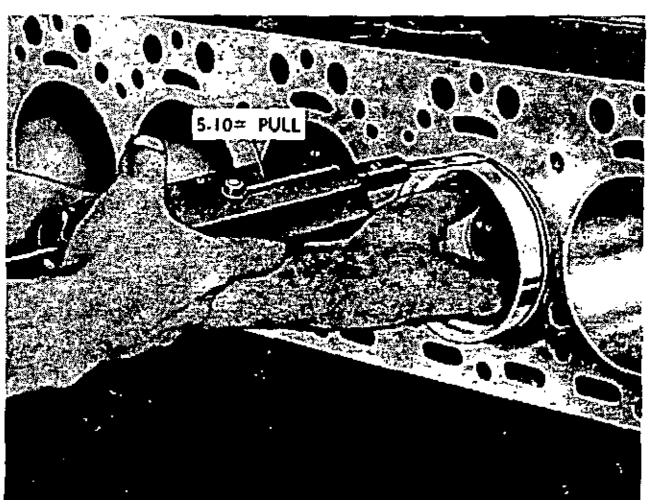


Figure 173—Checking Piston Fit in Bore

When the correct fit is obtained you must be able to withdraw the feeler with a pull of 5-10 pounds on the scale, the feeler inserted between the piston and the cylinder midway between the piston pin bosses where the diameter of the piston is the greatest. Check the fit of the piston when it is approximately 2″ down in the cylinder bore in an inverted position.

PISTON FIT WITH 5 TO 10-LB. PULL

ZD129	.003
GD157	.004
GD193	.005
ED201, ED208	.004
HD260, HD277	.004
JD382	.005

Figure 174—Piston Fit Chart

PISTON RINGS

Check the piston rings in the cylinders for gap regardless of whether you are using a service set of piston rings in cylinder bores which have been ridge reamed and roughed up or if you are using new cylinder liners.

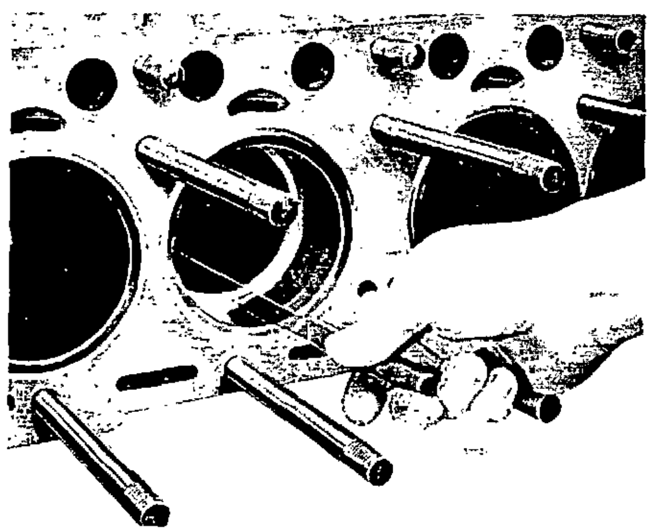


Figure 175—Checking Ring Gap

To do this, insert a piston in the cylinder bore in an inverted position and then insert each ring one at a time about 2″ down in the bore and bring the bottom edge of the piston up against the ring to square it up in the cylinder bore.

Check the gap between the ends of the ring with a feeler gauge in accordance with specifications shown in the Limits and Clearance chart. If any of the rings do not have enough gap, they may

Figure 176—Filing Piston Ring to Increase Gap

be filed either in a ring filing fixture or by clamping the file in a vise and holding the two ends against opposite sides of the file.

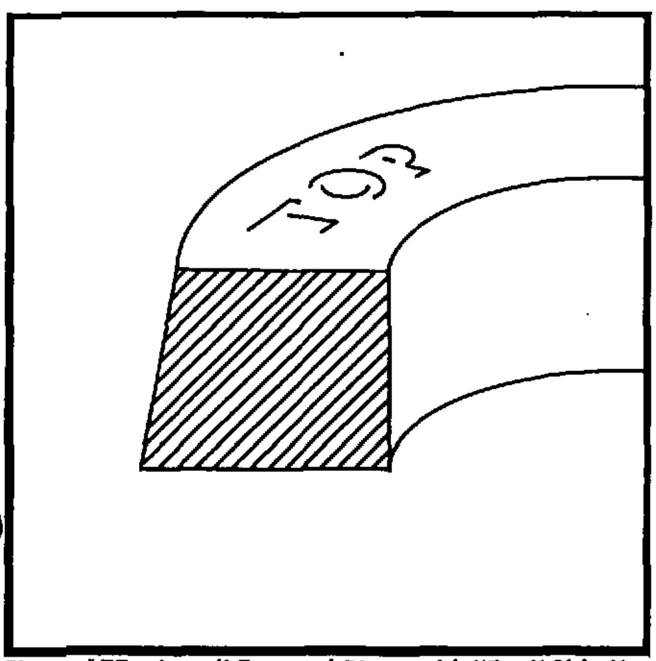


Figure 177—Install Tapered Rings with "Top" Side Up

Tapered piston rings must be installed with "top" side up as shown in illustration.

PISTON RING GAPS

ZD129	.010 - .020
GD157	.010 - .020
GD193	.010 - .020
ED201, ED208	.010 - .020
HD260, HD277	.010 - .020
JD382	.012 - .023

PISTON PINS

Check the bushing in the upper end of the connecting rod for wear. If worn and you are using the original pistons with a service set of rings, an oversize piston pin may be obtained in .003 or .005″ oversize.

The piston pin hole in the piston and the bushing in the connecting rod may be honed to increase their diameter to obtain the desired fit as shown in your Limits and Clearance Chart.

Note that while the chart specifies a light push fit of the pin in the piston, there is a definite clearance of the piston pin in the connecting rod.

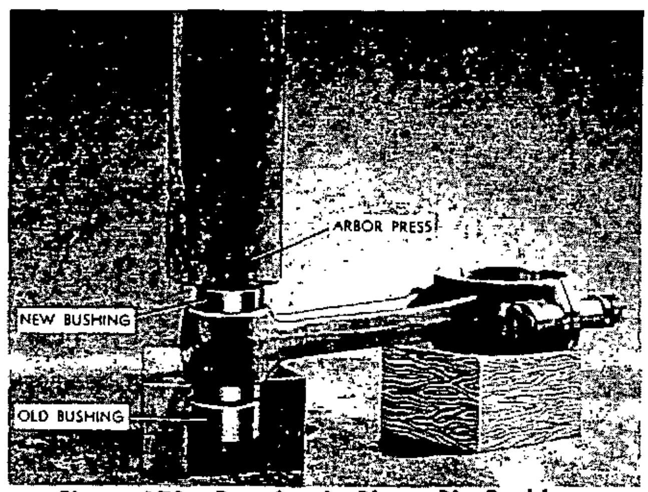


Figure 178—Pressing in Piston Pin Bushing

CONNECTING ROD

Replace the bushing in the connecting rod if new pistons and sleeves are used. Using an arbor press, press out the old bushing and press in the new one — after which the bushing must be honed to obtain the correct fit of the pin in the bushing as shown on Limits and Clearance Chart.

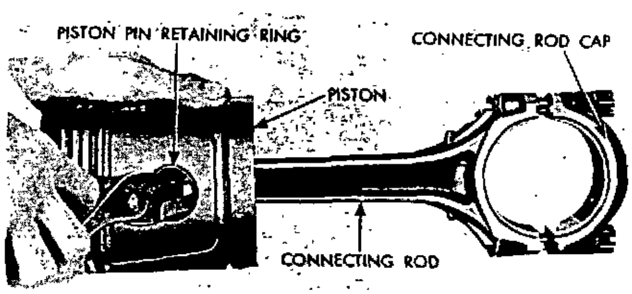
If there is an excess of stock in the piston pin bushing, it may be reamed first, then honed. In any event, the final operation should be done with a hone to obtain the desired fit with better than 75% bearing area on the pin.

ENGINE REPAIR AND OVERHAUL

PISTON AND CONNECTING ROD ASSEMBLY

1. Assemble the pistons on the connecting rod by first heating them in some form of oven or in hot water to a minimum temperature of 160°F. When heated, the piston pin will enter the piston very easily and can be tapped through the connecting rod and into place without distorting the piston.

The snap rings must be assembled in the grooves, making sure they are fully seated in place.



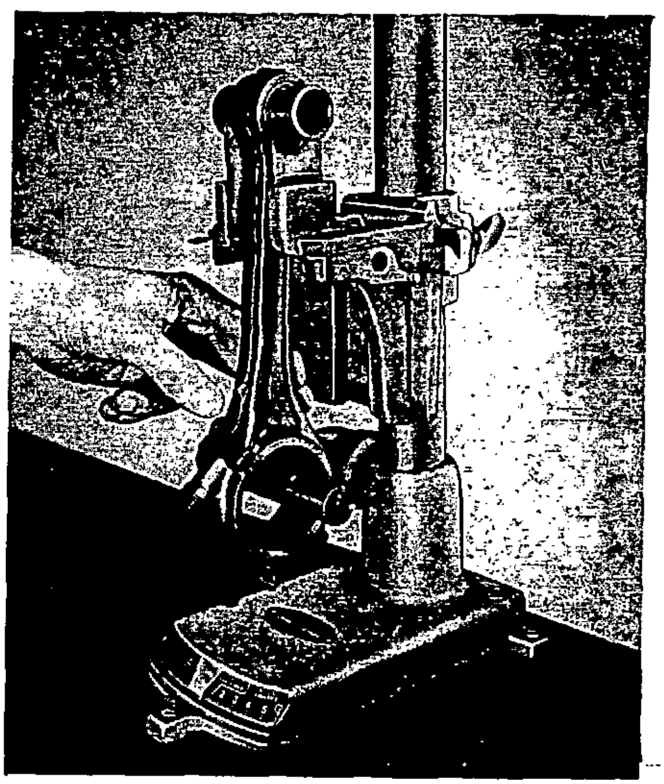


Figure 179—Checking Connecting Rod for Twist

2. The piston pin hole in the connecting rod must be parallel to and in plane with, the large bore in the bearing end of the connecting rod.

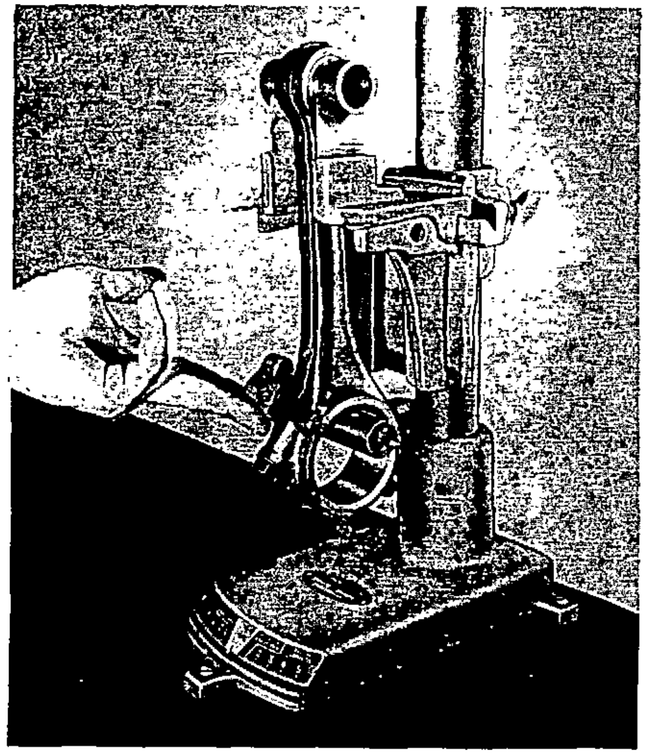


Figure 180—Checking Connecting Rod for Alignment

This may be checked on a fixture with the piston pin assembled in the rod before assembling the piston; but regardless of this preliminary check, the completed piston and rod assembly must be rechecked and there must not be more than .002" twist or out of squareness checked over a spread of approximately 4 inches.

The connecting rod can be bent or twisted to meet this specification.

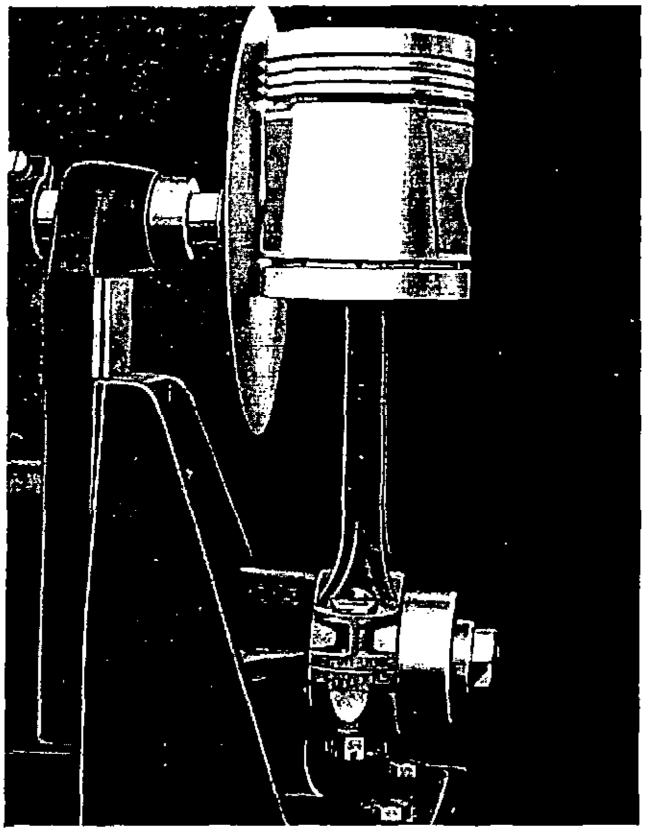


Figure 181—Checking Connecting Rod Assembly for Squareness and Twist

RECOMMENDED METHOD OF INSTALLING PISTON RINGS

1. Grip the connecting rod in a vise with lead lined jaws to hold the piston firmly and roll each ring in its groove to be sure there are no burrs or other interference with the free action of the ring in the groove.

2. Hold the ring tool with recess side up and place the ring in with the bottom side up. Note: Start with the lowest ring first.

3. Position ring in the tool so the expanding fingers will fully engage both ends.

4. Apply pressure on handles so ring is completely expanded. Pass the expanded ring and tool recessed side down over the piston to the proper groove.

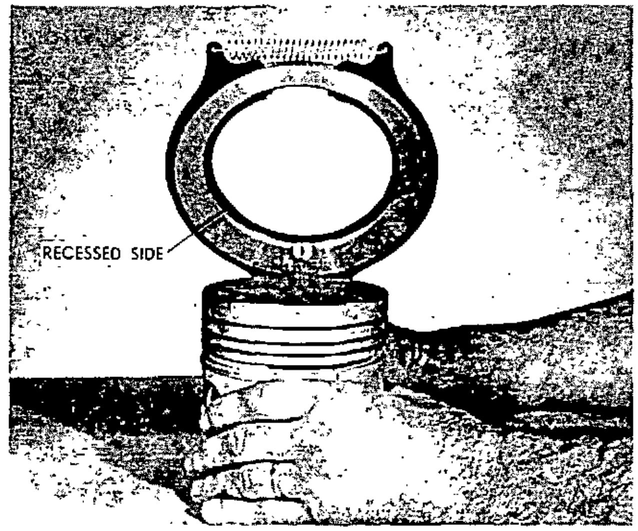


Figure 182—Installing Rings with Ring Expander Tool

5. Check the ring side clearance at various positions with a feeler in accordance with the tolerances shown on the Limits and Clearance Chart.

If any of the rings lack clearance in the grooves they can be removed and lapped on a flat plate, using crocus cloth to narrow them down within the desired clearance.

Figure 183—Checking Ring Clearance in Groove

CRANKSHAFT AND MAIN BEARINGS

1. Remove starting jaw and washer and remove the crankshaft pulley with a puller.

2. Remove the screws holding gear cover to the front of the block as well as those holding the injection pump drive housing to the gear cover.

