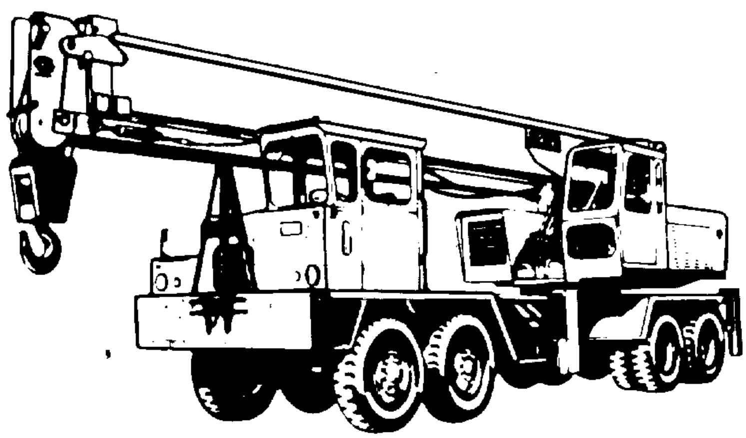
TECHNICAL MANUAL

ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS LIST AND SPECIAL TOOLS LIST)

FOR

CRANE, TRUCK MOUNTED HYDRAULIC 25 TON (CCE) GROVE MODEL TM S-300-5 (NSN 3810-01-054-9779)



VOLUME 3
(ENGINE)

HEADQUARTERS, DEPARTMENT OF THE ARMY

8 MAY 84

WARNING

EXHAUST SYSTEM COMPONENTS CAN CAUSE SEVERE BURNS

During normal operation the *vehicle exhaust pipe and muffler can become very hot. Be careful not to touch these components with your bare hands. Do not allow your body to come in contact with the pipe or muffler. Exhaust system components may be hot enough to cause serious burns.

WARNING

AVOID ACCIDENTAL ENGINE STARTS

Accidental Engine Startup may cause severe injuries to service personnel engaged in maintenance operations of or near moving parts (pulleys, belts, fan blades, etc.). Prevent accidental engine starts by removing battery cables from battery posts. Make sure mechanism at governor stops engine in top position (no-fuel position) to prevent accidental engine firing.

WARNING

COMPRESSED AIR FOR CLEANING

Compressed air used for cleaning purposed shall not exceed 30 psi. Use only with effective chip guarding and personal protective equipment (goggles/shield, gloves, etc).

WARNING

ELECTROCUTION HAZARD

NEVER OPERATE this crane within any distance of a power source or power line without first notifying the power or utility company.

NEVER OPERATE crane any part thereof or load within 20 feet of any electrical power line or power source or such distance as is specified or required by local or other applicable safety codes or regulations.

NEVER OPERATE crane without consulting local or other applicable safety codes or regulations.

NEVER OPERATE, service or maintain this crane without proper instructions. Remember it is the employer's responsibility to implement the above and to provide all safety devices or means that may be necessary or required for any use operation, set-up or service.

CHANGE
NO.1

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC,

ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE
MANUAL (INCLUDING REPAIR PARTS LIST AND SPECIAL
TOOLS LIST)
FOR

CRANE, TRUCK MOUNTED, HYDRAULIC
25 TON (CCE)
GROVE MODEL TM $-300-5
NSN 3810-01-054-9779

TMS-3810300-24&P3, 8 May 1984, is changed as follows:

1. Chapter III, pages 1 through 258 and chapter IV pages 259 through 273 of this manual have been replaced by TM5381030020P, ORGANIZATIONAL MAINTENANCE REPAIR PARTS AND SPECIAL TOOLS LISTS, and TM5381030034P, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE REPAIR PARTS AND SPECIAL TOOLS LISTS.

File this change sheet in front of the publication for reference purposes.

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

R.L. PILWORTH
Brigadier General, United States Army
The Adjutant General

Distribution:
To be distributed in accordance with DA Form 1225AR, Organizational, Direct Support and General Support Maintenance requirements for Cranes, Truck Mounted, Hydraulic, 25T, Model TMS-300-5.

WARNING

CARBON MONOXIDE CAN KILL YOU!

DO NOT OPERATE vehicles in an enclosed area unless carbon monoxide (exhaust) is channeled out of work area (duct).

DO NOT OPERATE an engine, in or out of the vehicle, in an enclosed area unless there is a way for the carbon monoxide to escape (duct; draft or fan propelled fresh air supply).

DO NOT PERMIT an operating vehicle outside your work area to expel carbon monoxide into the area where you work.

WARNING

SERIOUS BODILY INJURY OR DEATH COULD OCCUR IF THE FOLLOWING BASIC SAFETY PROCEDURES ARE NOT OBSERVED

Only machines with published "ON RUBBER" capacities are permitted to travel with a load.

Before elevating boom, make certain that area above and beneath boom is clear of all obstructions and personnel.

Before lowering boom, make certain that area above and beneath boom is clear of all obstructions and personnel.

Before lowering or raising cable (load) assure that area beneath load is clear of all obstructions and personnel.

Outriggers must be extended and set anytime the boom is removed from the cradle, either lifting or positioning. Outriggers may be retracted from "ON RUBBER" operation with the boom centered over the rear as indicated by the "ON RUBBER" load chart. (Outriggers must be extended and set to place the boom in the "ON RUBBER" position.)

NOTE

PASSENGERS

Passengers are not authorized to ride in the crane cab to and from work sites. The crane operator may be permitted to ride in the cab for short distances where very light loads are being relocated, provided these loads are within the limits of operation without outriggers. These limits are specified on the load and boom angle charts located inside the crane cab.

MAKE SAFETY FIRST --- NOT LAST
READ YOUR OPERATOR'S HANDBOOK !

When Working On The Engine ..

1. Consider the hazards of the job and wear protective gear such as safety glasses, safety shoes, hard hat, etc. to provide adequate protection.

2. When lifting an engine, make sure the lifting device is fastened securely. Be sure the item to be lifted does not exceed the capacity of the lifting device.

3. Always use caution when using power tools.

4. When using compressed air to clean a component, such as flushing a radiator or cleaning an air cleaner element, use a safe amount of air. Recommendations regarding the use of air are indicated throughout the manual. Too much air can rupture or in some other way damage a component and create a hazardous situation that can lead to personal injury.

5. Avoid the use of carbon tetrachloride as a cleaning agent because of the harmful vapors that it releases. Use perchlorenthylene or trichlorethylene. However, while less toxic than other chlorinated solvents, use these cleaning agents with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield, and apron. Exercise caution against burns when using oxalic acid to clean the cooling passages of the engine.

6. Avoid excessive injection of ether into the engine during start attempts. Follow the instructions on the container or by the manufacturer of the starting aid.

7. When working on an engine that is running, accidental contact with the hot exhaust manifold can cause severe burns. Remain alert to the location of the rotating fan, pulleys and belts. Avoid making contact across the two terminals of a battery which can result in severe arcing.

8. Use extreme caution in releasing the radiator cap when engine has been running or is overheated.

9. When servicing the battery, do not smoke or allow an open flame near batteries. Batteries generate hydrogen which is a highly explosive gas.

<u>Key to WARNING and CAUTION Notes:</u>

WARNING precedes operating procedures or practices which, if not correctly followed could result in personal injury or death.

CAUTION precedes operating procedure or practice which if not strictly followed could cause damage to or destruction of equipment.

Information in this manual does not replace federal. state. or local regulations. safety codes. or insurance requirements.

Technical Manual
No. 5-3810-300-24 & P3

HEAQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 8 May 1984

ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL (INCLUDING REPAIR PARTS LIST AND SPECIAL TOOLS LIST) FOR

CRANE, TRUCK MOUNTED, HYDRAULIC 25 TON (CCE) GROVE MODEL TM S-300-5 (NSN 3810-01-054-9779)

Procured under Contract No. DSA 700-77-C-8511

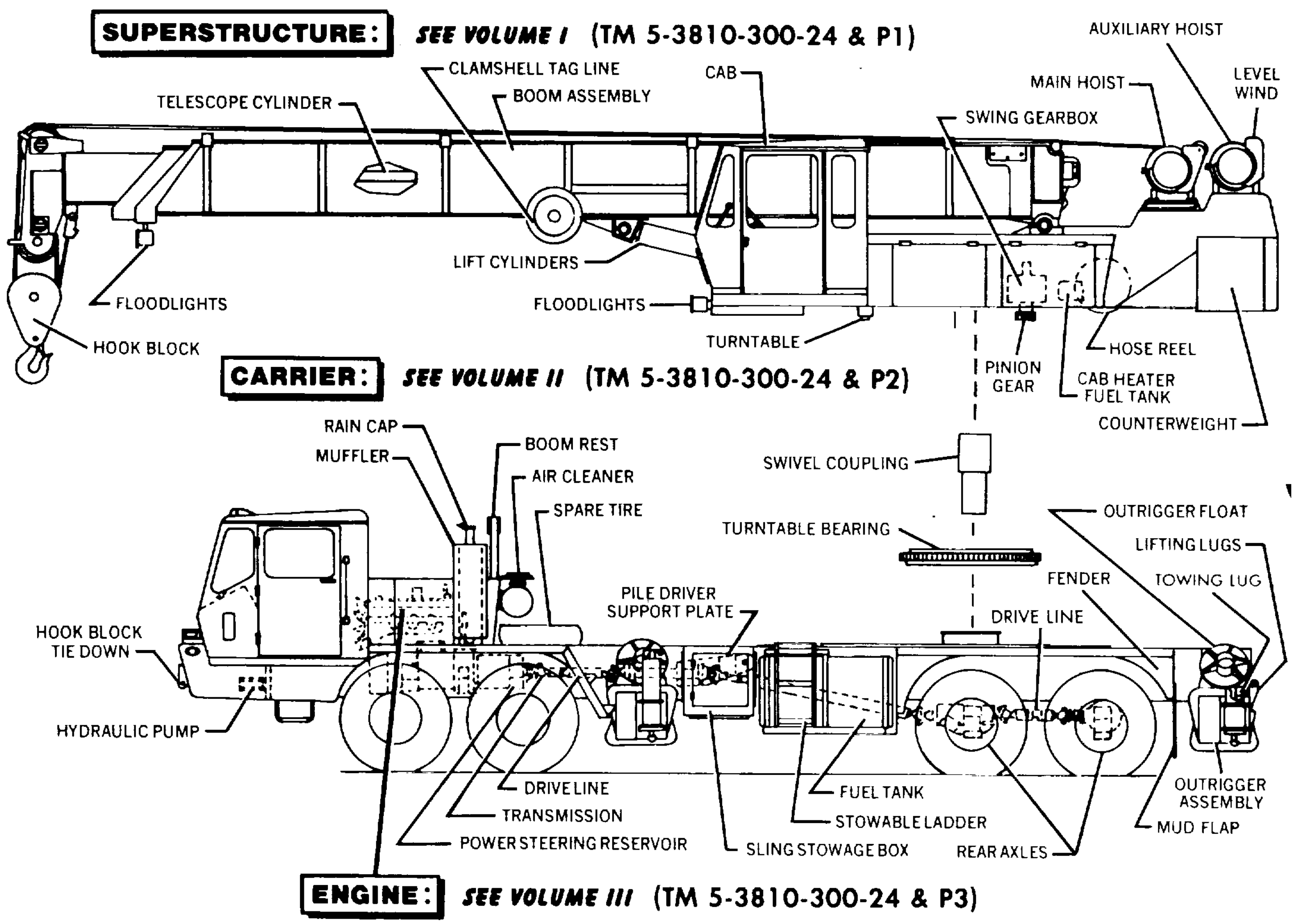
REPORTING OF ERRORS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 20282 located in the back of this manual direct to: Commander, US Army Tank Automotive Command, ATTN: DRSTA-MB, Warren, MI 48090. A reply will be furnished direct to you.

VOLUME III (ENGINE)

This technical manual is an authentication of the manufacturers commercial literature and does not conform with the format and content specified in AR 3103, Military Publications. This technical manual does, however, contain available information that is essential to the operation and maintenance of the equipment.

Illustration I TMS300-5 Component Location.



IMPORTANT MAINTENANCE INFORMATION

The quarterly Equipment Improvement Report and Maintenance Digest TB 43-0001-41 series contains valuable field information on the equipment covered in this manual. The information in TB 43-0001-41 series is compiled from some of the Equipment Improvement Reports (SF 368) that you prepared on the vehicle covered in this manual. Many of these articles result from comments, suggestions, and improvement recommendations that you submitted to the EIR program. The TB 430001-41 series contains information on equipment improvements, minor alternations, proposed Modification Work Orders (MWO's), actions taken on some of your DA Form 2028's, and advance information on proposed changes that may affect this manual.

TABLE OF CONTENTS

Pages 1 thru 4 are intentionally omitted

PRINCIPLES OF OPERATION

The diesel engine is an internal combustion power unit, in which the heat of fuel is converted into work in the cylinder of the engine.

In the diesel engine, air alone is compressed in the cylinder; then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

The Two Cycle Principle

In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes respectively as shown in Fig. 1. In contrast, a four-cycle engine requires four piston strokes to complete an operating cycle; thus, during one half of its operation, the four-cycle engine functions merely as an air pump.

A blower is provided to force air into the cylinders for expelling the exhaust gases and to supply the cylinders with fresh air for combustion. The cylinder wall contains a row of ports which are above the piston when it is at the bottom of its stroke. These ports admit the air from the blower into the cylinder as soon as the rim of the piston uncovers the ports as shown in Fig. I (scavenging).

The unidirectional flow of air toward the exhaust valves produces a scavenging effect, leaving the cylinders full of clean air when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is subjected to compression as shown in Fig. 1 (compression).

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion chamber by the unit fuel injector as shown in Fig. I (power). The intense heat generated during the high compression of the air ignites the fine fuel spray immediately. The combustion continues until the fuel injected has been burned.

The resulting pressure forces the piston downward on its power stroke. The exhaust valves are again opened when the piston is about half way down, allowing the burned gases to escape into the exhaust manifold as shown in Fig. I (exhaust). Shortly thereafter, the downward moving piston uncovers the inlet ports and the cylinder is again swept with clean scavenging air. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft, or, in other words, in two strokes; hence, it is a "two-stroke cycle".

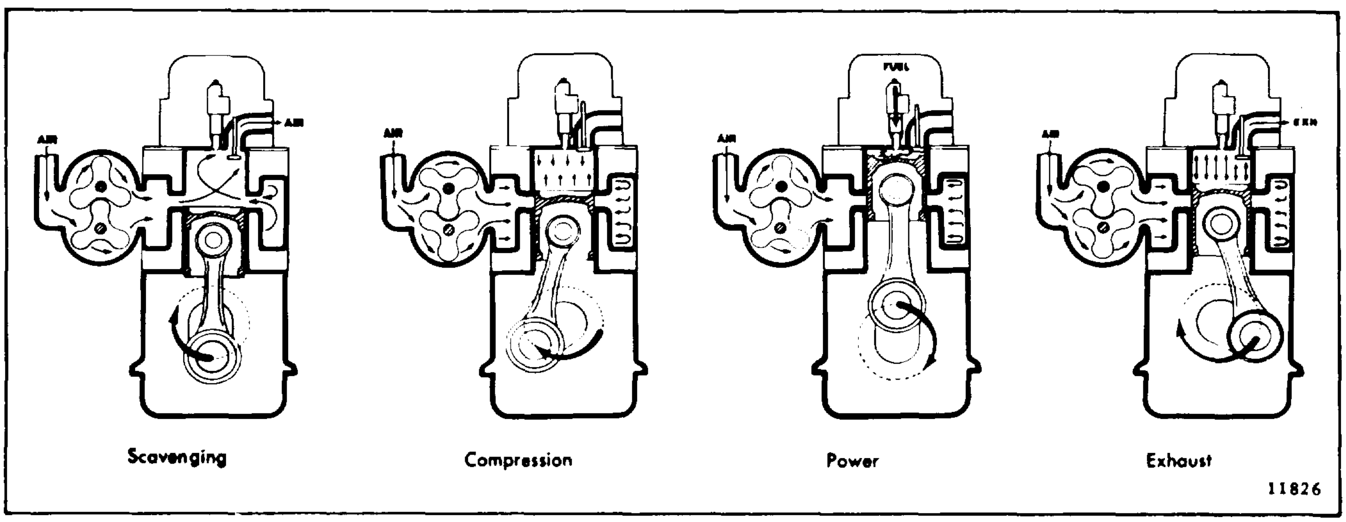


Fig. 1 - The Two-Stroke Cycle

GENERAL DESCRIPTION

The two-cycle diesel engines covered in this manual are produced in 3, 4 and 6 cylinder models having the same bore and stroke and many of the major working parts such as injectors, pistons, connecting rods, cylinder liners and other parts that are interchangeable.

The blower, water pump, governor and fuel pump form a group of standard accessories which can be located on either side of the engine. Further flexibility in meeting installation requirements can be had by placing the exhaust manifold and the water outlet manifold on either side of the engine (Fig. 2). This flexibility in the arrangement of parts is obtained by having both the cylinder block and the cylinder head symmetrical at both ends and with respect to each other.

Each engine is equipped with an oil cooler, full-flow lubricating oil filter, fuel oil strainer, fuel oil filter, air cleaner, governor, fan and radiator, and starting motor.

Full pressure lubrication is supplied to all main, connecting rod and camshaft bearings, and to other moving parts within the engine. A gear-type pump draws oil from the oil pan through an intake screen, through the oil filter and then to the oil cooler. From the oil cooler, the oil enters a longitudinal oil gallery in the cylinder block where the supply divides; a portion entering the by-pass filter, if used, and then draining back into the oil pan, part going to the cam and balance shaft end bearings and cylinder head, with the remainder going to the main bearings and connecting rod bearings via the drilled crankshaft.

Coolant is circulated through the engine by a centrifugal-type water pump. Heat is removed from the coolant, which circulates in a closed system, by the radiator. Control of the engine temperature is accomplished by a thermostat which regulates the flow of the coolant within the cooling system.

Fuel is drawn from the supply tank through the fuel strainer by a gear-type fuel pump. It is then forced through a filter and into the fuel inlet manifold in the cylinder head and to the injectors. Excess fuel is returned to the supply tank through the fuel outlet manifold and connecting lines. Since the fuel is constantly circulating through the injectors, it serves to cool the injectors and also carries off any air in the fuel system.

Air for scavenging and combustion is supplied by a blower which pumps air into the engine cylinders via the air box and cylinder liner ports. All air entering the blower first passes through an air cleaner.

Engine starting is provided by an electric starting motor energized by a storage battery. A battery charging generator, with a suitable voltage regulator, serves to keep the battery charged.

Engine speed is controlled by a mechanical governor.

GENERAL SPECIFICATIONS

	6-71
Type	2 Cycle
Type	2 Cycle
Number of Cylinders	6
Bore (inches)	4.25
Bore (mm)	108
Stroke (inches)	5
Stroke (mm)	127
Compression Ratio (Nominal) (Standard Engines)	17 to 1
Compression Ratio (Nominal) ("N" Engines)	18.7 to 1
Total Displacement - cubic inches	426
Total Displacement - litres	6.99
Firing Order - R.H. Rotation	1-5-3-6-2-4
Number of Main Bearings	7

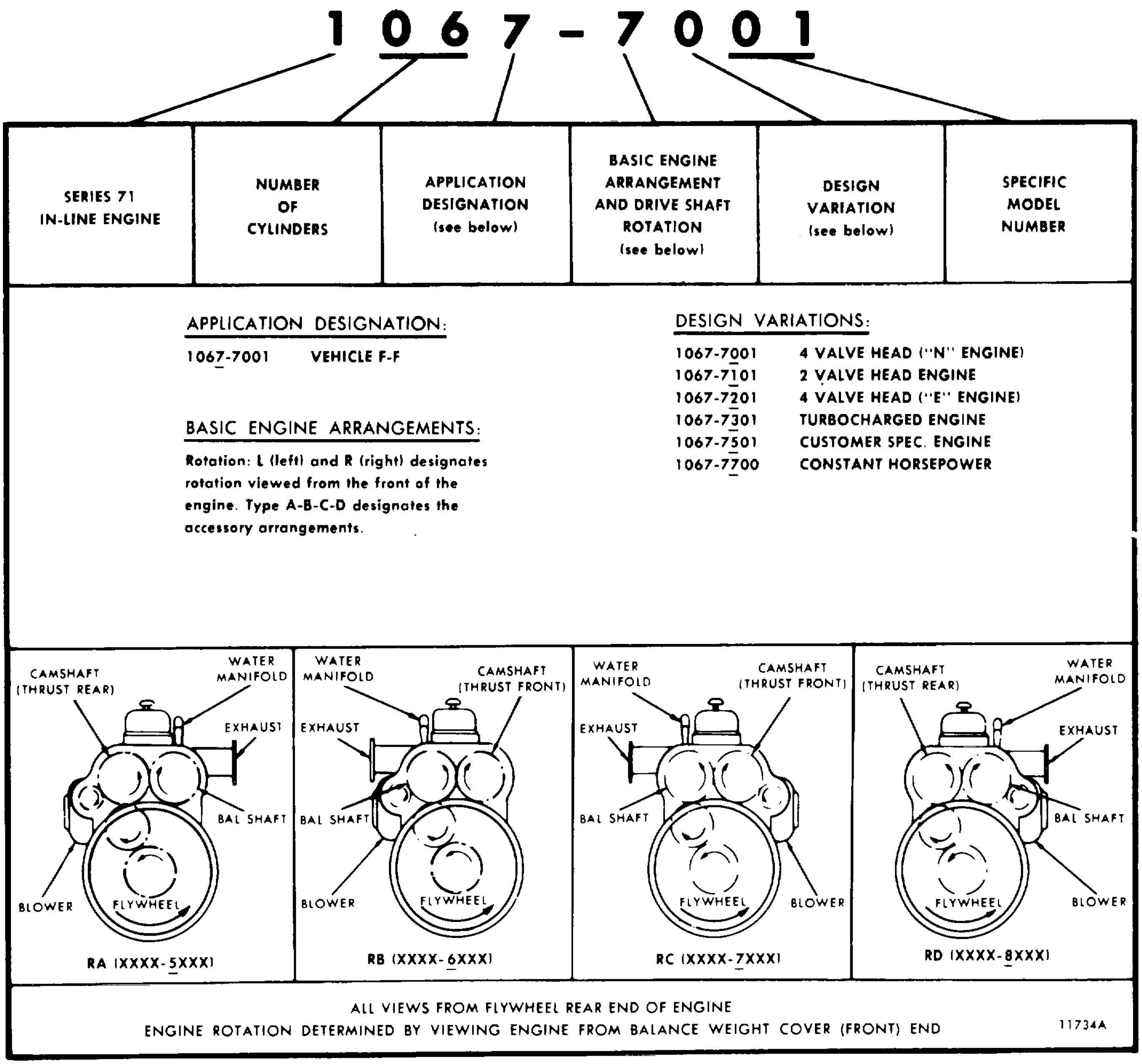


Fig. 2 - Model Numbering (Current Engines), Rotation and Accessory Arrangements

ENGINE MODEL, SERIAL NUMBER AND OPTION PLATE

Engine Model and Serial Numbers

On all current Series 71 engines, the engine serial number and the engine model number are stamped on the cylinder block (Figs. 3 and 4). The engine serial number and model number are also stamped on the Option Plate (when used) attached to the valve rocker cover.

Engine Serial Number

The engine serial number is prefixed by numerals indicating the number of cylinders and the letter "A" which designates a Series 71 engine.

Engine Model Number

Current Series 71 engines are identified by an eight digit model number (Fig. 2). The engine model number 10677001 illustrated is interpreted as follows: Series 71 Inline engine (1), six-cylinder (06), vehicle engine (7), right-hand rotation with "C" accessory arrangement (7), four-valve head "N" engine (0) and specific model variation No. I (01).

Option Plate

An option plate, attached to the valve rocker cover, carries the engine serial number and model number and, in addition, lists any optional equipment used on the engine (Fig. 5). An exhaust emission certification label, separate from the option plate, is mounted

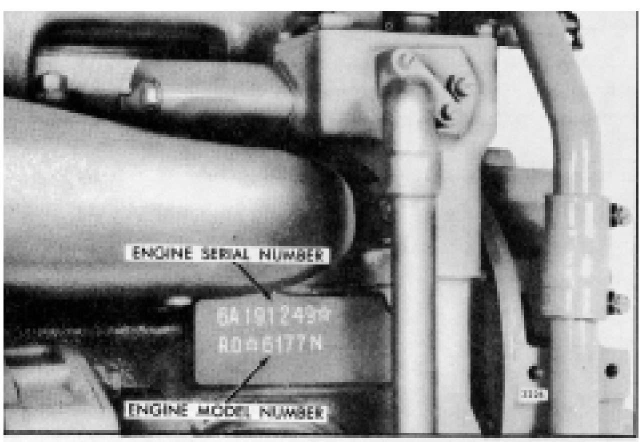


Fig. 3 Typical Engine Serial Number and Model Number as Stamped on Cylinder Block (Former Engines)

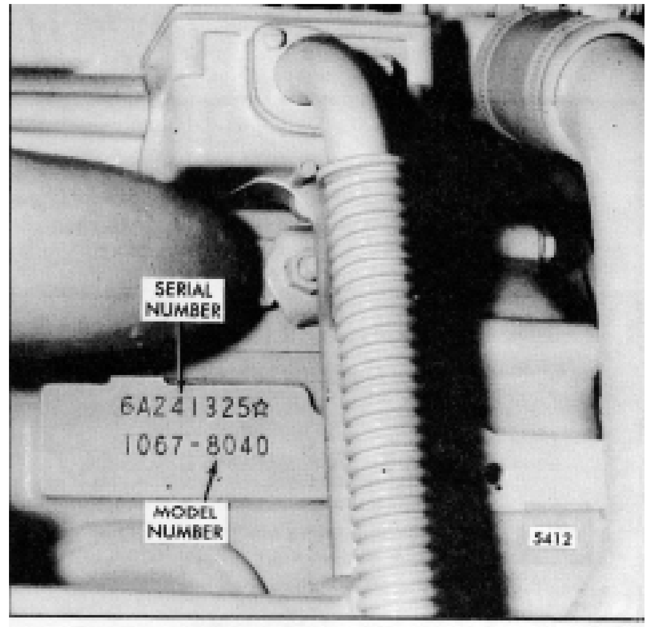


Fig. 4 Typical Engine Serial Number and Model Number As Stamped on Cylinder Block (Current Engines)

permanently in the option plate retainer. The current label includes information relating to an engine family for the maximum fuel injector size and maximum speed. Refer to Section 14 for further information regarding emission regulations.

With any order for parts, the engine model number and serial number must be given. In addition, if a type number is shown on the option plate covering the equipment required, this number should also be included on the parts order.

All groups of parts used on an engine are standard for the engine model unless otherwise listed on the option plate.

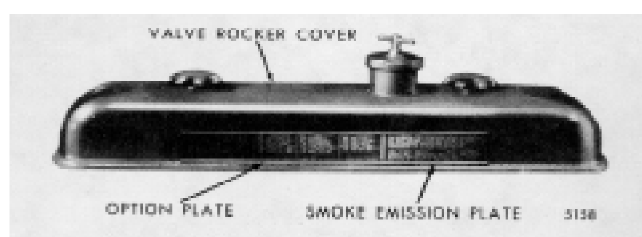


Fig. 5 - Option Plate

GENERAL PROCEDURES

In many cases, a serviceman is justified in replacing parts with new material rather than attempting repair. However, there are times where a slight amount of reworking or reconditioning may save considerable added expense. Crankshafts, cylinder liners and other parts are in this category. For example, if a cylinder liner is only slightly worn and within usable limits, a honing operation to remove the glaze may make it suitable for reuse, thereby saving the expense of a new part. Exchange assemblies such as injectors, fuel pumps, water pumps and blowers are also desirable service items.

Various factors such as the type of operation of the engine, hours in service and next overhaul period must be considered when determining whether new parts are installed or used parts are reconditioned to provide trouble-free operation.

For convenience and logical order in disassembly and assembly, the various sub-assemblies and other related parts mounted on the cylinder block will be treated as separate items in the various sections of the manual.

DISASSEMBLY

Before any major disassembly, the engine must be drained of lubricating oil, water and fuel. Lubricating oil should also be drained from any transmission attached to the engine.

To perform a major overhaul or other extensive repairs, the complete engine assembly, after removal from the vehicle and transmission, should be mounted on an engine overhaul stand; then the various subassemblies should be removed from the engine. When only a few items need replacement, it is not always necessary to mount the engine on an overhaul stand.

Parts removed from an individual engine should be kept together so they will be available for inspection and assembly. Those items having machined faces, which might be easily damaged by steel or concrete, should be stored on suitable wooden racks or blocks, or a parts dolly.

CLEANING

Before removing any of the sub-assemblies from the engine (but after removal of the electrical equipment), the exterior of the engine should be thoroughly cleaned. Then, after each sub-assembly is removed and disassembled, the individual parts should be cleaned. Thorough cleaning of each part is absolutely necessary before it can be satisfactorily inspected. Various items of equipment needed for general cleaning are listed below.

The cleaning procedure used for all ordinary cast iron parts is outlined under Clean Cylinder Block in Section 1.1; any special cleaning procedures will be mentioned in the text wherever required.

Steam Cleaning

A steam cleaner is a necessary item in a large shop and is most useful for removing heavy accumulations of grease and dirt from the exterior of the engine and its sub-assemblies.

Solvent Tank Cleaning

A tank of sufficient size to accommodate the largest part that will require cleaning (usually the cylinder block) should be provided and provisions made for heating the cleaning solution to 180-200 F (82-90 C).

Fill the tank with a commercial heavy-duty solvent which is heated to the above temperature. Lower large parts directly into the tank with a hoist. Place small parts in a wire mesh basket and lower them into the tank. Immerse the parts long enough to loosen .all of the grease and dirt.

Rinsing Bath

Provide another tank of similar size containing hot water for rinsing the parts.

Drying

Parts may be dried with compressed air. The heat from the hot tanks will quite frequently complete the drying of the parts without the use of compressed air.

Rust Preventive

If parts are not to be used immediately after cleaning, dip them in a suitable rust preventive compound. The rust preventive compound should be removed before installing the parts in an engine.

INSPECTION

The purpose of parts inspection is to determine which parts can be used and which must be replaced. Although the engine overhaul specifications given throughout the text will aid in determining which parts should be replaced, considerable judgment must be exercised by the inspector.

The guiding factors in determining the usability of worn parts, which are otherwise in good condition, is the clearance between the mating parts and the rate of wear on each of the parts. If it is determined that the rate of wear will maintain the clearances within the specified maximum allowable until the next overhaul period, the reinstallation of used parts may be justified. Rate of wear of a part is determined by dividing the amount the part has worn by the hours it has operated.

Many service replacement parts are available in various undersize and/or oversize as well as standard sizes. Also, service kits for reconditioning certain parts and service sets which include all of the parts necessary to complete a particular repair job are available.

A complete discussion of the proper methods of precision measuring and inspection are outside the scope of this manual. However, every shop should be equipped with standard gages, such as dial bore gages, dial indicators, and inside and outside micrometers.

In addition to measuring the used parts after cleaning, the parts should be carefully inspected for cracks, scoring, chipping and other defects.

ASSEMBLY

Following cleaning and inspection, the engine should be assembled using new parts as determined by the inspection.

Use of the proper equipment and tools makes the job progress faster and produces better results. Likewise, a suitable working space with proper lighting must be provided. The time and money invested in providing the proper tools, equipment and space will be repaid many times.

Keep the working space, the equipment, tools and engine assemblies and parts clean at all times. The area where assembly operations take place should, if possible, be located away from the disassembly and cleaning operation. Also, any machining operations J should be removed as far as possible from the assembly area.

Particular attention should be paid to storing of parts and sub-assemblies, after removal and cleaning and prior to assembly, in such a place or manner as to keep them clean. If there is any doubt as to the cleanliness of such parts, they should be recleaned.

When assembling an engine or any part thereof, refer to the table of torque specifications at the end of each section for proper bolt, nut and stud torques.

WORK SAFELY

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune, take these precautions before starting to work on an engine:

Disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.

Make sure the mechanism provided at the governor for stopping the engine is in the stop position. This will mean the governor is in the no fuel position. The possibility of the engine firing by accidentally turning the fan or by being bumped by another vehicle is minimized.

Some Safety Precautions To Observe When Working On The Engine

1. Consider the hazards of the job and wear protective ' gear such as safety glasses, safety shoes, hard hat, etc. to provide adequate protection.

2. When lifting an engine, make sure the lifting device is fastened securely. Be sure the item to be lifted does not exceed the capacity of the lifting device.

3. Always use caution when using power tools.

4. When using compressed air to clean a component, such as flushing a radiator or cleaning an air cleaner element, use a safe amount of air. Recommendations regarding the use of air are indicated throughout the manual. Too much air can rupture or in some other way damage a component and create a hazardous situation that can lead to personal injury.

5. Avoid the use of carbon tetrachloride as a cleaning agent because of the harmful vapors that it releases. Use perchlorethylene or trichlorethylene. However, while less toxic than other chlorinated solvents, use these cleaning agents with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield, and apron.

Exercise caution against burns when using oxalic acid to clean the cooling passages of the engine.

6. Use caution when welding on or near the fuel tank. Possible explosion could result if heat build-up inside the tank is sufficient.

7. Avoid excessive injection of ether into the engine during start attempts. Follow the instructions on the container or by the manufacturer of the starting aid.

8. When working on an engine that is running, accidental contact with the hot exhaust manifold can cause severe burns. Remain alert to the location of the rotating fan, pulleys and belts. Avoid making contact across the two terminals of a battery which can result in severe arcing.

ENGLISH TO METRIC CONVERSIONS

Multiply	by	to get equivalent number of:
	LENGTH	
Inch	25.4	millimetres (mm)
Foot	0.304 8	metres (m)
Yard	0.914 4	metres
Mile	1.609	kilometres (km)
	AREA	
Inch^2	645.2	millimetres^2 (mm^2)
	6.45	centimetres^2 (cm^2)
Foot^2	0.092 9	metres^2 (m^2)
Yard^2	0.836 1	metres^2
	VOLUME	
Inch^3	16 387.	mm^3
	16.387	cm^3
	0.016 4	litres (l)
Quart	0.946 4	litres
Gallon	3.785 4	litres
Yard^3	0.764 6	metres^3 (m^3)
	MASS	
Pound	0.453 6	kilograms (kg)
Ton	907.18	kilograms
Ton	0.907	tonne (t)
	FORCE	
Kilogram	9.807	newtons (N)
Ounce	0.278 0	newtons
Pound	4.448	newtons

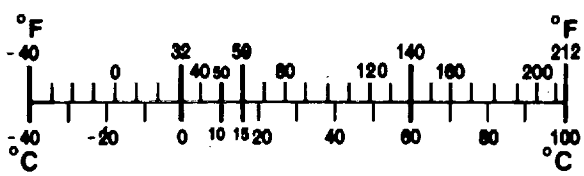
Multiply	by	to get equivalent number of:
	ACCELERATION	
Foot/sec^2	0.304 8	metre/sec^2 (m/s^2)
Inch/sec^2	0.025 4	metre/sec^2
	TORQUE	
Pound-inch	0.112 98	newton-metres (N·m)
Pound-foot	1.355 8	newton-metres
	POWER	
Horsepower	0.746	kilowatts (kW)
	PRESSURE OR STRESS	
Inches of mercury	3.377	kilopascals (kPa)
Inches of water	0.249 1	kilopascals
Pounds/sq. in.	6.895	kilopascals
	ENERGY OR WORK	
BTU	1 055.	joules (J)
Foot-pound	1.355 8	joules
Kilowatt-hour	3.6x10^6 or 3 600 000	joules (J = one W·s)
	LIGHT	
Footcandle	10.76 4	lumens/metre^2 (lm/m^2)
	FUEL PERFORMANCE	
Miles/gal	0.425 1	kilometres/litre (km/l)
Gal/mile	2.352 7	litres/kilometre (l/km)
	VELOCITY	
Miles/hour	1.609 3	kilometres/hr (km/h)

Degree (angle) 0.017 5 radians (rad)
Ounce (mass)-inch 720.077 8 milligram-metre (mg·m) (balancing)

TEMPERATURE

$°F = \frac{9}{5}(°C) + 32$

$°C = \frac{5}{9}(°F - 32)$



USE CONVERSION TABLES LIKE THIS:

13 hp = ? kW Read across the 10 line to the 3 column. Read 9.7 kW

POWER – HORSEPOWER TO KILOWATTS

(1 hp = 0.7456999 kW)

hp	0	1	2	3	4	5	6	7	8	9
	kW	kW	kW	kW	kW	kW	kW	kW	kW	
0		0.75	1.49	2.24	2.98	3.73	4.47	5.22	5.9	
10	7.5	8.2	8.9	9.7	10.4	11.2	11.9	12.7		
20	14.9	15.7	16.4	17.2	17.9	18.6	19.4	[illegible]		
30	22.4	23.1	23.9	24.6	25.4	26.1	[illegible]			
40	[illegible]									

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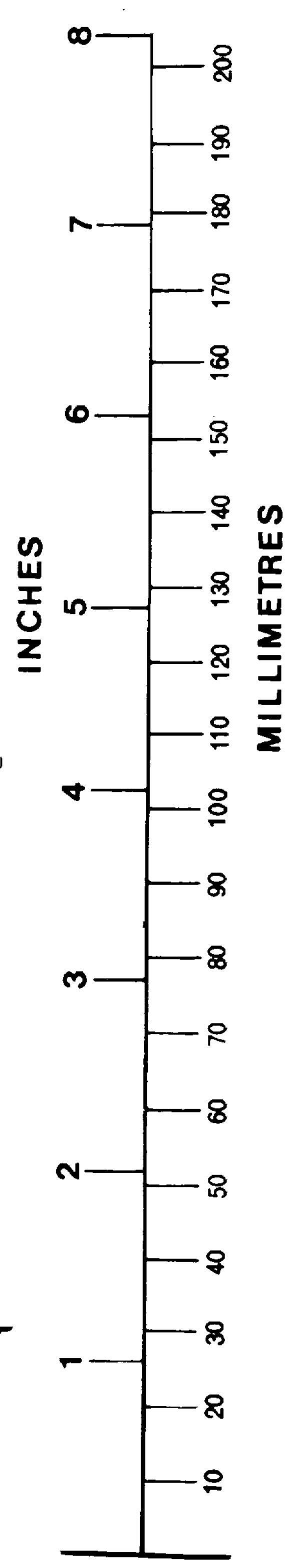
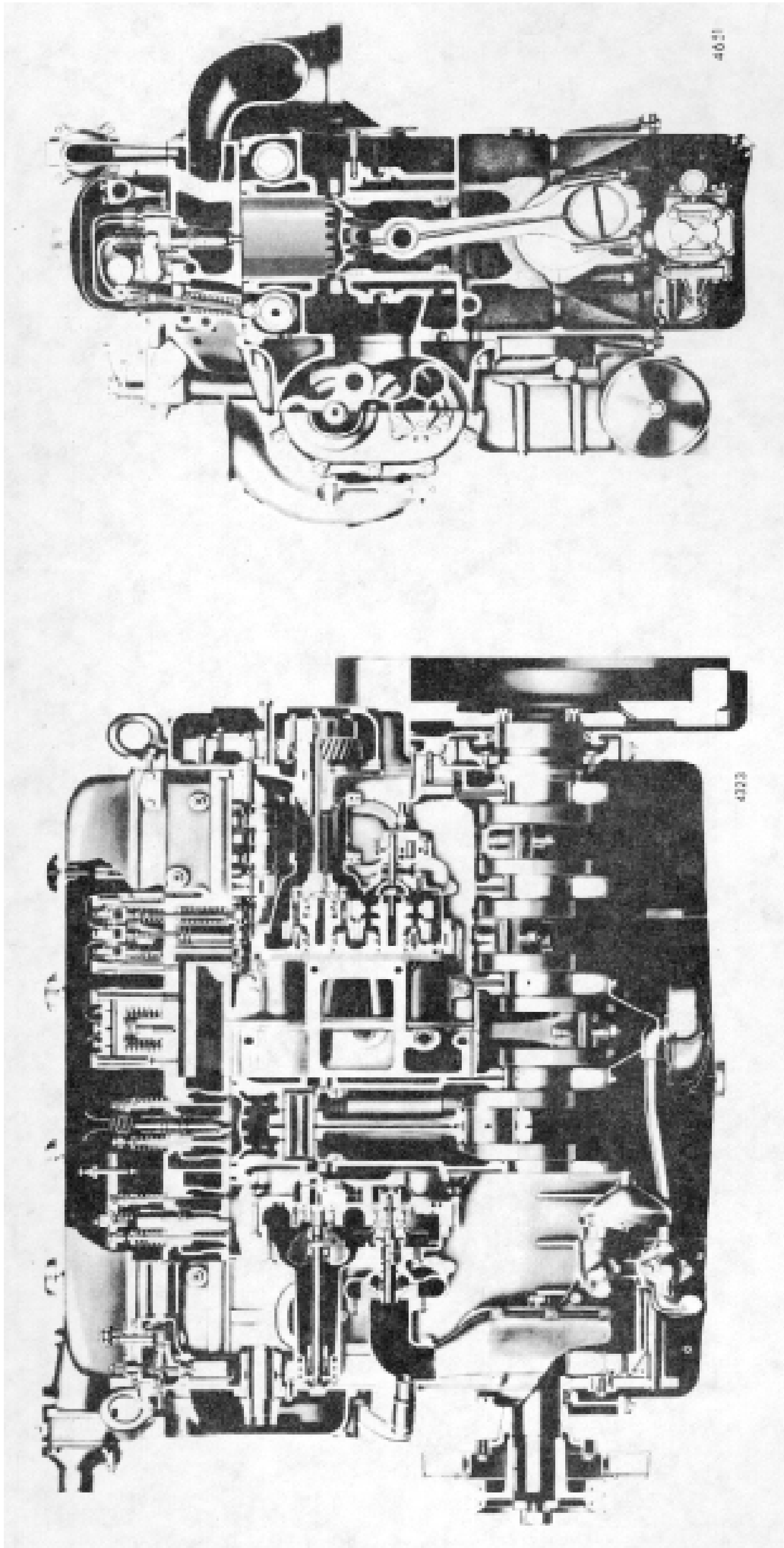
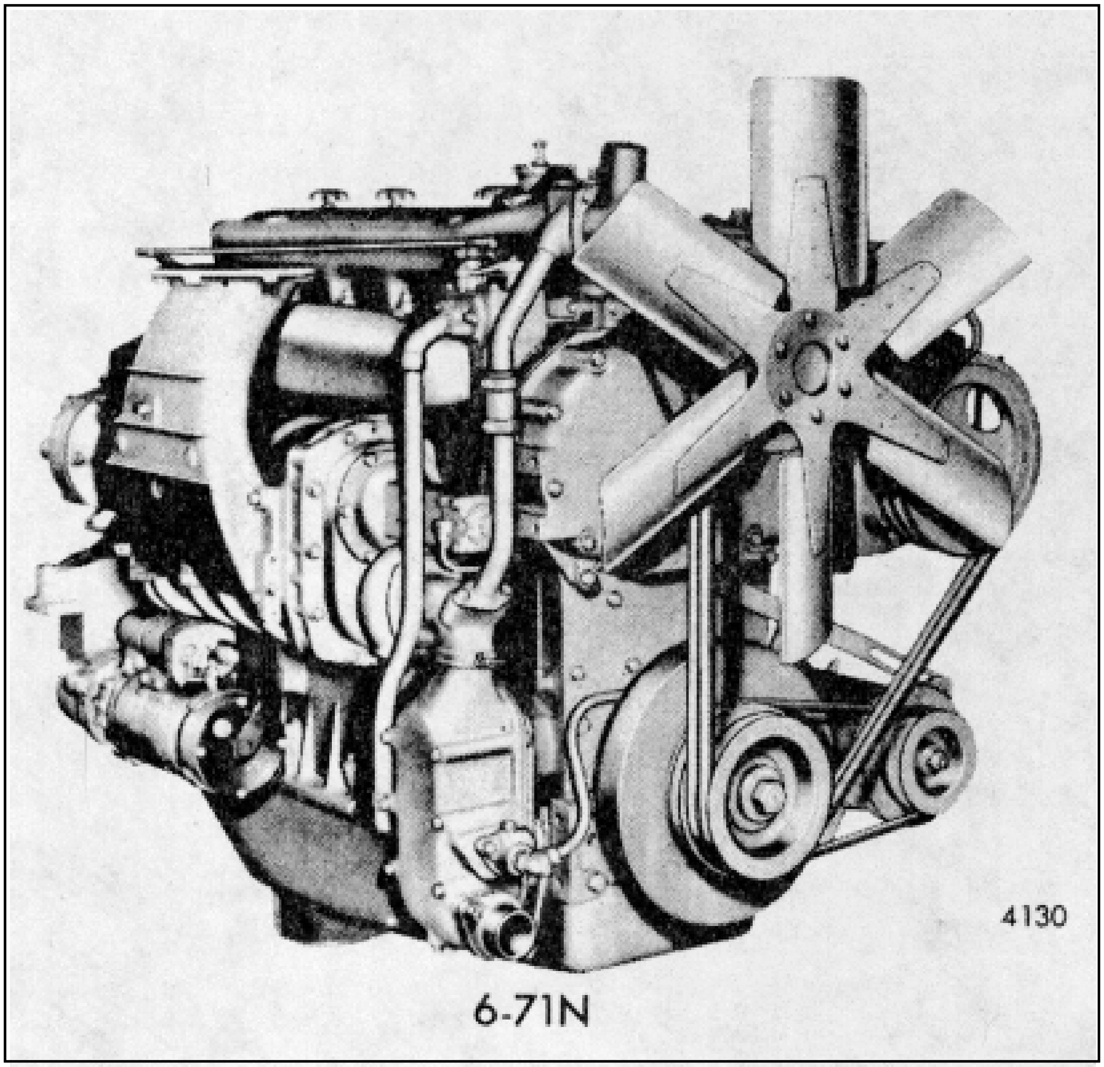




Cross-Sections of Typical Series 71 Engine



Typical Engine Model

CHAPTER II

SECTION 1.

ENGINE (less major assemblies)

CONTENTS

CYLINDER BLOCK

The cylinder block (Figs. 1 and 2) serves as the main structural part of the engine. Transverse members, cast integrally, provide rigidity and strength and ensure alignment of the block bores and bearings under load. The two ends of the block are similar, so the flywheel housing and gear train can be assembled to either end.

The block is bored to receive replaceable cylinder liners. Water jackets, which extend the full length of the bores, are divided into upper and lower sections which are connected by hollow struts (Fig. 2). Coolant from the pump enters at the bottom of each water jacket and leaves at the top of the block through holes which register with corresponding openings in the cylinder head.

