Operation and Maintenance
Instructions

Six Cylinder Diesels

TD-6427 TD-427
RD-6572 RD-572
SD-6802 SD-802

Continental Motors Corporation
Muskegon, Michigan

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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

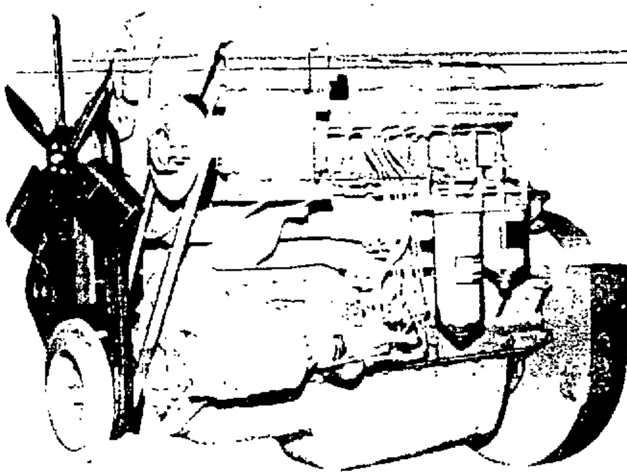


Figure 1
TD6427 Transportation Diesel

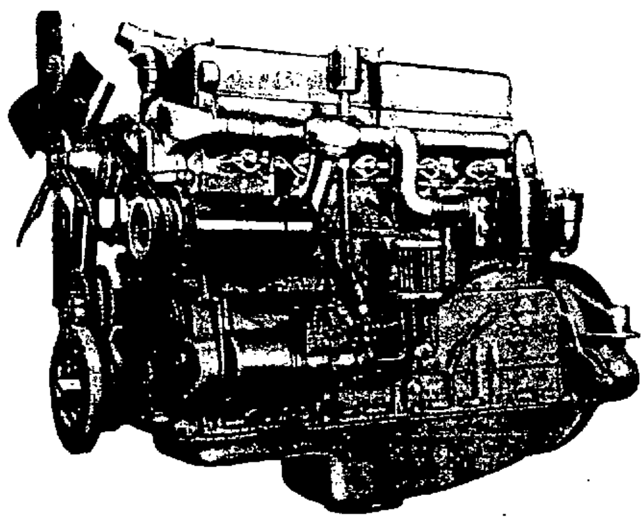


Figure 2
RD6572 Transportation Diesel

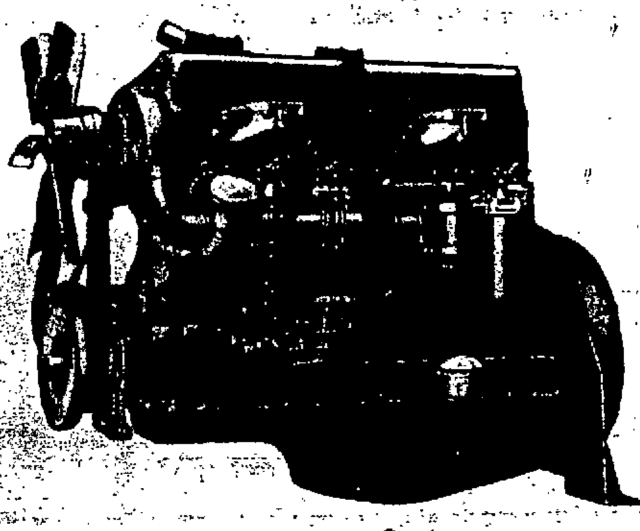


Figure 3
SD802 Industrial Diesel

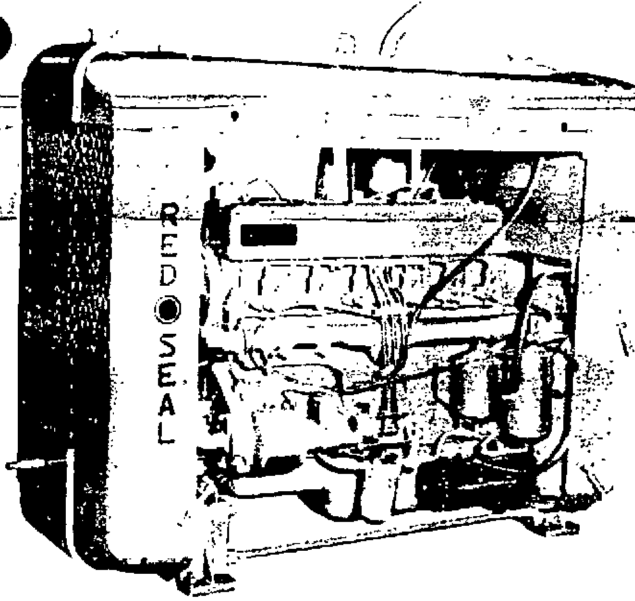


Figure 4
TD427 Industrial Diesel

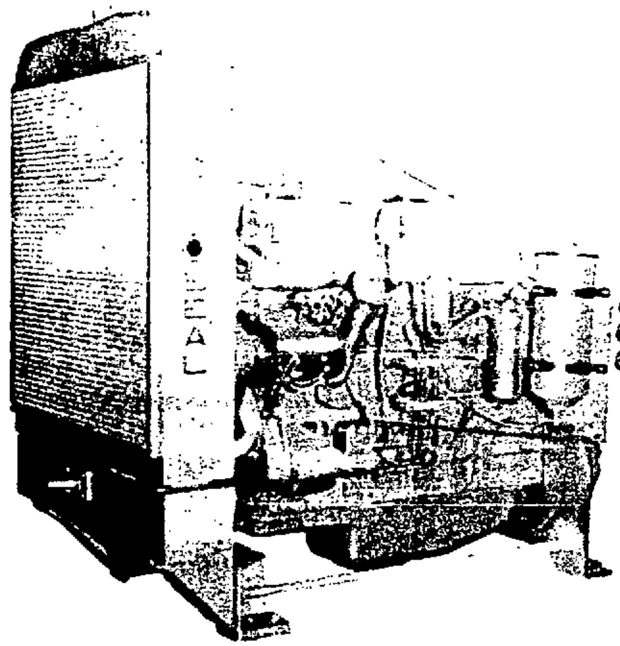


Figure 5
RD572 Industrial Diesel

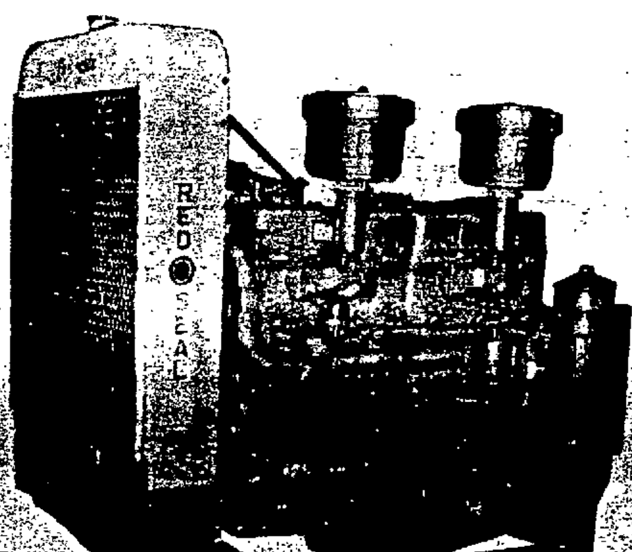


Figure 6
SD802 Industrial Diesel

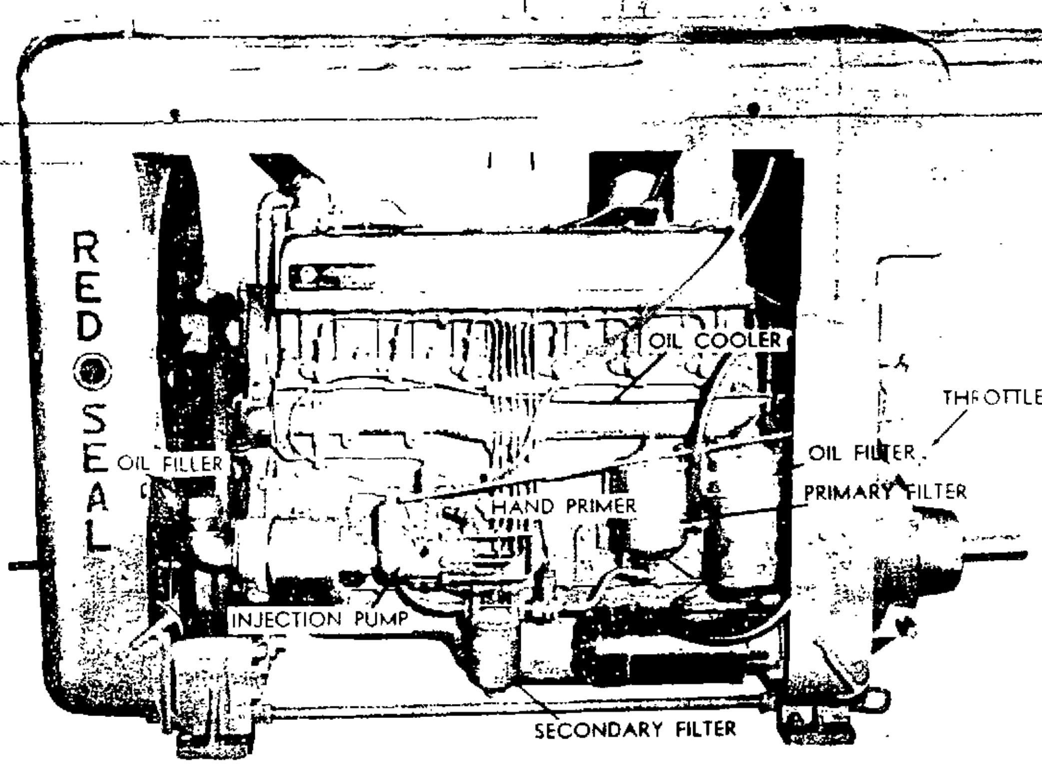


Figure 7

Closed Power Unit (Fuel Injection Side)

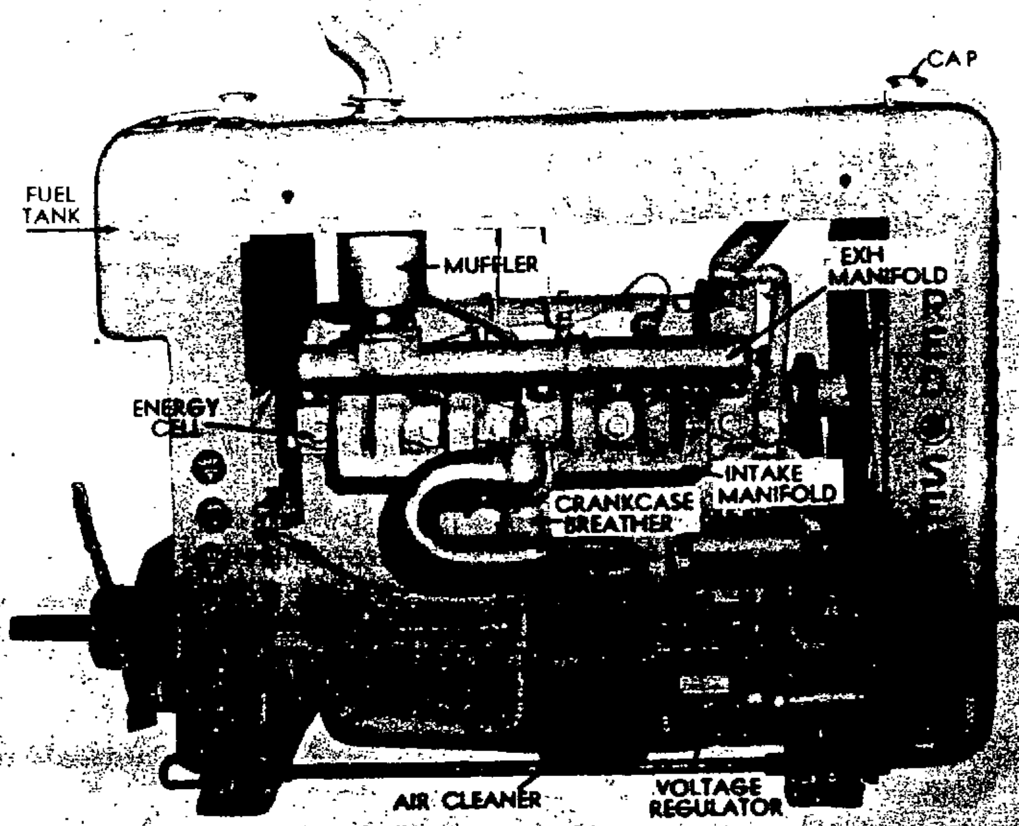


Figure 8

Closed Power Unit (Manifold Side)

SIX CYLINDER DIESEL ENGINE SPECIFICATIONS

MODEL	TD-427	TD-6427	RD-572	RD-6572	SD-802	SD-6802
No. of cylinders	6	6	6	6	6	6
Bore and stroke	4-5/16 x 4⅞	4-5/16 x 4⅞	4¾ x 5⅜	4¾ x 5⅜	5-9/16 x 5½	5-9/16 x 5½
Displacement, cu. in.	427	427	572	572	802	802
Compression Ratio	14.4:1	14.4:1	14.49:1	14.49:1	14.7:1	14.7:1
B.H.P.	132 at 2200	146 at 2600	154 at 2000	172 at 2400	202 at 1800	225 at 2200
Torque, lb. ft.	336 at 1600	336 at 1600	428 at 1300	428 at 1300	620 at 1300	620 at 1300
Oil Press. at 1800 RPM	40-50	40-50	55-65	55-65	55-65	55-65
Min. at idling	7	7	7	7	7	7
Firing order	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4
Main brg. frt.	2⅞ x 1¾	2⅞ x 1¾	3¼ x 1-59/64	3¼ x 1-59/64	3¾ x 1⅞	3¾ x 1⅞
(4) Intermediate	2⅞ x 1⅝	2⅞ x 1⅝	3¼ x 1-13/16	3¼ x 1-13/16	3¾ x 2⅛	3¾ x 2⅛
Center	2⅞ x 2⅝	2⅞ x 2⅝	3¼ x 2¾	3¼ x 2¾	3¾ x 3	3¾ x 3
Rear	2⅞ x 2-23/32	2⅞ x 2-23/32	3¼ x 2-25/32	3¼ x 2-25/32	3¾ x 3⅛	3¾ x 3⅛
Conn. rod brg. Dia. and Length	2½ x 1-11/16	2½ x 1-11/16	3 x 1-15/16	3 x 1-15/16	3½ x 2-7/16	3½ x 2-7/16
Oil Capacity						
Crankcase only	8	8	14	14	18	18
Oil filter	2	6	8	8	8	8
Total	10	14	22	22	26	26
Valve clearance (hot and idling)						
Intake	.018	.018	.020	.020	.020	.020
Exhaust	.022	.022	.024	.024	.024	.024
Wt.—Bare Engine	1300 [illegible?]	1270	1845 [illegible?]	1785 [illegible?]	2185 [illegible?]	2140
*Fuel capacity	17 gal.		34 gal.		34 gal.	
*Water capacity	8½ gal.		16 gal.		17½ gal.	

INFORMATION FOR ORDERING PARTS

When ordering parts, refer to the **engine name plate** attached to side of the cylinder block, which includes the following data:

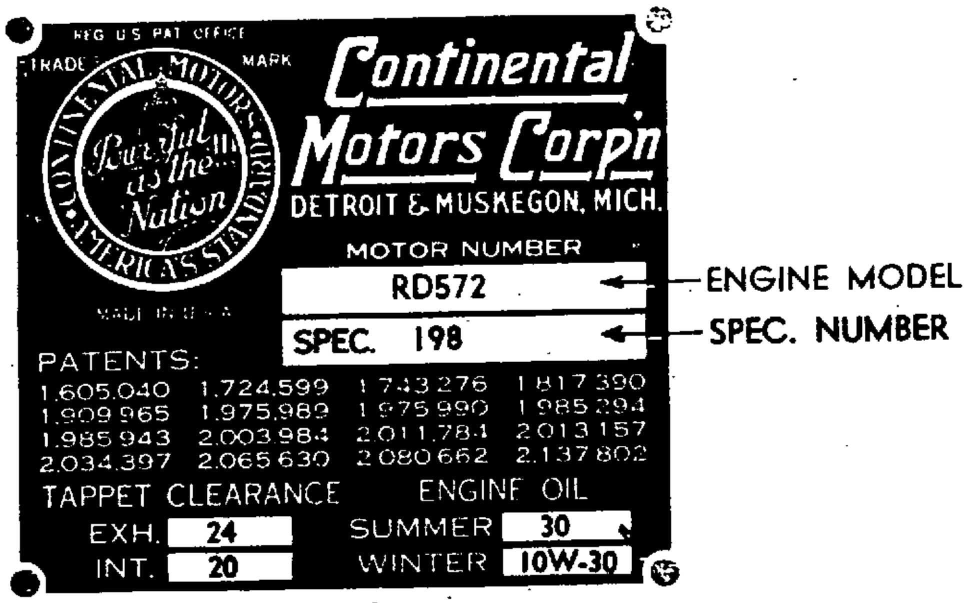


Figure 9
Nameplate

ALWAYS INCLUDE THIS INFORMATION ON YOUR PARTS ORDER.

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 both *fuel and air* are mixed in the carburetor *before* entering the cylinder through the intake valve.

In a diesel engine, only pure *air* is drawn into the cylinder through the intake valve and compressed. At the proper time a measured quantity of fuel is injected into this compressed air thus forming a combustible mixture.

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 by 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, forcing 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 rapid compression of the air, which ignites the fuel as it is sprayed in under high pressure.

GENERAL INFORMATION

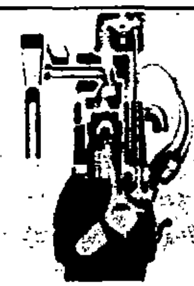
6 CYLINDER DIESEL	STROKE	6 CYLINDER GASOLINE
 **INTAKE** Air only is drawn into the cylinder through the open intake valve by the suction created by the DOWNWARD moving piston.	INTAKE	**INTAKE** *The proper proportion of* gasoline and air mixed by the carburetor is drawn into the cylinder through the open intake valve by the suction created by the DOWNWARD mov-*ing 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 tempera*-ture to between 900° and 1000° F.	COMPRESSION	**COMPRESSION** The intake valve is now closed and the mixture is compressed by the UPWARD moving piston. 
 **INJECTION AND COMBUSTION** At a definite point, short-*ly 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, the spark plug fires and ignites the compressed mixture. 
 **POWER** The expansion of the gases resulting from the burning of this mixture 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 10 — 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 the 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 amount of expansion is directly related to the compression, the diesel is able to deliver more power from a given quantity of fuel. This is basically the reason for its superior efficiency, which results in its saving in fuel cost.

THE CONTINENTAL *"Cushioned Power"* DIESEL ENGINE

Continental Red Seal Diesel Engines are the four-stroke-cycle type and developed to operate efficiently on Commercial Diesel Engine Fuel which, when injected into the combustion chamber, is 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. 11).

Figure 11
Fuel Injected into Combustion Chamber (Top View)

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.**

The air and fuel trapped in the energy cell likewise ignites, Fig. 12, but due to the design

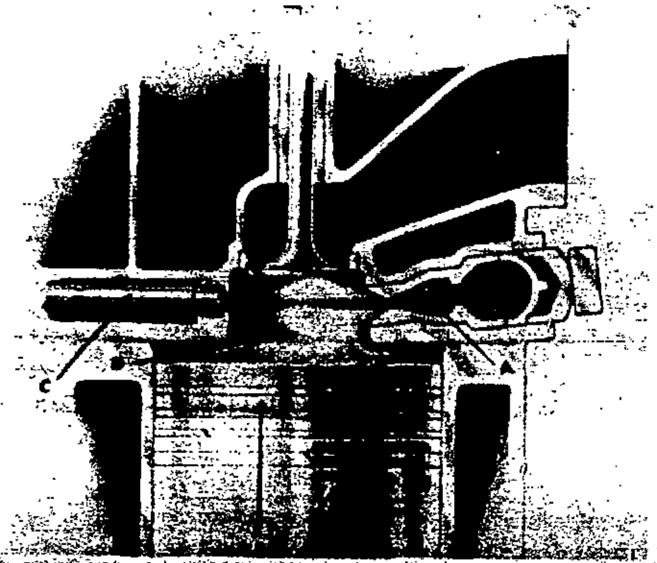


Figure 12
Combustion Starting in Energy Cell

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 modified force against the head of the piston continues well through the power stroke.

THE CONTINENTAL DIESEL ENGINE

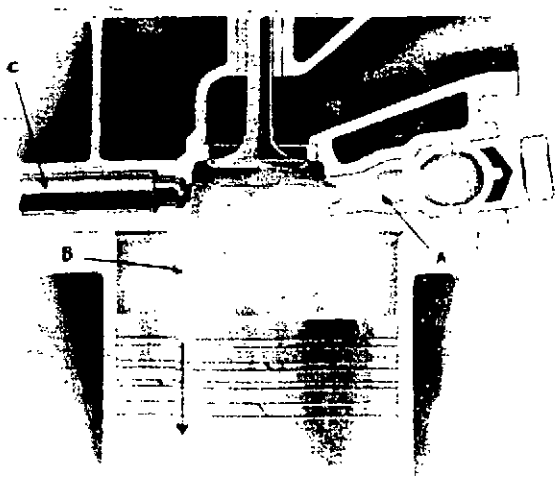


Figure 13
Power Stroke

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.

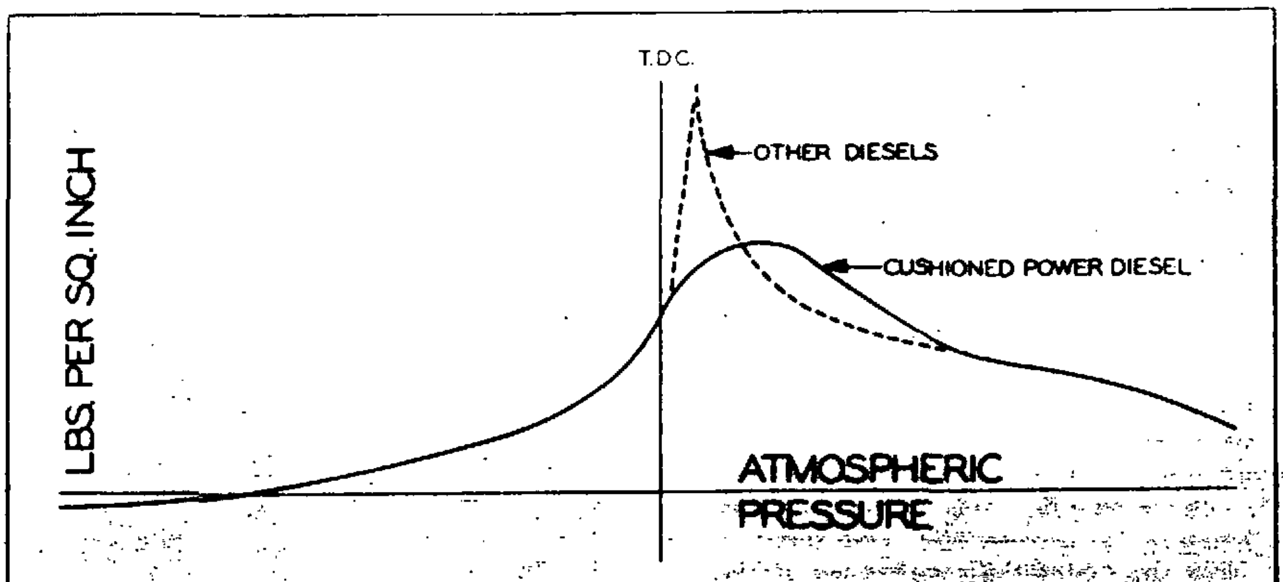


Figure 14
"Cushioned Power" Controlled Combustion pressure

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 — 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.	Transportation High Speed Engines 2400 RPM Max.
A.P.I. Gravity @ 60° F	Lower Gravity Fuels contain more heat Units/Gal.	30 - 40	30 - 40
Cetane Number	Indicative of Ignition Quality, Higher number—better Starting and Idling.	40 minimum	50 minimum
Volatility: Initial Boiling Point	To prevent premature vaporization during hot weather operation.	320°F. minimum	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	525°F. maximum 600°F. maximum 700°F. maximum
Distillation Recovery	Lower % recovery indicates heavy oil fractions which cause smoke and poor combustion.	98%	98%
Total Sulphur	Sulphurous acids corrode and increase engine wear.	.5% maximum	.5% maximum
Corrosion (Copper) 8 hours @ 212°F.	Discoloration or pitting on polished copper strip shows same effect on engine parts.	pass test	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.	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.

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

Always strain or filter fuel before filling supply tank — **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.

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.**

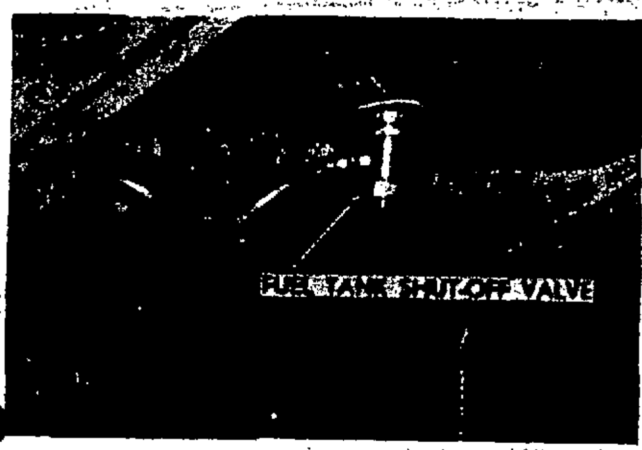


Figure 15
Fuel Tank Shut Off Valve

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

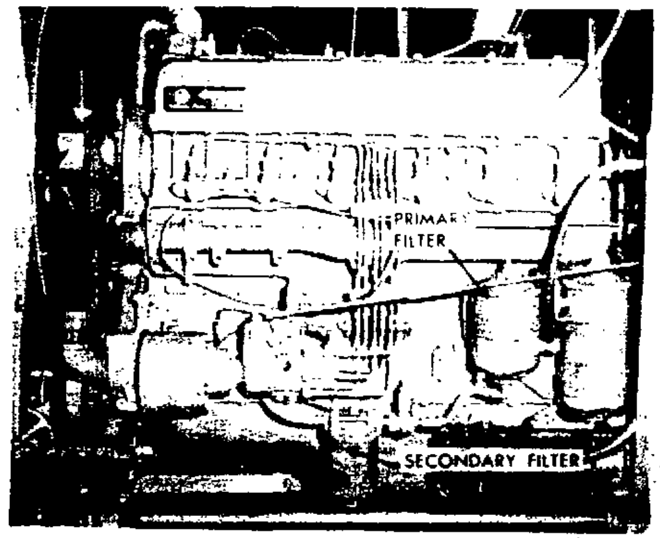


Figure 16
Two Stages of Filtration with the Roosa Pump

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.**

> **CLEAN FUEL IS A**
>
> ***MUST***
>
> **FOR GOOD DIESEL OPERATION**

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 SIX CYLINDER DIESELS

TEMPERATURE RANGE	OPERATING CONDITIONS		S.A.E. NUMBER
	NORMAL	SEVERE	
Below 10° F	Service DG	Service DS	5W - 20*
10° to 32° F	Service DG	Service DS	10W - 30*
32° to 90° F	Service DG	Service DS	30
Above 90° F	Service DG	Service DS	40

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 Vacuum 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 temperatures 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 crankshaft to all main and connecting rod bearings as well as to the timing gears, with "forced feed" to overhead valve rocker arms, the overflow from which lubricates the tappets. The oil pressure is automatically regulated by a spring loaded Relief Valve.

Overhead valve rocker arms are lubricated from the center main bearings on the TD series, and from the Camshaft on the RD and SD.

The gear type oil pump is driven by a gear cut on the camshaft and has several times the capacity required by the engine — the excess being by-passed or returned to the sump. Oil is supplied the pump by a floating screen which picks up clean oil from the upper portion of oil in the crankcase.

To insure piston pin lubrication and prevent piston scuffing during the warm-up period — the large end of the connecting rods have drilled spurt holes pointing toward the 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 of the "forced feed" type from the crankshaft intermittently on the TD series, and from the camshaft on the RD and SD.

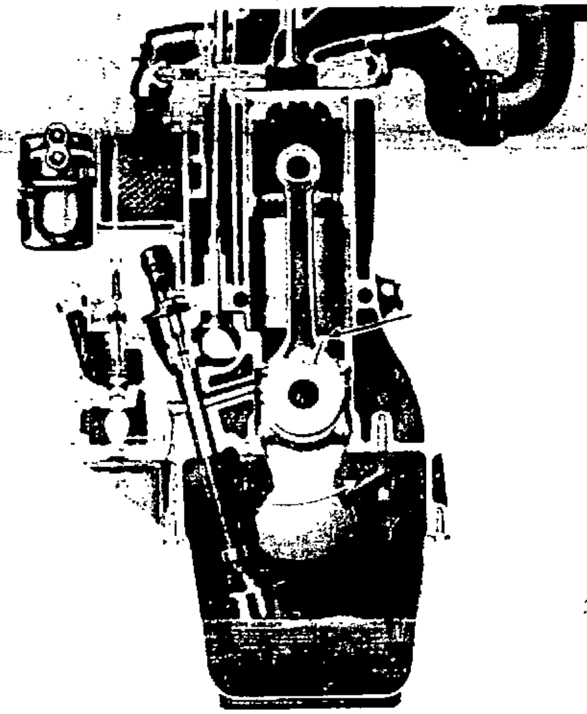


Figure 18
Sectional View Showing Oil Pump and Connecting Rod Spurt Hole

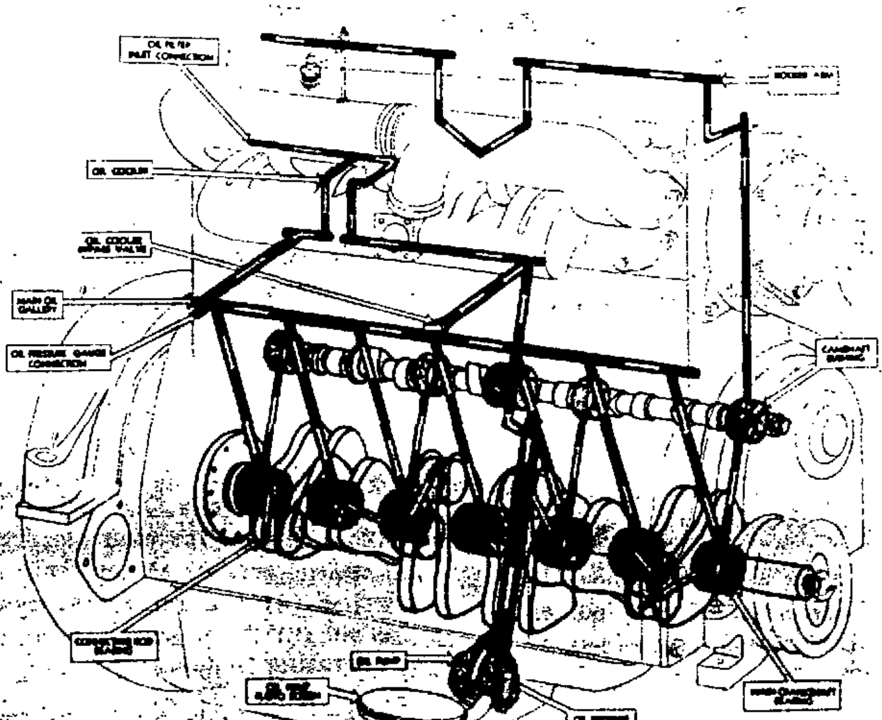


Figure 17
Lubrication Diagram, RD6572

OIL FILTER

A lubricating oil filter is provided to separate and remove the grit, sludge and foreign particles from the oil to prevent these injurious materials from being circulated in the engine. This will prevent operating failures, prolong bearing life and reduce maintenance expense.

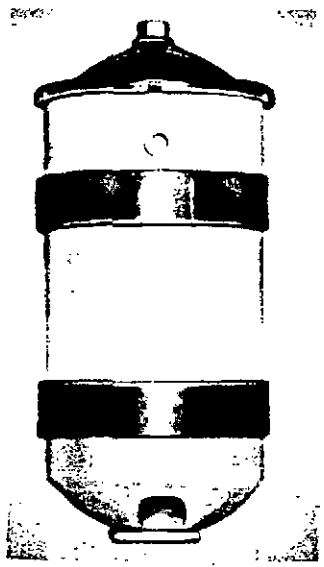


Figure 19
Oil Filter

This by-pass type filter allows only a part of the oil to circulate through the filter at one time; however, all the engine oil eventually passes through and is cleaned. It also includes a replaceable element which collects and retains all the foreign matter.

Eventually the minute passages in the element become clogged and unless replaced at regular intervals, ceases to pass oil through and will by-pass the oil around it. This results in abrasive particles remaining in the oil and circulating to the bearings. To prevent this, replace the filter element every time oil is changed.

OIL COOLER

Each of these engines is equipped with a built-in oil cooler or oil-temperature regulator which controls the oil temperature in direct relation to the cooling water.

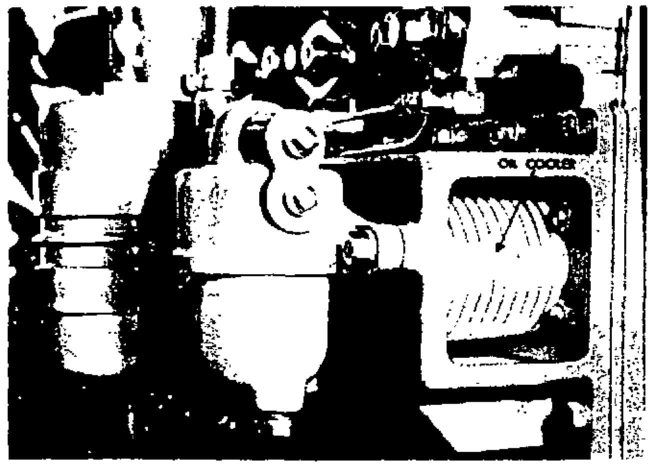


Figure 20
Oil Cooler

In each instance the oil, under pressure, from the pump passes through the oil cooler before entering the main gallery line leading to the bearings and other parts of the engine.

While this is specifically designated as an oil cooler, it actually serves to bring the oil up to a more satisfactory operating temperature along with the temperature rise of the cooling water, and at the same time limits this increase, to hold it in direct relation to the cooling water, thus preventing it from reaching too high a temperature to satisfactorily lubricate the engine and help to cool the parts with which it comes in contact.

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.

ENGINE LUBRICATION SYSTEM

In normal operation, the Continental Diesel engines should have the oil and filter element changed after every 50 hours or 2000 miles of operation. The oil should be drained when the engine is at normal operating temperature.

OIL PUMP

The oil pump on the six cylinder diesel engines is mounted on the center main bearing cap. It is a gear type pump, with a helical gear on the upper end of the shaft driven by a mating gear cut on the camshaft.

The suction screen is of the floating (Float-O) type and must be free to follow the level of oil in the crankcase.

The pump supplies a quantity of oil under pressure, well in excess of the engine requirements, and is very rarely a source of trouble. If, for any reason it does not operate satisfactorily, it can be removed and repaired or replaced, without difficulty.

Normal oil pressure under operating conditions are from 40-50 lbs. in the TD427 and TD6427 and 55-65 lbs. on the RD572, RD6572, SD802 and SD6802, while at idle speed it should not fall below 7 lbs.

If the pressure fluctuates or falls below these limits, **STOP THE ENGINE IMMEDIATELY** and locate the cause. Refer to trouble shooting section for procedure.

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 this dust in the oil cup.

Air cleaners, if properly serviced, will remove practically all foreign material from air entering engine. Their efficiency is materially *decreased* by 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.

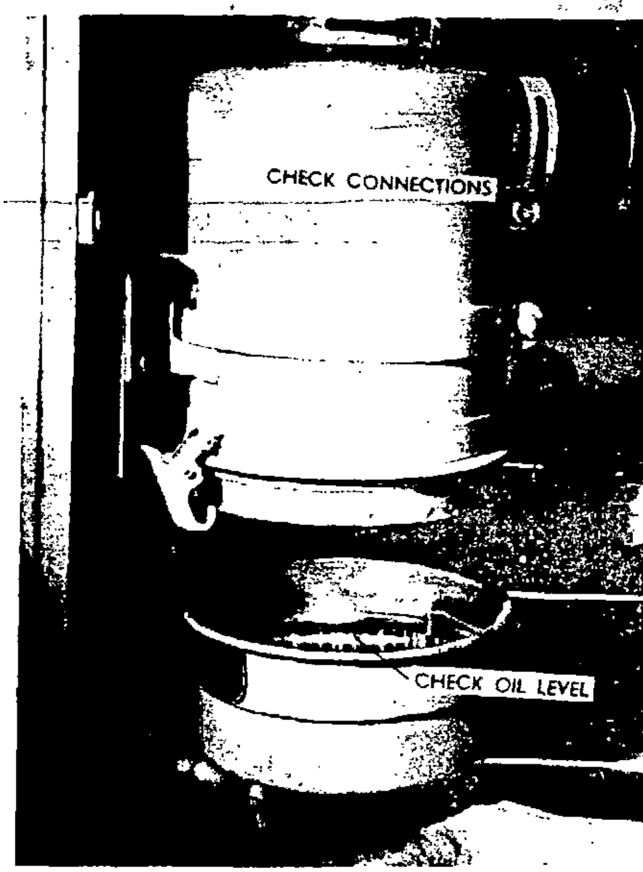


Figure 21
Air Cleaner

The length of time an engine may be permitted to run before the air cleaner is serviced depends entirely on operating conditions. 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 *rapidity with 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.

A planned air cleaner servicing program will increase the effective life of your engine.

THE AIR CLEANER ARRANGEMENT SHOULD NOT HAVE RESTRICTIONS GREATER THAN 10" WATER.

"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 #10 oil to high level mark — regardless of outdoor temperature.**
2. Start engine and run-in at following schedule:

INDUSTRIAL

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.

TRANSPORTATION

Start engine and run-in according to following schedule:

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

¼ hour at 1200 RPM — no load.
¼ hour at 1500 RPM — no load.
¼ hour at 1800 RPM — no load.
¼ hour at 2000 RPM — no load.

***If the engine is being run-in on a dynamometer,* the next steps should be:**

1 hour at 2000 RPM — ¼ load.
1 hour at 2000 RPM — ½ load.
1 hour at 2200 RPM — ¼ load.
1 hour at 2200 RPM — ½ load.
½ hour at 2200 RPM — full load.

If engine is being run-in, in the vehicle, the next step, after the ½ hour at 2000 RPM — no load, is to drive the empty vehicle for 1 hour, maintaining engine RPM at 2000.

The vehicle may then be loaded and put on the road, but operator should maintain engine speeds between 2000 and 2200 RPM for the first 100 miles and MUST, at no time, *operate with the throttle more than half open.*

During the next 200 miles, the same engine RPM should be maintained with ¾ throttle, with occasional acceleration at full throttle, for a maximum of 3 minutes at a time. Longer periods of full throttle during this stage of the break-in could cause scuffed rings and other damage to the engine.

Throughout the next 200 miles of operation, maintain engine speeds between 1800-2200 RPM, *at no time letting it drop below* **this range while on the highway. Prolonged periods of operation at full throttle must be avoided, while, otherwise normal operation is maintained.**

Judicious use of throttle and gear shift during the first 500 miles of operation, can mean the difference between an unsatisfactory engine and one that will give good performance with a minimum of fuel, oil and maintenance expense.

3. **At end of first day's operation — while warm:**
   - **(1) Torque down cylinder head studs to specifications.**
   - **(2) Adjust intake and exhaust valve to specified clearances.**
   - **(3) Check cooling system hoses and fan belt tension and make needed adjustments from initial settings.**
4. **After 50 hours or 500 miles operation**
   - **(1) Change crankcase oil in accordance with recommendations.**
   - **(2) Make 50 hour preventive maintenance inspection.**

SECTION III
OPERATION

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 down time for repairs will not occur.

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.

BEFORE ATTEMPTING TO START THE ENGINE

CHECK:

1. Lubricating oil level in crankcase.

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

It has high and low level markings, 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 the level to the high mark, ***but do not overfill.***

Figure 22
Bayonet Oil Gauge Rod

> 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. Cooling system.

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

If water, only, is used or if anti-freeze does not contain rust inhibitor, this must be added to coolant in proportion to capacity of cooling system.

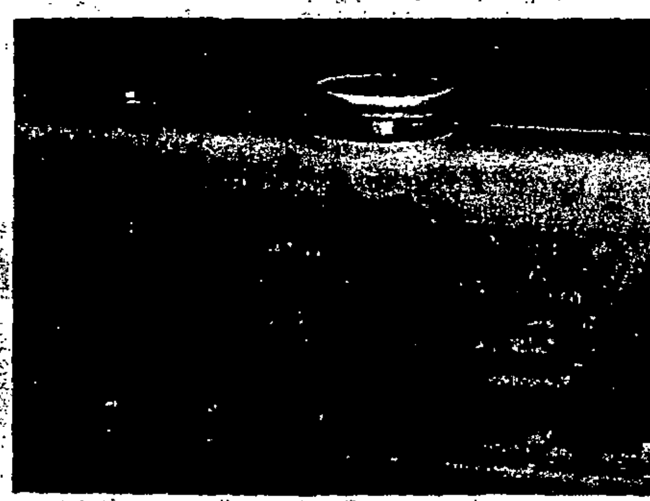


Figure 23
Coolant Filler

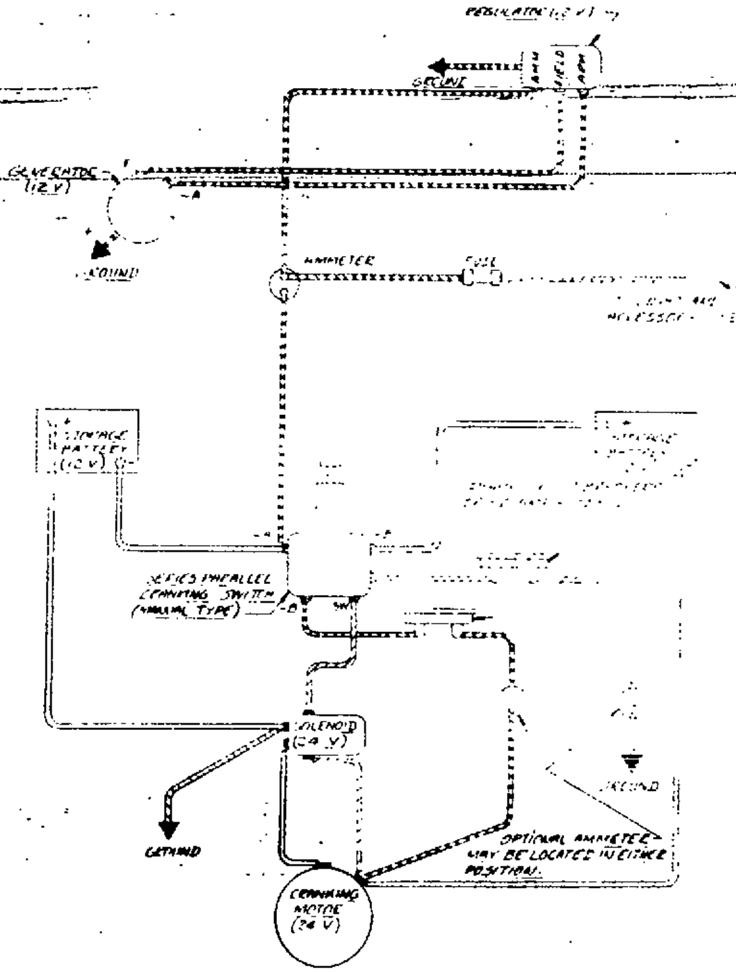


Figure 24

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.