ENGINE REPAIR AND OVERHAUL

3. Remove the oil pump suction tube preparatory to checking the crankshaft journal and main bearing clearances.

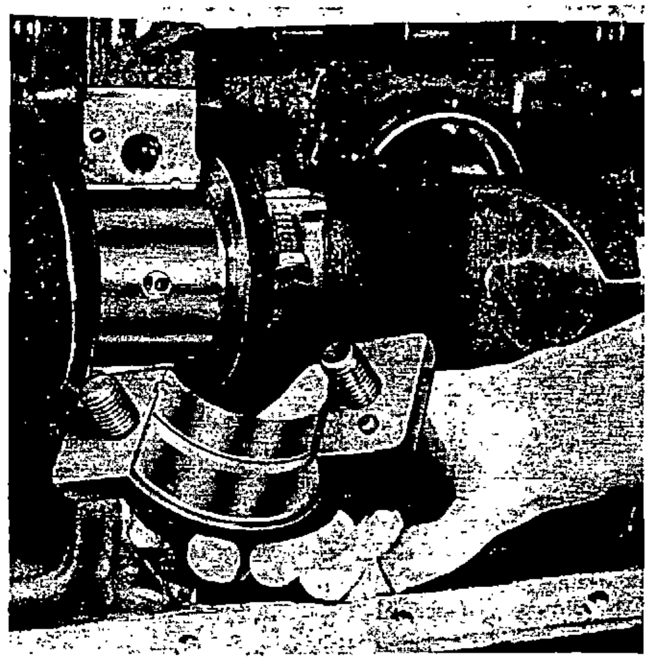


Figure 184—Inspecting Main Bearing and Crankshaft

4. Remove each main bearing cap, one at a time, and inspect the bearing and crankshaft journal.

The main bearings, being lined with a lead-base babbitt, will naturally be a very dark gray, almost black in color.

If there is any indication of flaking out, scoring or actual wear, — **they must be replaced.**

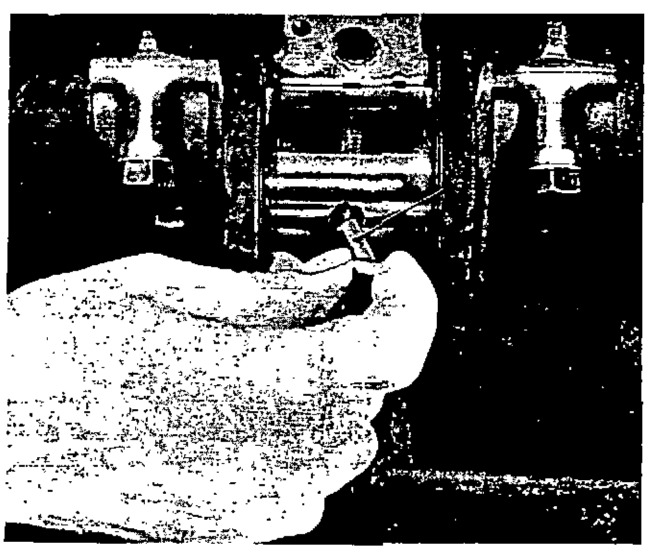


Figure 185—Removing Upper Half of Bearing with Special Tool

5. If the visual inspection appears satisfactory, they should be removed and checked for thickness using a ball micrometer.

To remove the upper half of the bearing shell use a special tool obtainable at most parts houses, which is a pin with an angular head. It may be inserted in the oil hole of the crankshaft and as the crankshaft is turned in a clockwise direction, the head of this pin picks up the bearing shell and forces it out of the bore in the block.

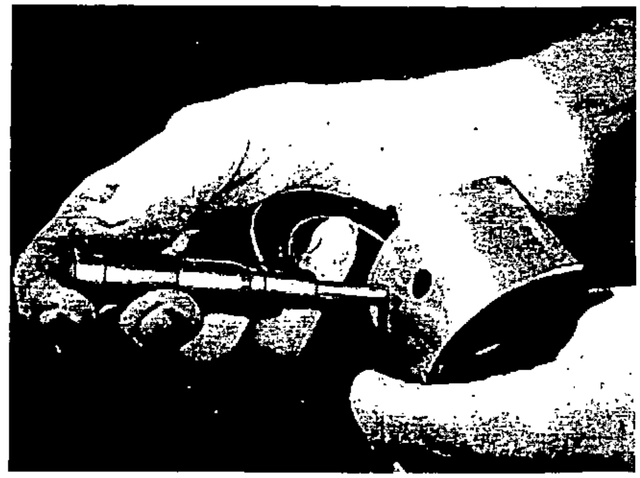


Figure 186—Measuring Bearing Thickness

The thickness of the bearing shells are given in the Limits and Clearance Chart, and if this thickness has been reduced more than .0005, the bearing shell must be replaced.

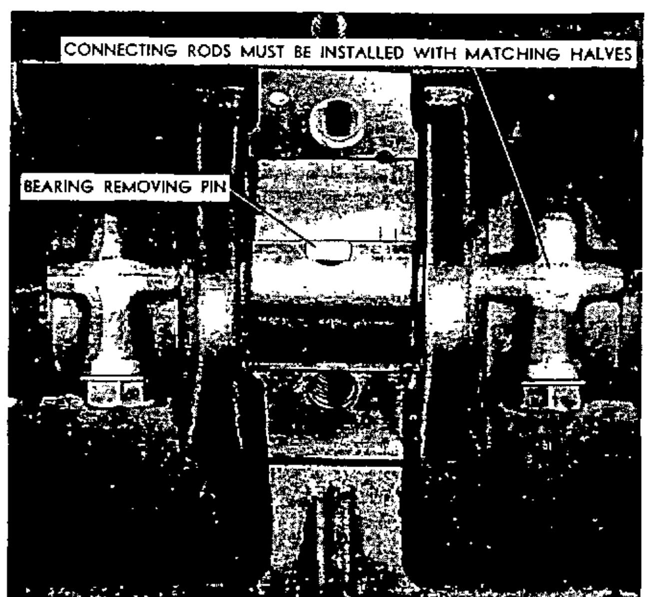


Figure 187—Replacing Upper Half of Main Bearings

6. The crankshaft is either tocco-hardened or nitrided and is subject to very little wear and normally safe to use unless it is scored and cut for lack of lubrication.

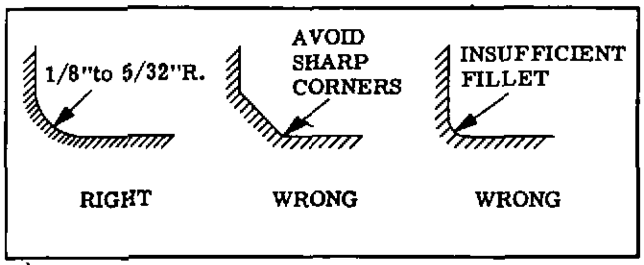


Figure 188—Crankshaft Fillet Radii

If visual inspection of the crankshaft shows no indication of excessive wear or scoring, the clearance of the bearing should be checked, using a piece of feeler stock ½" wide and approximately ⅛" shorter than the length of the bearing, dressing all edges carefully to be sure there are no burrs to mark the bearing.

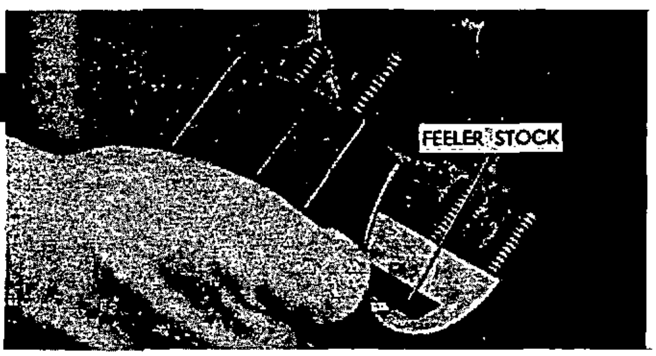


Figure 189—Checking Bearing Clearance with Feeler Stock

7. Check each bearing, one at a time, by laying the above piece of feeler stock (the thickness of which should be equivalent to the maximum clearance permissible in the bearing) lengthwise, in the bearing shell, on a film of oil. Then assemble the bearing cap and tighten the screws, torquing them to the specifications, — then try to turn the crankshaft by hand to determine whether or not you can feel a drag.

If a definite drag is felt and the piece of feeler stock is equivalent to, but no more in thickness than the maximum clearance specified, you may be sure that neither the crankshaft or bearing are worn excessively as far as clearance is concerned.

When using new bearings and the crankshaft is not worn, checking with a piece of feeler stock as outlined above should lock up the crankshaft, making it possible to turn only by use of a bar or wrench.

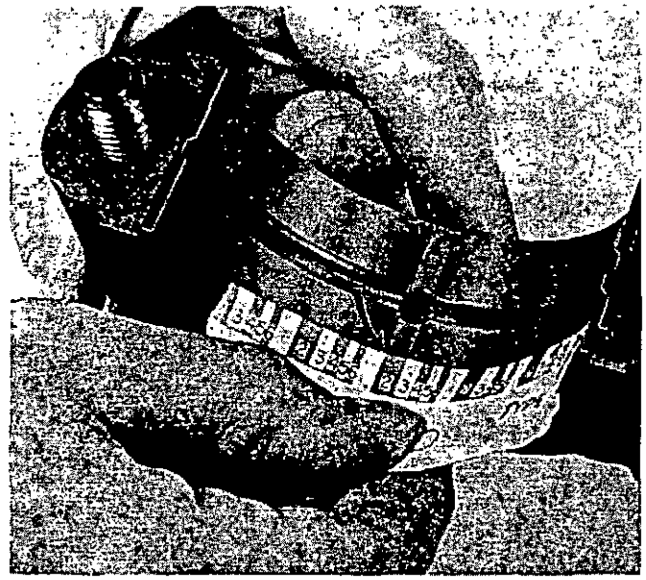


Figure 190—Checking Bearing Clearance with Plastigage

The same check can be made by using a piece of Plastigage of the diameter specified to check certain clearances.

By placing this Plastigage in the bearing and tightening it in place, the width of the Plastigage after crushing determines the bearing clearance as shown on the accompanying chart. When using this method **DO NOT TURN** the crankshaft as that would destroy the plastigage.

If crankshaft is scored, or worn enough so that new bearings will not fit with the required clearance, it should be removed and reground. Tocco-hardened crankshafts may be reground to decrease the diameter a maximum of .040. A reduction of more than .040 reduces the hardened area beyond limits of safety.

Nitrided Crankshafts are hardened over all surfaces to .015"-.025" depth and the bearing surfaces are only polished after this process.

CAUTION: Nitrided shafts must not be reground without re-nitriding.

Preferably, they should be exchanged at our dealers when replacement is required.

Before shaft is reground, it must be checked for straightness and straightened to be within

ENGINE REPAIR AND OVERHAUL

.002 indicator reading. When reground, fillet radii must be within limits and must be perfectly blended into thrust and wearing surface. (See Fig. 188)

8. Connecting rod bearings and crank pins may be checked in the same manner with one exception; instead of trying to turn the crankshaft when the connecting rod bearing is tightened on it with a piece of feeler gauge assembled, try to move the connecting rod from side to side.

When the connecting rod is perfectly free, it will have from .006 to .010" side play and can be moved by a light touch of the fingers. With feeler stock assembled having a thickness equal to the maximum specified clearance, enough drag should be felt so as to require pressure to move the rod from side to side.

Using new bearing shells and feeler stock equivalent to the specified clearance in thickness, if the crank pin is not worn you will quite probably have to use a hammer to move the rod from side to side, indicating that the clearance is well within the specification range.

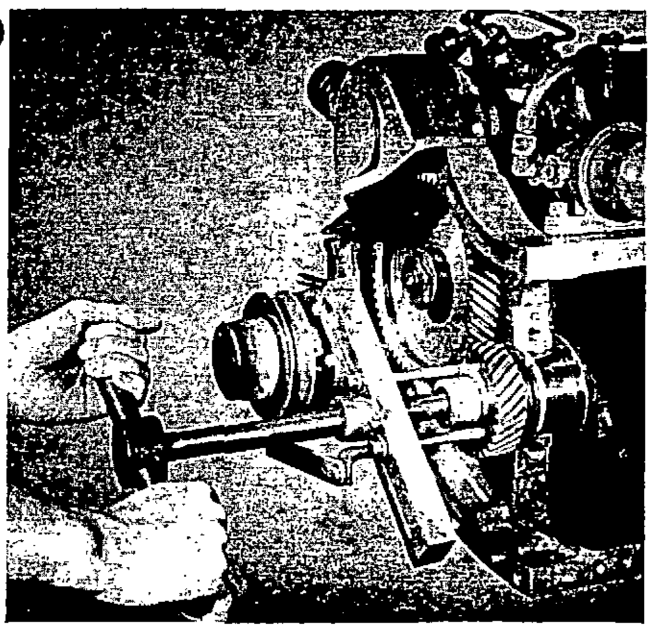


Figure 191—Removing Crank Gear

CAMSHAFT

1. Using a puller, remove the cam and crank gears.

2. Remove the screws holding the camshaft thrust plate to the block which will permit pulling the camshaft forward out of the bearings.

3. Using a 1/4" wide piece of feeler stock with edges dressed to remove any burrs, check the fit of the camshaft journal in the bearing hole or bushing.

If the clearance exceeds 50% greater than the specified maximum, you must then determine where the wear has occurred. This can be done by measuring the bearing journal with micrometers, and if the wear is found to be on the journals, the camshaft should be replaced.

As an alternative, if the camshaft is in good condition otherwise and has no scores or damage to the cam lobes, — the journal may be ground undersize and then built up with hard chrome plate and ground to the original diameter or if necessary an oversize diameter.

If wear is found to be in the bushings instead, these must be replaced using precision service bushings which require no reaming, only care in assembly to line up the oil holes and not to damage the bushings as they are being pressed in.

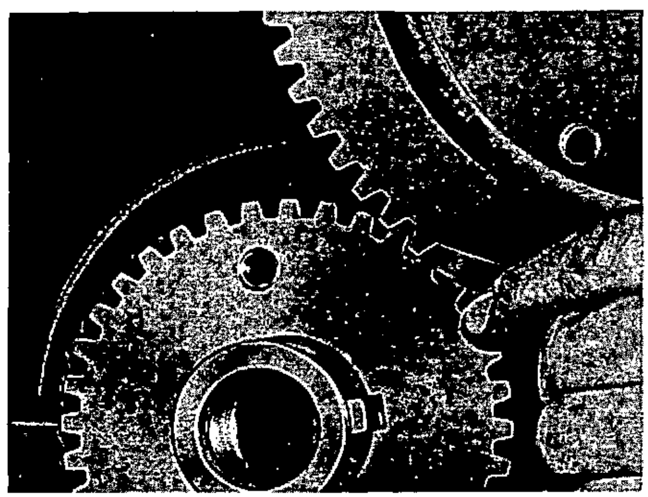


Figure 192—Checking Backlash of Timing Gear

TIMING GEARS

1. Timing gears and timing gear fits must be checked carefully while the engine is being overhauled. To check the fit, use a screw driver to force the mating teeth as far apart as possible and check this clearance with a feeler gauge. If this clearance is .002" or greater, or if the gear teeth are badly scuffed and worn, the gear must be replaced.

Camshaft gears marked similar to the original as far as sizes are concerned should be used as replacements.

2. Examine the camshaft thrust plate carefully for scoring and wear and if any indication of either shows, a new thrust plate should be assembled without question.

3. Assemble the cam gear to the camshaft by

holding the camshaft forward so that in driving or pressing the gear on there is no possibility of the camshaft bumping the expansion plug at the rear end and forcing it out of position, thus causing an oil leak.