An air box (Fig. 2) surrounding the water jackets conducts the air from the blower to the air inlet ports in the cylinder liners. Air box openings (Fig. 3) on the side of the block opposite to the blower provide access to the air box and permit inspection of the pistons and compression rings through the air inlet ports in the cylinder walls. The six-cylinder block has two additional air box openings on the blower side.

The camshaft and balance shaft bores are located on opposite sides near the top of the block.

The upper halves of the main bearing supports are cast integral with the block. The main bearing bores are line-bored with the bearing caps in place to ensure longitudinal alignment. Drilled passages in the block carry the lubricating oil to all moving parts of the engine, eliminating the need for external piping.

The perimeter of the top surface of the cylinder block is grooved, outside of the cam pockets, to accommodate a block-to-head oil seal ring. The top surface of the block is also counterbored at each water or oil passage to accommodate individual seal rings (Fig. 4).

Each cylinder liner is retained in the block by a flange at its upper end. The liner flange rests on a cast iron insert located in the counterbore in the block bore. An individual compression gasket is used at each cylinder.

When the cylinder head is installed, the gaskets and seal rings compress sufficiently to form a tight metal to-metal contact between the head and block.

New service replacement cylinder block assemblies include the main bearing caps and bolts, dowels and the necessary plugs.

Since the cylinder block is the main structural part of the engine, the various sub-assemblies must be removed from the cylinder block when an engine is overhauled.

The hydraulically operated overhaul stand (Fig. 5) provides a convenient support when stripping a cylinder block. The engine is mounted in an upright position. It may then be tipped on its side, rotated in either direction 90 or 180 where it is locked in place and then, if desired, tipped back with either end or the oil pan side up.

Remove and Disassemble Engine

Before mounting an engine on an overhaul stand, it must be removed from the vehicle and disconnected from the transmission. Details of this procedure will vary from one application to another. However, the following steps will be necessary.

1. Drain the cooling system.

2. Drain the lubricating oil.

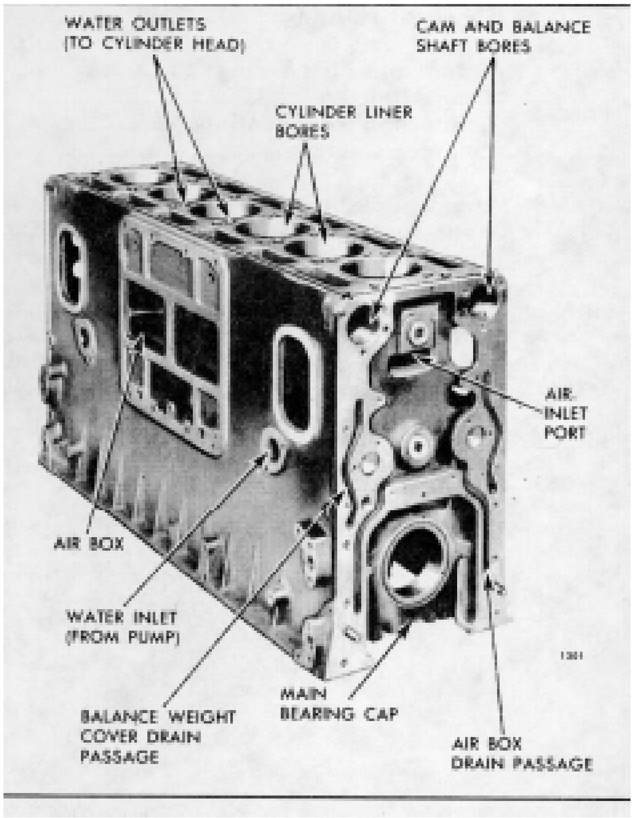


Fig. 1 - Typical Cylinder Block

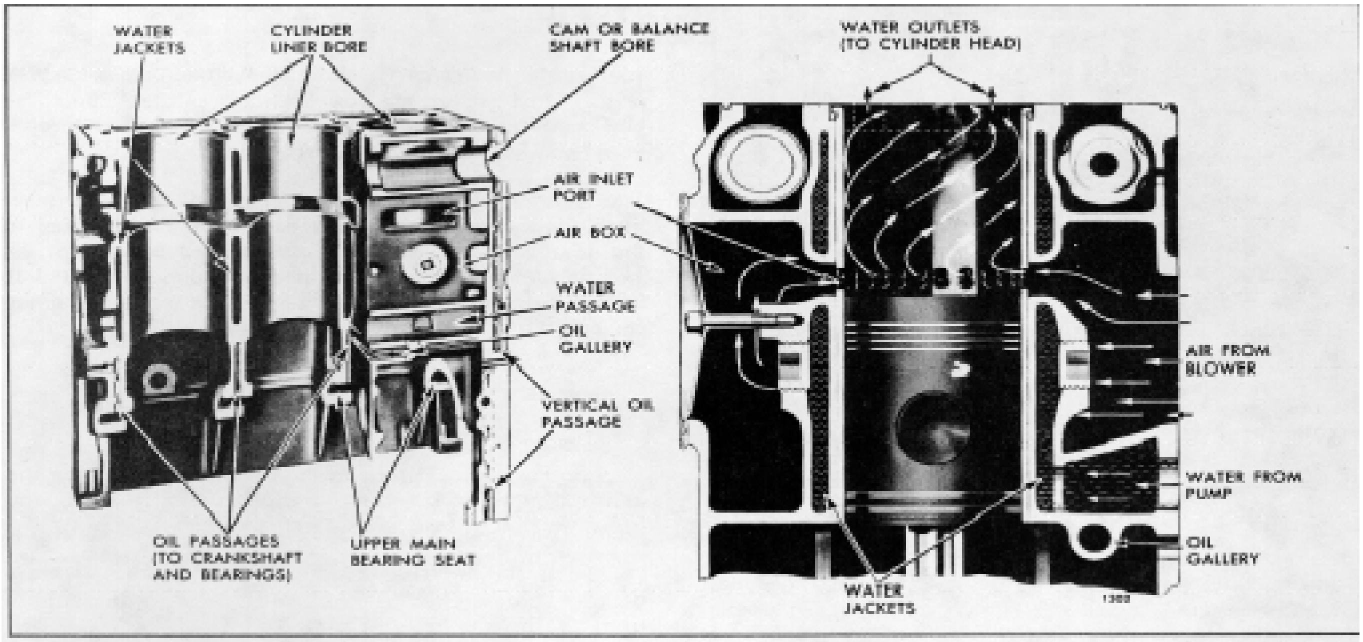


Fig. 2 - Cutaway View of Cylinder Block Showing Air and Water Passages

3. Disconnect the fuel lines.

4. Remove the air cleaner and mounting bracket.

5. Remove the turbocharger, if used.

6. Disconnect the exhaust piping and remove the exhaust manifold.

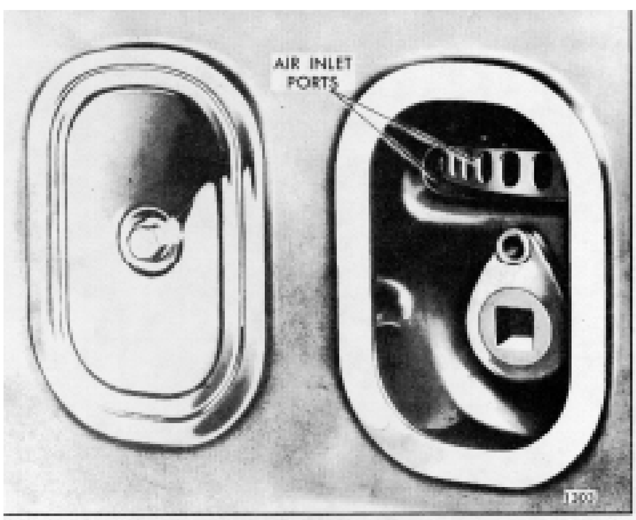


Fig. 3 - Air Box Covers and Air Inlet Ports.

7. Disconnect the throttle controls.

8. Disconnect and remove the starting motor, battery charging generator and other electrical equipment.

9. Remove the air compressor, if used.

10. Remove the radiator and other related cooling system parts.

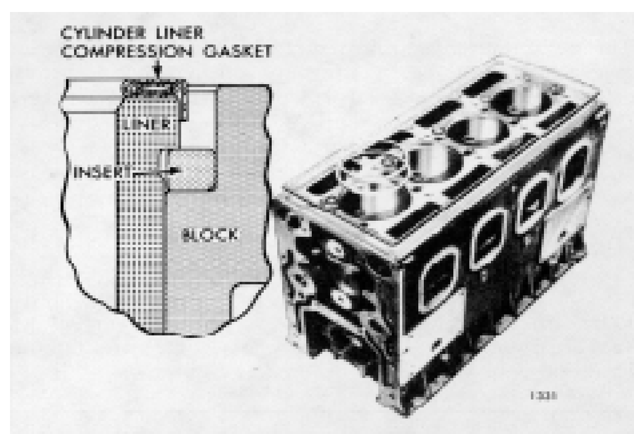


Fig. 4 - Sealing Arrangement of Cylinder Block

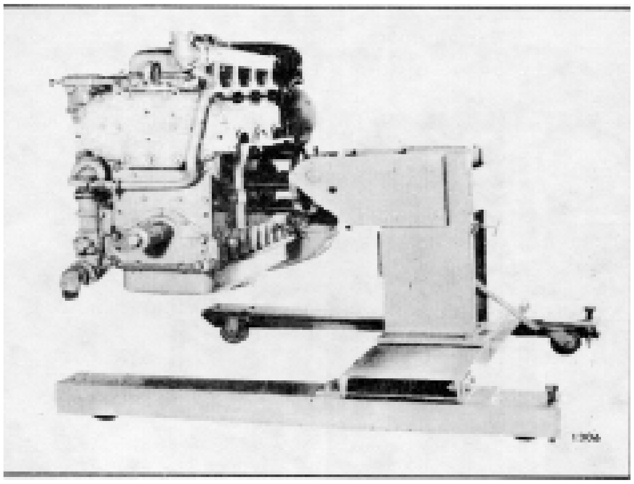


Fig. 5 - Engine Mounted on Overhaul Stand

11. Remove the air box covers.

12. Disconnect any other lubricating oil lines, fuel lines or electrical connections.

13. Separate the engine from the transmission.

14 Remove the engine mounting bolts.

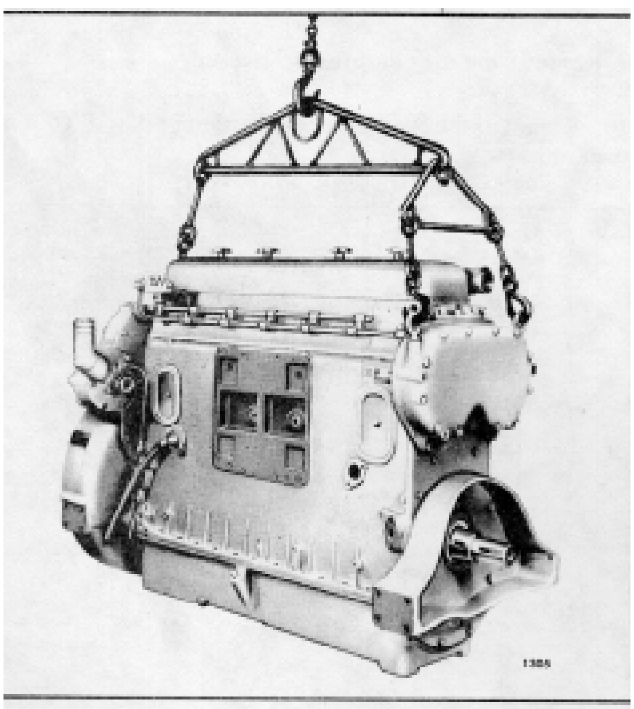


Fig. 6 Lifting Engine with Sling

15. Use a sling with a spreader bar (Fig. 6) and lift the engine from the chassis.

16. Locate the center lug of the overhaul stand adapter plate in the proper air box opening on the side of the block opposite the blower. The center lug is located in the number four opening of six cylinder engines.

The adapter plate, used with the hydraulic engine overhaul stand, must be attached to the mounting plate on the overhaul stand with six spacers and bolts (Fig. 5). The spacers provide the necessary clearance for the front balance weight cover and the flywheel housing when the engine is tipped on its side and rotated.

17. Loosen the lock nuts on the two holding lugs on the adapter plate and lower the engine while guiding the lugs into the air box openings.

18. Turn the holding lugs crosswise in the air box openings and tighten the lock nuts, drawing the engine tight against the adapter plate.

19. To be sure the engine does not shift on or break away from the overhaul stand, insert a 7/16" -14 x 2" bolt, with a plain washer under the head of the bolt, through the hole in the adapter plate and into the pad on the cylinder block.

> **CAUTION:** Be sure the engine is securely mounted to the overhaul stand before releasing the lifting sling. Severe injury to personnel and destruction of engine parts will result if the engine breaks away from the overhaul stand.

20. With the engine mounted on the overhaul stand, remove all of the remaining sub-assemblies and parts

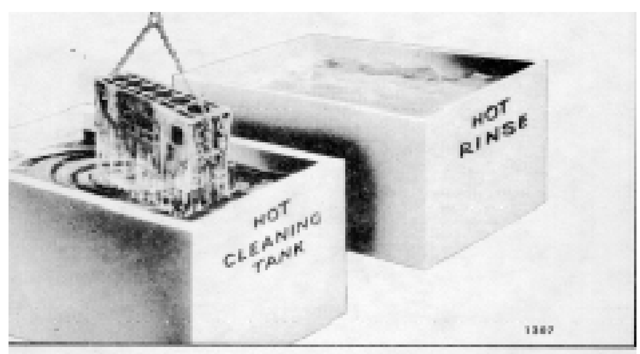


Fig. 7 - Cleaning Cylinder Block

from the cylinder block. The procedure for removing each sub-assembly from the cylinder block, together with disassembly, inspection, repair and reassembly of each, will be found in the various sections of this manual.

After stripping, the cylinder block must be thoroughly cleaned and inspected.

Clean Cylinder Block

Scrape all gasket material from the cylinder block. Then remove all oil gallery plugs and core hole plugs (except cup plugs) to allow the cleaning solution to contact the inside of the oil and water passages. This permits more efficient cleaning and eliminates the possibility of the cleaning solution attacking the aluminum core hole plug gaskets.

If a core hole plug is difficult to remove, hold a

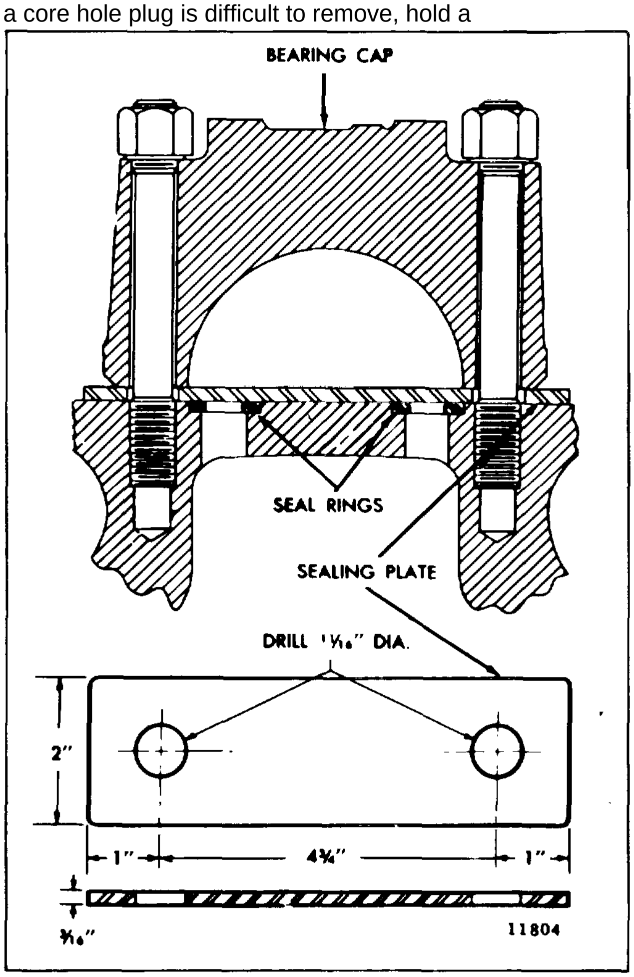


Fig. 8 - Sealing Plate Details for Pressure Testing Cylinder Block

3/4" drift against the plug and give it a few sharp blows with a one-pound hammer. With a 1/2" flexible handle and a short extension placed in the countersunk hole in the plug, turn the plug slightly in the direction of tightening. Then turn it in the opposite direction and back the plug out.

Clean the cylinder block as follows:

1. Remove the grease by agitating the cylinder block in a hot bath of commercial heavy-duty alkaline solution (Fig. 7).

2. Wash the block in hot water or steam clean it to remove the alkaline solution.

3. If the water jackets are heavily scaled, proceed as follows:

   a. Agitate the block in a bath of inhibited commercial pickling acid,.
   b. Allow the block to remain in the acid bath until the bubbling action stops (approximately 30 minutes).
   c. Lift the block, drain it and reimmerse it in the same acid solution for 10 minutes.
   d. Repeat Step "c" until all scale is removed.
   e. Rinse the block in clear hot water to remove the acid solution.
   f. Neutralize the acid that may cling to the casting by immersing the block in an alkaline bath.

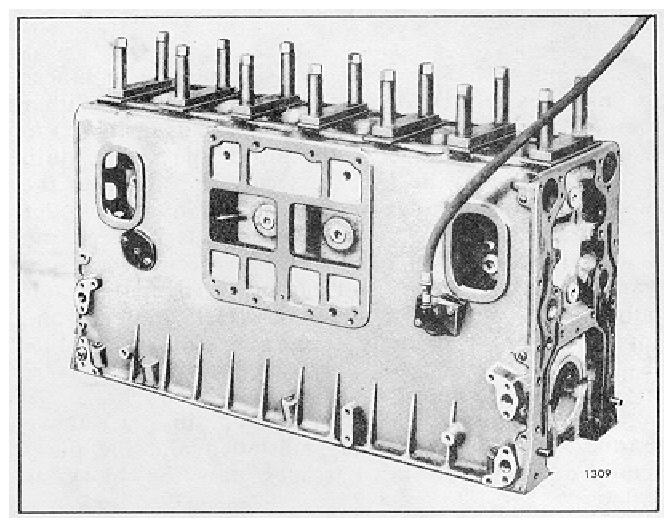


Fig. 9 Cylinder Block Prepared for Pressure Test

g. Wash the block in clean water or steam clean it.

4. Dry the cylinder block with compressed air.

5. Make certain that all water passages, oil galleries and air box drain holes have been thoroughly cleaned.

> **NOTE:** The above cleaning procedure may be used on all ordinary cast iron and steel parts of the engine. Mention will be made of special cleaning procedures whenever necessary.

After the cylinder block has been thoroughly cleaned and dried, reinstall the core hole plugs. Coat the threads of the plugs with sealant. Install the core hole plugs in the sides of the block from 2" to 2-1/4" below the machined surface of the block. They must be water tight. The core hole plugs in the ends of the block are flanged to provide a positive stop against the counterbore of the hole, thus preventing the plugs from entering the water jacket and restricting the flow of water. Soft aluminum gaskets are used with the plugs. Coat the threads of the end plugs with sealant and, using new gaskets, reinstall the plugs and tighten them to 150-180 lb-ft (204-244 Nm) torque.

> **CAUTION:** Excessive torque applied to the core hole plugs may result in cracks in the water jacket.

Pressure Test Cylinder Block

Extremely tight fitting cylinder liners, severe scoring of the liners and overheating of the engine may result in cracks in the cylinder bores. Overheating of the engine may also result in cracks between the water jackets and the oil passages.

The cylinder block may be pressure tested for cracks or leaks by either one of two methods. In either method, it will be necessary to make plates (Fig. 8) to seal the water openings in the top of the block. Main bearing caps may be used to secure the plates to the block with the cylinder head bolts and nuts. Cylinder head seal rings may be used as gaskets between the plates and the block. It will also be necessary to use water hole cover plates and gaskets to cover the water pump inlet openings in the block. Drill and tap one cover plate to provide a connection for an air line (Fig. 9).

With the cylinder block prepared in the above manner, the core hole plugs installed and the plugs removed from the oil passages, test the block as follows:

METHOD "A"

This method may be used when a large enough water

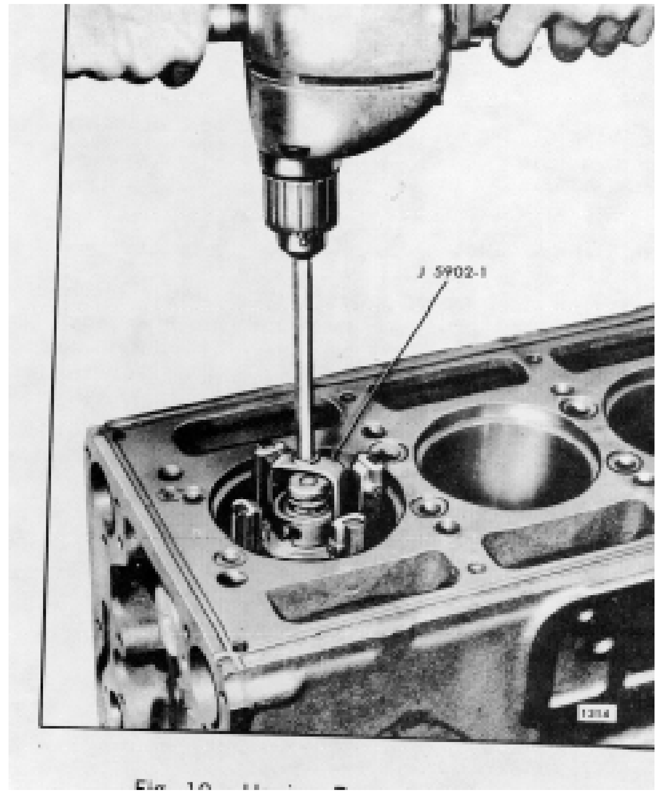


Fig. 10 Honing Bore of Cylinder Block

tank is available and the cylinder block is completely stripped of all parts.

I. Immerse the block for twenty minutes in a tank of water heated to 180-200° F (82-93 C).

2. Apply 40 psi (276 kPa) air pressure to the water jacket and observe the water in the tank for bubbles which indicate the presence of cracks or leaks in the block. A cracked cylinder block must be replaced by a new block.

3. After the pressure test is completed, remove the block from the water tank. Then remove the plates and gaskets and dry the block with compressed air.

METHOD "B"

This method may be used when a large water tank is unavailable, or when it is desired to check the block, for cracks without removing the engine from the vehicle. However, it is necessary to remove the cylinder head, blower, oil cooler, air box covers and oil pan.

1. Attach sealing plates and gaskets as in Method "A". However, before attaching the last sealing plate, fill the water jacket with a mixture of water and one

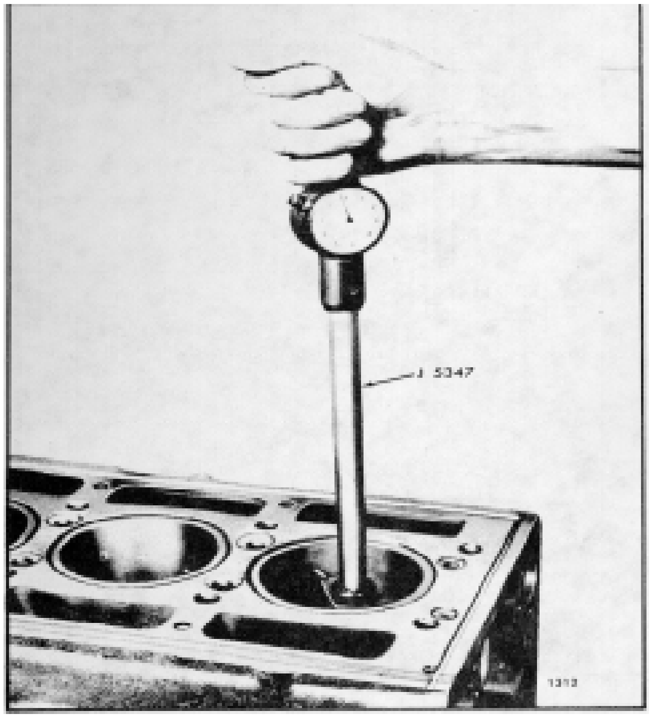


Fig. 11 - Checking Bore of Cylinder Block

gallon of permanent type antifreeze. The antifreeze will penetrate small cracks and its color will aid in detecting their presence.

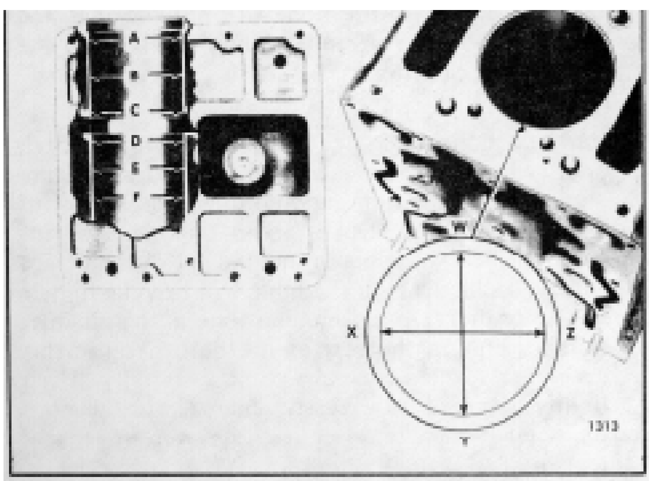


Fig. 12 - Cylinder Bore Measurement Diagram

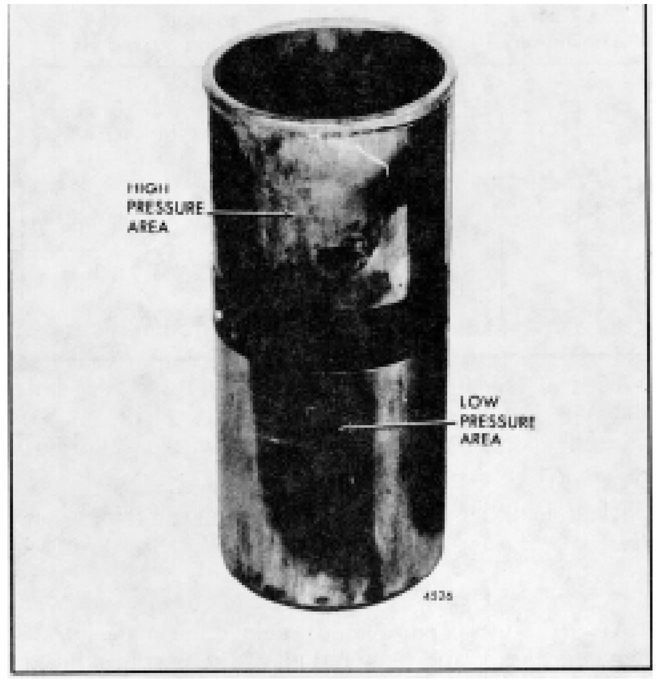


Fig. 13 - High Pressure Areas on Cylinder Liner

2. Install the remaining sealing plate and tighten it securely.

3. Apply 40 psi (276 kPa) air pressure to the water jacket and maintain this pressure for at least two hours to give the water and antifreeze mixture ample time to work its way through any cracks which may exist.

4. At the end of the test period, examine the cylinder bores, air box, oil passages, crankcase and exterior of the block for presence of the water and antifreeze mixture which will indicate the presence of cracks. A

For Average Block Bore I.D. Size of	Use Liner O.D. Size	To Give A Liner-to-Block Clearance of
	CAST IRON BLOCK	
4.6260" 4.6275"	Standard	.000’ to .0025"
4.6270" 4.6285"	.001" Oversize	.0(Y’ to .0025"

TABLE 1

Block Boring Dimensions	Liner 0.0. Size	Maximum Block Bore I.D. on a Used Block
	CAST IRON BLOCK	
4.631" 4.632"	.005" Oversize	4.6325"
4.636" 4.637"	.010" Oversize	4.6375"
4.646' 4.647"	.020" Oversize	4.6475"
4.656" 4.657"	.030" Oversize	4.6575"

TABLE 2

cracked cylinder block must be replaced by a new block.

5. After the test is completed, remove the plates, drain the water jacket and blow out all of the passages in the block with compressed air.

Inspect Cylinder Block

After cleaning and pressure testing, inspect the cylinder block.

Since most of the engine cooling is accomplished by heat transfer through the cylinder liners to the water jacket, a good liner-to-block contact must exist when the engine is operating. Whenever the cylinder liners are removed from an engine, the block bores must be inspected.

> **NOTE:** Before attempting to check the block bores, hone them throughout their entire length until about 75% of the area above the ports has been "cleaned-up".

1. Hone the block bores as follows:

   a. Use a hone in which the cutting radius of the stones can be set in a fixed position to remove irregularities in the bore rather than following the irregularities as with a spring-loaded hone. Clean the stones frequently with a wire brush to prevent stone loading. Follow the hone manufacturer's instructions regarding the use of oil or kerosene on the stones. Do not use

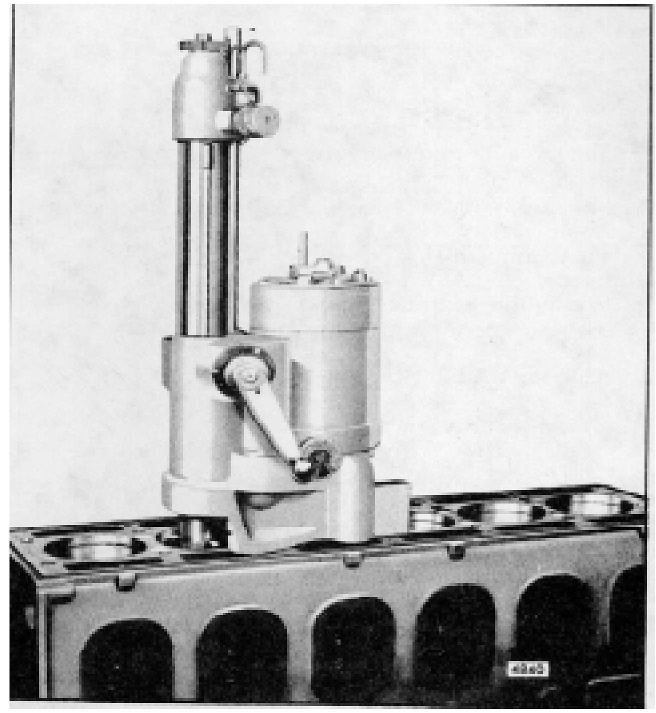


Fig. 14 Boring Cylinder Block with Portable Boring Bar

   use such cutting agents with a dry hone. Use 120 grit stones J 5902-14.

   b. Insert the hone in the bore (Fig. 10) and adjust the stones snugly to the narrowest section. When correctly adjusted, the hone will not shake in the bore, but will drag freely up and down when the hone is not running.

   c. Start the hone and "feel out" the bore for high spots which will cause an increased drag on the stones. Move the hone up and down the bore with short overlapping strokes about I " long. Concentrate on the high spots in the first cut. As these are removed, the drag on the hone will become lighter and smoother. Do not hone as long at the air inlet port area as in the rest of the bore because this area, as a rule, cuts away more rapidly. Feed lightly to avoid an excessive increase in the bore diameter. Some stones cut rapidly even under low tension.

   d. When the bore is fairly clean, remove the hone, inspect the stones and measure the bore. Determine which spots must be honed most. Moving the hone from the top to the bottom of the bore will not correct an out-of-round condition. To remain in one spot too long will cause the bore to become irregular. Where and how much to hone can be judged by feel. A heavy cut in a distorted bore produces a steady drag on the hone and makes it difficult to feel the high spots. Therefore, use a light cut with frequent stone adjustments.

e. Wash the cylinder block thoroughly after the honing operation is completed.

2. Check the cylinder block bores:

a. Visually check the contact area as revealed by the honed surface. There must not be any low spots which are larger in area than a half dollar.
b. Measure the entire bore of each cylinder with cylinder bore gage J 5347 (Fig. 11) which has a dial indicator calibrated in .0001 "increments. The standard block bore is 4.6260" to 4.6270". First, place the bore gage in the master ring gage J 8386-01 which has an I.D. of 4.6270" and set the dial to zero. Next rotate the dial clockwise .0005" to give a zero dial indicator setting of 4.6265". Take measurements on the cleaned-up surface only at positions A, B, C, D, E and F in the bore on axes 90 apart (Fig. 12). Read the measurements from the zero mark on the gage.

NOTE: Dial bore gage setting master tool J 23059 may be used in place of the master ring gage.

c. The cylinder block is alternately expanding and contracting, during engine operation, due to temperature variations. This may result in irregularities in the block bores (out-of-round and taper), the effects of which will be seen as high pressure areas on the outside of the cylinder liner (Fig. 13).
d. If a new liner and piston is installed in the block without properly fitting the liner, galling and seizing of the piston may result. This is caused by the new piston having to travel over the irregularities without time to conform to the particular shape of the block bore.

3. Fit the liner to the cylinder block: a. The liner-to-block clearance with new parts is zero to .002". With used parts, the maximum liner-to block clearance is .0025". Examine the block bore measurements to determine if standard or .001" oversize O.D. liners can be used, or if the Pa, cylinder block should be bored oversize. A light push fit between the liner and the block is desirable. However, a good fit between the cylinder liner and block may be obtained by comparing the average bore sizes with Table 1.

4. If necessary, bore the cylinder block as follows:

a. Each bore in a used block must not be out-of round or tapered more than .002". If the average block bore is over 4.6285", the block should be bored oversize as shown in Table 2.

b. A typical commercially available portable boring bar is illustrated in Fig. 14. Instructions on correct use of the boring bar are provided by the manufacturer.

c. After boring the block for an oversize cylinder liner, check the bore finish to be sure it is smooth (120 RMS). Heat transfer from the cylinder liner to the block will be adversely affected if the block bore isn't smooth.

d. Wash the block thoroughly after the boring operation.

e. When an oversize liner is used, stamp the size of the liner on the top deck of the block adjacent to the liner counterbore. An oversize liner insert must be installed whenever an oversize liner is used (Section 1.6.3).

5. Check the top of the block for flatness with an accurate straight edge and a feeler gage (Fig. 15).

a. The top surface of the block must not vary more than .003" transversely and not over .009" longitudinally. It will be difficult to prevent water, oil and compression leaks if the top surface of the block exceeds these tolerances.

b. If it is necessary to machine the top surface of the block to correct for the above conditions, do not remove more than .008" of metal. Stamp the amount of stock removed on the face of the block. The distance from the centerline of the crankshaft to the top of the block must not be less than 16.176"(Fig. 16).

c. If stock is removed from the top surface of the block, check the depth of the seal ring grooves and counterbores. The cylinder head seal strip grooves must be .092"-.107" deep. The large water hole counterbores (between the cylinders) must be .109"-.120" deep, and the combination water and oil hole counterbores and small water hole counterbores must be .087"-.098" deep. If necessary, deepen the grooves or counterbores to

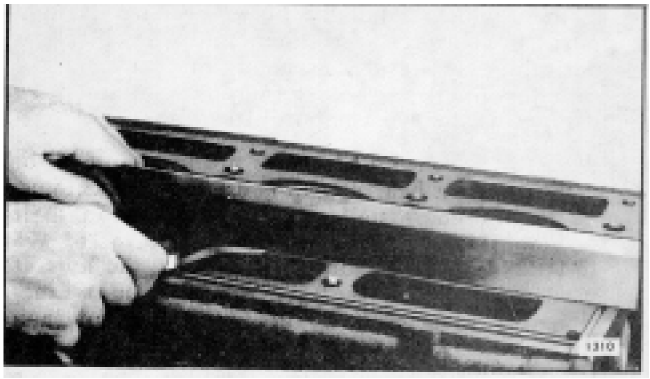


Fig. 15 - Checking Top Face of Cylinder Block

the specified limits to retain the proper "crush" on the seal rings. It is not necessary to deepen the counterbores for the cylinder liners since .004" and .008" undersize thickness inserts are available for adjusting the liner position as outlined in Section 1.6.3 under Fitting Cylinder Liner in Block Bore.

6. Make sure the cylinder liner counterbores in the block are clean and free of dirt. Then check the depth (Fig. 17). The cylinder bores have been counterbored to a depth which will accommodate an approximately 3/16" thick replaceable liner insert. The depth must be .4770" to .4795" and must not vary more than

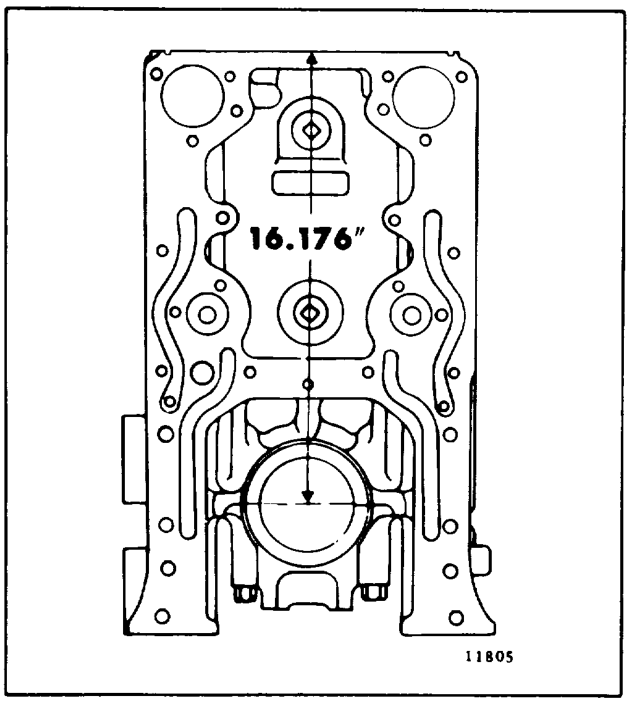


Fig. 16 - Minimum Distance from Center Line of Crankshaft to Top of Cylinder Block

.0015" throughout the entire circumference. The counterbored surfaces must be smooth and square with the cylinder bore within .001 "total indicator reading. There must not be over .001 "difference between any two adjacent cylinder counterbores when measured along the cylinder longitudinal centerline of the cylinder block.

7. Check the main bearing bores as follows:

a. Check the bore diameters with the main bearing caps in their original positions. Apply a small quantity of International Compound No. 2, or equivalent, to the threads on the bolts or studs and nuts and to the bolt head (or nut) contact area. Then install and tighten the bolts to 165-175 Lb-ft (224-238 Nm) torque or stud nuts to 140-155 Lb-ft (190-211 Nm) torque. The specified bore diameter is 3.812" to 3.813". If the bores do not fall within these limits, the cylinder block must be rejected.

CAUTION1: Main bearing cap bolts are especially designed for this purpose and must not be replaced by ordinary bolts.

NOTE: Bearing caps are numbered to correspond with their respective positions in the cylinder block. It is imperative that the bearing caps are reinstalled in their original positions to maintain the main bearing bore alignment. The number of the front main bearing cap is stamped on the face of the oil pan mounting flange of the cylinder block, adjacent to its permanent location in the engine as established at the time of manufacture. The No. 1 main

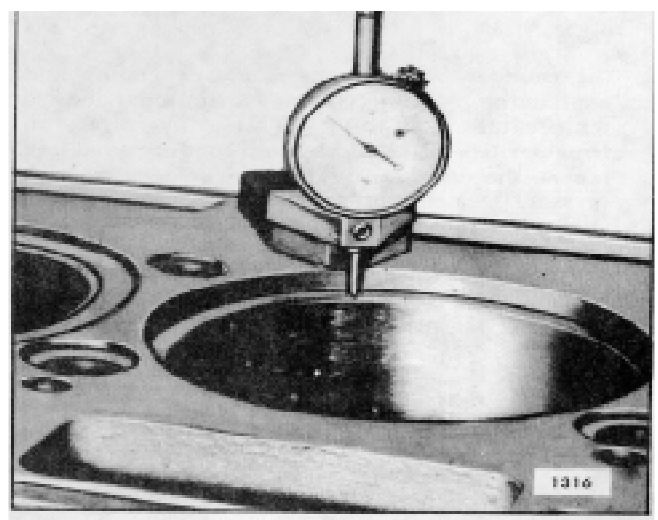


Fig. 17 - Checking Depth of Counterbore for Cylinder Liner with Tool J 22273

bearing cap is always located at the end opposite the flywheel end of the cylinder block Fig. 18), regardless of engine rotation or accessory arrangement. As originally manufactured, the main bearing caps are installed with the numbered side facing the blower side of the engine. Machining of the cylinder block and main bearing caps is such that the mating parts are "offset" to prevent installation of the bearing caps 180° from their correct position. However, if an engine has been converted for a new application and the cylinder and bearing numbering sequence has been reversed, the bearing caps must be reinstalled in the original positions regardless if the block and bearing caps have or have not been re-numbered.

b. Finished and unfinished main bearing caps are available for replacing broken or damaged caps. When fitting a finished replacement bearing cap, it may be necessary to try several caps before one will be found to provide the correct bore diameter and bore alignment. If a replacement bearing cap is installed, be sure to stamp the correct bearing position number on the cap.

NOTE: Use the unfinished bearing caps for the front and intermediate bearing positions. The finished bearing caps, machined for the crankshaft thrust washers, are to be used in the rear bearing position.

c. Main bearing bores are line-bored with the bearing caps in place and thus are in longitudinal alignment. Bearing bores may be considered properly aligned with one another if the crankshaft can be rotated freely by hand after new bearing shells have been installed and lubricated and the bearing caps have been secured in place and the bolts tightened to 180-190 lb-ft (224-258 Nm) torque (or nuts tightened

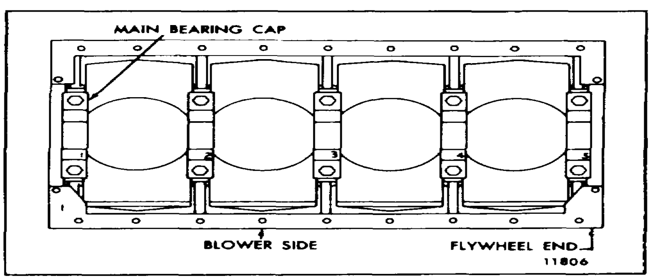


Fig. 18-Cylinder Block Markings

to 155-185 lb-ft (211-251 Nm) torque). If a main bearing bore is more than .001 " out of alignment, the block must be line-bored or scrapped. Misalignment may be caused by a broken crankshaft, excessive heat or other damage.

d. If the main bearing bores are not in alignment or a replacement bearing cap is used, the block must be line-bored. Install the bearing caps in their original positions and tighten the bolts to 165-175 lb-ft (244-238 Nm) torque (or tighten the nuts, if used, to 140-155 lb-ft (190-211 Nm) torque). Line- bore the block, but do not remove more than .001 " stock. After boring, all bores must be within the specified limits of 3.812 " to 3.813 "

8. Refer to the Cylinder Block Plugging Charts shown at the end of this manual and install the necessary plugs and dowels.

9. Replace loose or damaged dowel pins. The dowels at the ends of the cylinder block must extend 5/8" from the face of the block.

The dowels used to retain the crankshaft thrust washers on the rear main bearing cap must extend .110" to .120" from the surface of the bearing cap.

NOTE: When required, an oversize rear main bearing cap dowel pin is available.

10. Replace main bearing cap studs, if used, which are damaged or broken. Install new studs to a height of 4" + 1/32" above the upper bearing seat at a torque of 35-75 lb-ft (47-102 Nm).

11. If used, replace damaged or broken cylinder head studs. Install and drive a new stud to a height of 4-3/8" + 1/32" at a minimum torque of 75 lb-ft (102 Nm) torque.

12. Examine the tapped bolt holes for the cylinder head or main bearing cap bolts and, if the threads are damaged, "clean-up" the threads or install a helical thread insert. The tapped holes may be tapped with a 5/8"-11 UNC3B tap. All cylinder head bolt or stud holes must have the threads extending 1.84" below the block surface.

NOTE: The current service replacement cylinder blocks use a special cylinder head bolt in all positions.

13. Check the drive pins (which plug the vertical oil galleries) in the corners of the block to be sure they are flush with or below the top surface of the block.

14. Check the remaining cylinder block surfaces and threaded holes. Check all of the mating surfaces, or

mounting pads, for flatness, nicks and burrs. The flatness of the blower mounting pad must not vary more than .004". Clean-up damaged threads in tapped holes with a tap or install helical thread inserts, if necessary.

15. After inspection, if the cylinder block is not to be used immediately, spray the machined surfaces with engine oil. If the block is to be stored for an extended period of time, spray or dip it in a polar type rust preventive such as Valvoline Oil Company's "Tectyl 502-C", or equivalent. Castings free of grease or oil will rust when exposed to the atmosphere.

Assemble and Install Engine

After the cylinder block has been cleaned and inspected, assemble the engine as follows:

> **NOTE**: Before a reconditioned or new service replacement cylinder block is used, steam clean it to remove the rust preventive and blow out the oil galleries with compressed air.

1. Mount the cylinder block on the overhaul stand.
2. If a new service replacement block is used, stamp the engine serial number and model number on the pad located in the upper right-hand corner on the blower side of the block. Also stamp the position 1 numbers on the main bearing caps (Fig. 18) and the position of the No. I bearing on the oil pan mounting flange of the block.
3. Install all of the required cylinder block plugs and drain cocks. Use a good grade of non-hardening sealant on the threads of the plugs and drain cocks. Install the plugs flush with or below the surface of the block.
4. Clean and inspect all engine parts and subassemblies and, using new parts as required, install them on the cylinder block by reversing the sequence of disassembly. The procedures for inspecting and installing the various parts and sub-assemblies are outlined in the following sections of this manual.
5. Use a chain hoist and suitable sling to transfer the engine to a dynamometer test stand.
6. Complete the engine build-up by installing all remaining accessories, fuel lines, electrical connections, controls etc.
7. Operate the engine on a dynamometer, following the RUN-IN procedure outlined in Section 13.2.1.
8. Reinstall the engine in the vehicle.