5. Storage Batteries.

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

Specific gravity must be 1.250 or higher. Check with hydrometer, or other suitable equipment.

Terminals and cable connections must be tight, clean, and free from corrosion.

Normally all batteries are grounded on the positive side.

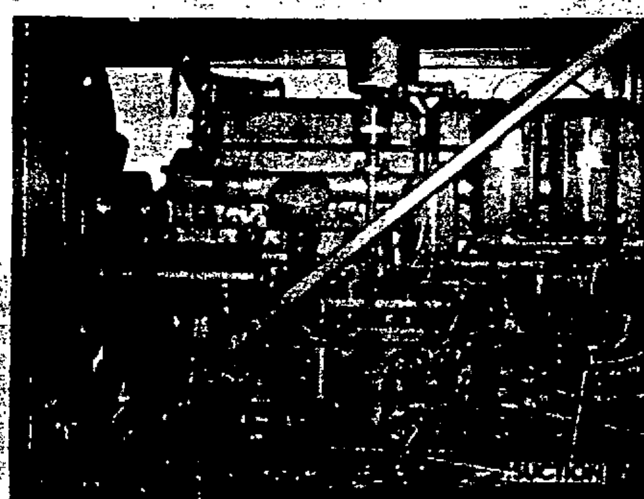


Figure 24 A
Checking Water, Fuel and Oil Connections

OPERATION

STANDARD INDUSTRIAL

TD427 and transportation TD6427 have 12 volt starters and require one 12 volt 200 ampere-hour battery for above freezing temperatures and two similar batteries in parallel for 0°F or colder operations.

Industrial RD572 and SD802 engines have 24 volt starters and require two 12 volt, 200 ampere-hour batteries in series.

Transportation RD6572 and SD6802 engines also have 24 volt starters; however the two 12 volt, 200 AH batteries are in parallel and the 24 volt starting circuit is obtained through a series—parallel switch as shown in Figure 24.

6. Clutch.

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

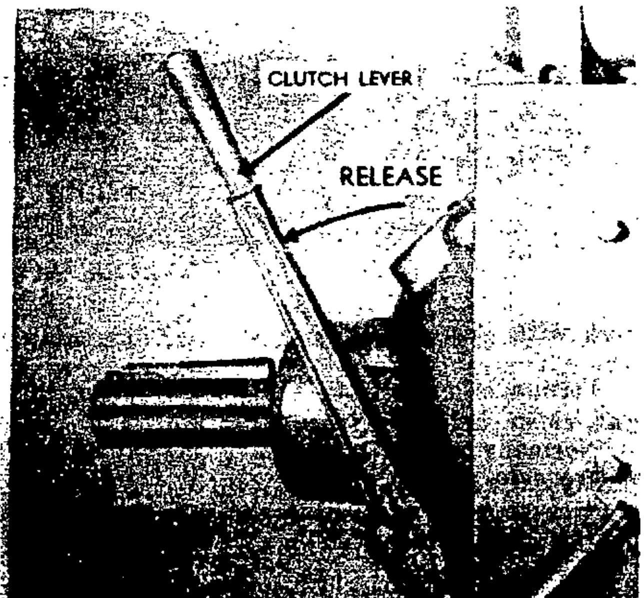


Figure 25
Release Load on Clutch Lever

7. Ability to crank engine with starter.

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

8. Bleed Air From Fuel System

The fuel system must be vented or bled to remove trapped air in the lines and filters before starting new or rebuilt engines. This is also required when the filters have been serviced or any low pressure lines disconnected.

Failure to remove the trapped air in the fuel system will prevent starting and result in useless discharging of the battery.

Nearly all the six cylinder engines have injection pumps with hand primers to facilitate venting and the fuel system can be bled of air as follows:

(1.) Fuel tank shut-off valve must be in open position.

(2.) Remove bleed plug from the top of the final stage filter or loosen several turns without disconnecting the hose connection at the inlet to the injection pump.

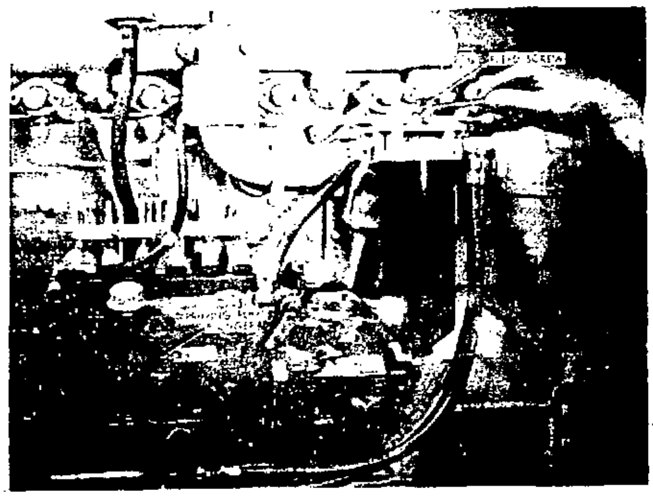


Figure 26

(3.) Using hand primer, pump fuel from the tank through the lines and filters until a solid stream without air bubbles flows. Then tighten hose connection or vent plug.

(4.) Loosen connections at the nozzle holders and crank engine with starter until fuel flows without air bubbles. Then tighten the connections and engine is ready to start.

Figure 27
Loosening High Pressure Connections

If the fuel injection pump is not equipped with a hand primer, the engine may be turned with the starter for the above bleeding operations; however, ample battery capacity is needed.

Engines with PSB injection pumps and no hand primer can be manually primed by removing the supply pump from the injection pump with the inlet and outlet lines in place. Then by rotating the driven gear in clockwise direction, fuel will be pumped to fill and vent the system. This method should be used to conserve battery capacity when a reserve supply is not available.

STARTING PROCEDURE

1. Pull fuel stop control *out* to fully closed position and crank engine over several times with starter.

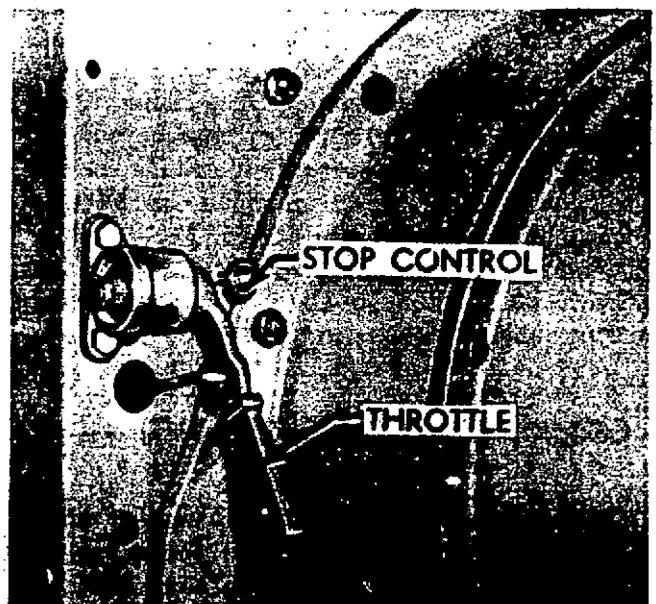


Figure 28
Power Unit Controls

2. Move fuel stop control *in* to wide open position.
3. Open throttle approximately one quarter.
4. Turn engine over with starter again and it should start without difficulty.

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.

White smoke from the exhaust indicates fuel entering engine; however, this turns blue when hot enough to fire.

If engine fails to start after several attempts, consult Trouble Shooting section.

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

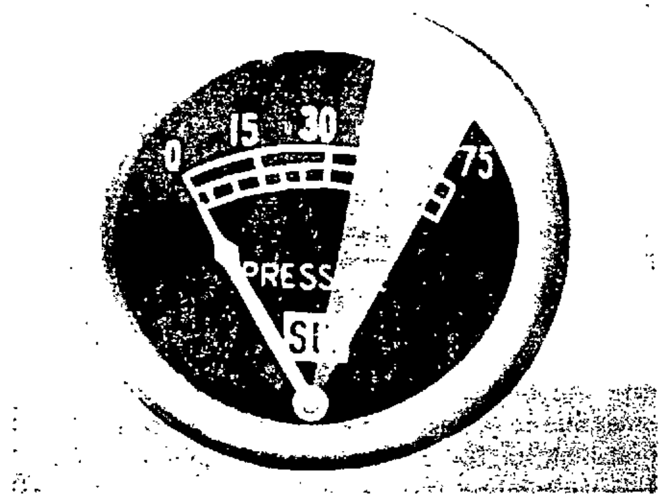


Figure 29
Correct Operating Oil Pressure Range

6. If oil pressure is satisfactory, 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.*

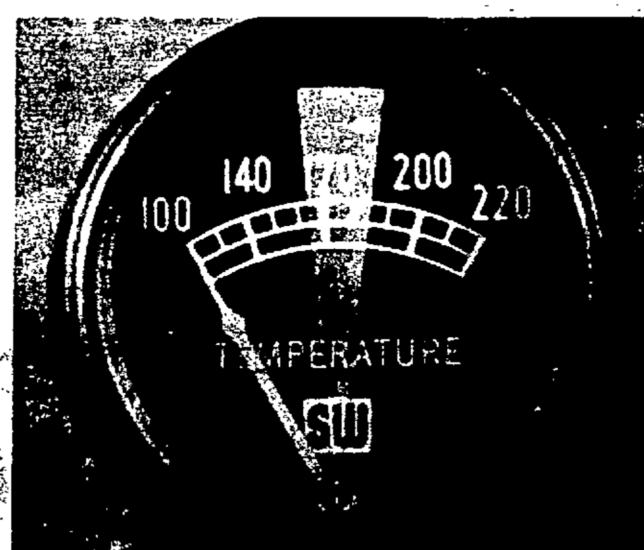


Figure 30
Correct Operating Temperature Range

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.

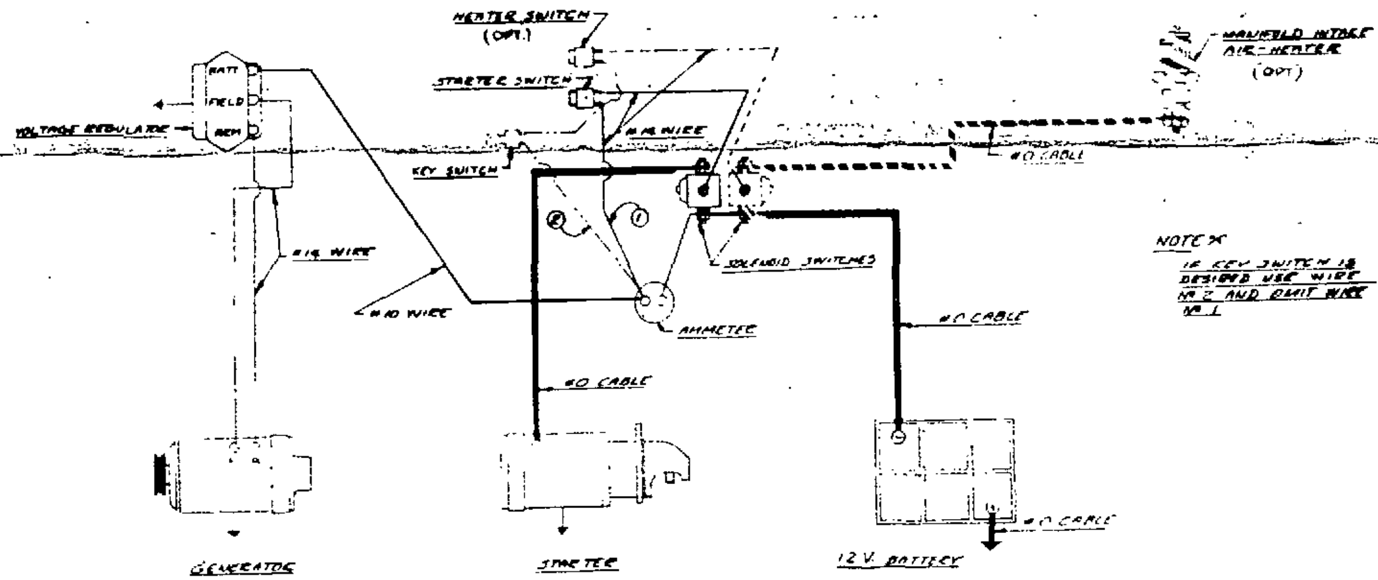


Figure 30A
Wiring Diagram and Picture of Heater

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 TO START: (FIG. 31)

(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.

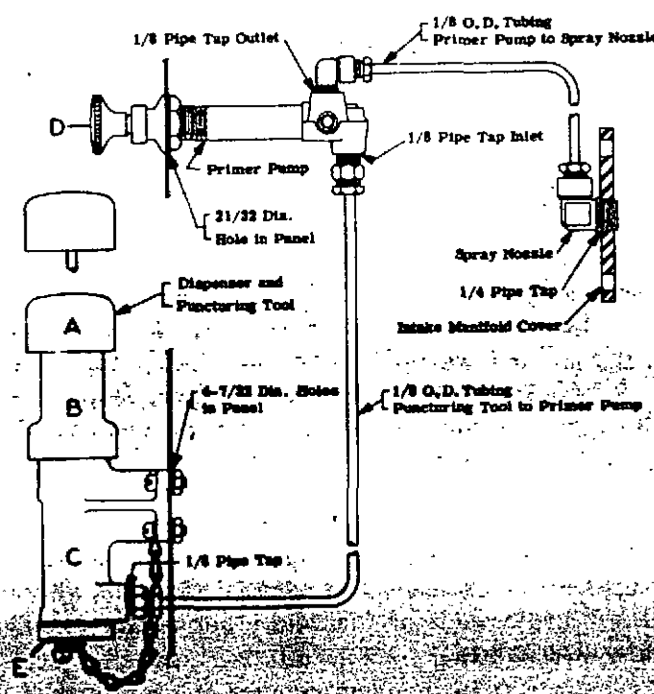


Figure 31
Ether Cold Weather Starting Equipment

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 to 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.

Lubricating oil—must be watched more carefully in cold weather to be sure that dilution is not building up in the crankcase since, despite all precautions, there may be occasions when small quantities of raw fuel condense and wash down the cylinder walls. This is more likely to occur in engines that do not operate for extended periods at comparatively high speed, and temperatures in the crankcase do not reach a point where these heavy ends of fuel and other contaminants are disposed of.

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.

DIRT IS THE WORST ENEMY OF A DIESEL ENGINE

It may be introduced into the engine with air, fuel, oil or water, or by a careless workman. To eliminate possible damage to the engine:

1. Keep outside of engine clean. Dirt on the outside will find its way into the inside of an engine, besides interfering with proper engine cooling.

2. Use clean fuel. Clean fuel is one of the MOST IMPORTANT of all Diesel fuel requirements.

All funnels and measures should be kept in dustproof cases. Hose nozzles, filler flanges and caps should be thoroughly cleaned before using, avoiding the use of linty or dirty rags.

Because of the close fits required to give satisfactory operation, DIRT and WATER in the fuel can cause scored and sticking plungers in injection pumps.

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.

(NOTE: If tank is not equipped with a drain cock, a reliable type should be assembled in place of the plug.)

Drain primary filter at the same time, to remove all foreign material, either dirt or water, trapped during the last operating period.

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.

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 scheduled 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

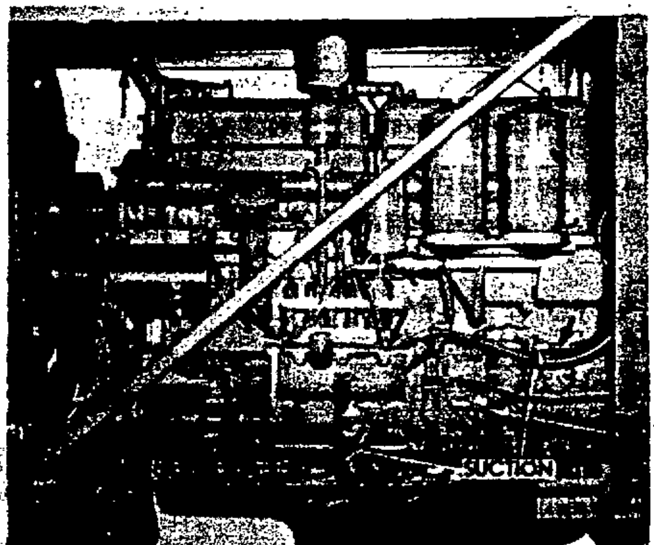


Figure 32
Check Points for Possible Leakage

1 Over-all Visual Inspection of Engine

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

2 Check Oil Level of Engine & Injection Pump

The dipstick indicates the high and low oil level in the crankcase — make allowance for additional drainage back into oil pan if engine has not been stopped over one half hour. Since the most efficient level is between the two dipstick marks, *DO NOT ADD OIL UNTIL LEVEL APPROACHES THE LOW MARK ON DIPSTICK*

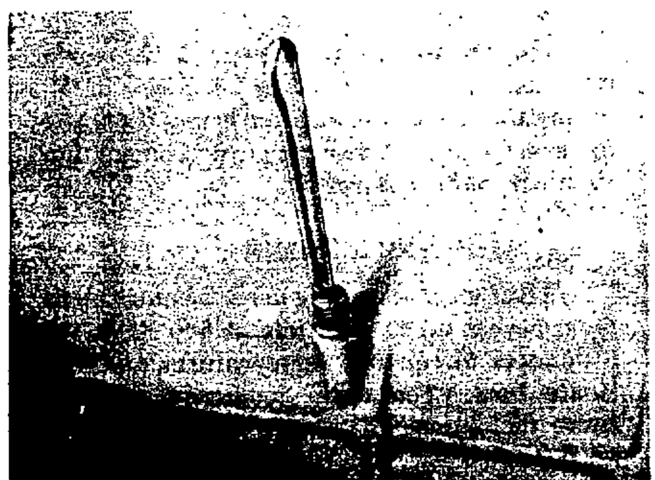


Figure 33
Check Oil Level of Engine

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 PSB pumps are engine-lubricated and Roosa pumps require no lubrication other than the fuel oil.

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

PREVENTIVE MAINTENANCE SCHEDULES

③ Check Radiator

If necessary, add clear water or recommended anti-freeze solution to bring to normal level. Visually inspect fan and belt for condition and adjustment.

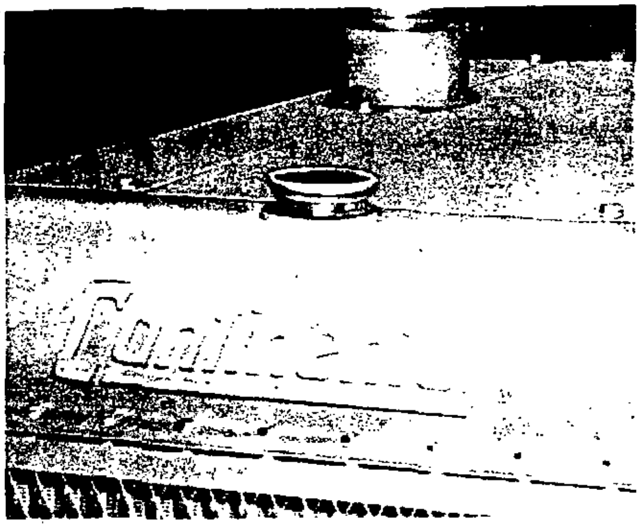


Figure 34

④ Fill with Clean Fuel Oil

This 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 — it is easier to keep dirt out of fuel than remove it later. Use *only* Diesel fuel oil that meets Continental recommended specifications.

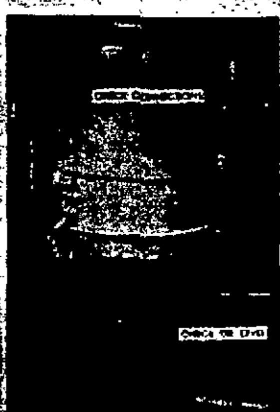


Figure 35—Air Cleaner

⑤ 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.

⑥ 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.

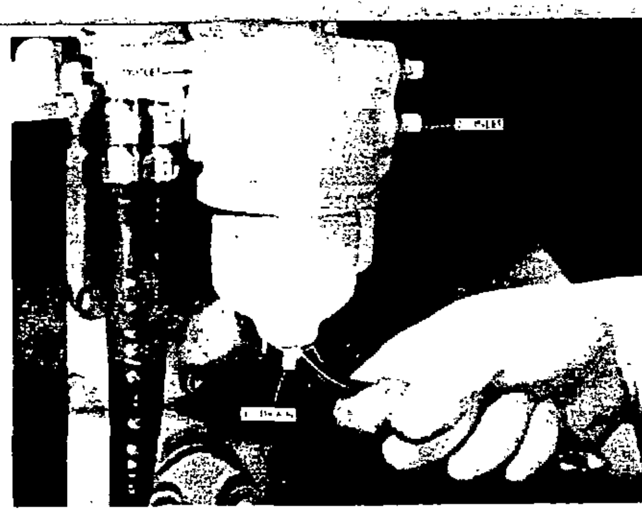


Figure 36
Drain Primary Filter

⑦ Check oil pressure

Note oil pressure gauge, which should indicate 40-65 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 in Trouble Shooting Section.

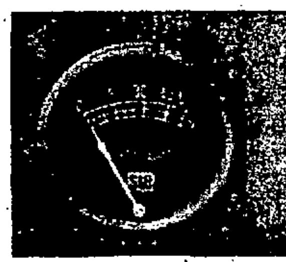


Figure 37
Operating Oil Pressures

⑧ Note any unusual noise

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.

PREVENTIVE MAINTENANCE SCHEDULES

EVERY 50 HOURS OR 2,000 MILES

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.

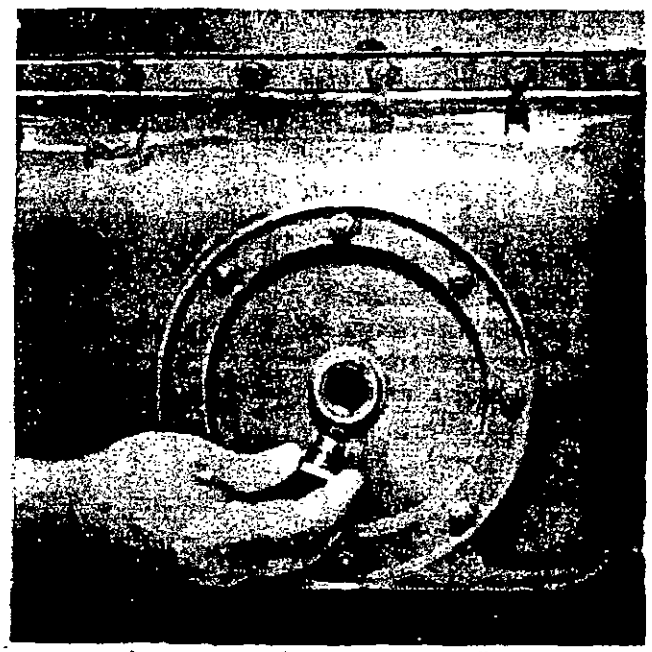


Figure 38
Oil Pan Drain Plug & Inspection Hole Cover

The crankcase oil must be changed after 50 hours or 2,000 miles service and when the oil is hot so complete drainage will result.

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

When engine is started, after assembly, *check for cover leakage under full oil pressure.*

Figure 39
Removing Oil Filter Element

❸ Clean Primary Fuel Oil Filter

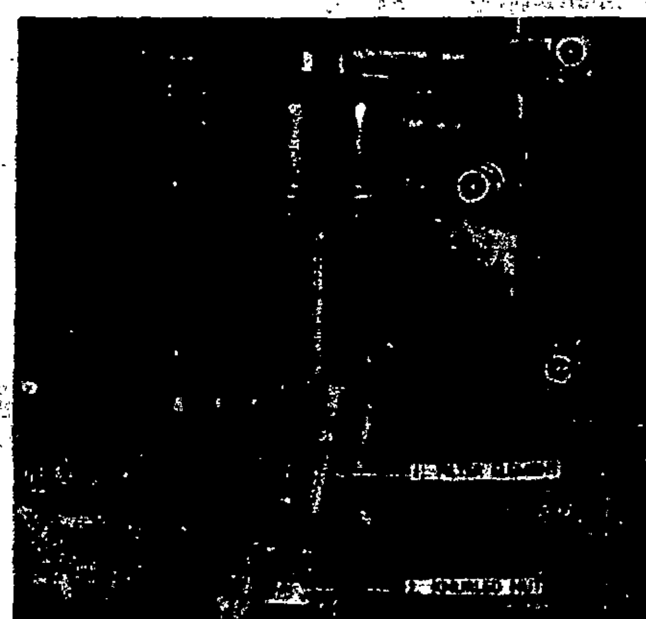


Figure 40
Primary Filter Disassembled for Cleaning

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

Figure 41
Air Cleaner

❹ Service 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 hoses and connections. *Be sure that no unfiltered air can enter the engine intake manifold.*

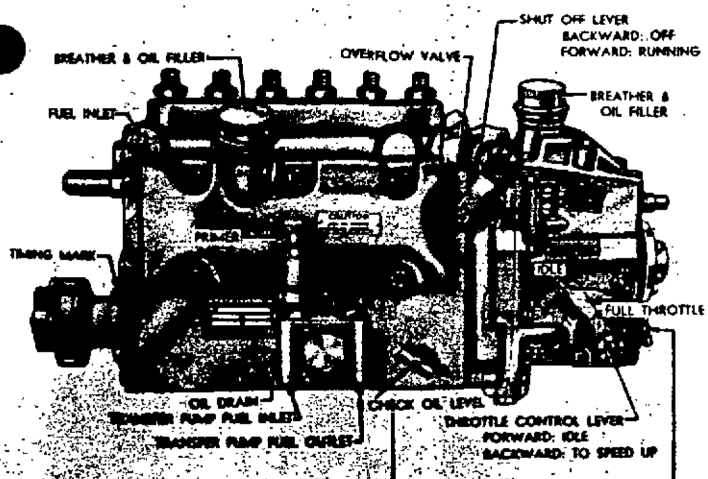


Figure 42
APE Pump Drain Plugs

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

Remove drain plug (1) in side of housing and drain sump. Replace drain plug and fill housing through the oil gauge rod hole until oil flows out high level drain cock (2) — then close drain cock.

Drain Bosch mechanical governor by removing drain plug (3) in the side of the housing. Replace plug and add engine oil until oil flows out drain cock (4), on rear of governor. Allow it to drain down to level before closing. — *Too much oil will affect governor operation.*

NOTE: Bosch PSB single-plunger pumps are engine-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. If air compressor is used, check belt tension which should show a ½" minimum deflection.

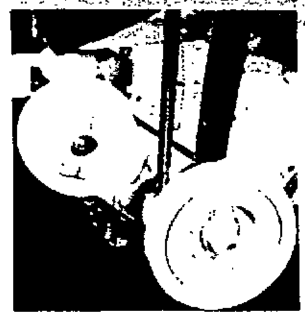


Figure 43
Fan Belt Tension

❼ Check Battery

Check specific gravity of each cell. This should be at least 1.250. Add distilled water, if required, to raise level ⅜" above the separators.

Particular attention should be given battery during cold weather. The cranking power of a fully charged battery @ 80° F is reduced 60% at 0° F; yet the power required to crank the engine is 2½ times greater at this temperature.

Figure 44
Checking Battery

PREVENTIVE MAINTENANCE SCHEDULES

8 Lubricate Starter and Generator

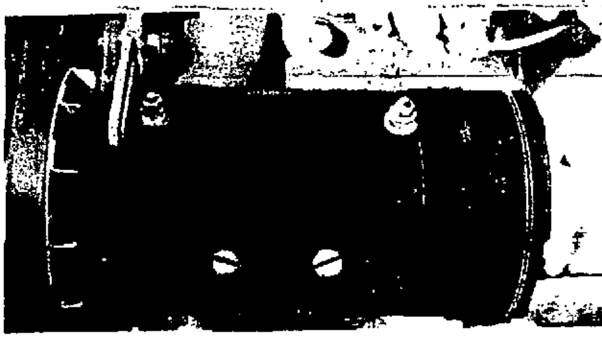


Figure 45
Generator Lubrication

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

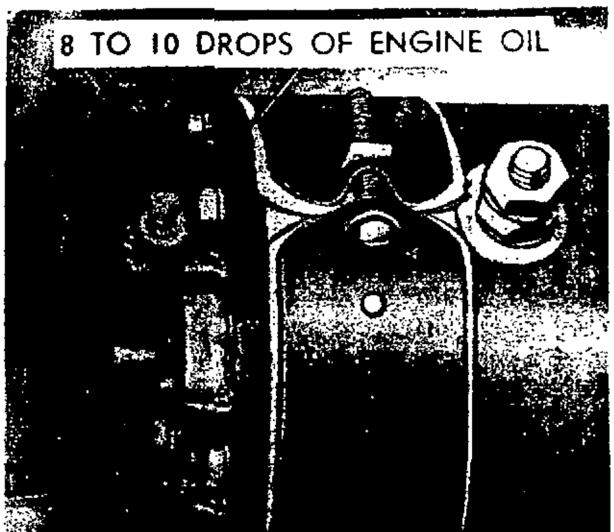


Figure 46
Starter Lubrication Point

9 Lubricate Power Take-off

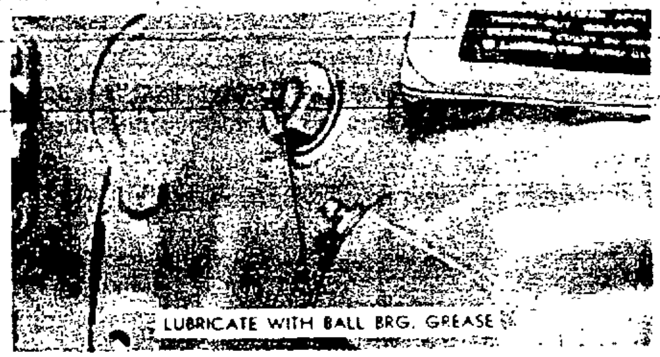


Figure 47

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

10 Lubricate Water Pump

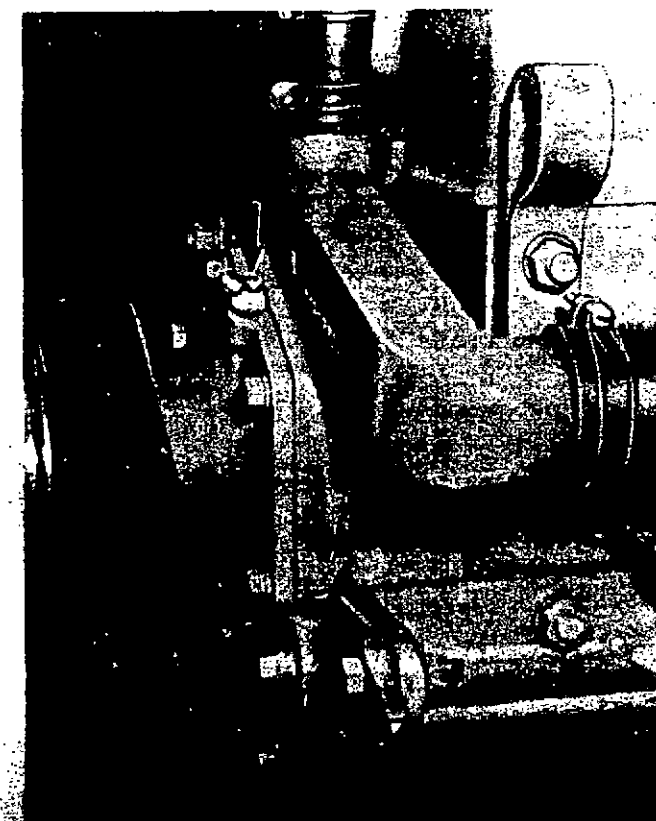


Figure 48
Lubricate water pump with a good ball bearing grease such as Mobilgrease No. 5.

PREVENTIVE MAINTENANCE SCHEDULES

EVERY 250 HOURS OR 10,000 MILES

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

2 Clean Exterior of Engine

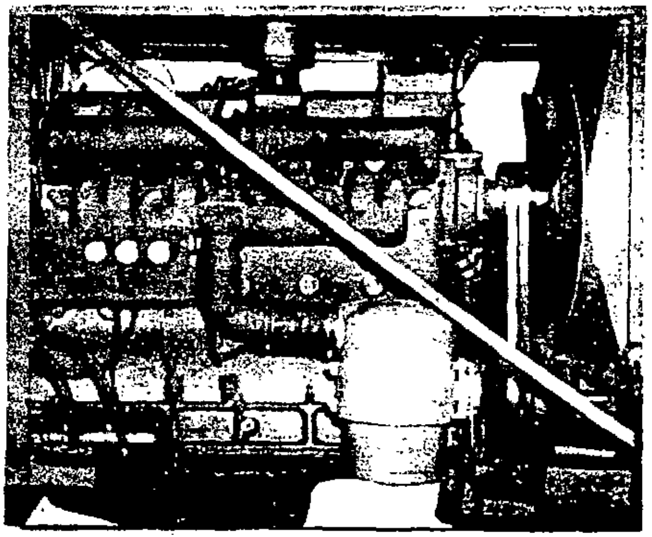


Figure 49

Use steam if available otherwise some commercial solvent may 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 and is idling.

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 50
Adjusting
Valve Tappet Clearance

	INTAKE	EXHAUST
TD	.018	.022
RD	.020	.024
SD	.020	.024

Figure 51
Injection Pump Timing
Marks (PSB Pump)

4 Check Injection Pump Timing to Engine

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

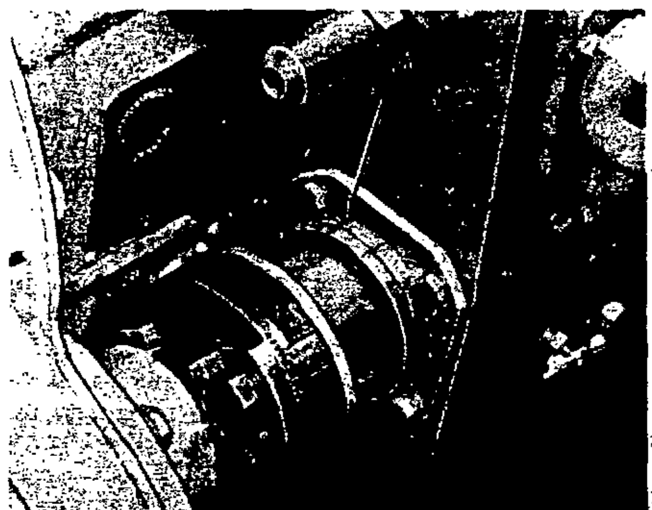


Figure 52
Injection Pump Timing APE Pump

5 Check Engine for even running and Exhaust Smoke for indication of Completeness of 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, low operating temperature or the energy cells carboned up.

PREVENTIVE MAINTENANCE SCHEDULES

Blue smoke indicates excessive oil consumption and white smoke indicates "missing" cylinders. (Further details are given in Section VI under Fuel Injection.)

EXHAUST SMOKE CHART

Smoke Number	Color	Explanation
0	Clear	No smoke visible, only heat *distortion of objects through* exhaust gas vapor.
1	Trace	Very faint smoke
2	Light Gray	Definite smoke visible without any doubt
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 53

❻ Check Governor Setting with Hand Tachometer

An accurate hand tachometer should be used at the 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.

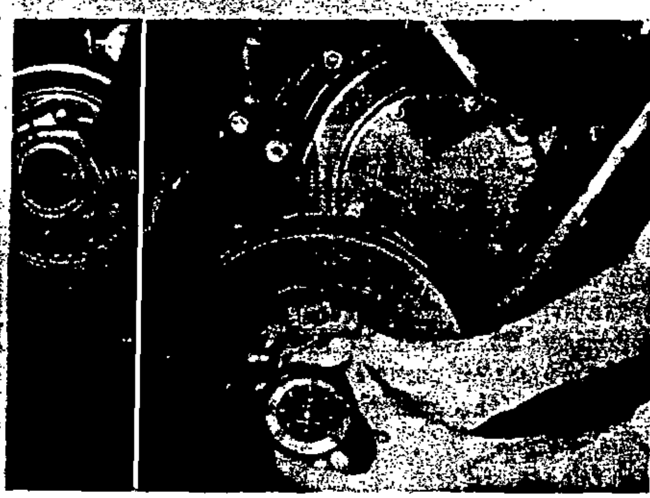


Figure 54
Hand Tachometer in Operation

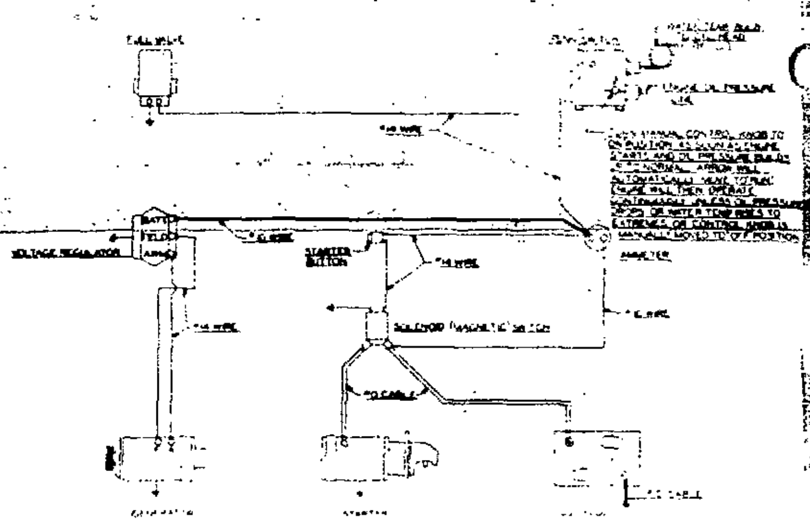


Figure 55
Schematic Drawing of Safety Controls

❼ 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.

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.

PREVENTIVE MAINTENANCE SCHEDULES

EVERY 500 HOURS OR 20,000 MILES

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

❷ Clean Oil Pump Screen

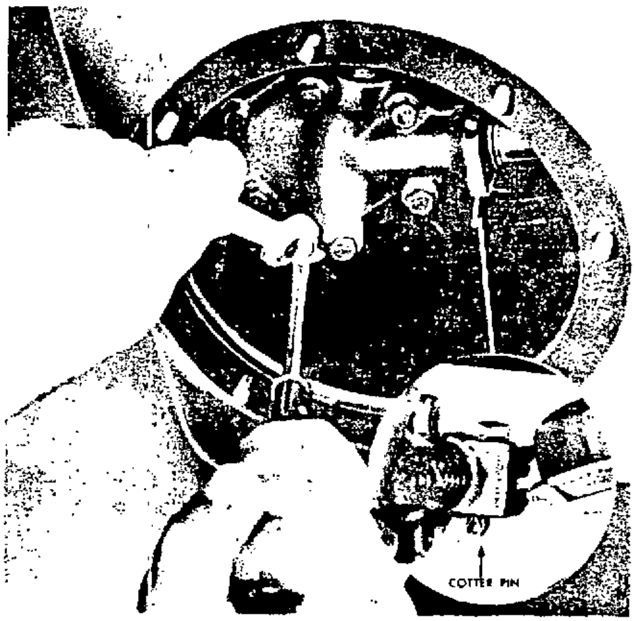


Figure 56

Remove hand hole cover from oil pan sump — the Float-o screen can be disassembled from pump body for cleaning by removing cotter pin. If, previous to the 500 mile period, the oil pressure indicates lower than normal, 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.

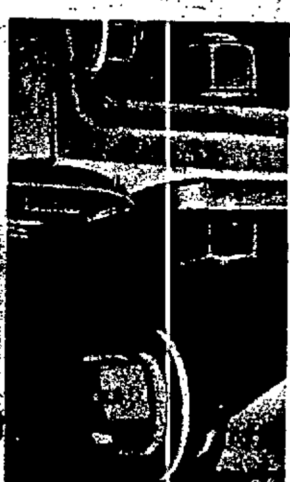


Figure 57
Check Mounting Bolts

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.

❹ **Inspect Manifold Assembly**

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

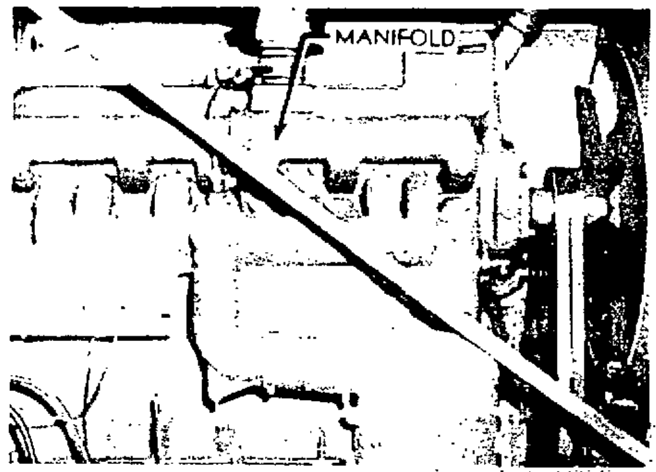


Figure 58

❺ **Check Cylinder Head Nuts**

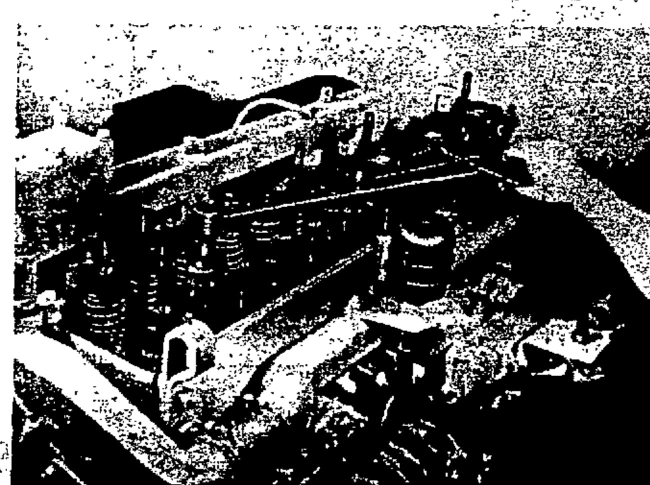


Figure 59
Tightening Cylinder Head Nuts with Torque Wrench

Tighten if necessary in the recommended sequence and to the following torque:

TD Series	130-140 ft. lbs.
RD Series	145-155 ft. lbs.
SD Series	145-155 ft. lbs.