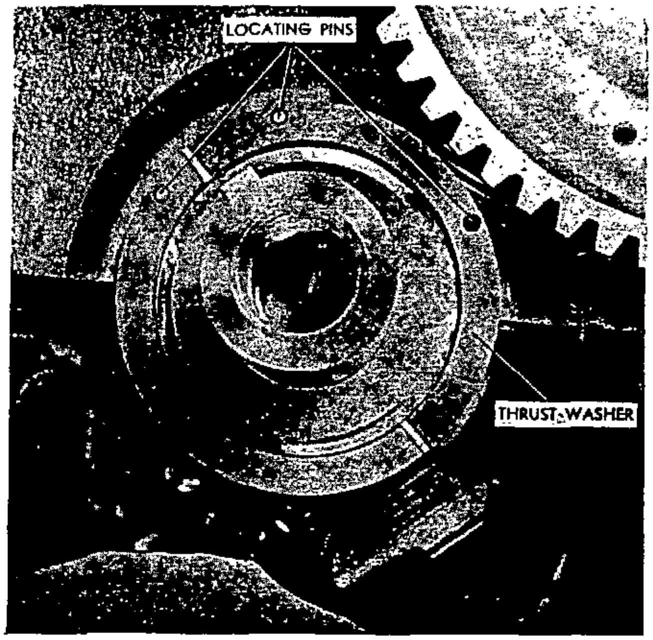


Figure 193—Crankshaft Thrust Washer
(Front Bearing Thrust)

4. Inspect crankshaft thrust washers for wear and scoring. Replace if necessary before reassembling gear.

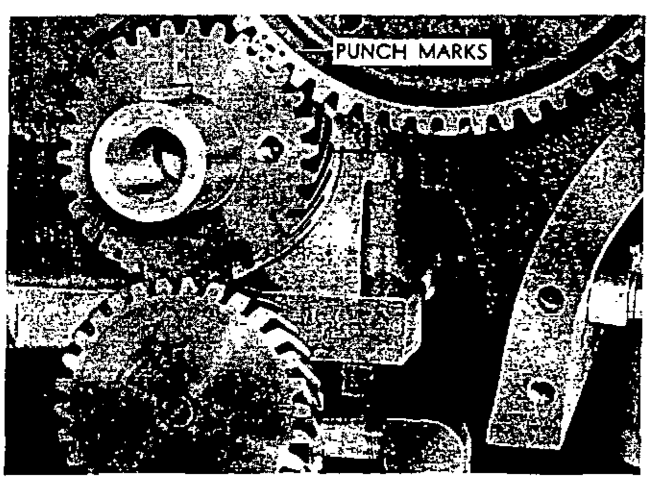


Figure 194—Timing Gears Assembled According to Timing Mark

5. Drive the crank gear on the shaft making sure that the marked teeth on the cam gear straddle the marked tooth on the crank gear, which assures you of the crankshaft and camshaft being in time.

6. Check for clearance with the above gears assembled in place, since it may be possible that it is not within specifications. Repeat the operation previously outlined. Using a screwdriver pry the teeth as far apart as possible and check the clearance with a feeler gauge. If a .002" feeler will not enter the gap the clearance is not excessive.

To be certain that there is enough clearance, hold your finger at the junction of the two gears and with a light hammer tap the rim of the cam gear and note if there is vibration felt at this point.

If there is vibration and a .002" feeler gauge will not enter the gap between the two gear teeth, the gear fit is within specifications.

7. Crankshaft gears and camshaft gears are furnished in standard and under and over sizes. Gears marked "S" are standard; if they are marked with figures "1" or "2" in a letter "U" this signifies undersize. If they are marked with figures in the letter "O" this signifies oversize.

Gears can be selected to give the desired fit. Always assemble a new lock and tighten the cam nut firmly, drawing up to specified torque. Turn the lock over so that the nut is firmly locked in place.

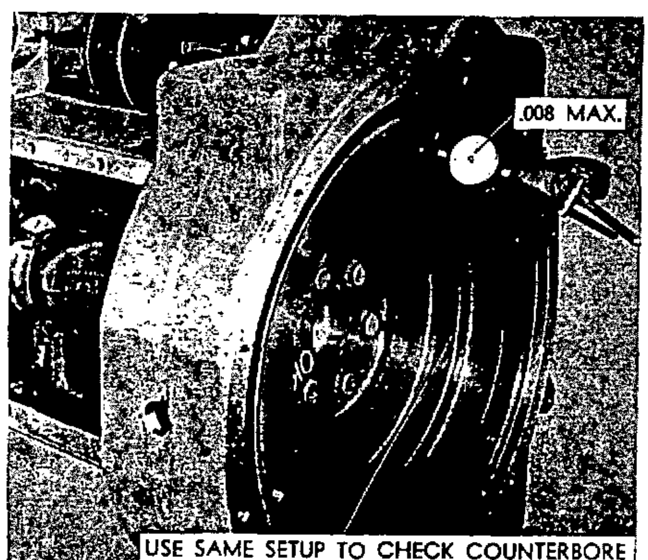


Figure 195—Checking End Play

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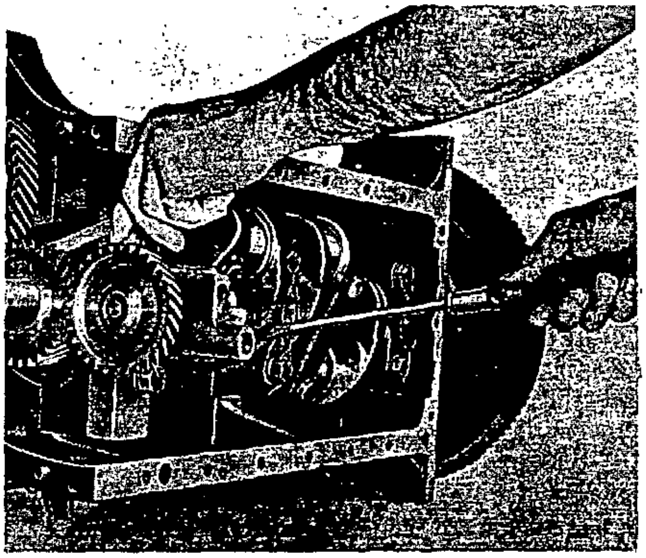

*Figure 196—Alternative Method of Checking Crankshaft End Play with Feeler Gauge**

CRANKSHAFT END PLAY

1. Check the crankshaft end play before replacing the gear cover. A shim pack containing shims of .002" and .008" thickness is incorporated in the assembly between the front end of the main bearing journal and the crank gear and by removing or adding shims, this end play can be corrected to fall within the specifications.*

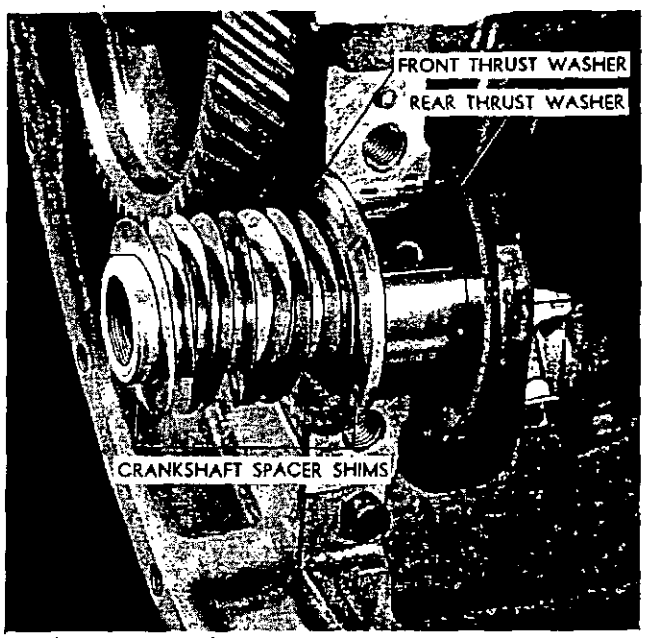

*Figure 197—Thrust Washers & Shims Controlling Crankshaft End Play**

At all times when checking end play, the crank gear must be tightened firmly against the shim pack, which can be done by using a sleeve or the regular pulley, slipping it over the crankshaft and using the standard assembly parts to tighten the pulley and gear in place.

FRONT OIL SEAL

Check the front oil seal carefully to determine whether or not it is damaged. If it has been damaged, replace it.

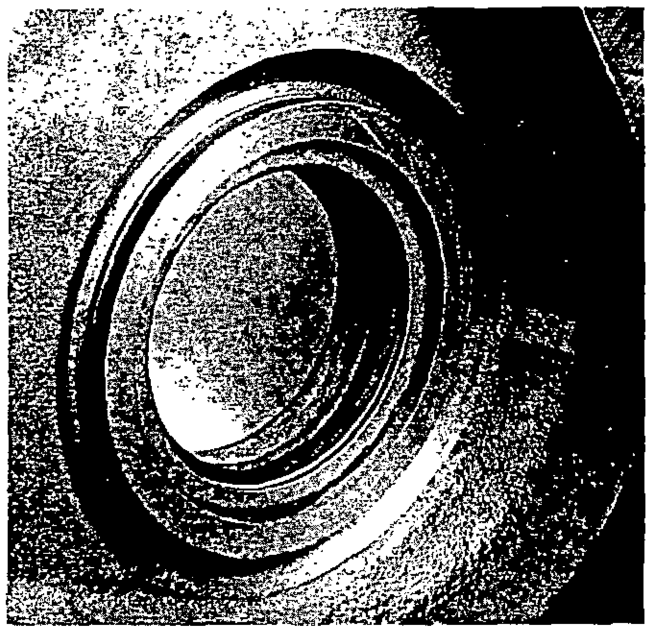

Figure 198—Crankshaft Front Oil Seal

If the oil seal is in good condition and shows no sign of cuts or excessive wear, it may serve satisfactorily through another period of operation provided the contact surface on the fan drive pulley is in good condition.

Examine this surface very carefully since any roughness or scratches of any kind will cause an oil leak and eventually damage the seal.

If the surface is damaged and the pulley is otherwise satisfactory, it may be salvaged by building up the damaged surface and the contact area by brazing, then turning the surface again to the specified size and polishing it very carefully.

Another method of salvaging the fan drive pulley hub is to turn the surface down in diameter and shrink on a steel sleeve, finishing the O.D. to the original specification and carefully polishing it.

If this is done, make certain there are no rough edges left to damage the seal during assembly. If the belt surfaces in the pulley are damaged, replace the pulley without question.

*Present production of many models include center thrust flange bearing and no shims are used; end play is automatically controlled by the thrust faces of the flange bearing.

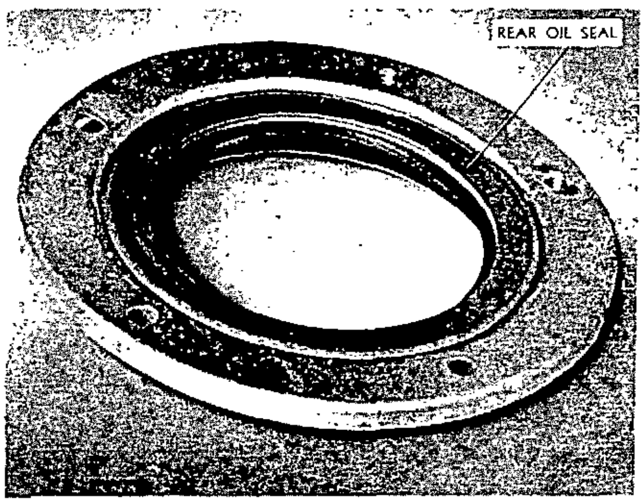

Figure 199—Rear Oil Seal (Spring type)

REAR CRANKSHAFT OIL SEALS

All of the four-cylinder Continental Diesel engines except the HD-260 and the JD-382 use the "spring" type oil seals to keep the dust out and the oil in. The seal contacts the polished surface of the crankshaft flange and is pressed into a seal retainer which bolts to the rear of the cylinder block.

Replacement of worn rear oil seals of this spring type, should be done as follows:

1. Remove cap screws mounting the seal retainer to the block.

2. Remove old oil seal with a driver which fits the seal.

3. Press in new oil seal using driver so as not to damage seal assembly — with the scraping edge of seal contact next to the engine.

4. Examine carefully the surface on which the seal makes contact. Any scratches or other damage to this surface must be polished out before reassembly of seal, otherwise it will be damaged and become ineffective.

5. Mount retainer and oil seal assembly on block.

HD-260 and JD-382 Diesel engines have the rear crankshaft oil seals incorporated in the rear crankshaft bearings. The rear bearing cap acts as a filler block as well. There are three types of installations; each of which are handled as follows to insure correct installation of new seals when needed, depending upon serial number of engine:

GROUP #1 INSTALLATION

HD-260 (All serial numbers from #1 — #6332).

JD-382 (All serial numbers from #1 — #1031).

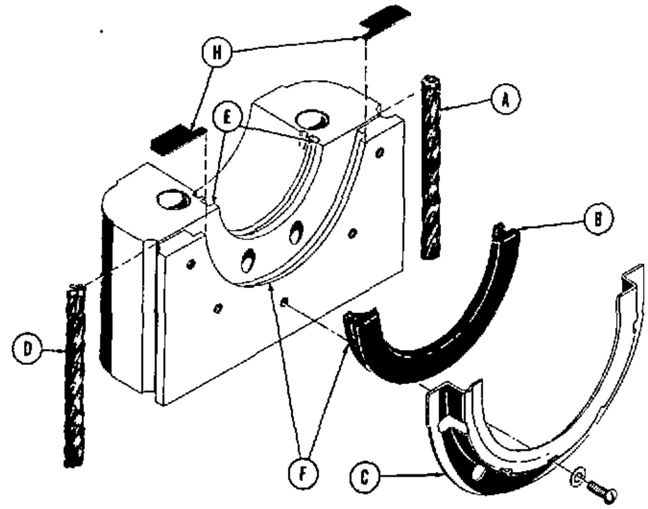

Figure 200—Filler Block and Seals

> **CAUTION:** These instructions **MUST** be followed **exactly** to obtain a satisfactory installation!

1. Remove rear main bearing cap by using puller as shown in figure 201. As the cap is pulled, tilt forward to clear flywheel housing.

2. After removal of old seals thoroughly clean all surfaces with which they make contact.

3. Use rubber cement to cement gaskets "H" to top of bearing cap.

4. Break sharp edge slightly on main bearing cap "E" and do likewise on engine block to avoid cutting the seals during installation.

5. Install crankshaft seal "B". Flange "F" on main bearing cap as well as on the engine block must fit into groove "F" in the oil seal "B".

6. Install retainer "C" on bearing cap. Tighten screws securely. (Only one metal retainer (C) is required.)

7. Oil Seal "B" can be installed without removing the crankshaft. Make certain the ends on the engine block are prepared as outlined in Item 3. Use only light grease in groove of oil seal

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"F". This will assist in sliding the seal into place. Pressure should be applied to the oil seal so the oil seal will hug the crankshaft which will aid greatly in sliding the seal into place.

8. Exercise care when installing the main bearing cap with the metal retainer "C" in place to avoid damage to the oil seal "B". The metal retainer must slide over the ends of the oil seal in the engine block.

9. Coat each butting end of the oil seal with a light coat of rubber cement; allow to become tacky before assembly.

10. Install rear bearing cap.

11. Coat packing "A" & "D" with a non-hardening cement such as No. 2 Permatex and drive in place with a punch as shown in drawing.

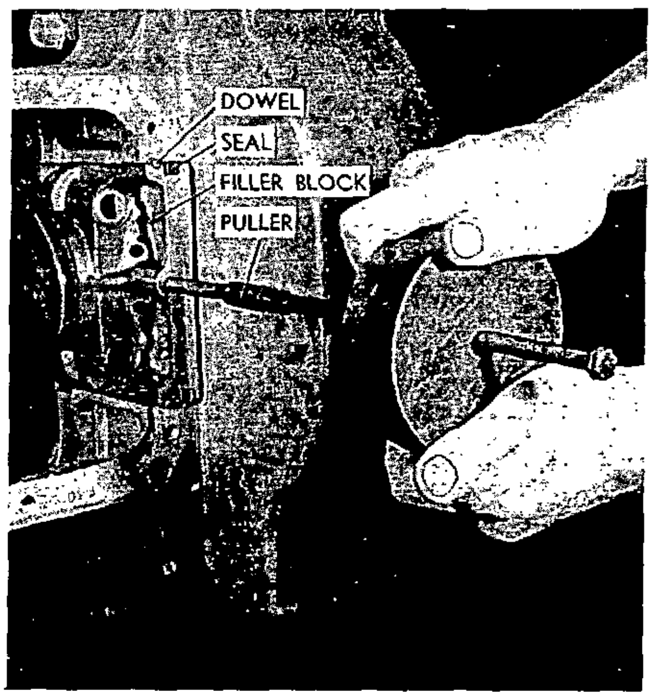

Figure 201—Removing Rear Oil Seal HD-260 & JD-382

GROUP #2 INSTALLATION

HD-260 (All serial numbers from #6332 — #10591).