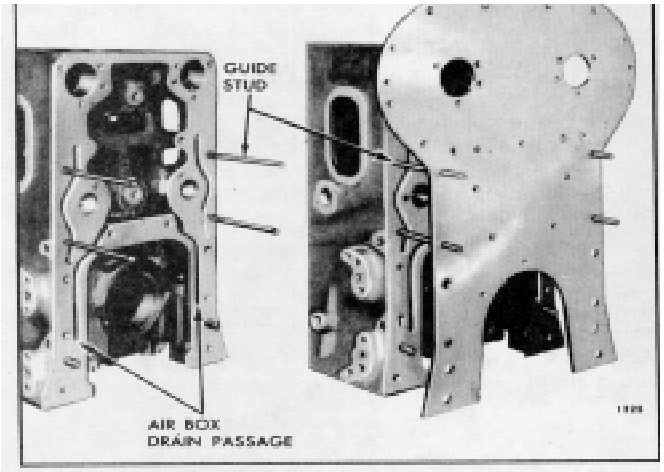


Fig. 1 - Installing Front End Plate

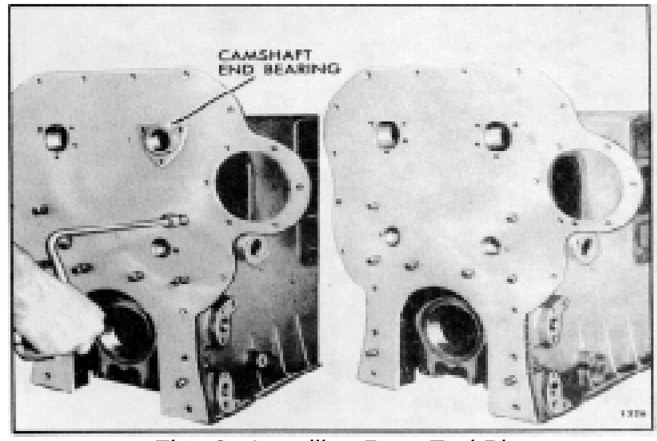


Fig. 2 - Installing Rear End Plate

A flat steel plate, one bolted to each end of the cylinder block, provides a support for the flywheel housing at the rear and the balance weight cover and crankshaft cover at the front of the engine. Since the blower drive gear assembly is supported on the rear end plate, this plate has a different contour than the one used at the front. Gaskets are used between the block and each end plate.

Inspection

When an end plate is removed, it is essential that all of the old gasket material be removed from both surfaces of the end plate and the cylinder block. Clean the end plate as outlined under Clean Cylinder Block in Section 1.1.

Inspect both surfaces of each end plate for nicks, dents, scratches or score marks and check the plates for warpage. Also check the tapped holes in the end plates at this time. If nicks or scratches on the sealing surfaces of the end plates are too deep to be cleaned up, replace the end plates.

Install End Plates

With all of the necessary plugs properly installed and the end plate-to-cylinder block dowels in place, attach the cylinder block front and rear end plates as outlined below.

1. Affix a new gasket to each end of the cylinder block, using a non-hardening gasket cement. Also apply an even coating of gasket cement to the outer surface of each gasket (the surface next to the end plate).

2. Use guide studs J 1927-01 as shown in Fig. 1 to set the front end plate next to the cylinder block and install the bolts and lock washers. Do not tighten the bolts at this time. Wipe the excess gasket cement from the bores in the end plate and the cylinder block.

3. Insert a camshaft end bearing through the SMALL bearing bore in the end plate and into the bore of the block to accurately align the end plate as shown in Fig. 2.

4. With the bearing in place, tighten the 3/8" -16 end plate retaining bolts to 30-35 lb-ft (41-47 Nm) torque. Tighten the 1/2"-13 bolts to 71-75 lb-ft (96-102 Nm) torque. Remove the camshaft bearing which served as a pilot while attaching the end plate.

5. Use the guide studs J 1927-01 and the camshaft end bearing to install the rear end plate in the same manner as outlined above.

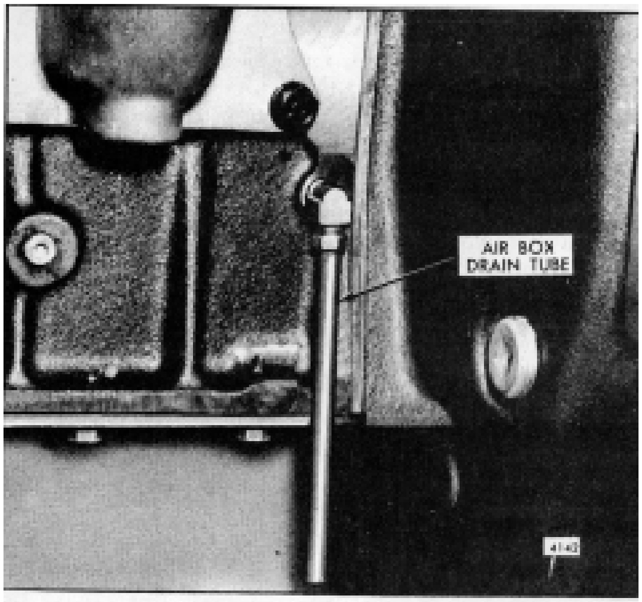


Fig. 1-Air Box Drain Tube

During normal engine operation, water vapor from the air charge, as well as a slight amount of fuel and lubricating oil fumes, condenses and settles on the bottom of the air box. This condensation is removed by the air box pressure through cored passages located at the front and rear of the cylinder block with drain outlets (Fig. I) in the side of the block.

Air box drains must be kept open at all times, otherwise water and oil that may accumulate will be drawn into the cylinders.

Inspection
A periodic check for air flow from the air box drain tubes should be made (refer to Section 15.1).

CYLINDER HEAD

The cylinder head (Figs. 2 and 3) is a one-piece casting securely held to the top of the cylinder block by special bolts.

The exhaust valves, fuel injectors and the valve and injector operating mechanism are located in the cylinder head.

Depending upon the engine application, either two or four exhaust valves are provided for each cylinder.

Exhaust valve seat inserts, pressed into the cylinder head, permit accurate seating of valves under varying conditions of temperature and materially prolong the life of the cylinder head.

To ensure efficient cooling, each fuel injector is inserted into a thin-walled tube (Fig. 4) which passes through the water space in the cylinder head. The lower end of the injector tube is pressed into the cylinder head and flared over; the upper end is flanged and sealed with a neoprene seal. The sealed

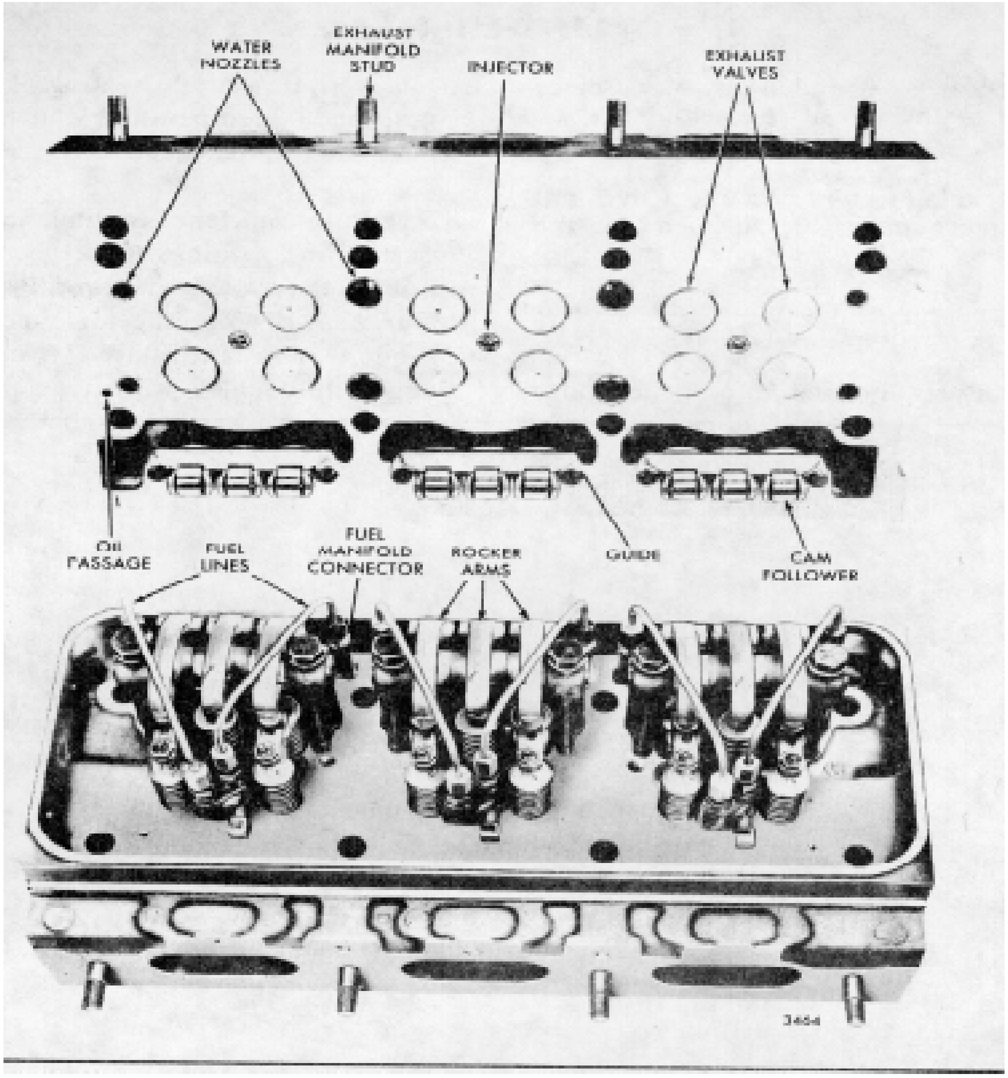


Fig. 2-Cylinder Head Assembly (Four Valve)

upper end and flared lower end of the injector tube prevent water and compression leaks.

No water space is provided around the injectors in very early four-valve cylinder heads. Therefore, no injector tubes are required in these heads.

The exhaust passages from the exhaust valves of each cylinder lead through a single port to the exhaust manifold. The exhaust passages and the injector tubes are surrounded by engine coolant.

In addition, cooling of the above areas is further ensured by the use of water nozzles (Figs. 5 and 6) pressed into the water inlet ports in the cylinder head. The nozzles direct the comparatively cool engine coolant at high velocity toward the sections of the cylinder head which are subjected to the greatest heat.

The fuel inlet and outlet manifolds are cast as an integral part of the current cylinder heads. Tapped holes are provided for connection of the fuel lines at various points along each manifold. On former cylinder heads, separate fuel manifolds are attached to the side of the head (refer to Section 2.4).

The water manifold is also cast as an integral part of the cylinder head.

To seal compression between the cylinder head and the cylinder liner, separate laminated metal gaskets are provided at each cylinder. Water and oil passages between the cylinder head and cylinder block are

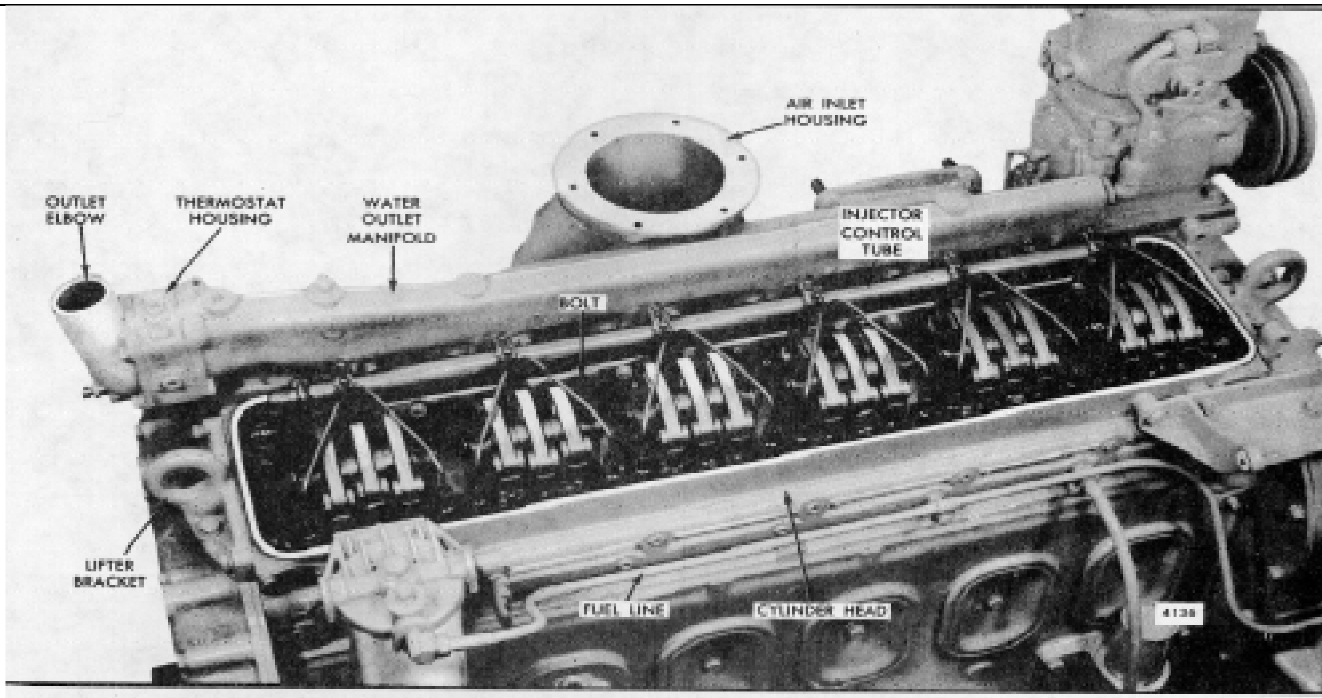


Fig. 3 - Typical Mounting of Cylinder Head

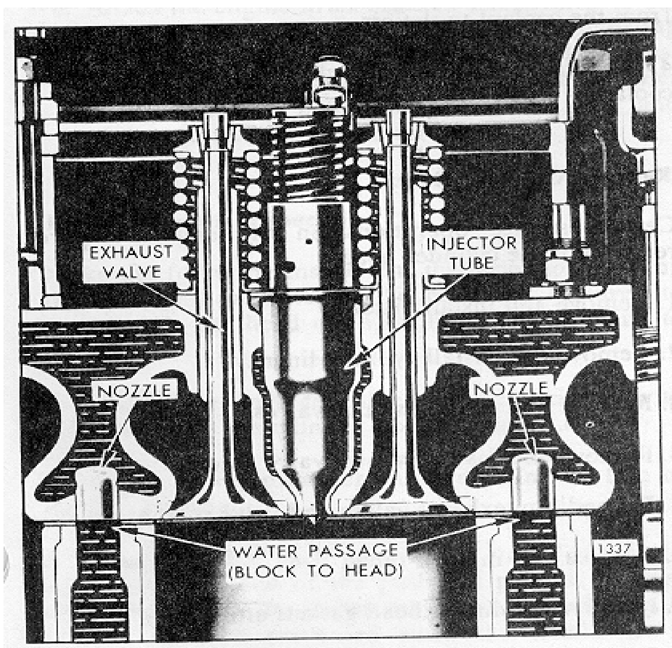


Fig. 4 - Coolant Passages Around Exhaust Valves and Fuel Injectors

sealed with synthetic rubber seal rings which fit into counterbored holes in the block. A synthetic rubber seal fits into a milled groove near the perimeter of the block. When the cylinder head is drawn down, a positive leakproof metal-to-metal contact is assured between the head and the block.

Cylinder Head Maintenance

The engine operating temperature should be maintained between 160-185 c F or 71-85 c C and the cooling system should be inspected daily and kept full at all times. The cylinder head fire deck will overheat and crack in a short time if the coolant does not cover the fire deck surface. When necessary, add water slowly to a hot engine to avoid rapid cooling which can result in distortion and cracking of the cylinder head (and cylinder block).

Abnormal operating conditions or neglect of certain maintenance items may cause cracks to develop in the cylinder head. If this type of failure occurs, a careful inspection should be made to find the cause and avoid a recurrence of the failure.

Unsuitable water in the cooling system may result in lime and scale formation and prevent proper cooling. The cylinder head should be inspected around the 31 exhaust valve water jackets. This can be done by removing an injector tube. Where inspection discloses such deposits, use a reliable non-corrosive scale remover to remove the deposits from the cooling system of the engine, since a similar condition will exist in the cylinder block and other components of the engine. Refer to Section 13.3 for engine coolant recommendations.

Loose or improperly seated injector tubes may result in compression leaks into the cooling system and also result in loss of engine coolant. The tubes must be tight to be properly seated. Refer to Section 2.1.4.

Overtightened injector clamp bolts may also cause head cracks. Always use a torque wrench to tighten the bolts to the specified torque.

Other conditions which may eventually result in cylinder head cracks are:

1. Excess fuel in the cylinders caused by leaking injectors.

2. Slipping fan belts can cause overheating by reducing air flow through the radiator.

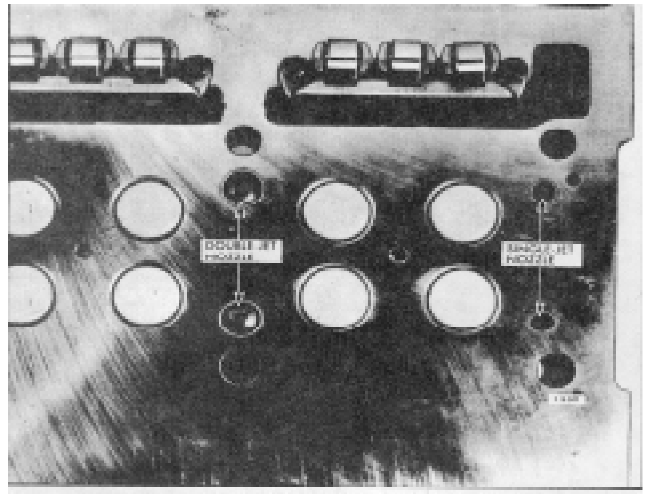


Fig. 6 - Water Nozzles in Four-Valve Cylinder Head

3. Accumulation of dirt on the radiator core which will reduce the flow of air and slow the transfer of heat from the coolant to the air.

4. Inoperative radiator cap which will result in loss of coolant.

Remove Cylinder Head

Certain service operations on the engine require removal of the cylinder head:

1. Remove and install pistons.

2. Remove and install cylinder liners.

3. Remove and install exhaust valves.

4. Remove and install exhaust valve guides.

5. Recondition exhaust valves and valve seat inserts.

6. Replace fuel injector tubes.

7. Install new cylinder head gaskets and seals.

8. Remove and install camshaft.

Due to the various optional and accessory equipment used, only the general steps for removal of the cylinder head are covered. If the engine is equipped

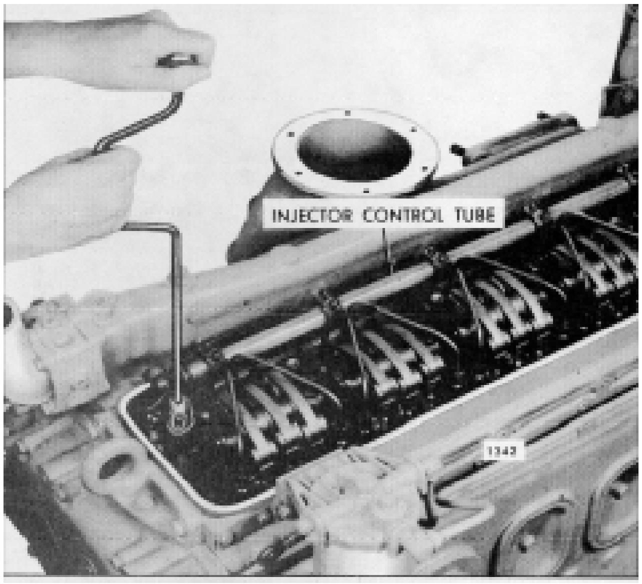


Fig. 7 - Removing or Installing Injector Control Tube

with accessories that affect cylinder head removal, note the position of each before disconnecting or removing them to ensure correct re-installation. Then refer to Fig. 3 and remove the cylinder head as follows:

1. Drain the cooling system.
2. Disconnect the exhaust piping at the exhaust manifold.

3. Remove the air cleaners and the air inlet housing.

4. Remove the exhaust manifold.
5. Disconnect the fuel lines at the cylinder head and remove the fuel filter (Fig. 3).
6. Remove the thermostat housing assembly.

7. Remove the water manifold.

8. Clean and remove the valve rocker cover and the governor cover.
9. Disconnect the fuel rod from the injector control tube lever and the governor. Remove the fuel rod.
10. Remove the injector control tube (Fig. 7) and brackets as an assembly.

11. If the cylinder head is to be disassembled for reconditioning of the exhaust valves and valve seat

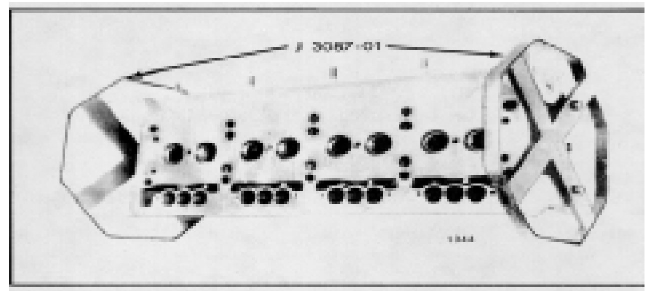


Fig. 8 - Cylinder Head Mounted on Holding Plates

inserts or for a complete overhaul, remove the fuel pipes and injectors at this time. Refer to Section 2.1 or 2.1.1 for removal of the injectors.

12. Loosen (three or four turns) the two bolts directly below each lifter bracket which attach the balance weight cover and flywheel housing to the front and rear end plates. Otherwise, the threaded ends of the bolts may interfere with removal of the cylinder head.

13. Remove the two bolts which secure the front lifter bracket to the balance weight cover and the two bolts attaching the rear lifter bracket to the flywheel housing.

14. Check the torque on the cylinder head bolts and stud nuts (if used), before removing the head. Then remove the bolts and nuts and, using lifting hooks and a chain hoist, lift the cylinder head from the cylinder block. Checking the torque before removing the head bolts and examining the condition of the compression

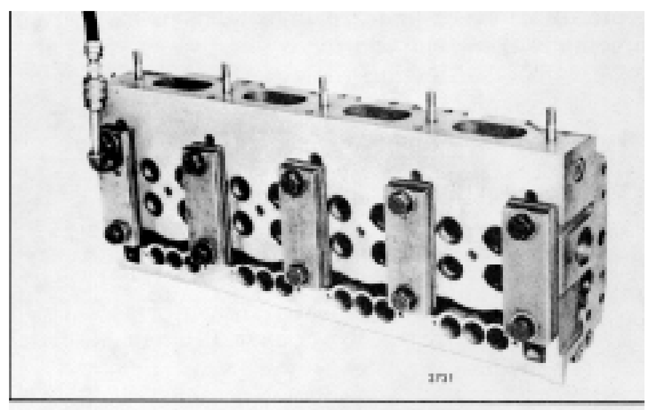


Fig. 9 - Cylinder Head Prepared for Pressure Test

gaskets and seals after the head is removed may reveal the causes of any cylinder head problems.

CAUTION: When placing the cylinder head assembly on a bench, protect the cam followers and injector spray tips, if the injectors were not removed, by resting the valve side of the head on 2 " thick wood blocks.

15. Place the cylinder head on its side and remove the engine lifter brackets and gaskets. Then attach the cylinder head holding plates J 3087-01 (Fig. 8) to raise the head above the work bench.
16. Remove and discard the cylinder head compression gaskets, oil seals and water seals.
17. After the cylinder head has been removed, drain the lubricating oil from the engine. Draining the oil at this time will remove any coolant that may have worked its way to the oil pan when the head was removed.

Disassemble Cylinder Head

If complete disassembly of the cylinder head is necessary, refer to Sections 1.2.1 and 1.2.2 for removal of the exhaust valve and injector operating mechanism.

Clean Cylinder Head

After the cylinder head has been disassembled and all of the plugs (except cup plugs) have been removed, thoroughly steam clean the head. If the water passages are heavily coated with scale, remove the injector tubes and water nozzles. Then clean the cylinder head in the same manner as outlined for cleaning the cylinder block (Section 1.1).

Clean all of the cylinder head components with fuel oil and dry them with compressed air.

Inspect Cylinder Head

1. Pressure check the cylinder head as follows:

   a. Seal off the water holes in the head with steel plates and suitable rubber gaskets secured in place with bolts and washers as shown in Fig. 9. Drill and tap one of the cover plates for an air hose connection.
   b. Install scrap or dummy injectors to ensure proper seating of the injector tubes. Dummy injectors may be made from old injector nuts and bodies --the injector spray tips are not necessary. Tighten the injector clamp bolts to 20-25 lb-ft (27-34 Nm) torque.
   c. Apply 80-100 psi (552-689 kPa) air pressure to the water jacket. Then immerse the cylinder head in a tank of water, previously heated to 180-200'F or 82-93 ° C, for about twenty minutes to thoroughly heat the head. Observe the water in the tank for bubbles which indicate a leak or crack. Check for leaks at the top and bottom of the injector tubes, oil gallery, exhaust ports, fuel manifolds, and the top and bottom of the cylinder head.
   d. Relieve the air pressure and remove the cylinder head from the water tank. Then remove the plates, gaskets and injectors, and dry the head with compressed air.

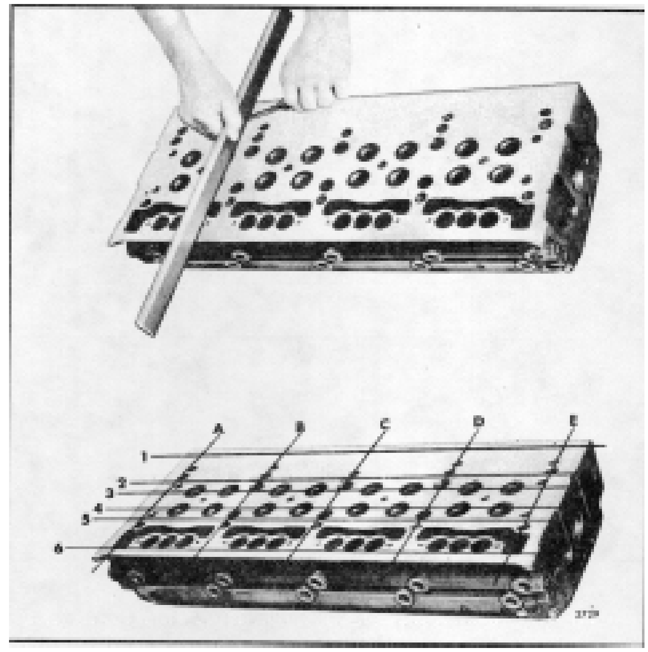


Fig. 10 - Checking Bottom Face of Cylinder Head

Engine	Maximum Longitudinal Warpage	Maximum Transverse Warpage
6-71	010"	.004"'

TABLE 1

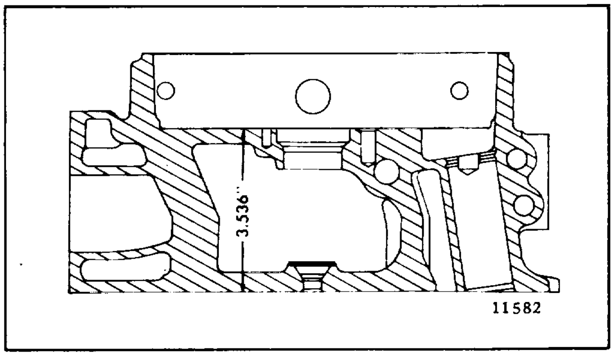


Fig. 11 - Minimum Distance Between Top and Bottom Faces of Cylinder Head

e. If the pressure check revealed any cracks, install a new cylinder head.

2. Check the bottom (fire deck) of the cylinder head for flatness:

a. Use a heavy, accurate straight-edge and feeler gages, tool J 3172, to check for transverse warpage at each end and between all cylinders. Also check for longitudinal warpage in six places as shown in Fig. 10. Refer to Table I for maximum allowable warpage.

b. Use the measurements obtained and the limits given in Table I as a guide to determine the advisability of re-installing the head on the engine or of refacing it. The number of times a cylinder head may be refaced will depend upon the amount of stock previously removed.

c. If the head is to be refaced, remove the injector tubes prior to machining. Do not remove more than .020" (total) of metal from the fire deck of any cylinder head. The distance from the top deck to the bottom (fire deck) of the cylinder head must not be less than 3.536" (Fig. 11). Stamp the amount of stock removed on the face of the fire deck near the outer edge of the head, in an area not used as a sealing surface.

CAUTION: When a cylinder head has been refaced, critical dimensions such as the protrusion of valve seat inserts, exhaust valves, injector tubes and injector spray tips must be checked and corrected. The push rods must also be adjusted to prevent the exhaust valves from striking the pistons after the cylinder head is re-installed in the engine.

3. Install new injector tubes (Section 2.1.4) if the old tubes leaked or the cylinder head was refaced.

4. Inspect the exhaust valve seat inserts and valve guides (refer to Section 1.2.2).

5. Inspect the cam follower bores in the cylinder head for scoring or wear. Light score marks may be cleaned up with crocus cloth wet with fuel oil. Measure the bore diameter. The cam follower-to-cylinder head clearance must not exceed .006 " with used parts (refer

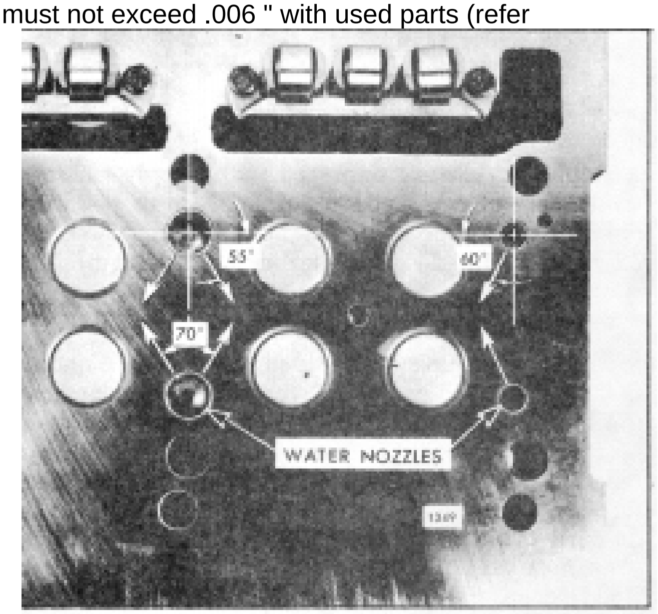


Fig. 13 - Correct Installation of Water Nozzles in Four-Valve Cylinder Head

to Section 1.0 for specifications). If the bores are excessively scored or worn, replace the cylinder head.

6. Check the water hole nozzles to be sure they are not loose. If necessary, replace the nozzles as follows:

> **NOTE**: Early engines did not incorporate water nozzles in the cylinder head. It is recommended that nozzles be installed when an early engine is in for a regular overhaul or for reconditioning of the cylinder head.

a. Remove the old nozzles.
b. Make sure the water inlet ports in the cylinder head are clean and free of scale. The water holes at each end of the head may be cleaned up with a 1/2" drill and the intermediate holes may be cleaned up with a 13/16" drill. Break the edges of the holes slightly.
c. For the positioning of the nozzles in a four-valve cylinder head, refer to Fig. 13. Press the nozzles flush to .0312"recessed below the surface of the cylinder head.
d. Check to make sure the nozzles fit tight. If necessary, use a wood plug or other suitable tool to expand the nozzles, or tin the outside diameter with solder to provide a tight fit. If solder is used, make sure the orifices in the nozzles are not closed with solder.

7. Replace broken or damaged studs. Apply sealant to the threads of new studs and drive them to 10-25 lb-ft (14-34 Nm) torque (water manifold cover studs) or to 25-40 lb-ft (34-54 Nm) torque (exhaust manifold studs).

8. Pilot sleeves have been added to the head mounting bolt holes at each end of the four-valve cylinder heads (on the camshaft side on current heads or exhaust side of former heads). Make sure the sleeves are flush or recessed below the fire deck of the cylinder head: Replace damaged sleeves. Pilot sleeves can be installed on early cylinder heads by reaming the end bolt holes (camshaft side of head) to .687 " /.688" diameter by .750" deep and pressing the sleeves flush or slightly recessed below the fire deck. The sleeves, which act as a hollow dowel to provide a closer fit between the mounting bolts and the cylinder head, help to guide the head in place without disturbing the seals and gaskets.

9. Inspect all other components removed from the cylinder head.

If a service replacement cylinder head is to be installed, it must be thoroughly cleaned of all rust preventive compound, particularly inside the integral fuel manifolds, before installing the plugs. A simple method of removing the rust preventive compound is to immerse the head in solvent, oleum or fuel oil, then scrub the head and go through all of the openings with a soft bristle brush. A suitable brush for cleaning the various passages in the head can be made by attaching a 1/8" diameter brass rod to brush J 8152. After cleaning, dry the cylinder head with compressed air.

A service replacement cylinder head includes the exhaust valve guides, valve seat inserts, water nozzles, injector tubes, pilot sleeves, bridge guides, valve spring seats and the necessary plugs. In addition, studs, cover plates, gaskets, lock washers and nuts are provided to seal the water outlet openings that are not required on certain engines. A length of flexible fuel hose and fittings are also included where required.

Injector clamp bolts or studs are not included and it is necessary to use new parts or transfer the old parts to the new head. Injector clamp bolts are interchangeable with the former studs and nuts; the special washer is used with either the bolt or stud.

> **CAUTION**: When replacing a former cylinder head equipped with separate fuel manifolds by a current head, a reversal of fuel flow through the injectors may occur. Replace the injector fuel filters to prevent foreign matter in the old filters from entering the injectors.

Assemble Cylinder Head

After cleaning and inspection, assemble the cylinder head as follows:

1. Install the necessary plugs and tighten them to the specified torque (Section 1.0). Drive headless plugs flush to .0625" below the surface of the cylinder head. The 3/8" socket head oil gallery plug, at each end of the head, must not protrude more than .0625", and a .2187" diameter rod placed in the vertical oil feed hole must pass the inner face of the plug.

> **CAUTION**: Apply a small amount of "dual purpose" sealer to the threads of the plugs only. Work the sealant into the threads and wipe the excess with a clean lintless cloth so that

sealant will not be washed into the fuel and oil passages.

2. After the following parts are cleaned and inspected, and replaced if necessary, re-install them in the old cylinder head or transfer them to the new head.

a. Exhaust valves, valve seat inserts and springs (Section 1.2.2).
b. Cam followers, guides, push rods, springs, retainers, rocker arms, shafts, brackets and other related parts (Section 1.2.1).
c. Place new washers on the fuel connectors. Then install the connectors and tighten them to 40-45 Ib-ft (54-61 Nm) torque.

   NOTE: If separate fuel manifolds are used (early cylinder head), install the manifolds and fuel connectors (refer to Section 2.4). If a new cylinder head is used, discard the manifolds and old fuel connectors.
d. The fuel injectors, fuel pipes, injector control tube assembly and water manifold, if used, can be installed at this time or after the cylinder head is installed on the engine.
e. Attach the engine lifter brackets temporarily to the cylinder head, without gaskets, to permit lifting the head into position. The lifter brackers must not be permanently attached until the cylinder head attaching bolts have been installed and tightened to the specified torque.

Pre-Installation Inspection

Make the following inspections just prior to installing the cylinder head whether the head was removed to service only the head or to facilitate other repairs to the engine.

1. Check the cylinder liner flange heights with relationship to the cylinder block (Section 1.6.3).
2. Make sure the piston crowns are clean and free of foreign material.
3. Make sure that each push rod is threaded into its clevis until the end of the push rod projects through the clevis. This is important since serious engine damage will be prevented when the crankshaft is rotated during engine tune-up.
4. Check the cylinder block and cylinder head gasket surfaces, counterbores and seal grooves to be sure they are clean and free of foreign material. Also check to ensure that there are no burrs or sharp

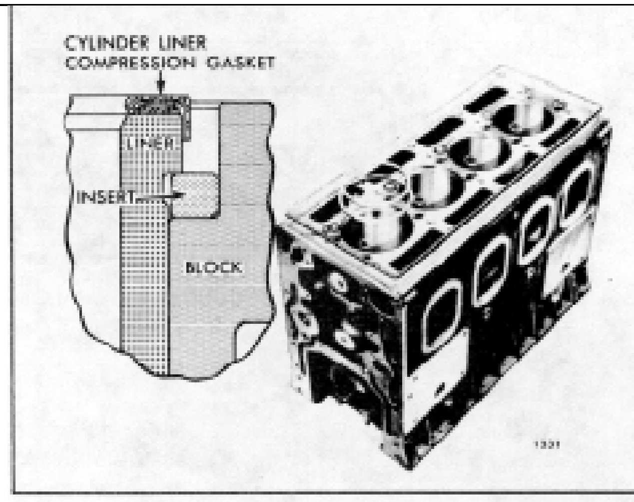


Fig. 14 - Cylinder Head Seals and Gaskets

ensure that there are no burrs or sharp edges in the counterbores.

5. Inspect the cylinder head bolt holes in the block for accumulation of water, oil or any foreign material. Clean the bolt holes thoroughly and check for damaged threads.

6. Check for extruded areas around the stud holes in the top of the cylinder block, if studs are used. Also check the studs for damaged threads.

7. Check the four corner plugs or drive pins, used to plug the vertical oil galleries, to ensure that they are flush with or below the top surface of the cylinder block.

Install Cylinder Head

1. Refer to Fig. 14 and install the water and oil seal rings and compression gaskets as follows:

a. Place a new compression gasket on top of each cylinder liner.

b. Place new seal rings in the counterbores of the water and oil holes in the cylinder block.

c. Install a new oil seal in the groove at the perimeter of the cylinder block. The seal must lay flat in the groove. Do not stretch the seal and do not use any adhesive or other material to secure it in the groove.

NOTE: Never install used compression gaskets or seals.

2. To install the cylinder head on the engine without

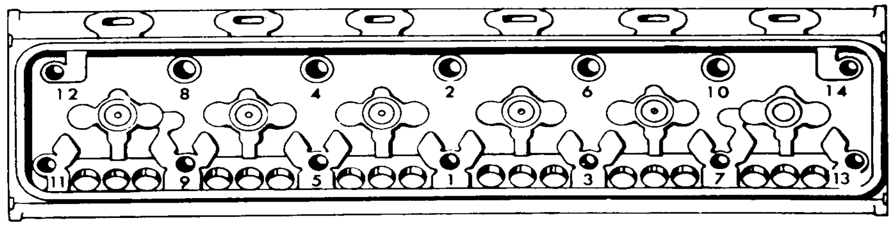


Fig. 15-Cylinder Head Bolt Tightening Sequence

disturbing the gaskets and seals, install guide studs J 9665 in two corner bolt holes in the cylinder block.

NOTE: Current four-valve cylinder heads have piloting sleeves installed in the corner bolt holes on the camshaft side of the head (former heads had the piloting sleeves on the exhaust side). The sleeves provide more accurate alignment of the cylinder head with the block bores. Do not install the guide studs in the bolt holes which line- up with piloting sleeves in the head. The guide studs are not required on early engines which include cylinder head studs in the block.

3. Insert the hooks of a chain, attached to a hoist, in the vent holes of the cylinder head, or the lifter brackets, and lift the head into position above thev cylinder block.

4. Make a final visual check of the compression gaskets and seals to ensure that they are in place before the cylinder head is lowered. This is a very important check. Gaskets and seals which are not seated properly will cause leaks and " blow-by" and result in poor engine performance and damage to the engine.

5. Wipe the bottom of the cylinder head clean. Then lower the head until it is about I/2 " from the surface of the cylinder block.

6. Apply a small amount of International Compound No. 2, or equivalent, to the threads and underside of the head of all cylinder head attaching bolts (to stud threads and head contact surface of stud nuts, if used). Then install a bolt through each piloting sleeve (four- valve head) at the corners of the head and thread them finger tight into the cylinder block. Continue to tighten these bolts (finger tight) as the head is lowered into position on the cylinder block.

NOTE: Either one of two types of stud nuts are used. Both faces of one nut are square with the threads. The other type nut has a shoulder on one face. The shoulder side must contact the cylinder head.

IMPORTANT: Cylinder head bolts are especially designed for this purpose and must not be replaced by ordinary bolts.

7. After the head is in place, remove the guide studs and chain hoist and install the remaining bolts. However, before tightening the bolts (or nuts), loosen - the lifter bracket-to-cylinder head attaching bolts, otherwise the head may be prevented from seating properly on the cylinder block. A similar condition could exist if the exhaust manifold is attached to the cylinder head. Clearance must be assured between the exhaust manifold and the bosses on the cylinder block. On some engine models, these bosses serve as a rest

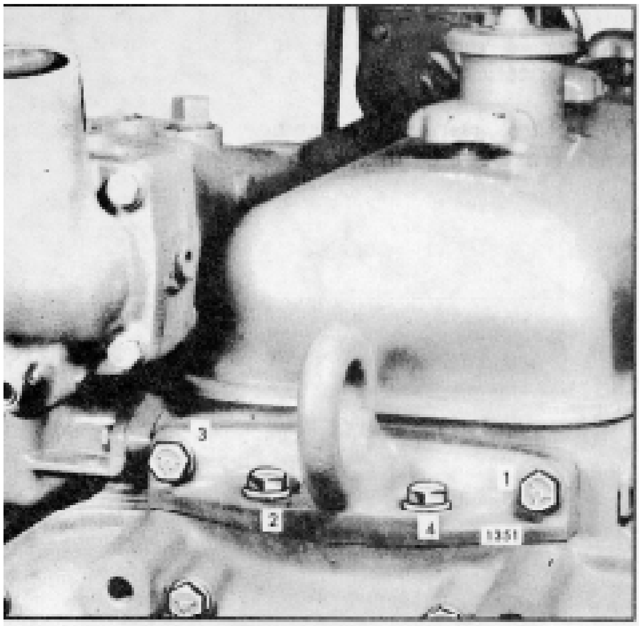


Fig. 16 - Lifter Bracket Bolt Tightening Sequence

for the exhaust manifold after the cylinder head has been installed on the cylinder block.

8. Tighten the bolts (or nuts) to 175-185 lb-ft (238-251 Nm) torque with a torque wrench, one-half turn at a time, in the sequence shown in Fig. 15. Begin on the cam follower side of the head to take up tension in the push rod springs. Tighten the bolts to the high side of the torque specification, but do not exceed the limit or the bolts may stretch beyond their elastic limits. Attempting to tighten the bolts in one step may result in trouble and consequent loss of time in diagnosis and correction of difficulties, such as compression leaks, when the engine is put into operation.

> **NOTE**: Tightening the cylinder head bolts will not correct a leaking compression gasket or seal. The head must be removed and the damaged gasket or seal replaced.

9. Tighten the two flywheel housing attaching bolts directly below the rear lifter bracket. Install a new gasket and secure the rear engine lifter bracket to the cylinder head and the flywheel housing. Tighten the bolts to 55-60 lb-ft (75-81 Nm) torque when threaded into cast iron or 35-40 lb-ft (47-54 Nm) torque when threaded into aluminum (Fig. 16).

10. Affix a new gasket to the front lifter bracket and attach the bracket to the cylinder head and the balance weight cover. Tighten the bolts in the same sequence and to the same torque as on the rear lifter bracket bolts.

11. If the fuel injectors were not previously installed, refer to Section 2.1 or 2.1.1 and install them at this time.

12. On a four-valve cylinder head, adjust the exhaust valve bridges as outlined in Section 1.2.2.

13. Tighten the rocker arm bracket bolts to the specified torque (Section 1.0).

14. Align the fuel pipes and connect them to the injectors and the fuel connectors. Use socket J 8932-01 to tighten the connections to 12-15 lb-ft (16-20 Nm) torque.

> **CAUTION**: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

15. Set the injector control tube assembly in place on the cylinder head and install the attaching bolts finger tight. When positioning the control tube, be sure the ball end of each injector rack control lever engages the slot in the corresponding injector control rack. With one end of the control tube return spring hooked around an injector rack control lever and the other end hooked around a control tube bracket, tighten the bracket bolts to 10-12 lb-ft (14-16 Nm) torque.

16. After tightening the bolts, revolve the injector control tube to be sure the return spring pulls the injector racks out (no-fuel position) after they have been moved all the way in (full-fuel position). Since the injector control tube is mounted in self-aligning bearings, tapping the tube lightly will remove any bind that may exist. The injector racks must return to the no-fuel position freely by aid of the return spring only. Do not bend the spring. If necessary, replace the spring.

17. Attach the fuel rod to the differential lever in the governor housing. Secure the governor to the cylinder head with bolts and lock washers.

18. Connect the governor fuel rod to the injector control tube lever.

19. Install the fuel filter and connect the fuel lines.

20. Install the exhaust manifold.

21. If used, install the water manifold.

22. Install the temperature gage thermocouple in the adaptor at the rear end of the water manifold.

23. Install the thermostat and secure the thermostat

housing to the water manifold with four bolts and lock washers.

24. Install the hose between the thermostat housing outlet elbow and the radiator and secure it with two clamps.

25. Install any other equipment or parts that were previously removed.

26. Refer to Section 13.1 under Preparation for Starting Engine First Time and fill the cooling system and lubrication system.

27. Before starting the engine, perform an engine tune-up as outlined in Section 14.

VALVE AND INJECTOR OPERATING MECHANISM

Three rocker arms are provided for each cylinder (Fig. 1); the two outer arms operate the exhaust valves and the center arm operates the fuel injector.

Each set of three rocker arms pivots on a shaft supported by two brackets. A single bolt secures each bracket to the top of the cylinder head. Removal of the two bracket bolts permits the rocker arm assembly for one cylinder to be raised, providing easy access to the fuel injector and the exhaust valve springs.

The rocker arms are operated by the camshaft through cam followers and short push rods extending through the cylinder head.

Each cam follower operates in a bore in the cylinder head. A guide for each set of three cam followers is attached to the bottom of the cylinder head to retain the cam followers in place and to align the cam follower rollers with the camshaft lobes.

A coil spring, inside of each cam follower, maintains a pre-determined load on the cam follower to ensure contact of the cam roller on the camshaft lobe at all times.

Lubrication

The valve and injector operating mechanism is lubricated by oil from a longitudinal oil passage on the camshaft side of the cylinder head, which connects with the main

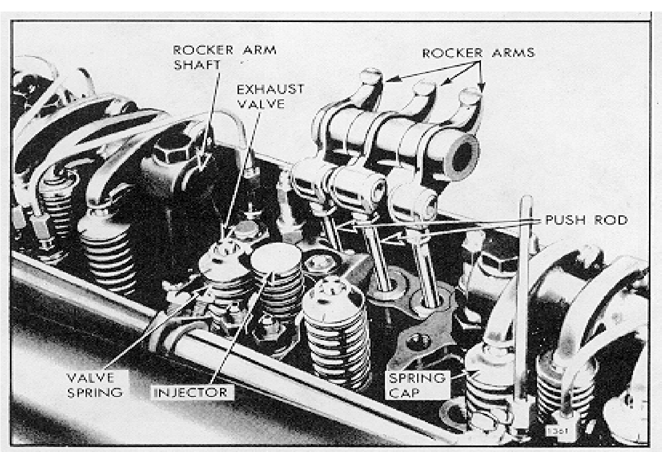


Fig. 1-Valve and Injector operating Mechanism (Two-Valve Head)

with the main oil gallery in the cylinder block. Oil from this passage flows through drilled passages in the rocker shaft bracket bolts to the passages in the rocker arm shaft to lubricate the rocker arms (Fig. 2).