PREVENTIVE MAINTENANCE SCHEDULES

6 Replace Secondary or Final Stage Fuel Filter, or Element

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

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

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

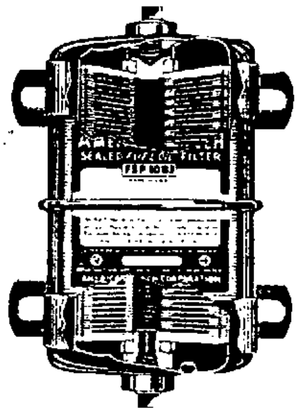


Figure 60
Secondary Fuel Filter

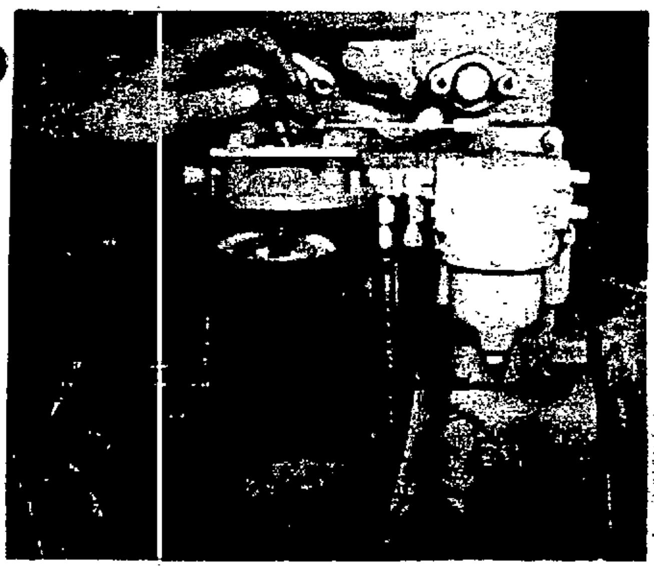


Figure 61
Replacing Filter Element

7 Compression Check

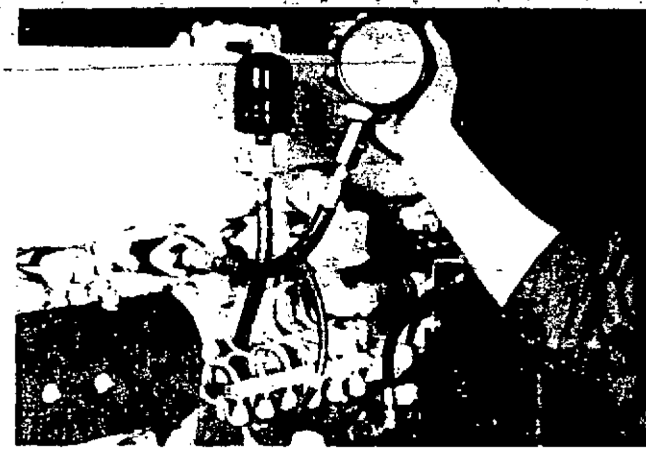


Figure 62
Checking Compression

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 and maintain engine performance.

8 Clean and Check Injector Nozzles

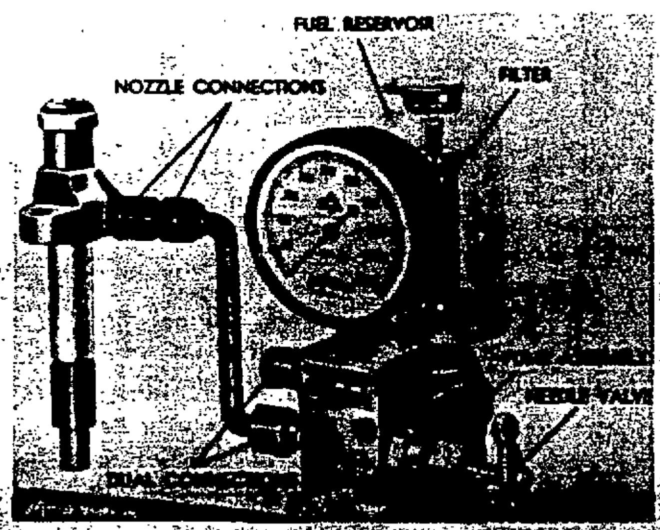


Figure 63
Nozzle Testing Fixture

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. (Section VI)

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 in Section VI.

Figure 63-A

PREVENTIVE MAINTENANCE SCHEDULES

9 Check Starter and Generator Brushes and Commutator

Figure 64
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 ½ 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, in order to prevent damage to valves, pistons and bearings.

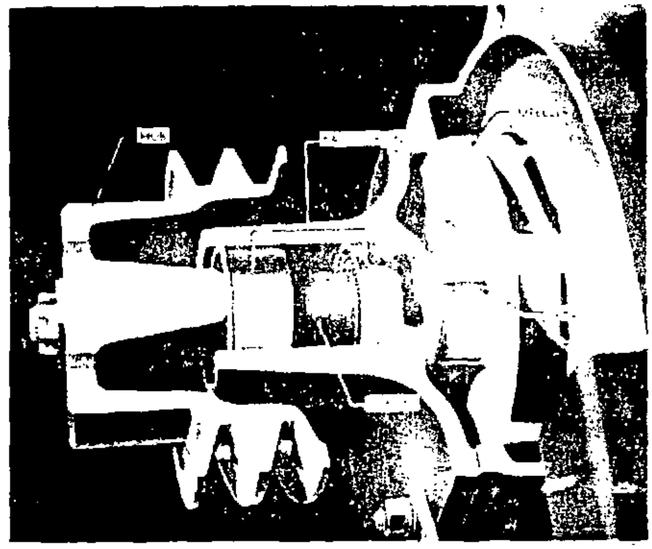


Figure 66
Water Pump

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 TD engines have one thermostat and the RD and SD have two thermostats.

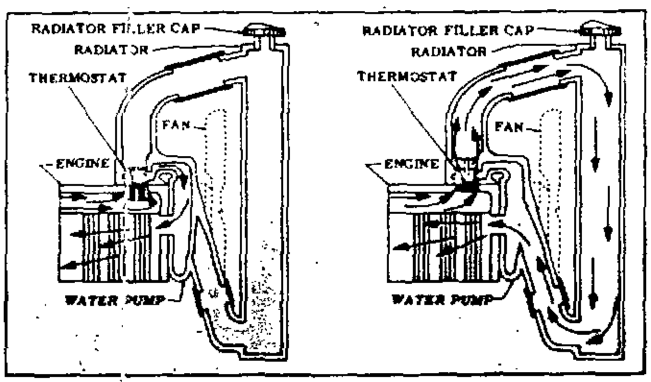


Figure 65
Thermostat Flow Control
Thermostat Closed, Water Re-Circulating through Engine ONLY

Thermostat Open, Water Circulating through BOTH Engine and Radiator

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.

The cooling water is circulated by a water pump located at the front of the engine block.

On the RD and SD engines, the major portion of the coolant is directed through a distribution manifold into the cylinder head where it carries away heat from the combustion chamber and valve seats. A smaller portion is directed to the oil cooler after which it enters the water jacket at the rear of the cylinder block.

On the TD, a major portion of the coolant passes through the oil cooler entering the water jacket at the rear of the cylinder block; the balance enters the front directly from the water pump. It is distributed to the cylinder head through cast passages.

On the TD, the cylinder walls are cooled by direct flow, while the RD and SD are cooled by a combination of direct flow and convection currents. This keeps the cylinder barrels at a 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, depending upon the application, where it is cooled before re-entry into the engine.

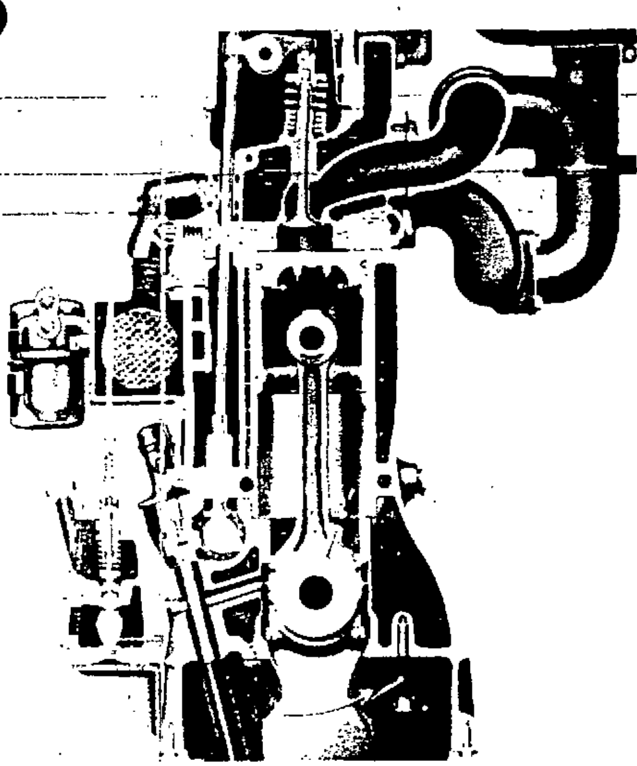


Figure 67
Cooling by Convection and Pump Circulation

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 ¼ 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.

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:

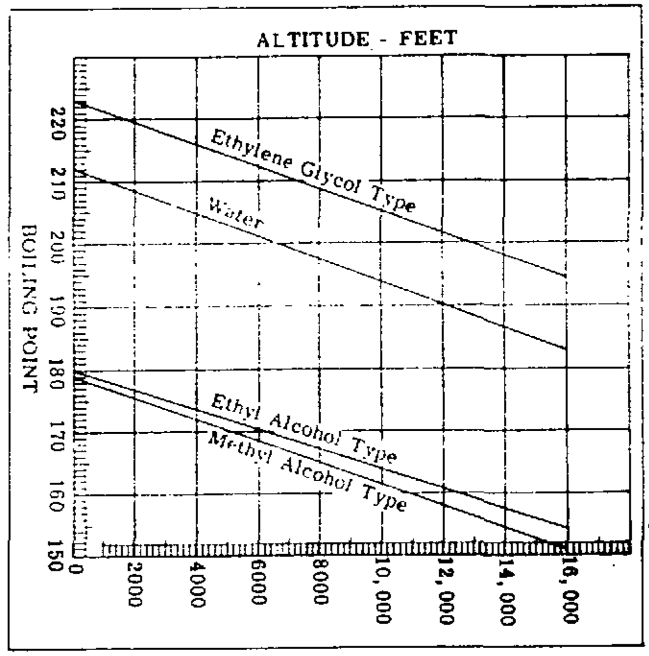


Figure 68
Effect of Altitude on Boiling Point of Coolant

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** ***as shown in chart on following page.***

COOLING SYSTEM

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 Zerone, 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, Prestone, Zerex, Peak (permanent type)—When there are no leaks add water only to make up for evaporation.	1 to 4	2 to 5	1 to 1

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

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.

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.

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.

Every 500 hours of operation or 20,000 miles the radiator and cooling system should be well cleaned and flushed with clean water.

Wherever possible, only soft clean water should be used in the cooling system. Hard water will

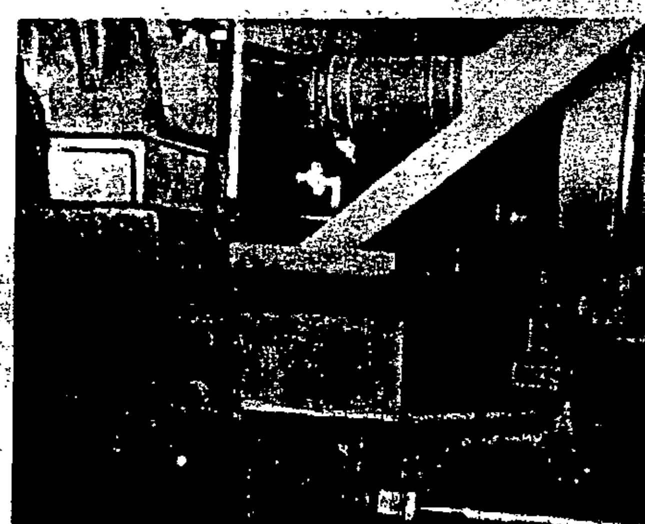


Figure 69
Radiator Drain

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 render the cooling system unable 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 indicates that the cooling system should be thoroughly flushed and cleaned before adding fresh coolant.

Dependable cleaning compounds must be used, following the recommended procedure. 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 added.

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.

This flushing operation 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. Tighten radiator cap.
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. (Not more than 10#)
6. Shut off the air, again fill the radiator with water and apply air pressure — repeat until the flushing stream runs clear.
7. Clean and inspect radiator cap.

To Reverse flush the engine

1. Remove the thermostat.
2. Clamp the flushing gun in the *upper* hose.
3. Partly close the water pump inlet to fill the engine water jacket 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.

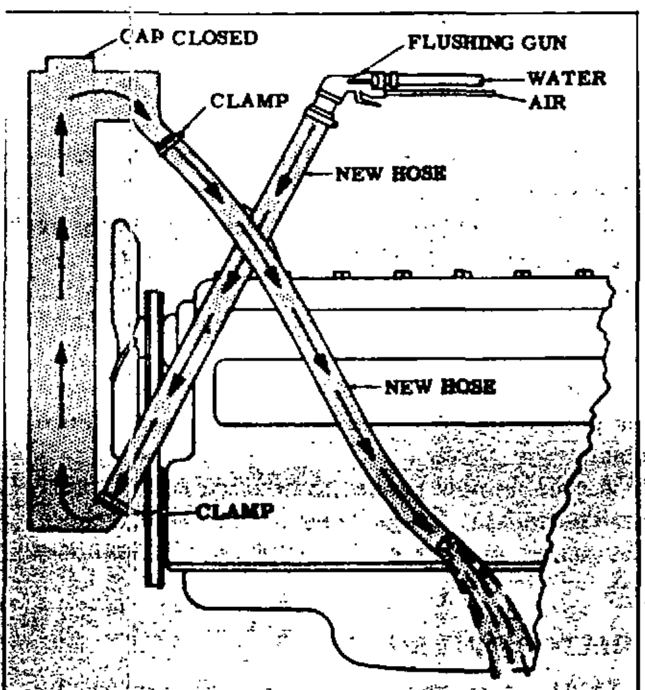


Figure 70
Reverse Flushing Radiator

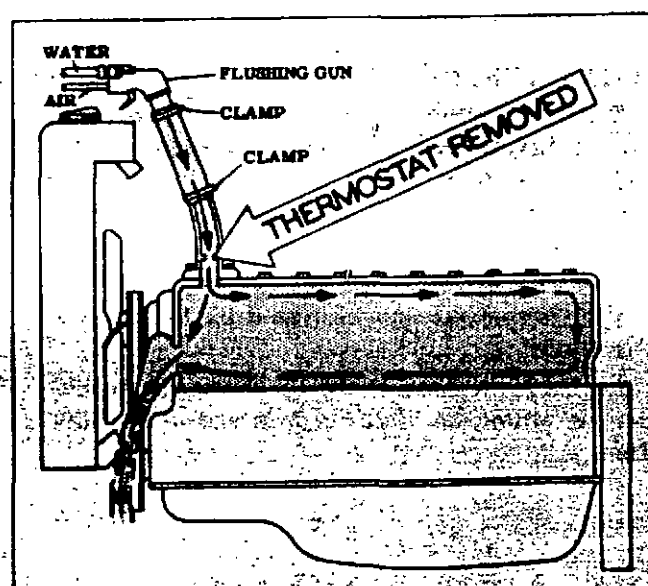


Figure 71
Reverse Flushing Engine

COOLING SYSTEM

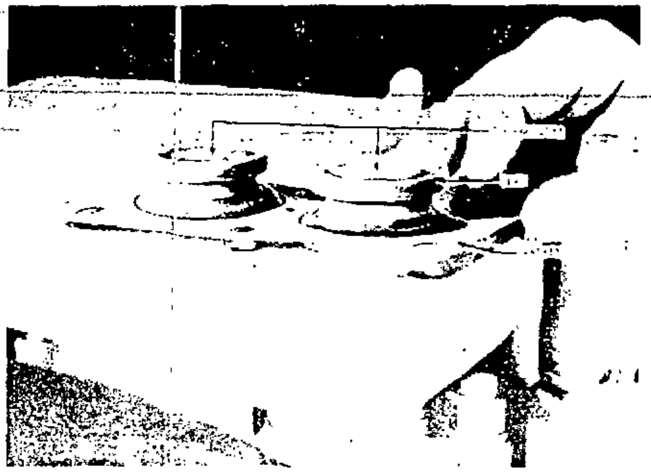


Figure 72
Installing Thermostats on RD and SD Series

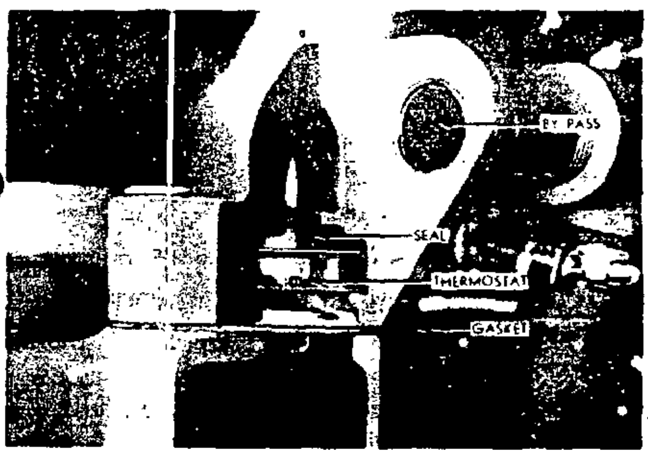


Figure 73
Installing Thermostat on TD

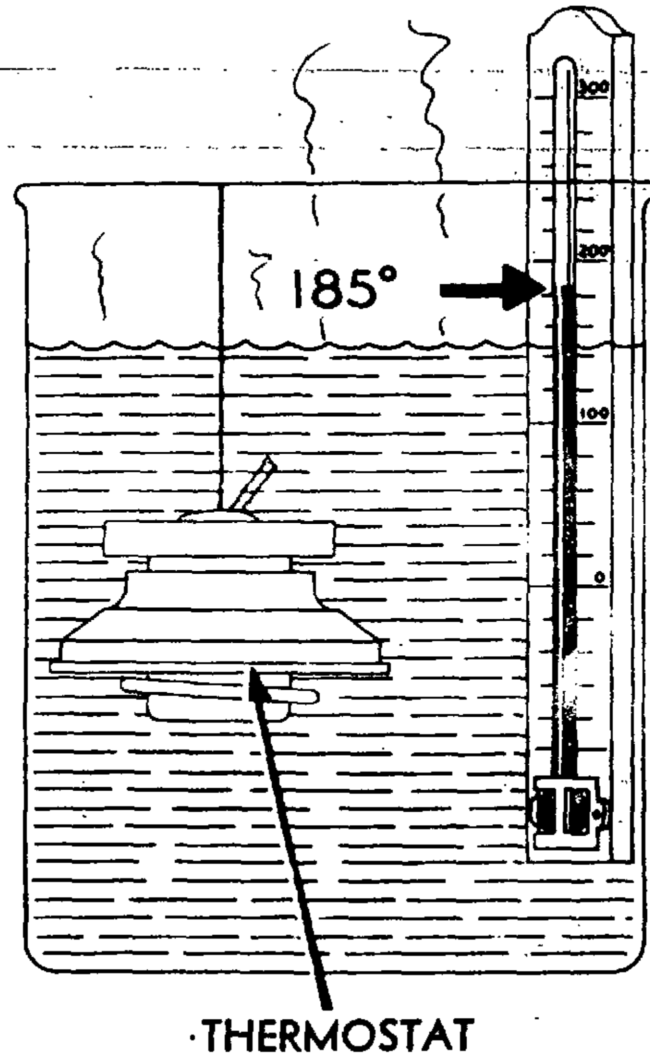


Figure 74
Testing Thermostat

TESTING THERMOSTAT

Remove thermostat housing cover and thermostats. 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 must be replaced.

The thermostat can be tested by 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. Thermostat should be fully open between 180° and 185°.

When replacing the thermostats be sure seal is in place, and seal seat as well as counterbore is clean.

Assemble new gasket to housing contact surface. Thermostat flange must seat in counterbore with gasket sealing contact between it and the cover.

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. Pressure developing within the system raises the boiling point of the coolant and permits higher temperatures without overflow loss from boiling.

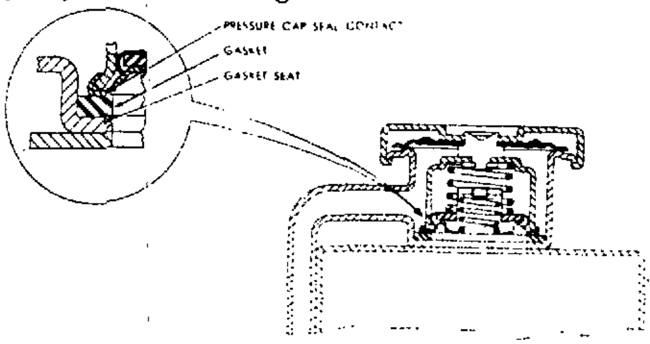


Figure 75
Pressure Cap

Most pressure valves open at 4½ 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 an air tight cooling system is necessary with particular attention to tight connections and a radiator designed to withstand the extra pressure.

FAN BELT TENSION

When tightening fan belts, loosen the generator mounting and 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 76
Adjusting Fan Belt Tension

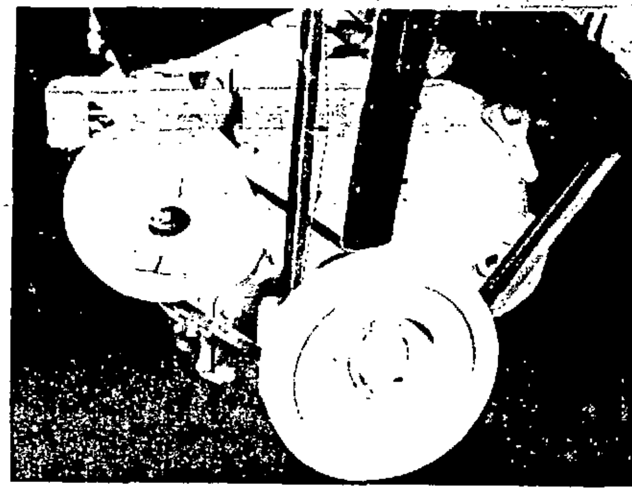


Figure 77
Checking Deflection

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

Tighten generator mounting and adjusting bolts when adjustment is completed.

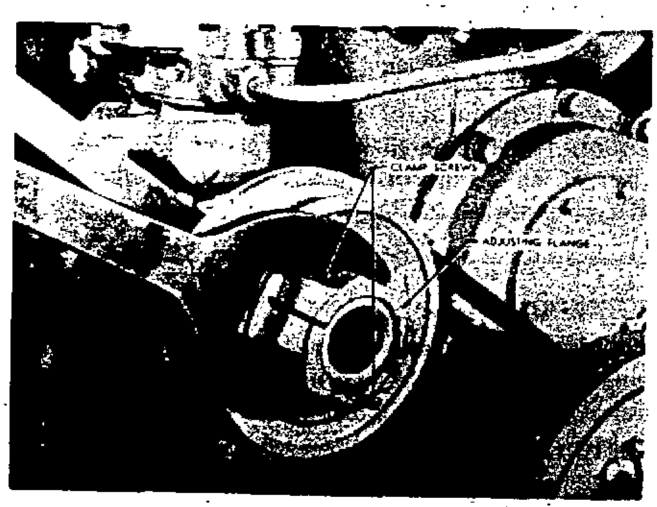


Figure 78
Adjusting Air Compressor Belt Tension

If the engine is equipped with an air compressor, belt driven, as illustrated, this belt should be checked for tension and adjusted, if necessary, at the same time.

The belt should have a minimum of ½″ slack and not more than ¾″.

Adjustment is made by loosening clamp screws, then, holding rear section of pulley with one wrench, turning adjustable section clockwise to tighten belt to desired tension.

Be sure to tighten clamp screws when adjustment is completed.

COOLING SYSTEM

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 79
Cylinder Block Drain Plugs

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 to sludge and engine parts to corrode.

Over-cooling may be caused by operating conditions such as excessive idling, low speeds and light loads during cold weather. We recommend the use of a thermostatic or manually controlled shutter to 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 at the front of the engine 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 a cast manifold to the cylinder block on the TD, and to the cylinder heads on the RD and SD.

The water pump requires no attention other than regular lubrication every 50 hour period with a good ball bearing grease such as Mobilgrease No. 5. Replace bearings when they show excessive looseness. A water leak indicates a damaged seal, which must be replaced.

On the TD the water pump body is bolted to the cylinder block while on the RD and SD it is bolted to the cylinder head. Also, in each case, it serves only as a cast chamber in which the impeller operates and includes both inlet and outlet openings.

The working parts of the pump are carried in a cast support which is assembled to the body with studs and nuts, and is easily removable for servicing. A fan hub or pulley is mounted on the forward end of the pump shaft, to which a fan may be bolted.

To service or rebuild the pump, as the case may be, follow the procedure outlined:

1. Remove screws holding fan to hub, and remove fan.

2. Remove the 6 nuts and lockwashers holding the support assembly to the water pump body. This assembly may then be lifted off and taken to the bench for inspection and further repairs.

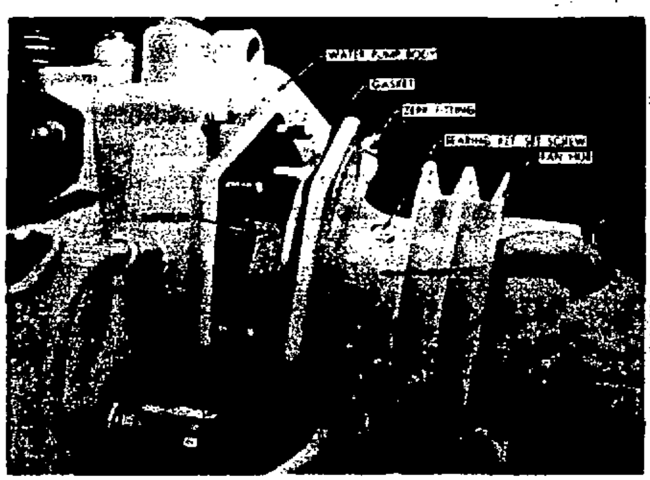


Figure 80
Removing Fan Hub and Works Assembly

3. The impeller and seal can be removed from the shaft by first removing the pin which holds the impeller to the shaft, after which the shaft can be pressed out of the impeller which will carry the seal with it.

4. Next, remove the fan hub or fan pulley from the forward end of the shaft, then the internal snap ring which holds the forward bearing in place, after which the entire shaft and bearing assembly can be removed from the support housing.

COOLING SYSTEM

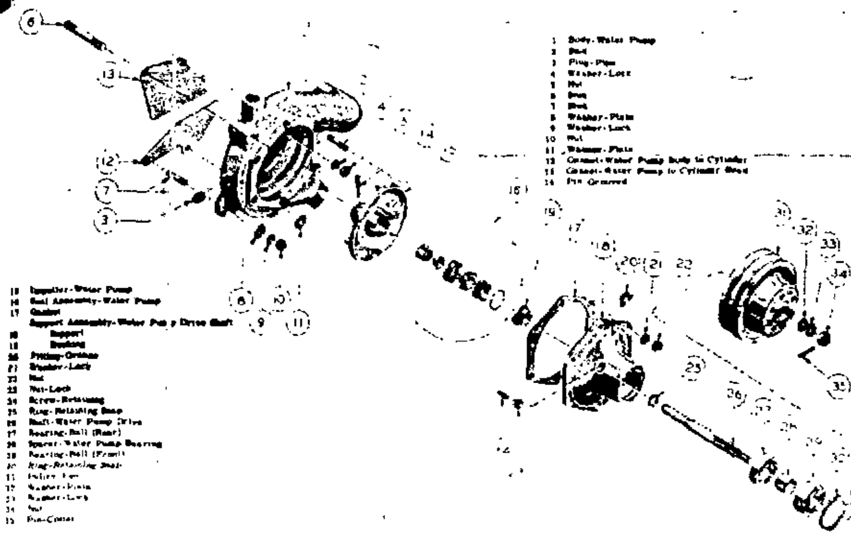


Figure 81
Exploded View of Water Pump (RD)

5. This pump is equipped with a carbon graphite seal which rides on a stainless steel bushing; the face of which is comparatively broad which permits wide area contact of the seal on this bushing flange.

6. The face of the bushing must be smooth and square with the hole so that the seal, though it is spring loaded, can maintain satisfactory contact with the bushing.

7. If the bushing has been replaced or if a worn and scored bushing is to be remachined and used again, the face must be machined after assembly, and the simplest method to use, is to insert the support in a lathe on an arbor which fits the bearing counterbore, and turn the contact face of the bushing absolutely square and polish it to a smooth finish.

8. When reassembling a new carbon seal a light film of lubricant should be placed on the contact area so as to provide immediate lubrication for the beginning of operation.

9. Ball bearings in this water pump operating entirely free from any water require only a good grade of ball bearing lubricant. Never, under any circumstances, use any of the special water pump greases which, when not subjected to water, will harden and have no lubricating effect whatever.

10. There is a relief hole cast in the support so that any water that may leak through the seal will drain off and this is where you will first notice any water pump leaks, at this cast opening in the support on the underside.

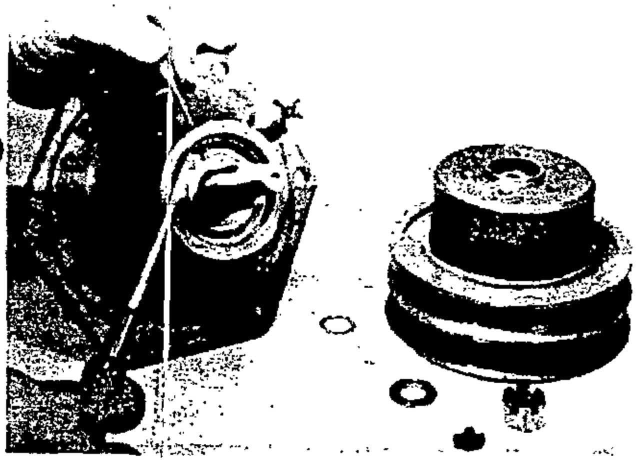


Figure 82
Removing Snap Ring

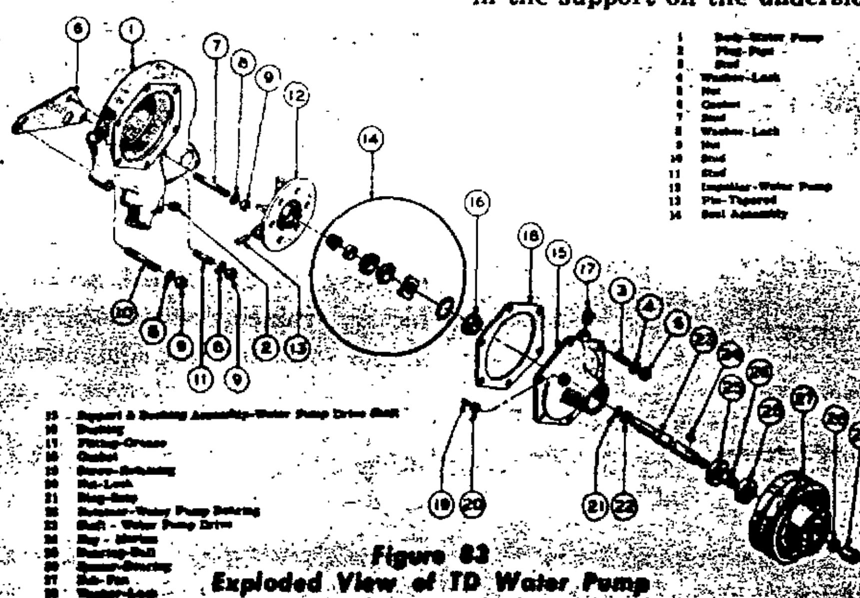


Figure 83
Exploded View of TD Water Pump

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.

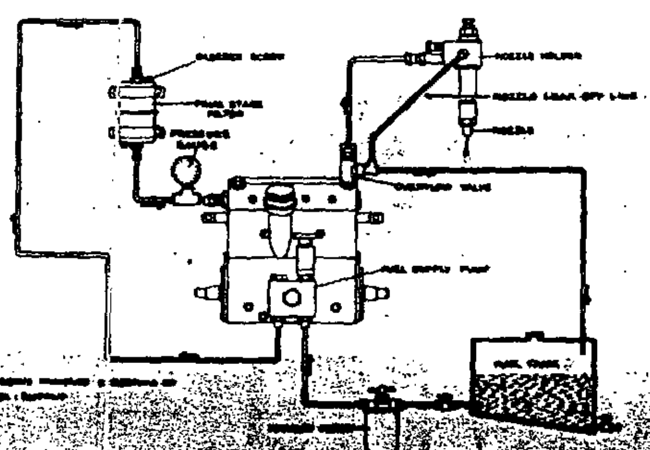


Figure 84
Schematic View of Fuel Supply System with APE Pump

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.

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.

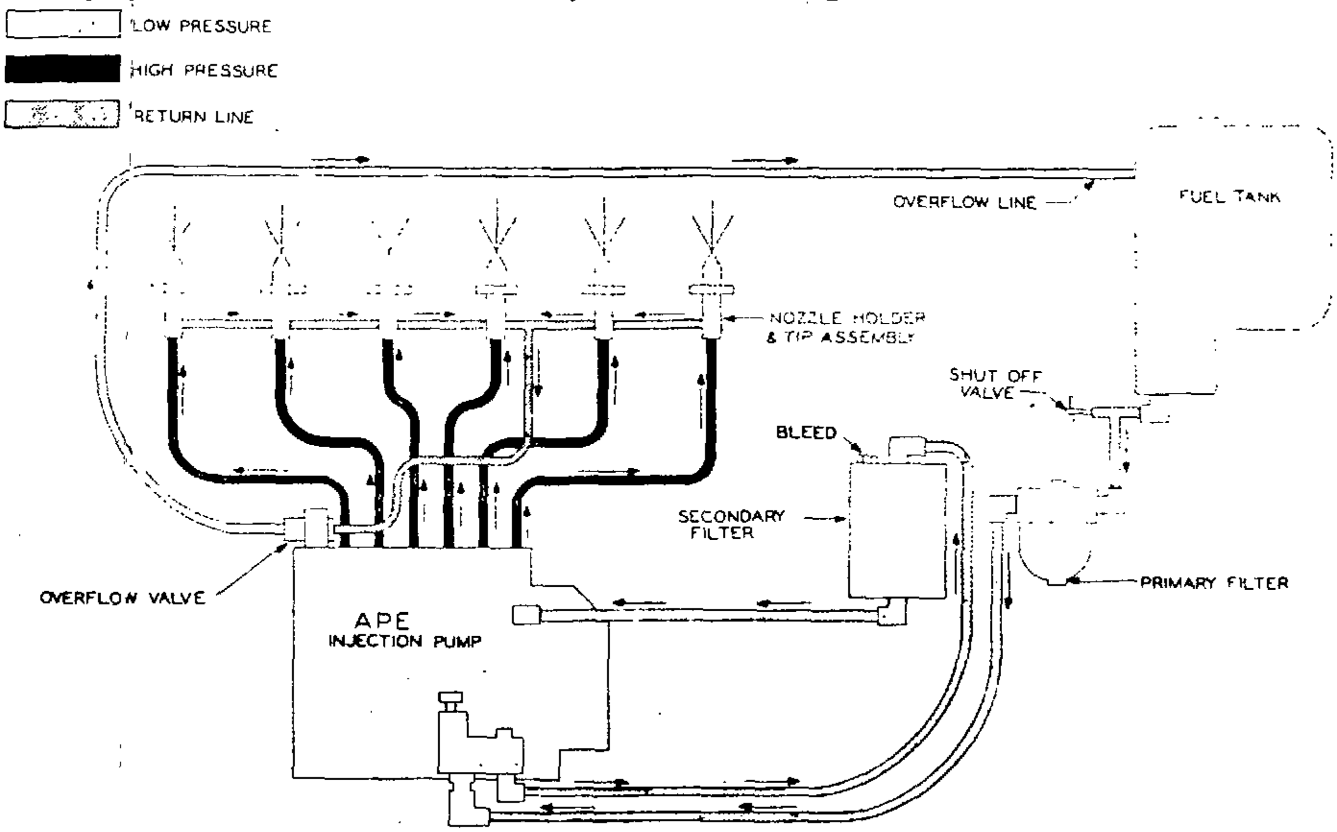


Figure 85
Schematic View of Fuel System with APE Pump

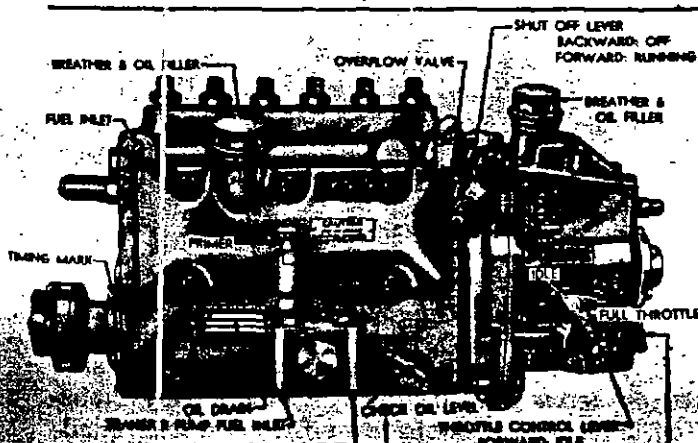


Figure 86
APE Pump

Figure 86A
Correct Installation of Pump, Injection Lines and Supporting Clamps

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 compart-

FUEL INJECTION SYSTEM

ment 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, after all other factors have been eliminated, may be caused by a sludging condition inside the injection pump. This condition should be checked and corrected as follows:

1. Open oil drains on both pump housing and governor and allow oil to drain.
2. Clean the injection pump externally with fuel oil.
3. Carefully remove the pump inspection cover and the governor housing top cover and examine internal condition of both units.
4. Flush out any reddish-brown sludge deposits or gummy oil conditions with a pressure or squirt gun using fuel oil or other solvents.
5. Actuate the control rack while flushing to remove any deposits from the gear segments within the pump and governor linkages.
6. Allow units to drain completely, then refill with clean engine oil to level.
7. Spray springs and gear segments lightly with oil and replace covers.

The injection pump and governor are provided with breather caps. When cleaning engines with pressure cleaners, they should be tightly covered to prevent the entrance of steam or water into the injection pump.

FUEL SUPPLY PUMP

In the conventional multi-plunger model APE injection pump, the Type SPA fuel supply pump is of the self-regulating, plunger type capable of building pressure up to a predetermined point controlled by the plunger return spring. The pump is not normally required to self-regulate, 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, permits 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.

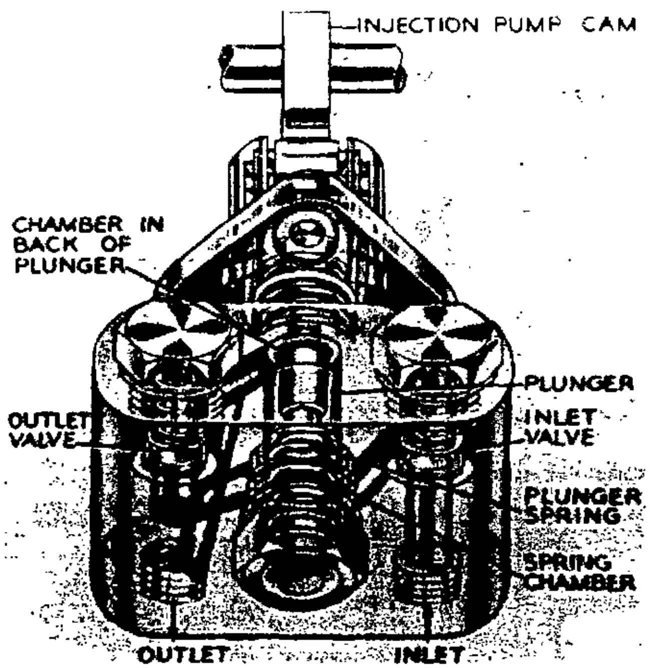


Figure 87
Bosch Fuel Supply Pump (SPA)

The direction of fuel flow is always indicated by an arrow inscribed on the supply pump housing. 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 be traced to such causes as clogged fuel filters or air leaks in the fuel lines due to loose connections.

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.

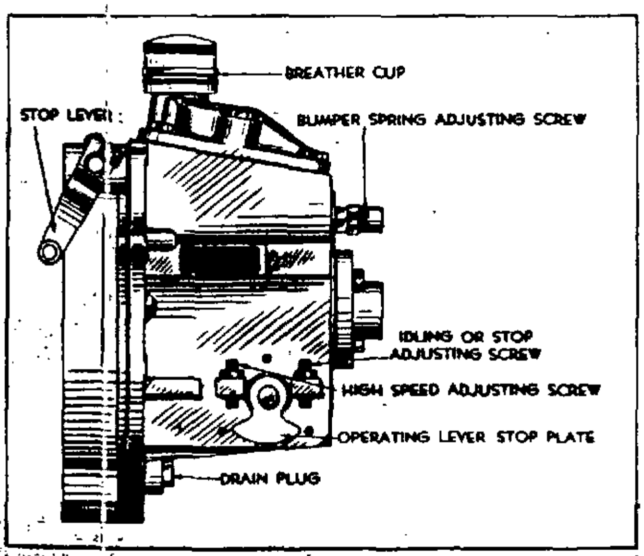


Figure 88 — GV Type Mechanical Governor

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

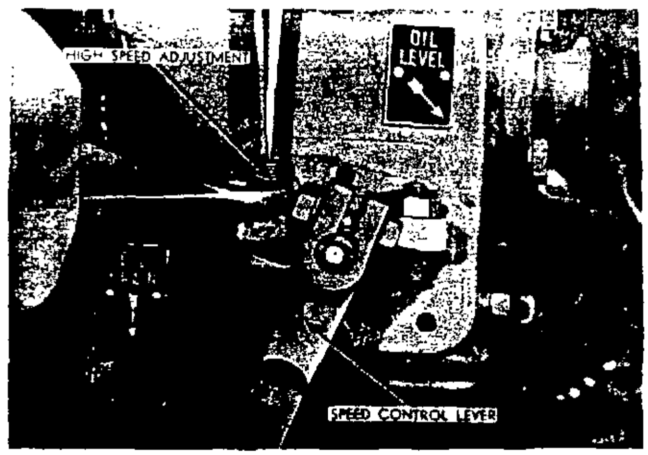


Figure 89
High Speed Adjustment

When the engine reaches its maximum speed, check by means of a tachometer whether this is the recommended high idling speed. 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

Figure 90 shows the adjustment of the high idle bumper spring. With the engine still operating at the high idle speed, the bumper spring adjusting screw should be turned in until the spring just touches the fulcrum yoke assembly without *any appreciable increase in engine speed.*

FUEL INJECTION SYSTEM

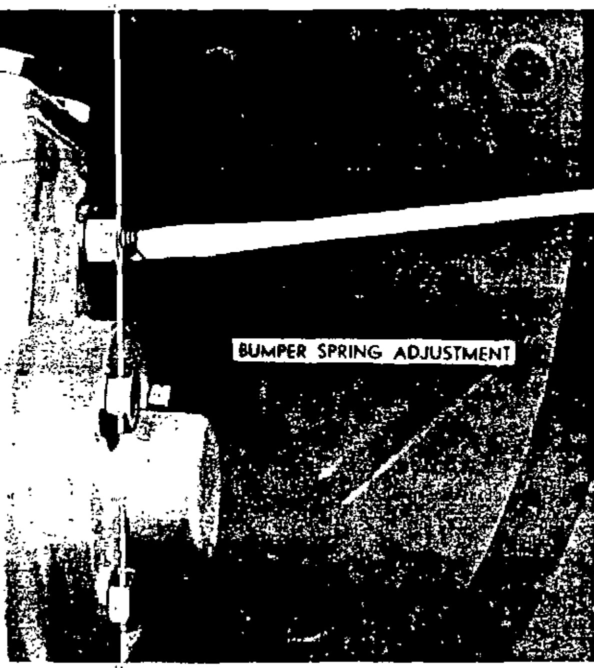


Figure 90
High Idle Bumper Spring Adjustment

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 IDLE SPEED ADJUSTMENT

Illustrated in figure 91 is a governor being adjusted for low idle speed. Move the operating lever counter clockwise 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.

The nominal idling and maximum speeds controlled by the governor cannot be varied to any great extent and still maintain a satisfactory operating range; 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 speed and range, new springs are required and an American Bosch authorized service station should be consulted.