JD-382 (All serial numbers from #1031 — #3590).

Engines included in both Group #2 and Group #3 serial numbers use moulded Neoprene side seals "A" and "D" instead of the wick type used in Group #1 and Group #2 differs only

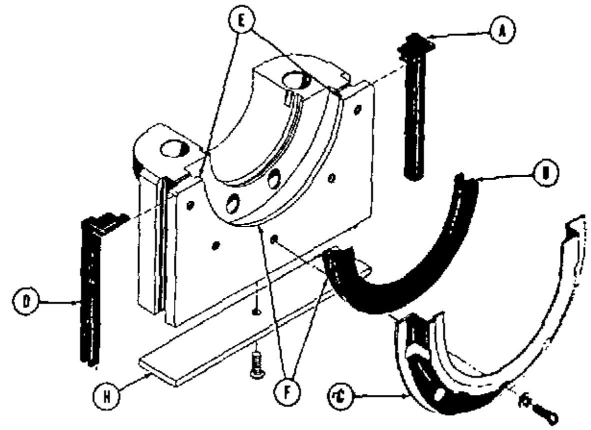

Figure 202—Filler Block and Seals

from Group #3 and present production in that the side seals "A" and "D" are of different section. — However, the installation method is exactly the same as given under Group #3.

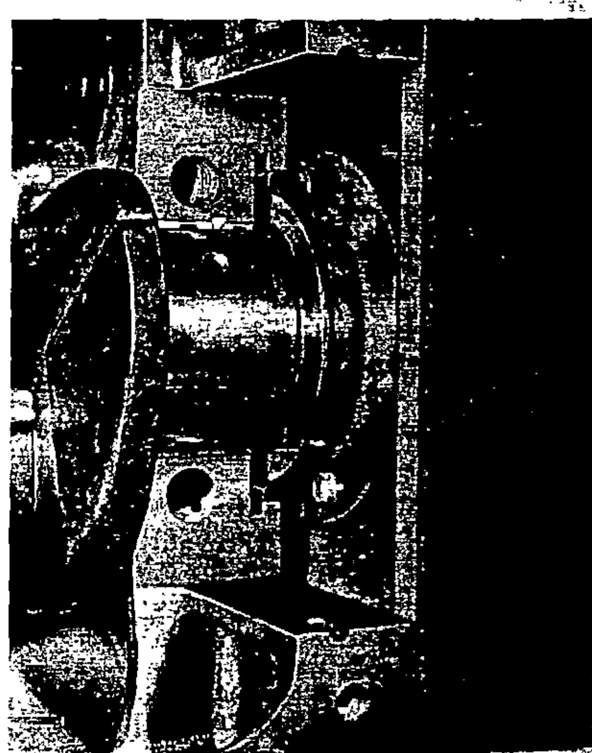

Figure 203—Rear Bearing Filler Block & Bearing Cap Removed Showing Position of Seal in Place on HD-260 & JD-382

GROUP #3 INSTALLATION

HD-260 (All serial numbers from #10592 and up).

JD-382 (All serial numbers from #3591 and up).

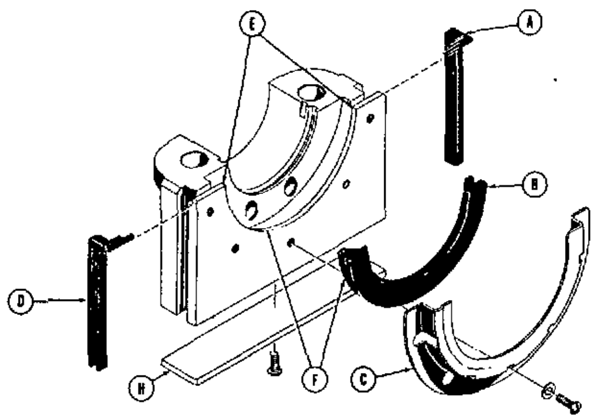

Figure 204—Filler Block and Seals

CAUTION: These instructions **MUST** be followed **exactly** to obtain a satisfactory installation!

1. Remove rear main bearing cap by using puller as shown in illustration. As the cap is pulled, tilt forward to clear flywheel housing.

2. After removal of old seals thoroughly clean all surfaces with which they make contact.

3. After adding a thin coat of clear shellac install side seals "A" & "D" in bearing caps as shown above.

4. Break sharp edge slightly on main bearing cap "E" and do likewise on engine block to avoid cutting the seals during installation.

5. Install crankshaft seal "B". Flange "F" on main bearing cap as well as on the engine block must fit into groove "F" in the oil seal "B".

6. Install retainer "C" on bearing cap. Tighten screws securely. (Only one metal retainer (C) is required.)

7. Oil Seal "B" can be installed without removing the crankshaft. Make certain the ends on the engine block are prepared as outlined in Item 3.

Use only light grease in groove of oil seal "F". This will assist in sliding the seal into place. Pressure should be applied to the oil seal so that it will hug the crankshaft which will aid greatly in sliding the seal into place.

8. Exercise care when installing the main bearing cap with the metal retainer "C" in place to avoid damage to the oil seal "B". The metal retainer must slide over the ends of the oil seal in the engine block.

9. Use strip of steel "H" to hold seals "A" and "D" temporarily in place when reassembling bearing cap.

10. Coat each butting end of the oil seal with a light coat of rubber cement; allow to become tacky before assembly.

11. Install rear bearing cap.

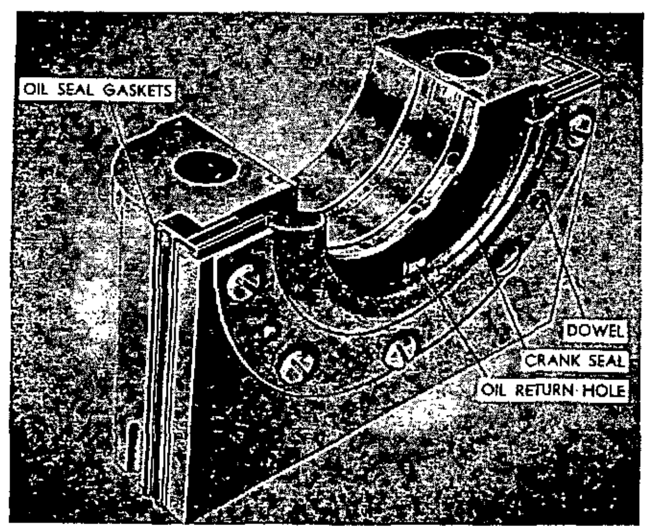

Figure 205—Rear Bearing Cap & Filler Block Showing Seal in Place (HD, JD)

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Figure 206—Reassembling Rear Oil Seal (HD, JD)

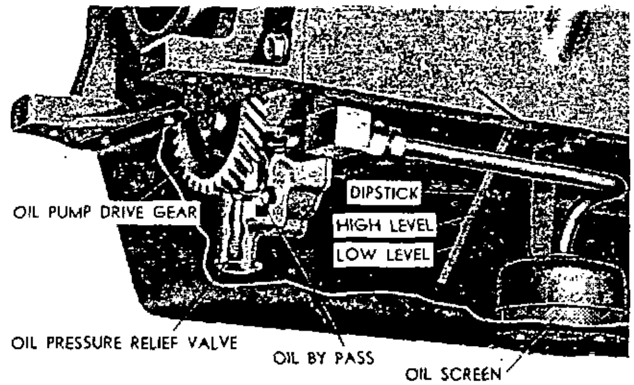


Figure 208

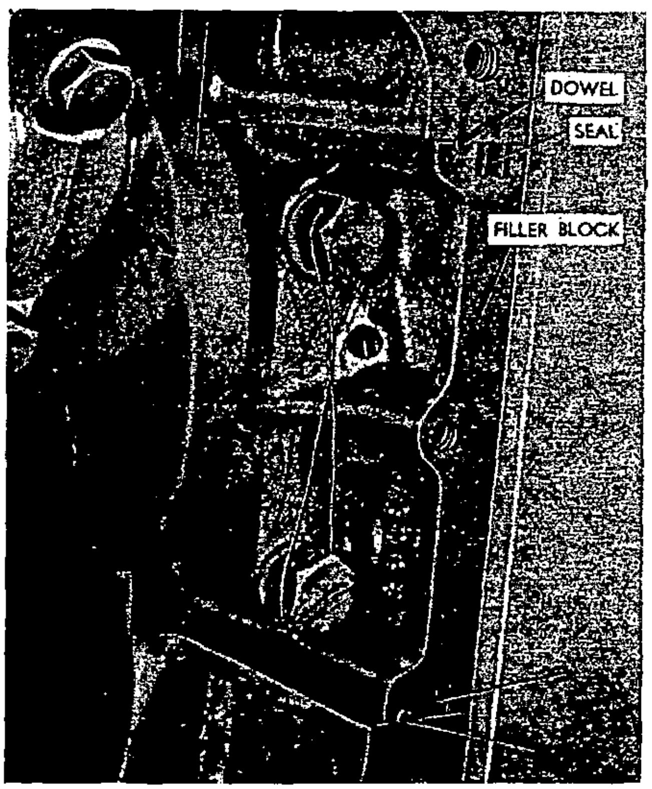
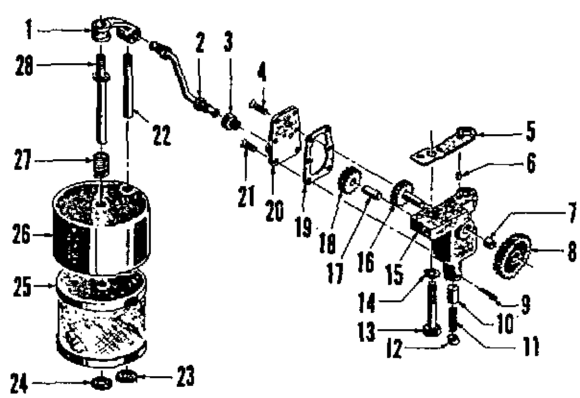


Figure 207—Rear Bearing Filler Block Showing Lock Wires in Place

OIL PUMP

The oil pump assembles to the front main bearing and is held in place by the main bearing cap screws. The oil pump drive gear meshes with and is driven by the crankshaft gear. These gears have a specified drive or clearance fit, which must be checked when reassembling the engine to be sure that it falls within the specifications.



1. Inlet tube support
2. Inlet tube assembly
3. Fitting
4. Screw
5. Shim
6. Pin
7. Bushing
8. Driver Gear
9. Cotter Pin
10. Relief Valve
11. Relief Valve Spring
12. Spring Retainer
13. Screw
14. Washer
15. Body Assembly
16. Drive gear and shaft assembly
17. Stud
18. Idler Gear
19. Gasket
20. Cover
21. Screw
22. Suction Tube
23. Felt Washer
24. Felt Washer
25. Oil Strainer Assembly
26. Cover
27. Spring
28. Tube Assembly

Figure 209

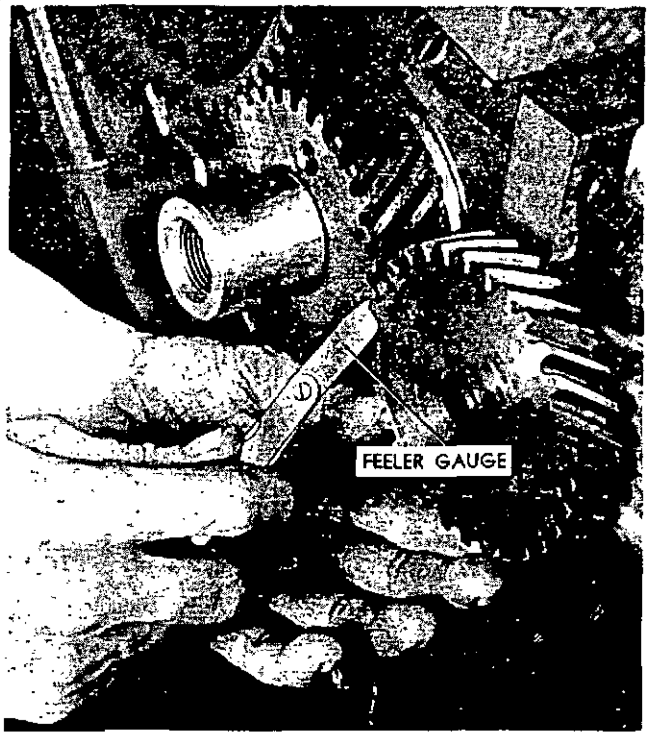


Figure 210—Checking Backlash Between Crank Gear and Oil Pump Drive Gear

Shims are available for adjusting the center distances of the oil pump and crankshaft gears so that correct clearances can be maintained.

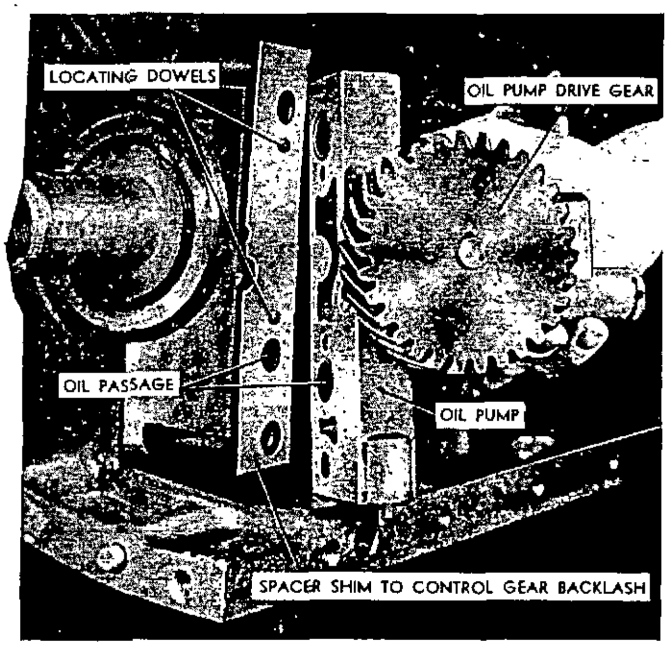


Figure 211—Removing Oil Pump

The oil pump is of the gear type and while it is removed, the oil pump gears should be inspected for excessive wear of the gear teeth as well as any possibility of the gears rubbing the oil pump body or cover — either of which would require overhauling the pump.

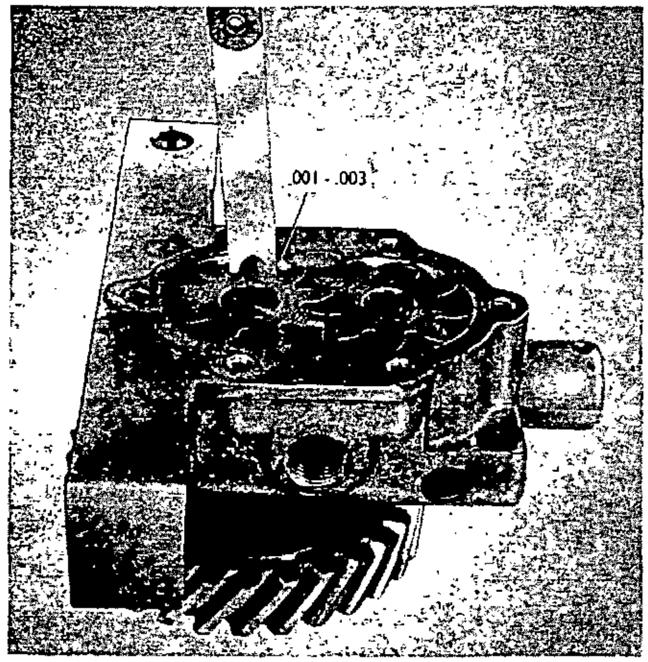


Figure 212—Checking Oil Pump Gear Clearance in Body

New gears, a new shaft, or if severely damaged, even a complete new pump may be necessary to restore dependable lubrication of the engine — which must be determined by careful inspection of the parts.