Overflow oil from the rocker arms lubricates the exhaust valves, valve bridges and cam followers. The oil then drains from the top deck of the cylinder head through oil holes in the cam followers, into the camshaft pockets in the cylinder block and back to the oil pan.

The cam follower rollers are lubricated with oil from the cam followers, oil picked up by the camshaft lobes and by oil emitted under pressure from milled slots in the camshaft intermediate bearings.

Lubrication of the rocker arms and shafts on aluminum cylinder heads is provided by a vertical oil passage at one end of the cylinder head that aligns with the oil gallery in the cylinder block. Lubricating oil from this vertical passage enters the rocker arm shaft bracket through an elongated hole in the end of a spacer between the cylinder head and the rockershaft bracket and fills the cavity surrounding the bracket hold-down bolt. The oil flows to the passages in the rocker arm shaft and then to the cavity surrounding the hold-down bolt in the opposite rocker shaft bracket. From this bracket, which is assembled on top of one end of a slotted intermediate spacer, oil passes along a slot in the spacer to the adjacent bracket mounted on the other end of the spacer. The intermediate spacers thus serve to channel lubricating oil from one valve and injector rocker arm unit to the adjacent unit.

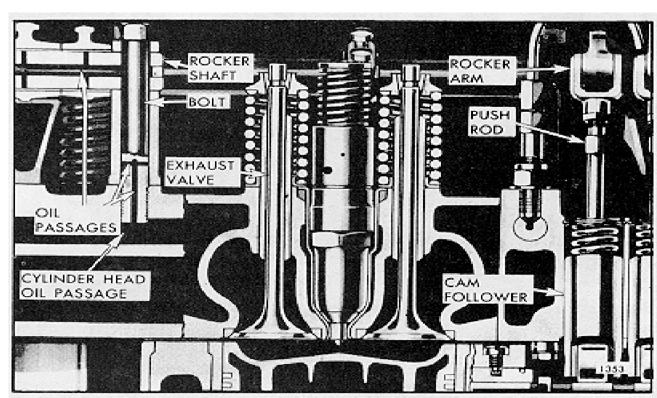


Fig. 2-Lubrication of Valve Operating Mechanism

Service

Some service operations may be performed on the valve and injector operating mechanism without removing the cylinder head:

1. Adjust valve clearance.
2. Replace a valve spring.
3. Replace or adjust an exhaust valve bridge or replace a valve bridge guide (four-valve head).
4. Replace a rocker arm.
5. Replace a rocker arm shaft or bracket.
6. Replace a fuel injector.

It is also possible to replace a push rod, push rod spring, the spring seats or a cam follower without removing the cylinder head. However, these parts are more easily changed from the lower side when the cylinder head is off the engine. Both methods are covered in this section.

To replace the exhaust valves, valve guides and valve seat inserts, the cylinder head must be removed (refer to Section 1.2.2).

Remove Rocker Arms and Shaft

1. Clean and remove the valve rocker cover.
2. Remove the fuel pipes from the injector and the fuel connectors.

   CAUTION: Immediately after removing the fuel pipes, cover the injector fuel inlet and outlet openings with shipping caps to prevent dirt or foreign material from entering.

3. Turn the crankshaft, or crank the engine with the starting motor, to bring the injector and valve rocker arms in line horizontally.

   CAUTION: Do not bar the crankshaft in a left-hand direction of rotation with a wrench or barring tool on the crankshaft bolt, or the bolt may be loosened.

4. Remove the two bolts which secure the rocker arm shaft brackets to the cylinder head. Remove the brackets and shaft.

   CAUTION: When removing the rocker arm shaft, fold the three rocker arms back just far enough so the shaft can be removed. *Do not force the rocker arms all the way back with the shaft in place as this may impose a load that could bend the push rods.*

5. Loosen the lock nuts at the upper ends of the push rods, next to the clevises, and unscrew the rocker arms from the push rods.

   NOTE: If the rocker arms and shafts from two or more cylinders are to be removed, tag them so they may be reinstalled in their original positions.

Inspection

Wash the rocker arms, shaft, brackets and bolts with clean fuel oil. Use a small wire to clean out the drilled oil passages in the rocker arms and rocker shaft bolts. Dry the parts with compressed air.

Inspect the rocker arm shaft and rocker arm bushings for wear. A maximum shaft to bushing clearance of .004" is allowable with used parts (refer to Section 1.0). Service replacement bushings must be reamed to size after installation.

The current injector rocker arm used on coach engines does not use a bushing at the push rod clevis. The bore area is "lubrited" to provide improved lubrication in this area.

Inspect the rocker arms for galling or wear on the pallets (valve or injector contact surfaces). If worn, the

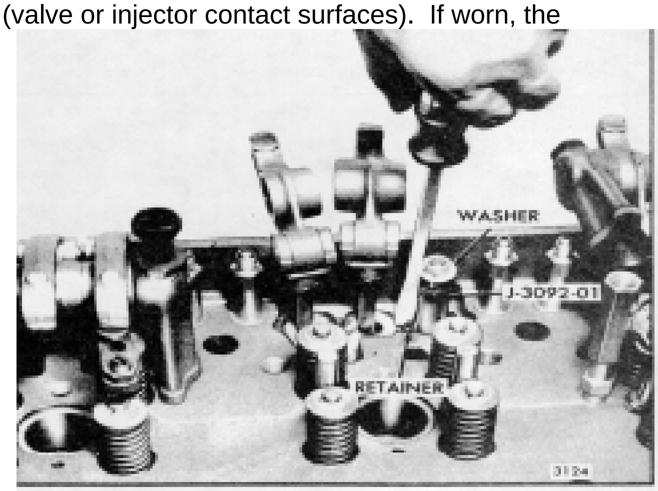


Fig. 3 - Removing Push Rod from Upper Side of Cylinder Head

surface may be refaced up to a maximum of .010". However, proceed with caution when surface grinding to avoid overheating the rocker arm. Maintain the radius and finish as close to the original surface as possible. Also inspect the valve bridges (four-valve head) for wear.

Remove Cam Follower and Push Rod (with Cylinder Head on Engine)

When removing the cam followers and associated parts, tag them so they may be reinstalled in their original location.

To remove a push rod, spring, spring seats and cam follower from the top of the cylinder head, proceed as follows:

1. Remove the rocker arm shaft and brackets as outlined under Remove Rocker Arms and Shaft.
2. Loosen the lock nut and unscrew the rocker arm from the push rod to be removed. Remove the lock nut.
3. Install remover J 3092-01, a flat washer and the lock nut on the push rod, with the lower end of the tool resting on the upper spring seat.
4. Thread the nut down to compress the spring.
5. Remove the spring seat retainer from the groove in the cylinder head (Fig. 3).
6. Unscrew the lock nut to release the spring. Then remove the nut, flat washer and tool from the push rod.

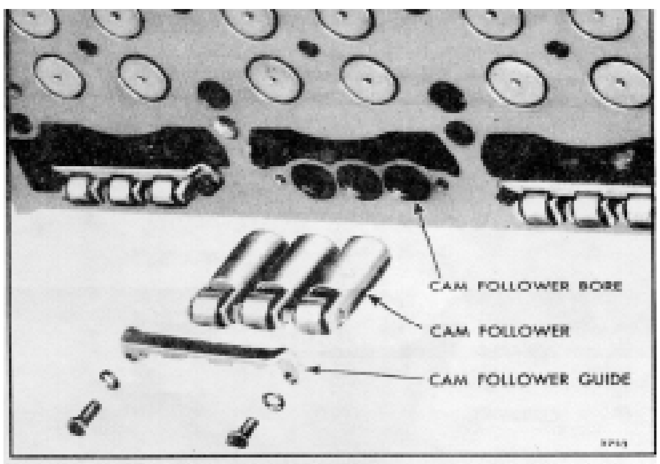


Fig. 4. Cam Followers and Guide.

7. Pull the push rod, spring, spring seats and cam follower out of the cylinder head.

Remove Cam Follower and Push Rod (Cylinder Head Removed)

When removing the cam followers and associated paits, tag them so they may be reinstalled in their original location.

1. Rest the cylinder head on its side (Fig. 4) and remove the cam follower guide.
2. Pull the cam follower out of the cylinder head.
3. Remove the fuel pipes from the injector and the fuel connectors.

   CAUTION: Immediately after removing the fuel pipes, cover the' injector fuel inlet and outlet openings with shipping caps to prevent dirt or foreign material from entering.
4. Loosen the push rod lock nut and unscrew the push rod from the rocker arm clevis.
5. Pull the push rod and spring assembly from the bottom of the cylinder head.
6. Remove the push rod lock nut, spring and spring seats from the push rod.

If the cylinder head is to be replaced, remove the spring retainers and install them in the new head.

Inspection

Proper inspection and service of the cam follower is very necessary to obtain continued efficient engine performance. When any appreciable change in injector timing or exhaust valve clearance occurs during engine operation, remove the cam followers and their related parts and inspect them for excessive wear. This change in injector timing or valve clearance can usually be detected by excessive noise at idle speed.

Wash the cam followers with lubricating oil or Cindol 1705 and wipe dry. Do not usefuel old. Fuel oil working its way in between the cam roller bushing and pin may cause scoring on initial start-up of the engine since fuel oil does not provide adequate lubrication. The push rods, springs and spring seats may be washed with clean fuel oil and dried with compressed air.

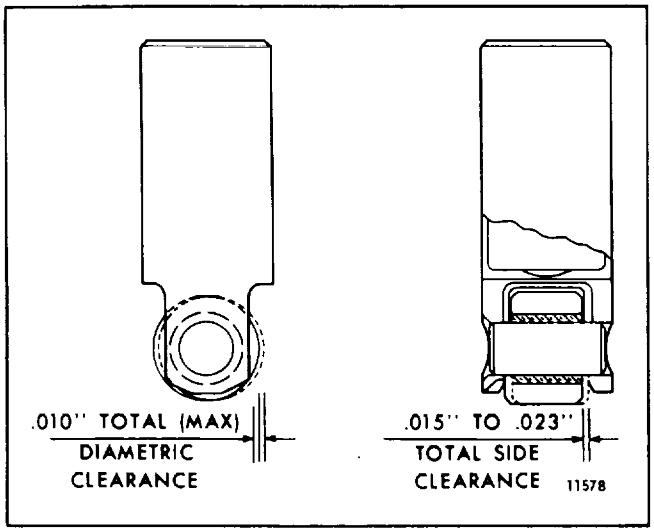


Fig. 5 Cam Roller Clearances

Examine the cam follower rollers for scoring, pitting or flat spots. The rollers must turn freely on their pins. Measure the total diametric clearance and side clearance. Install a new roller and pin if the clearances exceed those specified in Fig. 5. Cam followers stamped with the letter "S" on the pin, roller and follower body are equipped with an oversize pin and roller. The same clearances apply to either a standard or oversize cam follower assembly.

Examine the camshaft lobes for scoring, pitting or flat spots. Replace the camshaft if necesary.

Check the cam follower-to-cylinder head clearance. The Clearance must not exceed .006 " with used parts.

Examine the cam follower bores in the cylinder head to make sure they are clean, smooth and free of score marks. If necessary, clean-up the bores.

Inspect the push rods and spring seats for wear. The current push rods have milled wrench flats and a bright "turned" finish and the lower spring seats are serrated along the push rod contact surfaces (Fig. 6).

CAUTION: When replacing a push rod or lower spring seat, do not use a plain spring seat (Fig. 6) with a current type push rod. Any other combination of spring seat and push rod may
be used.

Examine the cam follower springs for wear or damage and check the spring load. Replace a spring when a load of less than 172 lbs. (765 N) will compress it to a length of 2.125". Use spring tester J 9666 and an accurate torque wrench to check the spring load (Fig. 7).

Replace Cam Roller and Pin

To replace a cam roller and pin, proceed as follows:

> **CAUTION:** Do not attempt to bore out the legs of a standard cam follower for an oversize pin.

I. Clamp fixture J 5840 securely in a vise as shown in Fig. 8. Then place the cam follower in the groove in

Fig. 6 - Comparison of Push Rods and Lower Spring eats

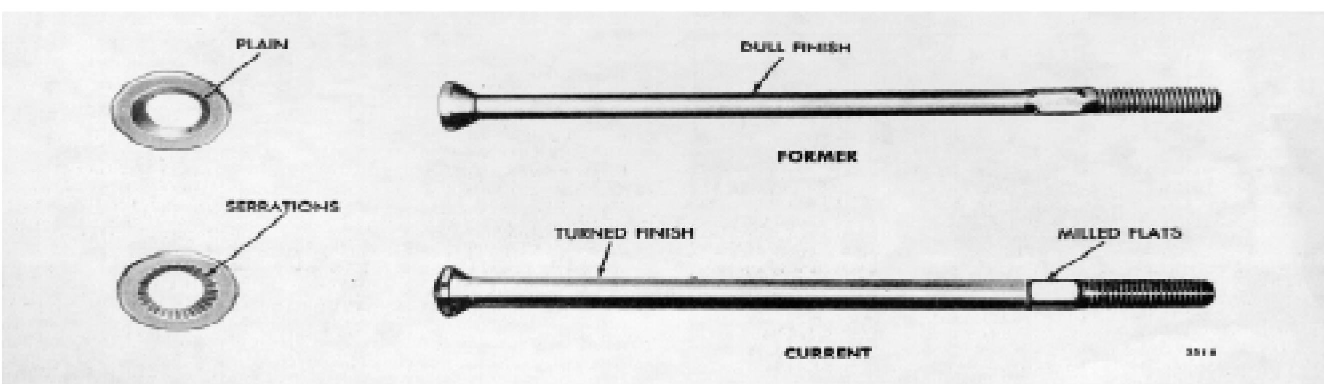


Fig. 6 - Comparison of Push Rods and Lower Spring Seats

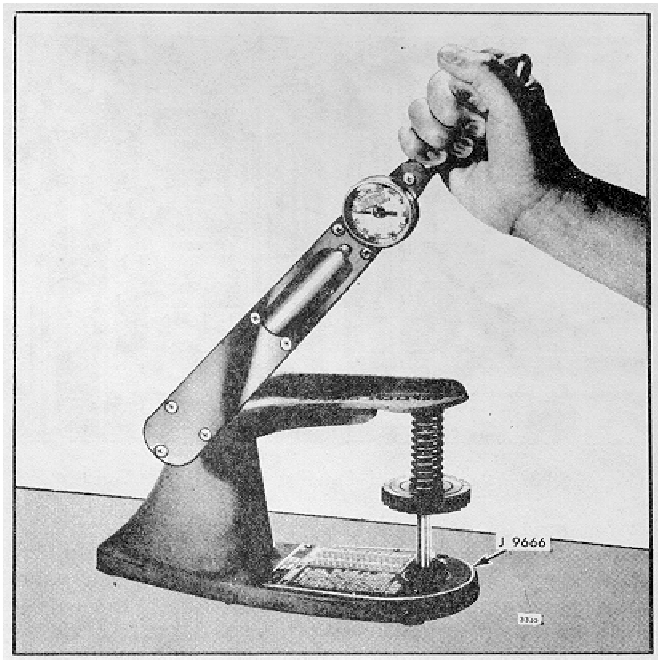


Fig. 7 Testing Cam Follower Spring

the top of the fixture, with the follower pin resting on top of the corresponding size plunger in the fixture.

2. Drive the pin from the roller with a suitable drift. Exercise caution in removing the cam follower body and roller from the fixture as the roller pin is seated on a spring-loaded plunger in the fixture.

3. Before installing the new roller and pin, remove the preservative by washing the parts with clean lubricating oil or Cindol 1705 and wipe dry. Do not use fuel oil. After washing the parts, lubricate the roller and pin with Cindol 1705.

4. Position the cam follower body in the groove of the fixture, with the small plunger extending through the roller pin hole in the lower leg of the follower body.

5. Position the new cam roller in the cam follower body. When released, the plunger will extend into the roller bushing and align the roller with the cam follower body.

6. Start the new pin in the cam follower body, then carefully tap it in until it is centered in the can follower body.

7. Remove the cam follower from the fixture and

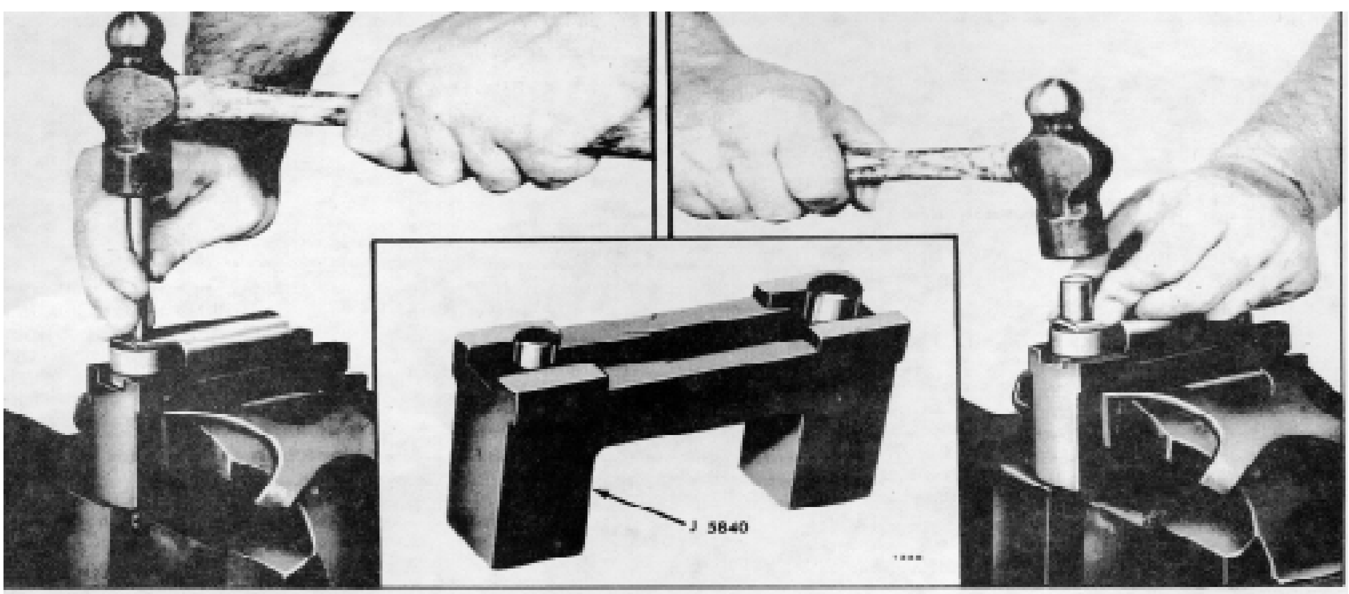


Fig. 8-Removing or Installing Cam Follower Roller

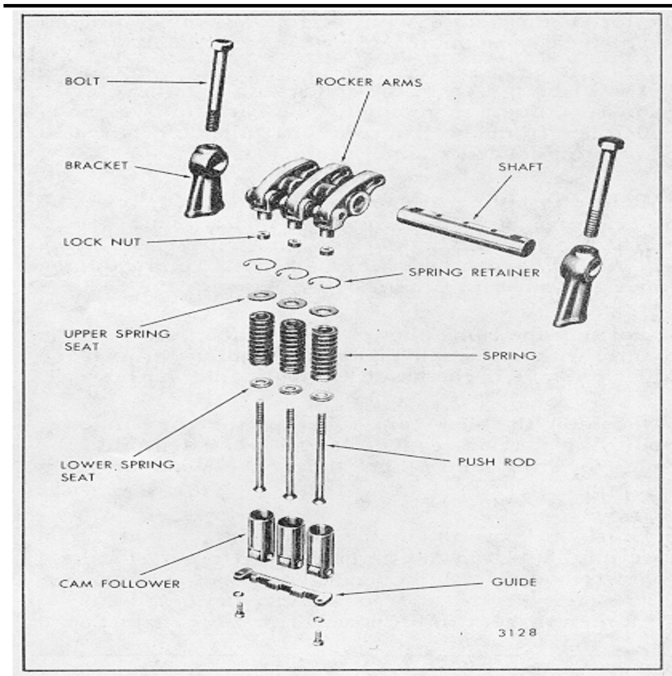


Fig. 9 - Valve and Injector Operating Mechanism and Relative Location of Parts

check the side clearance (Fig. 5). The clearance must be .015" to .023".

Install Cam Follower and Push Rod

If new cam follower assemblies are to be installed, remove the preservative by washing with Cindol 1705 and wipe dry. *Do not usefuel oil.*

Before cam followers are installed, immerse them in clean Cindol 1705 (heated to 100-125°F or 38-52-C) for at least one hour to ensure initial lubrication of the am roller pins and bushings. Rotate the cam rollers during the soaking period to purge any air from the bushing-roller area. The heated Cindol oil results in better penetration as it is less viscous than engine oil and flows more easily between the cam roller bushing and pin. After the cam followers are removed from the heated Cindol 1705, the cooling action of any air trapped in the bushing and pin area will tend to pull the lubricant into the cavity.

NOTE: Heat the Cindol 1705 in a small pail

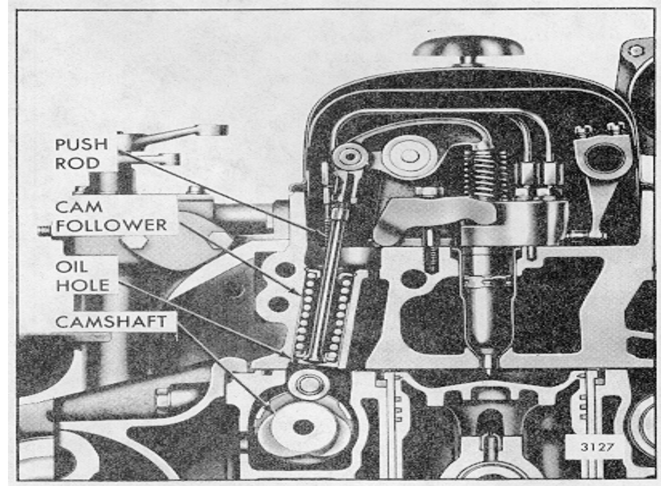


Fig. 10 - Installation of Cam Followers

with a screen insert. The screen will prevent the cam followers from touching the bottom of the pail and avoid the possibility of contamination.

Install used cam followers and push rods in their original locations. Refer to Fig. 9 and proceed as follows:

CYLINDER HEAD ON ENGINE:

1. Note the oil hole in the bottom of the cam follower. With the oil hole directed away from the exhaust valves (Fig. 10), slide the cam follower in position in the cylinder head.

2. Assemble the serrated lower spring seat (Fig. 6), spring and upper spring seat on the push rod.

3. Place a flat washer over the upper spring seat and start the lock nut on the push rod. Place tool J 3092-01 on the push rod between the washer and the upper spring seat and place the push rod assembly in- the cam follower. Then thread the lock nut on the push rod until the spring is compressed sufficiently to permit the spring retainer to be installed. Install the retainer with the tangs facing the notch in the cylinder head.

4. Remove the nut, flat washer and tool. Then reinstall the lock nut and thread it as far as possible on the push rod.

CYLINDER HEAD REMOVED FROM ENGINE:

Refer to Fig. 9 and install the cam follower and pushrod as follows:

1. Assemble the serrated lower spring seat (Fig. 6), spring, upper spring seat and lock nut on the push rod.

2. With the spring retainer in place in the cylinder head, slide the push rod assembly in position from the bottom of the head.

3. Note the oil hole in the bottom of the cam follower. With the oil hole directed away from the exhaust valves (Fig. 10), slide the cam follower in position from the bottom of the head.

4. Attach the follower guide to the cylinder head to hold the group of three cam followers in place. Check to make sure there is clearance between the cam followers and the cam follower guide. Tighten the guide bolts to 12-15 Ib-ft (16-20 Nm) torque (cast iron head) or 7-9 Ib-ft (0.8-1.02 Nm) torque (aluminum head).

Install Rocker Arms and Shaft

Note that the injector rocker arm (center arm of the group) is slightly different from the exhaust valve rocker arms; the boss for the shaft on the left and right-hand valve rocker arms is longer on one side. The extended boss of each valve rocker arm must face toward the injector rocker arm.

1. Thread each rocker arm on its push rod until the end of the push rod is flush with or above the inner side of the clevis yoke. This will provide sufficient initial clearance between the exhaust valve and the piston when the crankshaft is turned during the valve clearance adjustment procedure.

2. If removed, install the cylinder head on the engine (refer to Section 1.2).

3. Lubricate the valve bridge guides (four-valve cylinder head) with sulphurized oil (E.P. type) and position the valve bridges in place on the guides. Refer to Exhaust Valve Bridge Adjustment in Section 1.2.2 and adjust the valve bridges.

4. If removed, install the fuel injectors.

5. Apply clean engine oil to the rocker arm shaft and slide the shaft through the rocker arms. Then place a bracket over each end of the shaft, with the finished face of the bracket next to the rocker arm.

6. Insert the rocker arm bracket bolts through the brackets and the shaft. Tighten the bolts to the specified torque (refer to Section 1.0).

7. Align the fuel pipes and connect them to the injectors and fuel connectors. Tighten the fuel pipe nuts to 12-15 lb-ft (16-20 Nm) torque using socket J 8932-01.

> **CAUTION**: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

8. Fill the cooling system.

9. Adjust the exhaust valve clearance (Section 14.1) and time the injectors (Section 14.2).

10. If necessary, perform an engine tune-up.

EXHAUST VALVES

Four exhaust valves are provided for each cylinder (Fig. 2). The valve heads are heat treated and ground to the proper seat angle and diameter, and the valve stems are ground to size and hardened at the end which contacts the rocker arm or exhaust valve bridge.

Pre-finished replaceable valve guides are pressed into the cylinder head (Fig. 3). Reaming of these guides is unnecessary. Certain engines are equipped with exhaust valve guide oil seals.

Exhaust valve seat inserts are pressed into the cylinder head and permit accurate seating of the exhaust valves under varying conditions of temperature and materially prolong the life of the cylinder head (Fig. 3). The inserts are ground to very close limits and the freedom from warpage, under ordinary conditions, reduces valve reconditioning to a minimum. The exhaust valves and valve seat inserts are ground to an approximate 30" seating angle.

The exhaust valve springs are held in place by the valve spring caps and tapered two-piece valve locks (Fig. 3).

Excess oil from the rocker arms lubricates the exhaust valve stems. The valves are cooled by the flow of air from the blower past the valves each time the air inlet ports are uncovered.

Exhaust Valve Clearance
Correct valve clearance adjustment is important

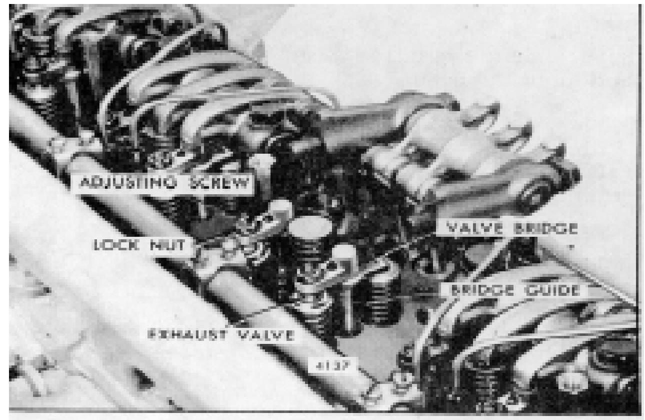


Fig. 2 - Location of Exhaust Valves

for proper operation of the engine. Too little clearance between the exhaust valve stem and the rocker arm causes a loss of compression, misfiring cylinder, and eventual burning of the valves and valve seat inserts. Too much clearance results in noisy operation of the engine, especially in the idling speed range. Refer to Section 14.1 for the procedure to be followed when adjusting the valve clearance.

Exhaust Valve Maintenance

Efficient combustion in the engine requires that the exhaust valves be maintained in good operating condition. Valve seats must be true and unpitted to assure leakproof seating, valve stems must work freely and smoothly within the valve guides, and the correct valve clearance must be provided.

Proper maintenance and operation of the engine is important to long valve life. Engine operating temperature should be maintained between 160°F. And 1850F. Low operating temperatures, usually due to extended periods of idling or light engine loads, result in incomplete combustion, formation of excessive carbon deposits and fuel lacquers on valves and related parts, and a greater tendency for lubricating oil to sludge.

Lubricating oil and oil filters should be changed periodically to avoid the accumulation of sludge. Use only good quality oil as specified for the engine.

Unsuitable fuels may also cause formation of deposits on the valves, especially when operating at low temperatures.

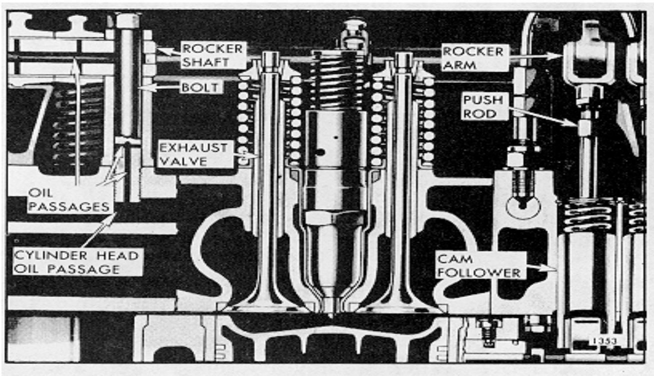


Fig. 3 - Assembly of Exhaust Valves and Guides

When carbon deposits, due to partially burned fuel, build up around the valve stems and extend to that portion of the stem which operates in the valve guide, sticking valves will result. Thus, the valves cannot seat properly and pitted and burned valves and valve seats and loss of compression will result.

Valve sticking may also result from valve stems which have been scored due to foreign matter in the lubricating oil, leakage of antifreeze (glycol) into the lubricating oil which forms a soft sticky carbon and gums the valve stems, and bent or worn valve guides. Sticking valves may eventually result in valves being held in the open position, being struck by the piston and becoming bent or broken.

It is highly important that injector timing and valve clearance be accurately adjusted and inspected periodically. Improperly timed injectors will have adverse effects upon combustion. Tightly adjusted valves will cause rapid pitting of the valve seats and a hotter running condition on the valve stems.

The cylinder head must first be removed before the exhaust valves, valve seat inserts or valve guides can be removed for replacement or reconditioning. However, the valve springs may be removed without removing the cylinder head, if necessary.

Remove Exhaust Valve Spring

It is possible, if occasion requires, to remove or replace the exhaust valve springs without removing the cylinder head. The springs, however, are normally removed when the head is off the engine.

To remove an exhaust valve spring without removing the cylinder head from the engine, proceed as follows:

1. Remove the valve rocker cover.

2. Rotate the crankshaft to bring the valve and injector rocker arms in line horizontally.

> **NOTE**: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt will be loosened.

3. Disconnect and remove the fuel pipes from the injectors and the fuel connectors.

> **CAUTION**: Immediately after removing the fuel pipes, cover each injector opening with a shipping cap to prevent dirt or other foreign matter from entering the injector.

4. Remove the two bolts holding the rocker arm shaft brackets to the cylinder head. Then, remove the brackets and shaft.

5. Remove the exhaust valve bridge (four valve cylinder head only), and bridge spring, if used.

6. Remove the cylinder block air box cover so piston travel may be observed; then, turn the crankshaft until the piston is at the top of its stroke.

7. Thread the valve spring compressor adaptor J 7455-7 into the rocker shaft bolt hole in the cylinder head. Apply pressure to the end of the valve spring compressor handle J 7455-3

Fig. 4 - Removing Exhaust Valve Spring with Tool J 7455

to compress the valve spring. Remove the two-piece tapered valve lock (Fig. 4).

8. Release the tool and remove the spring cap, valve spring and spring seat; also remove and discard the valve guide oil seal if used.

To remove an exhaust valve spring with the cylinder head removed from the engine, use the following procedure:

1. Support the cylinder head on wood blocks 2" thick to keep the cam followers clear of the work bench.
2. Remove the fuel pipes from the injector and the fuel connectors.
3. Remove the two bolts holding the rocker arm shaft bracket to the cylinder head. Lift the rocker arms and brackets up and away from the injector.
4. Remove the fuel injector.
5. Remove the exhaust valve bridges and bridge springs, if used.
6. Remove the exhaust valve spring from the cylinder head as previously outlined above. In addition, use a block of wood under the cylinder head to support the exhaust valve.
7. Remove the cam followers and push rod assemblies as outlined in Section 1.2.1 under "Remove Cam Follower and Push Rod Assembly (Cylinder Head Removed from Engine)".

Inspect Exhaust Valve Spring

Clean the spring with fuel oil and dry it with compressed air. Then inspect the spring for pitted or fractured coils. Use spring tester J 9666 and any accurate torque wrench to check the spring load (Fig. 5).

Replace the exhaust valve spring, used on the two-valve cylinder head, when a load of less than 25 pounds will compress it to 2.20" (installed length).

The exhaust valve spring used on the current four valve cylinder head has an outside diameter of approximately 61/64". Replace this spring when a load of less than 25 pounds will compress it to 1.80" (installed length).

On former four valve cylinder heads a lighter exhaust valve spring (55/64" O.D.) was used for each valve and also for the valve bridge. Replace this spring when a load of less than 79 pounds will compress it to a length of 1.416". When replacement of either the exhaust valve spring or valve bridge spring is required, it will be necessary to use the current larger exhaust valve

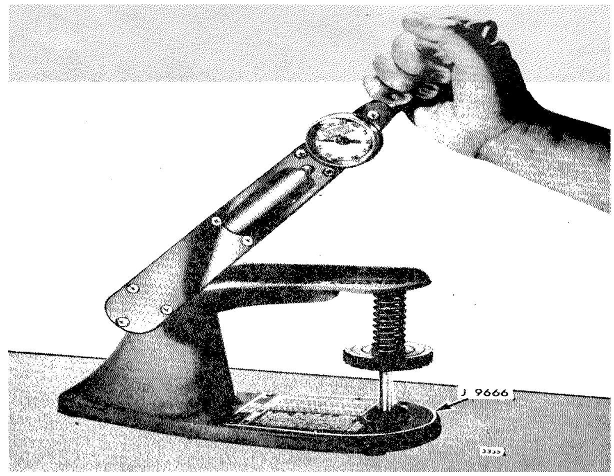


Fig. 5 - Testing Exhaust Valve Spring

springs, spring seats and caps, as the valve bridge spring is no longer required.

Inspect the valve spring seats and caps for wear. If worn, replace.

Examine the contact surfaces of the exhaust valve bridge guides, bridges and adjusting screws for wear and galling. Replace excessively worn parts.

Remove Exhaust Valves

With the cylinder head off the engine, remove the exhaust valves as follows:

1. Remove the valve springs as outlined under "Remove Exhaust Valve Spring" in this section.
2. Turn the cylinder head over on its side, using care to keep the valves from dropping out.
3. Number each valve to facilitate re-installation in the same position. Then, withdraw the valves from the cylinder head.

Inspect Exhaust Valves

Carbon on the face of a valve indicates blowby due to a faulty seat. Black carbon deposits extending from the valve seats to the valve guides may result from cold operation due to light loads or the use of too light a grade of fuel. Rusty brown valve heads with carbon deposits forming narrow collars near

1.2.2 EXHAUST VALVES

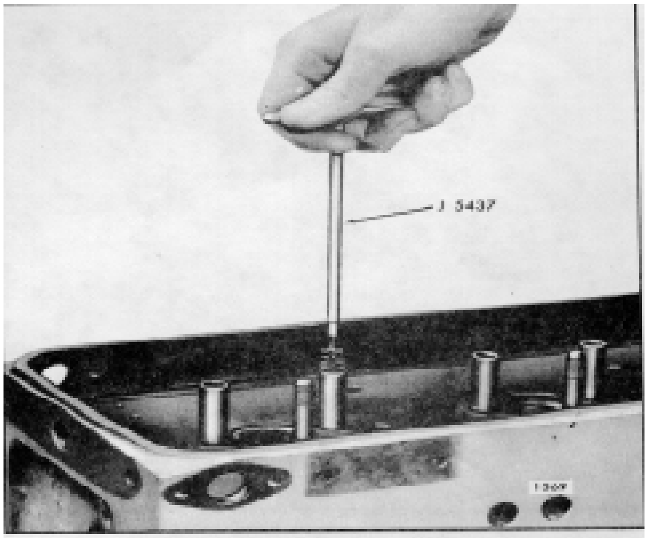


Fig. 6 - Cleaning Exhaust Valve Guide

the valve guides evidence hot operation due to overloads, inadequate cooling, or improper timing which results in carbonization of the lubricating oil.

Clean the carbon from the valve stems and wash the valves with fuel oil. The valve stems must be free from scratches or scuff marks and the valve faces must be free from ridges, cracks, or pitting. If necessary, reface the valves or install new valves. If the valve heads are warped, replace the valves.

If there is evidence of engine oil running down the exhaust valve stem into the exhaust chamber, creating a high oil consumption condition because of excessive idling and resultant low engine exhaust back pressure, install valve guide oil seals.

Inspect Exhaust Valve Guides
Clean the inside diameter of the valve guides with brush J 5437 (Fig. 6). This brush will remove all gum or carbon deposits from the guides, including the spiral grooves.

Inspect the valve guides for fractures, chipping, scoring, or excessive wear. Check the valve-to-guide clearance, since worn valve guides may eventually result in improper valve seat contact. If the clearance exceeds 005", replace the valve guides.

The current valve guides (Fig. 7) are machined at the upper end. They replace the former 45° chamfered valve guides.

Remove Exhaust Valve Guide
1. Support the cylinder head, bottom side up, on 2" thick wood blocks.
2. Drive the valve guide out from the bottom of the cylinder head with tool J 6569.

Install Exhaust Valve Guide
Place the cylinder head right side up on an arbor press and install the valve guide as follows:

1. Insert the internally threaded end of the valve guide in the proper valve guide installing tool (refer to chart). Be sure to use the correct tool to avoid damage to the valve guide, and to locate the valve guide to the proper dimension.

   When replacing valve guides, the current guide which is machined for use with a valve guide seal should be used in place of the 45° chamfered valve guide (Fig. 7). The current guide will facilitate field installation of valve guide seals when it is felt their use will be beneficial.

CAUTION: Be sure to use the correct installing tool, otherwise damage to the valve guide will result.

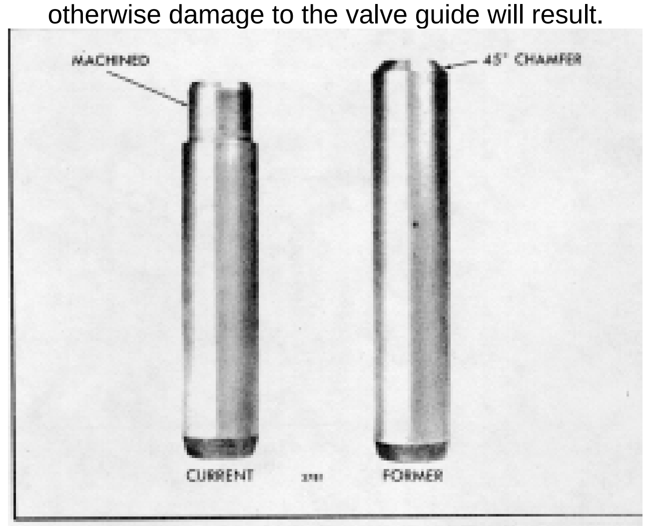


Fig. 7 - Former and Current Valve Guides Used in Cylinder Head

VALVE GUIDE INSTALLER CHART

Tool No	Cylinder Head	Valve Guide	Distance Of Guide Above Top Of Head
J 9729 J 21520	4 Valve 4 Valve	450 Chamfer Machined	.880" .690"

2. Position the valve guide squarely in the bore in the cylinder head and press the installing tool gently to start the guide in place (Fig. 8). Then, press the guide in until the tool contacts the cylinder head.

CAUTION: Do not use the valve guides as a means of turning the cylinder head over or in handling the cylinder head.

Service replacement valve guides are completely finish reamed during manufacture and, therefore, do not require reaming after installation.

Inspect Exhaust Valve Bridge and Guide

Inspect the valve bridge guide, valve bridge, and adjusting screw for wear. Replace excessively worn parts.

Former engines were equipped with spring-loaded exhaust valve bridges. The valve bridge guides were threaded into the cylinder head and incorporated integral spring seats (Fig. 9). The threaded valve bridge guides were replaced by press-fit guides. To conform with this

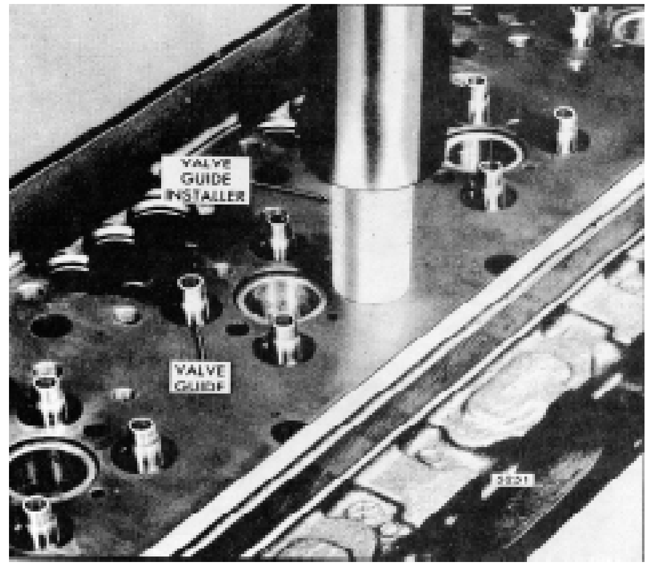


Fig. 8 - Installing Valve Guide

change, current cylinder heads incorporate reamed valve bridge guide holes in place of the 7/16"-14 tapped holes. To permit the use of spring-loaded valve bridges on a replacement cylinder head which incorporates the press-fit guides, separate valve bridge spring seats were used.

The press-fit valve bridge guide is hardened steel while the valve bridge is relatively soft steel. The former threaded valve bridge guide was soft steel

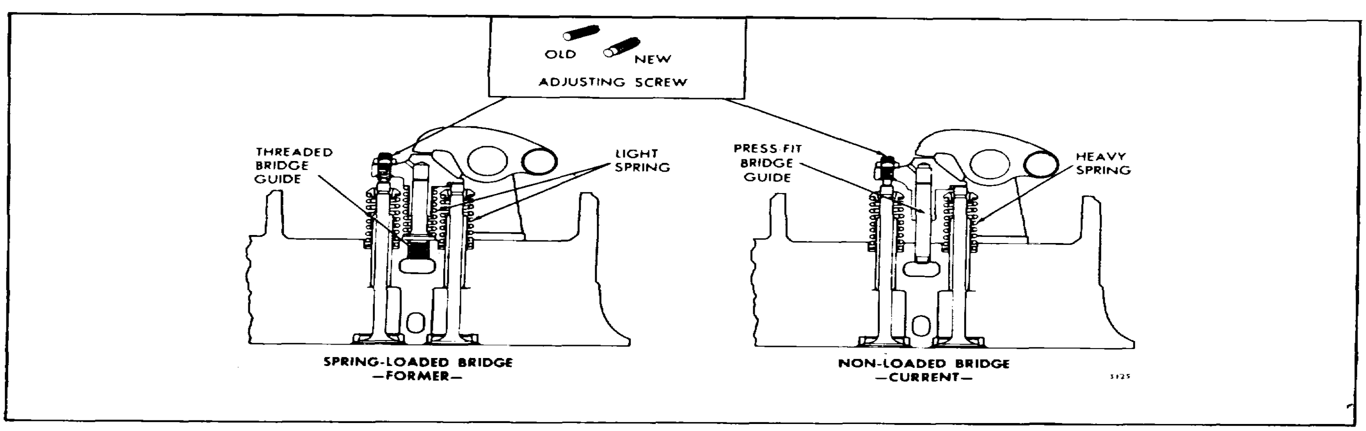


Fig.9 -- Exhaust Valve Bridge and Guide

1.2.2 EXHAUST VALVES

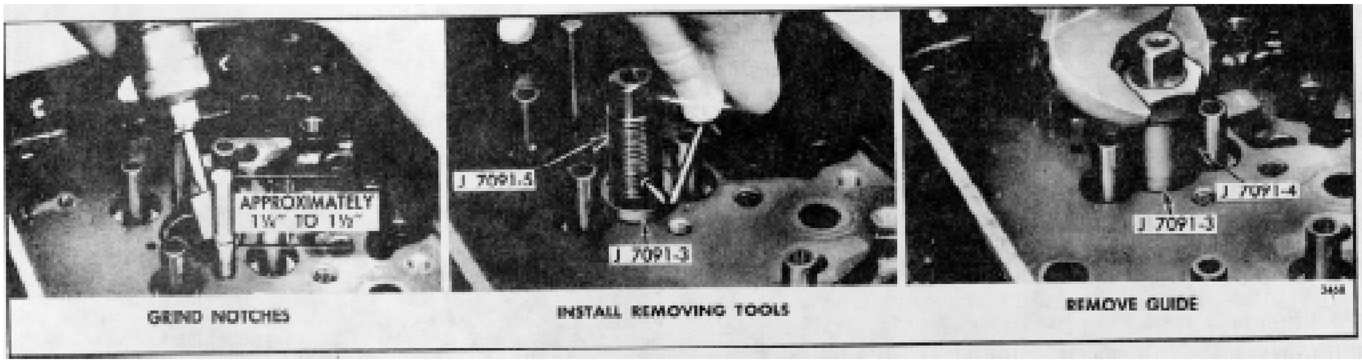


Fig. 10-Removing Press-Fit Exhaust Valve Bridge Guide

and was used with a hardened steel valve bridge. The soft valve bridge may be identified by the letter "S" forged on one side of the bridge.

Avoid a combination of a soft steel guide and soft steel bridge -- otherwise premature wear of the bridge and guide will occur. For service, a threaded valve bridge guide of hardened steel is available and is identified by a 3/16" or 1/4" drill spot in the top end.

In addition, a new valve bridge adjusting screw with a redesigned valve contact surface replaced the former adjusting screw. The new screw may be identified by the machined (undercut) surface at the lower end of the screw. Only the new adjusting screw will be available for service and it is recommended that the former adjusting screws be replaced at the time of an engine overhaul.