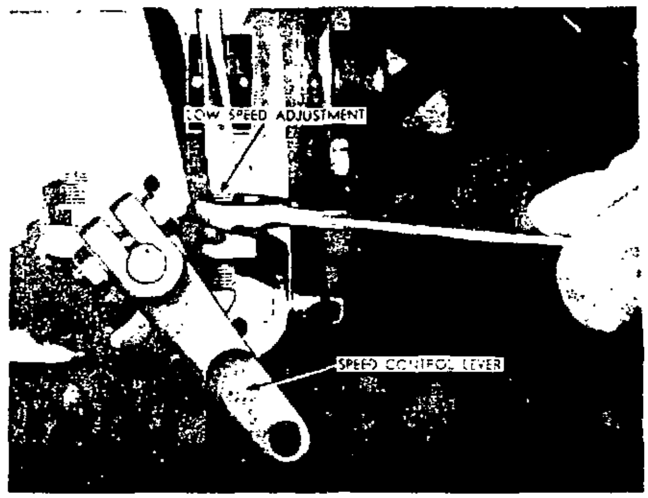


Figure 91
Low Idle Speed Adjustment

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.

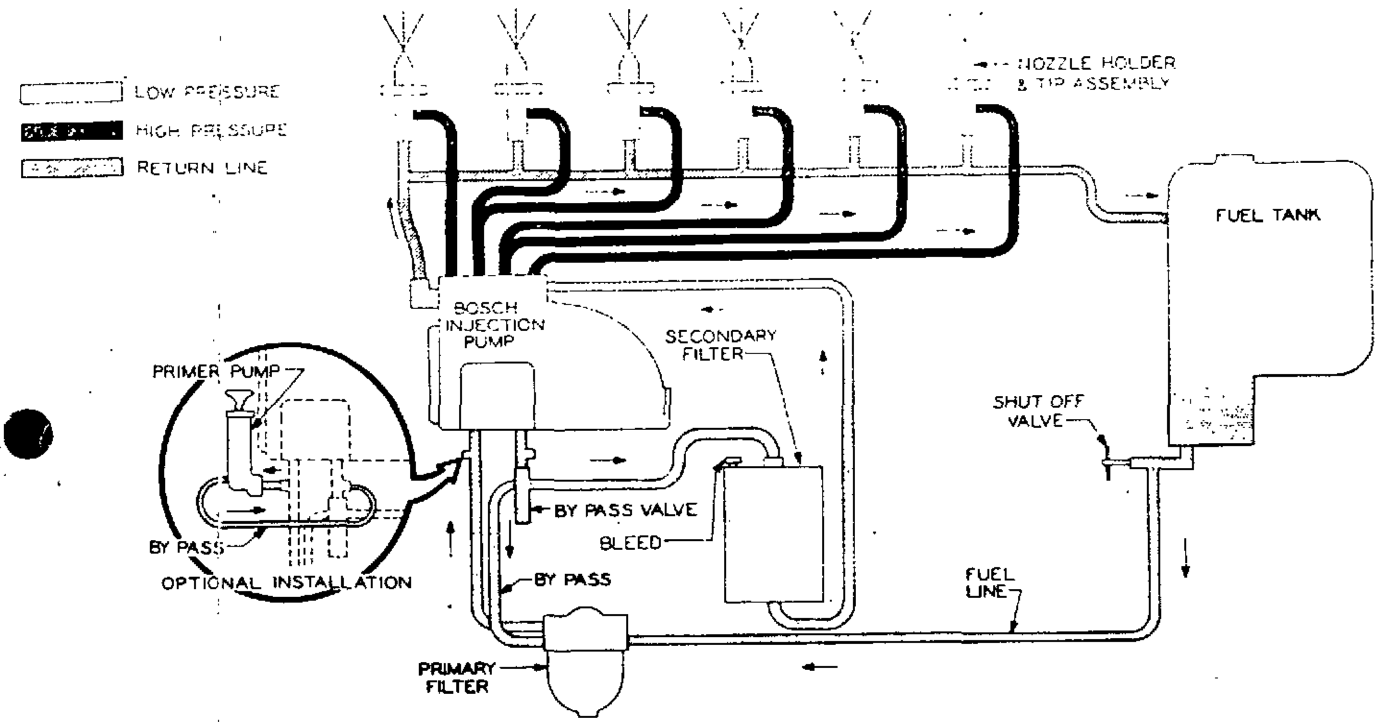


Figure 92
Schematic Drawing of PSB Pump

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 on the side, driven from the gear on the camshaft.

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 lipped section of the plunger. This

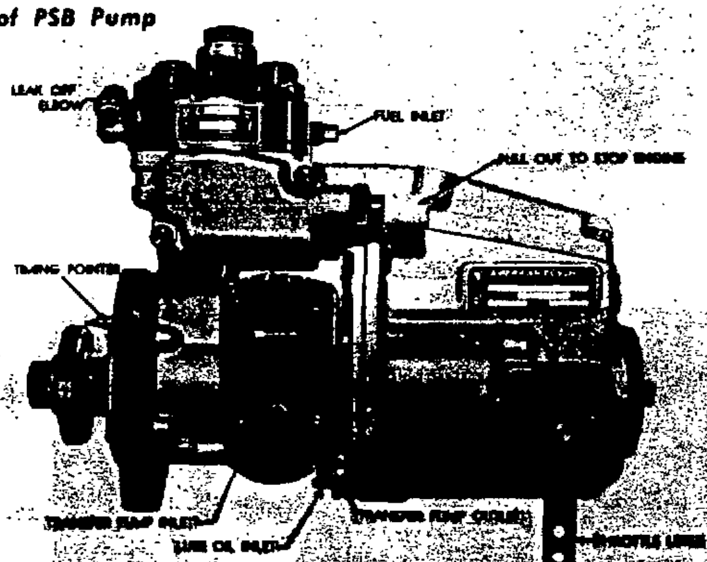


Figure 93
Bosch PSB Fuel Injection Pump & Governor

FUEL INJECTION SYSTEM

little filter requires no servicing unless the entire pump is to be subjected to a major overhaul and should otherwise not be disturbed. Removal 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.

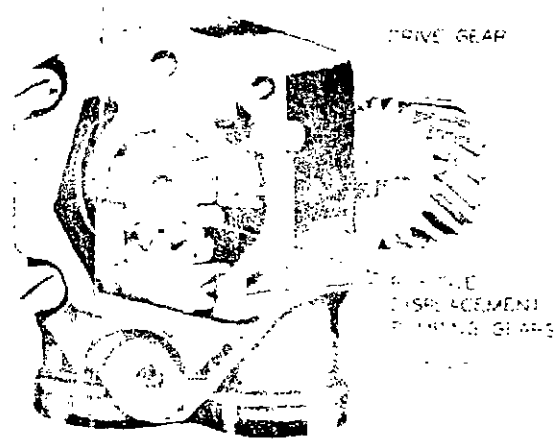


Figure 94
Fuel Supply Pump (SGV)

PSB injection pumps use SGB positive displacement gear type fuel supply pumps.

To manually prime the fuel system with this 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 rotating the driven gear in the normal direction of operation, the fuel system can be primed.

Figure 95 shows the use of the hand primer which is available as optional equipment to provide easy priming of the fuel system.

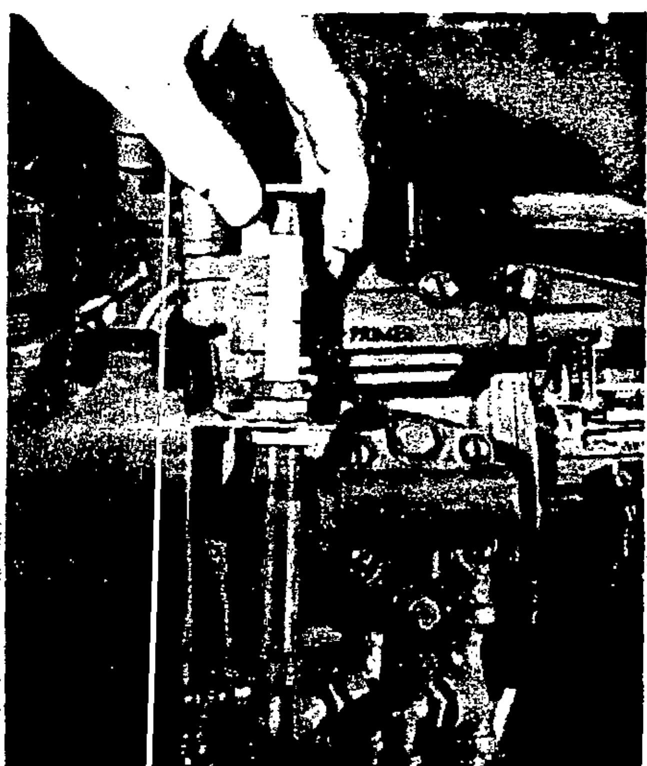


Figure 95
Hand Primer in Operation

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. A defective by-pass relief valve 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.

By inserting a gauge between secondary and final stage filter, the faulty 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.

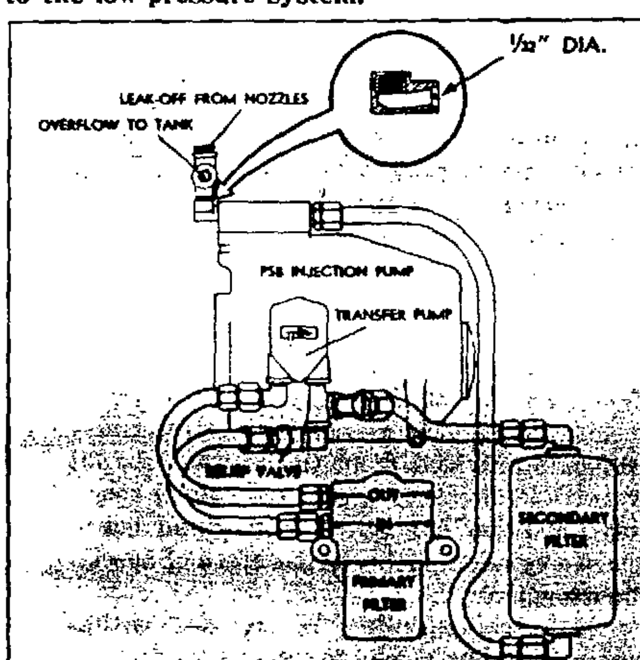


Figure 96
Bosch PSB Pump By Pass System

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, *excessive pressure build up is prevented* by causing 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 due to excessive pressure build up 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.

PSB PUMP WITH INTERNAL SPRING GOVERNOR

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, Fig. 97, 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 and two movable weights pinned on opposite sides of the spider. The weights swing freely about their pins.

The sliding sleeve moves freely on the governor shaft and has a ball thrust bearing 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 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 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 is bolted to the top of the housing; the smoke limit cam at the top of the fulcrum lever bears against this in operation.

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

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 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.

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.

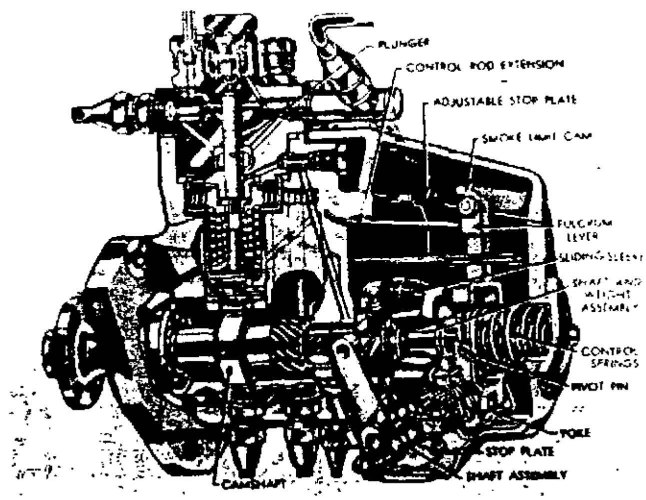


Figure 97
Sectional View of PSB Pump and Governor

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

Illustrated in figure 98 is a governor being adjusted for high idle speed. The speed control lever has been moved counterclockwise toward full load 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 if this is the high idling speed specified for your operation. If the speed is too low, raise the high speed adjusting screw and, if the speed is too high, lower

FUEL INJECTION SYSTEM

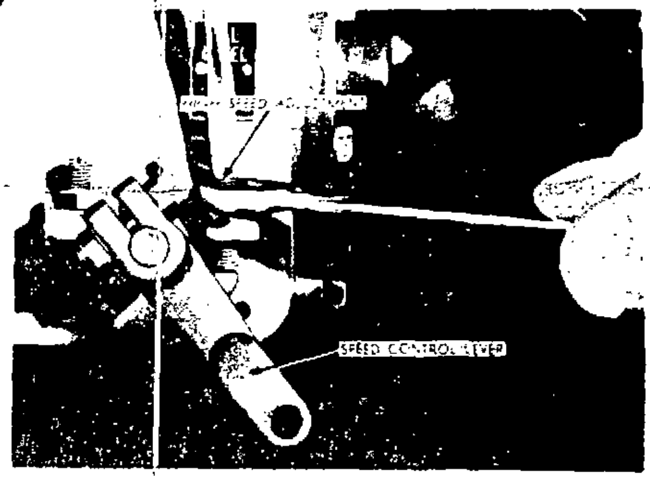


Figure 98
High Speed Adjustment

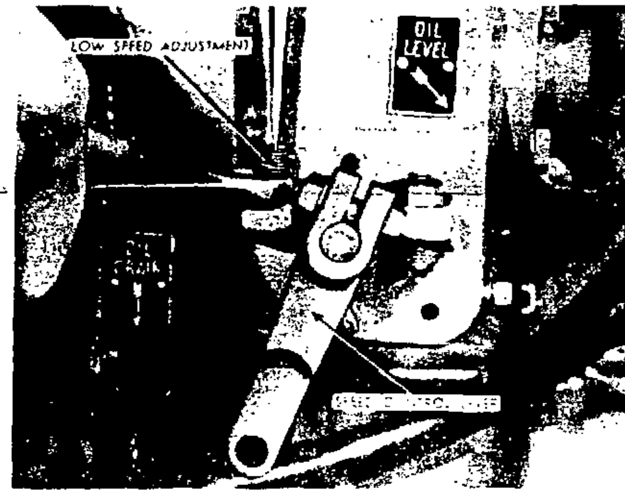


Figure 99
Low Speed Adjustment

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 speed control lever shaft is in contact with the adjusting screw.

LOW IDLE SPEED ADJUSTMENT

Illustrated in figure 99 is a governor being adjusted for low idle speed. Move the speed control lever clockwise 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.

> 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

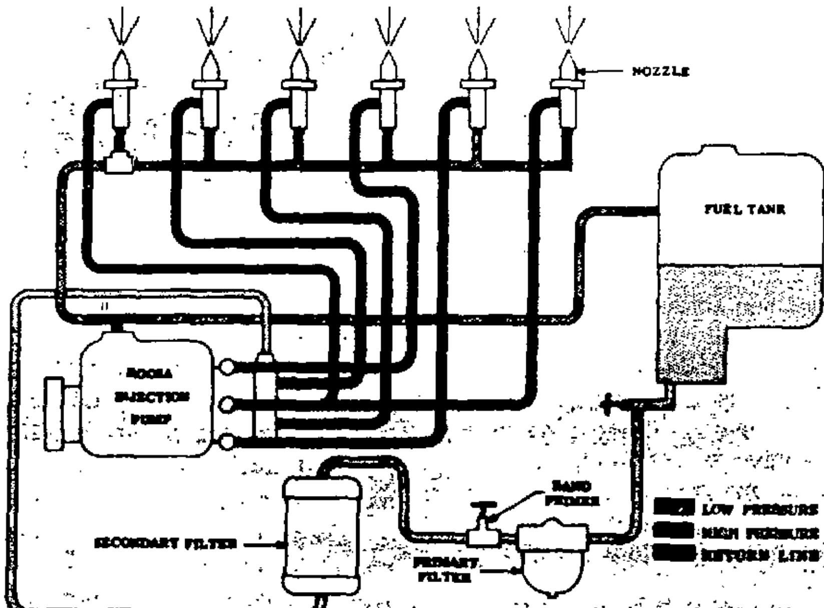


Figure 99A

80 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.

All standard six-cylinder Continental diesel engines have the model "D" injection pumps with integral centrifugal governors. They are mounted in a horizontal position and driven from the timing gears at one-half engine speed.

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.

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.

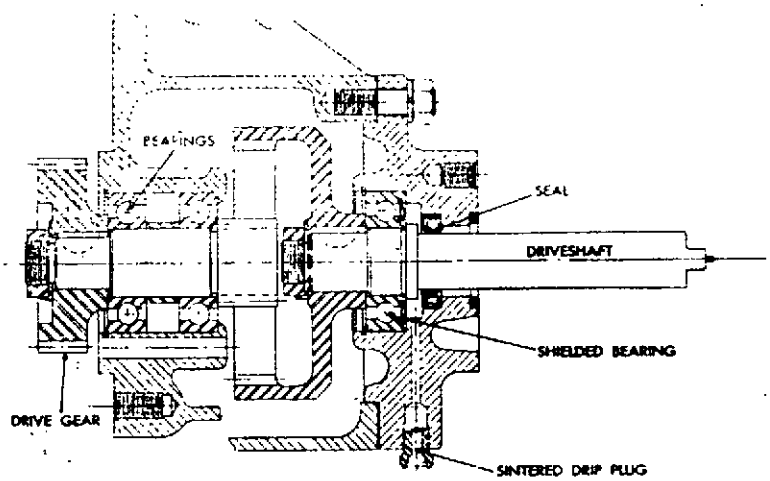


Figure 99B
Horizontal Roosa Pump Drive

COMPONENTS AND FUNCTIONS (Fig. 99C)

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.

(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

FUEL INJECTION SYSTEM

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).

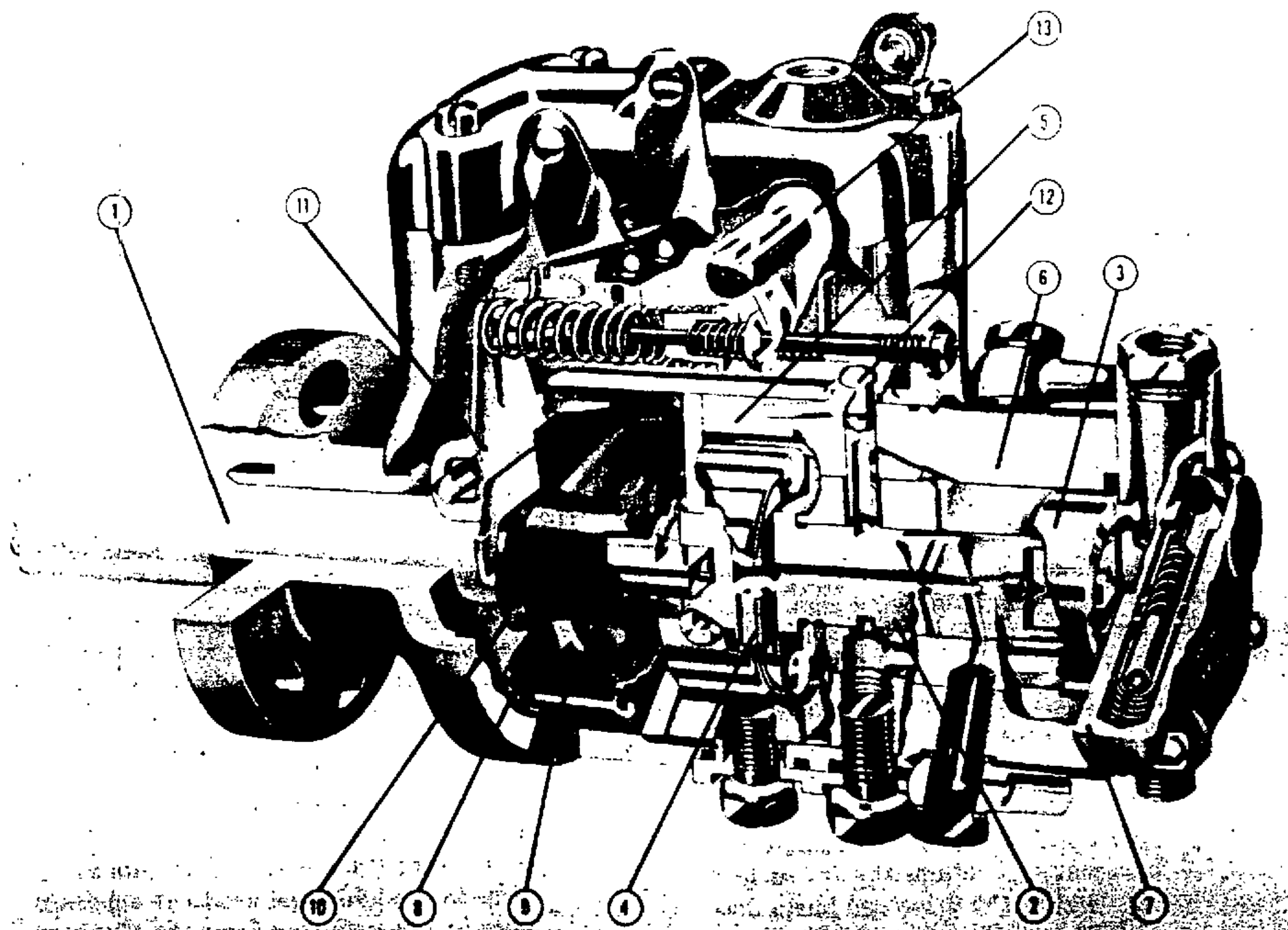


Figure 99C

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.

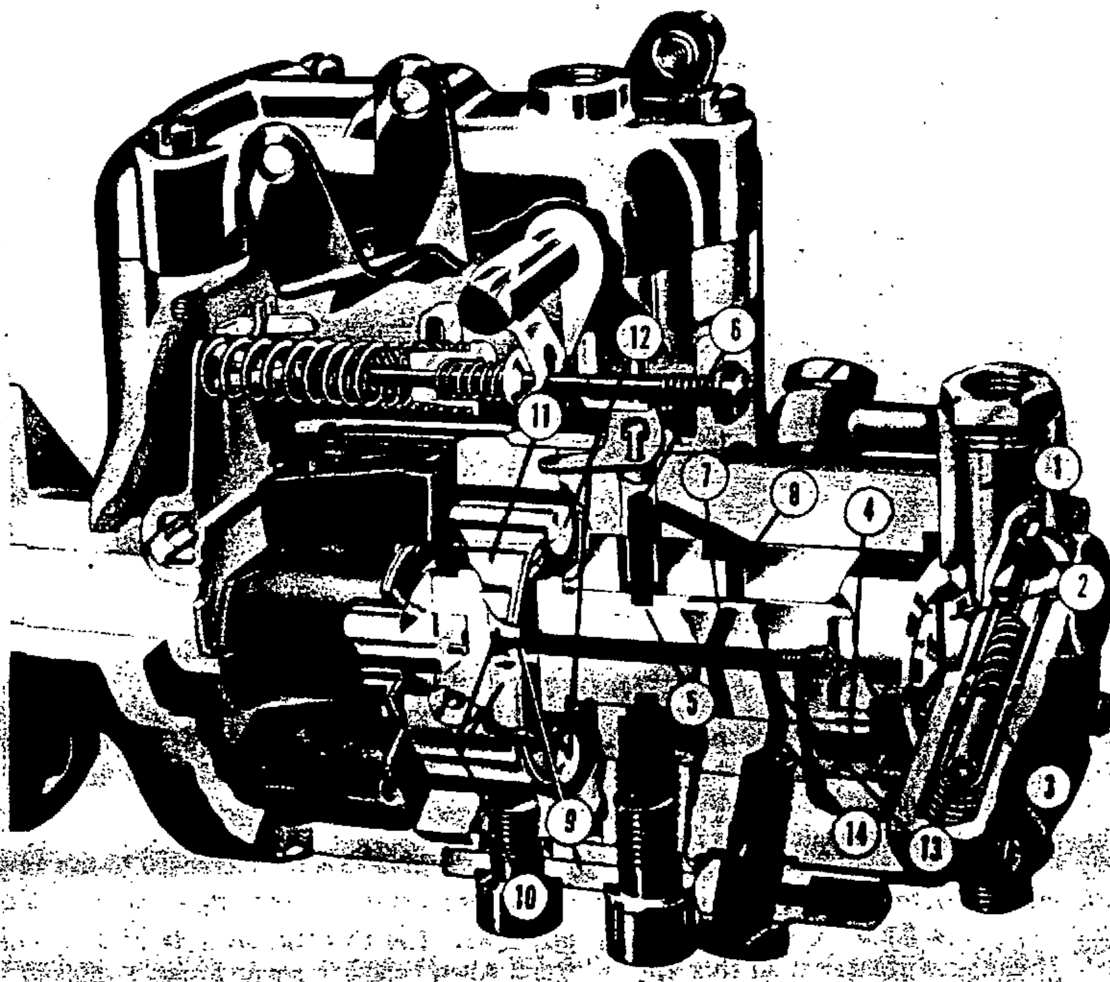


Figure 99D

FUEL INJECTION SYSTEM

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.

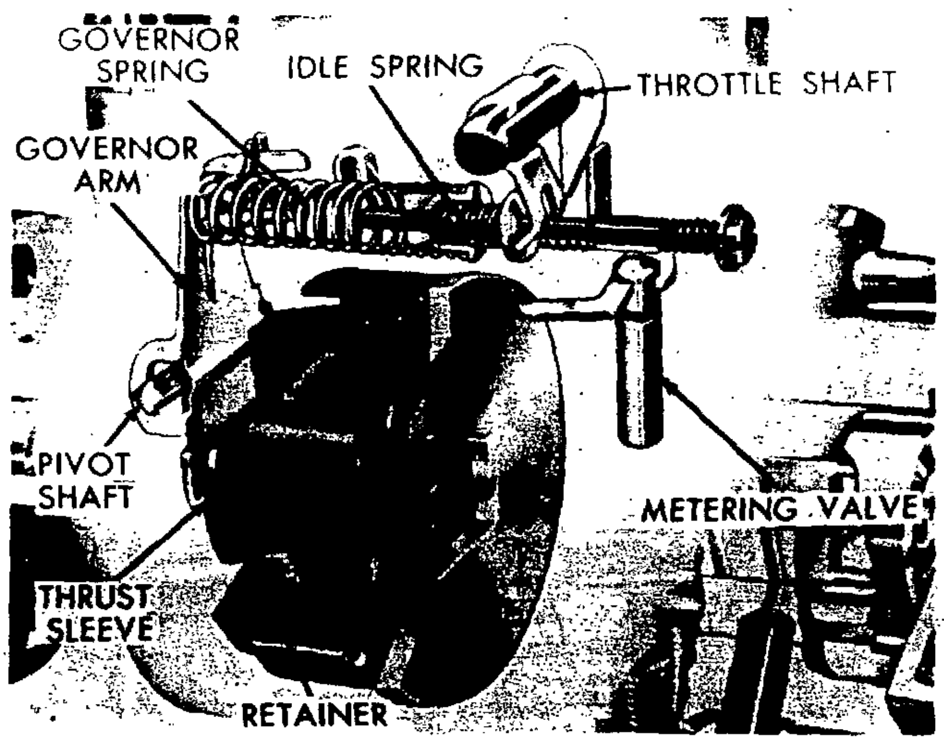


Figure 99E

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. 99F 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.

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

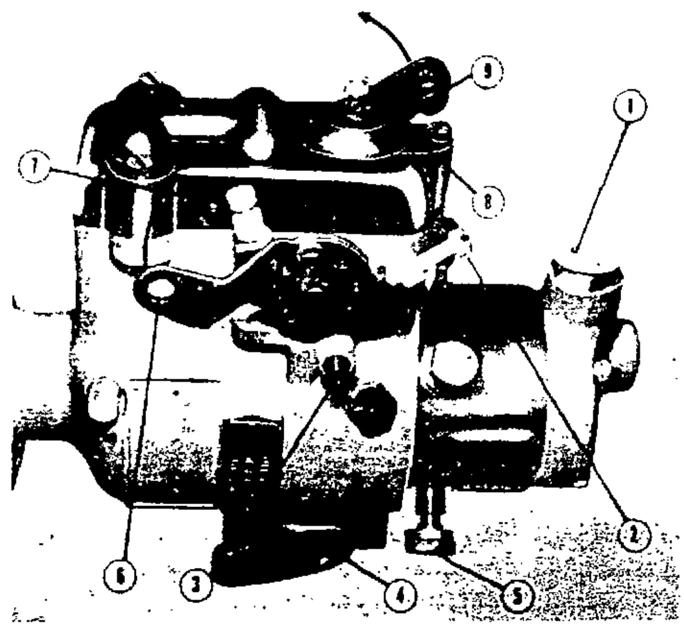


Figure 99F

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.**

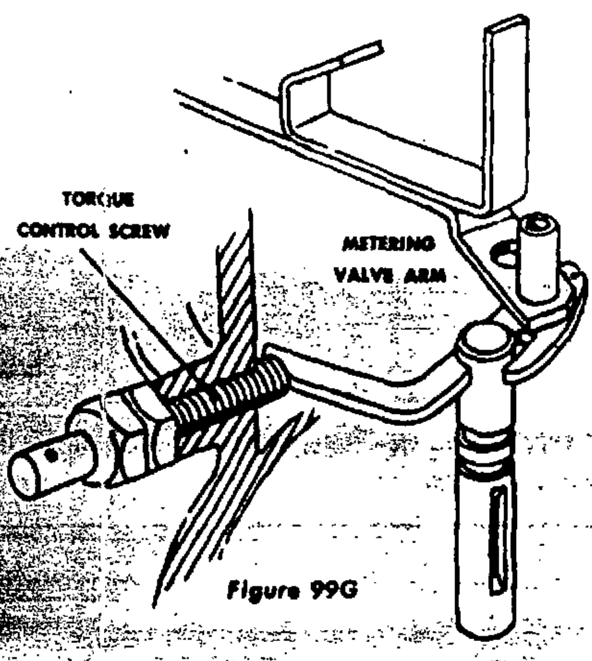


Figure 99G

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 dynamo-meter 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. 99G) will reduce the fuel; turning out or

FUEL INJECTION SYSTEM

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.

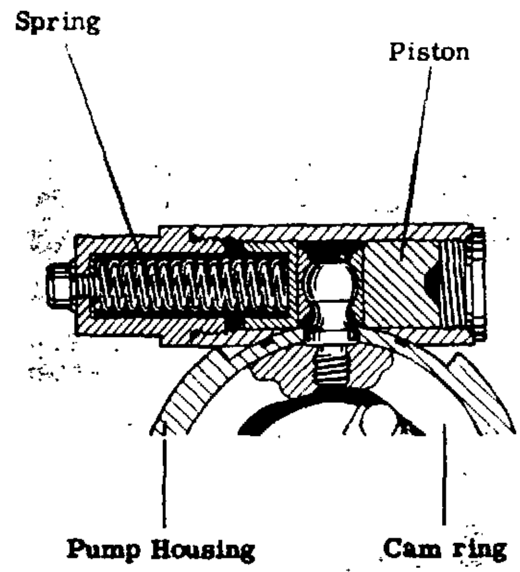


Figure 99H

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.

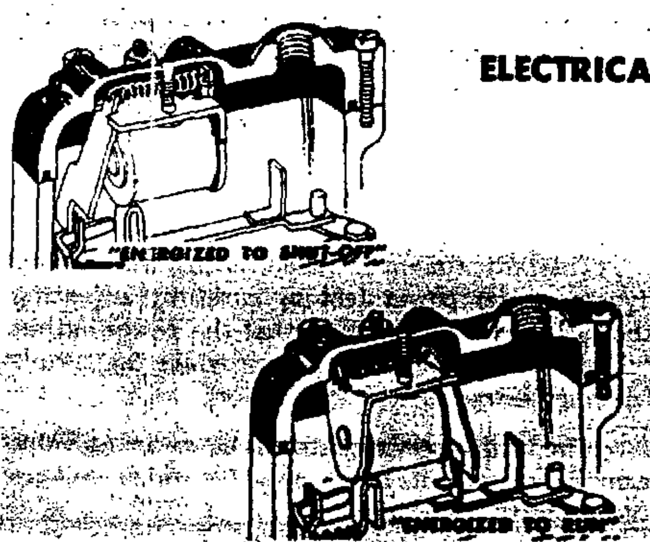


Figure 99J

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.

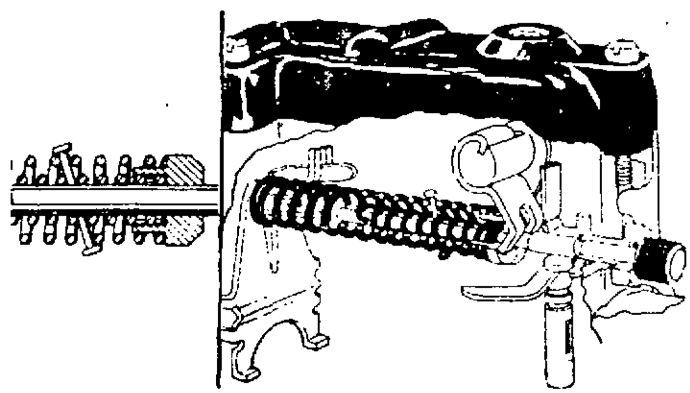


Figure 99K

HAND PRIMER PUMP

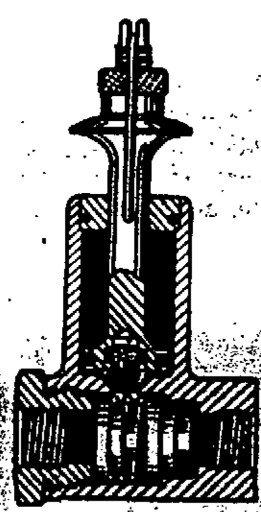


Figure 99L

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.

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

FUEL INJECTION SYSTEM

NOZZLE ASSEMBLIES

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

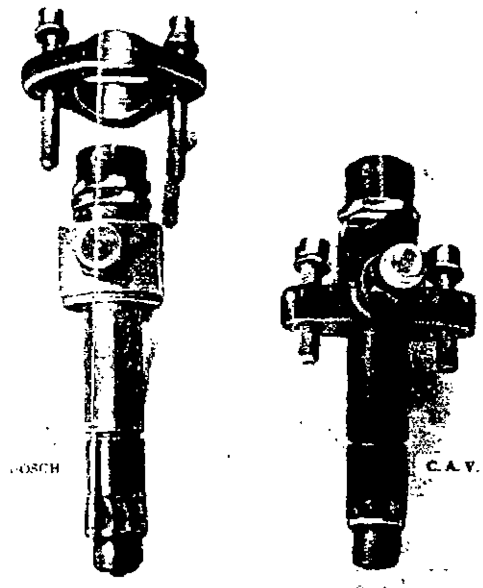


Figure 100
Bosch and C. A. V. Nozzles

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. 101, 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.

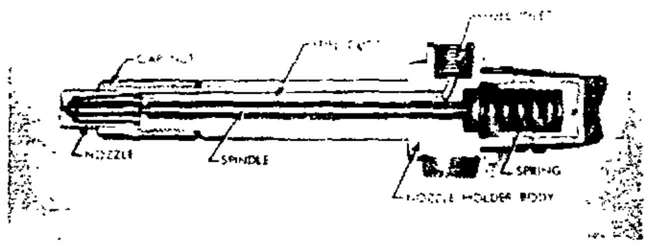


Figure 101
Sectional View of Nozzle and Nozzle Holder

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

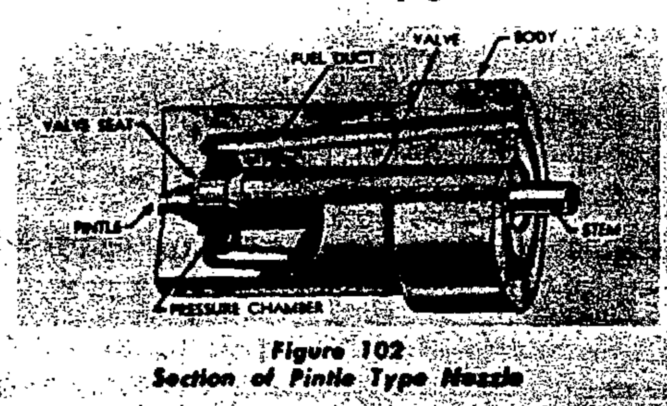


Figure 102
Section of Pintle Type Nozzle

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 102.

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 4 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.

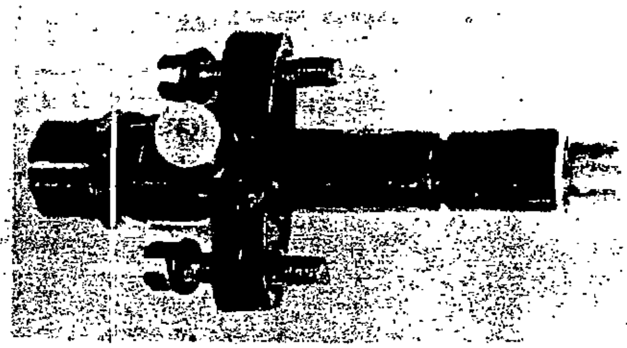


Figure 103
Side View of Nozzle Holder and Nozzle

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.)

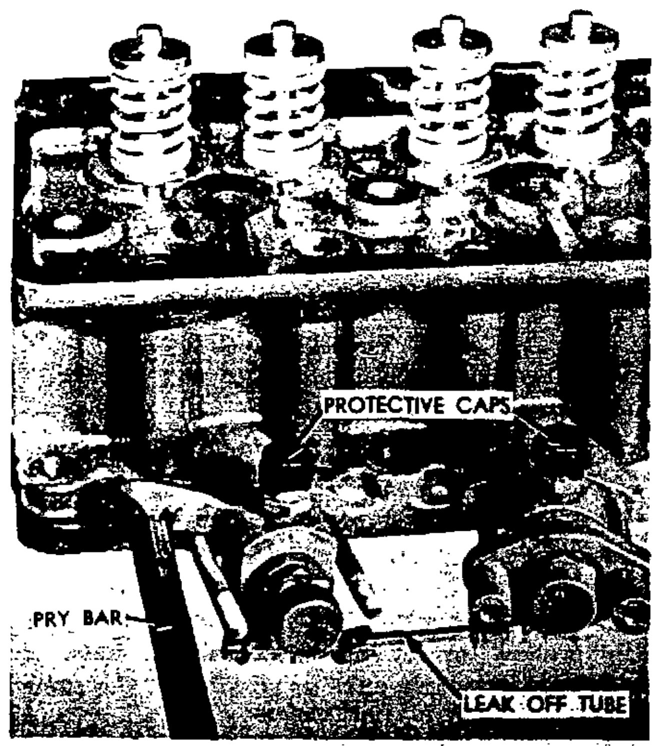


Figure 104
Removing Nozzle Holder Assembly

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.**

FUEL INJECTION SYSTEM

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 101.

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. 105.)

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. 105). (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.

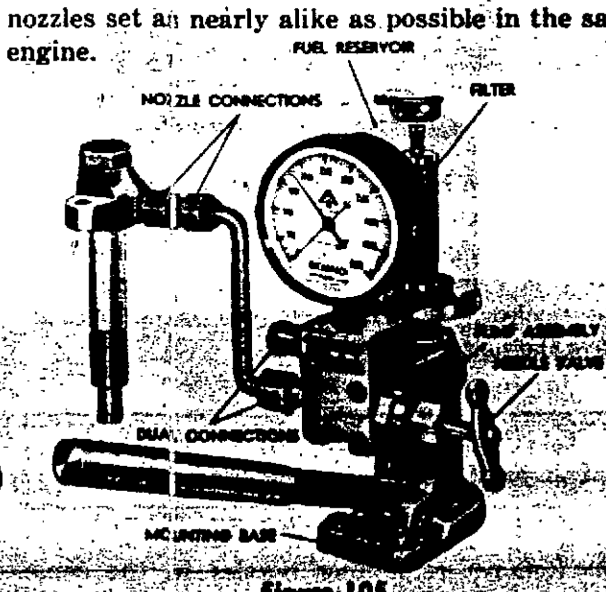


Figure 105
Checking Nozzle Opening Pressure

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.

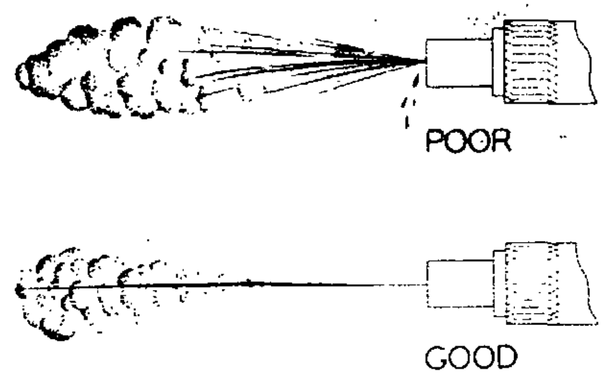


Figure 106
Nozzle Spray Patterns

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.

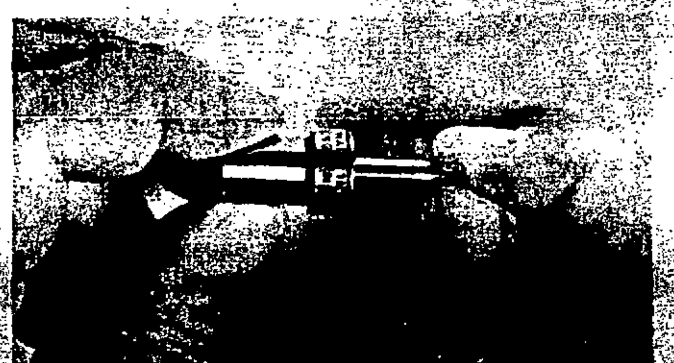


Figure 107
Removing the Nozzle Valve From Nozzle Body

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

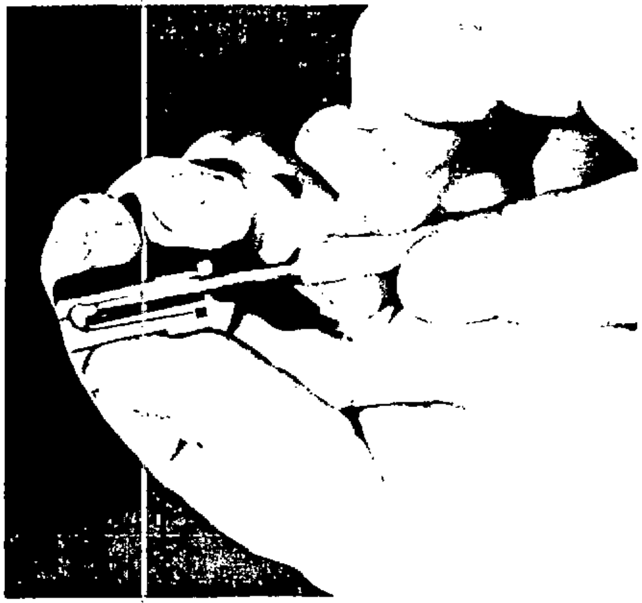


Figure 108
Cleaning Nozzle Cavity

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 helpful 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. Figure 108 and 109.

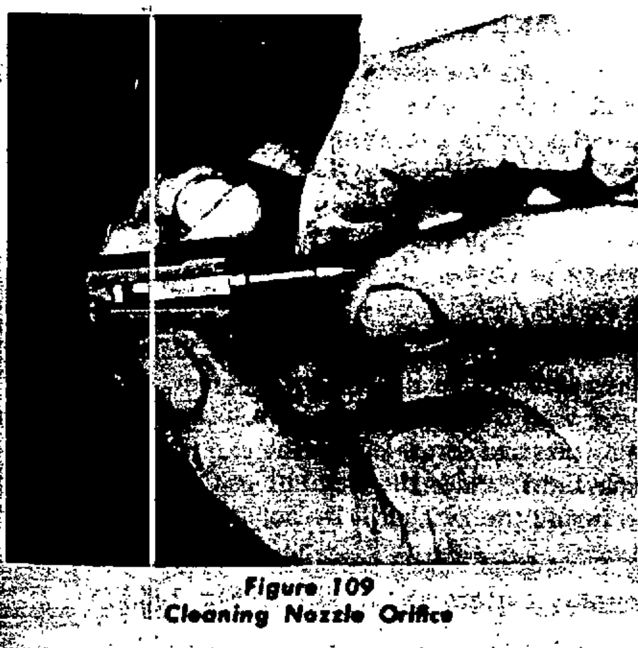


Figure 109
Cleaning Nozzle Orifice

FUEL INJECTION SYSTEM

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. 110).