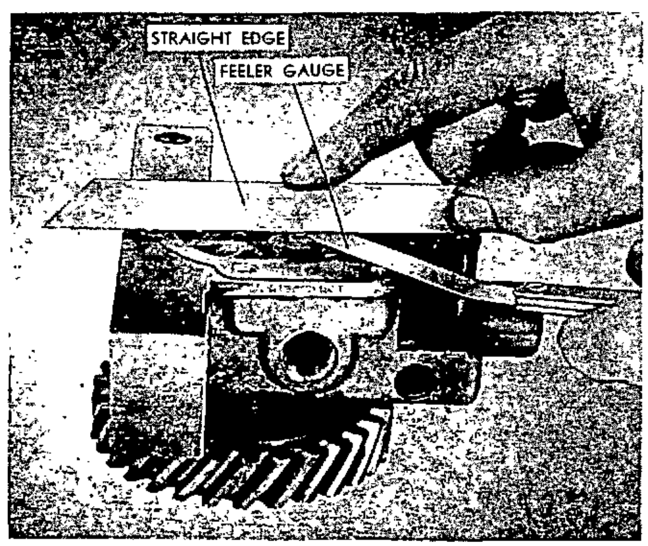


Figure 213—Checking End Clearance

The oil pressure is regulated by a pressure regulating spring. The normal pressure at operating speed is 30-40 pounds* and approximately 10 pounds at idle.

Whenever the pressure is below these limits

*on the ED series, it is 10-20#.

ENGINE REPAIR AND OVERHAUL

or fluctuates, *stop the engine* — find the cause and correct it before severe engine damage results. Usually the trouble will be no oil in crankcase, broken or loose lines or a clogged strainer screen.

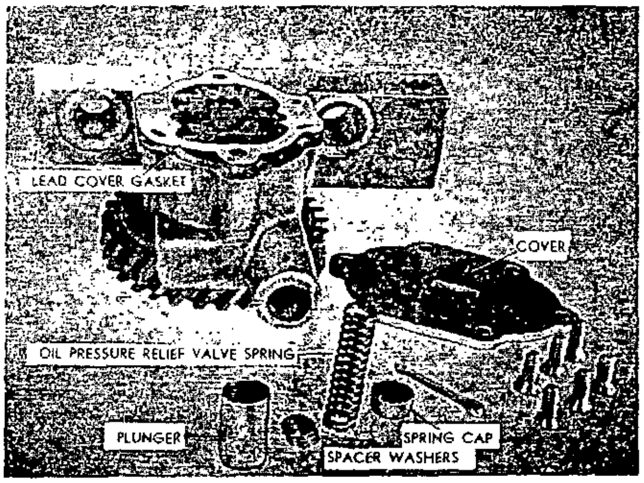


Figure 214—Oil Pump Disassembled

FLYWHEEL AND FLYWHEEL HOUSING

The flywheel is machined and balanced so that the clutch face or locating counterbore will run true with its axis.

To be sure that the crankshaft flange has not been sprung or otherwise damaged or that the counterbore in the flywheel, which locates it on the crankshaft, is not damaged, mount an indicator on the flywheel housing and check the flywheel for runout.

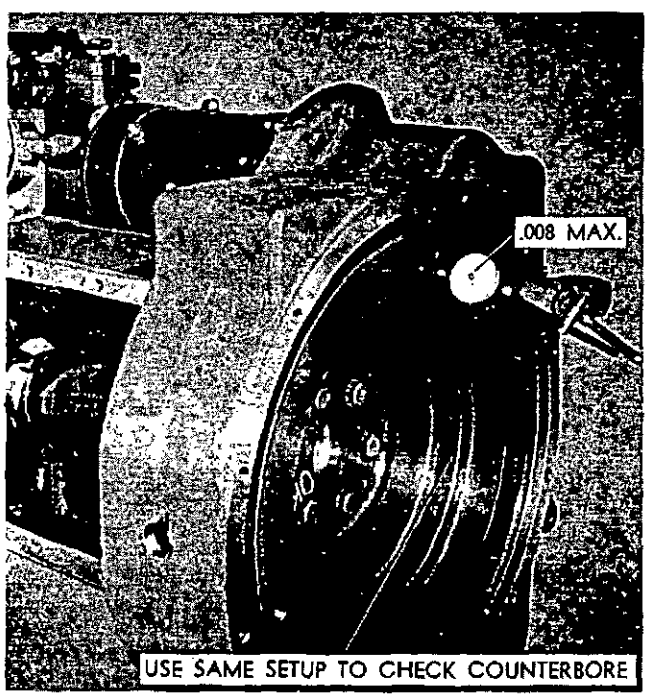


Figure 215—Checking Flywheel Runout

The indicator should be set up so that it contacts the clutch face or the vertical surface of the clutch counterbore, then turn the flywheel at least one full revolution at the same time holding against the crankshaft to offset the possibility of end play.

Re-locate the indicator to check the inside diameter of the counterbore. In both cases the maximum indicator reading must not be more than .008.

If more than one engine is being rebuilt at a time, the housing should be identified with its original cylinder block and should be reassembled to that block in the rebuilding process.

When assembled, mount the indicator on the flywheel so that it contacts the housing face and turn the crankshaft, at the same time holding against it to counteract end play. The maximum indicator reading must not exceed .008.

Re-locate the indicator to contact the housing bore and check this in the same manner. The same run-out limits prevail.

Dirt or nicks in the flywheel counterbore is the most prevalent cause of run-out of this part.

REASSEMBLING ENGINE

In the foregoing, we have outlined procedures for checking, repairing or replacing the many wearing parts in the engine.

In most cases, the instructions have covered the reassembly of parts or subassemblies made up of several parts.

When reassembling pistons and connecting rods, use a good ring compressor and oil the bores thoroughly. A hammer handle may be used to bump the pistons out of the ring compressor into the cylinder bore.

Once more, we call attention to care demanded to prevent connecting rods damaging the

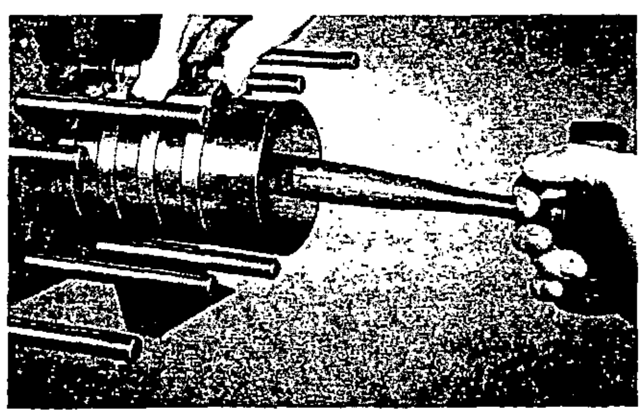


Figure 216—Assembling Piston in Cylinder

cylinder bore finish and at the same time as they are assembled on the crank pin, locate them carefully in order to protect the bearing surfaces.

Always lubricate the bearings with clean engine oil when assembling, and tighten them to the torque specified. Use lockwires, cotter pins or lockwashers as required to prevent nuts and screws from loosening.

Assemble the oil pan with new gaskets cemented in place. Tighten screws in accordance with limits prescribed in torque chart — to avoid looseness or overstressing.

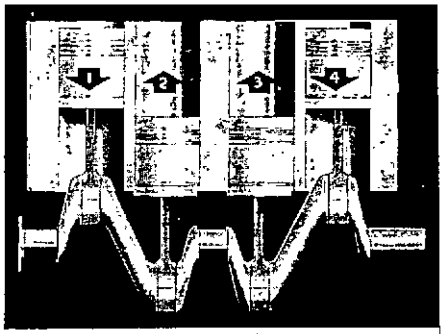


Fig. A

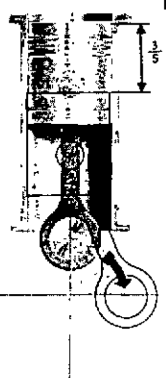


Fig. B
Upper half of the downward stroke

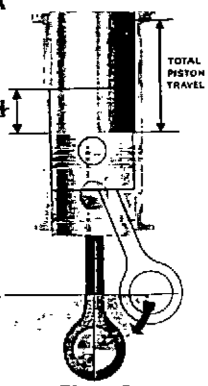


Fig. C
Lower half of the downward stroke

LANCHESTER BALANCER

The Lanchester Balancer is a balancing mechanism that is used on the "HD" and "JD" Diesel engines to provide smooth operation on engines operated above normal speeds for increased power and torque applications.

This balancer assembly consists of two counterweight gears mounted on a shaft, which is driven off the crankshaft gear at twice engine speed. This assembly is mounted to the engine crankcase and must be timed in relation to the engine firing order.

An integral oil pump assures full pressure lubrication to all bearings and full flow filtration provides a constant source of clean oil.

PRINCIPLE OF OPERATION

Although the two sets of pistons in a 4 cylinder "In-Line" engine are equal in weight, and move in opposite directions, their inertia forces do not fully neutralize one another — Fig. A.

This is caused by the pistons traveling farther and faster in the upper half of the downward stroke than they do in the lower half as shown in Fig. B and C.

The acceleration differences of the two sets of opposite moving pistons cause unbalanced secondary forces at twice engine speed — which are cancelled out by the balancer exerting an equal counteracting force — which is graphically shown on the following schematic drawing:

SCHEMATIC DRAWING SHOWING BALANCER OPERATION

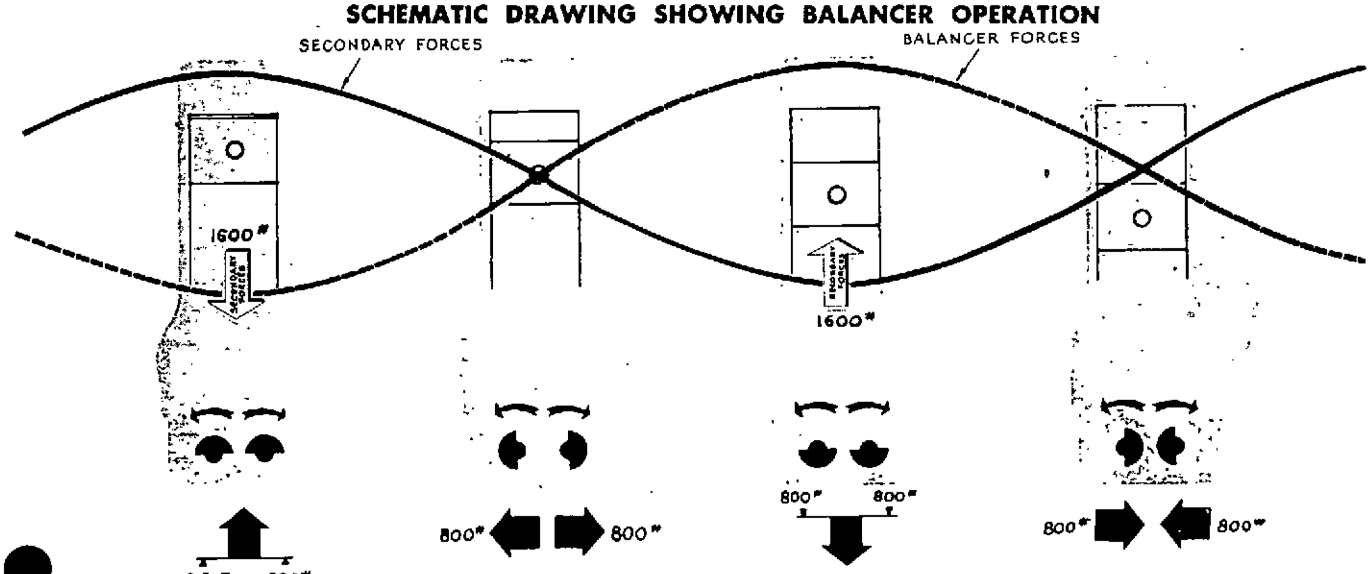


Fig. D
Pistons 1 and 4 at T.D.C.
The total downward secondary force is 1600 lbs. This is balanced by the two counterweights exerting an equal upward force.

Fig. E
45° after T.D.C.
Secondary forces are cancelled out due to the position of the pistons.

Fig. F
90° after T.D.C.
Secondary forces exert a total upward force of 1600 lbs. This is balanced by the downward force created by the two counterweights.

Fig. G
135° after T.D.C.
In this illustration secondary forces are cancelled out due to the position of the pistons.
The four operations shown here are repeated to complete one revolution of the crank.

LANCHESTER BALANCER
INSTALLATION AND TIMING INSTRUCTIONS

WARNING
It is imperative that these Instructions are followed implicitly, since severe damage to Engine and Balancer may occur if it is not TIMED correctly.

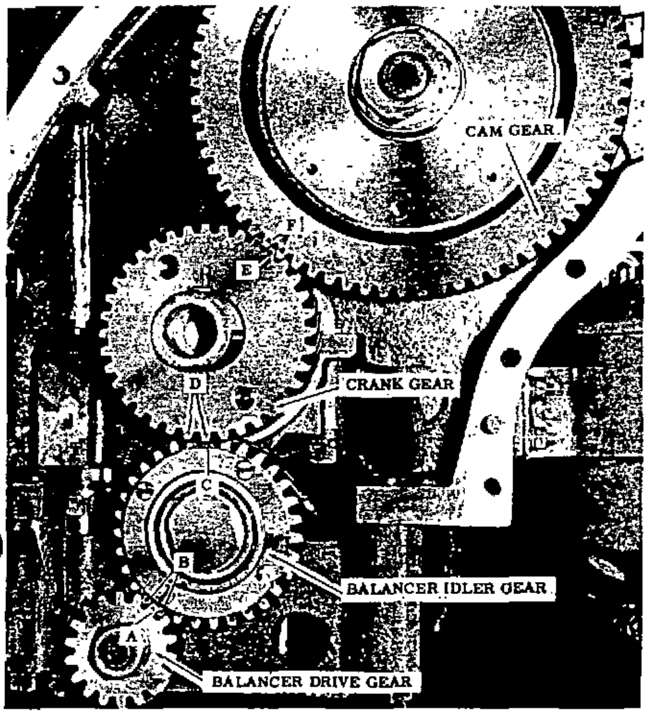


Fig. H — Timing Gear Drive

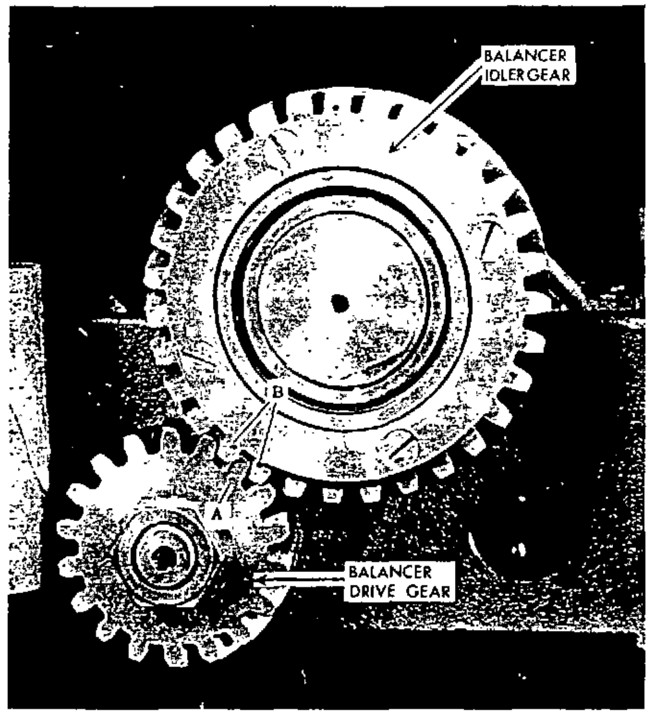


Fig. J — Timing Balancer Drive Gear

1 — Turn engine until #4 piston is on top dead center when on compression stroke — check by removing valve cover and turning both push rods by hand, indicating that both valves are closed.