Remove Exhaust Valve Bridge Guide

Remove the valve bridge guide from the four valve cylinder head as outlined below:

1. Remove the former threaded guide, identified by the hexagon section at the lower end, with a J 6846 thin wall socket.

2. Remove the press-fit guide (Fig. 10) with tool set J 7091-01 as follows:

   a. File or grind two diametrically opposite notches 1/16" deep in the side of the guide, approximately 1-1/4" to 1-1/2" from the upper end.

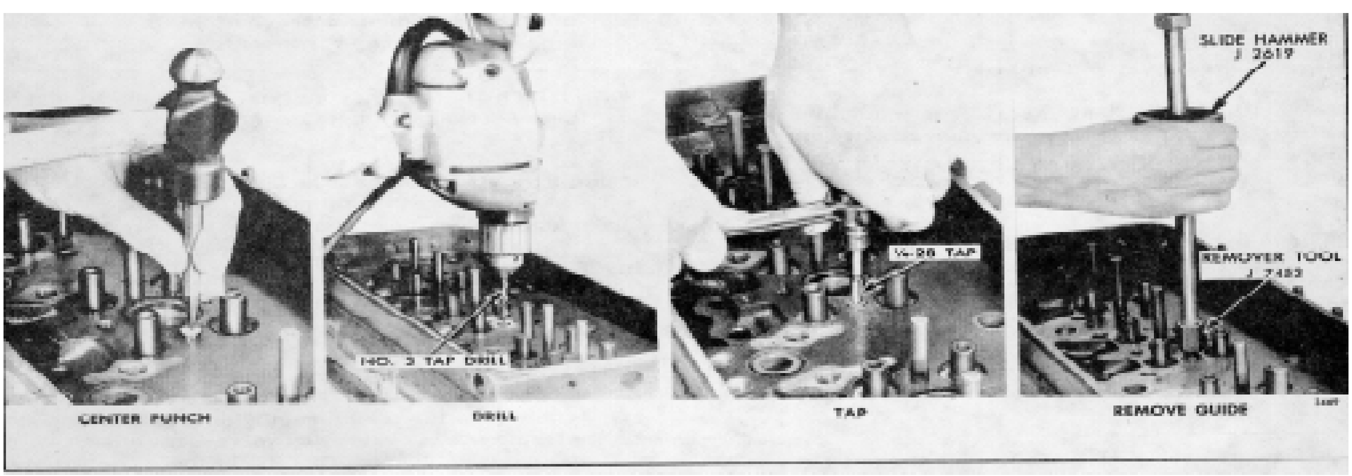


Fig. 11-Removing Broken Exhaust Valve Bridge Guide

b. Place spacer J 7091-3 over the guide. Then slide the guide remover J 7n91-5 over the guide and align the set screws with the notches in the guide. Tighten the set screws to hold the tool securely.
c. Place spacer J 7091-4 over the guide remover. Thread the nut on the guide remover and turn it clockwise to withdraw the guide from the cylinder head.

To remove a broken valve bridge guide, drill a hole approximately 1/2" deep in the end of the guide with a No. 3 (.2130") drill. Then, tap the guide with a 1/4"-28 bottoming tap. Thread remover J 7453 into the guide and attach slide hammer J 2,619 to the remover tool. One or two sharp blows with the puller weight will remove the broken guide (Fig. 11).

Install Exhaust Valve Bridge Guide

Install the former threaded valve bridge guide with a thin wall socket J 6846. Lubricate the threads and nylon insert before installing the guide. Tighten the guide to 46-50 lb-ft torque.

Install the press-fit bridge guide as follows:

1. Start the guide (undercut end first) straight into the cylinder head.
2. Place the installer J 7482 over the guide and drive it into place. The installer will properly position the guide to the correct height in the cylinder head.

Inspect Exhaust Valve Seat Insert

Inspect the valve seat inserts for excessive wear, pitting, cracking or an improper seat angle. The proper angle for the seating face of both the valve and insert is 30%.

Remove Exhaust Valve Seat Insert

The valve seat inserts are pressed into the cylinder head and, therefore, must be removed as outlined in the following procedure to avoid damage to the cylinder head.

1. Place the cylinder head on its side as shown in Fig. 12.
2. Place the collet of J 6567 inside the valve seat insert so the bottom of the collet is flush with the bottom of the insert.

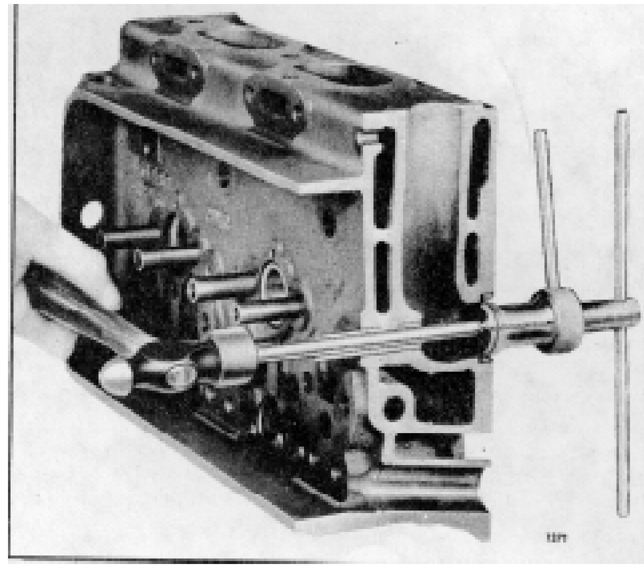


Fig. 12 - Removing Valve Seat Insert

3. Hold the collet handle and turn the T handle to expand the collet cone until the insert is held securely by the tool.

4. Insert the drive bar of the tool through the valve guide, and tap the drive bar once or twice to move the insert about 1/16".

5. Turn the T handle to loosen the collet cone and move the tool into the insert slightly so the narrow flange at the bottom of the collet is below the valve seat insert.

6. Tighten the collet cone and continue to drive the insert out of the cylinder head.

Install Exhaust Valve Seat Insert

Great care must be used during the installation of a valve seat insert since this part is a press fit in the cylinder head. Install the insert in the following manner:

1. Wash the cylinder head with fuel oil and dry it with compressed air.

2. Clean the valve insert counterbore in the cylinder head with trichloroethylene or other good solvent. Also, wash the valve seat insert with the same solvent. Dry both the counterbore and the insert with compressed air.

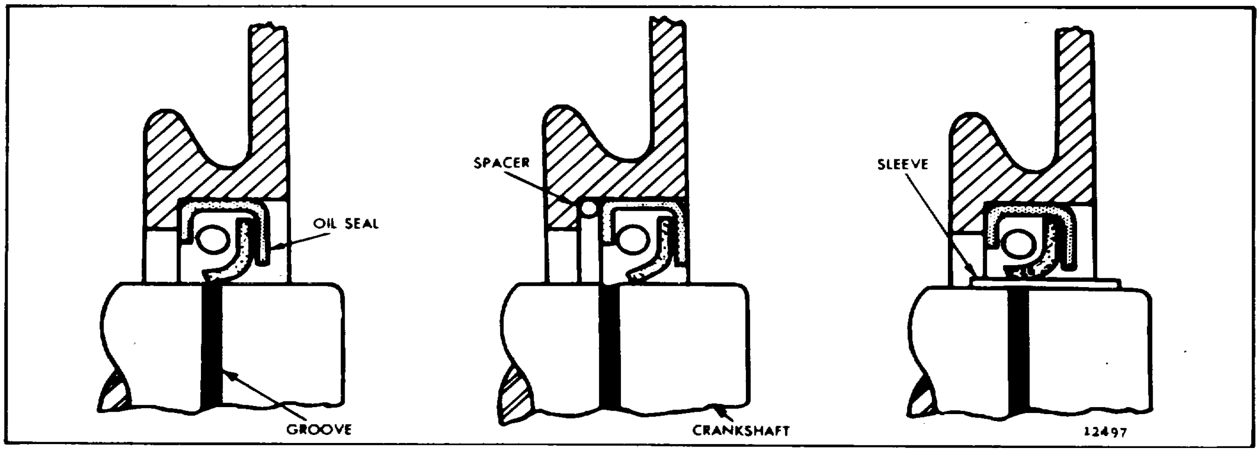


Fig. 5. Use of Rear Oil Seal Spacer or Sleeve on Grooved Crankshaft

in the front cover with the lip of the seal pointed toward the inner face of the cover.

NOTE: The vibration damper inner cone or oil seal spacer must be removed before installing the oil seal.

3. Drive the seal into the front cover with installer J 9783. The installer prevents damage to the seal by exerting force only on the outer edge of the seal casing.

4. Remove any excess sealant from the cover and seal.

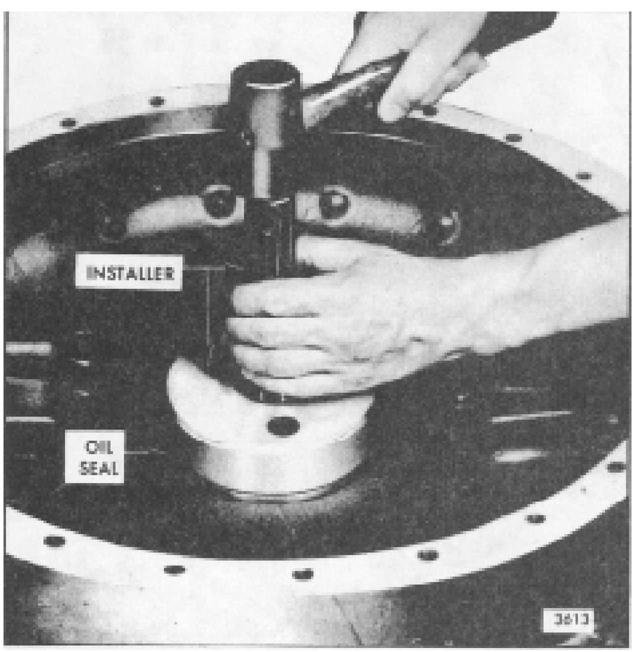


Fig. 6. Installing Oil Seal in Flywheel Housing

5. Install the crankshaft front cover as outlined in Section 1.3.5.

6. Install the vibration damper inner cone or oil seal spacer after the front cover and seal assembly is in place.

Install Crankshaft Rear Oil Seal

1. Support the inner face of the flywheel housing on a flat surface.

2. Install the rear oil seal spacer, if used. Install the spacer against the shoulder in the flywheel housing oil seal bore.

3. If the new seal is not pre-coated, apply a nonhardening sealant to the periphery of the metal casing. Then position the seal with the lip pointed toward the inner face (or shoulder in the counterbore) of the housing.

4. Coat the lip of the oil seal lightly with engine oil (single-lip seal) or vegetable shortening (double-lip seal). Do not scratch or nick the sealing edge of the oil seal.

5. Drive the seal into the housing with installer J 9727 and handle J 3154-1 (Fig. 6) until it is seated against the seal spacer (if used) or on the shoulder in the housing bore. The installer prevents damage to the seal by exerting force only on the outer edge of the seal casing.

If it is necessary to install the oil seal with the flywheel housing on the engine, place oil seal expander J 22425 (standard size seal) or expander J 4195 with handle J 8092 (oversize seal) against the end of the crankshaft. Then, with the lip of the seal pointed toward the engine, slide the seal over the tool and on the crankshaft. Remove the seal expander and drive the seal in place with installer J 9727 and handle J 3154-1.

6. Remove any excess sealant from the flywheel housing and the seal.

7. Install the flywheel housing as outlined in Section 1.5.

CAUTION: If the oil seal is of the type which incorporates a brass retainer in the inner diameter of the seal, be sure the retainer is in place on the seal before installing the flywheel housing on the engine. If the retainer is left out, oil leakage will result.

CRANKSHAFT MAIN BEARINGS

The crankshaft main bearings shells (Fig. 1) are precision made and are replaceable without machining. They consist of an upper bearing shell seated in each cylinder block main bearing support and a lower bearing shell seated in each main bearing cap. The bearing shells are prevented from endwise or radial movement by a tang at the parting line at one end of each bearing shell. The tangs on the lower bearing shells are off-center and the tangs on the upper bearing shells are centered to aid correct installation.

Various types of bearings have been used. Currently, multiple layer copper-lead coplated or aluminum triplated bearings are in use. These bearings have an inner surface, called the matrix, of copper-lead or aluminum. A thin deposit of babbitt is then plated onto the matrix. This babbitt overlay has excellent resistance to friction, corrosion and scoring tendencies which, combined with the material of the matrix, provides improved load carrying characteristics. These bearings are identified by the satin silver sheen of the babbitt when new and a dull gray after being in service.

The former copper-lead bearings had a copper color when new and turned very dark during engine operation.

An oil hole in the groove of each upper bearing shell, midway between the parting lines, registers with a vertical oil passage in the cylinder block. Lubricating oil, under pressure, passes from the cylinder block oil gallery by way of the bearing shells to the drilled passages in the crankshaft, then to the connecting rods and connecting rod bearings.

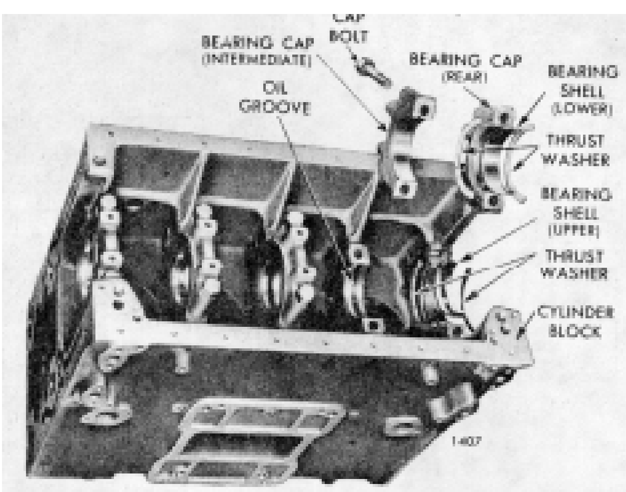


Fig. 1. Main Bearing Shells, Bearing Caps and Crankshaft Thrust Washers

The lower main bearing shells have no oil grooves; therefore, the upper and lower bearing shells must not be interchanged.

Thrust washers (Fig. 1), on each side of the rear main bearing, absorb the crankshaft thrust. The lower halves of the two-piece washers are doweled to the bearing cap: the upper halves are not doweled.

Main bearing trouble is ordinarily indicated by low or no oil pressure. All of the main bearing load is carried on the lower bearings; therefore, wear will occur on lower bearing shells first. The condition of lower bearing shells may be observed by removing the main bearing caps.

If main bearing trouble is suspected, remove the oil pan, then remove the main bearing caps, one at a time, as outlined below and examine the bearing shells.

Remove Main Bearing Shells (Crankshaft in Place)

The bearing caps are numbered 1, 2, 3, etc., indicating their respective positions and, when removed, must always be reinstalled in their original position.

All crankshaft main bearing journals, except the rear journal, are drilled for an oil passage. Therefore, the procedure for removing the upper bearing shells with the crankshaft in place is somewhat different on the drilled journals than on the rear journal.

Remove the main bearing shells as follows:

1. Drain and remove the oil pan to expose the main bearing caps.

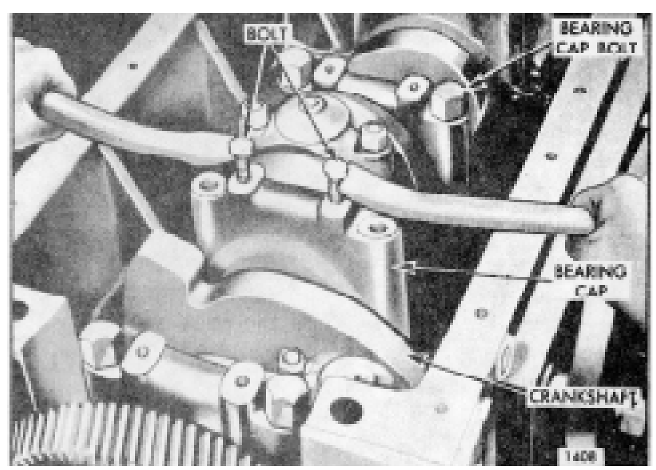


Fig. 2. Removing Main Bearing Cap

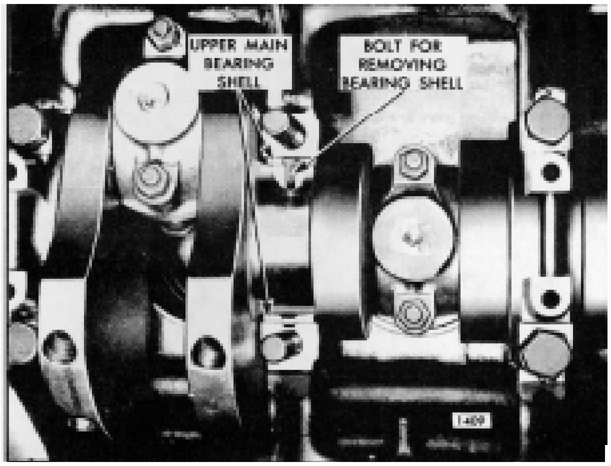


Fig. 3. Removing Upper Main Bearing Shell (Except Rear Main)

2. Remove the oil pump and the oil inlet and outlet pipe assemblies.

   NOTE: If shims are used between the oil pump and the main bearing caps, save the shims so that they may be reinstalled in exactly the same location.

3. Remove one main bearing cap at a time (Fig. 2) and inspect the bearing shells as outlined under *Inspection.* Reinstall each bearing shell and cap before removing another bearing cap:

   a. To remove all except the rear main bearing shell, insert a 1/4" x 1" bolt with a 1/2" diameter and 1/16" thick head (made from a standard bolt) into the crankshaft journal oil hole. Then revolve the shaft to the right (clockwise) and roll the bearing shell out of position as shown in Fig. 3. The bolt head must not extend beyond the outside diameter of the bearing shell.

   b. Remove the rear main bearing upper shell by tapping on the edge of the bearing with a small curved rod, revolving the crankshaft at the same time to roll the bearing shell out as shown in Fig. 4.

   c. The lower halves of the crankshaft thrust washers will be removed along with the rear main bearing cap. The upper halves of the washers can be removed for inspection by pushing on ends of washers with a small rod, forcing them around and out of the main bearing support.

Inspection

Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low oil or no oil. Check oil filter elements and replace them if necessary. Also check the oil by-pass valve to make sure it is operating freely.

After removal, clean the bearings and inspect them for scoring, pitting, flaking, etching, loss of babbitt or signs of overheating (Fig. 5). The lower bearing shells, which carry the load, will normally show signs of distress before the upper bearing shells. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are not detrimental to this type of bearing. They should not be replaced for these minor surface imperfections since function of the bearings is in no way impaired and they will give many additional hours of trouble-free operation.

Inspect the backs of the bearing shells for bright spots which indicate they have been moving in the bearing caps or bearing supports. If such spots are present, discard the bearing shells.

Measure the thickness of the bearing shells at point "C", 90° from the parting line, as shown in Figs. 6 and 7. Tool J 4757, placed between the bearing shell and a

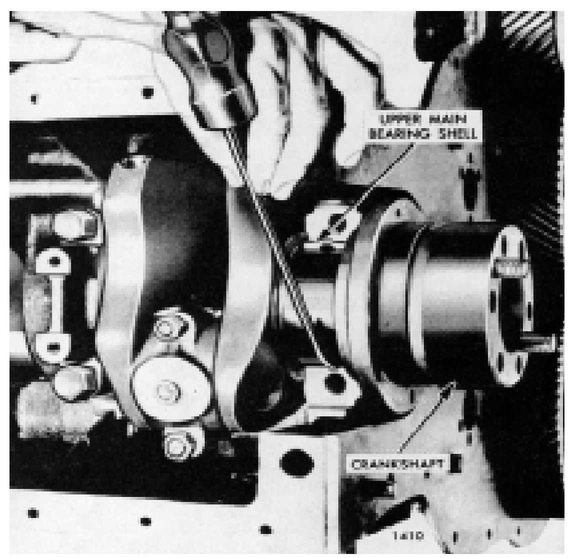


Fig. 4. Removing Upper Rear Main Bearing Shell

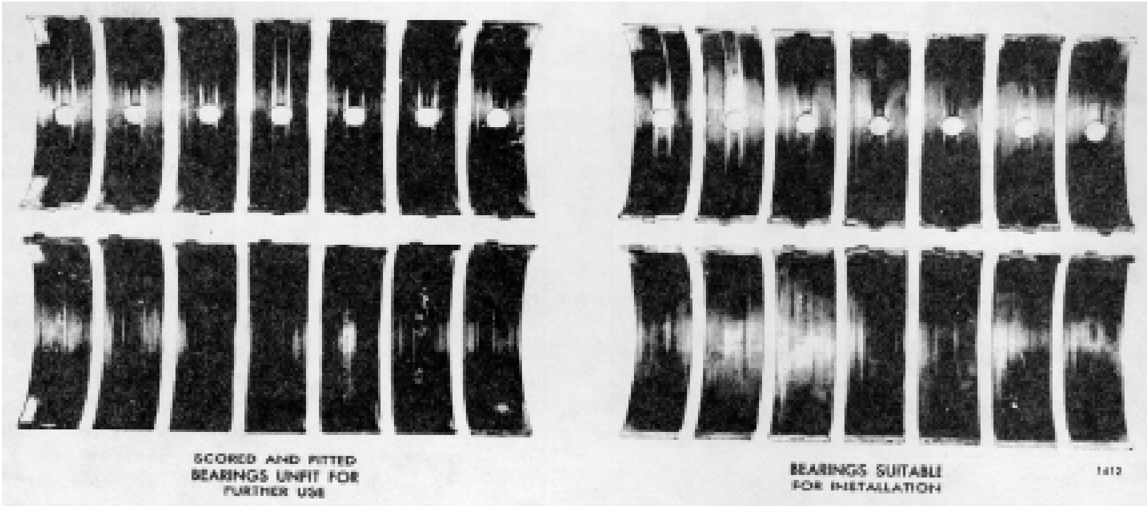


Fig. 5. Comparison of Main Bearing Shells

micrometer, will give an accurate measurement. The bearing shell thickness will be the total thickness of the steel ball in the tool and the bearing shell, less the diameter of the ball. This is the only practical method for measuring the bearing thickness, unless a special micrometer is available for this purpose. The minimum thickness of a worn standard main bearing shell is .1530" and, if any of the bearing shells are thinner than this dimension, replace all of the bearing shells. A new standard bearing shell has a thickness of .1548" to .1553". Refer to Table 1.

Bearing Size	Bearing Thickness	Minimum Thickness
Standard	.1548"/.1553"	.1530"
.002" Undersize	.1558"/.1563"	.1540"
.010" Undersize	.1598"/.1603"	.1580"
.020" Undersize	.1648"/.1653"	.1630"
.030" Undersize	.1698"/.1703"	.1680"

TABLE 1

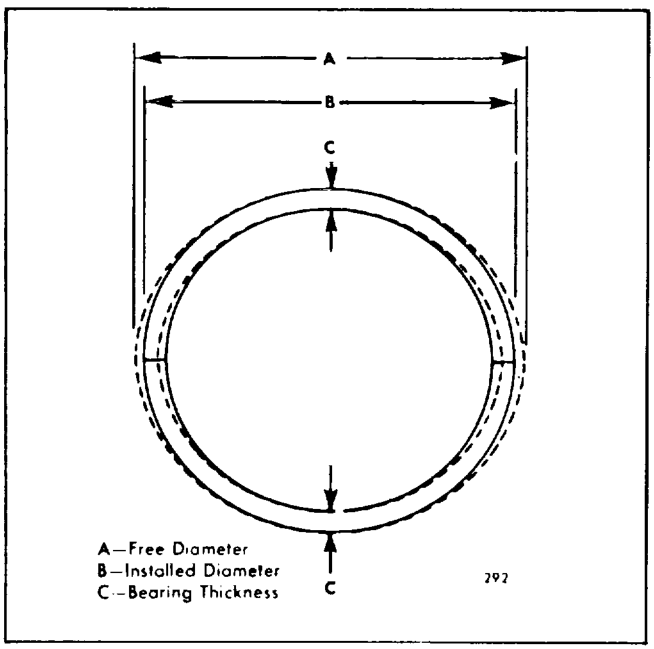


Fig. 6. Main Bearing Measurements

In addition to the thickness measurement, check the clearance between the main bearings and the crankshaft journals. This clearance may be determined with the crankshaft in place by means of a soft plastic measuring strip which is squeezed between the journal and the bearing (refer to *Shop Notes* in Section 1.0).

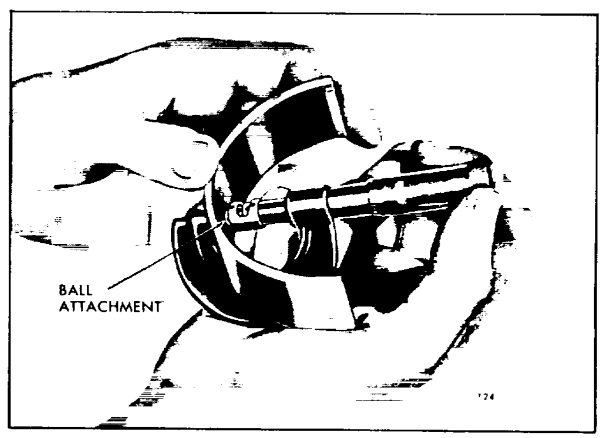


Fig. 7. Measuring Thickness of Bearing Shell

With the crankshaft removed, measure the outside diameter of the crankshaft main bearing journals and the inside diameter of the main bearing shells when installed in place with the proper torque on the bearing cap bolts. When installed, the bearing shells are .001" larger in diameter at the parting line than 90° from the parting line.

The bearing shells do not form a true circle when not installed. When installed, the bearing shells have a squeeze fit in the main bearing bore and must be tight when the bearing cap is drawn down. This *crush* assures a tight, uniform contact between the bearing shell and bearing seat. Bearing shells that do not have sufficient crush will not have uniform contact, as shown by shiny spots on the back, and must be replaced. If the clearance between any crankshaft journal and its bearing shells exceeds .0060", all of the bearing shells must be discarded and replaced. This clearance is .0014" to .0044" with new parts.

Before installing new replacement bearings, it is very important to thoroughly inspect the crankshaft journals. Very often, after prolonged engine operation, a ridge is formed on the crankshaft journals in line with the journal oil holes. If this ridge is not removed before the new bearings are installed, then, during engine operation, localized high unit pressures in the center area of the bearing shell will cause pitting of the bearing surface. Also, damaged bearings may cause bending fatigue and resultant cracks in the crankshaft. Refer to Section 1.3 under *Crankshaft Inspection* for removal of ridges and inspection of the crankshaft.

Do not replace one main bearing shell alone. If one shell requires replacement, install both new upper and lower bearing shells. Also, if a new or reground crankshaft is to be used, install all new bearing shells.

Bearing shells are available in .010", .020" and .030" undersize for service with reground crankshafts.

To determine the size bearings required, refer to *Crankshaft Grinding* in Section 1.3. Bearings which are .002" undersize are available to compensate for slight journal wear where it is unnecessary to regrind the crankshaft.

> **NOTE:** Bearing shells are NOT reworkable from one undersize to another under any circumstances.

Inspect the crankshaft thrust washers. If the washers are scored or worn excessively or the crankshaft end play is excessive, they must be replaced. Improper clutch adjustment can contribute to excessive wear on the thrust washers. Inspect the crankshaft thrust surfaces. Refer to *Install Crankshaft* in Section 1.3. If,

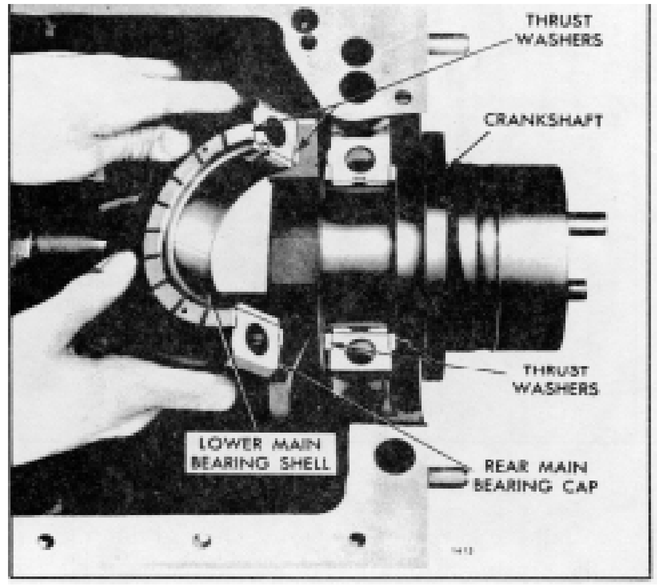


Fig. 8. Crankshaft Thrust Washers in Place

after dressing or regrinding the thrust surfaces, new standard size thrust washers do not hold the crankshaft end play within the specified limits, it may be necessary to install oversize thrust washers on one or both sides of the rear main bearing. A new standard size thrust washer is .1190" to .1220" thick. Thrust washers are available in .005" and .010" oversize.

Install Main Bearing Shells (Crankshaft in Place)

Make sure all of the parts are clean. Then apply clean engine oil to each crankshaft journal and install the upper main bearing shells by reversing the sequence of operations given for removal.

The upper and lower main bearing shells are not alike; the upper bearing shell is grooved and drilled for lubrication - the lower bearing shell is not. Be sure to install the grooved and drilled bearing shells in the cylinder block and the plain bearing shells in the bearing caps, otherwise the oil flow to the bearings and to the upper end of the connecting rods will be blocked off. Used bearing shells must be reinstalled on the same journal from which they were removed.

1. When installing an upper main bearing shell with the crankshaft in place, start the plain end of the bearing shell around the crankshaft journal so that, when the bearing is in place, the tang will fit into the groove in the bearing support.

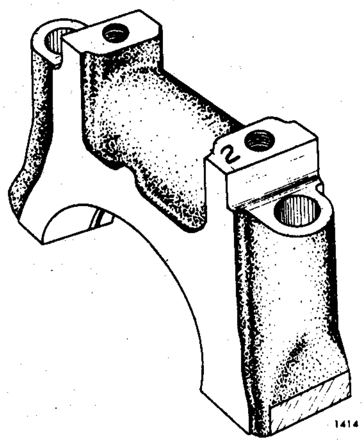


Fig. 9. Main Bearing Cap Marking

2. Install the lower main bearing shell so that the tang on the bearing fits into the groove in the bearing cap.

3. Assemble the crankshaft thrust washers (Fig. 8) before installing the rear main bearing cap. Clear both halves of each thrust washer carefully and remove any burrs from the washer seats - the slightest burr or particle of dirt may decrease the clearance between the washers and the crankshaft beyond the specified limit. Slide the upper halves of the thrust washers into place. Then assemble the lower halves over the dowel pins in the bearing cap.

   NOTE: The main bearing caps are bored in position and stamped 1, 2, 3, etc. (Fig. 9). They must be installed in their original positions with the marked side of each cap toward the blower side of the cylinder block.

4. With the lower main bearing shells installed in the bearing caps, apply a small quantity of International Compound No. 2, or equivalent, to the bolt or stud and nut threads and the bolt head (or nut) contact area. Install the bearing caps and draw the bolts (or nuts) up snug. Then rap the caps sharply with a soft hammer to seat them properly and tighten the bolts uniformly to 180-190 lb-ft torque. If studs and nuts are used, tighten the nuts to 155-185 lb-ft torque (cast iron block) or 120-140 lb-ft torque (aluminum block). Do not exceed the specified torque.

   NOTE: If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

5. Check the crankshaft end play as outlined under *Install Crankshaft* in Section 1.3.

6. Install the lubricating oil pump and the oil inlet and outlet pipe assemblies.

   NOTE: If shims were used between the pump and the bearing caps, install them in their original positions. Then check oil pump gear clearance (Section 4.1).

7. Install the oil pan, using a new gasket.

8. Fill the crankcase to the proper level on the dipstick with *heavy-duty* lubricating oil of the recommended grade and viscosity (refer to *Lubricating Oil Specifications* in Section 13.3).

9. After installing new bearing shells, operate the engine on a run-in schedule as outlined in Section 13.2.1.

CRANKSHAFT FRONT COVER

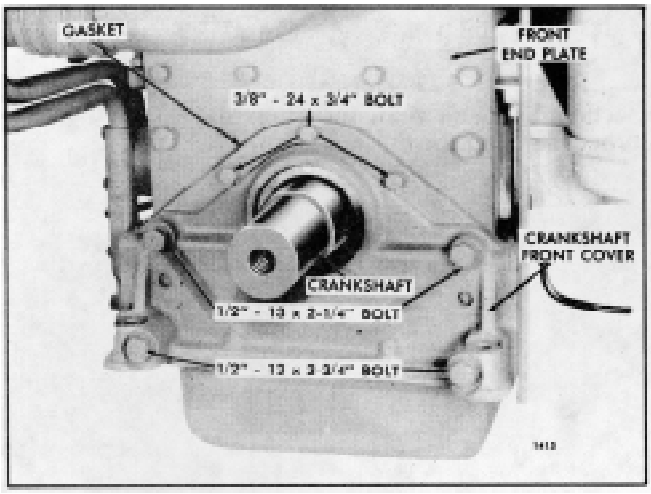


Fig. 1. Crankshaft Front Cover Mounting (Vibration Damper Removed)

The crankshaft front cover is mounted against the cylinder block end plate at the lower front end of the engine (Fig. 1). The engine is supported at the front end by engine supports attached to the front cover.

It will be necessary to remove the crankshaft front cover to remove and install the crankshaft or when the engine is overhauled.

Remove Crankshaft Front Cover

1. Drain the oil and remove the oil pan.
2. Remove the vibration damper (Section 1.3.6),

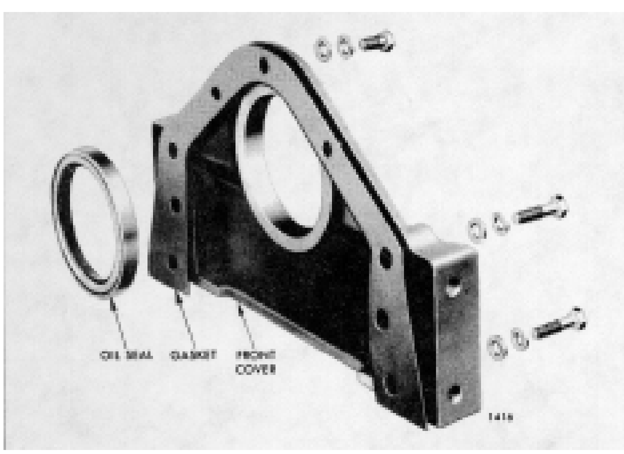


Fig. 2. Crankshaft Front Cover Details and Relative Location of Parts

crankshaft pulley (Section 1.3.7) and any other accessories that may be mounted on the front of the crankshaft.

3. Remove the vibration damper inner cone or oil seal spacer.
4. Remove the cover attaching bolts and washers (Fig. 1).
5. Strike the rear face of the ears on the cover with a soft hammer to free the cover from the dowels. Pull the cover straight off the end of the crankshaft.
6. Remove the cover gasket.
7. Remove and inspect the oil slinger.
8. Replace the oil seal (Section 1.3.2).

Install Crankshaft Front Cover

1. Install the oil slinger in place next to the oil pump drive gear, with the dished outer diameter of the slinger facing away from the gear.
2. Shellac a new gasket to the bolting flange of the crankshaft front cover.
3. Coat the lip of the oil seal lightly with cup grease.
4. Attach the cover to the cylinder block front end plate with bolts and lock washers.

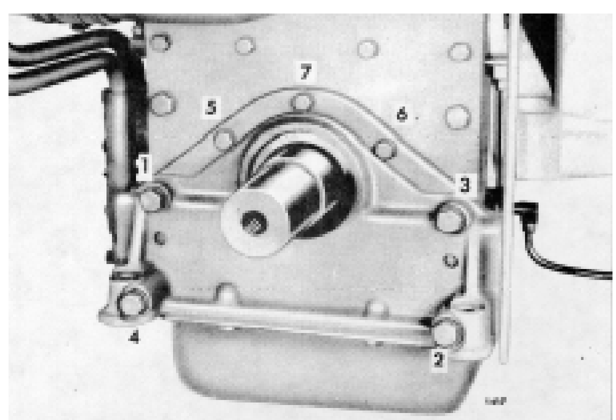


Fig. 3. Crankshaft Front Cover Bolt Tightening Sequence

5. Tighten the cover attaching bolts by following the tightening sequence indicated in Fig. 3. Follow this sequence as the bolts are drawn up and then tightened to their proper torque to effect a good seal between the mating parts. Tighten the 3/8"-24 bolts to 25-30 lb-ft (34-41 N•m) and the 1/2"-13 bolts to 80-90 lb-ft (108-122 N•m) torque.

6. Apply a light coating of engine oil to the vibration damper inner cone or the oil seal spacer and slide it into place on the crankshaft.

7. Install the oil pan, using a new gasket.

8. Refer to *Lubricating Oil Specifications* in Section 13.3 and refill the crankcase with oil to the proper level on the dipstick.

CRANKSHAFT VIBRATION DAMPER

Six cylinder vehicle engines require a vibration damper to reduce the crankshaft stresses to a safe value. Three different types of vibration dampers are available for the six cylinder engines and their particular use depends on the governed speed and other characteristics of the engine.

The three types of vibration dampers are described below.

The double (rubber) damper shown in Fig. 1, is made up of a light damper, a heavy damper, a hub, an inner cone, and an outer cone. The light and heavy dampers of the assembly are in turn made up of rubber blocks bonded to an inertia mass in the form of metal ring on one side, and a stamped metal disc on the opposite side.

The two metal parts are, therefore, entirely separated and free to move within certain prescribed limits by virtue of the rubber blocks. The light and heavy dampers are bolted and doweled together and to the driving hub. The hub in turn is secured in place at the front end of the crankshaft between an inner and outer cone as shown in Fig. 1. The two cones provide an adequate rigid mounting when the crankshaft cap, or a pulley, is drawn up tight against the outer cone by the bolt in the end of the crankshaft.

The single (rubber) damper is similar to the double damper described above except that only the light damper is used with the hub and cones.

Even though these vibration dampers are rigidly constructed, and should give no trouble if given proper care; nevertheless, since rubber is used in the assembly, certain precautions are necessary. Fuel oil and lubricating oil, as well as excessive heat, are destructive to rubber. The assembly, therefore, should be protected against these destructive agents. Furthermore, for the damper to function properly and safeguard the crankshaft, it should be securely fastened to the shaft by the cones and the crankshaft cap or pulley, which also act as a cone retainer.

The viscous (fluid) type damper provides faster response to load and speed changes, and high temperatures have a less adverse effect than on the rubber type damper.

The viscous damper assembly consists of a sealed outer shell, an internal flywheel, and a quantity of

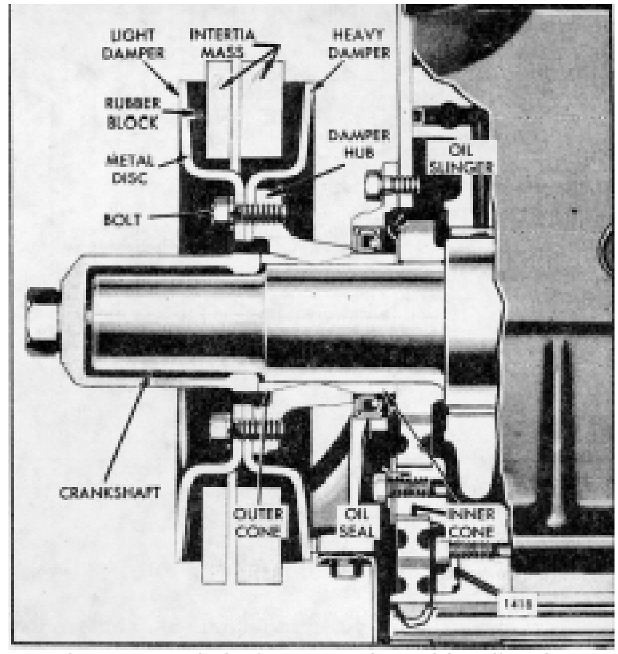


Fig. 1. Crankshaft Cap and Double Vibration Damper Assembly and Mounting

highly viscous fluid (Fig. 2). The very small clearance between the flywheel and the outer shell is filled with the fluid which causes the flywheel to be driven upon acceleration, and permits it to "freewheel" upon deceleration.

During operation, the outer shell, which is firmly attached to the crankshaft, turns at the same speed as the crankshaft, its motion being transferred to the flywheel through the fluid within the shell. Inasmuch as "fluid-drive" is more or less inefficient with frequent speed changes, considerable slippage of the flywheel will take place as the power impulses are transmitted through the crankshaft. In this type of operation, the slippage is desirable since the acceleration and deceleration of the flywheel in the damper lessens the amplitude of the vibrations, thereby reducing their effects to a point where they are not harmful to the engine.

The vibration damper must be removed whenever the crankshaft, crankshaft front cover, or crankshaft front oil seal is removed or replaced.

Remove Vibration Damper From Crankshaft

1. Remove the crankshaft pulley or cap retaining bolt and washer.

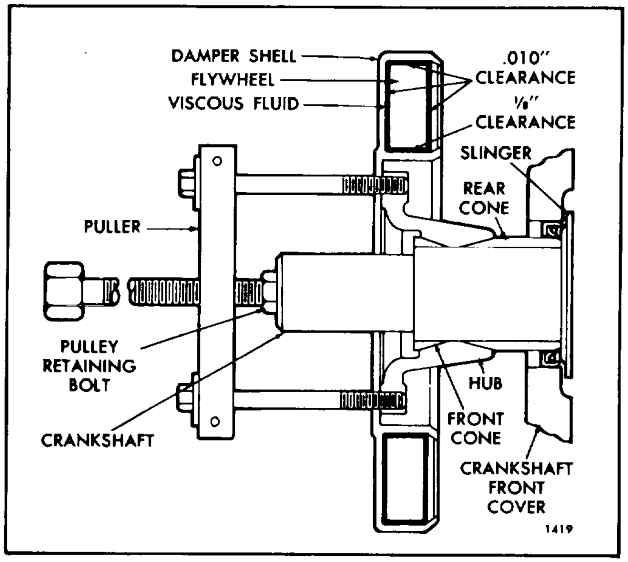


Fig. 2. Removing Vibration Damper Assembly (Viscous Type)

2. Remove the crankshaft pulley or cap.

3. On rubber type vibration dampers, remove two damper-to-hub bolts and lock washers diametrically opposite to each other. Two puller holes are provided in viscous damper.

4. Reinstall the pulley crankshaft bolt and a puller as shown in Fig. 2 to loosen the outer cone wedged between the crankshaft and the damper hub. After loosening cone it may be "fished" from the inner diameter of the damper hub with two thin shank screwdrivers.

   CAUTION: Pounding with a hammer, or prying with other tools must not be resorted to in removing the viscous type damper from the crankshaft. Dents in the damper outer case may render the damper ineffective. The damper cannot be repaired.

5. Slide the vibration damper or dampers with damper hub as an assembly off the end of the crankshaft by hand.

6. Slide the inner cone from the crankshaft.

Inspect Vibration Damper

After removal, clean the vibration damper in fuel oil and blow dry with compressed air.

CAUTION: Do not allow fuel oil to remain on a rubber type vibration damper too long, but blow it dry immediately after cleaning, otherwise damage due to the action of the fuel oil on the rubber may result.

Inspect the rubber type damper to see that the rubber is firmly bonded to the metal parts at each side. If the damper has been exposed to fuel oil, lubricating oil or excessive heat, the rubber may have become loosened from the metal. In this event, the damper should be discarded and replaced with a new one. Also, check to see that the metal discs "C", Fig. 1, are not bent.

Examine the viscous type damper for dents, nicks, fluid leakage or bulges in the outer casing of the damper. Any indications of the above are sufficient cause for replacing the damper. Due to the close clearances between the internal flywheel and outer casing, dents may render the damper ineffective.

Bulges or splits indicate fluid has ignited and expansion of resultant gases has bulged or forced the casing open at its crimped edges.

Since the viscous type damper is a precision built closely fitted and sealed device, it is not possible to repair it. Regardless of condition, the viscous type damper should be replaced at time of a periodic major engine overhaul.

If damage to the vibration damper is extensive, inspect the crankshaft as outlined in Section 1.3. A loose or defective vibration damper, after extended operation, may result in a cracked crankshaft.

Inspect the damper cones, hub, sleeve, spacer and the end of the crankshaft for galling or burrs. Slight scratches or burrs may be removed with emery cloth. If seriously damaged, the parts should be replaced and the end of the crankshaft refinished. Check the outside diameter of the inner cone for wear at the crankshaft front oil seal contact surface. If worn, the oil seal and cone should be replaced (Section 1.3.2).

Install Vibration Damper on Crankshaft

Refer to the illustrations for relative location of the parts and assemble as follows:

1. Coat the lip of the oil seal in the front cover (trunnion) lightly with cup grease or vegetable shortening and lubricate the sleeve and spacer, if used, with engine oil.

2. Slide the sleeve, if used, over the large diameter of the crankshaft and against the oil slinger, being sure the slinger is tight against the oil pump drive gear; then, slide the spacer against the sleeve.

3. With the Woodruff keys, if used, in place, slide the inner cone, tapered end pointing to the front of the crankshaft next to the oil slinger, or against the spacer, if used.

   NOTE: When the vibration damper and crankshaft pulley are bolted together and mounted on the front end of the crankshaft (Fig. 4), extra precaution should be taken to be certain that the inner cone does not prematurely clamp to the crankshaft.

4. If, for any reason, the light and heavy dampers were removed from the hub, assemble the two dampers over the dowels and against the hub with the flat faces of the dampers facing each other as shown in Figs. 1 and 3. Secure the dampers to the hub with bolts and lock washers.

5. Slide the damper and hub as an assembly - long end of hub facing crankshaft cover - into position.

   CAUTION: DO NOT hit viscous type damper with hammer to position it on the crankshaft.

6. Install the crankshaft pulley and vibration damper assembly with the damper assembly side of the pulley facing the crankshaft front cover.