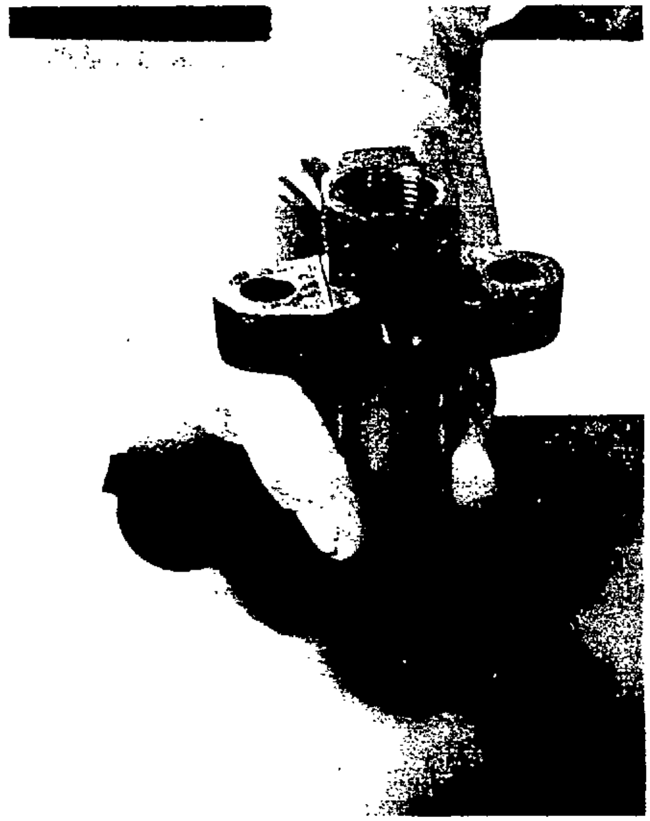


Figure 110
Cleaning the Lapped Surface of the Nozzle Holder

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. 110, 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.**

FUEL INJECTION SYSTEM

6. Clean the exterior of the nozzle holder, with the nozzle cap nut in place to protect the lapped surface. (Fig. 111.)

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

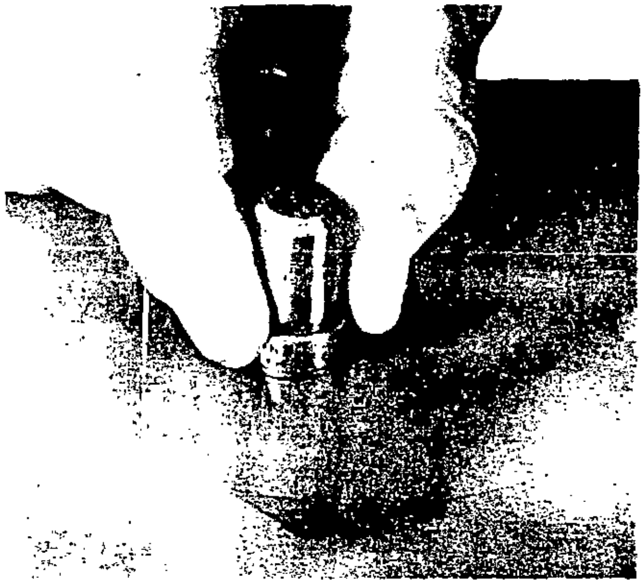


Figure 111
Cleaning the Lapped Surface of the Nozzle Body

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 111A.

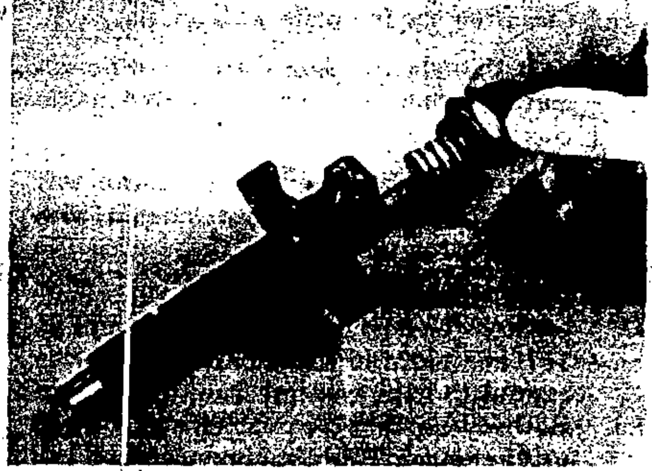


Figure 111A
Removing Spring and Spindle From the Nozzle Holder

REASSEMBLY

1. Flush the holder, being sure all passages are clean. Clamp the holder in a vise as shown in Fig. 111B.

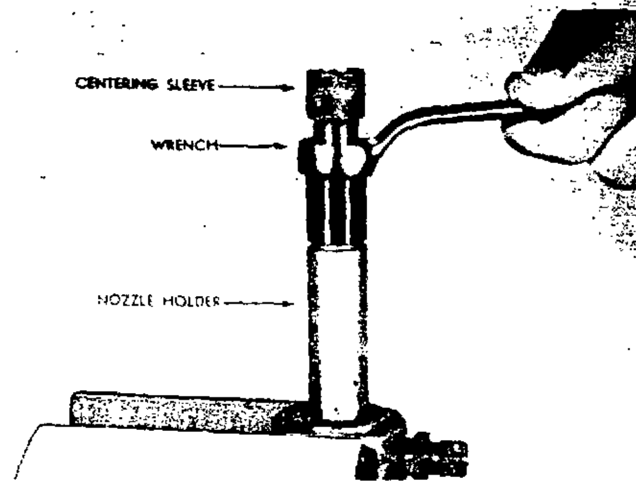


Figure 111B
Nozzle Assembly, Using Centering Sleeve

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. 111B) 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. 106.)

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 engins 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 full supply pump inlet and the secondary filter in the fuel line between the supply pump outlet and the injection pump inlet.

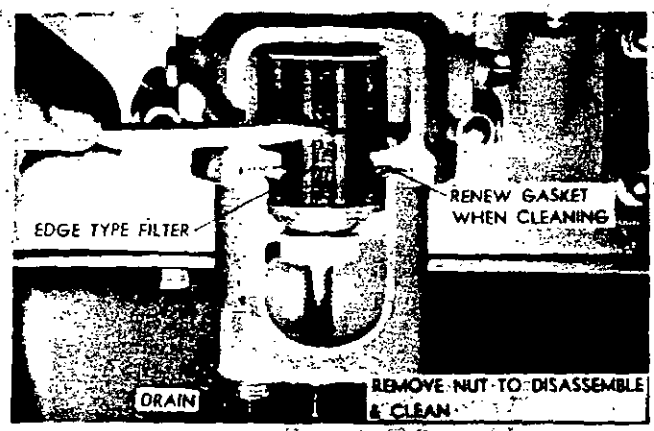


Figure 112
Edge Type Primary Filter

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 60 hours operation, the filter should be disassembled and thoroughly cleaned in fuel oil or solvent.

Figure 113
Replaceable Primary Filter

FUEL INJECTION SYSTEM

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").

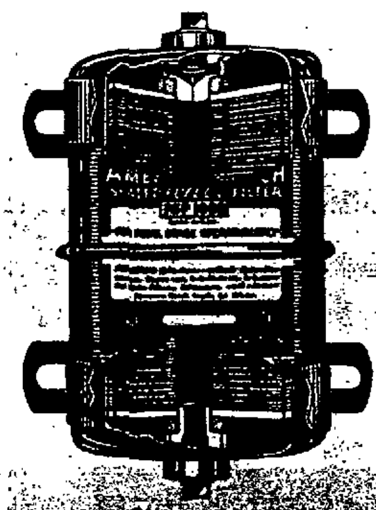


Figure 114
Sealed Secondary Fuel Filter

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.

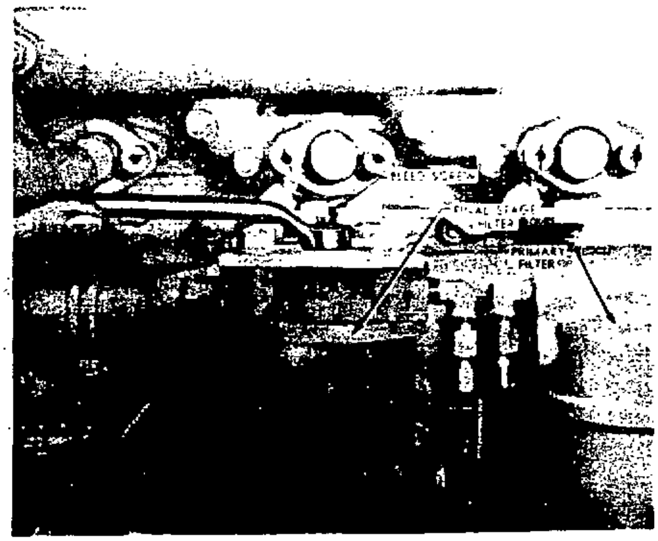


Figure 115
Replaceable Secondary Fuel Filter

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.

The fuel supply lines should be 3/8" copper tubing minimum when under 10 feet and 1/2" copper tubing for lines over 10 feet. The return lines should be 3/16" 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.

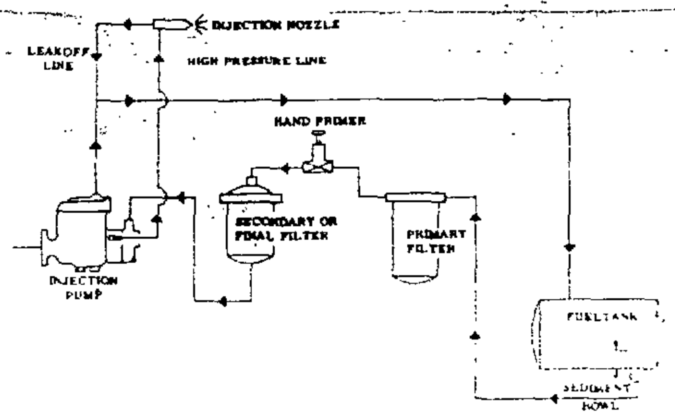


Figure 116
Schematic Drawing Showing Fuel Piping and Filtration

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 six-cylinder Diesels follow:

Figure 117
APE Pump

1. Turn engine until #1 piston is on compression stroke and pointer seen through the fly-wheel housing timing hole, Fig. 118, 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	TD-427	RD-572	SD-802
1000	24° BTDC	24° BTDC	26° BTDC
1200	26° BTDC	25° BTDC	28° BTDC
1400	28° BTDC	26° BTDC	30° BTDC
1600	30° BTDC	27° BTDC	32° BTDC
1800	32° BTDC	28° BTDC	34° BTDC
2000	34° BTDC	29° BTDC	

Transportation Engines			
RPM	TD-6427	RD-6572	SD-6802
2000		29° BTDC	34° BTDC
2200	32° BTDC	30° BTDC	34° BTDC
2400	32° BTDC	32° BTDC	

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

FUEL INJECTION SYSTEM

Figure 118
Flywheel Timing Marks

2. The marked line on the pump-coupling driven member should be in exact alignment with the offset timing line (not the vertical line) on the injection pump end plate — which is the port closing position for #1 cylinder fuel injection.

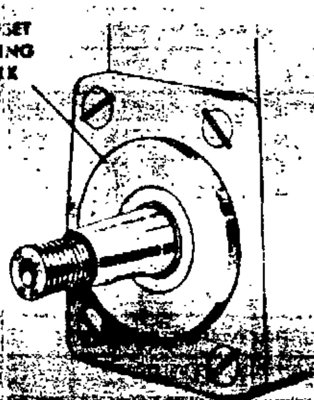


Figure 119
Timing Marks

The *offset* timing line on the injection pump end plate is on the engine block side for the TD, RD and SD engines which use clockwise rotation pumps as the pumps are driven from the timing gears.

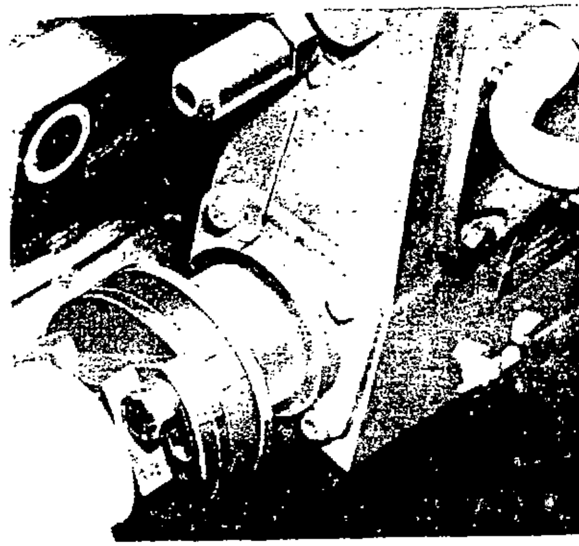


Figure 120

If the marks are not in alignment, when the specified flywheel mark is on the pointer, loosen the two cap screws which clamp the two flanges of the coupling and rotate the pump drive until the pump end plate and coupling marks are in *exact* alignment. Then tighten cap screws firmly as slippage would alter timing.

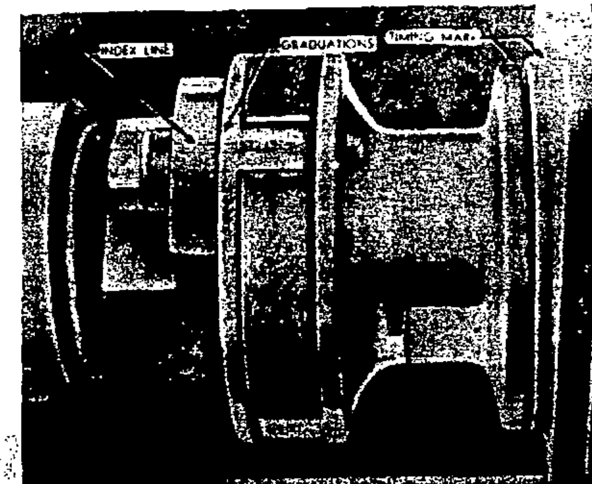


Figure 121
Adjustable Coupling Showing Graduations

NOTE: The drive flange of the coupling has 11 graduations. Each graduation equals 8° on the pump shaft and 6° on the flywheel which indicates the amount of error found before adjustment.

TIMING BOSCH PSB TYPE FUEL PUMP TO ENGINE

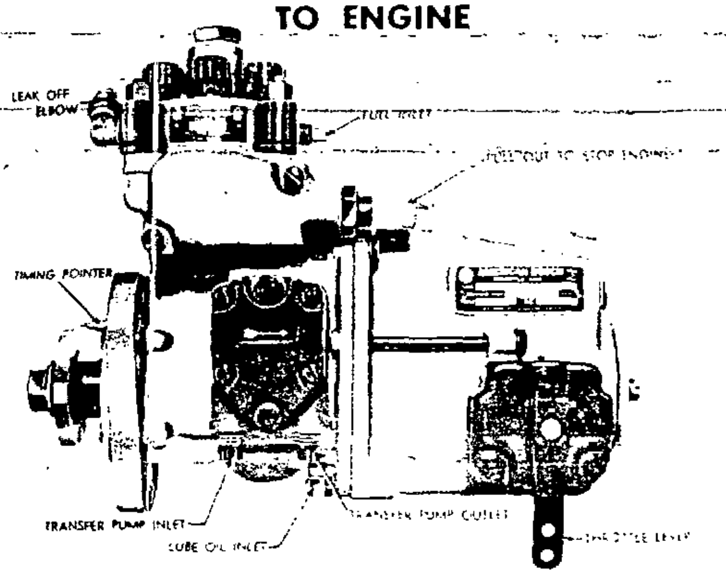


Figure 122
PSB Pump

1. Turn engine until #1 piston is on *compression* stroke and the pointer seen through the opening in the flywheel housing is aligned with the mark on flywheel corresponding to the maximum *engine governed speed.*

Figure 123
Timing Marks

INDUSTRIAL ENGINES		
RPM	TD427	RD572
1000	22°	20°
1200	24°	22°
1400	26°	24°
1600	28°	26°
1800	30°	28°
2000	32°	30°

TRANSPORTATION DIESELS		
RPM	TD6427	RD657
2200	34°	32°
2400	34°	32°

NOTE: Make certain that #1 piston is on compression stroke by turning both push rods *by hand* indicating both valves are closed.

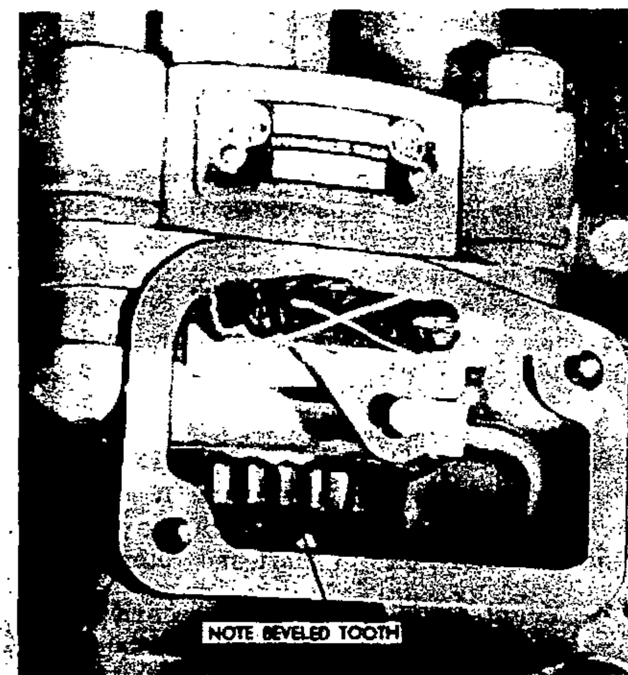


Figure 124
PSB Pump in Correct #1 Position

2. Remove pump control assembly by removing (2) retaining screws. Check pump plunger drive gear for ***tooth with beveled top corner and painted red*** **which should be visible in window opening. The pointer seen in the window opening is used for pump manufacture and has no bearing on timing to the engine.**

   If not visible disconnect pump and turn pump drive gear to relocate so as to be visible. (PSB pumps operate at crankshaft speed and unless this check is made, the pump may operate 180° out of correct position.)

Figure 125
PSB Timing Mark

3. Remove timing hole cover 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 — remove end plate and loosen adjusting screws: turn hub with ¾″ socket to complete alignment and tighten adjusting screws securely.

INSTALLING AND TIMING ROOSA-MASTER PUMP TO ENGINE

1. Turn engine clockwise until #1 piston is on the compression stroke and the timing line on the flywheel aligns itself with the pointer. (Check timing chart for standard timing information; for special adaptations; refer to customer's specification.)

2. With Roosa pump removed from engine, and with the timing cover removed, turn pump drive shaft until timing line on plate lines up with the timing line on the pump cam visible through the opening. The two lines must be in *exact* alignment when pointer is at the specified timing mark on flywheel.

3. Note that the shaft tang has a small off-center pin which enters a locating hole in the distributor rotor to prevent assembling 180° out of time. (If shaft does *not* have a locating pin, line up the off-center holes in shaft and rotor.)

4. Mount pump loosely in place and check timing marks. Then tighten the mounting nuts securely with the drive plate lined up with the timing line on the cam ring.

5. 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.

Note: When rotating crankshaft to the timing mark care must be taken to be certain that the crankshaft has not been rotated beyond the specified mark.

If the timing mark has been passed it will be necessary to turn the engine backwards at least ¼ turn and again rotate the crankshaft clockwise bringing the correct mark in line to the specified timing.

This is necessary to be sure of removing the backlash from the front end gears to obtain the correct timing.

Figure 125B
Flywheel Timing Marks

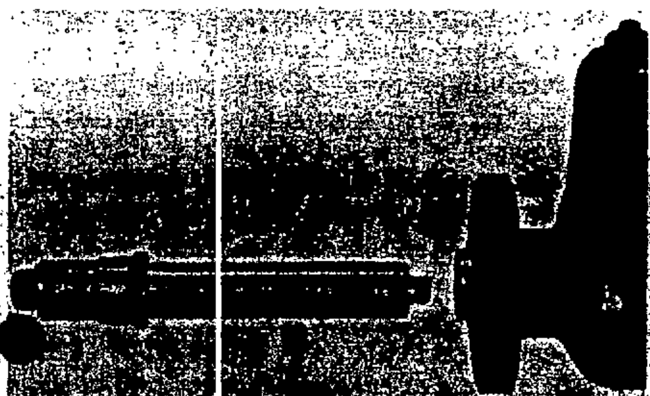


Figure 125A
One-Piece Drive Shaft (Horizontal Mounting)

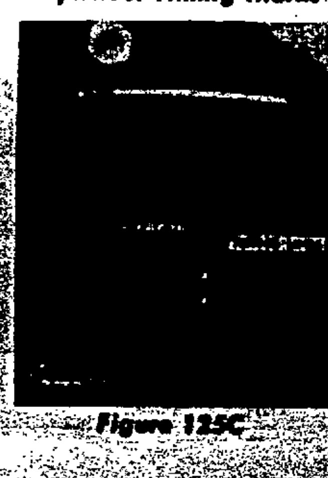


Figure 125C

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 correct degree mark on the flywheel rim (Shown on Timing Chart.)

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. 125C.

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-MASTER PUMP TIMING CHART

Engine R. P. M.	TD-427		RD-572		SD-802	
	Std.	Auto Adv.	Std.	Auto Adv.	Std.	Auto Adv.
1000	20°				26°	
1200	22°		26°		28°	
1400	24°		28°		30°	
1600	26°		30°		32°	22°
1800	28°	22°	32°	24°	34°	24°
2000	30°	24°				
2200	32°	26°				
2400	34°	28°				

ROOSA PUMP TRANSPORTATION DIESEL TIMING DEGREES B. T. D. C.

Engine R. P. M.	TD-6427		RD-6572	
	Std.	Auto Adv.	Std.	Auto Adv.
2000				
2200		24°		
2400		26°		29°
2600		28°		

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 2 gallon mixture of 50% high grade SAE 10 lube oil and pure white kerosene.

2 — Run engine at 1000 to 1200 RPM until it stops from lack of fuel.

3 — Drain and completely refill camshaft, spring and governor compartments of the APE type pump with the same oil — then tag engine for storage.

NOTE: For information on engine storage, refer to page 117.

SECTION VII
ENGINE REPAIR AND OVERHAUL

This section includes instructions for repairs and overhaul of the component units of Continental Red Seal six 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 of 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 hoses.

2. Remove cylinder head covers by taking out the screws holding them to the rocker arm supports.

3. Remove rocker arm shaft assemblies 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

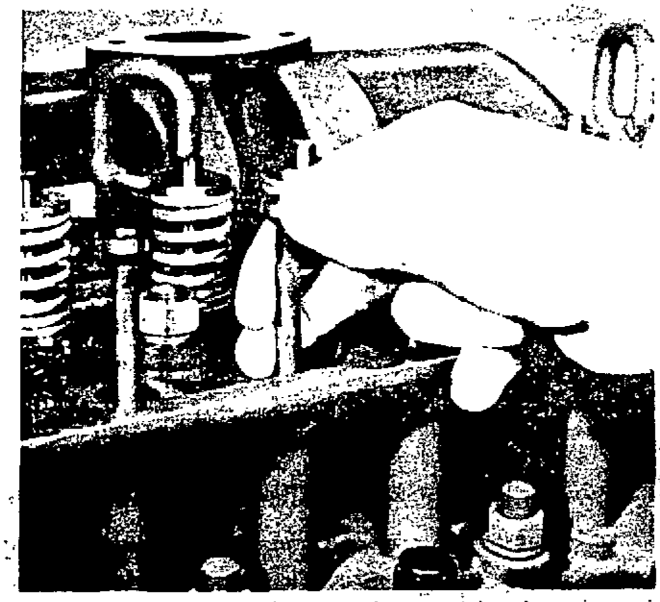


Figure 127
Snapping Push Rod out of Ball Socket of Tappet on TD Series

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.) Tappets in the RD and SD models are the mushroom type and will not lift out.

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

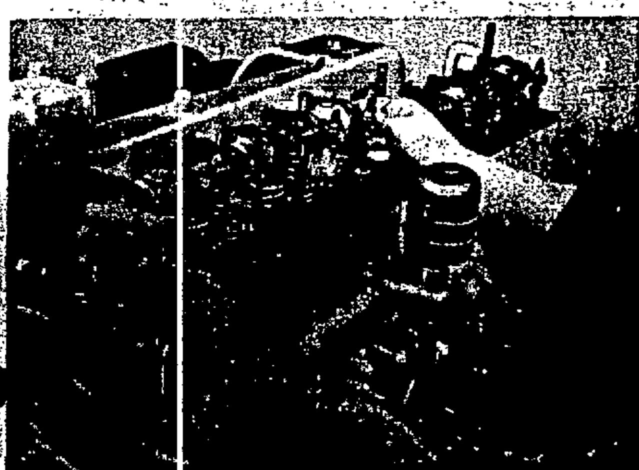


Figure 126
Removing Rocker Arm Assembly

Figure 128
Disconnecting Nozzle Leak-Off Line

Figure 129
Capping Nozzle Connection

Figure 130
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.

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

8. Remove hex-head plug on the TD or the self locking nuts and clamp on the RD and SD which hold the energy cell retainer against the cap and the energy cell firmly against the seat — then remove the cap.

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

ENGINE REPAIR AND OVERHAUL

> 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.

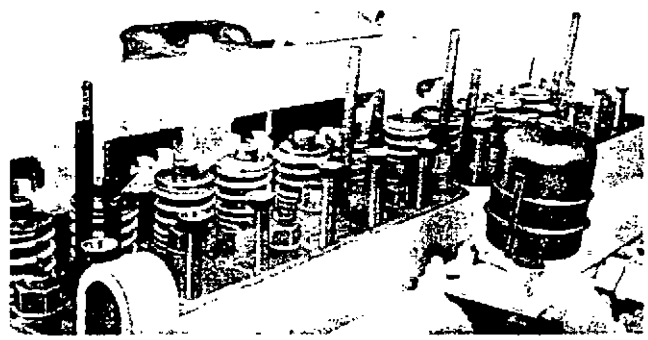


Figure 131
Cylinder Head Assemblies

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

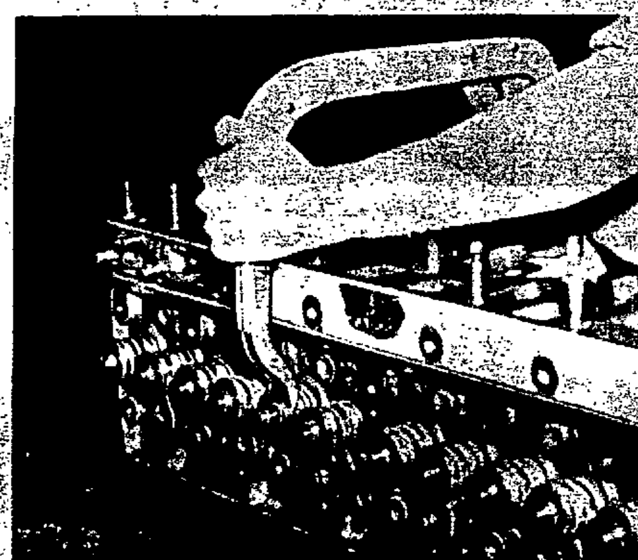


Figure 132
Removing Valve Springs

ENGINE REPAIR AND OVERHAUL

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

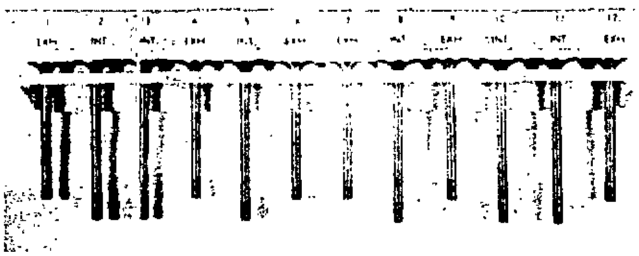


Figure 133
Valves in Rack

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

On the RD, make sure that holes in the three rocker arm support studs (figure 134) are clean and open as they are oil passages to the rocker arm system.

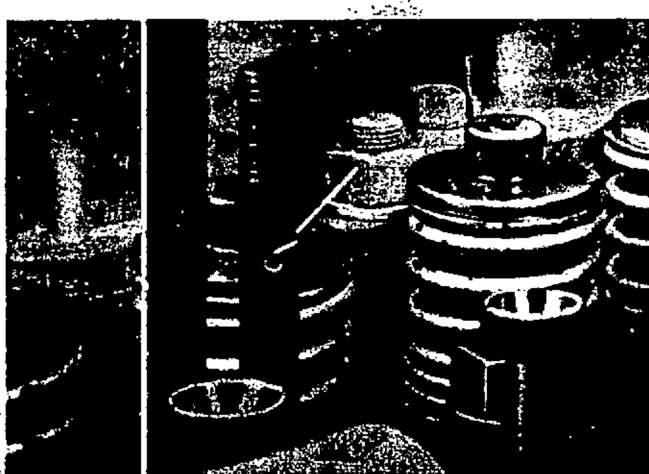


Figure 134
Studs Drilled for Oil Passages to Rocker Arms

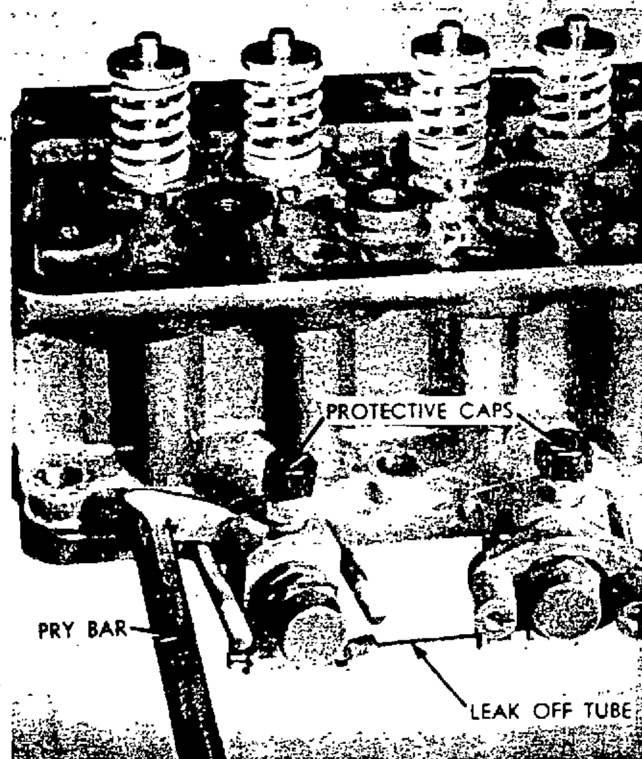


Figure 135
Removing Nozzle Holder Assemblies

Figure 136
Pulling Energy Cell With Special Tool

VALVE GUIDES

1. Clean the valve stem guides, removing lacquer or other deposits. Do not use tools that remove metal.

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

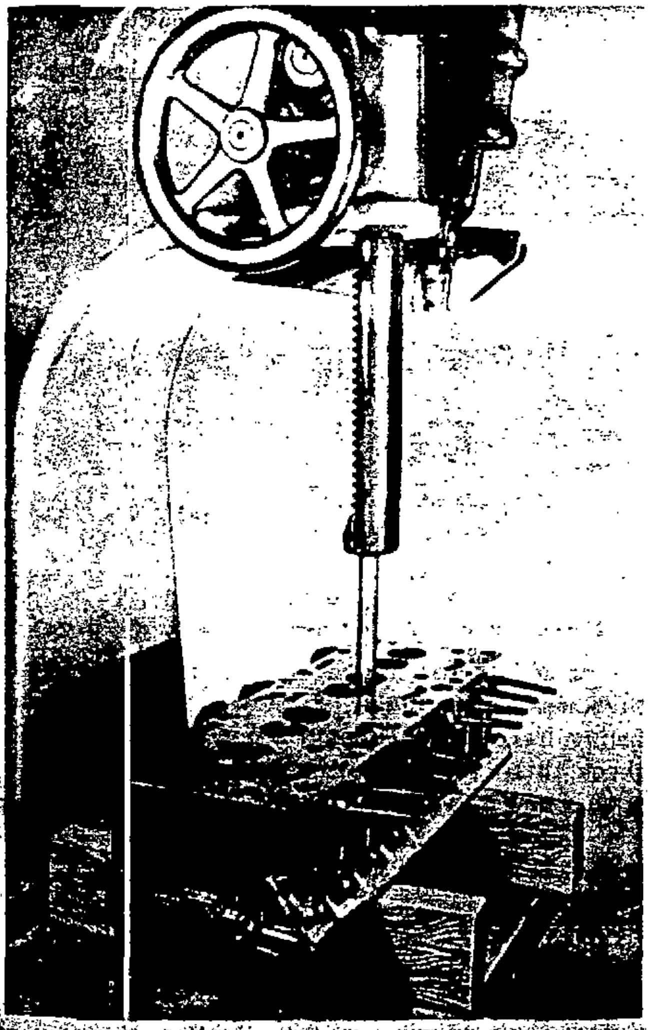
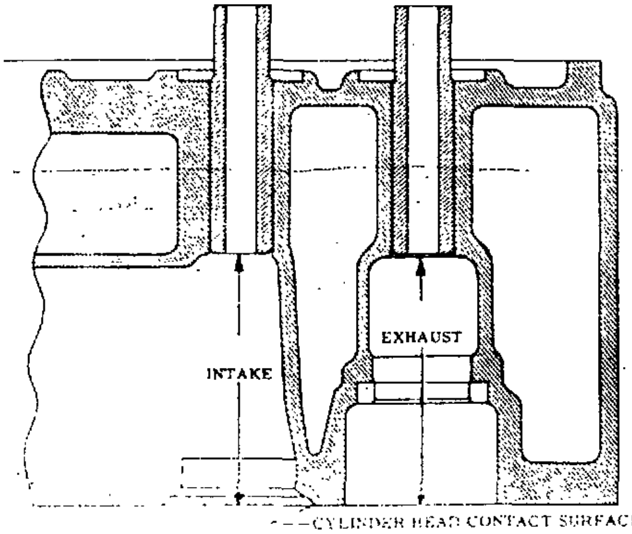


Figure 137
Removing Valve Guides from Combustion Chamber Side

it has increased. Remove all valve guides when necessary by pressing them out from the combustion chamber side.

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



	Intake	Exh.
TD	$2\frac{13}{32}$	$2\frac{25}{32}$
RD	$1\frac{11}{16}$	$2\frac{7}{8}$
SD	2	$2\frac{7}{8}$

Figure 138
Diagram Showing Valve Guide Location

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.

> Caution: Ferrox coated guides are pre-reamed and do not require reaming after installation.

VALVE SEAT INSERTS

1. Valve seat inserts are used *only* for the exhaust valves, and are 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 below.

Figure 139
Exhaust Valve Seat Insert Removal Tool

ENGINE REPAIR AND OVERHAUL

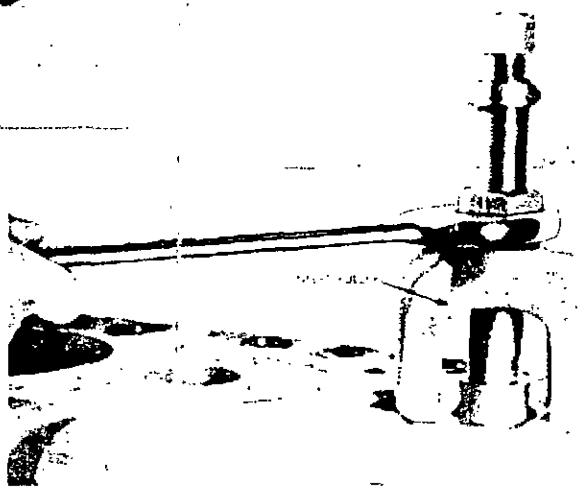


Figure 140
Removing Exhaust Valve Seat Insert

2. Continental does not recommend installing new inserts having the same outside diameter as the one removed. When required to replace an insert clean and re-machine counterbore for a .010 larger insert than the one removed, using a tool with a correct fitting pilot.

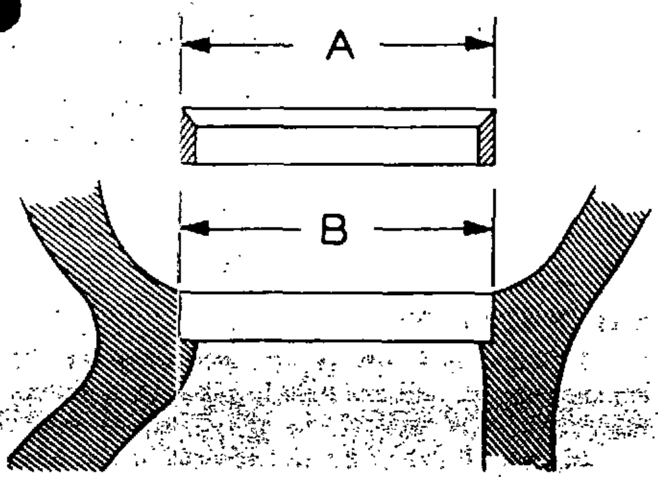


Figure 141
Insert and Counterbore

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.

The following chart shows the dimensions of standard inserts and counterbores:

Engine Model	Outside Dia. of Insert A	Inside Dia. of C'bore B	Press Fit
TD	1.817/1.816	1.818/1.812	.005/.003
RD	1.9725/1.9715	1.969/1.968	.0045/.0025
SD	2.2[illegible]45/2.2535	2.251/2.250	.0045/.0025

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 press fit. Chill insert in container with dry ice for 20 minutes before assembling.

*Insert may then be installed in the counter*bore 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.

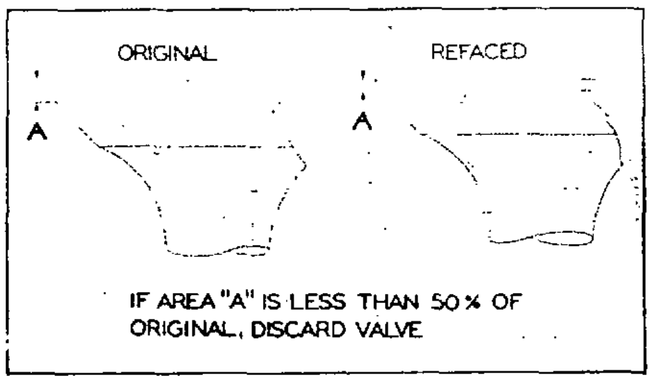


Figure 142
Allowable Head Thickness of Refaced Valves

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.

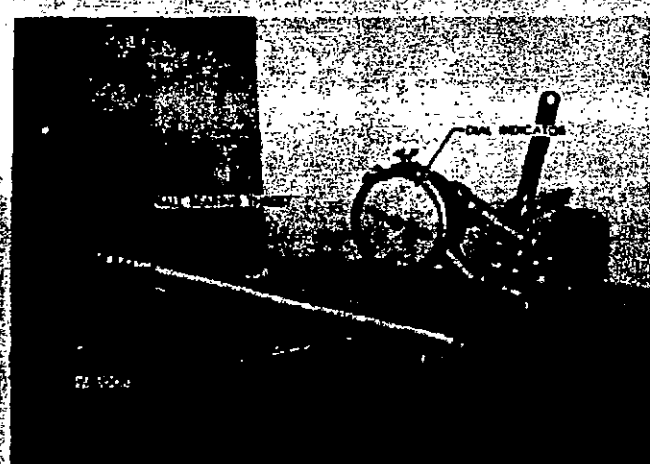


Figure 143
Checking Valve Face in V-Blocks

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.

4. Grind the intake and exhaust valve seats in the head in accordance with instructions in your limits and clearance chart.

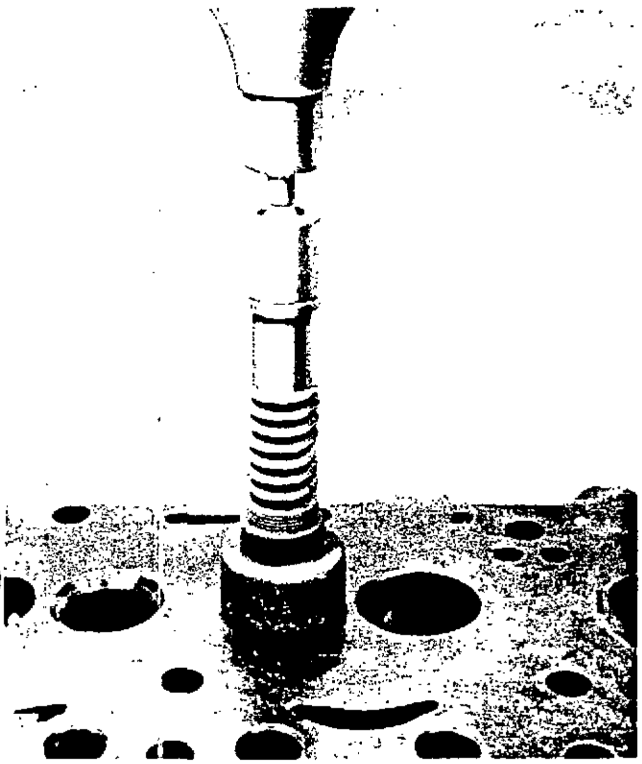


Figure 144
Grinding Intake Valve Seats

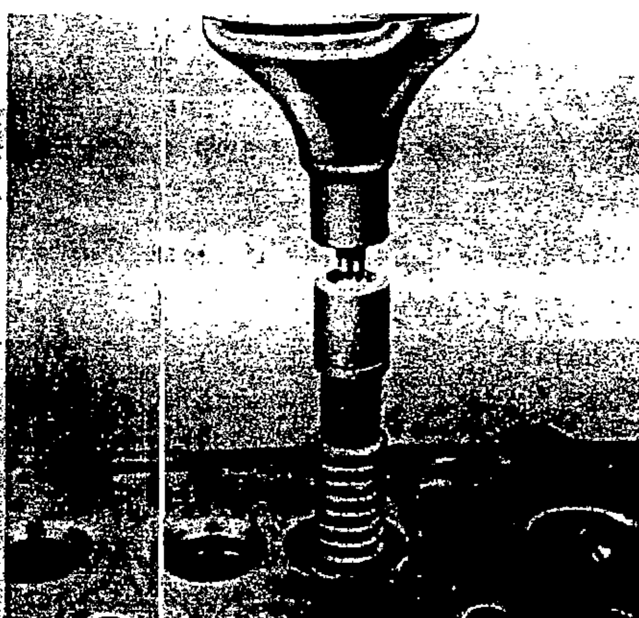


Figure 145
Grinding Exhaust Valve Seat

Before removing the arbor, indicate the seat. Total indicator reading must not be more than .002".

Use a pilot preferably 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
Checking Intake Valve Seat Run-out

the width of the valve face, leaving at least 1/64" on either side where the blue does not show.

If the contact is too 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.

ENGINE REPAIR AND OVERHAUL

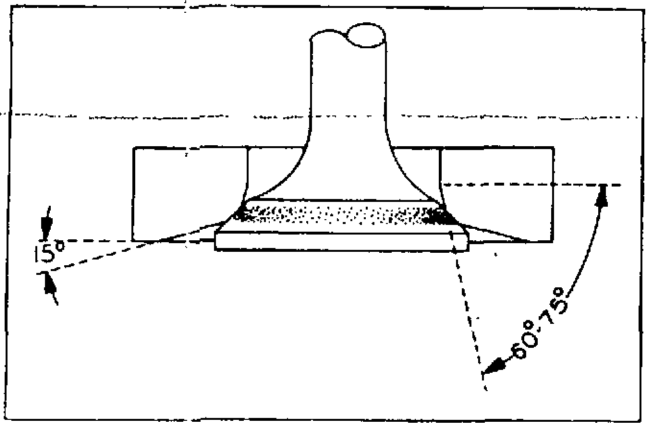


Figure 147
Method of Narrowing Valve Seats

Never allow valves to set down inside the seat.