2 — Check that the two marked teeth on cam gear "E" will straddle the marked tooth on crank gear "F" — which shows that the camshaft and crankshaft are in time.

3 — Note the two punch marks or beveled teeth on the lower portion of crankgear "D" — which must line up with the balancer idler gear "C". (See Fig. H)

4 — With the balancer assembly removed from the engine and facing the gear drive — rotate the gears by hand until the two punch marks on idler gear "B" straddle the mark on the balancer drive gear "A". (See Fig. J)

Note: Due to the balancer gear ratio — the two gears line-up only every 32 turns — so it may be necessary to rotate the gears several turns.

5 — Mount the complete balancer assembly to the crankcase with the cap screws only finger tight to hold in place. The "HD" balancer requires six cap screws and the "JD" balancer has four cap screws.

6 — With balancer in this position, line up marked tooth on top of idler gear "C" with two marked or beveled teeth on lower end of crank gear "D".

Important — Make certain that all gear drive timing marks are in line as shown above.

7 — Tighten cap screws to engine crankcase as follows:

HD Models (7/16 - 14 thread) —
Torque to 42 - 47 foot pounds.

JD Models (5/8 - 11 thread) —
Torque to 125 - 130 foot pounds.

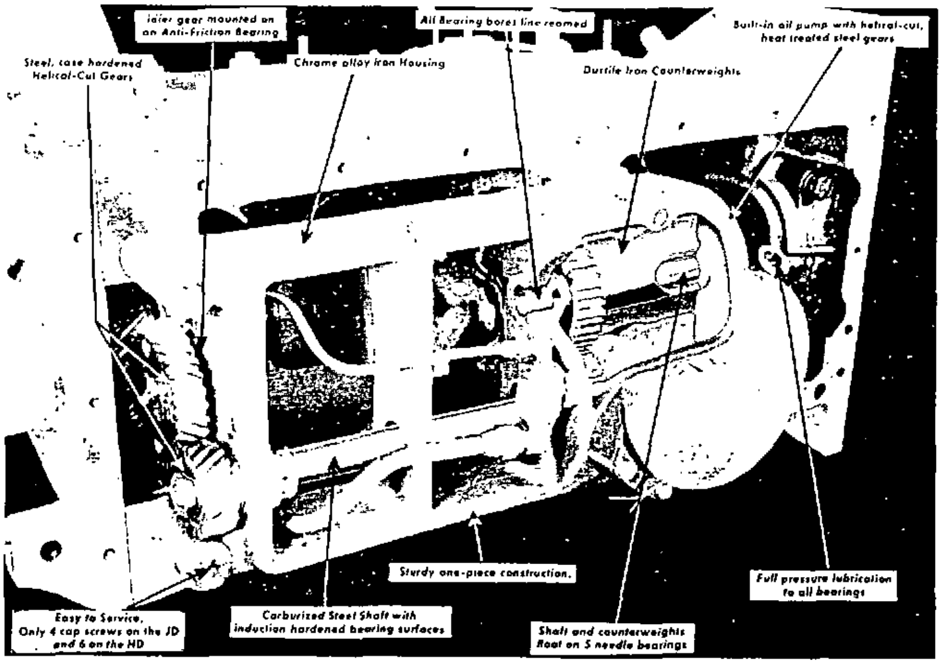


Fig. K — Lanchester Balancer Assembly

SECTION VIII
TROUBLE SHOOTING

A Preventive-Maintenance system including inspection, lubrication and adjustment as recommended in our Maintenance Section will prevent the greater portion of Diesel troubles.

Failure of a Diesel engine to perform satisfactorily is generally due to difficulties with the fuel supply system, such as air leaks in the suction line due to loose connections or restrictions to fuel flow because of clogged filters, rather than the injection pump or nozzles.

Any attempt to disassemble or repair fuel injection pumps must be made only by persons fully qualified and equipped.

Operators handling the same Diesel engine every day, soon develop a sense of impending trouble when abnormal operation occurs. Immediate attention to these danger signals can prevent major failures, insure dependable operation and increase the life of the engine.

Operators should depend on their well-developed senses of *feeling, hearing, seeing* and *smelling* and replace their sense of taste in this type of work — with a generous amount of "*common sense.*"

Following are listed some of the normal complaints encountered in routine operation of all Diesel engines — the probable causes and the recommended steps required to correct the difficulty:

Complaint	Probable Cause	Correction
(A) Engine Won't Turn Over	1 — Dead or weak battery	1 — Recharge or replace battery.
	2 — Poor ground connection	2 — Inspect and tighten ground cable.
	3 — Loose or faulty wiring connections	3 — Clean and tighten connections.
	4 — Starting switch faulty	4 — Replace switch or relay.
	5 — Starting motor defective	5 — Check brushes, commutator, drive spring and mounting bolts.
	6 — Internal engine seizure	6 — Turn engine manually — if unable to do this, check for foreign object in gears, on top of piston or for piston seizure.

TROUBLE SHOOTING

Complaint	Probable Cause	Correction
(B) Engine Turns But Won't Start	1 — Governor Stop Control in Stop Position	1 — Put Control in Operating position.
	2 — No Fuel Supply to Pump	2 — Fill Fuel Tank or open Shut-Off Valve.
	3 — Air in Fuel Injection Lines	3 — Check connections and bleed Fuel System.
	4 — Clogged or dirty filters	4 — Disassemble and clean primary filter and replace secondary filter if clogged.
	5 — Cranking speed under 115 RPM	5 — Recharge or replace battery, check starter, repair if necessary.
	6 — Water in Diesel Fuel	6 — Drain Fuel System — Refill with clean fuel or strain through chamois and bleed system.
	7 — Wrong injection pump timing	7 — Retime pump to engine according to recommendations.
	8 — Low atmospheric temperature	8 — Use cold starting equipment — either fluid injector or air heater.
	9 — Low compression — below 325 PSI	9 — See recommendations in "G".
(C) Runs "Rough" with Excessive Vibration	1 — Missing cylinder or cylinders	1 — Loosen fuel line to nozzle one at a time — if no change is noticeable that cylinder is missing. Clean and test nozzle for pressure, leakage and pattern.
	2 — Too low operating temperature — below 165° F	2 — Check shutter and thermostat— **Do Not Idle for Long Periods.**
	3 — Governor surge	3 — Adjust governor "bumper" spring — also check for broken or weak governor springs.
	4 — Air in fuel lines	4 — Check connections — Bleed fuel system.
	5 — Clogged air cleaner	5 — Clean and service air cleaner, tighten connections.
	6 — Engine idles too slowly	6 — Increase to recommended speed.
	7 — Poor fuel	7 — Use #2 Diesel engine fuel oil that meets specifications.

TROUBLE SHOOTING

Complaint	Probable Cause	Correction
(D) Loss of Power	1 — Wrong injection pump timing	1 — Retime Pump to engine according to recommendations.
	2 — Air in fuel lines	2 — Check connections and bleed fuel system.
	3 — Clogged or dirty filters	3 — Clean Primary Filter and replace secondary filter if necessary.
	4 — Restriction in air flow	4 — Service Air Cleaner and Connections.
	5 — Poor fuel	5 — Use recommended #2 Diesel Engine Fuel that meets specifications.
	6 — Poor Compression	6 — See "G" recommendations.
	7 — Injection nozzles faulty	7 — Clean and Test Faulty Nozzle for pressure leakage and spray pattern.
	8 — Energy cell faulty	8 — Clean, service or replace when necessary and lap contacts and seat.
	9 — Injection pump faulty	9 — Remove and have checked at Service Station.
(E) Overheating	1 — Lack of water	1 — Add water. Tighten hose connections and repair leaks as required.
	2 — Fan belts slipping	2 — Inspect belt condition and adjust tension.
	3 — Overloading the engine	3 — Reduce load. Keep engine speed up.
	4 — Thermostats sticking or inoperative	4 — Remove, clean and check thermostats and replace if required.
	5 — Fuel injection timing wrong	5 — Retime pump according to recommendation.
	6 — Back pressure in exhaust line	6 — Inspect for restriction in muffler and exhaust system, and clean.

TROUBLE SHOOTING

Complaint	Probable Cause	Correction
(F) Excessive Smoke	WHITE SMOKE—Indicates Misfiring	
	1 — Low engine temperature	1 — Check shutter and thermostat—increase engine temperature.
	2 — Faulty injectors	2 — Cut out individual injectors with engine running — clean and test faulty nozzle for pressure, leakage and spray pattern.
	3 — Poor fuel	3 — Use #2 Diesel fuel that meets specifications.
	4 — Poor compression	4 — See "G" recommendations.
	BLUE SMOKE — Indicates High Oil Consumption	
	1 — Worn or stuck rings	1 — See (I) high oil consumption recommendations.
	2 — Low engine water temperature	2 — Check shutter and thermostat.
	BLACK SMOKE	
	1 — Excessive fuel rate	1 — Calibrate injection pump to standard.
	2 — Overloading engine	2 — Reduce load.
	3 — Restriction in air supply	3 — Clean air cleaner.
	4 — Low engine water temperature	4 — Check shutter and thermostat.
(G) Poor Compression (Under 325# at 150 RPM)	1 — Valves holding open — no tappet clearance	1 — Adjust tappet clearance to specifications.
	2 — Leaky cylinder head gasket	2 — Clean head and block surfaces and replace gasket.
	3 — Leaky energy cell	3 — Clean or replace — lap seats gas tight.
	4 — Wrong valve timing	4 — Check and correct if necessary.
	5 — Burned or sticking valves or incorrect valve timing	5 — Clean and grind valves. Reface or replace as required.
	6 — Broken or weak valve springs	6 — Check and replace any not up to specifications.
	7 — Piston rings worn or broken	7 — Re-ring with recommended service kit.
	8 — Worn pistons and sleeves	8 — Replace sleeves and pistons.

TROUBLE SHOOTING

Complaint	Probable Cause	Correction
(H) Low Oil Pressure	1 — Low oil level	1 — Add oil to dipstick level.
	2 — Oil pressure gauge or line faulty	2 — Inspect lines and check with Master Gauge.
	3 — Oil too light — diluted	3 — Change oil and follow recommended lubrication.
	4 — Dirt in relief valve or broken spring	4 — Clean or replace spring.
	5 — Suction screen plugged	5 — Remove screen and clean in solvent.
	6 — Worn bearings	6 — Check with pressure tank for leakage test.
	7 — Worn oil pump	7 — Remove, repair or replace pump.
(I) High Oil Consumption	1 — Oil leaks	1 — Locate and repair.
	2 — Too high oil level maintained	2 — Maintain oil level between high and low marks on bayonet.
	3 — Incorrect grade of oil used	3 — Use recommended type and SAE number of lubricating oil.
	4 — Clogged crankcase breather (or pipe)	4 — Clean thoroughly.
	5 — Oil pressure too high — relief valve stuck	5 — Clean and free up valve — check spring tension.
	6 — Piston rings not properly run-in	6 — Break in all new and rebuilt engines as recommended.
	7 — Worn, broken or stuck piston rings and clogged oil control rings	7 — Re-ring with recommended service rings.
	8 — Worn pistons and liners	8 — Replace liners and pistons.
	9 — Worn bearings and valve guides	9 — Check with pressure tank for leakage.
(J) Poor Fuel Economy	1 — Operating with low water temperature	1 — Maintain 165° F — 185° F for maximum economy and performance.
	2 — Wrong fuel oil	2 — Use #2 Diesel fuel that meets specifications.
	3 — Loss of power	3 — Follow "D" recommendations.
	4 — Incorrect injection pump timing	4 — Follow recommendation for operation.
	5 — Nozzles faulty	5 — Cut out faulty nozzle—clean and test for pressure, leakage and spray pattern.
	6 — Energy cell carboned up	6 — Clean, service or replace as necessary and lap contact seat in.
	7 — Incorrect tappet clearance	7 — Adjust tappets .014 exh. & int. with engine warmed up.

TROUBLE SHOOTING

Complaint	Probable Cause	Correction
(K) Sudden Stopping	1 — No fuel	1 — Refill fuel tank and bleed fuel system.
	2 — Restriction in fuel flow	2 — Clogged or dirty filters — check lines for obstruction or break.
	3 — Air in fuel lines	3 — Bleed fuel system.
	4 — Transfer pump faulty	4 — Replace transfer pump.
	5 — Water in fuel	5 — Drain system and refill with clean fuel or strain remaining fuel through chamois.
	6 — Internal engine seizure	6 — Turn engine manually—if unable to do so check for foreign object in combustion chamber or for piston or bearing seizure.
(L) Engine Knocks and Noises	COMBUSTION KNOCKS (Excessive)	
	1 — "Lugging"	1 — Reduce load or increase speed.
	2 — Poor quality fuel	2 — Use only #2 Diesel engine fuel oil for good performance and economy.
	3 — Injection timed too early	3 — Follow recommended timing for operation.
	4 — Injection nozzle sticking	4 — Remove nozzle, check opening pressure, clean and adjust.
	MECHANICAL KNOCKS	
	1 — To locate knock	1 — "Short out cylinders" by loosening fuel line to nozzle one at a time — if no change in sound, knock is not occurring in that cylinder.
	2 — Main bearings	2 — Heavy, dull knock when accelerating under load. Examine bearing lining for wear or excessive clearance. Replace if necessary.
	3 — Connecting rod bearings	3 — Condition noted at idle or light load and disappears at full load. Check and correct as in Para. I, main bearings.
	4 — Loose piston pin	4 — Sharp metallic rap at idling speed or when starting cold. Replace pin with oversize.
	5 — Broken piston ring or pin	5 — Sharp, clicking noise that can not be eliminated by shorting out. Remove pistons, replace piston pin or rings if necessary.
	6 — Tappet noise	6 — Check clearance with engine warmed up. Adjust to specifications.
	7 — Timing gear noise	7 — Loose or worn-gears rattle; tight-gears whine. Check gear fit and examine teeth. Refit new set of gears if loose or worn badly.