Fig. 3. Double Vibration Damper Details and Relative Location of Parts

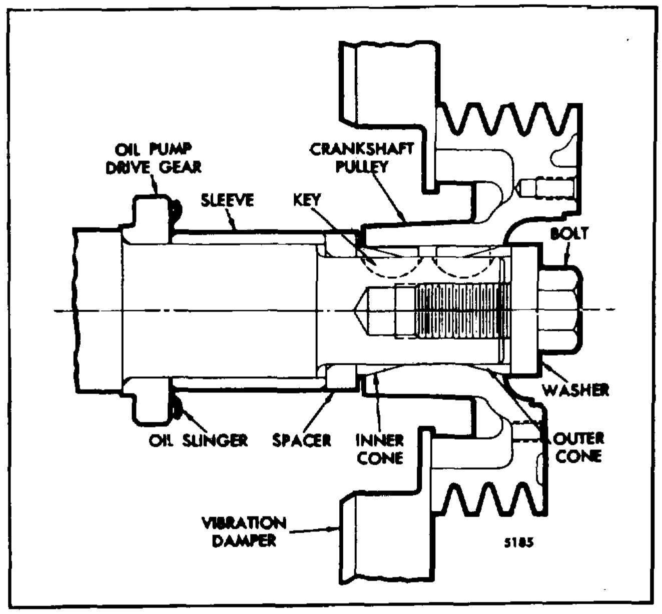


Fig. 4. Vibration Damper and Crankshaft Pulley Assembly Mounting

7. Slide the outer cone over the crankshaft and into the hub of the vibration damper, or the crankshaft pulley.

8. Install the crankshaft cap or the crankshaft pulley.

9. Thread the crankshaft cap or pulley retaining bolt with washer, if used, into the crankshaft and tighten the bolt as follows:

   a. Tighten to 180 lb-ft torque.

   b. Strike the end of the bolt a sharp blow with a 2 to 3 lb. lead hammer.

   c. Tighten to 300 lb-ft torque and strike the bolt again.

   d. Tighten to 290-310 lb-ft torque.

CAUTION: The damper assembly must be securely fastened to the crankshaft. When the bolt is drawn up to the specified torque, the cones will hold the damper rigidly in place.

CRANKSHAFT PULLEY

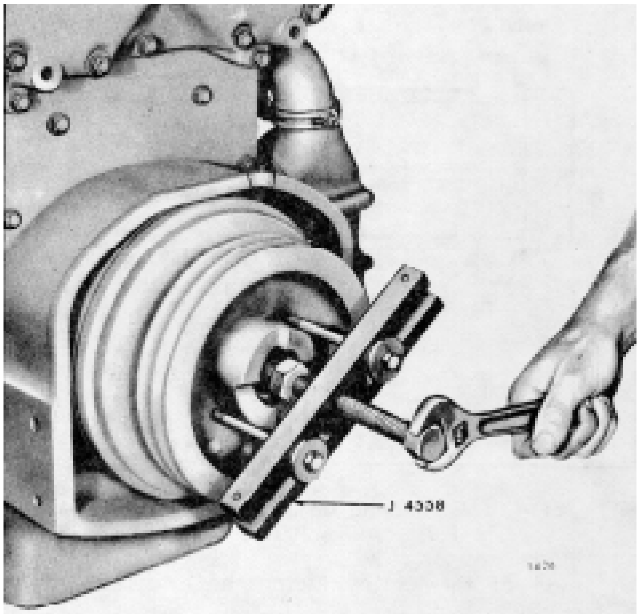


Fig. 1. Removing Pulley from Crankshaft

The engine application determines the type of crankshaft pulley to be used. The crankshaft pulley is keyed to the crankshaft and secured with a special washer and bolt.

Remove Crankshaft Pulley

The difference in the design of pulleys dictates the use of various puller tools as outlined below:

1. Remove the bolt and washer.

2. If a rigid type pulley without any tapped holes is being removed, use two-jaw puller J 4643.

3. If tapped holes are provided in the pulley hub, install the pulley bolt in the end of the crankshaft and use puller J 4558.

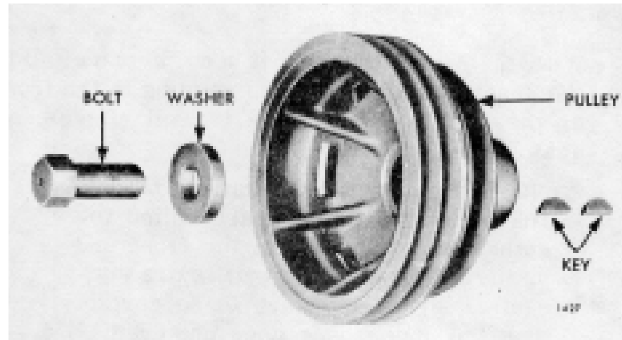


Fig. 2. Crankshaft Pulley Details

Install Crankshaft Pulley

Refer to Fig. 2 and install the crankshaft pulley as follows:

1. Place the Woodruff keys in the key slots in the front end of the crankshaft, if they were removed.

2. Slide the pulley over the end of the crankshaft.

3. Place the washer on the bolt and thread the bolt into the end of the crankshaft, drawing the pulley tight against the oil seal spacer.

If the engine is equipped with a vibration damper, the pulley must be drawn tight against the outer cone.

4. Tighten the crankshaft pulley retaining bolt as follows:

   a. Tighten the bolt to 180 lb-ft torque.

   b. Strike the end of the bolt a sharp blow with a 2 or 3 lb. lead hammer.

   c. Tighten the bolt to 300 lb-ft torque and strike the bolt again.

   d. Tighten the bolt to 300 lb-ft torque.

FLYWHEEL

The flywheel (Fig. 1) is attached to the rear end of the crankshaft with six self-locking bolts. Two dowels in the end of the crankshaft aid flywheel alignment and provide support when the flywheel bolts are removed. A scuff plate is used between the flywheel and the bolt heads to prevent the bolt heads from scoring the flywheel surface.

> **NOTE:** Some early engines did not incorporate crankshaft dowels.

A steel ring gear, which meshes with the starting motor pinion, is shrunk onto the rim of the flywheel.

On current engines, a split tube type retainer (Fig. 2) is driven in the end of the crankshaft to prevent the pilot bearing from entering the crankshaft cavity.

Former engines used a washer type retainer The flywheel is machined to provide true alignment with the clutch, and the center bore provides for installation of a clutch pilot bearing. The clutch is bolted to the flywheel.

An oil seal ring, which provides an oil tight connection between the crankshaft and the flywheel, is fitted into a groove on certain flywheel assemblies.

The flywheel must be removed for service operations such as replacing the starter ring gear, crankshaft or flywheel housing.

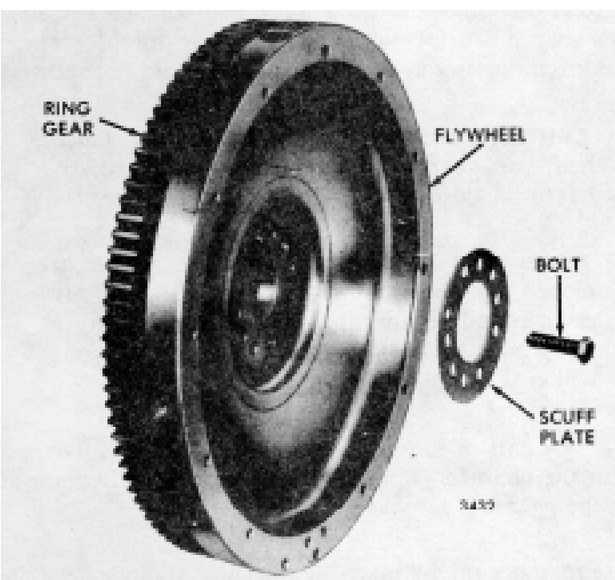


Fig. 1. Typical Flywheel Assembly

Remove Flywheel (Transmission Removed)

1. Remove the six flywheel attaching bolts and scuff plate.

CAUTION: If the crankshaft is not provided with dowels, install one flywheel bolt after removing the scuff plate to hold the flywheel in place until the lifting tool is attached.

2. Attach flywheel lifting tool J 6361-01 to the flywheel with two 7/16"-14 bolts of suitable length or use tool J 25026. Remove the remaining flywheel attaching bolt.

3. Attach a chain hoist to the lifting tool to support the flywheel as shown in Fig. 3.

4. Move the upper end of the lifting tool in and out to loosen the flywheel, then withdraw the flywheel from the crankshaft and the flywheel housing.

5. Remove the clutch pilot bearing, if used, as outlined in Section 1.4.1.

6. Remove the washer type pilot bearing retainer, if used. It is not necessary to remove the split tube type retainer.

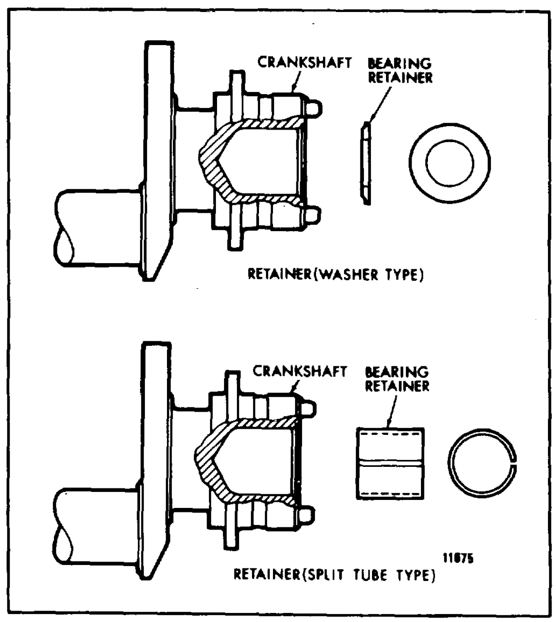


Fig. 2. Pilot Bearing Retainers

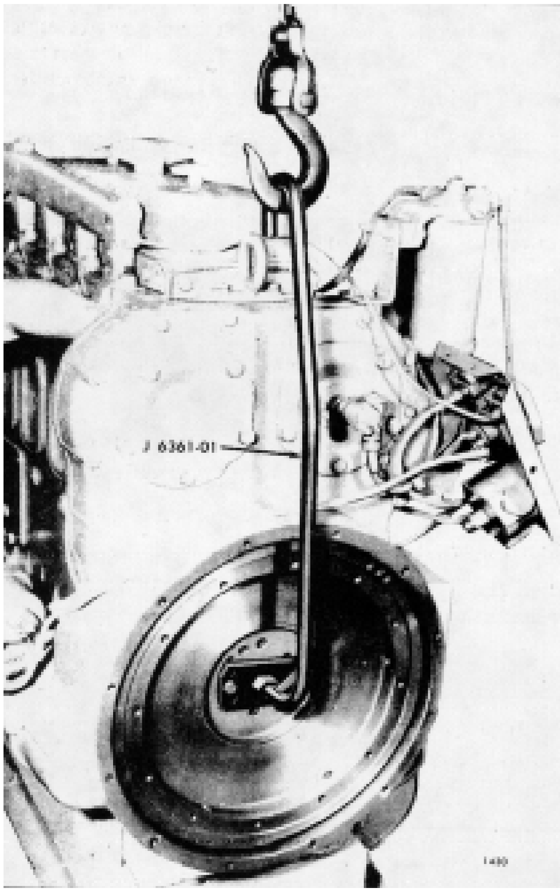


Fig. 3. Removing Flywheel

7. Remove the oil seal ring, if used.

Inspection

Check the clutch contact face of the flywheel for scoring, overheating or cracks. If scored, the flywheel may be refaced. However, *do not* remove more than .020" of metal from the flywheel. Maintain all of the radii when refacing the flywheel.

Replace the ring gear if the gear teeth are excessively worn or damaged. Check the butt end of the crankshaft and flywheel contact surface. If necessary, lightly stone the crankshaft end and the flywheel contact surface to remove any fretting or brinelling.

On crankshafts with dowels, be sure and check the dowel extension. Dowels must not extend more than 1/2" (13 mm) from the crankshaft.

Make sure that the crankshaft and flywheel contact surfaces and the bolt threads in the crankshaft end are clean and dry, to ensure proper metal-to-metal contact and maximum friction, before attaching the flywheel.

New bolts should be used to mount or remount the flywheel. However, if the original bolts are determined to be serviceable and are to be reused, clean them thoroughly before starting the assembly procedure.

Remove Ring Gear

Note whether the ring gear teeth are chamfered. The replacement gear must be installed so that the chamfer on the teeth faces the same direction with relationship to the flywheel as on the gear that is to be removed.

Then remove the ring gear as follows:

1. Support the flywheel, crankshaft side down, on a solid flat surface or hardwood block which is slightly smaller than the inside diameter of the ring gear.

2. Drive the ring gear off the flywheel with a suitable drift and hammer. Work around the circumference of the gear to avoid binding the gear on the flywheel.

Install Ring Gear

1. Support the flywheel, ring gear side up, on a solid flat surface.

2. Rest the ring gear on a flat **metal surface** and heat the gear uniformly with an acetylene torch, keeping the torch moving around the gear to avoid hot spots.

CAUTION: Do not, under any circumstances, heat the gear over 400°F (204°C); excessive heat may destroy the original heat treatment.

NOTE: Heat indicating "crayons", which are placed on the ring gear and melt at a certain temperature, may be obtained from most tool vendors. Use of these "crayons" will ensure against overheating the gear.

3. Use a pair of tongs to place the gear on the flywheel with the chamfer, if any, facing the same direction as on the gear just removed.

4. Tap the gear in place against the shoulder on the flywheel. If the gear cannot be tapped into place readily so that it is seated all the way around, remove it and apply additional heat, noting the above caution.

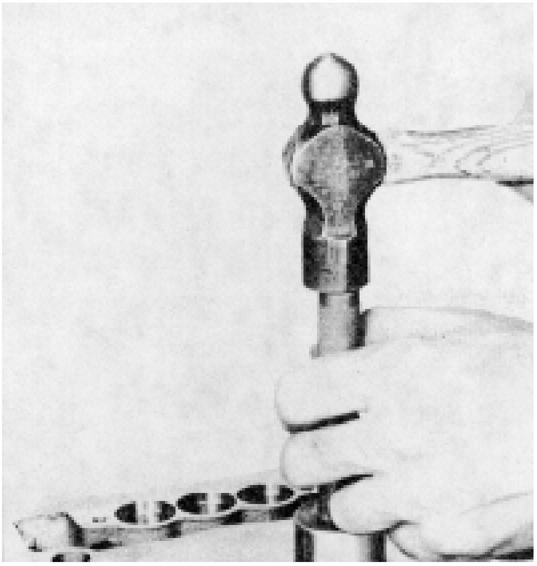


Fig. 13. Installing Valve Seat Insert

3. Inspect the valve seat insert counterbore in the cylinder head for cleanliness, concentricity, flatness and cracks. The counterbores in a two valve cylinder head have a diameter of 1.626" to 1.627" and a depth of .3705" to .3845". The counterbores in a four valve cylinder head have a diameter of 1.260" to 1.261" and a depth of .338" to .352". The counterbores must be concentric with the valve guides within .003" total indicator reading. If required, use a valve seat insert which is .010" oversize on the outside diameter.

4. Immerse the cylinder head for at least 30 minutes in water heated to 180°F. to 200°F.

5. Rest the cylinder head, bottom side up, on a work bench and locate the insert squarely in the counterbore, seating face up. Install the insert in the cylinder head while the head is still hot and the insert is at room temperature, otherwise installation will be difficult and the parts may be damaged.

6. Drive the insert in place with installer J 1736 (two valve head) or J 6568 (four valve head) as shown in Fig. 13 until it seats solidly in the cylinder head.

7. Grind the valve seat insert and check it for concentricity in relation to the valve guide as outlined below.

Recondition Exhaust Valve and Valve Seat Insert

Reface an exhaust valve which is to be reused as shown in Fig. 14. The edge of the valve at the valve head must not be less than 1/32" in thickness and still be within the specifications shown in Fig. 16, after refacing.

Before installing either a new or used valve, examine the valve seat insert in the cylinder head for proper valve seating. The proper angle for the seating face of both the valve and valve insert is 30°.

The angle of the valve seat insert must be exactly the same as the angle of the valve face to provide proper seating of the valve.

When a new valve seat insert is installed or an old insert is reconditioned, the work must be done with a grinding tool as illustrated in Fig. 15.

The eccentric grinding method for reconditioning a valve seat insert is recommended. This method produces a finer, more accurate finish since only one point of the grinding wheel is in contact with the valve seat at any time. A micrometer feed permits the operator to feed the grinding wheel into the work .001" at a time.

The eccentric valve seat grinder set J 8165, used to recondition or grind the valve seat inserts for a two valve cylinder head, consists of:

1. Grinder J 8165-1.
2. Dial gage J 8165-2.
3. Pilot J 8165-3.
4. Grinding wheel (15°) J 8165-4.
5. Grinding wheel (30°) J 8165-5.
6. Grinding wheel (60°) J 8165-7.

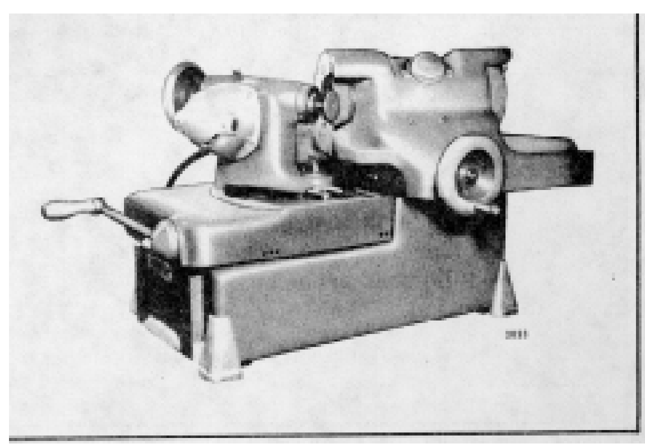


Fig. 14. Refacing Exhaust Valve

Eccentric valve seat grinder adapter set J 6390 is used in conjunction with J 8165 to grind the inserts in a four valve cylinder head and consists of the following:

1. Pilot J 6390-1.
2. Grinding wheel (15°) J 6390-2.
3. Grinding wheel (30°) J 6390-3.
4. Grinding wheel (60°) J 6390-4.

Grind the inserts as follows:

1. First apply the 30° grinding wheel on the valve seat insert.
2. Use the 60° grinding wheel to open the throat of the insert.
3. Grind the top surface of the insert with the 15° wheel to narrow the width of the seat to the dimensions shown in Fig. 16.

   CAUTION: Do not permit the grinding wheel to contact the cylinder head when grinding the inserts.

   If necessary, the grinding wheel may be dressed to the correct seat angle with the tool provided in the grinder set (Fig. 17).

   The maximum amount the exhaust valve should protrude beyond the cylinder head (when the valve is in the closed position), and still maintain the proper piston-to-valve clearance, is shown in Fig. 16. Grinding will reduce the thickness of the valve seat insert and cause the valve to recede into the cylinder head. If after several grinding operations, the valve recedes beyond these limits replace the valve seat insert.

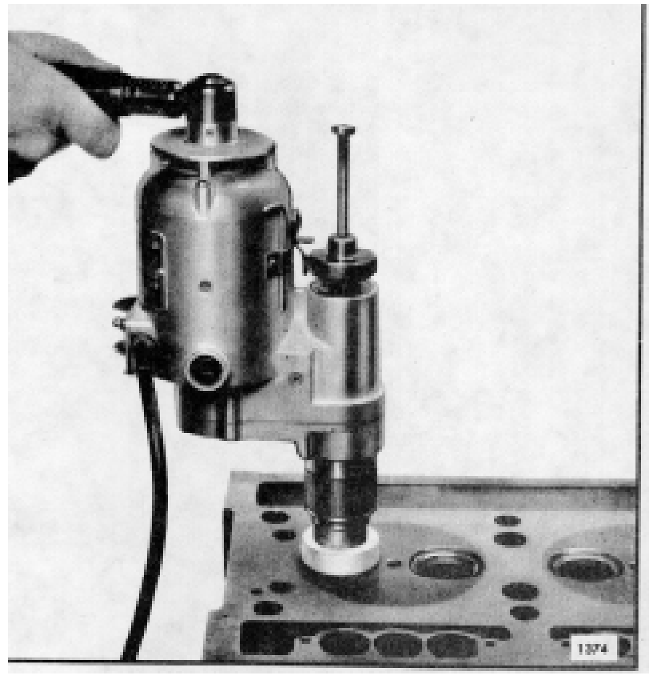


*Fig. 1**PAGE 5**. Reconditioning Valve Seat Insert*

CAUTION: Engines with 18.7:1 compression ratios must incorporate valve seat inserts that are no more than .251" thick to ensure adequate clearance between the pistons and exhaust valves.

4. After the grinding has been completed, clean the valve seat insert thoroughly with fuel oil and dry it with compressed air. Set the dial indicator J 8165-2 in position as shown in Fig. 18, and rotate it to determine the concentricity of each valve seat insert relative to the valve guide. Total runout should not exceed .002". If a runout of more than .002" is indicated, check for a bent valve guide before regrinding the insert.

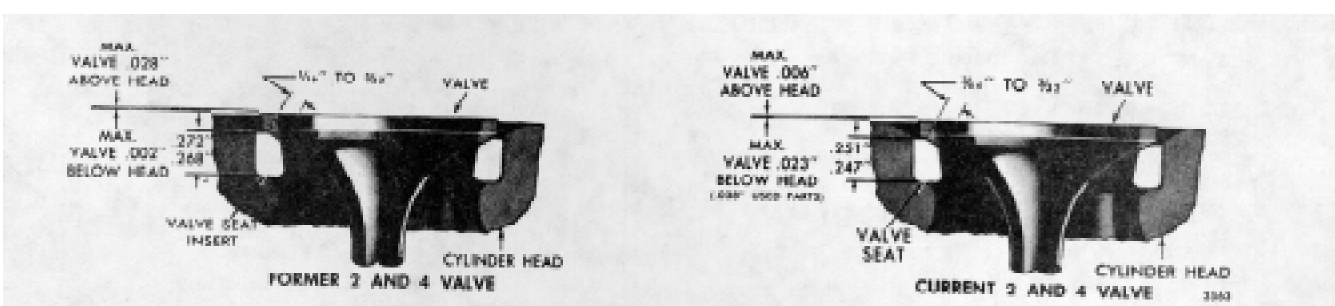


Fig.16. Relationship Between Exhaust Valve, Insert and Cylinder Head

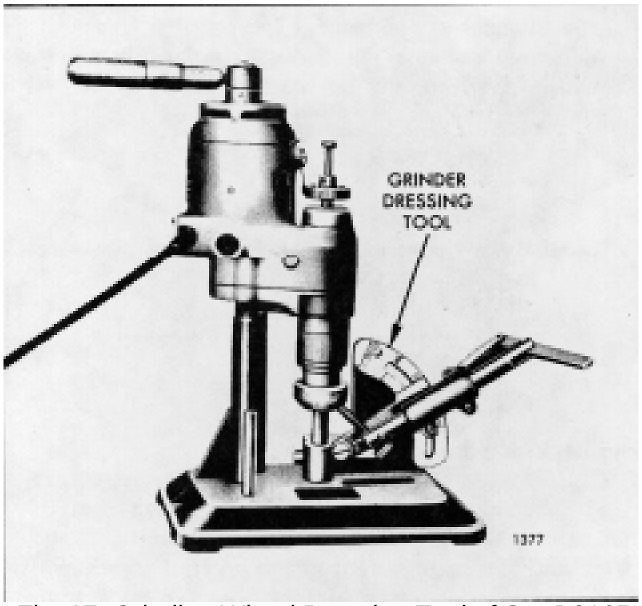


Fig. 17. Grinding Wheel Dressing Tool of Set J 8165

When a valve seat insert runout within the desired limits is obtained, determine the position of the contact area between the valve and the valve seat insert in the following manner:

1. Apply a light coat of Prussian blue, or a similar paste, to the valve seat insert.

2. Lower the stem of the valve in the valve guide and bounce, but do not rotate, the valve on the insert. This procedure will indicate the area of contact on the valve face. The most desirable area of contact is at the center of the valve face.

After the valve seat inserts have been ground and checked, thoroughly clean the cylinder head before installing the valves.

Install Exhaust Valves and Springs

After the valve guides have been checked or replaced, the valves and valve seat inserts replaced or reconditioned, and the proper valve spring caps and seats selected, install the exhaust valves as follows:

1. Clean the valve guides.

2. Lubricate the valve stems and slide the valves all the way into the guides.

   NOTE: If reconditioned valves are used, install them in the same relative location from which they were removed.

3. Hold the valves in place with a strip of masking tape and turn the cylinder head right side up on the work bench. Place a board under the head to support the valves and to provide clearance between the cam followers and the bench.

4. Install the valve spring seats.

5. Install the valve guide oil seal, if used, on the valve guide as follows:

   a. Place the plastic seal installation cap on the end of the valve stem. If the cap extends more than 1/16" below the groove on the valve stem, remove the cap and cut off the excess length.

   b. Lubricate the installation cap and start the seal carefully over the valve stem. Push the seal down slowly until the seal rests on the top of the valve guide.

   c. Remove the installation cap.

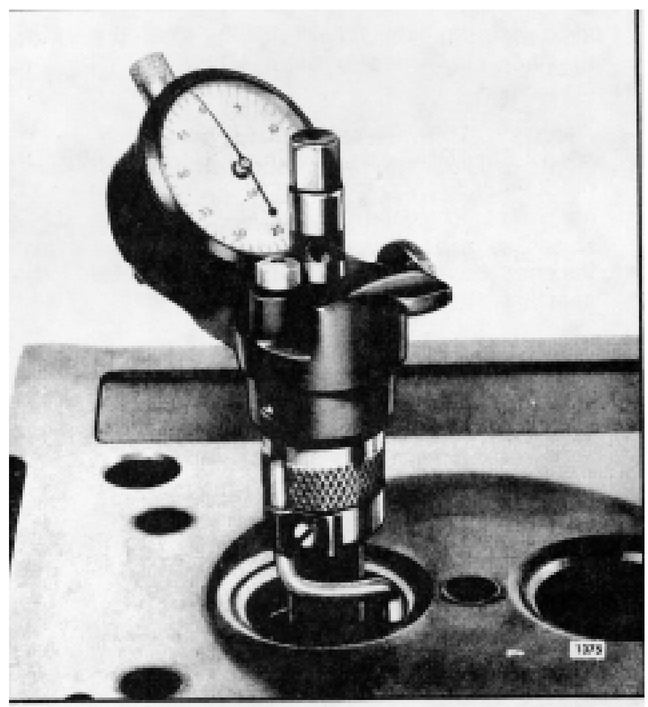


*Fig. 18. Determining Concentricity of Valve Seat Insert with Dial Indicator J 81**PAGE 6PAGE 5**-2*

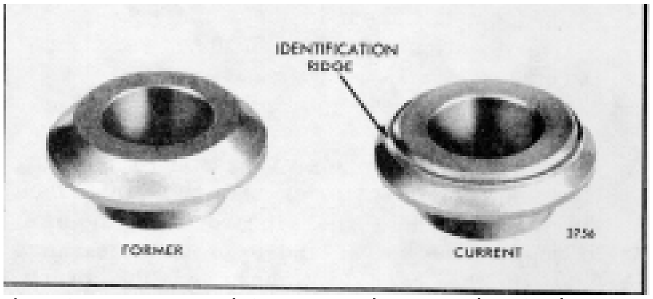


Fig. 19. Former and Current Exhaust Valve Spring Caps

6. Install the valve springs, and valve spring caps.

   NOTE: The current valve spring cap has a ridge for identification purposes on the upper tapered surface (Fig. 19).

7. Thread the valve spring compressor J 7455 into one of the rocker shaft bolt holes in the cylinder head (Fig. 4).

8. Apply pressure to the free end of the too; to compress the valve spring and install the two-piece tapered valve lock. Exercise care to avoid scoring the valve stem with the valve cap when compressing the spring.

   NOTE: Compress the valve spring only enough to permit installation of the valve locks. Compressing the spring too far may result in damage to the valve guide oil seal if used.

9. Release the tool and install the valve locks on the remaining exhaust valves in the same manner.

   NOTE: After the valves have been installed, make sure that none of the valve heads protrude more than the limits shown in Fig. 16 above the surface of the cylinder head when the valves are fully closed.

10. With the exhaust valves installed in the cylinder head, refer to Fig. 20 and, using spring checking gage WRE 500-60, note the gage reading the moment the exhaust valve starts to open. The minimum pressure required to start to open the exhaust valve must not be less than 20 pounds (2 valve spring design).

11. Install the cylinder head (see "Pre-Installation Inspection" and "Install Cylinder Head" in Section 1.2). Adjust the exhaust valve bridges.

Exhaust Valve Bridge Adjustment

On an engine equipped with a four valve cylinder head, the exhaust valve bridge assembly is adjusted and the adjustment screw is locked securely after the cylinder head is installed on the engine. Until wear occurs, or the cylinder head is reconditioned, no further adjustment is required on the valve bridge. A complete valve bridge adjustment is performed as follows:

1. Place the valve bridge in a vise or holding fixture J 21772 and loosen the lock nut on the bridge adjusting screw.

   CAUTION: Loosening or tightening the lock nut with the bridge in place may result in a bent bridge guide or bent rear valve stem.

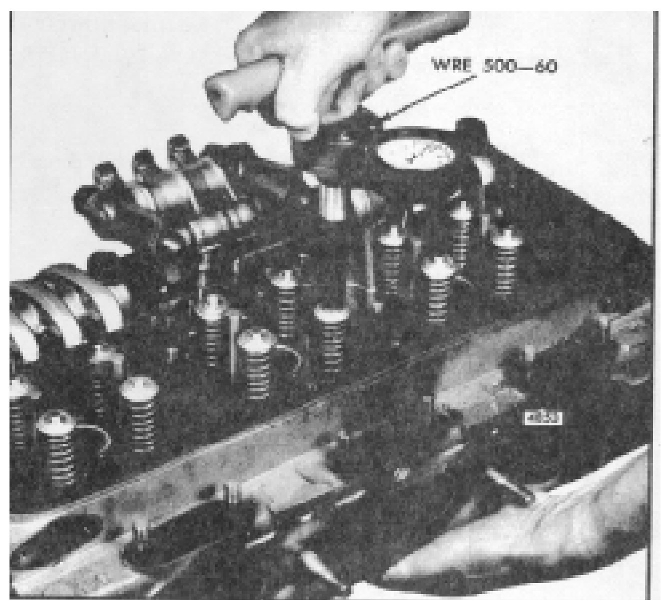


Fig. 20. Checking Pressure Required to Open the Exhaust Valve in Cylinder Head

2. Install the valve bridge on the valve bridge guide, without the spring (if a spring-loaded bridge is used).

3. While firmly pressing straight down on the pallet surface of the valve bridge, turn the adjusting screw clockwise until it just touches the valve stem. Then, turn the screw an additional 1/8 to 1/4 turn clockwise and tighten the lock nut finger tight (Fig. 21).

4. Remove the valve bridge and place it in a vise. Use a screw driver to hold the adjustment screw from turning and tighten the lock nut to 20-25 lb-ft torque.

5. Lubricate the valve bridge guide and the valve bridge with engine oil.

6. Reinstall the valve bridge in its ORIGINAL position, without the spring (if a spring-loaded bridge is used).

7. Place a .0015" feeler gage J 23185 under each end of the valve bridge. Use a narrow strip cut from .0015" feeler stock to fit in the bridge locating groove over the inner exhaust valve. While pressing down on the pallet surface of the valve bridge, both feeler gages must be tight. If both of the feeler gages are not tight, readjust the adjusting screw as outlined in Steps 3 and 4.

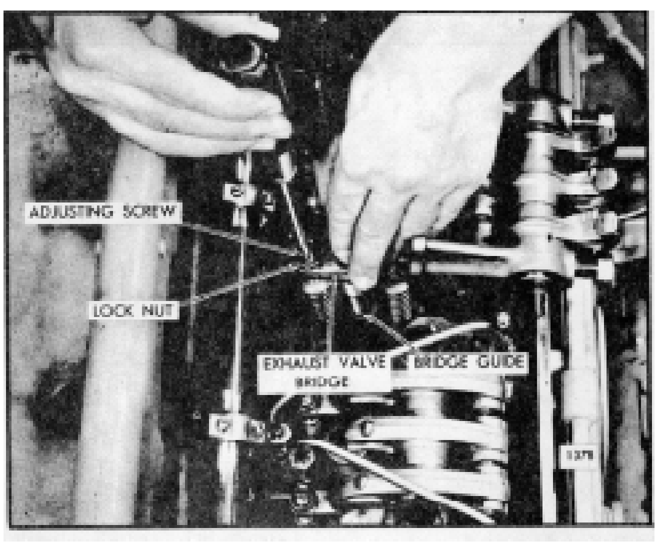


Fig. 21. Valve Bridge Adjustment

8. Remove the valve bridge and reinstall it in its ORIGINAL position with the spring in place (if a spring-loaded bridge is used).

9. Adjust the remaining valve bridges in the same manner.

10. Swing the rocker arm assembly into position, making sure the valve bridges are properly positioned on the rear valve stems. This precaution is necessary to prevent valve damage due to mislocated valve bridges. Tighten the rocker arm shaft bracket bolts to the torque specified in Section 1.2.0.

11. Align the fuel pipes and connect them to the injectors and the fuel connectors. Use socket J 8932-01 and a torque wrench to tighten the connections to 12-15 lb-ft torque.

    CAUTION: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

12. Fill the cooling system.

    NOTE: Remove the vent plug from the thermostat housing or open the vent valve when filling the cooling system.

13. Adjust the exhaust valve clearance and time the injectors as outlined in Section 14.1 and 14.2 before starting the engine.

14. Start the engine and check for leaks in the fuel, water and lubrication systems.

15. Perform the final tune-up as outlined in Section 14 after the engine has reached its normal operating temperature.

16. Install the valve rocker cover.

VALVE ROCKER COVER

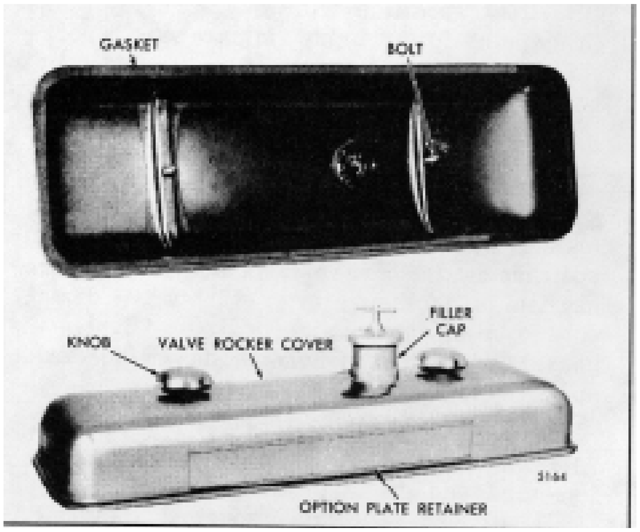


Fig. 1. Typical Valve Rocker Cover Assembly

The valve rocker cover assembly (Fig. 1) completely encloses the valve and injector rocker arm compartment at the top of the cylinder head. The top of the cylinder head is sealed against oil leakage by a gasket located in the flanged edge of the cover.

An option plate is inserted in a retainer (Fig. 1) attached to the valve rocker cover.

The valve rocker cover assembly on certain engines may include a breather assembly or an oil filler, depending upon the engine application.

Remove and Install Valve Rocker Cover

Clean the valve rocker cover before removing it from the engine to avoid dust or dirt from entering the valve mechanism. Then loosen the knobs and lift the cover straight up from the cylinder head. Use a new gasket when re-installing the cover.

CRANKSHAFT

The crankshaft (Figs. 1 and 2) is a one-piece steel forging, heat-treated to ensure strength and durability. All main and connecting rod bearing journal surfaces are induction hardened.

Complete static and dynamic balance of the crankshaft has been achieved by counterweights incorporated in the crankshaft.

The crankshaft end play is controlled by thrust washers located at the rear main bearing cap of the engine. Full pressure lubrication to all connecting rod and main bearings is provided by drilled passages within the crankshaft and cylinder block.

Two dowels (Fig. 2) and six tapped holes are provided in the rear end of the crankshaft for locating and attaching the flywheel. One hole is unequally spaced so that the flywheel can be attached in only one position.

Each main bearing journal is 3-1/2" in diameter and each connecting rod journal is 2-3/4" in diameter.

Remove Crankshaft

When removal of the crankshaft becomes necessary, first remove the transmission, then proceed as follows:

1. Clean the exterior of the engine.
2. Drain the cooling system.
3. Drain the engine crankcase.
4. Remove all engine to base attaching bolts. Then, with a chain hoist and sling attached to the lifter brackets or eye bolts at each end of the engine, remove the engine from the vehicle.
5. Remove all of the accessories and assemblies with their attaching parts as necessary to permit the engine to be mounted on an overhaul stand.
6. Mount the engine on an overhaul stand and fasten it securely to the mounting plate.

   CAUTION: Be absolutely sure the engine is securely attached to the stand before releasing the lifting sling. Severe injury to personnel and destruction of engine parts will result if the engine breaks away from the stand.

7. Remove the oil pan.
8. Remove the lubricating oil pump.
9. Remove the flywheel and flywheel housing.
10. Remove the crankshaft cap or pulley.
11. Remove the vibration damper, if used.
12. Remove the front engine support.
13. Remove the crankshaft front cover.
14. Remove the vibration damper inner cone or oil seal spacer.

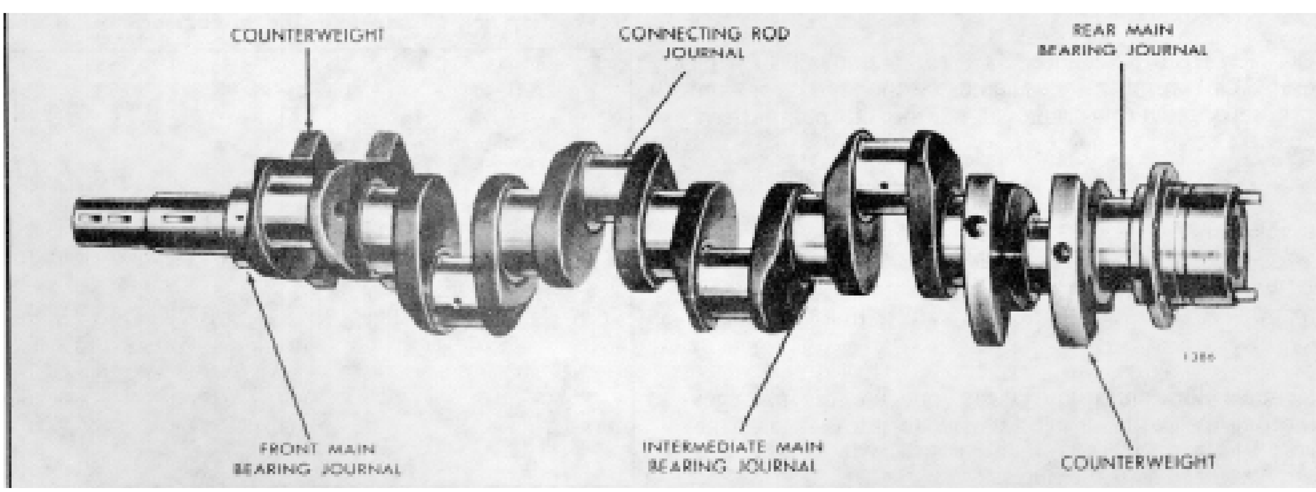


Fig. 1. Typical Six Cylinder Crankshaft

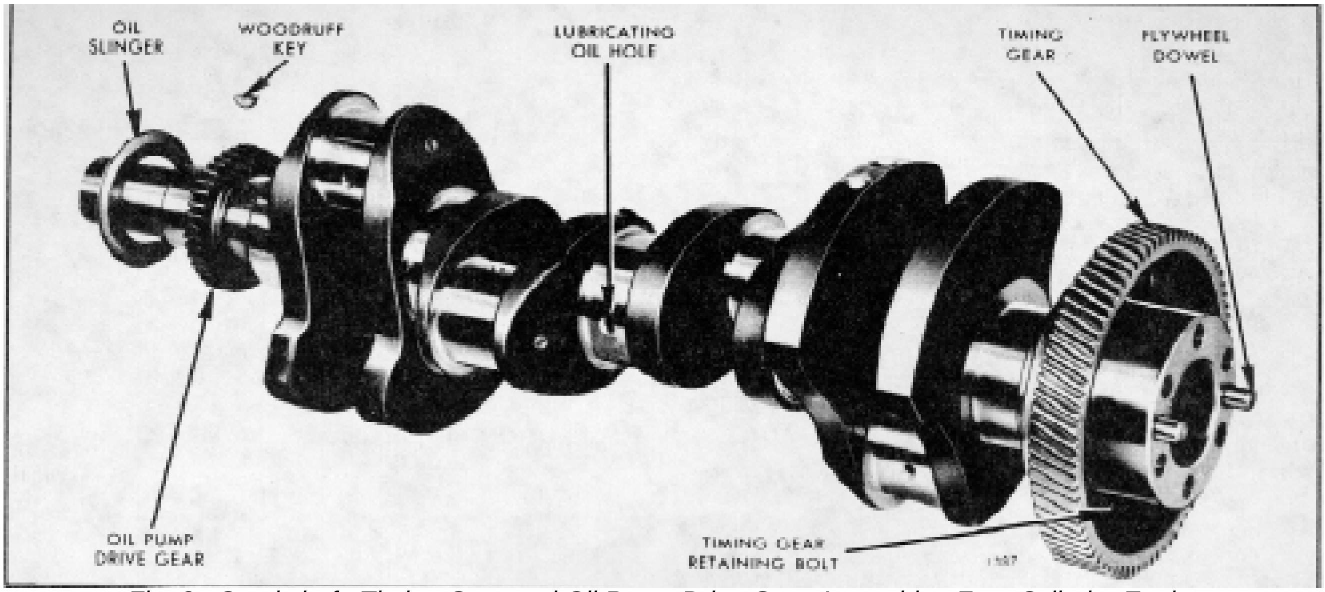


Fig. 2. Crankshaft, Timing Gear and Oil Pump Drive Gear Assembly - Four Cylinder Engine

15. Remove the cylinder head.

16. Remove the connecting rod bearing caps.

17. Remove the main bearing caps.

18. Remove the thrust washers from each side of the rear main bearing.

19. Remove the pistons, connecting rods and liners.

20. Remove the crankshaft, including the timing gear and oil pump drive gear (Fig. 2).

21. Refer to Section 1.7.5 for removal of the crankshaft timing gear and Section 4.1 for the procedure covering removal of the oil pump drive gear.

Inspection

After the crankshaft has been removed, clean and inspect it thoroughly before reinstalling it in the engine.

Remove the plugs and clean out the oil passages thoroughly with a stiff wire brush. Clean the crankshaft with fuel oil and dry it with compressed air. Then reinstall the plugs.

Inspect the keyways for evidence of cracks or wear. Replace the crankshaft, if necessary.

If the crankshaft shows evidence of excessive overheating, replace the crankshaft since the heat treatment has probably been destroyed.

Used crankshafts will sometimes show a certain amount of ridging caused by the groove in the upper main bearing shell or lower connecting rod bearing shell (Fig. 3). Ridges exceeding .0002" must be removed. If the ridges are not removed, localized high unit pressures on new bearing shells will result during engine operation.

The ridges may be removed by working crocus cloth, wet with fuel oil, around the circumference of the crankshaft

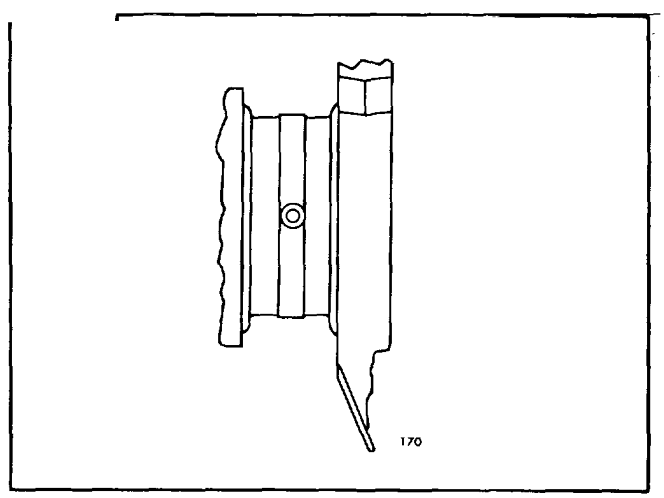


Fig. 3. Typical Ridging of Crankshaft

journal. If the ridges are greater than .0005", first use 120 grit emery cloth to clean up the ridge, 240 grit emery cloth for finishing and wet crocus cloth for polishing. Use of a piece of rawhide or other suitable rope wrapped around the emery cloth or crocus cloth and drawn back and forth will minimize the possibility of an out-of-round condition developing (keep the strands of rawhide apart to avoid bind). If rawhide or rope is not used, the crankshaft should be rotated at intervals. If the ridges are greater than .001", the crankshaft may have to be reground.

Carefully inspect the rear end of the crankshaft in the area of the oil seal contact surface for evidence of a rough or grooved condition. Any imperfections of the oil seal contact surface will result in oil leakage at this point.

Slight ridges on the crankshaft oil seal contact surface may be cleaned up with emery cloth and crocus cloth in the same manner as detailed for the crankshaft journals. If the crankshaft cannot be cleaned up satisfactorily, the oil seal may be repositioned in the flywheel housing as outlined in Section 1.3.2.

Check the crankshaft thrust surfaces for excessive wear or grooving. If only slightly worn, the surfaces may be dressed with a stone. Otherwise it will be necessary to regrind the thrust surfaces.

Check the oil pump drive gear and the crankshaft timing gear for worn or chipped teeth. Replace the gears, if necessary.

Check the crankshaft dowel extension. Current dowels extend 1/2" from the crankshaft while former dowels extend 5/8".

Inspect the crankshaft for cracks as outlined under *Inspection for Cracks.*

CRANKSHAFT RUNOUT

Engine	Journals	Max. Runout (Total indicator reading)
6-71	At No. 2 and No. 6	.002"
	At No. 3 and No. 5	.004"
	At No. 4	.006"

TABLE 1

Crankshaft Measurements

Support the crankshaft on its front and rear journals on V-blocks or in a lathe and check the alignment at the adjacent intermediate main journals with a dial indicator.

When the runout on the adjacent journals is in opposite directions, the sum must not exceed .003" total indicator reading. When the runout on the adjacent journals of the four and six cylinder crankshaft is in the same direction, the difference must not exceed .003" total indicator reading. If the runout limit is greater than given in Table 1, the crankshaft must be replaced.

Measure all of the main and connecting rod bearing journals (Fig. 6). Measure the journals at several places on the circumference so that taper, out-of-round and bearing clearances can be determined. If the crankshaft is worn so that the maximum journal-to-bearing shell clearance (with new shells) exceeds .0044", the crankshaft must be reground. Measurements of the crankshaft should be accurate to the nearest .0002". Also, if the journal taper of a used crankshaft exceeds .0015" or the out-of-round is greater than .001", the crankshaft must be reground.