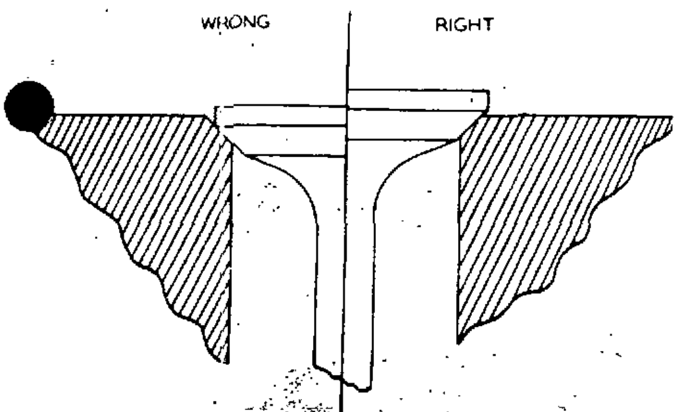


Figure 148
Valve Position in Head

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

A poor valve grinding job cannot be corrected by lapping with grinding compound.

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

VALVE SPRINGS

1. Check all valve springs on a spring tester to make sure they meet specifications regarding weight and length.

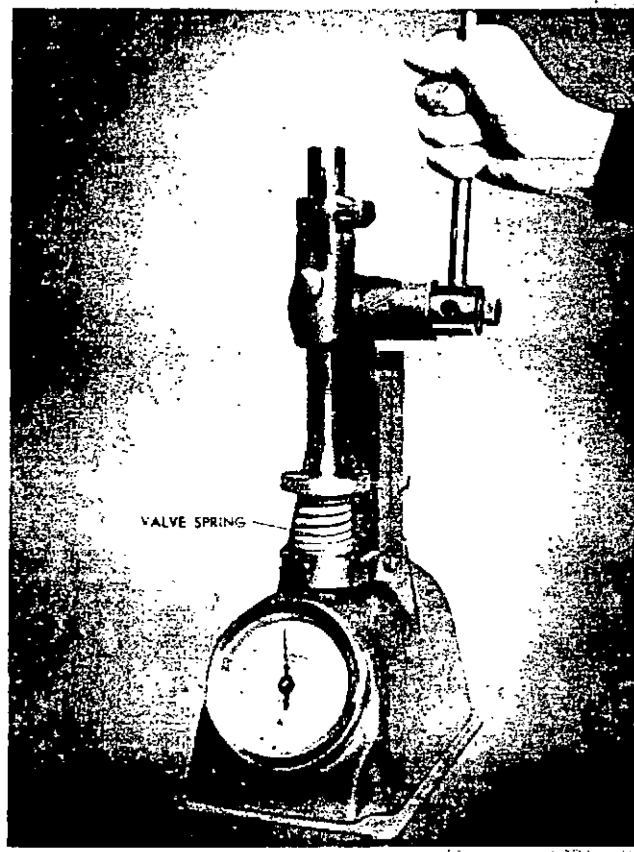


Figure 149
Valve Spring Tester

Springs, when compressed to the "valve open" or "valve closed" length, must fall within the specifications shown on the limits and clearance chart when new, and must not show more than 10% loss to re-use.

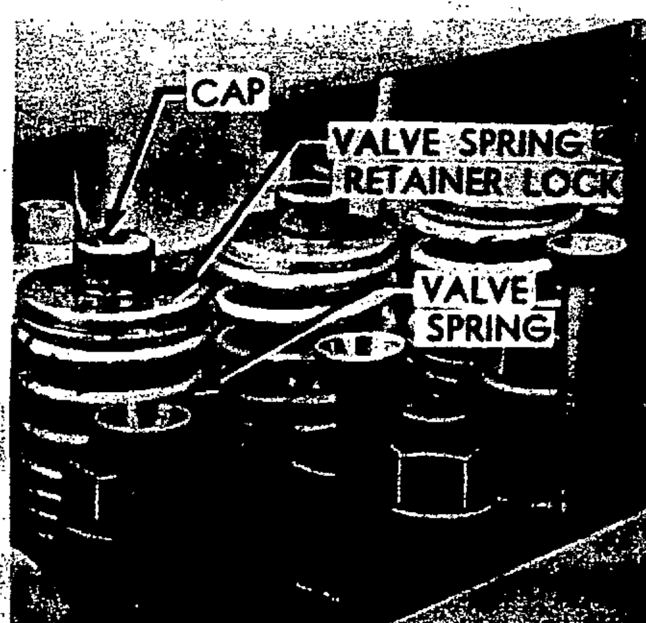


Figure 150
Valve Assembly
Note: Close Wound Coils Contact Head

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.

ENERGY CELLS

1. Clean all carbon and any other deposit from the energy cell counterbore being careful

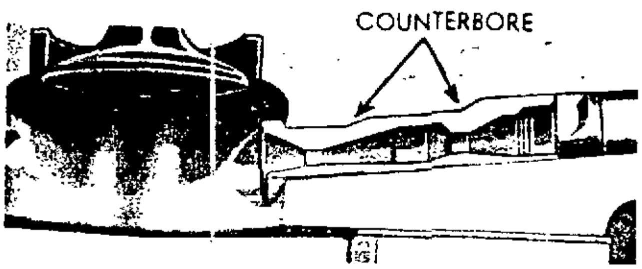


Figure 151
Energy Cell Counterbore

not to damage the large diameter angular seat on which the energy cell body makes contact.

2. Clean the energy cell body exterior as you would an exhaust or intake valve.
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. (See illustrations below.)

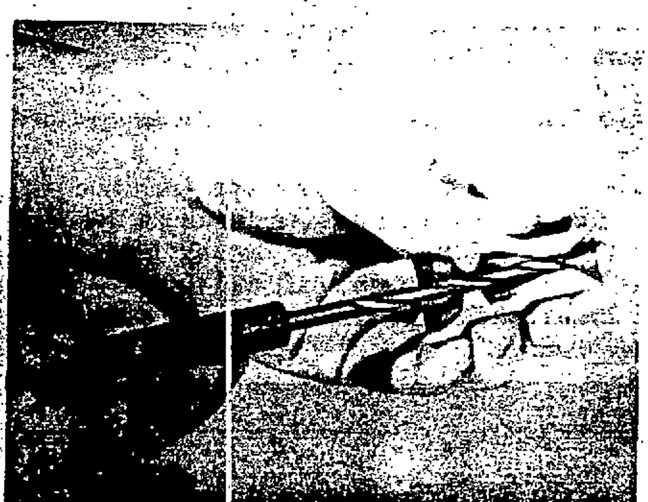


Figure 152
Cleaning Energy Cell Metering Holes with Special Reamer

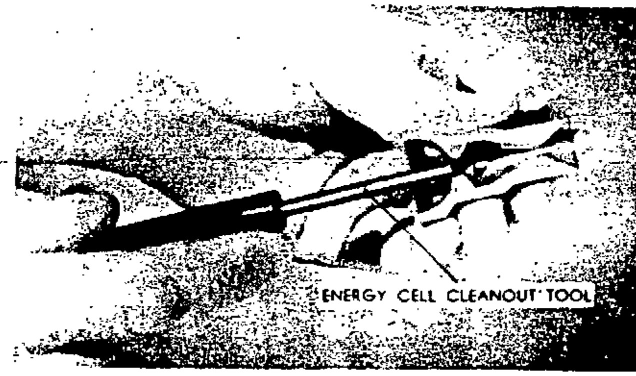


Figure 153
Cleaning Energy Cell with Special Scraper

3. 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.

CAUTION: Lap minimum to obtain clean seat.

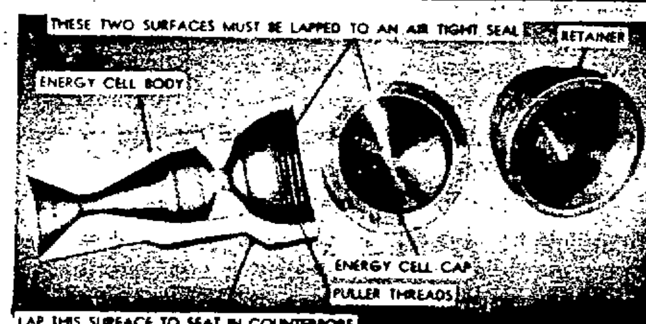


Figure 154
Sectional View of Energy Cell Parts

4. 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.

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, then the retainer and finally the hex head plug on the TD or the self locking nuts on the RD and SD.

Tighten and torque to specifications since there must be no possibility of any leak from the

ENGINE REPAIR AND OVERHAUL

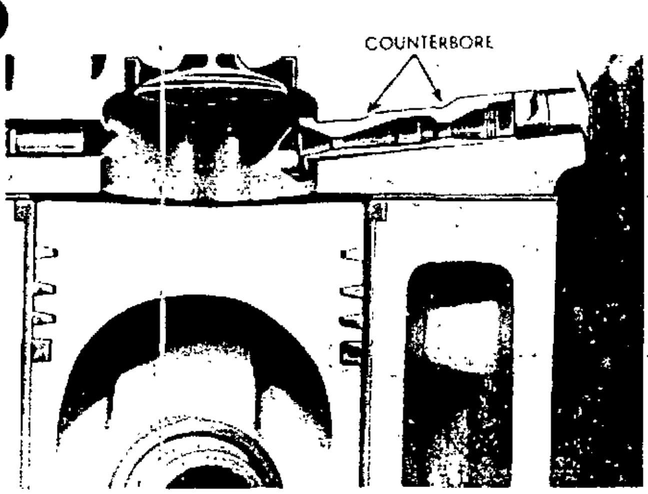


Figure 155
Energy Cell in Place

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 nozzles inject the metered amount of fuel received from the injection pump into the combustion chamber. For efficient performance and maximum economy they 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 a 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 inserting the nozzle holder assembly. There must be no carbon particles on seating surface to tilt the assembly or permit blow-by. If special reamer is not available, a round piece of wood or brass properly shaped can be used. Do not use other hard or sharp tools.

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

4. Tighten the 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.

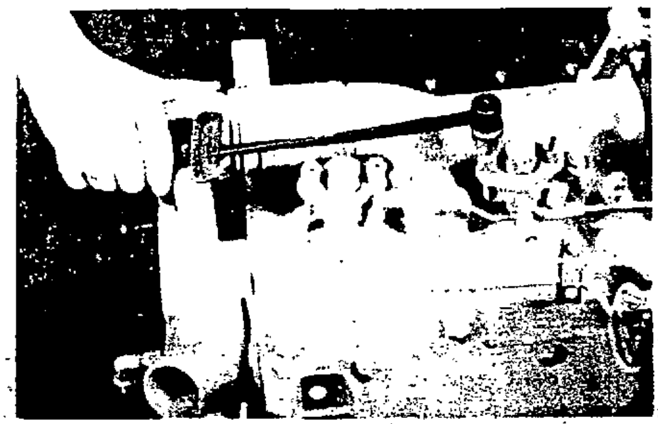


Figure 157
Torquing Nozzle Holder Clamp Nuts

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.

Figure 156
Cleaning Nozzle Recess in Cylinder Head

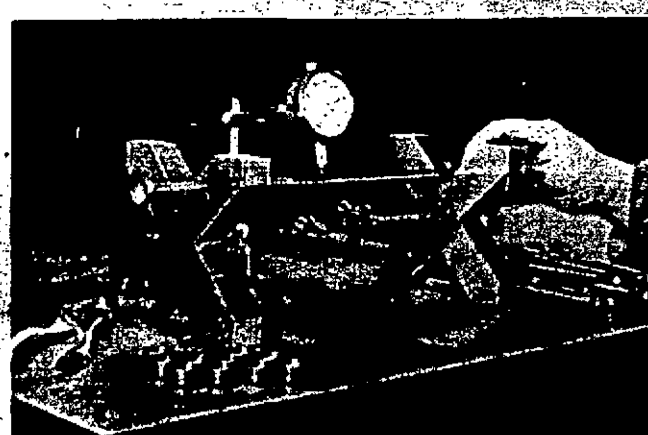


Figure 158
Push Rod Inspection for Runout

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.

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

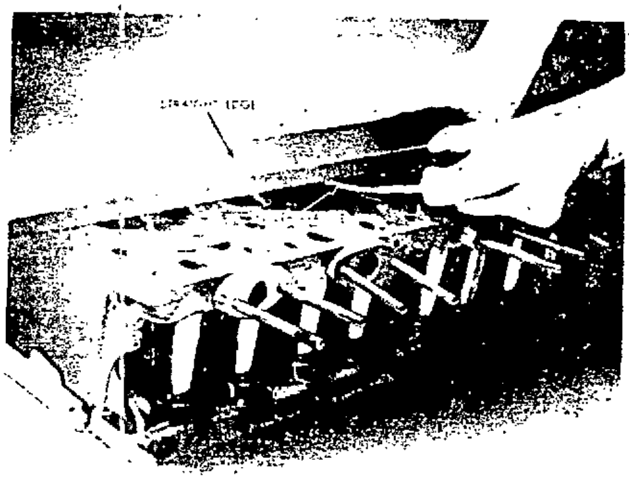


Figure 159
Checking Cylinder Head Flatness

INSTALLING HEAD

1. Make sure that gasket contact surfaces on the head and block are clean, smooth and flat. Check flatness with straight edge and feeler gauge in three positions lengthwise and five crosswise. The maximum permissible on the RD and SD head is .004 low in the center lengthwise, while on the TD .006 is acceptable, gradually decreasing towards the ends. Crosswise or in localized low spots maximum should not exceed .003.

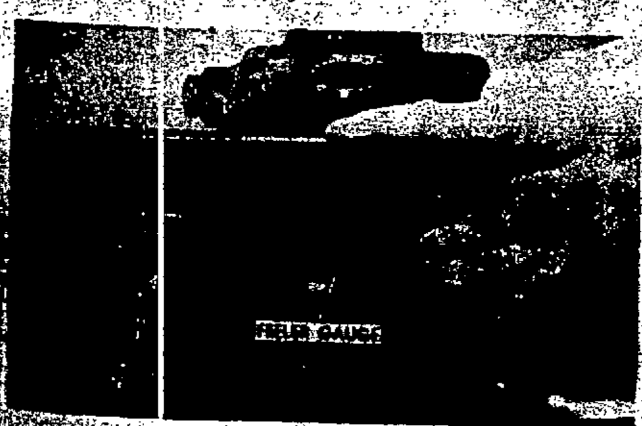


Figure 160
Checking Cylinder Head Flatness Crosswise

Cylinder head or block must be resurfaced if these limits are exceeded.

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.

3. Tighten with torque wrench in recommended sequence to the correct torque shown in Chart by going over them two times before pulling them down to the final torque specification on the third round.

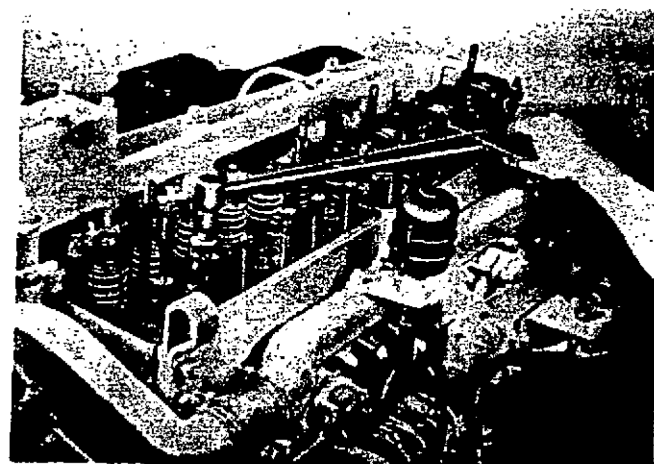


Figure 161
Torquing Cylinder Head Studs

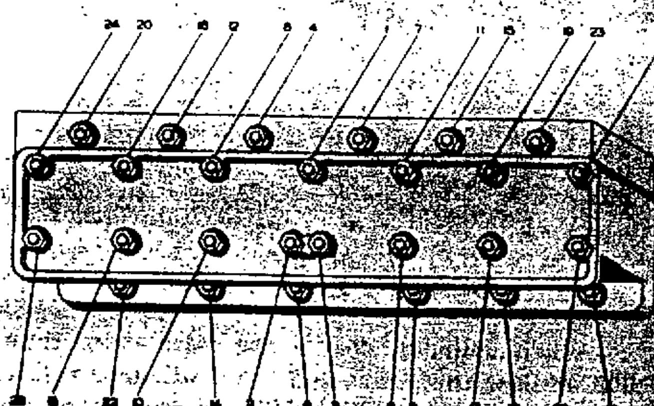


Figure 162
Cylinder Head Tightening Sequence (TD Series)

ENGINE REPAIR AND OVERHAUL

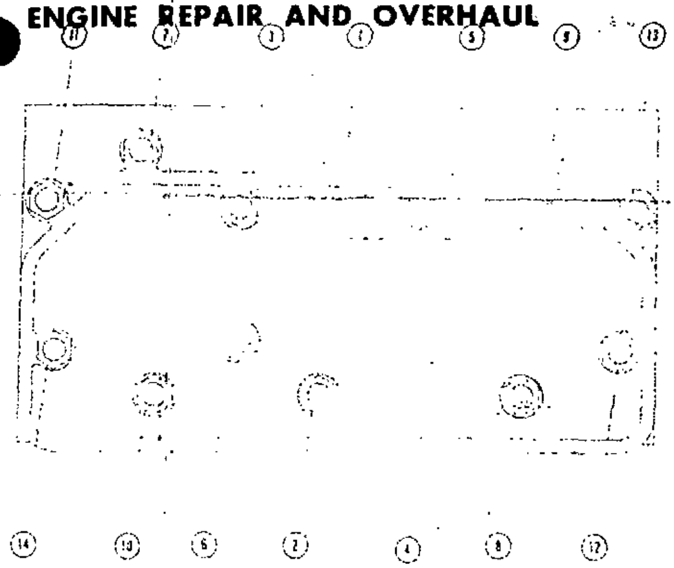


Figure 163
Cylinder Head Tightening Sequence (SD, RD Series)

CYLINDER BLOCK

Both the RD and SD series have replaceable liners of the dry sleeve type. In the TD series, the cylinders are machined in the cylinder block casting with no sleeves being used. As standard; however dry sleeves are available.

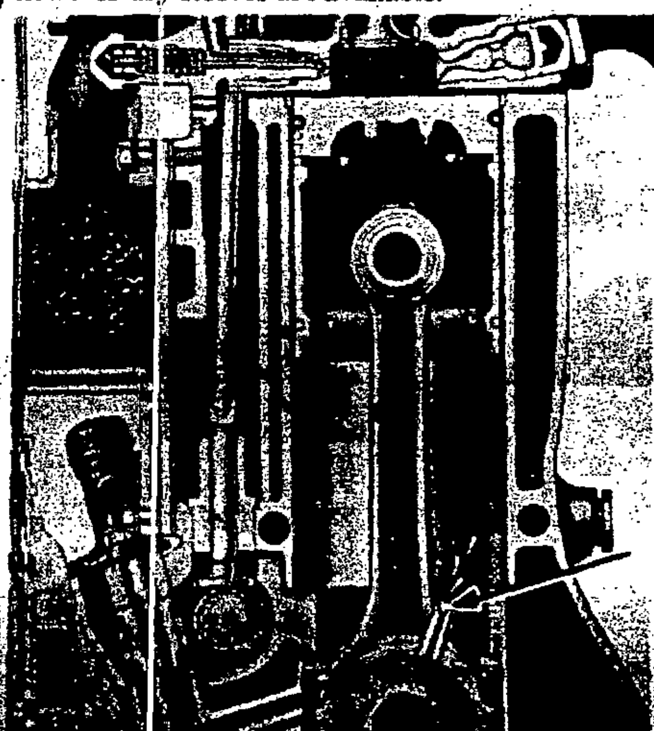


Figure 164
Sectional View of Cylinder

When cylinder sleeves are worn more than .008, replace the sleeve and use a standard piston and ring assembly. The TD engine, with no sleeves, must be rebored if worn more than .008

When wear is less than .008 in either case, a set of service rings may be used to restore the engine to satisfactory operating condition.

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.

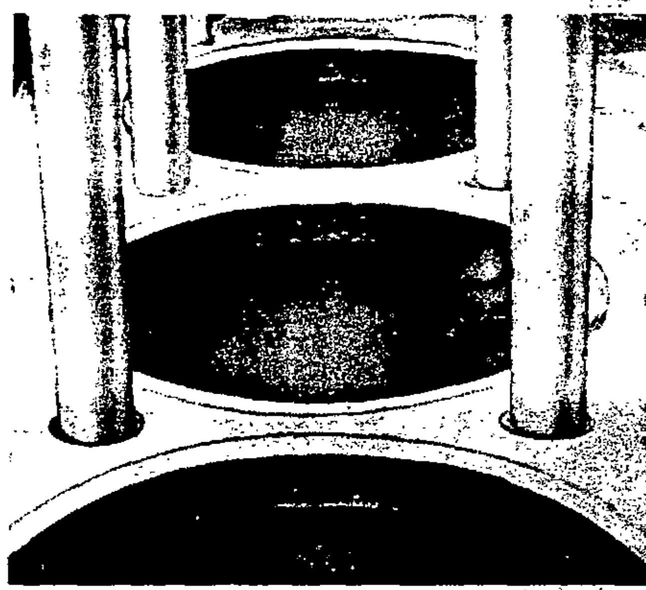


Figure 165
Deposits on Cylinder Sleeve Before Cleaning

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 166
Measuring Original Diameter of Sleeve (on RD and SD)

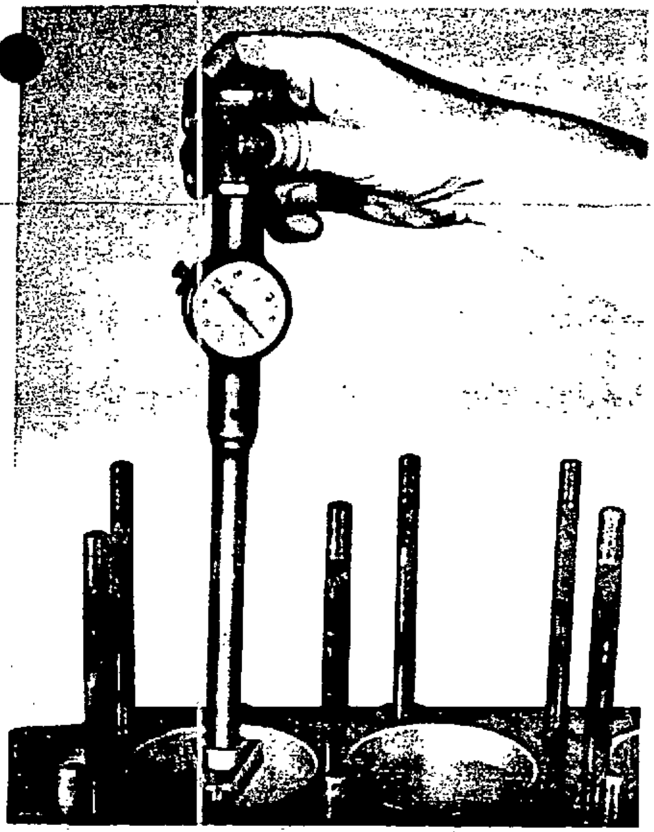


Figure 167
Measuring Original Diameter of Sleeve with Bore Gauge

3. Check in same manner the top of the ring travel area approximately ¼" below the shoulder.

Figure 168
Measuring Bore Wear ¼" Below Shoulder

ENGINE REPAIR AND OVERHAUL

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 replace sleeves or rebore the TD block having no sleeve.

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

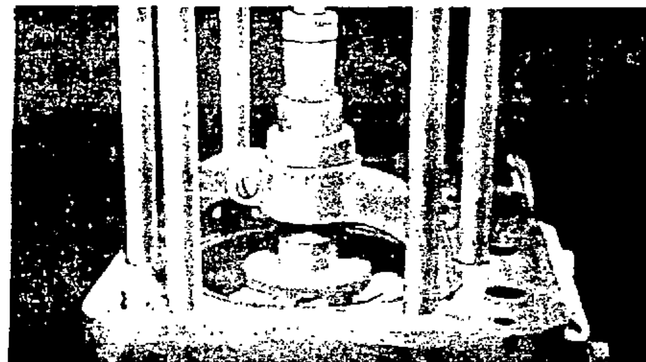


Figure 169
Ridge Reaming Top of Cylinders

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 hold them in place and it may be necessary to make some form of clamp to hold them while ridge reaming.

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

Figure 170
Removing Connecting Rod Cap

ENGINE REPAIR AND OVERHAUL

2. Drain the crankcase and remove the oil pan.

3. Remove cotter pins and nuts from the connecting rod bolts, permitting removal of caps. 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. If not already numbered, do so at this time.

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.

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.

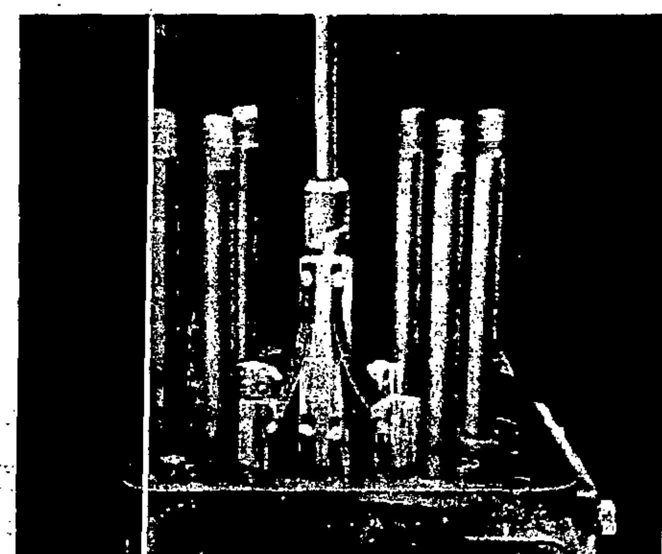


Figure 171
Breaking Cylinder Wall Glaze

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. The RD and SD Pistons have a cast in insert which eliminates top ring groove wear. (Figure 172)

Figure 172
Cast in insert

Worn ring grooves on the conventional piston used on the TD can be salvaged by installing a ring groove insert as furnished by several piston ring manufacturers.

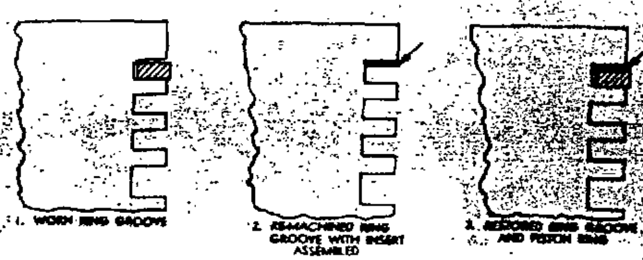


Figure 173
Ring Groove Insert

Some of them provide tools so that this job can be done manually in a shop not equipped with machines for this purpose.

REPLACING CYLINDER SLEEVE

When the bore wear measures over .008 or bores are badly scored or damaged, resleeving 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.

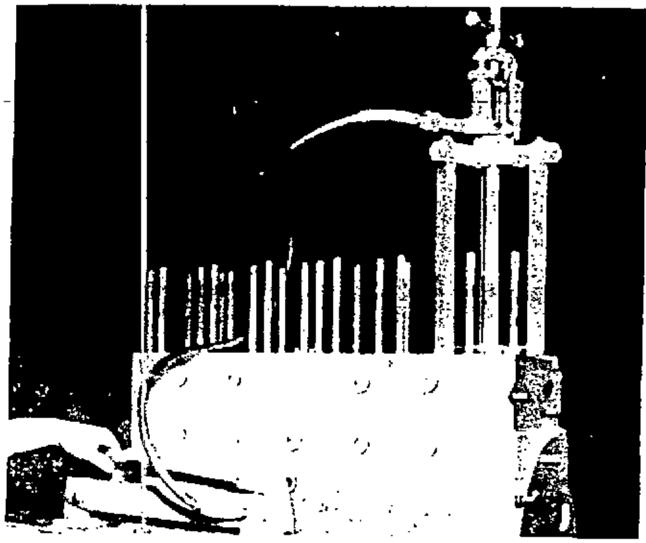


Figure 174
Sleeve Puller

1. Pull the sleeves, using a puller of the type shown in Fig. 174 which makes this a simple, easy operation.

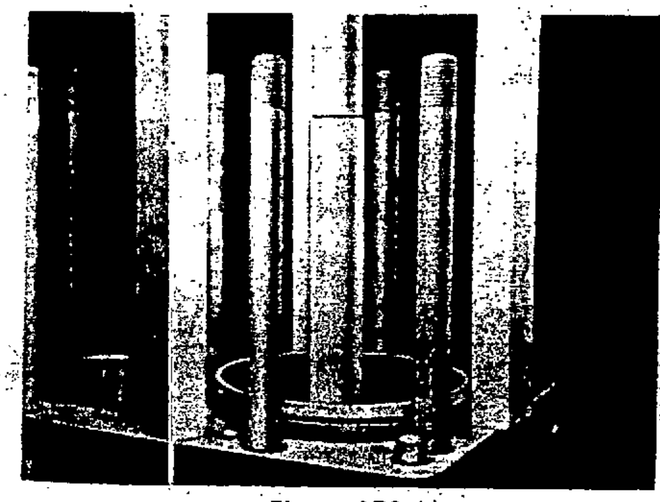


Figure 175
Close Up of Sleeve Pulling Operation

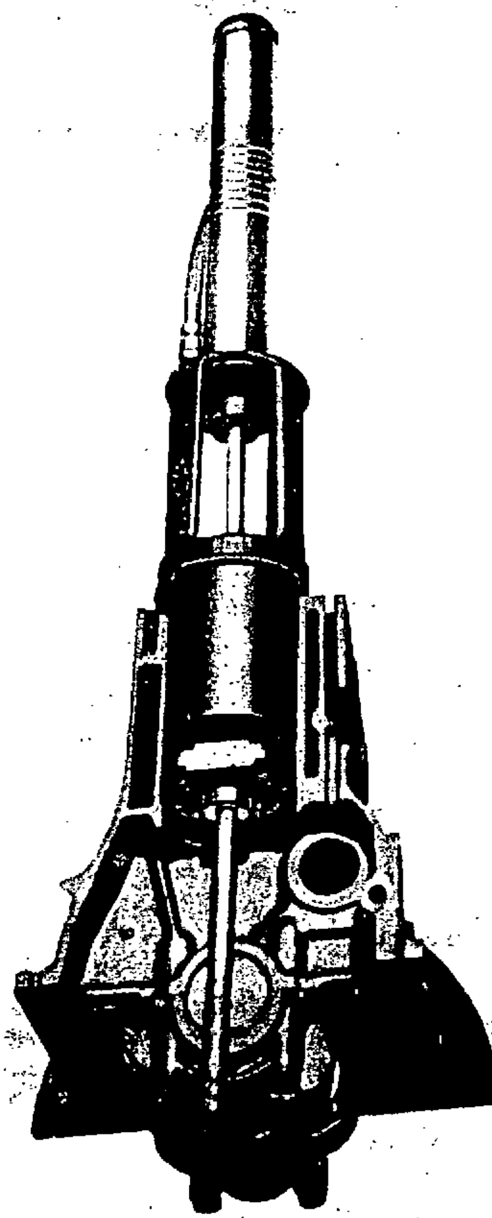


Figure 175A
Sectional View Showing a Sleeve Puller in Place

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

ENGINE REPAIR AND OVERHAUL

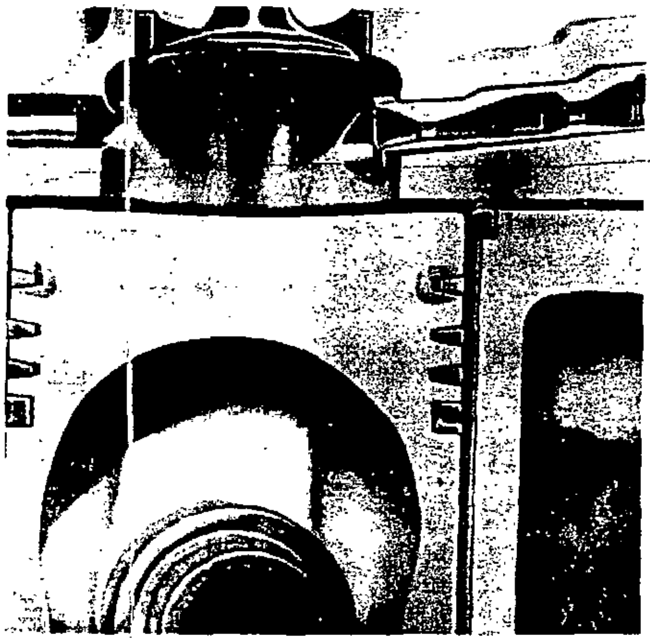


Figure 176
Cylinder Sleeve in Block (RD, SD)

3. Clean the bore in the cylinder block thoroughly removing any rust or corrosion that may have formed during the original operating period. A rotary wire brush or a glaze breaker can be used, or if neither of these is available, it can be done by hand, using fine emery cloth. (Under no circumstances, should you enlarge the bore by removing metal, just clean it up thoroughly so that the sleeve can make good contact, when assembled.)

4. Cylinder Liners are available in 3 standard sizes and selection should be made to provide a light push fit in the bore — NOT A DRIVE FIT.

5. After liner is assembled in cylinder block it must be honed to obtain the desired size and finish. The latter should be between 25 and 40 micro-inches if measured with a Profilometer — in other words, do not polish the bores.

If necessary to use a roughing hone to enlarge the inside diameter, use the finishing stones just enough to remove any burrs or scratches, moving the hone up and down rhythmically in the bore to obtain the desired criss-cross pattern.

6. While this work is being done, without removing crankshaft, the crankshaft bearing surfaces must be protected from dirt and abrasives. Tape the crank pins, which are completely unprotected when the connecting rods are removed, and use strips of clean rags, wet with oil, to wrap around the main bearing journal on each side of the main bearing.

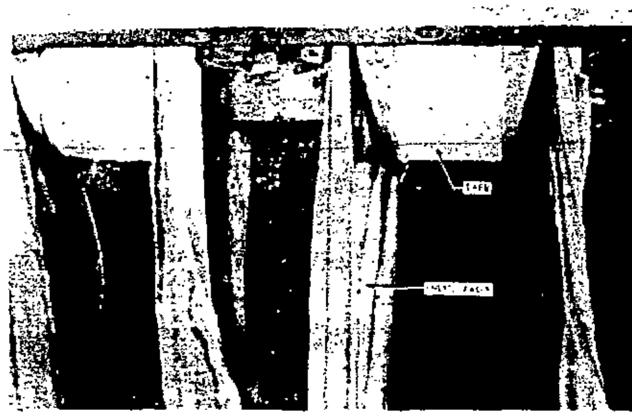


Figure 177
Protecting Rod and Main Bearing Surfaces

7. After the honing or glaze breaking operations are completed, clean the cylinder bores and crankcase thoroughly with a solution of water and one of the many detergents available.

8. Blow off with compressed air, then wipe with clean, oiled rag to protect the finished surface.

PISTON FIT

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.

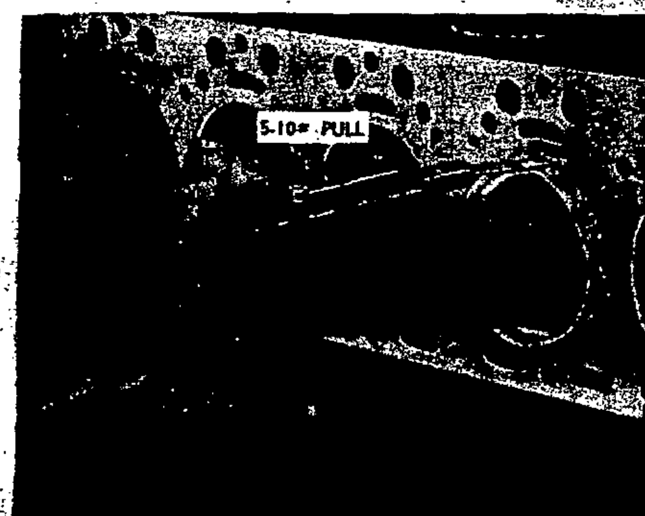


Figure 178
Checking Piston Fit in Bore

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# Pull	
TD	.006
RD	.007
SD	.008 (Use two .004 feelers)

PISTON RINGS

Check all piston rings in the cylinders for gap regardless of whether you are using (1) a re-ring set of piston rings in cylinder bores which have been ridge reamed or (2) a standard set with new cylinder sleeves or (3) an oversize set for cylinders that have been rebored.

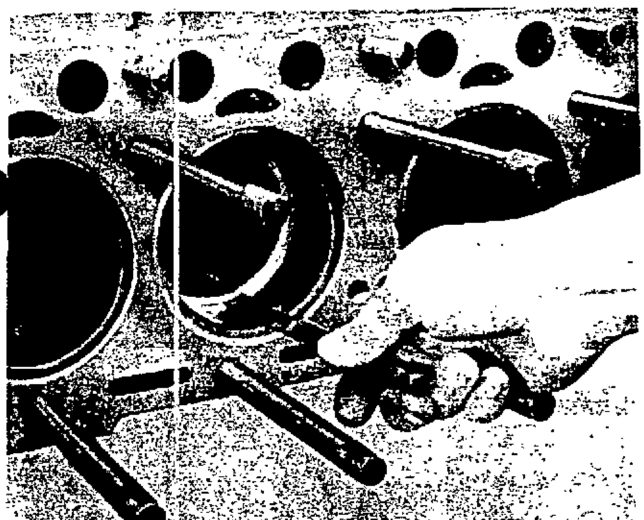


Figure 179
Checking Ring Gap

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 following chart. If any of the rings do not have enough gap, they may be filed

PISTON RING GAPS		
TD Series	.012-.020	All Rings
RD Series	.018-.025	All Rings
SD Series	.018-.032	All Rings

Figure 180
Filing Piston Ring to Increase Gap

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 as shown above.

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

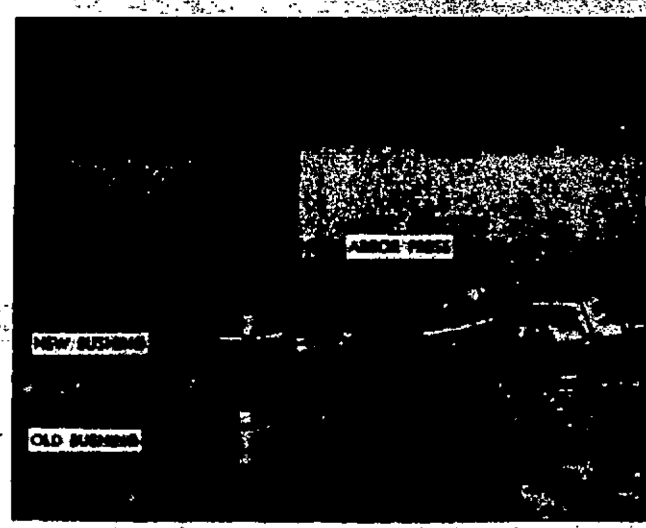


Figure 181
Pressing in Piston Pin Bushing

ENGINE REPAIR AND OVERHAUL

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.

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.

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.

With the piston heated, the pin will enter the piston very easily and can be pushed on 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.

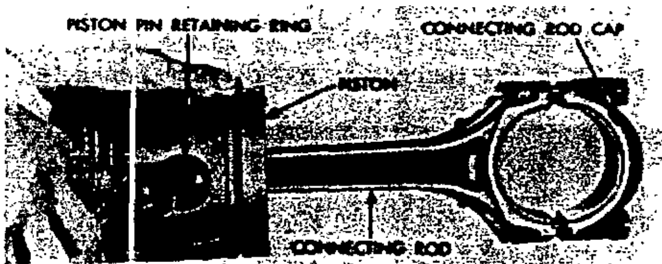


Figure 182
Installing Snap Ring

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.

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.

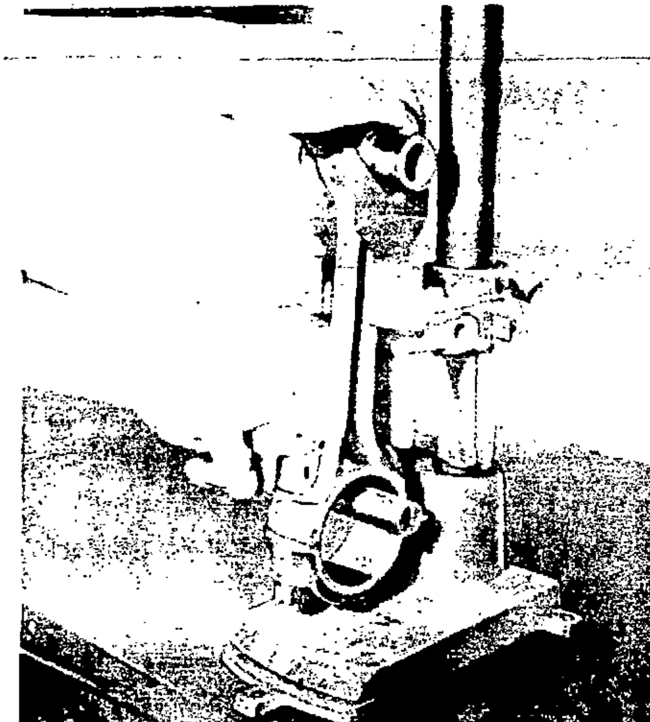


Figure 183
Checking Connecting Rod for Twist

Figure 184
Checking Connecting Rod for Alignment

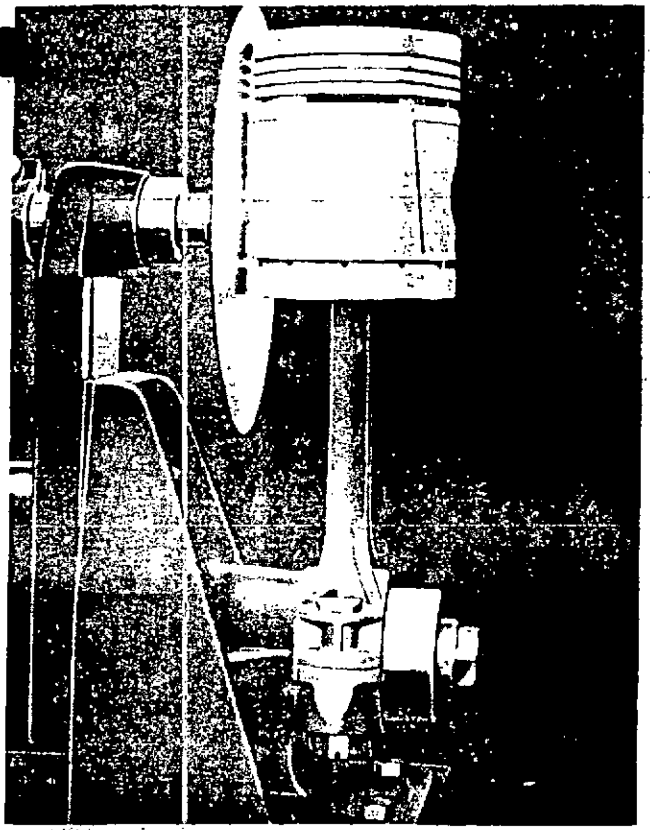


Figure 185
Checking Piston and Rod Assembly for Squareness and Twist

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

Pistons are cam and taper ground, and this must be taken into consideration when checking alignment of the assembly, since the diameter in line with the piston pin would be less at the top of the skirt than at the bottom.