SECTION IX
LIMITS AND CLEARANCE DATA

Engine Model	ZD-129	GD-157	GD-193	ED-201	ED-208	HD-260	HD-277	JD-382
Bore	3¼	3⅜	3¾	3⅝	3-11/16	3⅞	4	4½
Stroke	3⅞	4⅜	4⅜	4⅞	4⅞	5½	5½	6
Displacement cu. in.	129	157	193	201	208	260	277	382
Compression ratio	16.25:1	15.54:1	16.8:1	15.5:1	15.5:1	15.0:1	15.0:1	15.0:1
Firing order	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2	1-3-4-2

VALVE GUIDE	ZD-129 Int.	ZD-129 Exh.	GD-157 Int.	GD-157 Exh.	GD-193 Int.	GD-193 Exh.	ED-201/208 Int.	ED-201/208 Exh.	HD-260/277 Int.	HD-260/277 Exh.	JD-382 Int.	JD-382 Exh.
Length	1-13/16	1-13/16	2-17/32	2-17/32	2-17/32	2-17/32	2-11/16	2-11/16	2-7/8	2-21/32	2-21/32	2-21/32
Outside dia.	.5645/.5640		.6575/.6565		.6575/.6565		.6575/.6565		.752 /.751		.752 /.751	
Stem hole dia.(Reamed)	.3172/.3157		.3432/.3422		.3432/.3422		.3422/.3422		.4365/.436		.4365/.436	
*Wear limits, Max. dia.	.3187		.3447		.3447		.3455		.438		.438	
Distance, cylinder head contact face to guide	2-5/32	2-5/32	2-15/32	2-15/32	2-15/32	2-15/32	2-25/32	2-25/32	2-17/64	2-19/64	2-25/32	3-1/8

VALVES, INTAKE

	ZD-129	GD-157	GD-193	ED-201/208	HD-260/277	JD-382
Material	Chr. Ni. Steel	Chr. Ni. Steel	Chr. Ni. Steel	Chr. Ni. Steel	Chr. Ni. Steel	Chr. Ni. Steel
Overall length	5.852 /5.837	6.270 /6.245	6.426 /6.401	6.6915/6.6665	6.9798/6.9548	7.2756/7.2556
Stem dia.	.3149/ .3141	.3414/ .3406	.3414/ .3406	.3414/ .3406	.4352/ .4344	.4352/ .4344
*Wear limits, Min. dia.	.3121	.3386	.3386	.3386	.4324	.4324
Head dia.	1.266 /1.262	1.309 /1.299	1.340 /1.330	1.458 /1.448	1.520 /1.510	1.700 /1.690
Seat angle	45°	45°	45°	45°	45°	45°
Angle of vlv. face	44°	44°	44°	44°	44°	44°
Stem clearance lim.	.0031/ .0008	.0026/ .0008	.0026/ .0008	.0026/ .0008	.0021/ .0008	.0021/ .0008
*Wear limits, Max. cl.	.0051	.0046	.0046	.0046	.0041	.0041
Desired stem clear	.002	.0015	.0015	.0015	.0015	.0015

VALVES, EXHAUST

	ZD-129	GD-157	GD-193	ED-201/208	HD-260/277	JD-382
Material	XCR	XCR	XCR	XCR	XCR	XCR
Overall length	4.956 /4.9431	5.3537/5.3337	5.3537/5.3337	5.7695/5.7445	5.8079/5.7829	6.0256/6.0056
Stem dia.	.3132/ .3124	.3390/ .3382	.3390/ .3382	.3390/ .3382	.4325/ .4315	.4325/ .4315
*Wear limits, Min. dia.	.3104	.3362	.3362	.3362	.4295	.4295
Head dia.	1.052 /1.048	1.184 /1.174	1.184 /1.174	1.333 /1.323	1.395 /1.385	1.515 /1.505
Seat Angle	45°	45°	45°	45°	45°	45°
Angle of vlv. face	44°	44°	44°	44°	44°	44°
Clearance stem lim.	.0048/ .0025	.005 / .0032	.005 / .0032	.005 / .0032	.005 / .0035	.005 / .0035
*Wear limits, Max. cl.	.0068	.007	.007	.007	.007	.007
Desired stem clear	.0035	.004	.004	.004	.004	.004

*(These maximum wear limits are effective only when the total clearance of the mating parts does not exceed the maximum clearance limits as indicated)

LIMITS AND CLEARANCE DATA

Engine Model	ZD-129	GD-157	GD-193	ED-201 ED-208	HD-260 HD-277	JD-382
VALVE SPRINGS						
Outside dia.	1.022 / .992	1.302/1.282	1.302/1.282	1.150/1.130	1.302/1.282	1.302/1.282
Wire gauge	.144	.162	.162	.156	.162	.162
Spring length vlv. closed	1.741	1.7/8	1-7/8	1-21/32	1-7/8	1-7/8
Spring load, vlv. closed	58.5 — 61.5 lbs.	58-64 lbs.	58-64 lbs.	47-53 lbs.	58-64 lbs.	58-64 lbs.
*Wear limits, Min. Wgt.	52.5 lbs.	52 lbs.	52 lbs.	42 lbs.	52 lbs.	52 lbs.
Spring length, vlv. open	1.387	1.521	1.521	1-3/8	1.521	1.521
Spring load, vlv. open	107-113 lbs	115-123 lbs.	115-123 lbs.	103-110 lbs.	115-123 lbs.	115-123 lbs.
*Wear limits, Min. Wgt.	97 lbs.	105 lbs.	105 lbs.	93 lbs.	105 lbs.	105 lbs.
CAMSHAFT						
Brg. Journal, Dia., #1	1.8095/1.8090	1.809 /1.8085	1.8090/1.8080	1.9965/1.9960	1.9965/1.9955	2.1225/2.122
*Wear limits, Min. dia.	1.808	1.8075	1.807	1.995	1.9945	2.121
Brg. Journal, Dia., #2	1.7465/1.7460	1.7465/1.7455	1.7465/1.7455	1.7465/1.7460	1.7465/1.7455	1.7465/1.746
*Wear limits, Min. dia.	1.745	1.7445	1.7445	1.745	1.7455	1.745
Brg. Journal, Dia., #3	1.6840/1.6835	1.684 /1.683	1.6840/1.6830	1.6840/1.6835	1.684 /1.6835	1.684 /1.6835
*Wear limits, Min. dia.	1.6825	1.682	1.682	1.6825	1.682	1.6825
Cam lift	.214	.273	.2631	.2296	.230	.3016
Tappet clearance						
Intake	.012	.014	.014	.014	.014	.014
Exhaust	.012	.014	.014	.014	.014	.014
End play	.007 / .003	.007 / .003	.007 / .003	.009 / .005	.009 / .005	.009 / .005
CONNECTING RODS						
Length, Cent. to Ctr.	6.377 /6.373	7.002 /6.998	7.002 /6.998	8.377 /8.373	9.502 /9.498	10.502 /10.498
Bushing hole dia.	1.023 /1.022	1.188 /1.187	1.188 /1.187	1.188 /1.187	1.3753/1.3743	1.6249/ 1.6239
Brg. hole dia.	2.375 /2.3745	2.1870/2.1865	2.3745/2.3740	2.3745/2.374	2.6245/2.624	2.8745/ 2.874
Brg. thickness	.0619/ .0614	.0617/ .0612	.0617/ .0612	.0622/ .0617	.06175/ .0615	.0621/ .0616
*Wear limits—Min. th.	.0609	.0607	.0607	.0612	.0610	.0611
Dia. crank pin	2.250 /2.249	2.0625/2.0615	2.250 /2.249	2.249 /2.248	2.499 /2.498	2.7485/ 2.7475
*Wear limits—Min. dia.	2.248	2.0605	2.248	2.247	2.497	2.7465
Clearance lim.	.0032/ .0007	.0031/ .0006	.0031/ .0006	.0031/ .0006	.0035/ .0015	.0038/ .0013
Desired clearance	.0015	.0015	.0015	.0015	.0025	.0025
*Wear limits—Max. cl.	.0042	.0041	.0041	.0041	.0045	.0048
Width at brg. end	1.244 /1.241	1.3055/1.3035	1.3055/1.3035	1.5555/1.5535	1.804 /1.802	1.804 / 1.802
Desired side play	.006 min.	.006 min.	.006 min.	.006 min.	.006 min.	.0065 min.

*(These maximum wear limits are effective only when the total clearance of the mating parts does not exceed the maximum clearance limits as indicated)

LIMITS AND CLEARANCE DATA

Engine Model	ZD-129	GD-157	GD-193	ED-201 ED-208	HD-260 HD-277	JD-382
MAIN BEARINGS						
Dia. of brg. bore in block	2.692 /2.6913	2.5622/2.5615	2.5622/2.5615	2.8122/2.8115	3.0622/3.0615	3.5000/3.4992
Br. Shell Thickness	.0952/ .0947	.0928/ .0923	.0928/ .0923	.0930/ .0925	.0929/ .0924	.1235/ .1230
*Wear limits—Min. th.	.0942	.0918	.0918	.0920	.0919	.1225
Dia. of Mn. Brn. Jnl.	2.500 /2.499	2.375 /2.374	2.375 /2.374	2.625 /2.624	2.874 /2.873	3.251 /3.250
*Wear limits—Min. dia.	2.498	2.373	2.373	2.623	2.872	3.249
Clearance limits	.0036/ .0009	.0036/ .0009	.0036/ .0009	.0032/ .0005	.0035/ .0015	.004 / .0012
Desired clearance	.002	.002	.002	.002	.002	.0025
*Wear limits—Max. cl.	.0046	.0046	.0046	.0042	.0045	.005
C/S End Play	.006 / .004	.006 / .004	.006 / .004	.006 / .004	.008 / .005	.008 / .005
*Wear limits—Max. end play	.009	.009	.009	.009	.010	.010

PISTONS	ZD-129	GD-157	GD-193	ED-201	ED-208	HD-260	HD-277	JD-382
Actual inside dia. of sleeves	3.252 /3.250	3.377 /3.375	3.752 /3.750	3.627 /3.625	3.689 /3.687	3.877 /3.875	4.002 /4.000	4.502 /4.500
*Wear limits—Max. dia	3.258	3.385	3.760	3.635	3.697	3.885	4.010	4.510
[illegible]on pin hole dia.	.9684/ .9682	1.1253/1.1251	1.1094/1.1092	1.1094/1.1092	1.1094/1.1092	1.2500/1.2498	1.2500/1.2498	1.5000/1.4998
*Wear limits—Max. dia	.9686	1.1255	1.1096	1.1096	1.1096	1.2502	1.2502	1.5002
Ring Gr. Dia., 1st	2.916 2.906	2.992 2.982	3.333 /3.323	3.221 /3.211	3.277 /3.267	3.444 /3.434	3.569 /3.559	4.003 /3.993
2 and 3	2.897 2.887	3.028 3.018	3.379 /3.369	3.263 /3.253	3.221 /3.311	3.497 /3.487	3.622 /3.612	4.086 /4.076
4th	2.876 2.866	2.988 2.978	3.339 /3.329	3.223 /3.213	3.281 /3.271	3.457 /3.447	3.582 /3.572	4.047 /4.037
5th				3.223 /3.213	3.281 /3.271	3.497 /3.487	3.622 /3.612	4.047 /4.037
Ring Gr. Width Top	.1291/ .1281	.128 / .127	.128 / .127	.129 / .128	Top + 2nd .129/.128	.129 / .128	.129 / .128	.129 / .128
*Wear limits—Max. w.	.1311	.130	.130	.131	.131	.131	.131	.131
2 and 3	.1285/ .1275	.127 / .126	.128 / .127	(.129 /.128 (2) (.128 /.127 (3)	3rd Gr. .128/.127	.128 / .127	.128 / .127	.128 / .127
*Wear limits—Max. w.	.130	.129	.130	.131 (2) .130 (3)	.130	.130	.130	.130
4th	.2515/ .2505	.252 / .251	.2520 / .2505	.253 / .252	.253 / .252	.253 .252	.253 / .252	.253 .252
*Wear limits—Max. w.	.2535	.254	.254	.255	.255	.255	.255	.255
5th				.1905/ .1895	.1905 /.1895	.1905/ .1895	.1905/ .1895	.1905/ .1895
*Wear limits—Max. w.				.1925	.1925	.1925	.1925	.1925
Ring land dia. 1st	3.230 /3.226	3.354 /3.349	3.724 /3.720	3.599 /3.594	3.6675/3.6565	3.850 /3.843	3.975 /3.968	4.470 /4.465
2nd	3.230 /3.226	3.354 /3.349	3.727 /3.723	3.599 /3.594	3.6675/3.6565	3.850 /3.843	3.975 /3.968	4.470 /4.465
3rd	3.230 /3.226	3.354 /3.349	3.731 /3.727	3.599 /3.594	3.6675/3.6565	3.850 /3.843	3.975 /3.968	4.470 /4.465
4th		3.323 /3.319	3.731 /3.727	3.575 /3.570	3.6375/3.6325	3.825 /3.818	3.950 /3.943	4.456 /4.451
Feeler gauge	.003	.004	.005	.004	.004	.004	.004	.005
Lbs. Pull	5-10	5-10	5-10	5-10	5-10	5-10	5-10	5-10

*(These maximum wear limits are effective only when the total clearance of the mating parts does not exceed the maximum clearance limits as indicated)

LIMITS AND CLEARANCE DATA

Engine Model	ZD-129	GD-157	GD-193	ED-201	ED-208	HD-260	HD-277	JD-382
RINGS								
Type of ring Top 2 and 3 4th 5th	Chr. Comp. K T. F. comp. Ventilated oil	Chr. comp. T. F. comp. Ventilated oil	Chr. comp. T.F. T. F. comp. Ventilated oil	Chr. comp. T.F. T. F. comp. Ventilated oil Ventilated oil	Chr. Comp. K. T.F. T.F. Comp. Ventilated Oil Ventilated Oil	Chr. K.T.F. I.B. Comp. Ventilated oil Ventilated oil	Chr. Comp. K. T.F. T.F. Comp. Ventilated Oil Ventilated Oil	Pl. comp. T.F. comp. Ventilated oil Ventilated oil
Ring width								
Top	.1240/.1225	.1240/.1235	.1240/.1235	.1240/.1235	.1240/.1235	.124 /.1235	124 /.123	.124 /.123
*Wear limits—min. w.	.1205	.1215	.1215	.1215	.1215	.1215	.121	.121
2 and 3	.1240/.1225	.1240/.1235	.1240/.1235	.1240/.1230	.1240/.1235	.124 /.123	.1240/.1235	.124 /.123
*Wear limits—min. w.	.1205	.1215	.121	.121	.1215	.121	.1215	.121
4th	.2490/.2485	.2490/.2485	.2490/.2485	.2490/.2485	.2490/.2485	.249 /.2485	.2490/.2485	.249 /.2485
*Wear limits—min. w.	.2465	.2465	.2465	.2465	.2465	.2465	.2465	.2465
5th				.1865 .1860	.1865/.1860	.1865 .186	.1865/.1860	.1865 .186
*Wear limits—min. w.				.184	.184	.184	.184	.184
Ring thickness								
Top	.147 /.137	.162 /.152	.164 /.154	.181 /.171	.184 /.174	.194 /.184	.200 /.190	.225 /.215
2 and 3	.147 /.137	.153 /.143	.164 /.154	.160 /.150	.162 /.152	.167 /.157	.172 /.162	.183 /.173
4th	.147 /.137	.153 /.143	.164 /.154	.160 Max.	.162 /.152	.168/.158	.172 /.162	.183 /.173
5th				.159 Max.	.162 /.152	.168/.158	.172 /.162	.183 /.173
Ring gap clearance								
Top	.020 /.010	.016 /.008	.020 /.010	.023 /.013	.020 /.010	.020 /.010	.025 /.013	.020 /.012
2 and 3	.020 /.010	.015 /.010	.020 /.010	.015 /.008	.020 /.010	.020 /.010	.025 /.013	.023 /.013
4th	.018 /.010	.020 / .010	.018 /.010	.023 /.013	.018 /.010	.018 /.010	.025 /.013	.020 /.010
5th				.018 /.010	.018 /.010	.018 /.010	.023 /.013	.020 /.010
Ring side clearance								
Top	.0066/.0041	.0045/.003	.0045/.003	.0055/.004	.0055/.004	.0055/.004	.006 /.004	.005 /.003
*Wear limits—max. cl.	.0086	.0065	.0065	.0075	.0075	.0075	.008	.007
2 and 3	.0066/.0041	.0035/.002	.004 /.003	(.006 .004 (2) (.005 .003 (3)	.0055/.004 (2) .0045/.003 (3	.005 .003	.0045/.003 .0065	.004 .002
*Wear limits—max. cl.	.0086	.0055	.0065	.008 (2) .007 (3)	.0075 (2) .0065 (3)	.0075		.0065
4th	.003 /.0015	.0035/.002	.0035/.0015	.0045/.003	.0045/.003	.0045/.003	.0045/.003	.0045/.003
*Wear limits—max. cl.	.005	.0055	.0055	.0065	.0065	.0065	.0065	.0065
5th				.0045 .003	.0045/.003	.0045 .003	.0045/.003	.0045 .003
*Wear limits—max. cl.				.0065	.0065	.0065	.0065	.0065

PISTON PINS	ZD-129	GD-157	GD-193	ED-201 ED-208	HD-260 HD-277	JD-382
Length	2.691 /2.676	2.750 /2.735	3.065/3.050	3.065 /3.050	3.314 /3.307	3.718 /3.708
Diameter	.9683/.9681	1.1252/1.1250	1.1093/1.1091	1.1093/1.1091	1.2500/1.2498	1.5000/1.4998
*Wear limits—min. dia.	.9678	1.1247	1.1088	1.1088	1.2495	1.4995
Desired fit	Light push	Light push	Light push	Light push	Light push	Light push
Bushing hole dia. fin.	.9687/.9685	1.1255/1.1253	1.1097/1.1095	1.1097/1.1095	1.2504/1.2502	1.5005/1.5003
*Wear limits—max. dia.	.9697	1.1265	1.1107	1.1107	1.2514	1.5015
Pin Clearance in bushing	.0006/.0002	.0005/.0001	.0006/.0002	.0006/.0002	.0006/ .0002	.0007/ .0003
*Wear limits—max. cl.	.0016	.0015	.0016	.0016	.0016	.0017
Desired pin fit	.0004	.0003	.0004	.0004	.0004	.0005
Length (Bushing)	1.125/1.110	1.125 /1.093	1.250 /1.219	1.250 /1.219	1.260 /1.240	1.635 /1.615
Outside dia. (Bushing)	Press fit in 1.023 1.022 hole	Press fit in 1.188 1.187 hole	Press fit in 1.188 1.187 hole	Press fit in 1.188 1.187 hole	Press fit in 1.3753 1.3743 hole	Press fit in 1.6249/1.6239 hole

*(These maximum wear limits are effective only when the total clearance of the mating parts does not exceed the maximum clearance limits as indicated)

SECTION X
TORQUE SPECIFICATIONS

Continental Diesel engines have many studs, bolts, and cap screws of special material and sizes and it is very important that special care be exercised to replace all studs and bolts in their respective locations during assembly of engine.