Also measure the crankshaft thrust surfaces (Fig. 8).

Inspection for Cracks

Carefully check the crankshaft for cracks which start at an oil hole and follow the journal surface at an angle of 45° to the axis. Any crankshaft with such cracks must be rejected. Several methods of determining the presence of minute cracks not visible to the eye are outlined below.

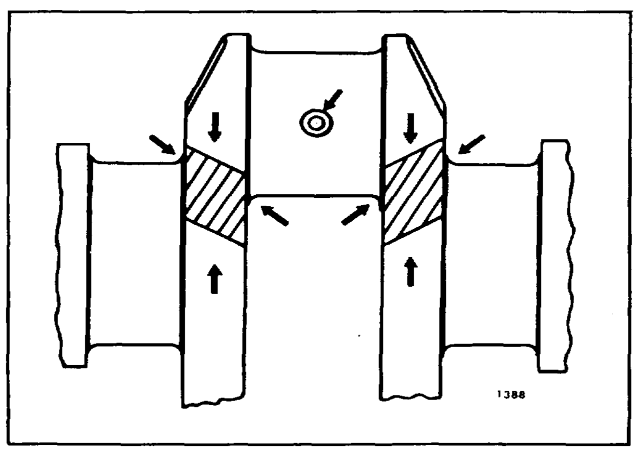


Fig. 4. Critical Crankshaft Loading Zones

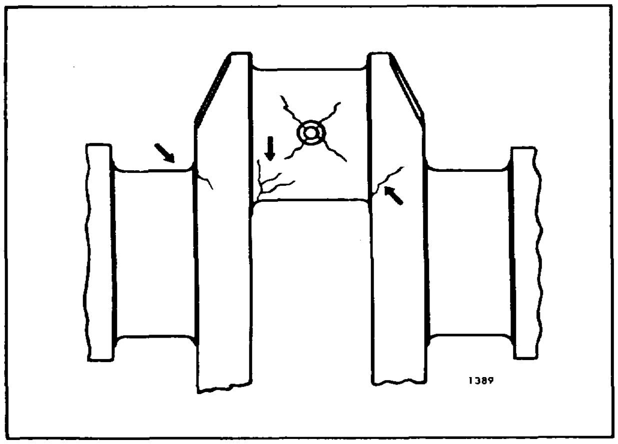


Fig. 5. Crankshaft Fatigue Cracks

Magnetic Particle Method: The part is magnetized and then covered with a fine magnetic powder or solution. Flaws, such as cracks, form a small local magnet which causes the magnetic particles in the powder or solution to gather there, effectively marking the crack. The crankshaft must be de-magnetized after the test.

Fluorescent Magnetic Particle Method: This method is similar to the magnetic particle method, but is more sensitive since it employs magnetic particles which are fluorescent and glow under "black light". Very fine cracks that may be missed under the first method, especially on discolored or dark surfaces, will be disclosed under the "black light".

Fluorescent Penetrant Method: This is a method which may be used on *non-magnetic* materials such as stainless steel, aluminum and plastics. A highly fluorescent liquid penetrant is applied to the part. Then the excess penetrant is wiped off and the part is dried. A developing powder is then applied which helps to draw the penetrant out of the flaws by capillary action. Inspection is carried out under "black light".

A majority of indications revealed by the above inspection methods are normal and harmless and only in a small percentage of cases is reliability of the part impaired when indications are found. Since inspection reveals the harmless indications with the same intensity as the harmful ones, detection of the indications is but a first step in the procedure. **Interpretation** of the indications is the most important step.

All Detroit Diesel crankshafts are magnetic particle inspected after manufacture to ensure against any shafts with harmful indications getting into the original equipment or factory parts stock.

Crankshaft failures are rare and when one cracks or breaks completely, it is very important to make a thorough inspection for contributory factors. Unless abnormal conditions are discovered and corrected, there will be a repetition of the failure.

There are two types of loads imposed on a crankshaft in service - a *bending* force and a *twisting* force. The design of the shaft is such that these forces produce practically no stress over most of the surface. Certain small areas, designated as critical areas, sustain most of the load (Fig. 4).

Bending fatigue failures result from bending of the crankshaft which takes place once per revolution.

The crankshaft is supported between each of the cylinders by a main bearing and the load imposed by the gas pressure on top of the piston is divided between the adjacent bearings. An abnormal bending stress in the crankshaft, particularly in the crank fillet, may be a result of misalignment of the main bearing bores, improperly fitted bearings, bearing failures, a loose or broken bearing cap, or unbalanced pulleys. Also, drive belts which are too tight may impose a bending load upon the crankshaft.

Failures resulting from bending start at the pin fillet and progress throughout the crank cheek, sometimes extending into the journal fillet. If main bearings are replaced due to one or more badly damaged bearings, a careful inspection must be made to determine if any cracks have started in the crankshaft. These cracks are most likely to occur on either side of the damaged bearing.

Torsional fatigue failures result from torsional vibration which takes place at high frequency.

A combination of abnormal speed and load conditions may cause the twisting forces to set up a vibration, referred to as torsional vibration, which imposes high stresses at the locations shown in Fig. 4.

Torsional stresses may produce a fracture in either the connecting rod journal or the crank cheek. Connecting rod journal failures are usually at the fillet at 45° to the axis of the shaft.

A loose, damaged or defective vibration damper, a loose flywheel or the introduction of improper or additional pulleys or couplings are usual causes of this type of failure. Also, overspeeding of the engine or resetting the governor at a different speed than intended for the engine application may be contributory factors.

Bearing Sizes	Conn. Rod Journal Dia. "A"	Main Bearing Journal Dia. "B"
Standard	2.750"	3.500"
.002" Undersize	2.750"	3.500"
.010" Undersize	2.740"	3.490"
.020" Undersize	2.730"	3.480"
.030" Undersize	2.720"	3.470"

TABLE 2

As previously mentioned, most of the indications found during inspection of the crankshaft are harmless. The two types of indications to look for are circumferential fillet cracks at the critical areas and 45° cracks (45° with the axis of the shaft) starting from either the critical fillet locations or the connecting rod journal holes as shown in Fig. 5. Replace the crankshaft when cracks of this nature are found.

Crankshaft Grinding

In addition to the standard size main and connecting rod bearings, .002", .010", .020" and .030" undersize bearings are available.

> **NOTE:** The .002 " undersize bearings are used only to compensate for slight wear on crankshafts on which regrinding is unnecessary.

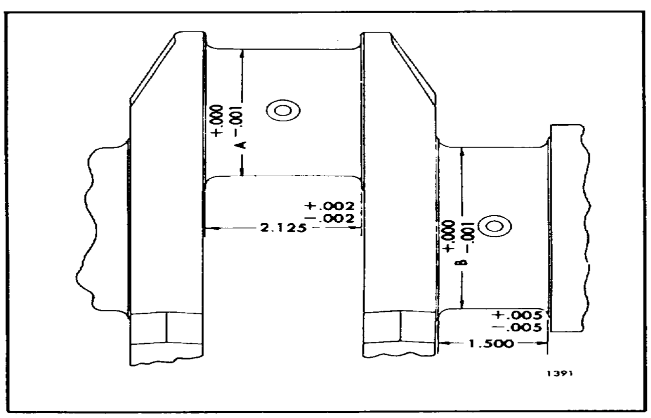


Fig. 6. Dimensions of Crankshaft Journals

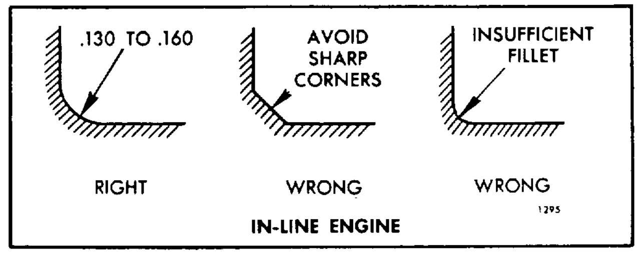


Fig 7. Crankshaft Journal Fillets

If the crankshaft is to be reground, proceed as follows:

1. Compare the crankshaft journal measurements taken during inspection with the dimensions in Table 2 and Fig. 6 and determine the size to which the journals are to be reground.

2. If one or more main or connecting rod journals require grinding, then grind all of the main journals or all of the connecting rod journals to the same required size.

3. All journal fillets must have a .130" to .160" radius between the crank cheek and the journal and must not have any sharp grind marks (Fig. 7). The fillet must blend smoothly into the journal and the crank cheek and must be free of scratches. The radius may be checked with a fillet gage.

4. Care must be taken to avoid localized heating which often produces grinding cracks.

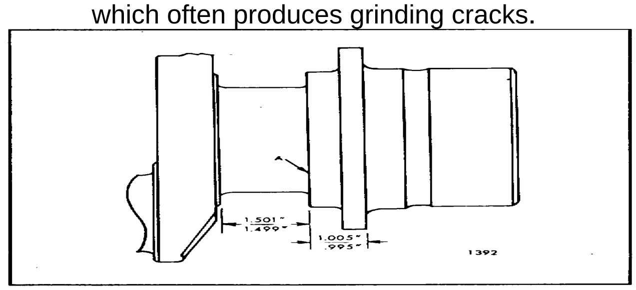


Fig. 8. Standard Dimension at Crankshaft Thrust Surfaces

Cool the crankshaft while grinding, using coolant generously. Do not crowd the grinding wheel into the work.

5. Polish the ground surfaces to an 8-12 R.M.S. finish. The reground journals will be subject to excessive wear unless polished smooth.

6. If the thrust surfaces of the crankshaft (Fig. 8) are worn or grooved excessively, they must be reground and polished. Care must be taken to leave a .130" to .160" radius between each thrust surface and the bearing journal.

7. Stone the edge of all oil holes in the journal surfaces smooth to provide a radius of ≈3/32".

8. After grinding is completed, inspect crankshaft by the magnetic particle method to see if cracks have originated due to the grinding operation.

9. De-magnetize the crankshaft.

10. Remove the plugs and clean the crankshaft and oil passages thoroughly with fuel oil. Dry the shaft with compressed air and reinstall the plugs.

Install Crankshaft

If a new crankshaft is to be installed, steam clean it to remove the rust preventive, blow out the oil passages with compressed air and install the plugs. Then install the crankshaft as follows:

1. Assemble the crankshaft timing gear (Section 1.7.5) and the oil pump drive gear (Section 4.1) on the crankshaft.

2. Refer to Section 1.3.4 for main bearing details and install the upper *grooved* main bearing shells in the block. If the old bearing shells are to be used again, install them in the same locations from which they were removed.

NOTE: When a new or reground crankshaft is installed, *ALL* new main and connecting rod (upper and lower) bearing shells and new thrust washers must also be installed.

3. Apply clean engine oil to all crankshaft journals and install the crankshaft in place so that the timing marks on the crankshaft timing gear and the idler gear match. Refer to Section 1.7.1 for the correct method of timing the gear train.

4. Install the upper halves of the crankshaft thrust washers on each side of the rear main bearing support and the doweled lower halves on each side of the rear

Thrust Washer

Nominal Size	Thickness	
	Min.	Max.
Standard	.1190"	.1220"
.005" Oversize	.1255"	.1270"
.010" Oversize	.1300"	.1320"

TABLE 3

main bearing cap. *The grooved side of the thrust washers must face toward the crankshaft thrust surfaces.*

NOTE: If the crankshaft thrust surfaces were reground, it may be necessary to install oversize thrust washers on one or both sides of the rear main journal. Refer to Fig. 8 and Table 3.

5. Install the lower bearing shells (no oil grooves) in the bearing caps. If the old bearing shells are to be used again, install them in the same bearing caps from which they were removed.

6. Install the bearing caps and lower bearing shells as outlined under *Install Main Bearing Shells* in Section 1.3.4.

NOTE: If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

7. Check the crankshaft end play by moving the crankshaft toward the gage (Fig. 9) with a pry bar. Keep a constant pressure on the pry bar

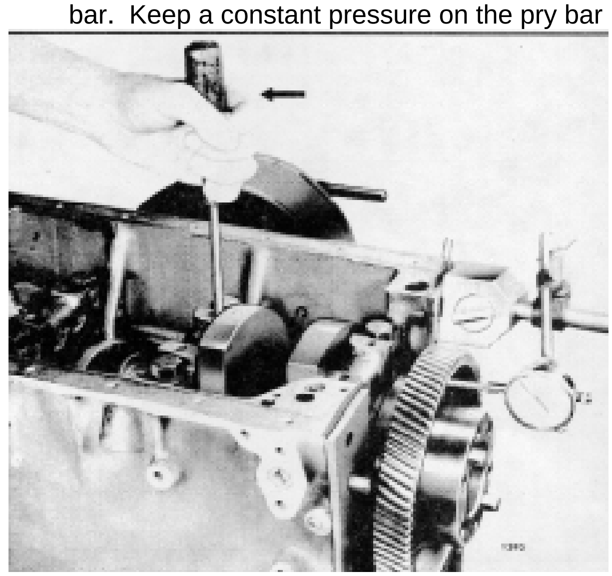


Fig. 9. Checking Crankshaft End Play

and set the dial indicator to zero. Then remove and insert the pry bar on the other side of the bearing cap. Force the crankshaft in the opposite direction and note the amount of end play on the dial. The end play should be .004" to .014" with new parts or a maximum of .018" with used parts. Insufficient end play can be the result of a misaligned rear main bearing or a burr or dirt on the inner face of one or more of the thrust washers.

8. Install the cylinder liner, piston and connecting rod assemblies (Section 1.6.3).

9. Install the cylinder head (Section 1.2).

10. Install the flywheel housing (Section 1.5), then install the flywheel (Section 1.4).

11. Install the crankshaft front cover and gasket.

    NOTE: Install the oil seal spacer or inner cone *after* the crankshaft front cover is in place to avoid damage to the oil seal lip.

12. Install the engine front support.

13. Install the vibration damper inner cone or oil seal spacer.

14. Install the vibration damper assembly, if used.

15. Install the crankshaft cap or pulley.

16. Install the lubricating oil pump assembly (Section 4.1).

17. Affix a new gasket to the oil pan flange and install the oil pan.

18. Use a chain hoist and sling attached to the lifting bracket or eye bolts at each end of the engine and remove the engine from the overhaul stand.

19. Install all of the accessories that were removed.

20. After the engine has been completely reassembled, refer to the *Lubricating Oil Specifications* in Section 13.3 and refill the crankcase to the proper level on the dipstick.

21. Close all of the drains and fill the cooling system.

22. After replacing the main or connecting rod bearings or installing a new or reground crankshaft, operate the engine as outlined in the run-in schedule (Section 13.2.1).

CRANKSHAFT OIL SEALS

An oil seal is used at each end of the crankshaft to retain the lubricating oil in the crankcase. The sealing lips of the oil seals are held firmly, but not tight, against the crankshaft sealing surfaces by a coil spring.

The front oil seal is pressed into the crankshaft front cover, and the lip of the seal bears against a removable spacer or vibration damper inner cone on the end of the crankshaft, next to the lubricating oil pump drive gear (Figs. 1 and 2).

A single-lip oil seal is used at the rear end of the crankshaft of some engines. A double-lip oil seal is used in engines where there is oil on both sides of the seal; the lips of the seal face in opposite directions. The rear oil seal is pressed into the flywheel housing (Figs. 3 and 4).

Oil leaks indicate worn or damaged oil seals. Oil seals may become worn or damaged due to improper installation, excessive main bearing clearances, excessive flywheel housing bore runout or grooved sealing surfaces on the crankshaft or oil seal spacers. To prevent a repetition of any oil seal leaks, these conditions must be checked and corrected.

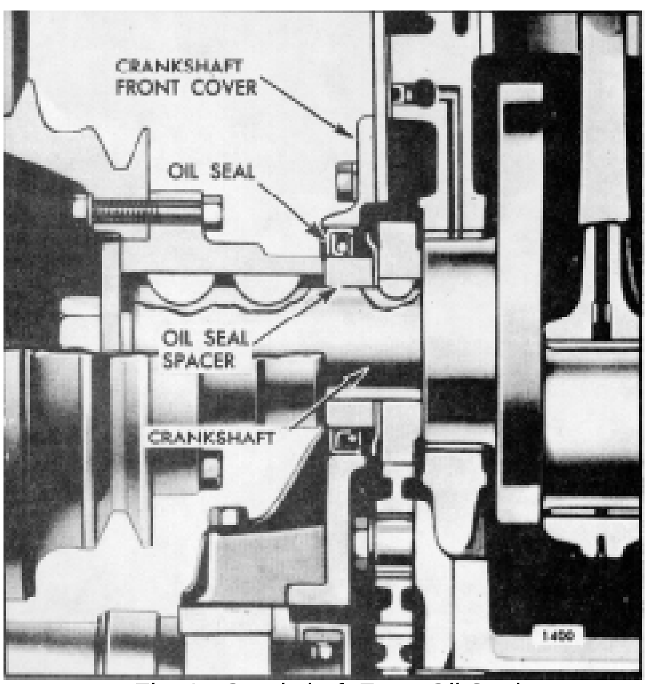


Fig. 1. Crankshaft Front Oil Seal

Remove Crankshaft Oil Seals

Remove the crankshaft front cover (Section 1.3.5) and the flywheel housing (Section 1.5) and remove the oil seals as follows:

1. Support the forward face of the front cover or the rear face of flywheel housing on wood blocks.

2. Drive the oil seal out and clean the seal bore in front cover or flywheel housing. Discard oil seal.

When necessary, an oil seal may be removed without removing the front cover or flywheel housing (except a front cover that is used with trunnion mounts this cover must be removed). This may be done by drilling diametrically opposite holes in the seal casing and threading metal screws, backed by flat washers, into the casing. Remove the seal by prying against the washers with pry bars.

Inspection

Inspect the rear end of the crankshaft for wear caused by the rubbing action of the oil seal, dirt build-up or fretting by the action of the flywheel. The crankshaft surface must be clean and smooth to prevent damaging the seal lip when a new oil seal is installed. Slight ridges may be removed from the crankshaft as outlined under *Inspection* in Section 1.3.

The maximum runout of the oil seal bore in the flywheel

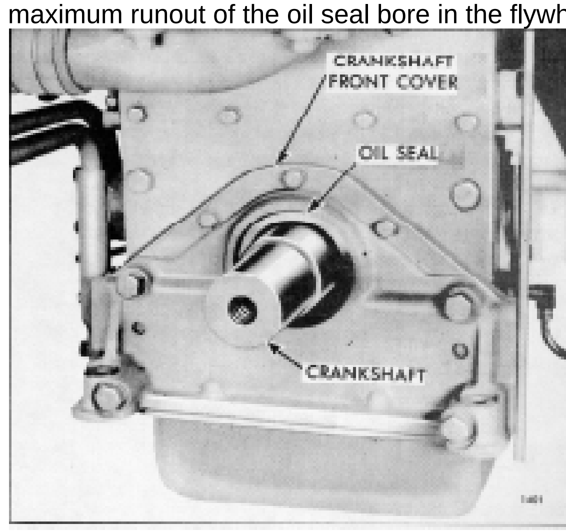


Fig. 2. Crankshaft Front Oil Seal Mounting

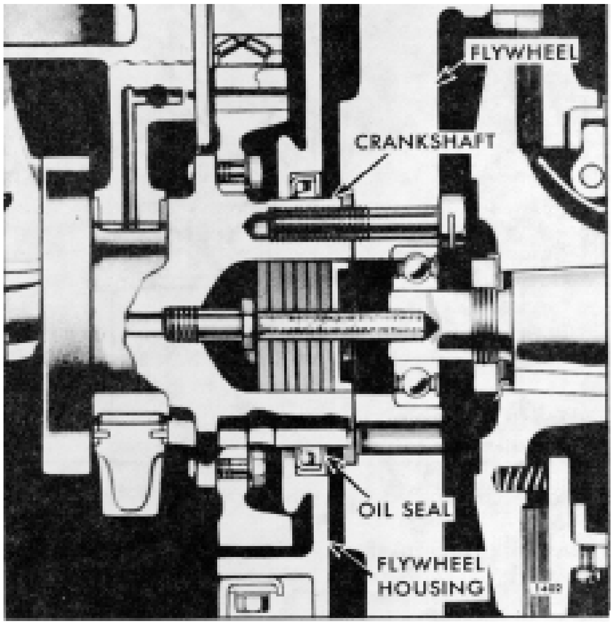


Fig. 3. Crankshaft Rear Oil Seal

housing is .008". The bore may be checked with a dial indicator mounted on the end of the crankshaft in a manner similar to the procedure for checking the flywheel housing concentricity as outlined in Section 1.5. This check must be made with the flywheel housing in place on the engine and the oil seal removed.

If the crankshaft rear oil seal surface is grooved excessively, an oil seal spacer (Fig. 5) may be installed between the counterbore in the flywheel housing and the oil seal. The spacer changes the relative position of the seal and establishes a new contact surface. However, the spacer cannot be used with a double-lip type seal since the grooves worn in the crankshaft are too close together to permit repositioning of the seal.

When the oil seal spacer can no longer be used, an oil seal sleeve (Fig. 5) may be installed on the crankshaft to provide a replaceable wear surface at the point of contact with the rear oil seal. The oil seal sleeve may be used with either a single-lip or double-lip type oil seal; it can also be used in conjunction with the seal spacer. But an oversize oil seal must be used with the sleeve.

Install an oil seal sleeve as follows:

1. Stone the high spots from the oil seal contact surface of the crankshaft.

2. Coat the area of the shaft where the sleeve will be positioned with shellac or an equivalent sealant.

3. Drive the sleeve squarely on the shaft with oil seal sleeve installer J 4194.

4. Wipe off any excess sealant.

5. Coat the outside diameter of the sleeve with engine oil.

To remove a worn sleeve, peen the outside diameter until the sleeve stretches sufficiently so it can be slipped off the end of the crankshaft.

Oil Seals

Current oil seals are made of an oil resistant synthetic rubber which is pre-lubricated with a special lubricant. *Do not remove this lubricant.* Keep the sealing lip clean and free from scratches. In addition, a plastic coating which acts as a sealant has been applied to the outer surface of the casing. Do not remove this coating.

Install Crankshaft Front Oil Seal

1. If the oil seal is not pre-coated, apply a nonhardening sealant to the periphery of the metal casing.

2. Coat the lip of the new oil seal lightly with grease or vegetable shortening. Then position the seal

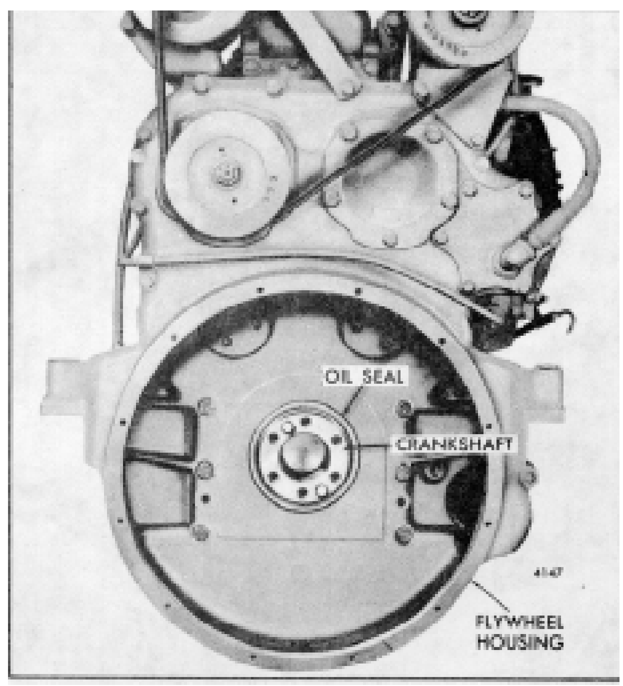


Fig. 4. Crankshaft Rear Oil Seal Mounting

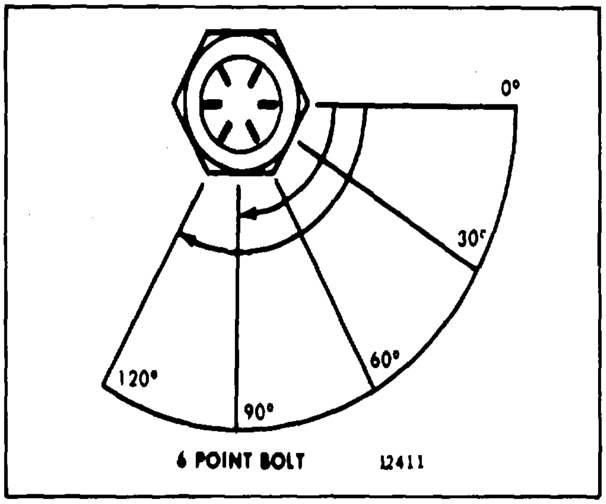


Fig. 4 - Torque-Turn Limits

Install Flywheel

1. Install a new oil seal ring (if used).

2. Attach the flywheel lifting tool and, using a chain hoist, position the flywheel in the flywheel housing (use guide studs). Align the flywheel bolt holes with the crankshaft bolt holes.

3. Install the clutch pilot bearing (if used).

4. Install the washer type pilot bearing retainer, if used. To install a split tube type retainer, drive the retainer in flush with the end of the crankshaft with a soft hammer.

> **CAUTION**: Do not mar the bearing contact surface of the retainer.

5. Install two bolts through the scuff plate 180° from each other. Snug the bolts to hold the flywheel and scuff plate to the crankshaft. Remove the guide studs.

6. Remove the flywheel lifting tool.

7. Apply International Compound No. 2, or equivalent, to the threads and to the bolt head contact area (underside) of the remaining bolts. The bolt threads must be completely filled with International Compound No. 2 and any excess wiped off.

> **NOTE**: International Compound No. 2 must never be used between two surfaces where maximum friction is desired, as between the crankshaft and the flywheel.

8. Install the remaining bolts and run them in snug.

9. Remove the two bolts used temporarily to retain the flywheel, apply International Compound No. 2 as described above, then reinstall them.

10. Use an accurately calibrated torque wrench and tighten the bolts to 50 lb-ft (68 Nm) torque.

11. Turn the bolts an additional 90° -120° (Fig. 4) to obtain the required clamping.

> **NOTE**: Since the torque-turn method provides more consistent clamping than the former method of flywheel installation, bolt torque values should be ignored.

> **IMPORTANT**: When a clutch pilot bearing is installed, index the flywheel bolts so that the corners of the bolt heads do not overlap the pilot bearing bore in the flywheel. Thus, one of the flats of each bolt head will be in line with the bearing bore. Always rotate bolts in the *increased clamp direction to prevent underclamping*.

12. Mount a dial indicator on the flywheel housing and check the runout of the flywheel at the clutch contact face. The maximum allowable runout is .001 "total indicator reading per inch of radius (or .001 mm per millimeter of radius). The radius is measured from the center of the flywheel to the outer edge of the clutch contact face of the flywheel.

CLUTCH PILOT BEARING

The clutch pilot bearing is pressed into the bore of the flywheel assembly and serves as a support for the inner end of the clutch drive shaft.

The clutch pilot bearing is held in place by a scuff plate or bearing retainer, secured in place by the flywheel attaching bolts.

Lubrication

A single-shielded ball type clutch pilot bearing should be packed with an all purpose grease if not previously packed by the manufacturer. A double-sealed ball type clutch pilot bearing is prepacked with grease and requires no further lubrication.

Remove Clutch Pilot Bearing (Transmission Removed)

With the flywheel attached to the engine, remove the ball type clutch pilot bearing as follows:

1. Remove the six bolts (and lock wires, if used) attaching the flywheel to the crankshaft. Remove the bearing retainer and reinstall two of the bolts to hold the flywheel in place.

> **CAUTION**: Install two 9/16 "-18 studs in place of two of the flywheel bolts, on engines without dowels in the end of the crankshaft, to prevent the flywheel from dropping off the end of the crankshaft.

2. With the clutch pilot bearing remover adaptor J 5901-2 attached to slide hammer J 5901-1, insert the fingers of the adaptor through the pilot bearing and tighten the thumb screw to expand the fingers against the inner race of the bearing.

3. Tap the slide hammer against the shoulder on the, shaft and pull the bearing out of the flywheel.

With the flywheel removed from the engine, the clutch pilot bearing may be removed as follows:

1. Place the flywheel on wood supports to provide clearance for the bearing.

2. Use bearing remover J 5901-2 as outlined above, or tool J 3154-04 with suitable adaptor plates, to tap the bearing from the flywheel.

Inspection

Wipe the prepacked double-sealed bearing clean on the outside and inspect it. Shielded bearings must not be washed; dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Clean the other types of bearing thoroughly with clean fuel oil and dry them with compressed air.

Check the bearing for free rolling by holding the inner race and revolving the outer race slowly by hand. Rough spots in the bearing are sufficient cause for rejecting it.

Install Clutch Pilot Bearing

1. Lubricate the outside diameter of the bearing with clean engine oil.

2. Start the bearing in the bore of the flywheel, with the numbered side of the bearing facing away from the engine, and drive the bearing in place with bearing installer J 3154-04 and suitable adaptor plates.

3. Install the flywheel on the crankshaft (refer to Section 1.4).

FLYWHEEL HOUSING

The flywheel housing (Fig. 1) is a one-piece casting, mounted against the rear cylinder block end plate, which provides a cover for the gear train and the flywheel. It also serves as a support for the starting motor and the transmission.

The crankshaft rear oil seal, which is pressed into the housing, may be removed or installed without removing the housing (Section 1.3.2).

The size of the tapped holes in the SAE No. 1 flywheel housings, used for transmission attaching bolts, has been increased from 3/8"-16 to 7/16"-14 to conform with a revision in SAE flywheel housing standards.

Remove Flywheel Housing

1. Mount the engine on an overhaul stand as outlined in Section 1.1.

2. Remove the starting motor, oil pan, flywheel and any accessories attached to the flywheel housing.

3. Remove the two bolts securing the engine lifter bracket to the cylinder head. This will leave the lifter bracket attached to the flywheel housing for convenience in handling.

4. Remove the twelve attaching bolts inside of the flywheel housing bell which attach the housing to the idler gear hub, spacer and cylinder block. Remove the twelve remaining bolts around the upper portion of the housing and the two bolts which go through the rear end plate from the front and thread into the housing (Fig. 1).

> **NOTE**: When removing the flywheel housing bolts, note the location of the various bolts and washers so they may be reinstalled in their proper location.

5. To guide the flywheel housing until it clears the end of the crankshaft, thread four pilot studs J 1927-01 into the cylinder block (Fig. 2).

6. With the flywheel housing supported by a chain hoist attached to the lifter bracket, strike the front face of the housing alternately on each side with a soft hammer to work it off the dowels and away from the cylinder block rear end plate:

Clean the flywheel housing and inspect it for cracks or any other damage.

> **NOTE**: The flywheel housing on some engine models had a 9.603 " radius from the center of the crankshaft bore to the center of the starter hole. These engines used a 103 tooth flywheel ring gear. These flywheel housings have been replaced by new housings with a 9.520 " crank-shaft bore to starter hole radius. A 102 tooth flywheel ring gear must be used with-the new housings. The old ring gear is retained for service for those engines still using the old housing.

It is very important that all old gasket material be thoroughly removed from the flywheel housing and the end plate, otherwise runout of the pilot and the face of the housing may be affected when the housing is installed on the engine.

The steel oil deflector used in the flywheel housing on certain former engines is no longer required and is not available for service. It may be discarded at time of flywheel housing removal.

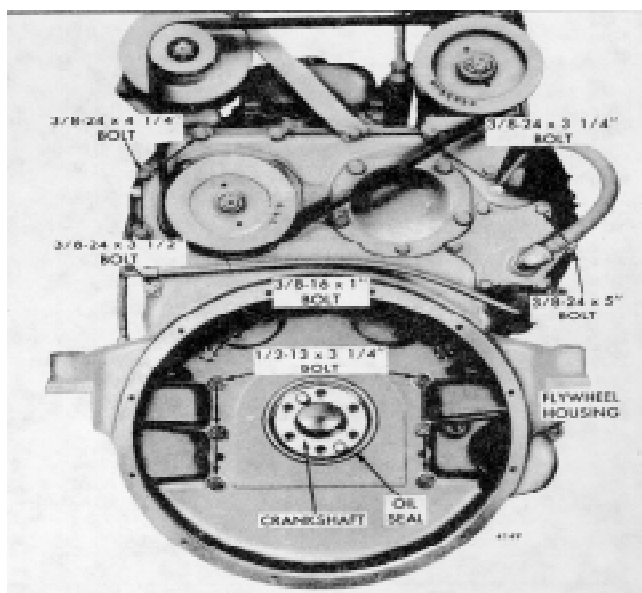


Fig. 1 - Typical Flywheel Housing Mounting

Inspection

1.5 Flywheel Housing

Remove and discard the crankshaft rear oil seal. Install a new oil seal as outlined in Section 1.3.2.

Install Flywheel Housing

1. Lubricate the gear train teeth with clean engine oil.

2. Affix a new housing-to-end plate gasket to the flywheel housing. Also, if an idler gear hole spacer is used, attach the gaskets to the hub or the spacer or both, as required. NO gasket is used with the current design hub or spacer (see Section 1.7.4).

> **NOTE**: On certain flywheel housings, the idler gear hole spacer is cast integrally in the housing, opposite the idler gear (Fig. 3). As a result of this integral cast design, a shim must be installed between the flywheel housing and the cylinder block end plate. Use grease to hold the shim on the spacer during installation of the flywheel housing.

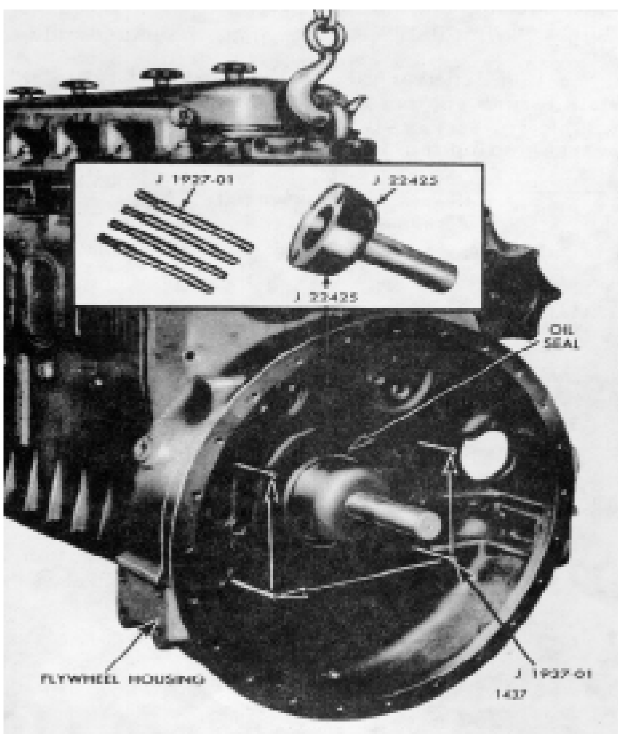


Fig. 2 - Remove or Installing Flywheel Housing

3. Coat the lip of the oil seal lightly with engine oil (single-lip seal) or vegetable shortening (double-lip seal). Do not scratch or nick the sealing edge of the oil seal.

4. Thread four pilot studs J 1927-01 into the cylinder block to guide the housing in place (Fig. 2). Use oil seal expander J 22425 (standard size seal) or expander J 4195 and handle J 8092 (oversize seal) on the end of the crankshaft to pilot the oil seal on the crankshaft.

5. With the housing suitably supported, position it over the crankshaft and up against the cylinder block rear end plate and gasket. Remove the oil seal expander.

6. Refer to Fig. I and install the six 3/8"-16 bolts with flat washers in the tapped holes of the idler gear hub and idler gear hole spacer, finger tight. Remove the pilot studs.

> **NOTE**: If the idler gear hole spacer is integrally cast into the housing, be sure the shim is in place.

A self-locking type bolt and steel washer are currently being used to attach the flywheel housing to the idler gear hub and hole spacer. With this type bolt, the additional operation of securing the bolts with a lock wire is eliminated, inasmuch as the head of the bolt is so designed that it will lock itself to the attaching member when the specified torque is applied.

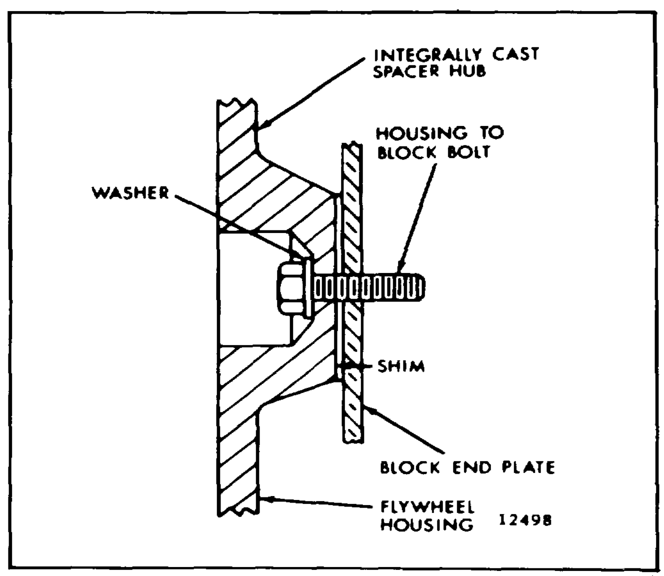


Fig. 3 - Idler Gear Hole Spacer Shim

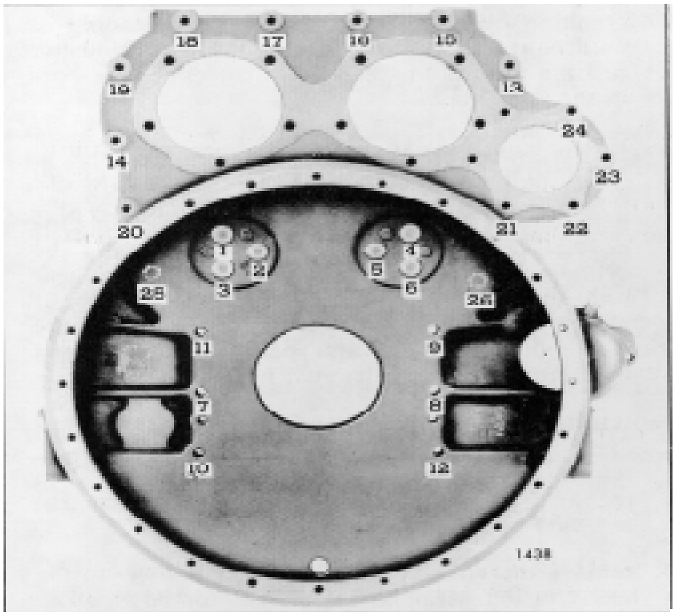


Fig. 4 - flywheel Housing Bolt Tightening Sequence (Operation 1)

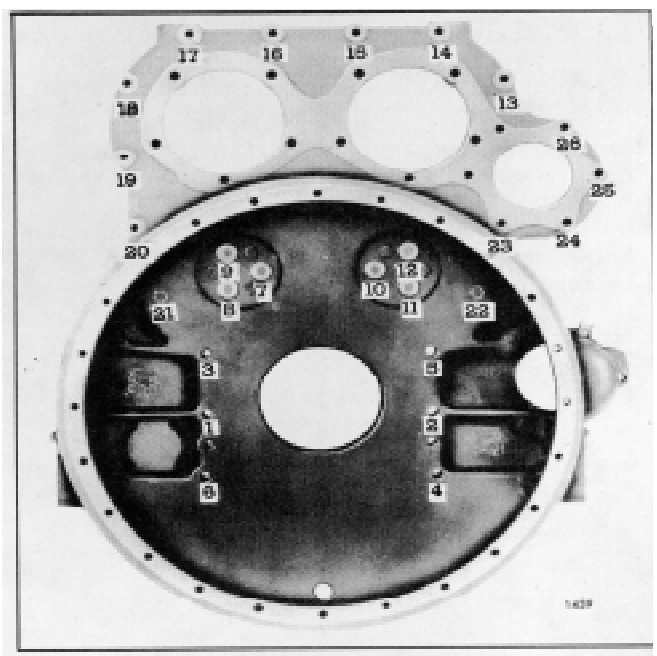


Fig. 5 - Flywheel Housing Bolt Tightening Sequence (Operation 2)

> **CAUTION**: The self-locking bolts must be used in sets of three. Former drilled head bolts, if used, MUST be locked in place with safety wire.

7. Install the six ½"-13 housing to block bolts with lock washers, finger tight.

8. Install the remaining flywheel housing attaching bolts and washers, finger tight.

9. Refer to Fig. 4 for the bolt tightening sequence. Start at number I and, using the proper sequence, bring all bolts to within 10-15 lb-ft (14-22 Nm) of their specified torque, drawing the mating parts together evenly.

> **NOTE**: When tightening the idler gear hub bolts, turn the crankshaft to prevent any bind or brinelling of the idler gear bearing. The crankshaft must be rotated for the flywheel housing bell tightening also.

10. Refer to Fig. 5 for the final bolt tightening sequence and, starting at number 1, tighten all of the bolts to the specified torque. Tighten the 3/8"-16 idler gear hub and hole spacer self-locking bolts to 40-45 lb-ft (54-61 Nm) torque. Tighten all other 3/8"-16 and 3/8"-24 bolts to 25-30 lb-ft (34-41 Nm) torque, and the ½" -13 bolts to 90-100 lb-ft or 122-136 Nm torque (cast iron housing); or 71-75 lb-ft or 96-102 Nm torque (aluminum housing). Be sure to rotate the crankshaft when tightening the idler gear hub bolts and flywheel housing bell.

If drilled head idler gear hub and spacer bolts are used, tighten them to 2540 lb-ft (34-54 Nm) torque. Line-up the lock wire holes in the bolt heads and install the lock wire, locking each group of three bolts together. The wide range in the torque specification permits alignment of the bolt heads.

11. Install the flywheel (Section 1.4).

12. Check the flywheel housing concentricity and bolting flange face with tool set J 9737-01 as follows:

   a. Refer to Fig. 6 and thread the base post J 9737-3 tightly into one of the tapped holes in the flywheel. Then assemble the dial indicators on the base post.

   b. Position the dial indicators straight and square with the flywheel housing bell face and inside bore of the bell. Make sure each indicator has adequate travel in each direction.

1.5 Flywheel Housing

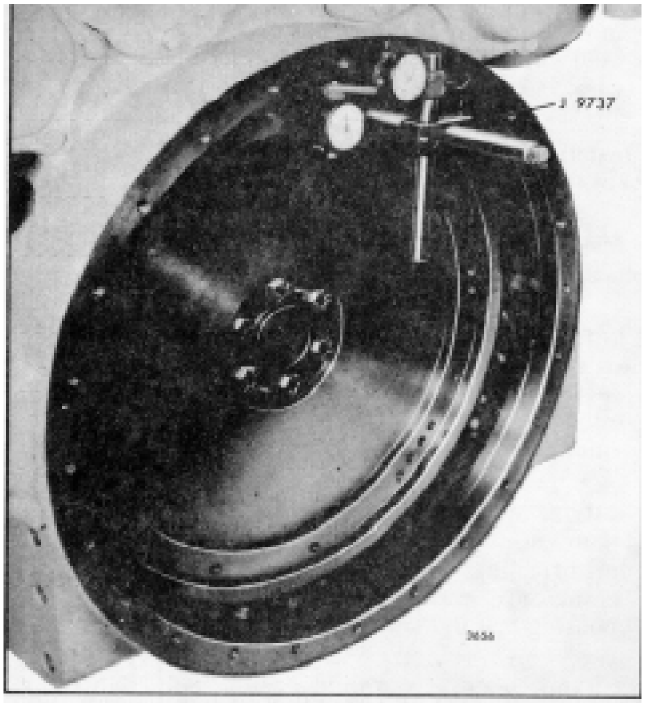


Fig. 6 - Checking Flywheel Housing Concentricity

NOTE: If the flywheel extends beyond the housing bell, the bore and face must be checked separately. Use the special adaptor in the tool set to check the housing bore.

c. Pry the crankshaft toward one end of the block to ensure the end play is in one direction only.

d. Adjust each dial indicator to read zero at the twelve o'clock position. Then rotate the crankshaft one full revolution, taking readings at 45 intervals (8 readings each for the bore and the bolting flange face). Stop and remove the wrench or cranking bar before recording each reading to ensure accuracy. The maximum total indicator reading must not exceed .013" for either the bore or the face.

e. If the runout exceeds the maximum limits, remove the flywheel housing and check for dirt or foreign material, such as old gasket material, between the end plate, flywheel. housing and the new gasket (and between the end plate and the cylinder block). Also make certain the idler gear hub and the idler gear hole spacer gaskets, if required, are used correctly. No gaskets are required with the hub and spacer on current units with the roller type idler gear bearing.

f. Reinstall the flywheel housing and the flywheel and tighten the attaching bolts in the proper sequence and to the specified torque. Then recheck the runout. If necessary, replace the flywheel housing.

13. Remove the bolts holding the lifter bracket to the flywheel housing. Affix a new gasket to the bracket, then alternately tighten the bracket-to-flywheel housing and bracket-to-cylinder head bolts, thus drawing the bracket into the corner formed by the cylinder head and housing (Section 1.2.3).

14. Install the oil pan.

15. Remove the engine from the overhaul and complete assembly of the engine.

NOTE: The starting motor pad bolt ho, have been relocated on certain SAE No. 1 and SAT No. 2 flywheel housings. If a current housing is installed on an early engine, the solenoid on a Sprag clutch type starting motor may have to be repositioned. Refer to Section 7.3 for the indexing procedure. It will be necessary to replace a Dyer drive type starting motor with a Sprag clutch type motor.

CROSS-HEAD TYPE PISTON

The cross-head piston (Figs. 14 and 15) is a two-piece piston consisting of a crown and skirt. A metal oil seal ring is used between the crown and skirt which are held together by the piston pin. Ring grooves are machined in the piston crown for a fire ring and two compression rings. The crown is also machined to accept a 150' slipper type bushing (bearing). The piston skirt incorporates two oil control ring grooves, piston pin holes and piston pin retainer counterbores. Equally spaced drain holes are located in the oil ring groove area to permit excess oil, scraped from the cylinder walls, to return to the crankcase. A lubricating oil tube and floating nut are contained inside of the piston pin. Two bolts and spacers are used to attach the connecting rod (Section 1.6.1) to the floating nut in the piston pin.

Internal parts of the piston are lubricated and cooled by the engine lubricating oil. Oil is pressure-fed up the drilled passage in the connecting rod, through the oil tube in the piston pin, then through the center hole in the bushing to the underside of the piston crown. A portion of the oil flows along the grooves in the bushing to lubricate the piston pin.