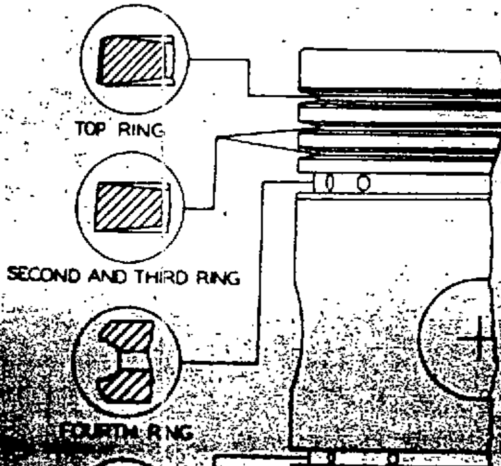


Figure 186
Cross Section of RD and SD Pistons and Rings (Keystone type)

ENGINE REPAIR AND OVERHAUL

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 of the straight side rings in its groove to be sure there are no burrs or other interference with the free action of the ring in the groove.

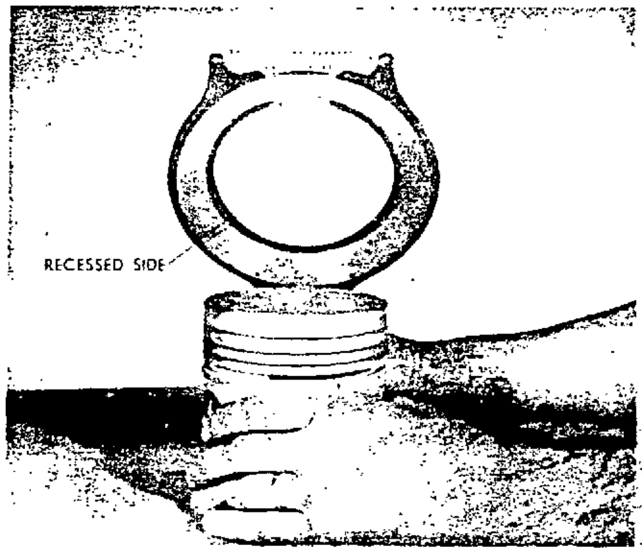


Figure 187
Installing Rings with Ring Expander Tool

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

Some piston rings are taper faced. These are clearly marked "TOP" on the side to be up when assembled on piston, see Fig. 188.

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.

ENGINE REPAIR AND OVERHAUL

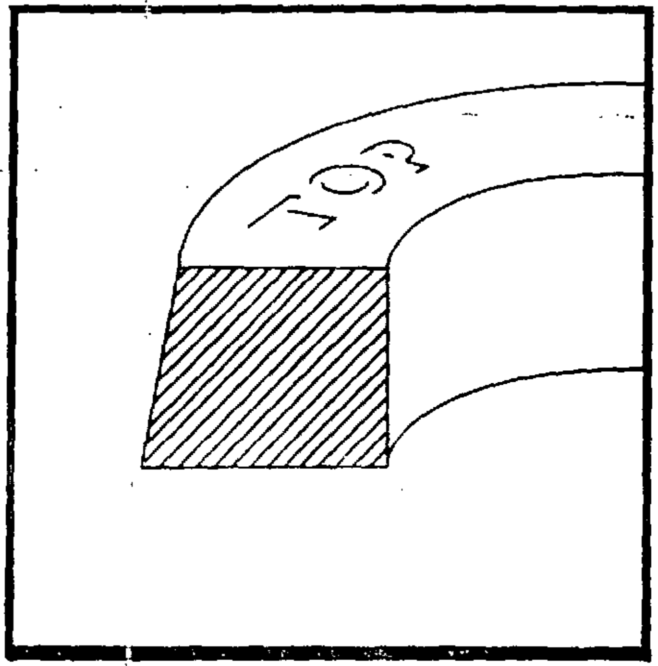


Figure 188
Install Tapered Rings with "Top" Side Up

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

Figure 189
Checking Ring Clearance in Groove

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 to obtain the desired clearance.

NOTE

Exception to these instructions must be taken in regard to checking clearance in grooves of the three top compression rings on the RD and SD.

These are the Keystone type ring, and the only check which can be made without special equipment is to note if the angle of the ring agrees with that of the groove.

CRANKSHAFT AND MAIN BEARINGS

1. Remove vibration dampener from crankshaft pulley. Remove starting jaw lock and starting jaw nut and washer. Using a puller, remove pulley from crankshaft.

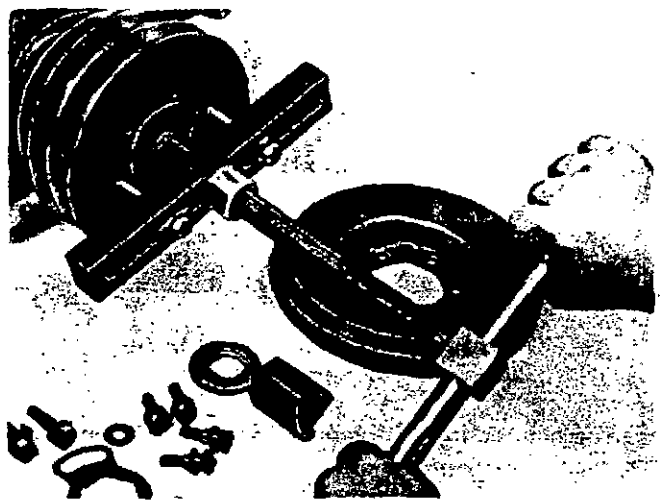


Figure 190
Removing Vibration Damper

2. Take out screws and remove gear cover.
3. Drop the oil pump, by removing nut or cap screws holding pump to center main bearing cap.

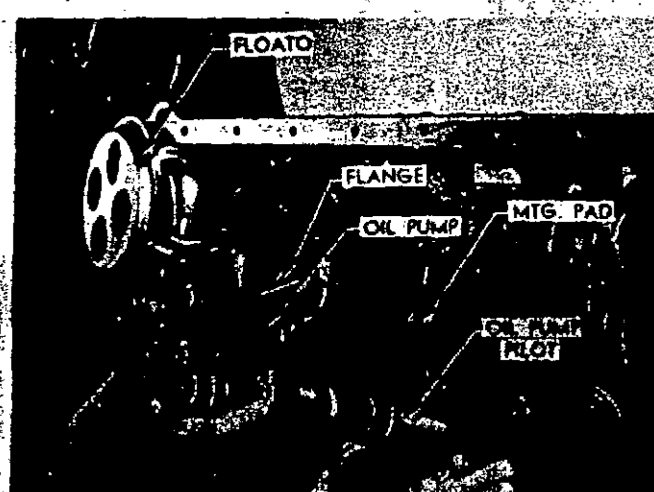


Figure 191
Removing Oil Pump

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

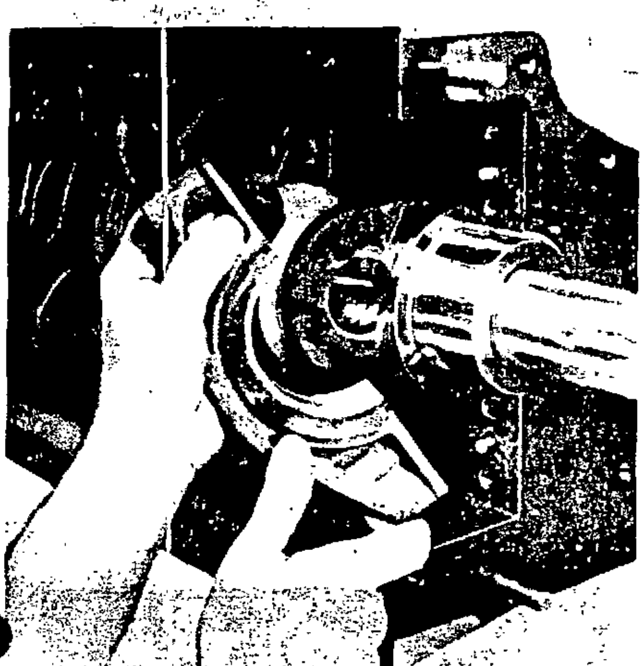


Figure 192
Removing Bearing Cap

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

While the lining of these bearings when new is smooth and highly polished, *a very few hours of operation will change their appearance completely.* **The bearing surface becomes a leaden gray in color and develops minute craters, almost cellular in appearance as indicated in the photograph, which follow the pattern of the matrix.** ***This appearance is a natural characteristic of this type bearing and in no way indicates failure.***

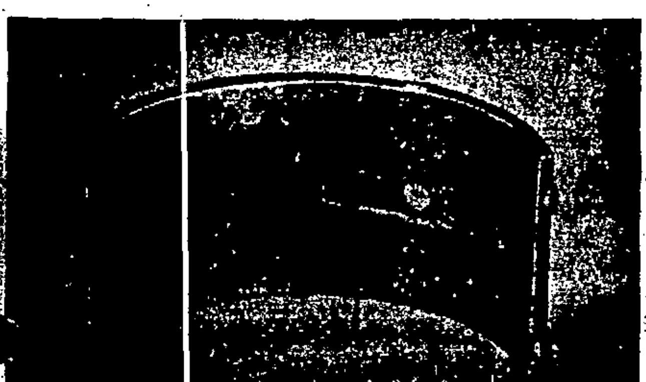


Figure 193
Appearance of a Good Bearing

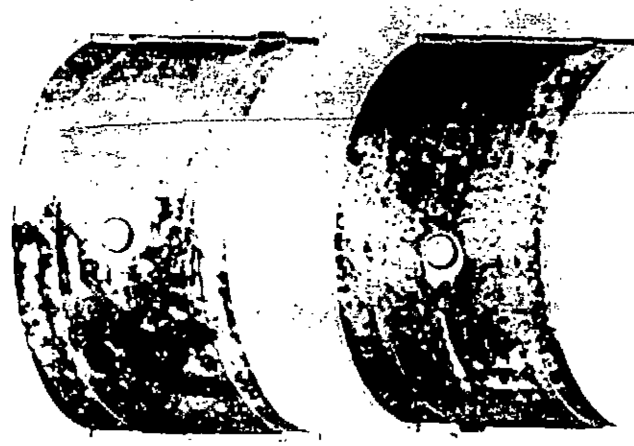


Figure 194
Bearing Damage Due to Corrosion

Figure 195
Scored Bearings Due to Dirt or Lack of Oil

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

ENGINE REPAIR AND OVERHAUL

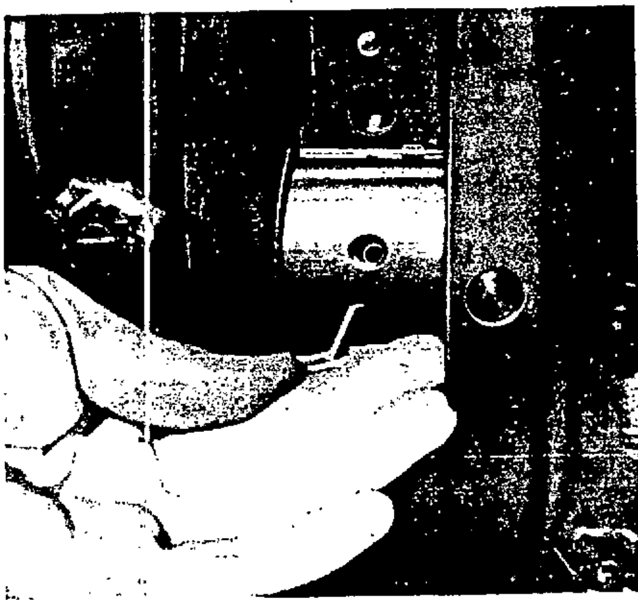


Figure 196
Removing Bearing

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.

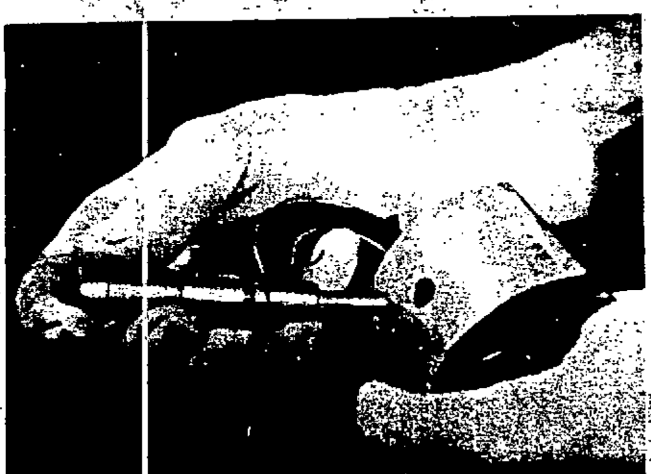


Figure 197
Measuring Bearing Thickness

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.

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

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 ½" shorter than the length of the bearing, dressing all edges carefully to be sure there are no burrs to mark the bearing.

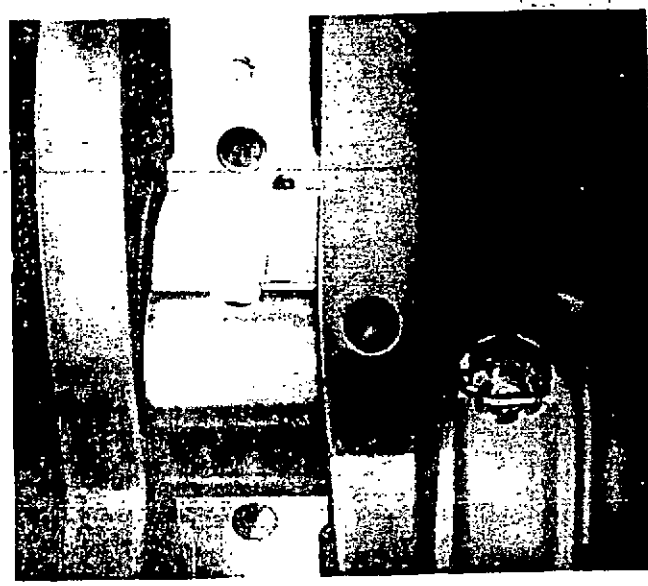


Figure 198
Replacing Bearing

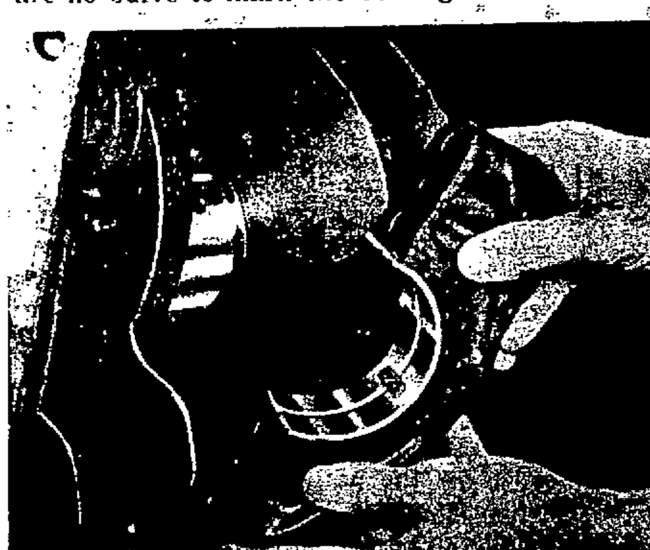


Figure 199
Checking Bearing Clearance

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. 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.

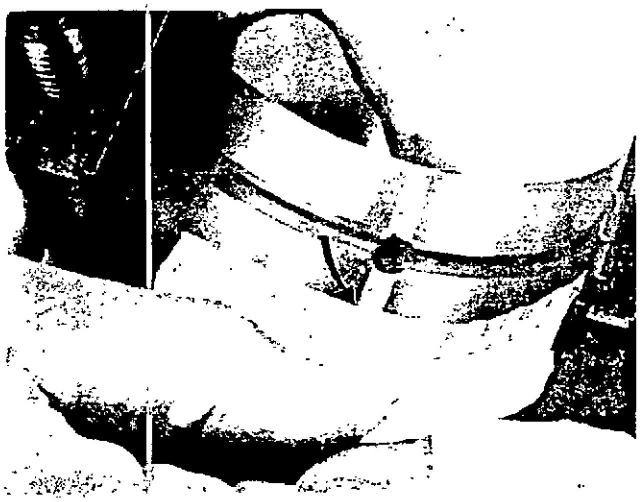


Figure 200
Checking Bearing Clearance with Plastigage

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 above.

> **CAUTION**
> 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 if necessary to be within .002 indicator reading. When reground, fillet radii must be within dimensional limits and must be perfectly blended into thrust and bearing surfaces.

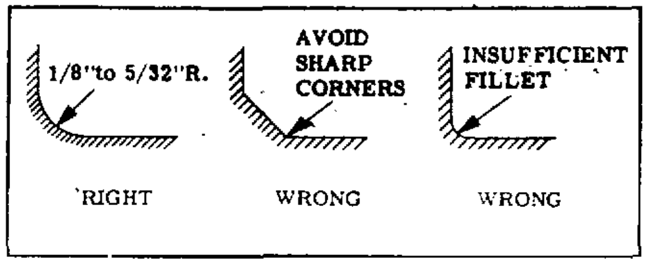


Figure 201
Crankshaft Fillet Radii

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.

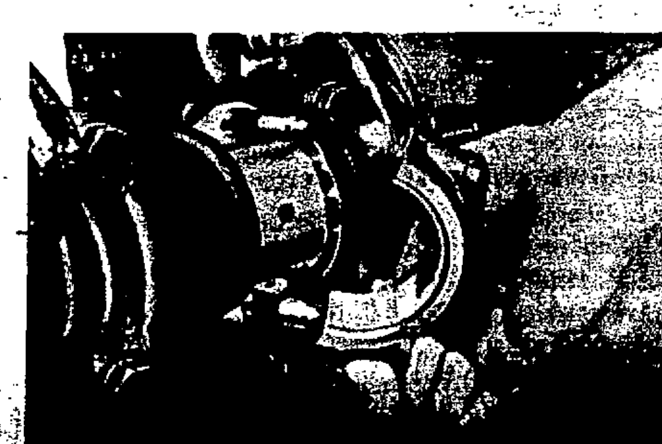


Figure 202
Checking Rod Bearings with Feeler Stock

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.

ENGINE REPAIR AND OVERHAUL

CAMSHAFT

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

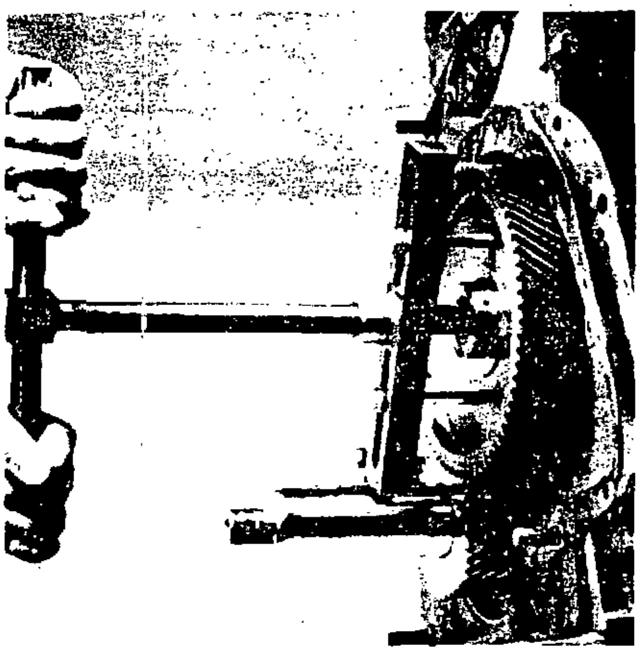


Figure 203
Pulling Cam Gear

2. Remove the screws holding the camshaft thrust plate to the front of the cylinder block, which makes it possible to pull the camshaft forward out of the bearings.

3. Remove push rods and unless engine is laying on its side, tappets must be removed or lifted before camshaft can be pulled.

4. Tappet chamber covers or side plates, which, on each of these engines includes the Oil Cooler Assembly, must also be removed.

5. Tappets on the TD can then be lifted out and lined up in sequence, for installation in the same location unless inspection shows that they require replacement.

6. On the RD, both the tappets and guides can be lifted out by removing the crabs holding the guides in place. These assemblies should be lined up in the same order in which they were in the engine, so they can be reassembled in the same location after thorough inspection.

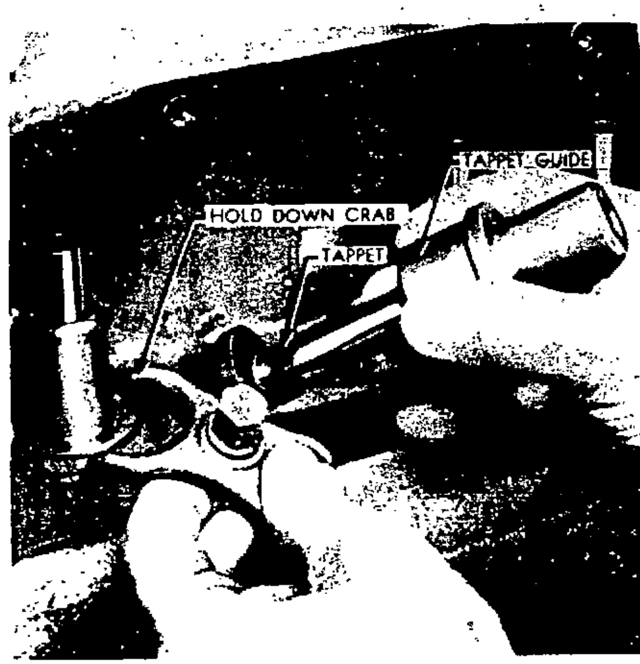


Figure 204
Removing Tappets

7. Tappets on the SD cannot be removed from the top, but must be lifted as high as possible in the guides, then held in this position.

This can be done by using magnetized rods long enough to reach down and lift the tappets, at the same time extending high enough above the cylinder block to permit holding in this position.

The present push rods with the ends cleaned, then coated with a tacky fibrous grease will also serve to lift the tappets and can be used to hold them up, away from the camshaft.

Either the magnetized rods or the push rods can then be held up by gripping them, in pairs, with rubber bands, or by using copper or soft wire wound tightly to hold them firmly against the push rod hole.

Another method is to use a piece of copper or soft iron wire in a similar manner, except that both ends have to be fastened with the wire stretched tightly. (With engine out of the installation and laid on its side, tappets can be pushed back, from cam, the latter pulled, then tappets removed for inspection.)

8. In either case before pulling the camshaft completely, check the clearance of the bearing journals in the bushing. To do this use strips of feeler stock 1/4" wide with edges dressed with a stone to eliminate any burrs or feathered edges.

9. If clearance is equal to or greater than the amount indicated under wear limits, check the diameter of the camshaft journals to determine

ENGINE REPAIR AND OVERHAUL

the next step. Excess wear at these positions require replacement of the shaft.

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

TAPPETS AND TAPPET GUIDES

1. Tappets must be inspected visually for scores or damage to the contact face. Two or three small pits in the latter is acceptable, more than that calls for replacement of the tappet.

2. Check the outside diameter with micrometers to determine if replacement is necessary because of wear.

3. Tappet guides or guide bushings may be checked for wear with a plug gauge or preferably with a telescope gauge and micrometers and are replaceable in every case.

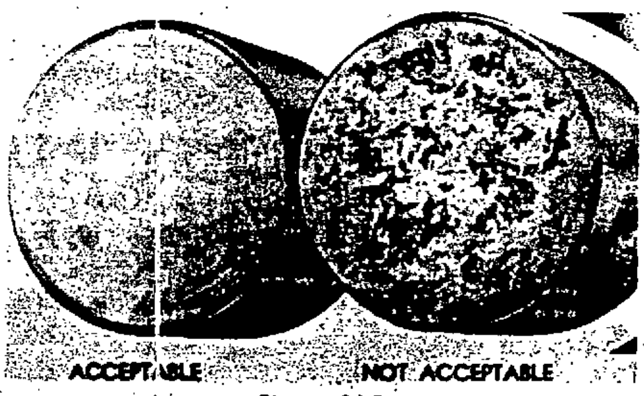


Figure 205

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 the 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. *Timing gears must be replaced in pairs.*

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

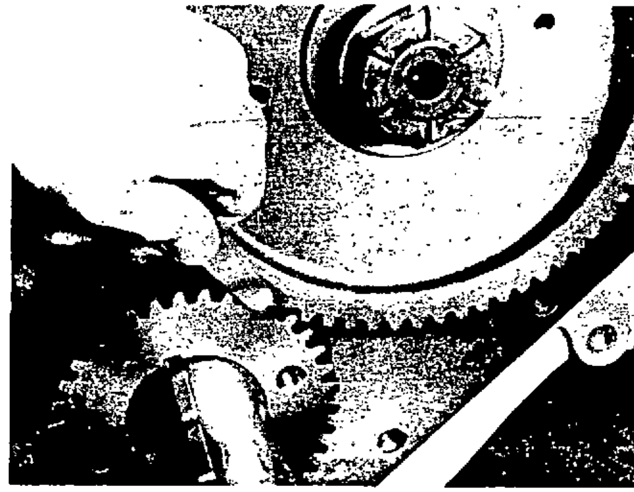


Figure 206
Checking Backlash in Timing Gears

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 driving or pressing it on, at the same time holding the camshaft forward so 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.

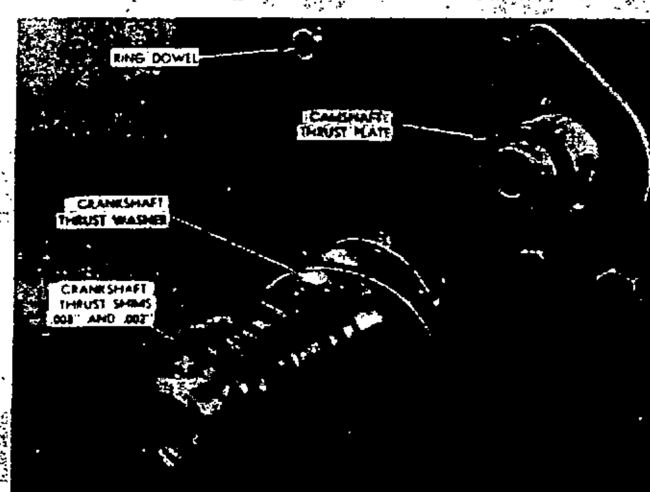


Figure 207
Crankshaft Shims and Thrust Washer

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

ENGINE REPAIR AND OVERHAUL

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.

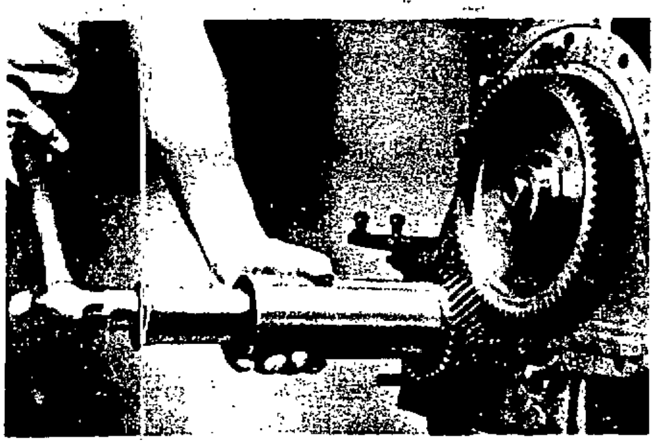


Figure 208
Assembling Crank Gear

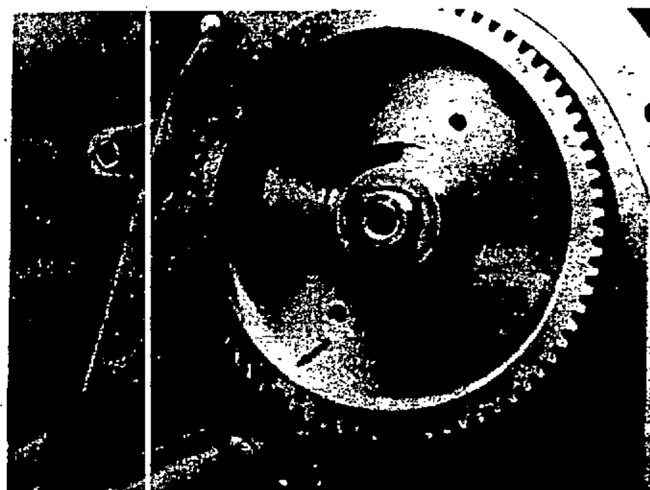


Figure 209
Timing Marks

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 .0015" 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 .0015" feeler gauge will not enter the gap between the two gear teeth, the gear fit is within specifications.

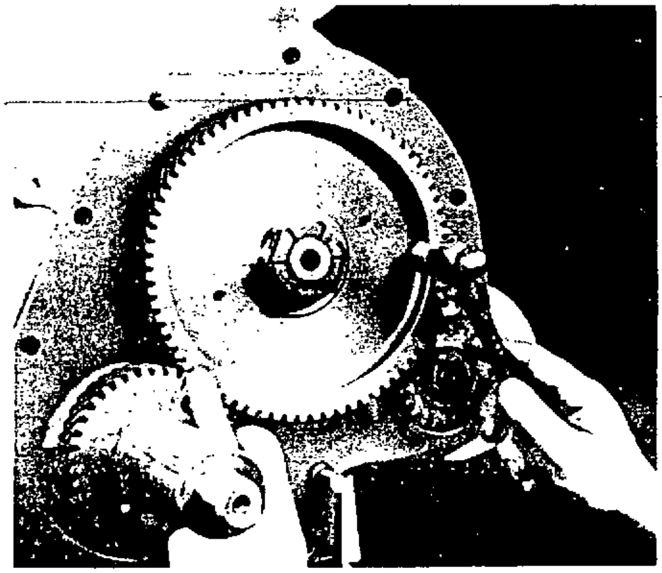


Figure 210
Checking Gear Fit

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 of 120-130 ft. pounds. Turn the lock over so that the nut is firmly held in place.

Check end play which should be .005-.009. If correct, turn the lock over so that the nut is firmly held in place.

This is very important as excessive play will affect pump timing.

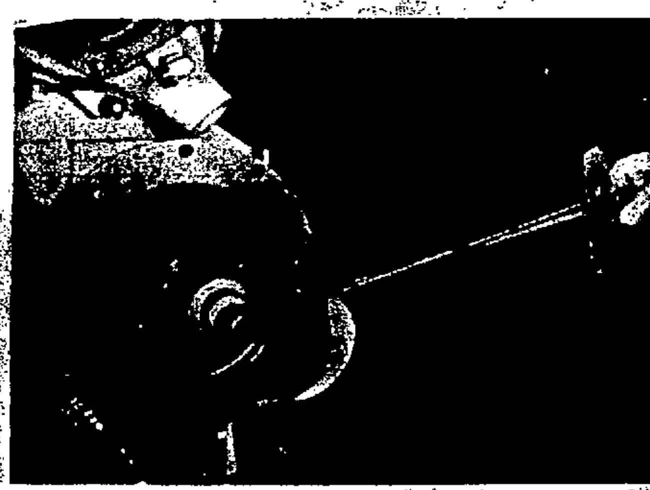


Figure 211
Torquing Cam Gear

CRANKSHAFT END PLAY

1. Check the crankshaft end play before replacing the gear cover. A shim pack containing

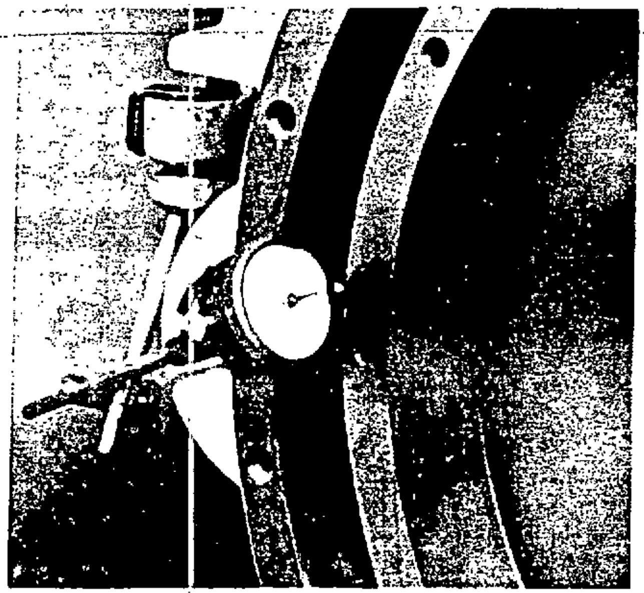


Figure 212
Checking End Play with Indicator

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.

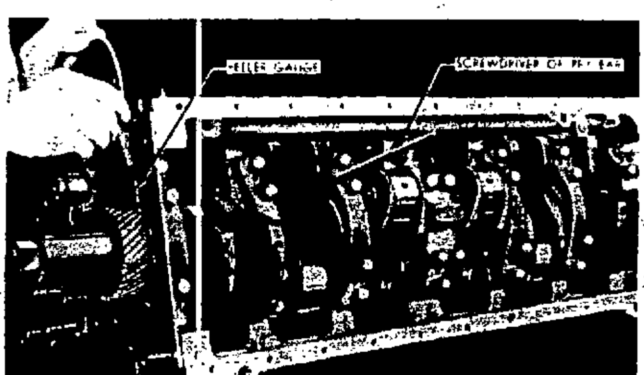


Figure 213
Checking End Play with Screwdriver

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.

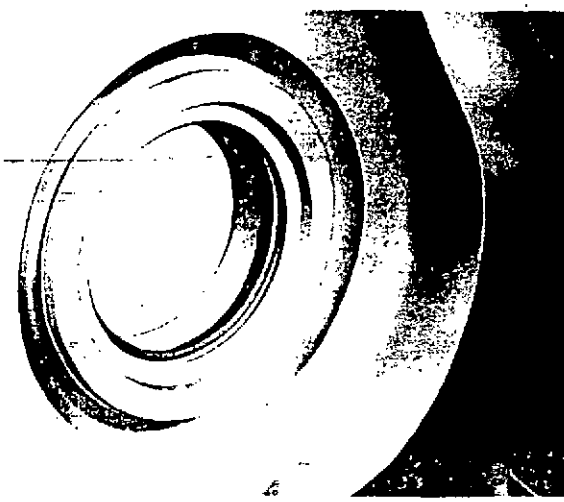


Figure 214
Crankshaft Front Oil Seal (inside view)

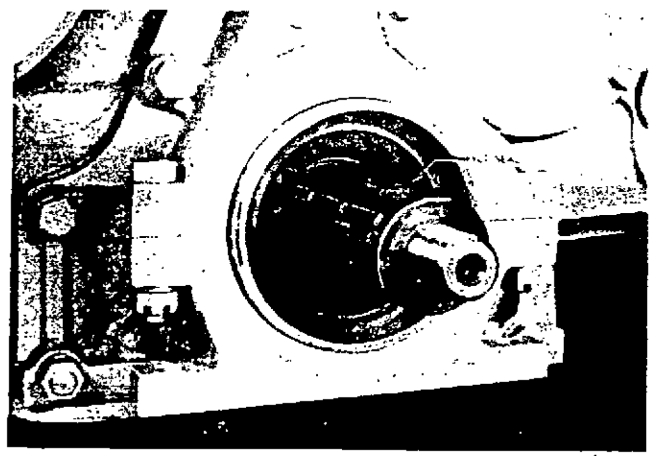


Figure 215
Front Oil Seal (outside view)

If the oil seal is in new 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 crankshaft 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 as-

ENGINE REPAIR AND OVERHAUL

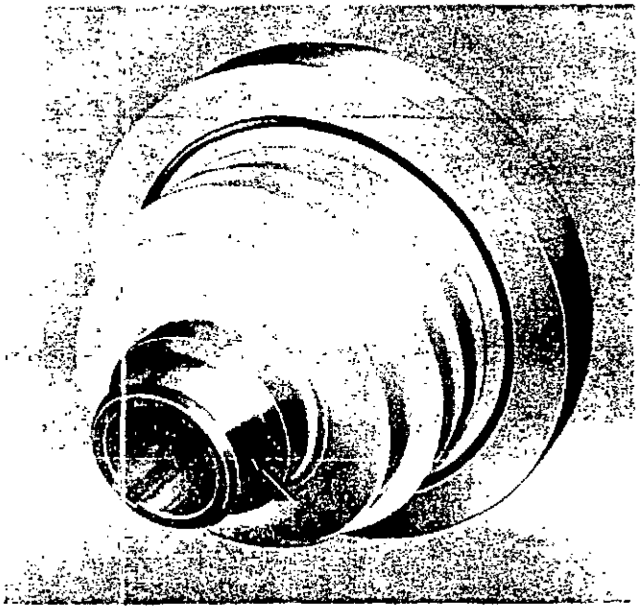


Figure 216
Seal Surface on Pulley

sembly. If the belt surfaces in the pulley are damaged, replace the pulley without question.

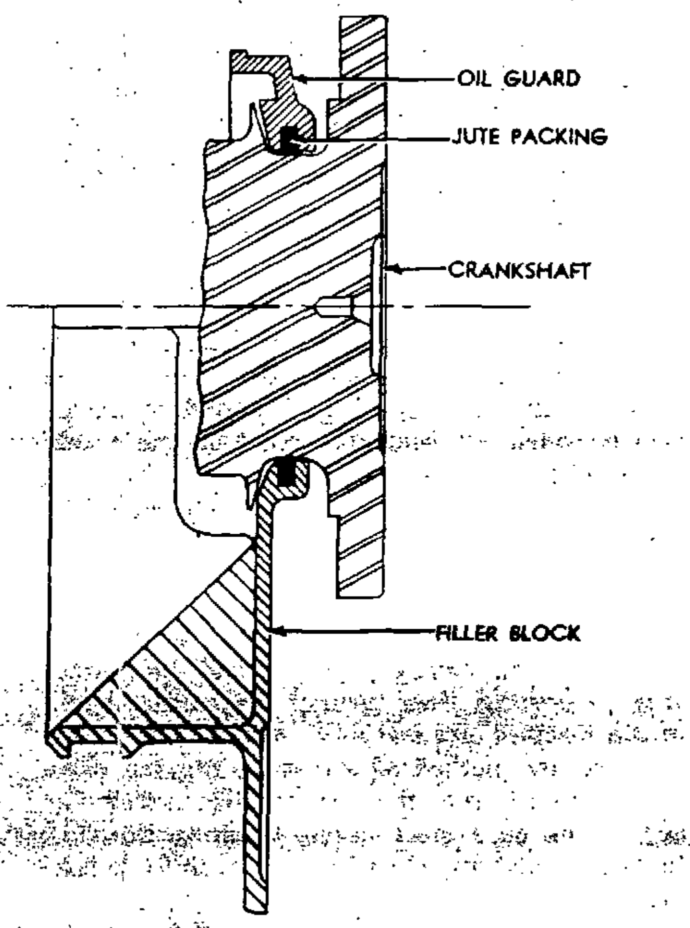


Figure 217
Rear Oil Seal

REAR CRANKSHAFT OIL SEALS
TD Series

The TD427 and TD6427 use the jute packing type of rear seal, which, if properly assembled, effectively seals against any possibility of oil leaks at the rear end of the crankshaft.

To replace this packing and reassemble this rear seal, it is necessary to follow instructions very carefully, otherwise your efforts may be useless.

1. The first step is to remove the filler block and oil guard, the latter being the semi-circular die casting which fits in the cylinder block, in a groove machined just to the rear of the rear main bearing.

2. Clean all surfaces and grooves thoroughly. If a scraper or wire brush is used, be very careful not to scratch or gouge the sealing surfaces. All dried cement or other material must be removed from these surfaces. Check filler block contact faces for flatness — Replace if warped.

3. The jute packing, as it is received, has a diameter approximately one-third greater than the width of the grooves. This must be crushed in a vice or otherwise flattened narrow enough to be inserted in the grooves.

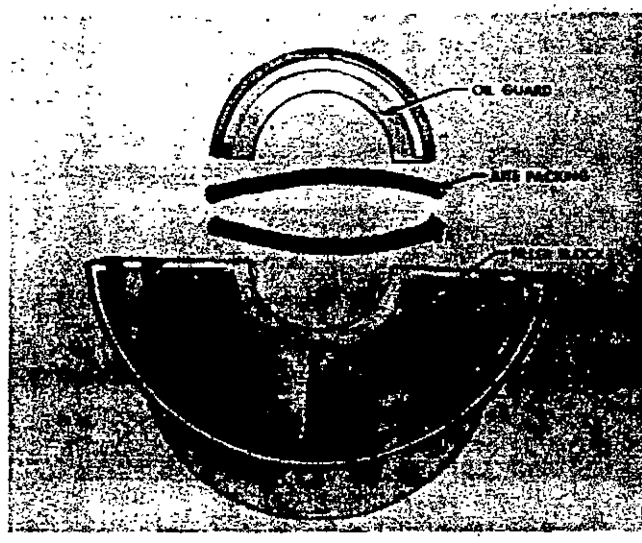


Figure 218
Rear Crankshaft Oil Seal (TD)

4. Next, press it into the grooves of both the filler block and oil guard as well as possible by hand. Then, using a piston pin, smooth hammer handle or some other tool with a smooth, rounded surface, iron this packing into the groove so that it is seated firmly and expanded to grip the sides.

You will find that the packing is long enough to protrude from the groove at either end in varying amounts.

5. With a sharp knife or razor blade, cut this off parallel to the surface of the casting, allowing it to protrude $\frac{1}{32}$ of an inch.

6. You are now ready to reassemble these parts in the engine. To do so, coat the outer or sealing surface of the oil guard with a non-hardening cement. Slide it into place around the crankshaft, if engine is still assembled or directly into the recess, if crankshaft is out.

When the assembly is made as outlined, and completed with a new oil pan gasket and the filler block assembled and properly tightened in place, there is no possibility of oil leaks developing at this point.

REAR CRANKSHAFT OIL SEALS — *RD and SD Series*

The RD572, RD6572, SD802 and SD6802 have an oil resistant synthetic rubber seal molded over a steel plate, which permits its assembly to the rear end of the cylinder block and filler block with small round head screws.

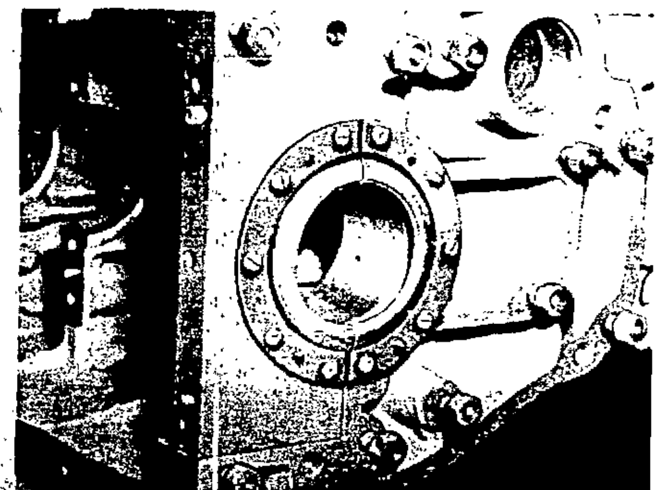


Figure 219
Seal Assembly on RD and SD

These are made in semi-circular form and two pieces are used to complete the assembly. Small dowel pins, two for each section, assure postive location in relation to the crankshaft.

Since the crankcase of these engines extends well below the crankshaft, the opening at the rear end must be filled flush with the bottom surface to complete the oil pan contact surface.

This opening is completely machined to have a flat contact surface and parallel sides so that a filler block with similar machined surfaces can be assembled.