The torque specifications, foot pounds, listed below, MUST be followed in order to have the assembled engine conform to the original specifications:

Size-Diameter	5/16″	3/8″	7/16″	1/2″	9/16″	5/8″
Cylinder Heads	....	35-40	70-75	100-110	130-140	145-155
Main Bearing Caps and Connecting Rods	20-25	35-40	70-75	85-95	100-110	130-140
Flywheels	20-25	35-40	70-75	85-95	100-110	145-155
Manifolds	15-20	25-30	50-55	80-90	100-110	130-140
Gear Covers, Water Pumps, Front and Rear End Plates, Oil Pans	15-20	25-30	50-55	80-90	....	....
Flywheel Housings	15-20	25-30	50-55	80-90	115-125	....
Camshaft Nut						
Cast Iron Camshaft	65-70	FOR ALL MODELS				
Steel Camshaft	120-130	FOR ALL MODELS				

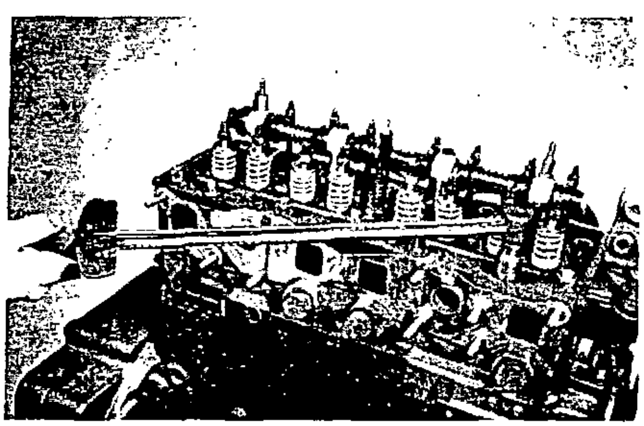


Figure 217—Torquing Cylinder Head Nuts

Section 11 — SPECIAL DIESEL TOOLS

Reference is made to special tools throughout the manual; these or their equivalent are necessary to do the various service operations in an efficient and satisfactory manner. These tools may be obtained from authorized Continental Distributors or the factory branches.

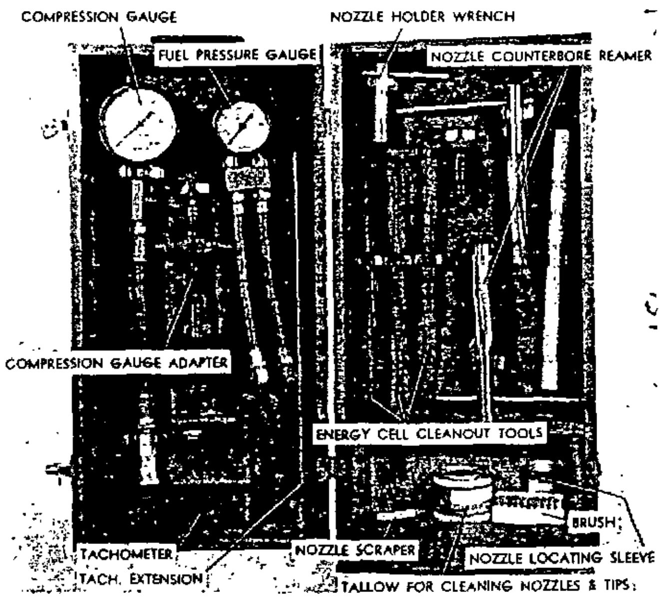


Figure 218—Recommended Tools for Servicing Fuel Injection Equipment Kit #RD6T125

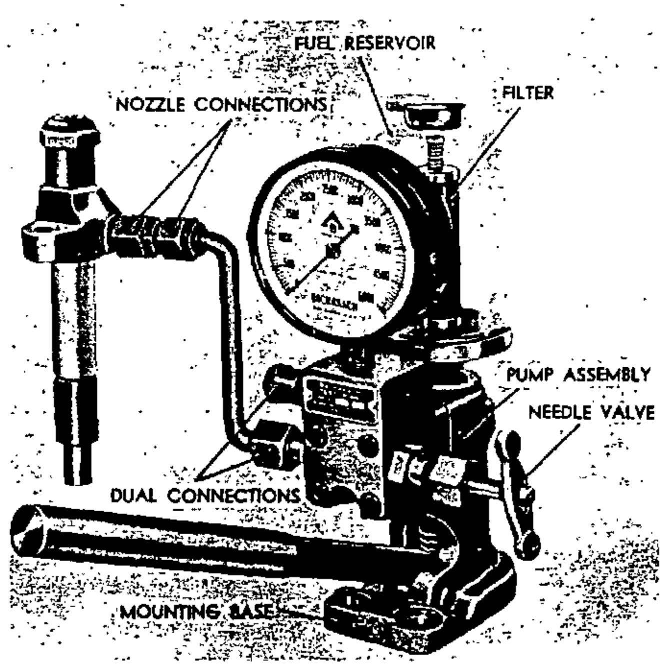


Figure 219—Nozzle Tester #HD260T177

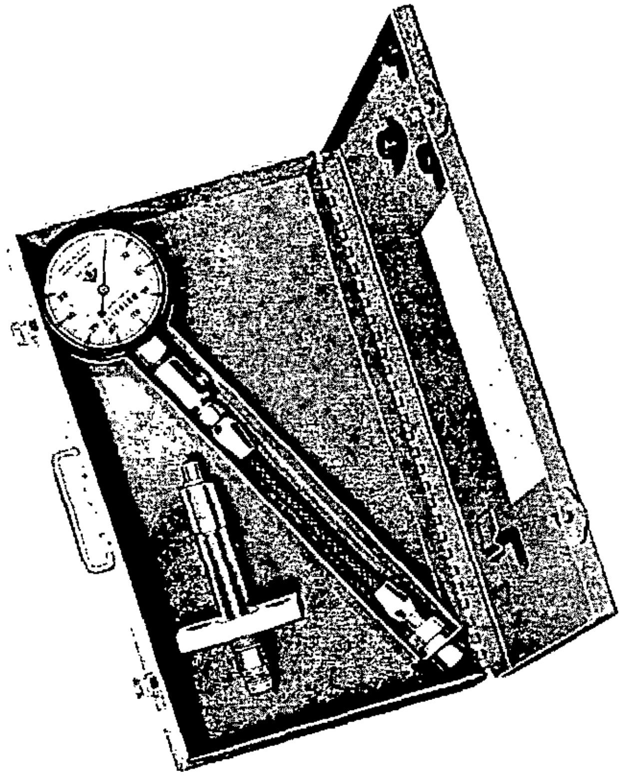


Figure 220—Compression Tester #HD260T176

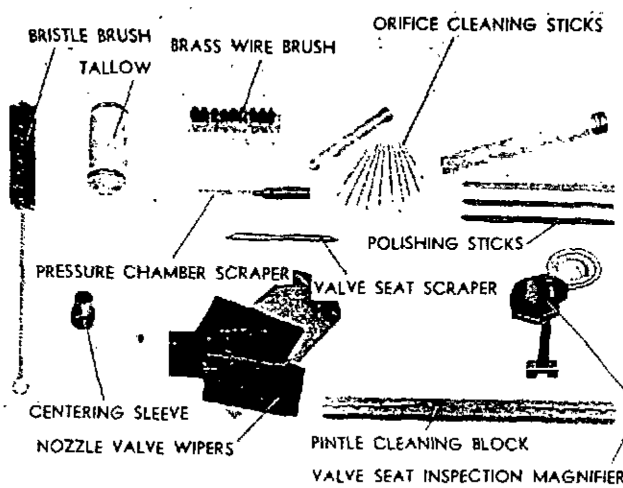


Figure 221—Nozzle Cleaning Kit Kit #HD260T178

Figure 222— #HD260T-196

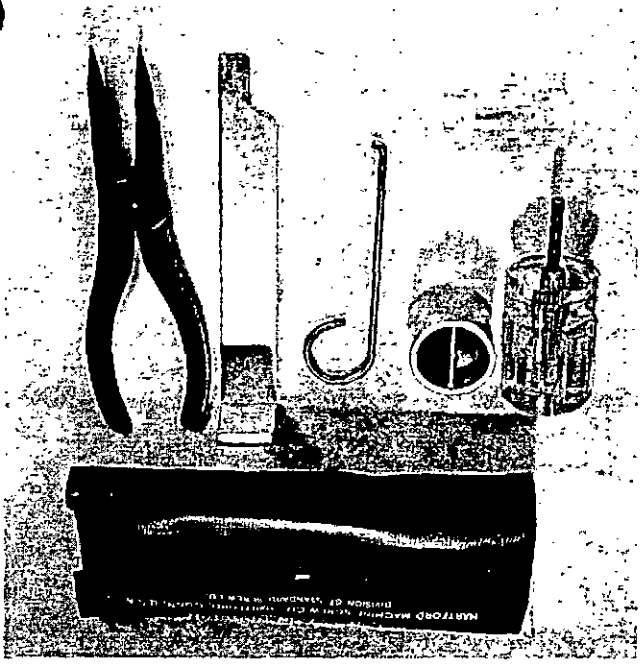


Figure 223—Roosa-Master tool kit #HD260T-196

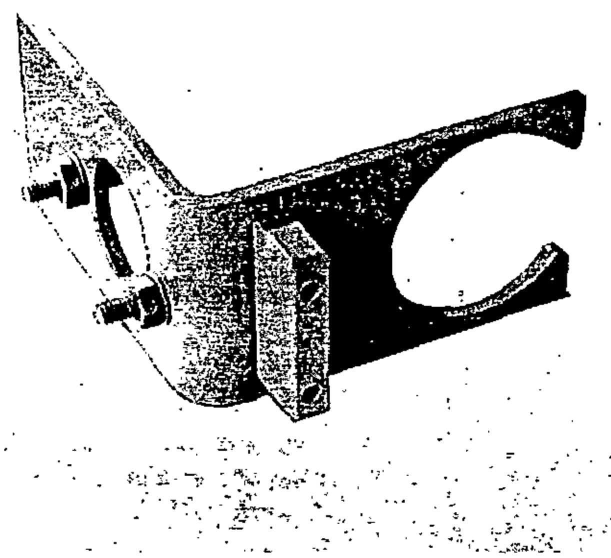


Figure 225—Vise pump fixture #HD260T-197

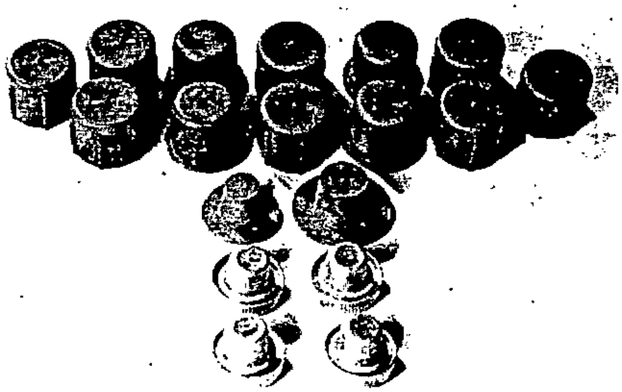


Figure 224—Plastic cap kit #HD260T-195

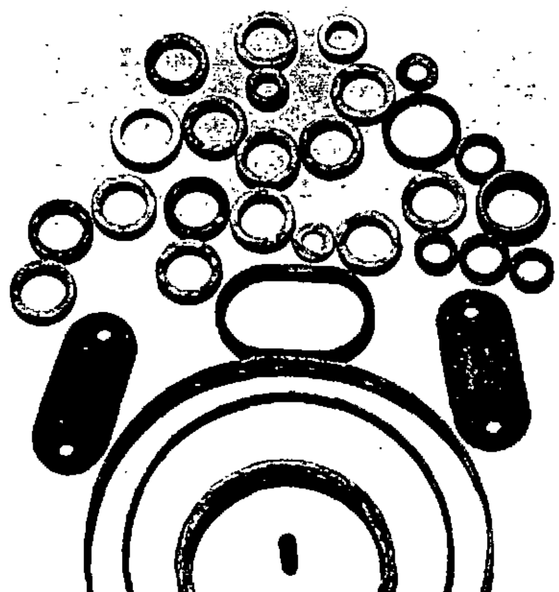


Figure 226—Overhaul gasket kits
For Model "E" Pump, kit #S-2344
For Model "D" Pump kit, #S-2357

10 "MUSTS" FOR OBTAINING BEST RESULTS FROM YOUR DIESEL ENGINE

1. OPERATING TEMPERATURES

Warm up thoroughly, before applying load, and maintain operating temperatures between 165°-185° F. A cold running engine promotes smoking, crankcase dilution, rapid engine wear.

2. OPERATING SPEED

Horsepower increases as the speed, so keep engine operating at recommended RPM, with gear ratio to permit it to handle the load with a minimum of effort. Lugging an engine at wide open throttle, at low RPM shortens engine life.

3. IDLING

Idle the engine at 1000 RPM to warm up. Long periods of idling at lower RPM, promotes carbon buildup on nozzle tips and in energy cells due to low combustion chamber temperatures.

4. STOPPING ENGINE

After each operating period, before stopping engine, allow it to idle at 600 RPM for 5 minutes to equalize temperatures and dissipate heat. Too rapid cooling down may cause distortion.

5. LUBRICATION

Use only H-D oils of the correct SAE number, that meet operating requirements. Change oil and filter elements regularly as outlined. Failure to follow these instructions can materially shorten engine life and increase maintenance costs.

6. AIR CLEANER

Diesel engines burn large quantities of air at all times — limited only by the amount that can enter through the intake valves. Air cleaners must be cleaned and serviced regularly so as to remove all foreign materials and abrasives from this incoming air.

7. FUEL FILTERS

Drain and clean primary filter and replace element or entire filter in secondary and final stage units to insure sufficient clean fuel to the injection pump at all times. Restricted fuel flow because of clogged filters affects performance while dirt entering the injection pump can do irreparable damage.

8. INJECTION EQUIPMENT

Eliminate all possible sources of trouble before suspecting injection pump or nozzles. If either of these are at fault, they should be checked and corrected by trained personnel only, and with the proper equipment.

9. COLD STARTING

Use only tried and proven methods for starting your Diesel in cold weather. Experimenting with other means can be expensive and cause unlimited damage.

10. PREVENTIVE MAINTENANCE

Follow recommended program as outlined. By doing this, troubles which might cause expensive breakdowns can be prevented, and the efficiency and performance of your Diesel maintained for an indefinite period.