The filler block becomes an integral part of the cylinder block, by being bolted and doweled

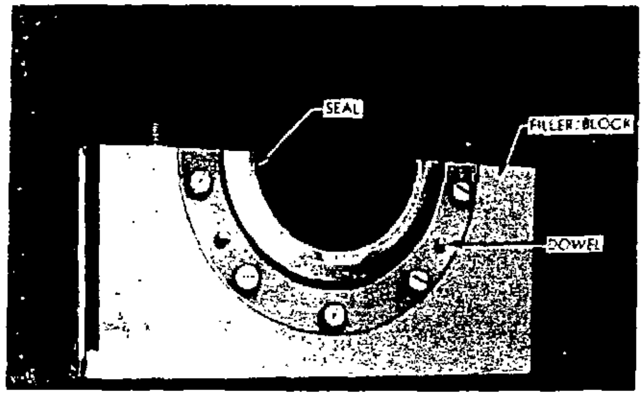


Figure 220
Seal and Retainer Gasket in Place on Filler Block

in position before the rear end of the block has the final machining operation making it flat and square with the bearing bore.

A gasket is assembled between the filler block and its seat in the block, on each side of the crankshaft sealing this contact area against oil leakage.

The sides of the filler block, where it fits into the milled slot in the cylinder block, are sealed, oil tight, by candlewick packing driven into a semi-cylindrical groove machined in the filler block.

When reassembling and repacking the filler block, do not attempt to fill the entire length of these grooves at one move, instead fill approximately $\frac{1}{3}$ at a time.

Use a packing tool made of $\frac{3}{16}$ or $\frac{1}{4}''$ rod with one side ground off for clearance, this section to be slightly longer than the depth of the filler block.

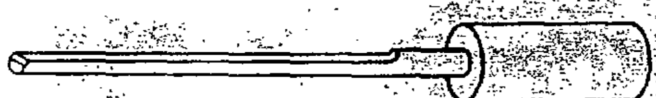


Figure 221
Packing Tool

Fill the groove approximately one-half full, crowding it in, with the tool, by hand. Then using a 12 oz. hammer and the packing tool, drive the packing in solidly as far as it will go.

Repeat this operation, at least twice, until the groove is completely filled.

CAUTION

If you try packing this all in one operation, you will have areas where the packing is not solid and leaks will occur.

ENGINE REPAIR AND OVERHAUL

As outlined previously, the rear crankshaft seal fastens to the rear of the cylinder block and filler block with small round head screws. The two halves are located in position by 2 dowel pins in each section.

A gasket is cemented to the cylinder block and filler block, before assembling the seal. Next, lightly coat each end of both synthetic rubber seals with Minnesota Mining and Manufacturing Company's EC847 Rubber Cement and allow to dry from 3 to 6 minutes or until it becomes tacky.

Coat the inside surface of the metal with Permatex #3 Aviation Gasket Cement. This will be the side from which the seal protrudes approximately 1/8 inch.

Assemble the seals in place, this 1/8" projection located freely in the bore in the cylinder and filler block, the sheet metal in place over the dowels. The ends butting together will seal and make a complete circle of the two pieces.

Assemble 5 screws in each section and tighten.

By following the foregoing procedure in every detail, a leak-proof rear end seal is assured.

OIL PUMPS

The oil pump is assembled to the center main bearing, held in position vertically against a machined pad, by a stud and nut on the TD and 2 cap screws on the RD and SD.

The extended portion of the body acts as a pilot, fitting closely in a reamed hole in the main bearing web, maintaining definite relationship between the camshaft and the oil pump drive shaft.

A gear assembled to the upper end of this shaft is driven by a mating gear cut on the camshaft and drives the oil pump gear which is assembled to the lower end of the pump shaft.

The pump shaft is carried in two bronze bushings assembled in the cast iron housing, which is also a part of the oil distributing system, transmitting oil to the drilled passages.

The gear type pump has a capacity well in excess of that required by the engine. In the TD, this surplus is dumped into the oil pan by the pressure relief. The RD and SD have a by-pass type of relief built into the pump so that the surplus is recirculated through the pump.

When the pump is removed, examine the drive gear carefully for wear, inspecting the gear on the camshaft at the same time. If scored or torn or worn deeply, both the camshaft and the gear on the pump must be replaced.

Examine the pick-up screen, which is the floating (Float-O) type to be sure it is not damaged. It must move freely when it is inserted in the pump body so it can follow the level of the oil.

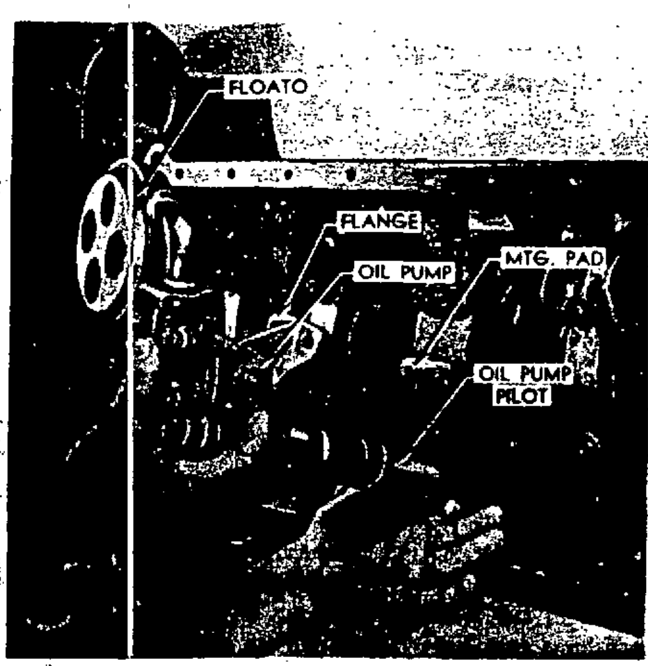


Figure 222
RD Oil Pump Assembly

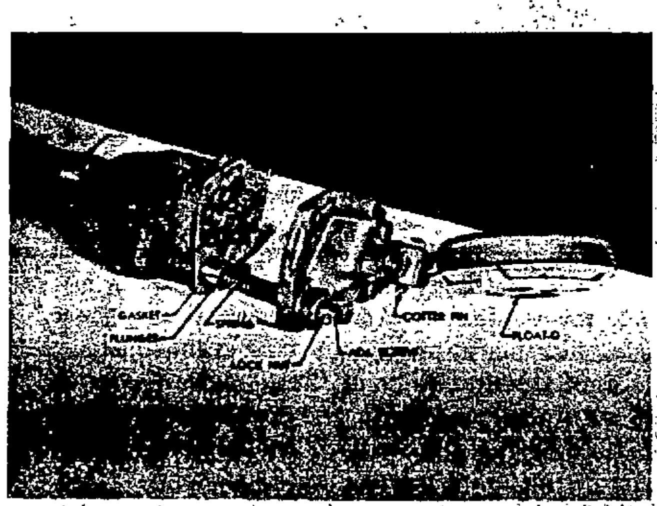


Figure 223
RD and SD Oil Pump Disassembled

Remove the cover, being careful not to damage the lead gasket which acts as a spacer as well as a gasket to seal the joint.

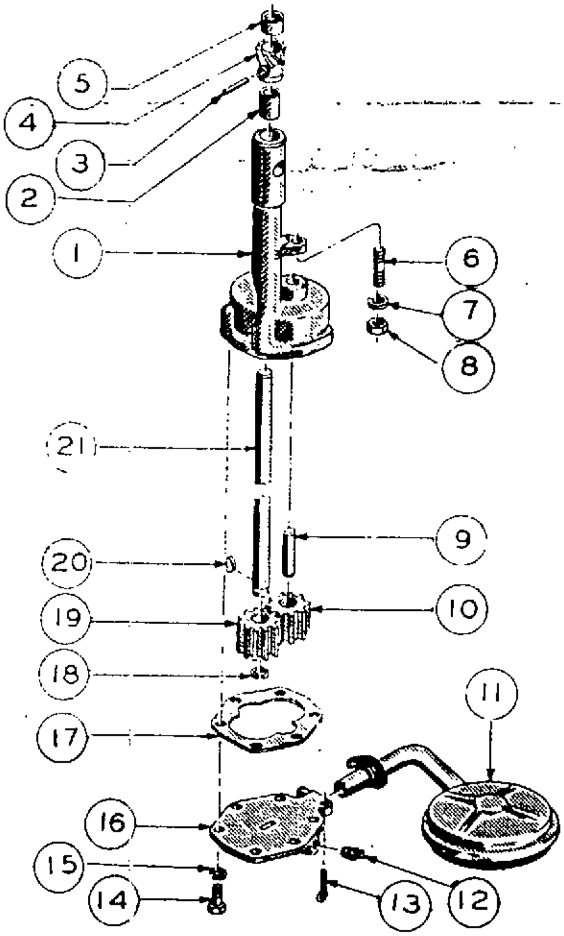


Figure 224
TD Oil Pump Exploded View

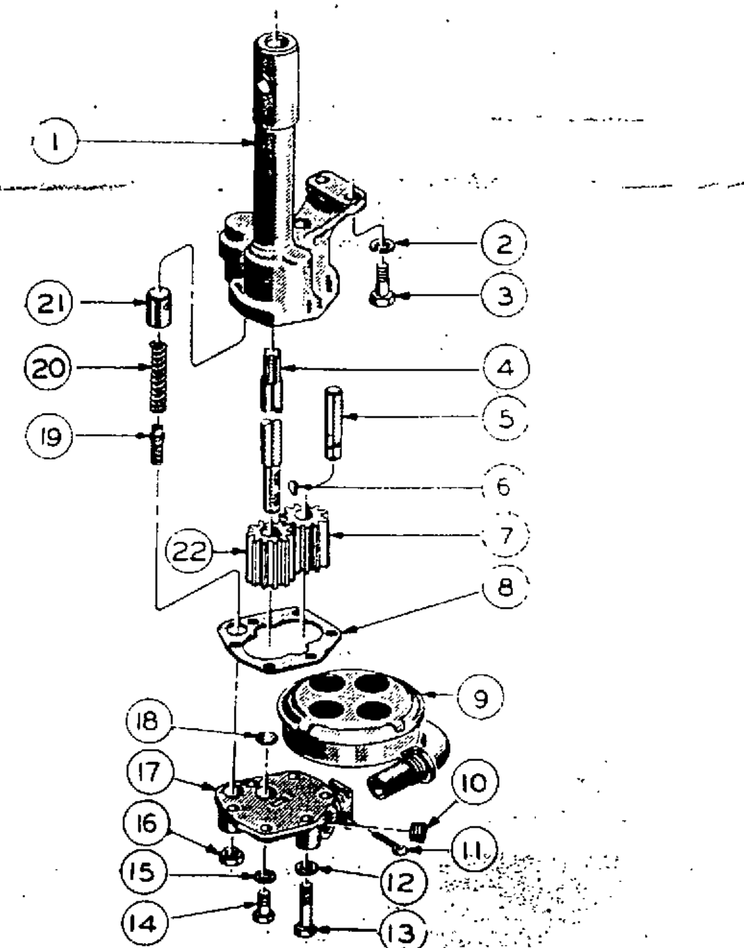


Figure 225
RD and SD Oil Pump Exploded View

1 Body Assembly (Body and Bushing)
2 Bushing
3 Pin
4 Gear-Oil Pump Drive
5 Sleeve
6 Stud
7 Washer-Lock
8 Nut
9 Stud
10 Gear-Oil Pump, Idler
11 Float-O-Assembly
12 Plug-Pipe
13 Pin-Cotter
14 Screw
15 Washer-Lock
16 Cover-Oil Pump
17 Gasket
18 Snap ring
19 Gear-Oil Pump, Driver
20 Key-Woodruff
21 Shaft-Oil Pump Drive

1 Body-Oil Pump
2 Washer-Lock
3 Screw
4 Shaft-Oil Pump Drive
5 Stud-Oil Pump Idler Gear
6 Key-Woodruff
7 Gear-Oil Pump, Idler
8 Gasket
9 Float-O-Assembly
10 Plug
11 Pin-Cotter
12 Washer
13 Screw
14 Screw
15 Washer-Lock
16 Nut
17 Cover-Oil Pump
18 Plug
19 Screw
20 Spring
21 Valve-Oil Pressure Relief
22 Gear-Oil Pump, Drive

ENGINE REPAIR AND OVERHAUL

Examine the gears and pump body for any sign of wear indicating lack of clearance. The gears should have from .001 to .003 clearance in the chamber and should make no contact with the walls.

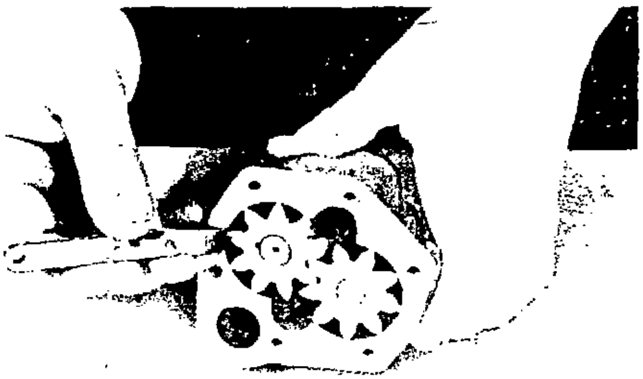


Figure 226
Checking Clearance in Gears

Inspect the cover and face of the gears for excessive wear or scoring. With the gasket assembled to the body there should be .0015 - .006 clearance between the gears and the cover.

Figure 227
Checking End Play

Worn or scored gears can be replaced, as can a worn cover. If the body shows wear in the chamber, it can be replaced, but in a case like this, a new pump would be the most economical.

Engine oil pressure must be maintained between 40-50 lbs. for satisfactory engine life. Pressure adjustment of the RD and SD is a screw type assembled in the pump cover.

Normally TD oil pressure @ 1800 RPM is 40-50 pounds and RD and SD engines 55-65 pounds.

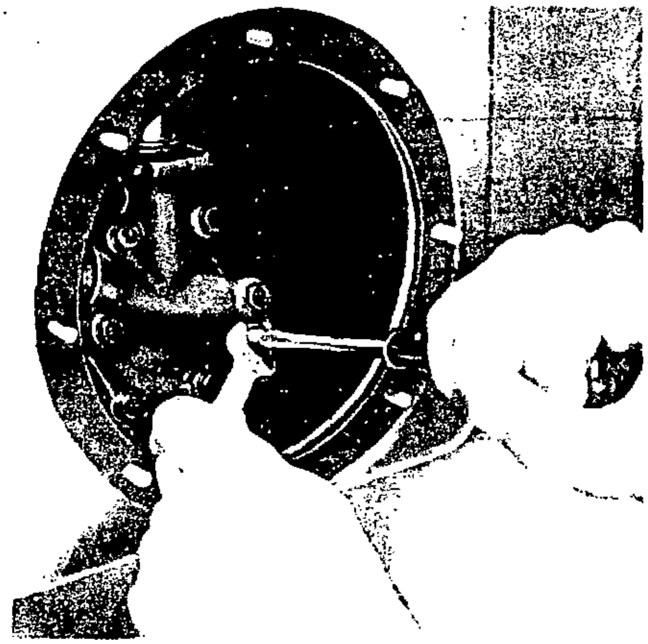


Figure 228
Adjusting Oil Pressure on RD and SD

Pressure relief on the TD is located externally on the left hand side, near the oil pan flange at the center. Pressure in this case is controlled by a plunger and spring, the latter specifically for a certain range. The only adjustment variation is either to change springs or assemble or remove washers from behind the present spring. Up to four washers are permissible.

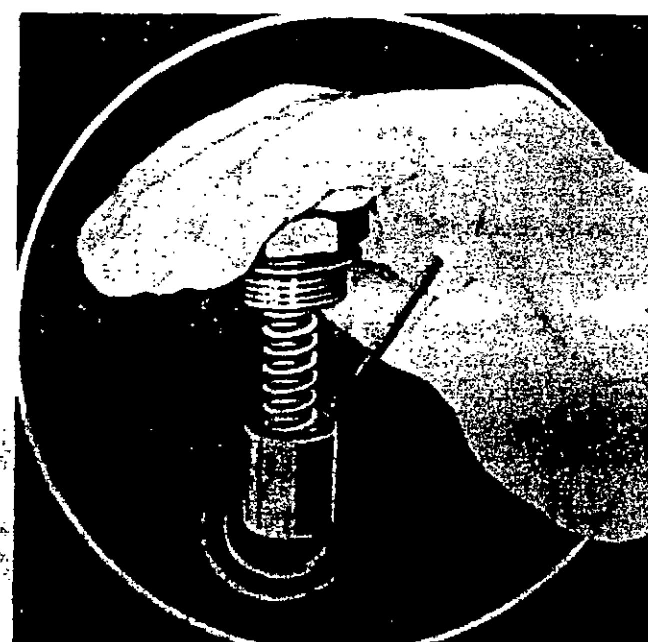


Figure 229
Oil Pressure Relief Valve (TD)

FLYWHEEL AND FLYWHEEL HOUSING

The flywheel is machined and balanced so that the clutch face and 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.

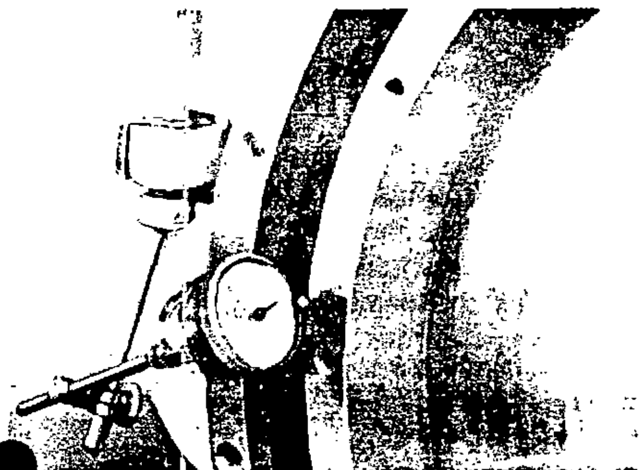


Figure 230
Checking Flywheel Runout

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.

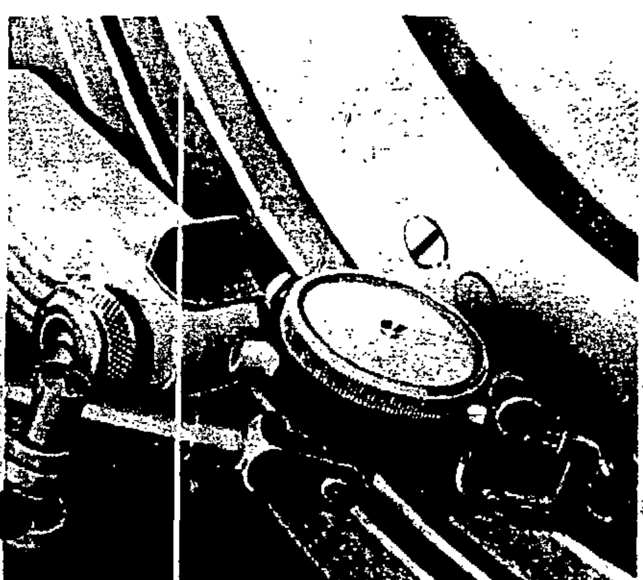


Figure 231
Checking Flywheel Counterbore

Excessive runout of the flywheel, in either position, is probably caused by dirt in or damage to counterbore locating the flywheel on the crankshaft flange.

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.

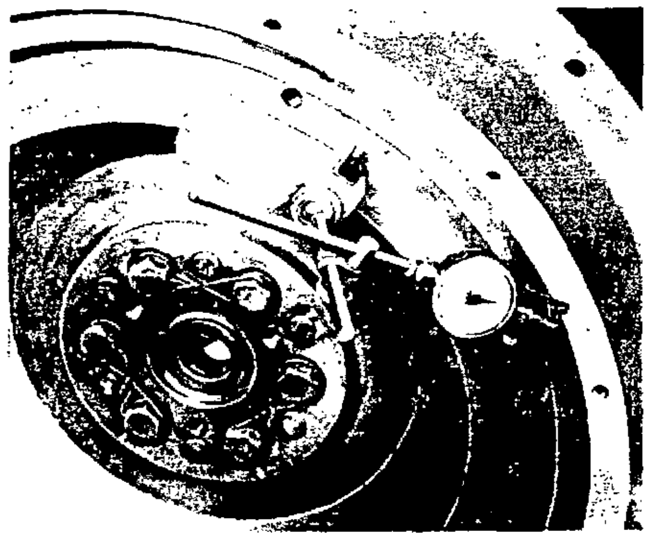


Figure 232
Checking Flywheel Housing Face Runout

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.

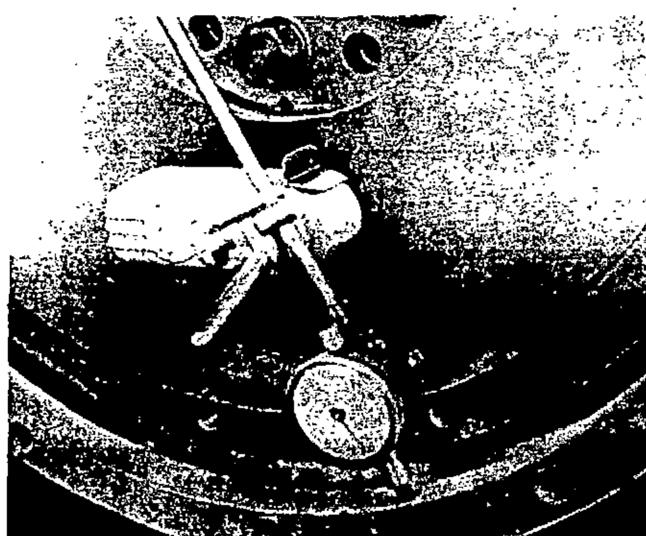


Figure 233
Checking Housing Bore

ENGINE REPAIR AND OVERHAUL

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.

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.

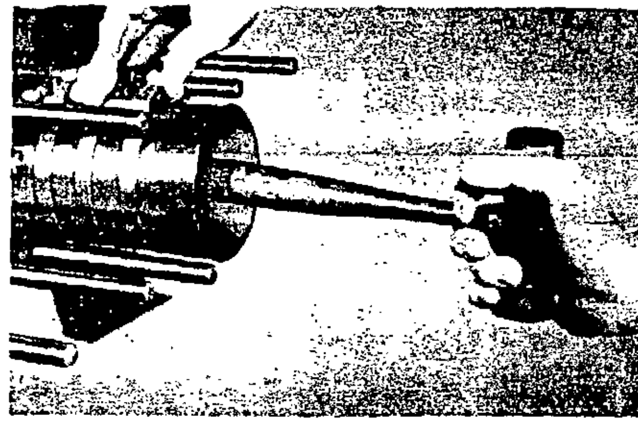


Figure 234
Assembling Piston in Cylinder

Once more, we call attention to care demanded to prevent connecting rods damaging the cylinder bore finish and at the same time as they are assembled over 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.

Before assembling the oil pan with new gaskets make certain that gasket surfaces are flat and clean. Tighten screws in accordance with limits prescribed in torque chart — to avoid looseness or overstressing.

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	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—no noticeable change indicates *that cylinder is missing.* Clean and test nozzle for pressure, leakage and pattern.
	2 — 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. 600 RPM Min.
	7 — Poor fuel	7 — Use 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 — Should be less than 10" water restrictions.
	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 authorized 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 within recommended operating range.
	4 — Thermostats sticking or inoperative	4 — Remove, clean and check thermostats and replace if required.
	5 — Wrong injection pump timing	5 — Retime pump according to recommendation.
	6 — Back pressure in exhaust line	6 — Inspect for restriction in muffler and exhaust system, and clean. Should be less than 20" water back pressure.

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 — Loosen fuel line to nozzle one at a time—no noticeable change indicates *that cylinder is missing.* Clean and test nozzle for pressure, leakage and pattern.
	3 — Poor fuel	3 — Use 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 — Worn valve guides or seals	2 — Replace to standard.
	BLACK SMOKE	
	1 — Retarded pump timing	1 — Check and retime if necessary.
	2 — Excessive fuel rate	2 — Check fuel stop or rate for original setting. Reset if necessary.
	3 — Overloading engine	3 — Reduce load.
	4 — Restriction in air supply	4 — Clean air cleaner.
	5 — Low engine water temperature	5 — Check shutter and thermostat.
	6 — Poor grade of fuel	6 — Use specified grade.
	7 — Clogged energy cell	7 — Clean or replace.
(G) Poor Compression (Under 325# at 150 RPM @ normal operating temp.)	**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 to air tight joint.**
	4 — Wrong valve timing	**4 — Check and correct if necessary.**
	5 — Burned or sticking valves	**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.**

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 lubrication recommendations.
	4 — Dirt in relief valve or broken spring	4 — Clean or replace spring if required.
	5 — Suction screen plugged	5 — Remove screen and clean in solvent.
	6 — Worn bearings	6 — Check with pressure tank for excessive leakage test. Check bearing clearances.
	7 — Worn oil pump	7 — Remove, repair or replace pump.
	8 — Oil cooler clogged — restricting flow (on TD only)	8 — Remove and clean.
(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 sleeves	8 — Replace sleeves, pistons and rings.
	9 — Worn bearings	9 — Check bearings with pressure tank for leakage.
	10—Worn valve guides	10—Check and replace if necessary.
(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 Diesel fuel that meets specifications.
	3 — Loss of power	3 — Follow "D" recommendations.
	4 — Incorrect injection pump timing	4 — Reset to timing recommended for operating speed.
	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 in contact seat.
	7 — Incorrect tappet clearance	7 — With engine warmed up, adjust tappets to specifications.

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.
	7 — Injection pump not functioning	7 — Check for failure or slipping of drive coupling.
(L) Engine Knocks and Noises	COMBUSTION KNOCKS (Excessive)	
	1 — "Lugging"	1 — Reduce load or increase speed.
	2 — Poor quality fuel	2 — Use only Diesel engine fuel oil for good performance and economy.
	3 — Injection timed too early	3 — Follow recommended instructions for timing.
	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.
	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	T D 427 T D 6427	RD 572 RD 6572	SD 802 SD 6802
Bore	4-5/16	4¾	5-9/16
Stroke	4⅞	5⅜	5½
Displacement cu. in.	427	572	802
Compression Ratio	14.4:1	14.5:1	14.7:1
Firing order	1-5-3-6-2-4	1-5-3-6-2-4	1-5-3-6-2-4

VALVE GUIDE	Int.	Exh.	Int.	Exh.	Int.	Exh.
Length	3¼	2-21/32	4½	3-3/16	4-23/32	3-13/16
Outside dia.	.8145/.8135	.815/.814	.8765/.8755	.8765/.8755	.8765/8755	.8765/.8755
Stem. hole dia. (Reamed)	.4365/436	.4365/.436	.499/.4985	.4995/.4985	.4990/.4985	.4995/.4985
*Wear limits, Max. dia.	.438	.438	.5005	.501	.5005	.501
Distance, cyl. head contact face to top of guide	2-13/32	2-25/32	1-11/16	2⅞	2	2⅞

VALVES, INTAKE			
Material	Chr. Ni. Steel	Chr. Ni. Steel	T.S. Steel
Overall length	7.1122/7.0872	7.7005/7.6855	8.3995/8.3785
Stem dia.	.4352/.4344	.4978/.4968	.4977/.4969
*Wear limits, Min. dia.	.4324	.4948	.4949
Head Dia.	1.865/1.855	2.021/2.011	2.332/2.322
Seat angle	45°	45°	45°
Stem Clearance lim.	.0021/.0008	.0022/.0007	.0021/.0008
*Wear limits, Max. cl.	.0041	.0042	.0041
Desired stem clear	.0015	.0015	.0015

VALVES, EXHAUST			
Material	Chr. Ni. Steel	Alloy Steel-Stellite Face	Steel-Stellite Face
Overall length	6.085	6.6672/6.6552	7.295/7.274
Stem dia.	.4325/.4315	.495/.494	.495/.494
*Wear limits, Min. Dia.	.4295	.492	.492
Head dia.	1.646/1.636	1-51/64	2.055/2.045
Seat angle	45°	45°	45°
Clearance stem lim.	.005/.0035	.0055/.0035	.0055/.0035
*Wear limits, Max. cl.	.007	.0075	.0075
Desired stem clear	.004	.0035	.0045

VALVE SPRINGS			
Outside dia. Outer	1.614/1.594	1.850/1.820	1.9075/1.8875
Outside dia. Inner	1.225/1.1075		1.375/1.355
Wire gauge Outer	.177	.207	.225
Wire gauge Inner	.125		.172
Spring length vlv. closed outer	1.548	2.117	2¾
Spring length vlv. closed inner	1.453		2-19/32
Spring load, vlv. closed outer	65-73#	63-71#	85-95#
*Wear limits, Min. Wgt. outer	59#	57#	78#
Spring load, vlv. closed inner	23-32#		41-49#
*Wear limits, Min. Wgt. inner	21#		37#
Spring length, vlv. open outer	1.110	1.617	2-3/16
Spring length, vlv. open inner	1.016		2-1/32
Spring load, vlv. open outer	125-135#	153-167#	192-208#
*Wear limits, Min. Wgt. outer	113#	138#	173#
Spring load, vlv. open inner	57-65#		95-105#
*Wear limits, Min. Wgt. inner	52#		86#

*(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	T D 427 T D 6427	RD 572 RD 6572	SD 802 SD 6802
CAMSHAFT			
Brg. Journal, Dia. #1	2.243/2.242	2.1225/2.122	2.2480/2.2475
*Wear limits, Min. dia.	2.241	2.121	2.2465
Brg. Journal, Dia. #2	2.243/2.242	2.1225/2.122	2.2480/2.2475
*Wear limits, Min. dia.	2.241	2.121	2.2465
Brg. Journal, Dia. #3	2.243/2.242	2.1225/2.122	2.2480/2.2475
*Wear limits, Min. dia.	2.241	2.121	2.2465
Brg. Journal Dia. #4	2.243/2.242	2.1225/2.122	2.2480/2.2475
*Wear Limits	2.241	2.121	2.2465
Cam lift	.3116	.390	.391
Camshaft Bushings dia.	2.245/2.2445	2.1245/2.124	2.2500/2.2495
*Wear limits	2.246	2.1255	2.2510
Clearance limits	.003/.0015	.0025/.0015	.0025/.0015
*Wear limits	.0045	.004	.004
Tappet Hole dia.	1.126/1.125	.6101/.6089	.6101/.6089
*Wear limits	1.1275	.6111	.6111
Tappet dia.	1.124/1.1235	.6087/.6082	.6087/.6082
*Wear limits	1.1225	.6072	.6072
Clearance limits	.0025/.001	.0019/.0002	.0019/.0002
*Wear limits	.004	.0029	.0029
End Play	.009/.005	.009/.005	.009/.005
CONNECTING RODS			
Length, Cent. to ctr.	8⅜	10.502/10.498	10.502/10.498
Bushing hole dia.	1.500/1.499	1.750/1.749	1.8755/1.8745
Brg. hole dia.	2.687/2.6865	3.202/3.2012	3.6935/3.6925
Brg. thickness	.09325/.09300	.100/.0997	.0955/.0950
*Wear Limits—Min. th.	.0925	.0992	.0945
Dia. crank pin	2.499/2.498	3.000/2.999	3.500/3.499
*Wear limits—Min. dia.	2.497	2.998	3.498
Clearance lim.	.003/.001	.0028/.0012	.0045/.0015
Desired clearance	.002	.002	.003
*Wear limits—max. cl.	.004	.0038	.0055
Width at brg. end	1.6795/1.6775	1.929/1.927	2.428/2.426
Side play	.010/.006	.0105/.0065	.012/.008
Desired side play	.006 Min.	.0065 Min.	.008 Min.
MAIN BEARINGS			
Dia. of brg. bore in block	3.0622/3.0615	3.5000/3.4992	4.000/3.999
Br. Shell Thickness	.09300/.09275	.1235/.1232	.1237/.1232
*Wear limits — Min. th.	.09225	.1227	.1227
Dia. of Mn. Brn. Jnl.	2.874/2.873	3.250/3.249	3.750/3.749
*Wear limits—Min. Dia.	2.872	3.248	3.748
Clearance limits	.0037/.0015	.0046/.0022	.0046/.0016
Desired clearance	.0025	.0035	.003
*Wear limits—Max. cl.	.0047	.0056	.0056
C/S End Play	.008/.005	.008/005	.008/.005
*Wear limits—Max. end play	.010	.012	.010
PISTONS			
Actual inside dia. of sleeves (cyl. on T1)	4.3145/4.3125	4.752/4.750	5.5645/5.5625
*Wear limits—max. dia.	4.3225	4.760	5.5725
Piston pin hole diameter	1.4378/1.4376	1.5000/1.4998	1.7500/1.7498
*Wear limits—Max. dia.	1.438	1.5002	1.7502
Ring Gr. Dia.,			
1st, 2nd and 3rd	3.908/3.898	4.227/4.217	4.953/4.943
4th	3.868/3.858	4.283/4.273	5.021/5.011
5th	3.868/3.858	4.283/4.273	5.021/5.011

*(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	T D 427 T D 6427	RD 572 RD 6572	SD 802 SD 6802
PISTONS			
Ring Gr. Width			
1st	.128/.127	5/32 Max.	5/32 Max.
*Wear limits—Max. w.	.130		
2nd and 3rd	.1265/.1255	5/32 Max.	5/32 Max.
*Wear limits—Max. w.	.1285		
4th	.2515/.2505	.2515/.2505	.2515/.2505
*Wear limits—Max. w.	.2535	.2535	.2535
5th	.189/.188	.189/.188	.189/.188
*Wear limits—Max. w.	.191	.191	.191
Ring land dia.			
1st	4.282/4.278	4.714/4.710	5.523/5.519
2nd	4.286/4.282	4.719/4.715	5.529/5.525
3rd	4.290/4.286	4.724/4.720	5.534/5.530
4th	4.290/4.286	4.724/4.720	5.534/5.530
Feeler gauge	.006	.007	.008 (Two .004 feelers)
Lbs. pull	5-10 lb. pull	5-10 lb. pull	5-10 lb. pull
RINGS			
Type of rings			
1st	Chr. Comp.	T.F. Chr. Comp. (Keystone)	Chr. T.F. Comp. (Keystone)
2nd and 3rd	T.F. Comp.	T.F. Comp. (Keystone)	T.F. Comp. (Keystone)
4th	Ventilated Oil Control	Ventilated Oil Control	Ventilated Oil Control
5th	Ventilated Oil Control	Ventilated Oil Control	Ventilated Oil Control
Ring width			
1st	.124/.123	5/32	.149/.1485
*Wear limits — min. w.	.121		
2nd and 3rd	.124/.123	5/32	.1505/.150
*Wear limits — min. w.	.121		
4th	.249/.2485	.249/.2485	.249/.2485
*Wear limits	.2465	.2465	.2465
5th	.1865/.186	.1865/.186	.1865/.186
*Wear limits — min. w.	.184	.184	.184
Ring thickness			
1st	.179/.169	.237/.227	.278/.268
2nd and 3rd	.170/.160	.237/.227	.278/.268
4th	.179/.169	.189 Max.	.210 Max.
5th	.179/.169	.189/.179	.210 Max.
Ring gap clearance			
1st	.020/.012	.023/.013	.032/.018
2nd and 3rd	.018/.013	.023/.013	.032/.018
4th	.020/.010	.025/.013	.032/.018
5th	.020/.012	.020/.010	.032/.018
Ring side clearance			
1st	.005/.003	Not Measurable	Not Measurable
*Wear limits — max. cl.	.0075		
2nd and 3rd	.0035/.0015	Not Measurable	Not Measurable
*Wear limits — max. cl.	.006		
4th	.0030/.0015	.0030/.0015	.0030/.0015
*Wear limits — max. cl.	.0055	.0055	.0055
5th	.0030/.0015	.0030/.0015	.0030/.0015
*Wear limits — max. cl.	.0055	.0055	.0055
PISTON PINS			
Length	3.630/3.625	2.988/2.973	4.539/4.524
Diameter	1.4375/1.4373	1.5000/1.4998	1.7500/1.7498
*Wear limits — min. dia.	1.437	1.4995	1.7495
Desired fit	Light push	Light Push	Light push
Bushing hole dia. fit.	1.4379/1.4377	1.5005/1.5003	1.7505/1.7503
*Wear limits — max. dia.	1.4389	1.5015	1.7515
Pin clearance in bushing	.0006/.0002	.0007/.0003	.0007/.0003
*Wear limits — max. cl.	.0016	.0017	.0017
Desired pin fit	.0004	.0005	.0005

*(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:

	TD427-TD6427		RD572-RD-6572		SD802-SD6802	
	Dia.	Ft. Lbs.	Dia.	Ft. Lbs.	Dia.	Ft. Lbs.
Cylinder Heads	9/16	130-140	5/8	145-155	5/8	145-155
Main Bearing Caps	½ 9/16	85-95 100-110	½ 9/16	85-95 100-110	½ 9/16	85-95 100-110
Conn. Rod Caps	½	85-95	½	85-95	7/16	85-95
Flywheels	½	85-95	½	85-95	5/8	85-95
Manifolds	7/16	50-55	7/16	50-55	7/16	50-55
Flywheel Housings	½	80-90	½	80-90	½	80-90
Gear Covers	3/8 7/16	25-30 50-55	½	80-90	½	80-90
Water Pumps	3/8	25-30	7/16	50-55	½	80-90
Front End Plates	7/16	50-55	3/8	25-30	3/8 ½	25-30 80-90
Oil Pans	3/8	25-30	3/8	25-30	3/8	25-30
Camshaft (Steel)	1	120-130	1¼	120-130	1¼	120-130

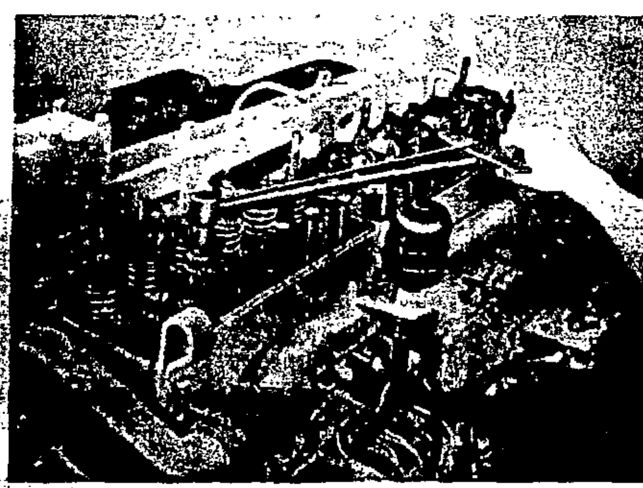


Figure 235
Torquing Cylinder Head Nuts

SECTION XI — SPECIAL TOOLS

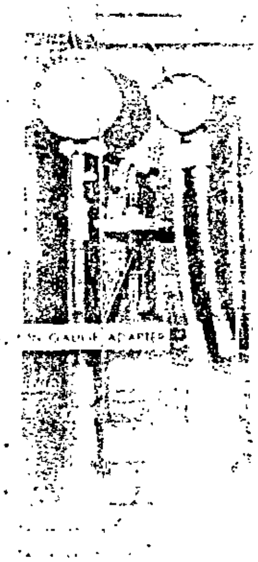


Figure 236
Recommended Tools for Servicing Fuel Injection Equipment
Kit #RD6T-125

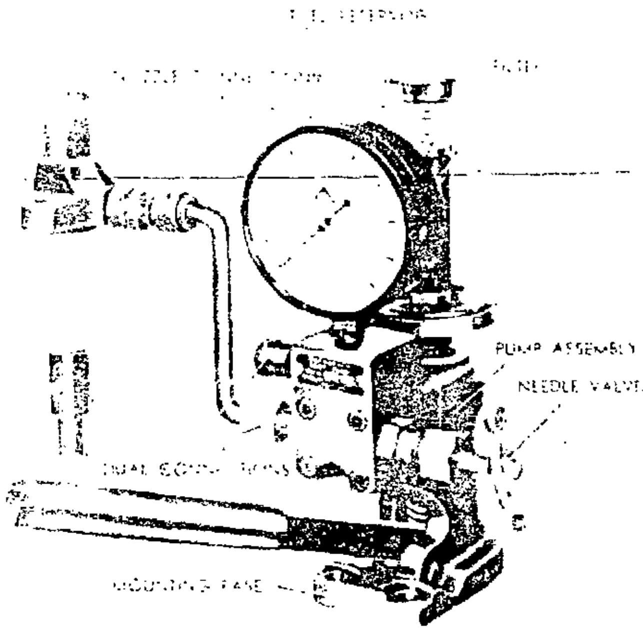


Figure 237
Nozzle Tester Kit #HD260T-177

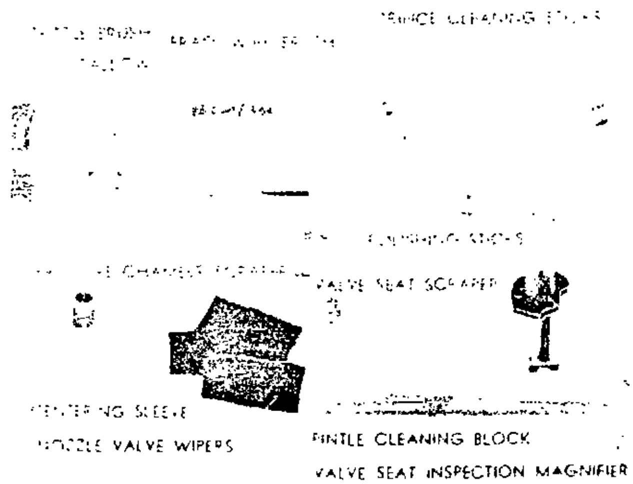


Figure 239
Nozzle Cleaning Kit #HD260T-178

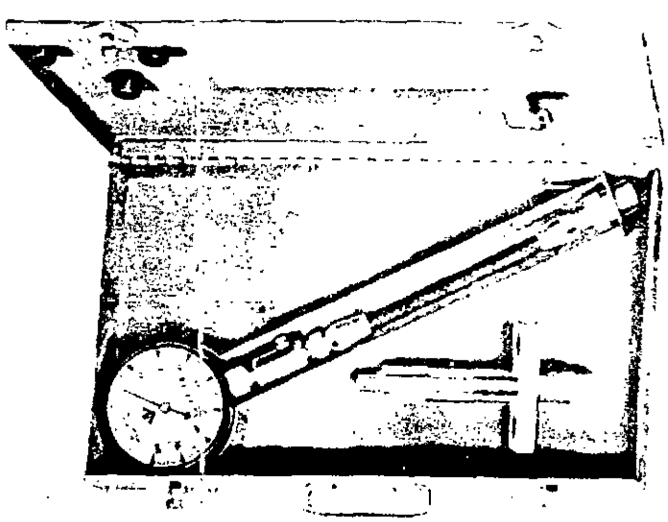


Figure 238
Compression Tester Kit #HD260T-176

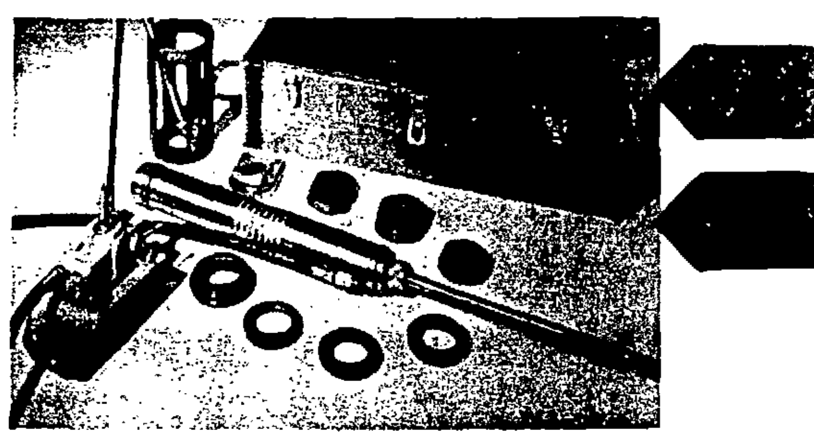


Figure 240
Sleeve Puller Kit #RD6T-130