During engine operation, gas loads pushing down on the piston crown are taken directly by the piston pin and bushing. The piston skirt, being separate, is free from vertical load distortion; thermal distortion is also reduced as the piston crown expands. As the connecting rod swings to one side during downward travel of the piston, the major portion of the side load is taken by the piston skirt.

The non-turbocharged (naturally aspirated) engines use an 18.7:1 compression ratio piston.

> **CAUTION**: Cross-head pistons and trunk-type pistons must not be used together in an engine. The difference in weight of the pistons will affect engine balance.

Inspect Piston Rings

When an engine is hard to start, runs rough or lacks power, worn or sticking compression rings may be the cause. Replacing the rings will aid in restoring engine operation to normal.

The compression rings may be inspected through the ports in the cylinder liners after the air box covers have been removed. If the rings are free and are not worn to the extent that the plating or grooves are gone, compression should be within operating specifications. Refer to Section 15.2 for the procedure for checking compression pressure.

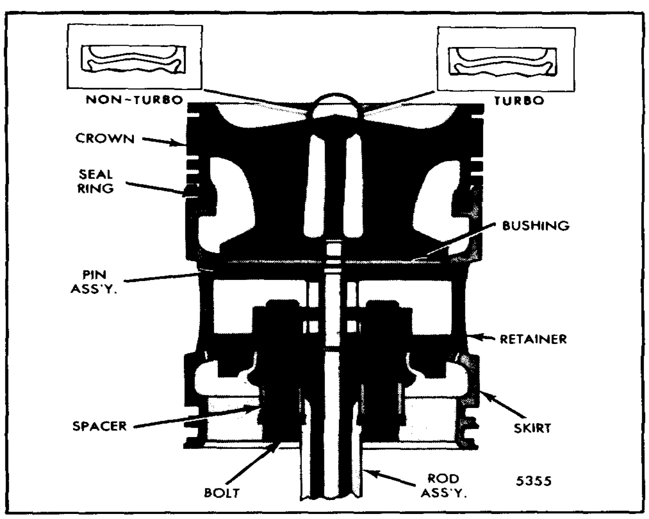


Fig. 14 - cross-Head Piston and Connecting Rod Assembly

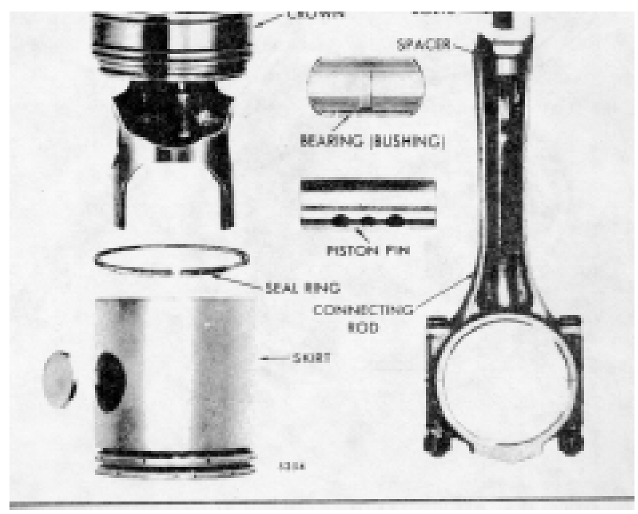


Fig. 15 - Cross-Head Piston and Connecting Rod Components

1.6 Piston and Piston Rings

Remove Piston and Connecting Rod

1. Drain the cooling system.

2. Drain the oil and remove the oil pan.

3. Remove the oil pump and inlet and outlet pipes, if necessary (Section 4.1).

4. Remove the cylinder head (Section 1.2).

5. Remove the carbon deposits from the upper inner surface of the cylinder liner.

6. Use a ridge cutter to remove any ridge in the cylinder liner at the top of the piston ring travel.

> **NOTE**: Move the piston to the bottom of its travel and place a cloth over the top of the piston to collect the cuttings. After the ridge has been removed, turn the crankshaft to bring the piston to the top of its stroke and carefully remove the cloth with the cuttings.

7. Remove the bearing cap and the lower bearing shell from the connecting rod. Then push the piston and rod assembly out through the top of the cylinder block. The piston cannot be removed from the bottom of the cylinder block.

Fig. 16 - Removing or Installing Piston Rings

8. Re-assemble the bearing cap and lower bearing shell to the connecting rod.

Disassemble Piston and Connecting Rod

Note the condition of the piston and rings. Then remove the rings and disassemble the piston as follows:

1. Secure the connecting rod in a vise equipped with soft jaws and remove the piston rings with tool J 8128 as shown in Fig. 16.

2. Punch a hole through the center of one of the piston pin retainers with a narrow chisel or punch and pry the retainer from the piston, being careful not to damage the piston or bushing. Remove the opposite retainer in the same manner.

3. Remove the two bolts and spacers which secure the connecting rod to the piston pin and remove the connecting rod.

4. Withdraw the piston pin.

5. Separate the piston skirt from the piston crown.

6. Remove the metal seal ring from the piston crown.

> **CAUTION**: Do not remove the bushings from the pistons used in series “N” engines because they are not serviced separately.

Cleaning

Clean the piston components with fuel oil and dry them with compressed air. If fuel oil does not remove the carbon deposits, use a chemical solvent that will not harm the piston pin bushing or the tin-plate on the piston.

The piston crown, including the compression ring grooves, is not tin-plated and may be wire-brushed to remove any hard carbon. Do not wire-brush the piston skirt. Clean the ring grooves with a suitable tool or a piece of an old compression ring that has been ground to a bevel edge.

Clean the inside surfaces of the piston crown and skirt and the oil drain holes in the lower half of the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.

Inspection

If the tin-plate on the piston skirt and the original grooves in the piston rings are intact, it is an indication of very little wear.

Excessively worn or scored piston skirts, rings or cylinder liners may be an indication of abnormal maintenance or operating conditions which should be corrected to avoid recurrence of the failure. The use of the correct types and proper maintenance of the lubricating oil filters and air cleaners will reduce to a minimum the amount of abrasive dust and foreign material introduced into the cylinders and will reduce the rate of wear.

Long periods of operation at idle speed and the use of improper lubricating oil or fuel must be avoided, otherwise a heavy formation of carbon may result and cause the rings to stick.

Keep the lubricating oil and engine coolant at the proper levels to prevent overheating of the engine.

Examine the piston skirt and crown for score marks, cracks, damaged ring groove lands or indications of overheating. Any piston that has been severely scored or overheated must be replaced. Indications of overheating or burned spots may be the result of an obstruction in the connecting rod oil passage.

Use the magnetic particle inspection methods outlined in Section 1.3 under Crankshaft Inspection to check for cracks in the piston.

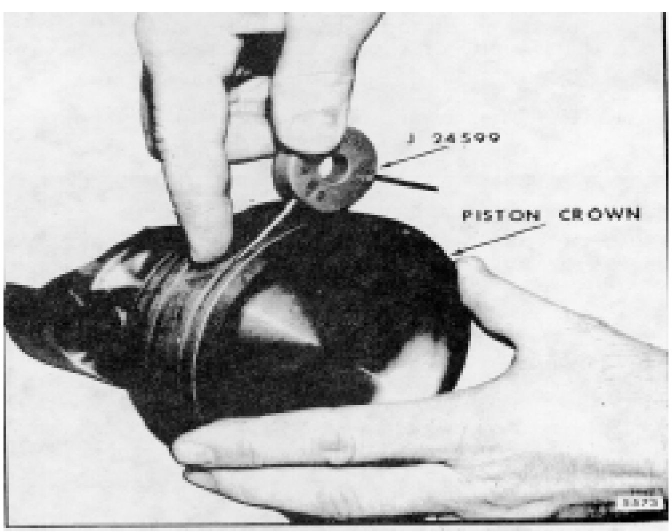


Fig. 17 - Checking Fire Ring Groove in Piston Crown

Check the cylinder liner and block bore for excessive out-of-round, taper or high spots which could cause failure of the piston (refer to Section 1.0 for specifications).

Check the tapered fire ring groove width in the current piston crown with tool J 24599 as shown in Fig. 17. Slide the "NO-GO" wire (.106" diameter) of the tool completely around the fire ring groove. Should the wire be below flush at any one area, the piston crown must be replaced. The "GO" wire (.100"diameter) should be flush or protrude slightly from the fire ring groove.

Inspection of the connecting rod, piston pin and piston pin bushing are covered in Section 1.6.1.

Other factors that may contribute to piston failure include oil leakage into the air box, oil pull-over from the air cleaner, dribbling injectors, combustion blow-by and low oil pressure (dilution of the lubricating oil).

Fitting Piston

Measure the piston skirt diameter lengthwise and crosswise of the piston pin bore. Measurements should be taken at room temperature (70°F or 21°C). Refer to Section 1.0 for specifications.

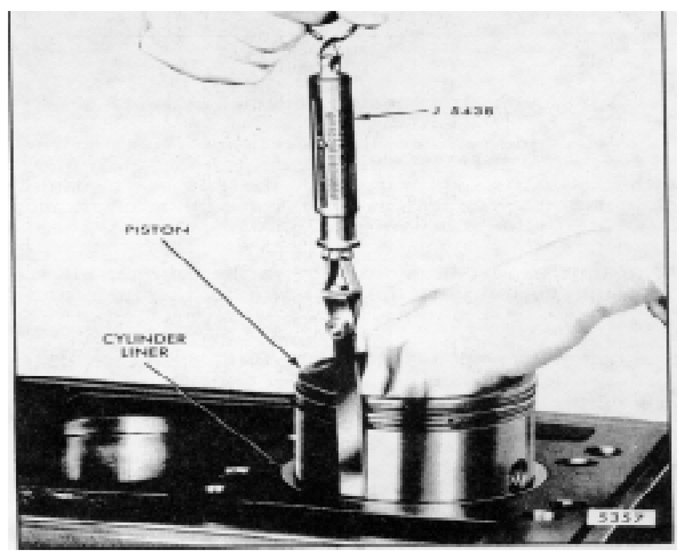


Fig. 18- Measuring Piston-to-Liner clearance

1.6 Piston and Piston Rings

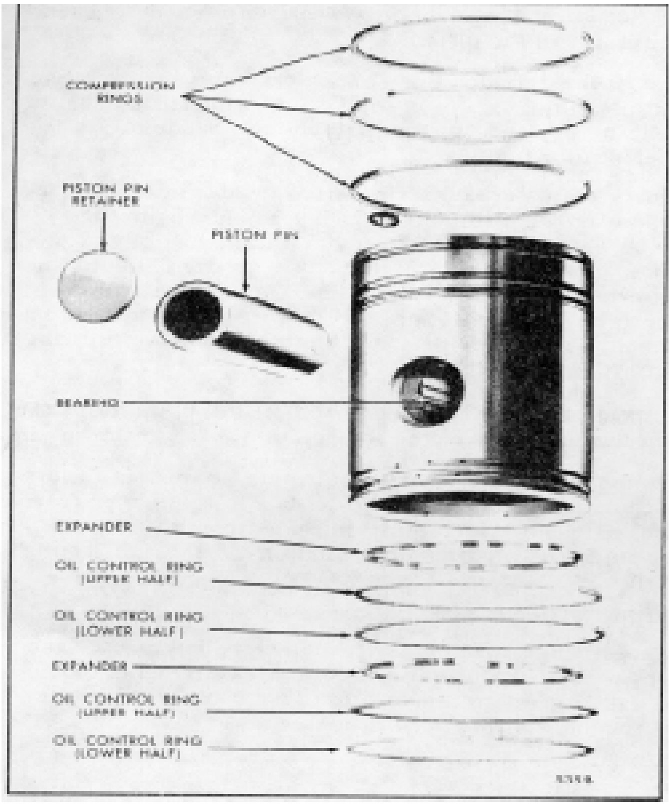


Fig. 19 - Piston Ring Location (Non-Turbocharged Engine)

A new cylinder liner has an inside diameter of 4.2495” to 4.2511 “ The piston-to-liner clearance, with new parts, will vary with the particular piston diameter (refer to Section 1.0). A maximum clearance of .012 “ is allowable with used parts.

With the cylinder liner installed in the cylinder block, hold the piston skirt upside down in the liner and check the clearance in four places 90° apart (Fig. 18).

Use feeler gage set J 5438 to check the clearance. The spring scale, attached to the proper feeler gage, is used to measure the force in pounds required to withdraw the feeler gage.

Select a feeler gage with a thickness that will require a pull of six pounds (26.7 N) to remove. The clearance will be .001 “greater than the thickness of the feeler gage used, i.e., a .004” feeler gage will indicate a clearance of .005 “ when it is withdrawn with a pull of six pounds (26.7 N). The feeler gage must be perfectly flat and free of nicks and bends.

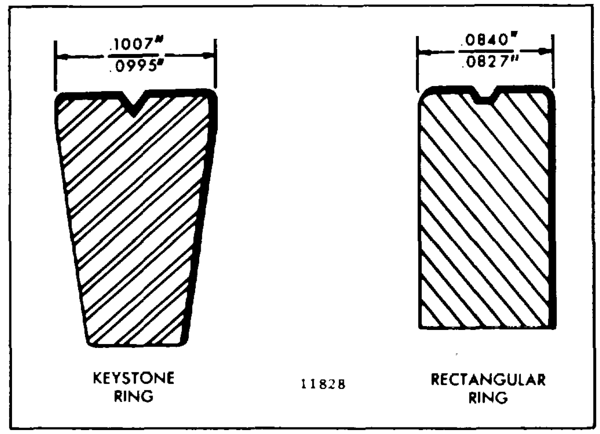


Fig. 20 - Comparison of Fire Rings

If any bind occurs between the piston and the liner, examine the piston and liner for burrs. Remove burrs with a fine hone (a flat one is preferable) and recheck the clearance.

Fitting Piston Rings

Each piston is fitted with a fire ring, two compression rings and two oil control rings (Fig. 19).

The top (fire) ring and the upper compression ring (second groove) are pre-stressed. Both are identified by an oval mark on the top side. In addition, the fire ring has a black oxide or copper colored finish on the top side.

> **NOTE**: The current piston crowns (18.7:1 compression ratio) have a tapered fire ring groove.

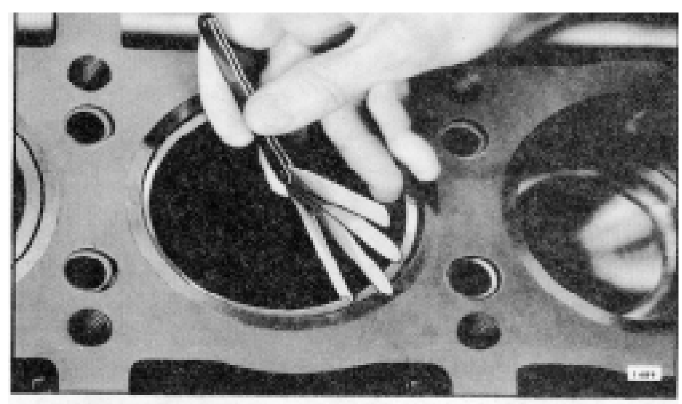


Fig. 21 - Measuring Piston Ring Gap

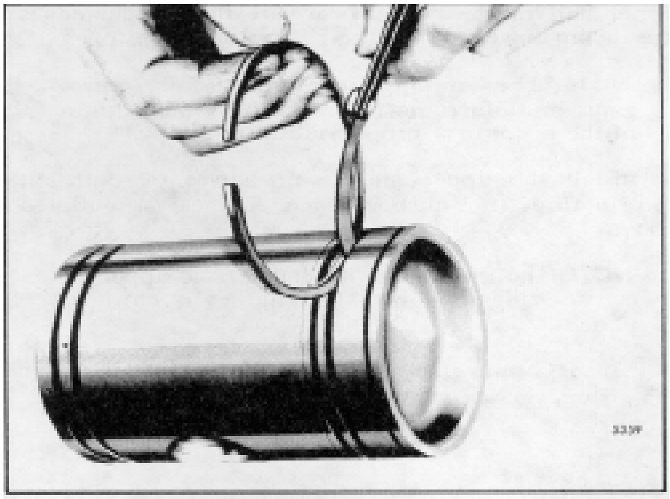


Fig. 22 - Measuring Piston Ring Side Clearance

To conform with this change, a tapered fire ring (Fig. 20) must be used. The former piston crown (17:1 compression ratio) had a rectangular fire ring . groove. Only pistons with the tapered fire ring groove are available for service.

A two-piece oil control ring is used in both oil ring grooves in the pistons for non-turbocharged (naturally aspirated) engines. A one-piece oil control ring in the upper ring groove and a two-piece ring in the lower ring groove are used in the pistons for turbocharged engines.

All new piston rings must be installed whenever a piston is removed, regardless of whether a new or used piston or cylinder liner is installed.

Insert one ring at a time inside of the cylinder liner and far enough down to be within the normal area of ring travel. Use a piston skirt to push the ring down to be sure it is parallel with the top of the liner. Then measure the ring gap with a feeler gage as shown in Fig. 21. Refer to Section 1.0 for ring gap specifications.

If the gap on a compression ring is insufficient, it may be increased by filing or stoning the ends of the ring. File or stone both ends of the ring so the cutting action is from the outer surface to the inner surface. This will prevent any chipping or peeling of the chrome plate on the ring. The ends of the ring must remain square and the chamfer on the outer edge must be approximately .015”.

Check the ring side clearance as shown in Fig. 22. Ring side clearances are specified in Section 1.0.

Install Piston Rings

Before installing the piston rings, assemble the piston as outlined under Assemble Connecting Rod to Piston in Section 1.6.1. Then refer to Figs. 16 and 19 and install the piston rings.

NOTE: Lubricate the piston rings and piston with engine oil before installing the rings.

COMPRESSION RINGS

1. Starting with the bottom ring, install the compression rings with tool J 8128 as shown in Fig. 16. To avoid breaking or overstressing the rings, do not spread them any more than necessary to slip them over the piston.

CAUTION: When installing the top compression (fire) ring, be sure the black oxide or copper colored side (also identified by an oval mark) is toward the top of the piston.

2. Stagger the ring gaps around the piston.

OIL CONTROL RINGS

The upper and lower oil control rings used on pistons for non-turbocharged engines consist of two halves (upper and lower).

1. Install the ring expanders in the oil control ring grooves in the piston.

CAUTION: When installing the oil control rings, use care to prevent overlapping the ends of ring expanders. An overlapped expander will cause the oil ring to protrude beyond allowable limits and will result in breakage when the piston is inserted in the ring compressor during installation in the cylinder liner. Do not cut or grind the ends of the expanders to prevent overlap-ping. Cutting or grinding the ends will decrease the expanding force on the oil control rings and result in high lubricating oil consumption.

IMPORTANT: When peripheral abutment type ring expanders (Fig. 11) are used, install them with the legs of the free ends toward the top of the piston. With the free ends pointing up, a noticeable resistance will be encountered during installation of the piston if the ends of the

1.6 Piston and Piston Rings

expander are overlapped and corrective action can be taken before ring breakage occurs.

2. To install the one-piece ring (turbocharged engines), position it over the upper ring groove, using tool J 8128, with the gap 180° from the gap in the expander and the scraper edge facing down. Press the ring against the gap side of the expander to prevent the ends of the expander from overlapping, then align the ring with the groove and release the tension on the tool, permitting the ring to slip in position.

Install the upper and lower halves of the lower oil control ring by hand. Install the upper half with the gap 180° from the gap in the expander. Then install the lower half with the gap 45 from the gap in the upper half of the ring. Make sure the scraper edges are facing down (toward the bottom of the piston).

> **NOTE**: The scraping edges of all oil control rings must face downward (toward the bottom of the piston) for proper oil control.

3. Install the upper and lower halves of both oil control rings (non-turbocharged engines) as outlined above.

> **NOTE**: The face of the top half of the upper oil control ring used on 71N engines is chrome-plated.

If there is a noticeable resistance during installation of the piston, check for an overlapped ring expander.

CONNECTING ROD

Cross-Head Type Piston

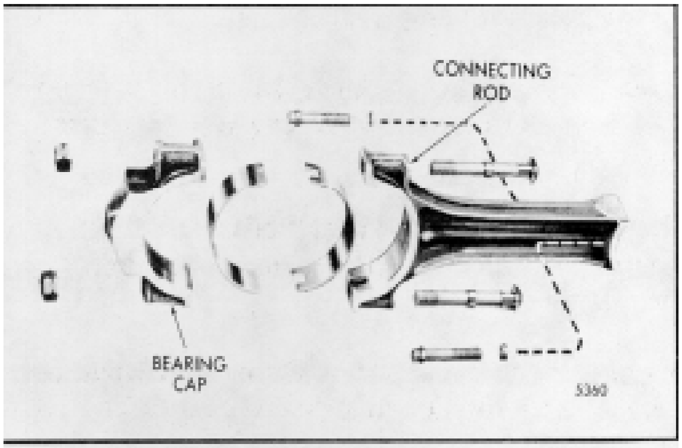


Fig. 11 - Connecting Rod Details

The connecting rod (Fig. 11) is forged to an "I" section with an open or saddle type contour at the upper end and a bearing cap at the lower end. The bearing cap and connecting rod are forged in one piece and bored prior to separation.

The upper end of the connecting rod is machined to match the contour of the piston pin. The piston pin is secured to the connecting rod with two self-locking bolts and spacers. The lower bearing cap is secured to the connecting rod by two specially machined bolts and nuts.

Lubricating oil is forced through a drilled oil passage in the connecting rod to the piston pin and bushing. A service connecting rod includes the bearing cap and the attaching bolts and nuts.

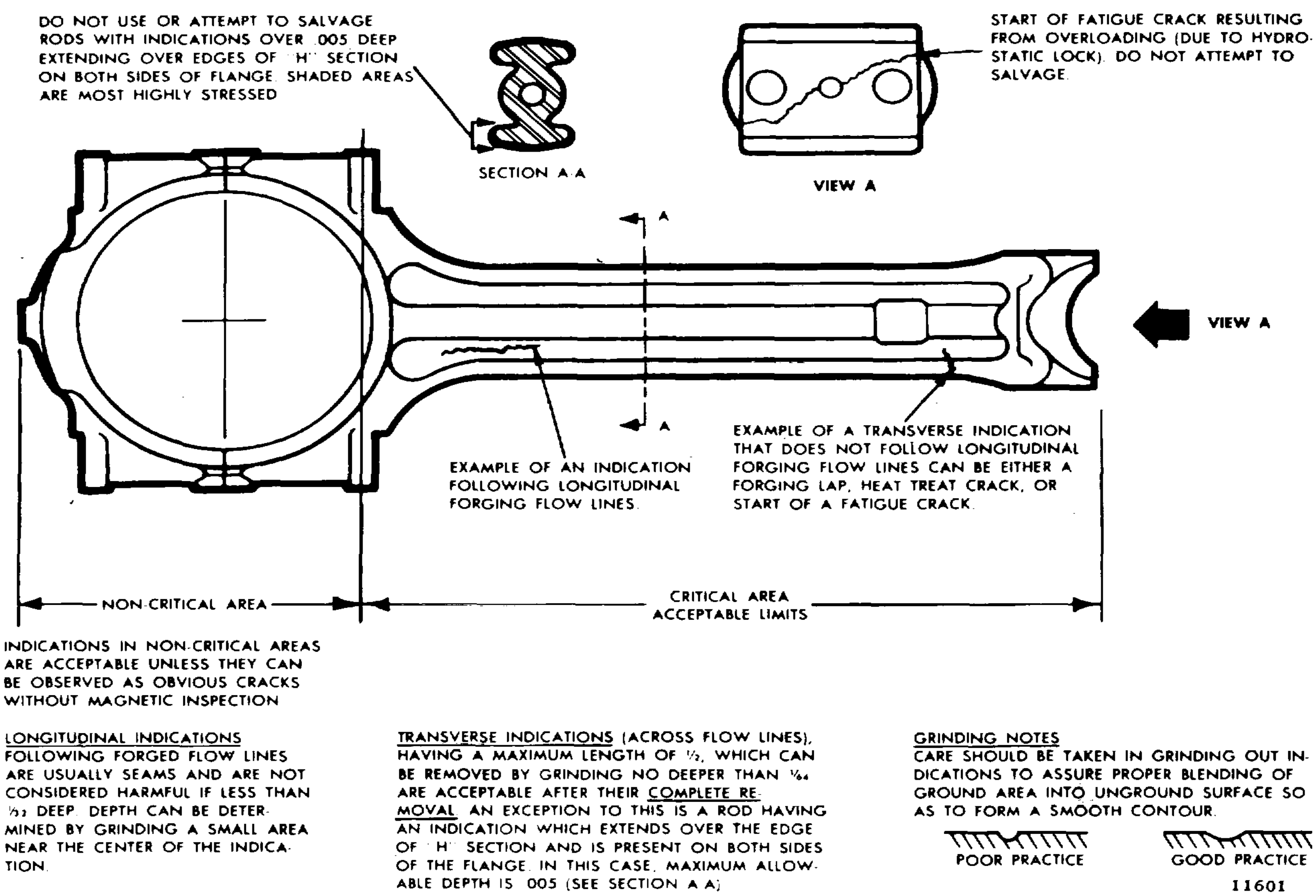


Fig. 12 - Magnetic Particle Inspection Limits for Connecting Rod

Fig. 13 - Installing Seal Ring

The replaceable connecting rod bearing shells are covered in Section 1.6.2.

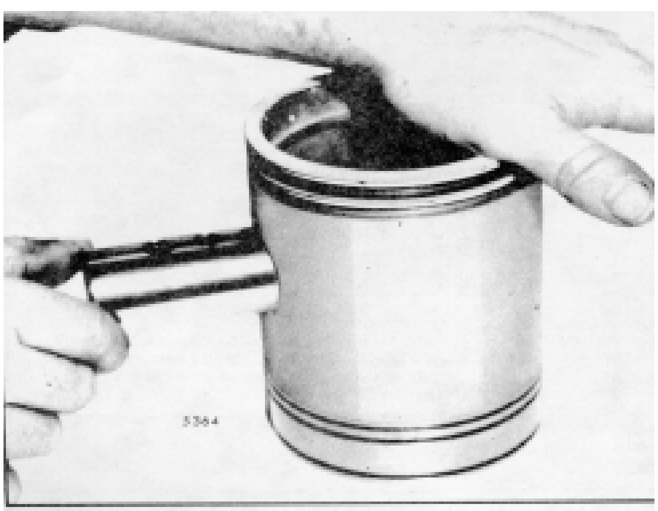


Fig. 14 - Installing Piston Pin

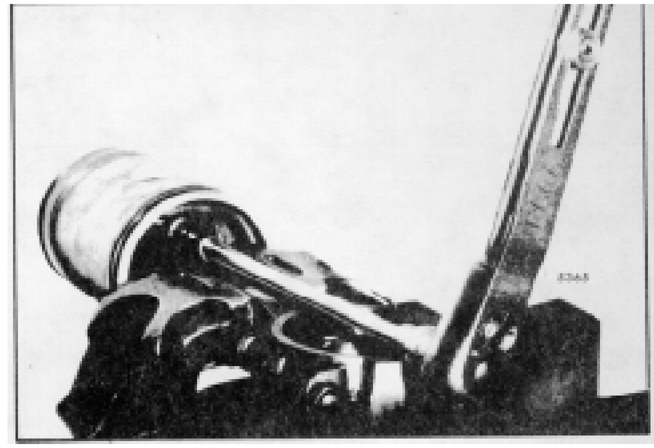


Fig. 15 - Tightening Connecting Rod to Piston Pin Bolts

Disassemble Connecting Rod from Piston

With the rod and piston assembly removed from the engine, disassemble the piston and connecting rod as outlined in Section 1.6.

Inspection

Clean the connecting rod and piston pin with fuel oil and dry them with compressed air. Blow compressed air through the oil passage in the connecting rod to be sure it is clear of obstructions.

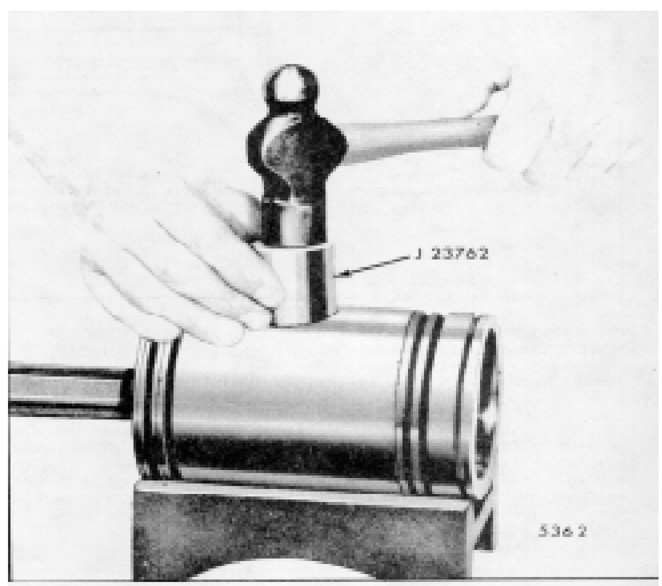


Fig. 16 - Installing Piston Pin Retainer

1.6.1 Connecting Rod

Check the connecting rod for cracks (Fig. 12) by the magnetic particle method outlined in Section 1.3 under Crankshaft Inspection.

If a new service connecting rod is required, stamp the cylinder number on the connecting rod and cap (refer to Section 1.6.3).

> **NOTE**: Clean the rust preventive from a service replacement connecting rod and blow compressed air through the drilled oil passage to be sure it is clear of obstructions. Also make sure the split line (cap to rod) is thoroughly cleaned to avoid trapped contaminants from adversely affecting bearing shell “crush”.

Inspect the bearing (bushing) for indications of scoring, overheating or other damage. Measure the thickness of the bushing along the center. Replace the bushing if it is damaged or worn to a thickness of .086 “ or less. A new bushing is .087” to .088 “ thick.

Inspect the piston pin for signs of fretting. When re-using a piston pin, the highly polished and lapped surface of the pin must not in any way be refinished. Polishing or refinishing the piston pin is not recommended as it could result in very rapid bushing wear. A new piston pin has a diameter of 1.4996” to 1.5000”. Replace the piston pin if it is worn to a diameter of 1.4980 “ or less.

Assemble Connecting Rod to Piston

1. Install the bearing (bushing) in the piston crown. It should slide into the piston crown without force. With new parts, there is .0005 “ to .0105 “ clearance between the edge of the bushing and the groove in the piston crown.

> **NOTE**: The bearing must be installed before assembling the piston skirt and crown.

2. Lubricate the metal seal ring (Fig. 13) with engine oil and install it with the chamfer or counterbore directed toward the bottom of the piston.

3. Compress the seal ring with ring compressor J 23453 and push the skirt into position on the piston crown.

> **IMPORTANT**: Before completely assembling the piston, check to make sure the seal ring does not stick in the ring groove. It is imperative for satisfactory engine operation that the seal ring is free in the piston crown groove. The seal ring-to-groove clearance is .0005” to .0030”. Check the full 360° circumference of the groove to be sure there are no tight spots. When the piston crown, seal ring and piston skirt are assembled, the skirt should spin freely on the crown (crown top down on the bench). If the seal ring sticks, remove high spots or nicks in the groove with a flat file. If this does not relieve sticking, replace the piston crown.

4. Lubricate the piston pin with Cindol 1705 oil and install it as shown in Fig. 14.

> **CAUTION**: Line up the piston pin opening in the piston skirt with the bearing (bushing) opening in the piston crown to prevent damage to the pin or bushing.

5. Install the spacers on the two 7/16”-20 x 2” connecting rod to piston pin attaching bolts.

6. Apply a small amount of International Compound No. 2, or equivalent, to the bolt threads and bolt head contact surfaces.

7. Install and tighten the bolts finger tight. Then clamp the connecting rod in a -vise and tighten the bolts to 55-60 Ib-ft (75-81 Nm) torque (Fig. 15). Do not exceed this torque.

8. Place a new piston pin retainer in position. Then place the crowned end of installer J 23762 against the retainer and strike the tool just hard enough to deflect the retainer and seat it evenly in the piston (Fig. 16).

9. Install the second piston pin retainer in the same manner.

> **CAUTION**: Due to the size of the counterbore in the piston skirt, be careful when installing the piston pin retainers and inspect them to be sure they are not buckled and that they are fully seated in the counterbores. The width of the land should be even around the retainer.

10. Install the piston rings on the piston as outlined in Section 1.6.

11. Install the piston and connecting rod assembly in the engine as outlined in Section 1.6.3.

CONNECTING ROD BEARINGS

The connecting rod bearing shells (Fig. I) are precision made and are replaceable without shim adjustments. They consist of an upper bearing shell seated in the connecting rod and a lower bearing shell seated in the connecting rod cap. The bearing shells are prevented from endwise or radial movement by a tang at the parting line at one end of each bearing shell.

Various types of bearings have been used. Currently, multiple layer copper-lead coplated or aluminum triplated bearings are in use. These bearings have an inner surface, called the matrix, of copper-lead or aluminum. A thin deposit of babbitt is then plated onto the matrix. This babbitt overlay has excellent resistance to friction, corrosion and scoring tendencies which, combined with the material of the matrix, provides improved load carrying characteristics. These bearings are identified by the satin silver sheen of the babbitt when new and a dull gray after being in service. The former copper-lead bearings had a copper color when new and turned very dark during engine operation.

The upper and lower connecting rod bearing shells are different and are not interchangeable. The upper bearing shell is grooved midway between the bearing edges, part way up from each parting line, with an oil hole through the shell at the termination of each groove. The lower bearing shell has a continuous oil groove, extending from one parting line to the other, in line with that of the upper bearing shell. These grooves maintain a continuous registry with the oil hole in the crankshaft connecting rod journal, thereby providing a constant supply of lubricating oil to the connecting rod bearings, piston pin bushings and spray nozzle through the oil passage in the connecting rod.

Remove Bearing Shells

The connecting rod bearing caps are numbered 1, 2, 3, etc., with matching numbers stamped on the connecting rods. When removed, each bearing cap and the bearing shells must always be reinstalled on the original connecting rod.

Remove the connecting rod bearings as follows:

1. Drain the oil and remove the oil pan.

2. Remove the lubricating oil pump and the pump inlet and outlet pipes.

> **NOTE**: If shims are used between the oil pump body and the main bearing caps, save the shims so they may be reinstalled when installing the oil pump.

3. Remove one connecting rod bearing cap. Push the piston and rod assembly up into the cylinder liner far enough to permit removal of the upper bearing shell. Do not pound on the edge of the bearing shell with a sharp tool.

4. Inspect the upper and lower bearing shells as outlined under Inspection.

5. Install the bearing shells and bearing cap before another connecting rod bearing cap is removed.

Inspection

Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low oil or no oil.

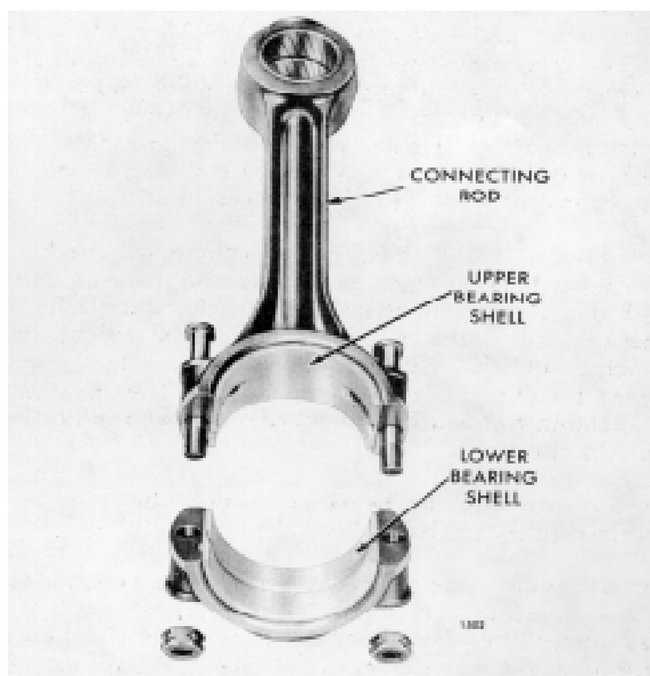


Fig. 1 - Connecting Rod and Bearing Shells

1.6.2 Connecting Rod Bearings

Bearing Size	*New Bearing Thickness	Minimum Worn Thickness
standard	.1548"/.1553"	.1530"
.002" Undersize	.1558"/.1563"	.1540"
.010" Undersize	.1598"/.1603"	.1580"
.020" Undersize	.1648"/.1653"	.1630"
.030" Undersize	.1698"/.1703"	.1680"

*Thickness 90° from parting line of bearing.

After removal, clean the bearings and inspect them for scoring, pitting, flaking, chipping, cracking, loss of babbitt or signs of overheating. If any of these defects are present, the bearings must be discarded. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are NOT detrimental to this type of bearing. The bearings should not be replaced for these minor surface imperfections. The upper bearing shells, which carry the load, will normally show signs of distress before the lower bearing shells do.

Inspect the backs of the bearing shells for bright spots which indicate they have been shifting in their supports. If such spots are present, discard the bearing shells. Also inspect the connecting rod bearing bore for burrs, foreign particles, etc.

Measure the thickness of the bearing shells, using a micrometer and ball attachment J 4757, as described under Inspection in Section 1.3.4. The minimum thickness of a worn standard connecting rod bearing shell should not be less than .1530" and, if either bearing shell is thinner than this dimension, replace both bearing shells. A new standard bearing shell has a thickness of .1548 " to .1553". Refer to Table 1.

In addition to the thickness' measurement, check the clearance between the connecting rod bearing shells and the crankshaft journal. This clearance may be checked by means of a soft plastic measuring strip which is squeezed between the journal and the bearing (refer to Shop Notes in Section 1.0). The maximum connecting rod bearing-to-journal clearance with used parts is .006".

Before installing the bearings, inspect the crankshaft journals (refer to Inspection in Section 1.3).

Do not replace one connecting rod bearing shell alone. If one bearing shell requires replacement, install both new upper and lower bearing shells. Also, if a new or reground crankshaft is to be used, install all new bearing shells.

Bearing shells are available in .010", .020"and .030 " undersize for service with reground crankshafts. To determine the size bearings required, refer to Crankshaft Grinding in Section 1.3. Bearings which are .002" undersize are available to compensate for slight journal wear where it is unnecessary to regrind the crankshaft.

> **CAUTION**: Bearing shells are NOT reworkable from one undersize to another under any circumstances.

Install Connecting Rod Bearing Shells

With the crankshaft and the piston and connecting rod assembly in place, install the connecting rod bearings as follows:

1. Rotate the crankshaft until the connecting rod journal is at the bottom of its travel, then wipe the journal clean and lubricate it with clean engine oil.

2. Install the upper bearing shell—the one with the short groove and oil hole at each parting line—in the connecting rod. Be sure the tang on the bearing shell fits in the groove in the connecting rod.

3. Pull the piston and rod assembly down until the upper rod bearing seats firmly on the crankshaft journal.

4. Note the numbers stamped on the connecting rod and the bearing cap and install the lower bearing shell -- the one with the continuous oil groove—in the bearing cap, with the tang on the bearing shell in the groove in the bearing cap.

5. Install the bearing and cap and tighten the connecting rod bolt nuts to 60-70 lb-ft (81-95 Nrn) torque (lubrite nut) or 65-75 lb-ft (88-102 Nm) torque (castellated nut).

6. Install the lubricating oil pump and the oil inlet and outlet pipes.

> **NOTE**: If shims were used between the oil pump body and the main bearing caps, install the shims in exactly the same location from which they were removed.

7. Install the oil pan, using a new gasket.

8. Refer to the Lubricating Oil Specifications in Section 13.3 and fill the crankcase to the proper level on the dipstick.

If new bearings were installed, operate the engine on the run-in schedule as outlined in Section 13.2.1.

CYLINDER LINER

The replaceable type cylinder liner (Fig. 1) is accurately machined and heat treated to provide a long wearing scuff-resistant surface. The flange at the top fits into a counterbore in the cylinder block and rests on a replaceable cast iron insert which permits accurate alignment of the cylinder liner. Compression is sealed with an individual laminated compression gasket for each cylinder.

The liner is cooled by means of a water jacket in the cylinder block and by the scavenging air introduced into the cylinder through the air inlet ports around the liner (Figs. 1 and 2). The air inlet ports are machined at an angle to create a uniform swirling motion to the air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

The wear on a liner and piston is directly related to the amount of abrasive dust and dirt introduced into the engine combustion chamber through the air intake. This dust, combined with lubricating oil on the cylinder wall, forms a lapping compound and will result in rapid wear. Therefore, to avoid pulling contaminated air into the cylinder, the air cleaners must be serviced regularly

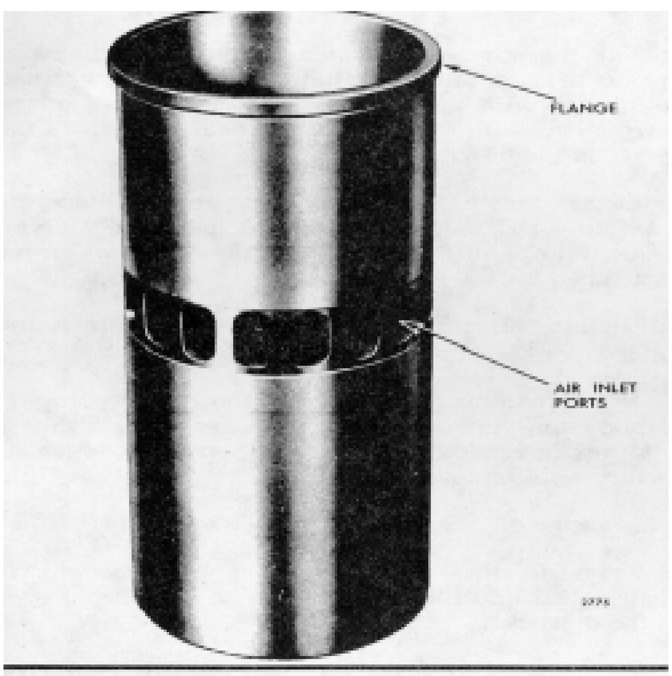


Fig. 1 - Typical Cylinder Liner

according to the surroundings in which the engine is operating.

Inspect Air Inlet Ports

The air inlet ports in the cylinder liner should be kept free of carbon formation for efficient engine operation. To avoid sludge accumulation at the ports, use the proper types of fuel and lubricating oil as specified and change the lubricating oil and oil filters at regular intervals. Maintain the engine at its specified operating temperature and avoid prolonged periods at idle speed or light loads. When idling is necessary, maintain the engine speed at about 800 rpm. Also keep the injectors timed correctly. If necessary, clean the air inlet ports, without removing the liners, as follows:

1. Remove the cylinder head and air box covers.

2. Install a cylinder liner hold-down clamp (Fig. 3).

3. Hand crank the engine until the piston, in the liner whose ports are to be cleaned, is at the bottom of its stroke.

4. Clean all of the ports, with a suitable tool or pointed hardwood stick, from the inside of each liner. Then remove all chunks of carbon from the air box and make sure the air box drains are open.

5. After cleaning the ports, examine the inside of the liner around the ports for burrs. Remove burrs by hand with 250 grit emery paper. Failure to remove burrs can result in early failure of the pistons and rings.

6. Remove the hold-down clamp.

7. Install the cylinder head and air box covers.

The air inlet ports may also be cleaned by removing the liners and placing them in a hot caustic soda or lye solution long enough to loosen the carbon deposits. Final cleaning may then be accomplished by brushing the loosened carbon deposits from the ports.

Remove Cylinder Liner (Cast Iron Cylinder Block)

It is very important that the proper method is followed when removing a cylinder liner. Do not attempt to push the liner out by inserting a bar in the liner ports

Cylinder Line 1.6.3

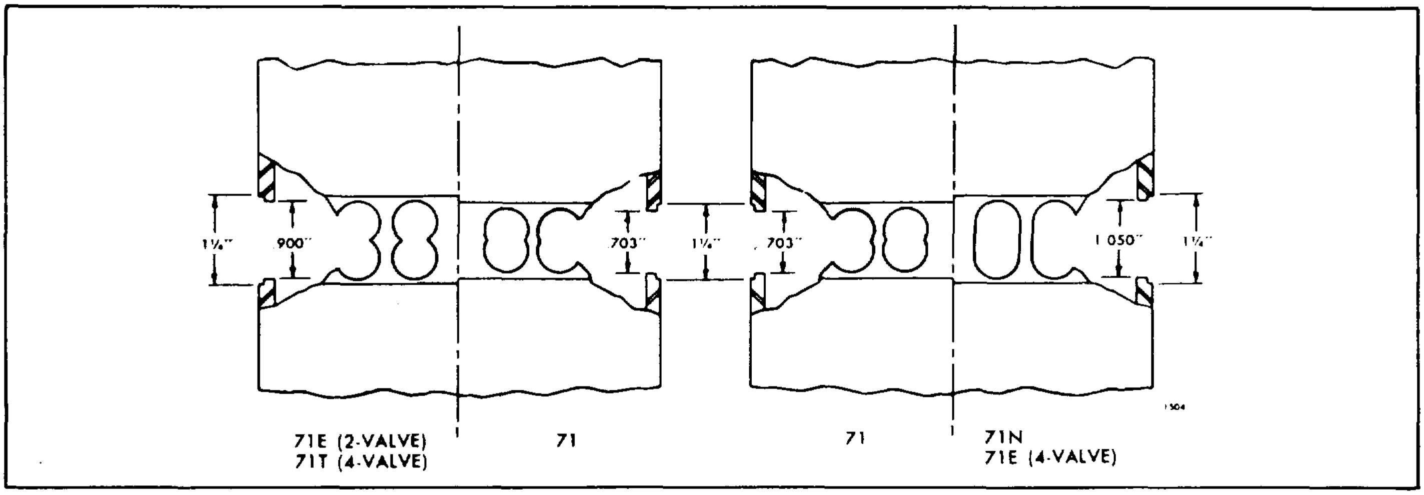


Fig. 2 - Comparison of Cylinder Liners

and rotating the crankshaft, otherwise the piston may be damaged or the upper ring groove may collapse.

Remove a cylinder liner from a cast iron block as follows:

1. Remove the piston and connecting rod assembly as outlined in Section 1.6.

2. Remove the cylinder liner with tool J 1918-02 as follows:

   a. Slip the lower puller clamp up on the puller rod and off the tapered seat. Cock the clamp so it will slide down through the liner. The clamp will drop back on the tapered seat after it clears the bottom of the liner. Then slide the upper puller clamp down against the top edge of the liner.

   b. With the tool in place, strike the upset head on the upper end of the puller rod a sharp blow with the puller weight, thus releasing the liner (Fig. 4).

   c. Remove the tool from the liner. Then remove the liner from the block.

   d. Remove and tag the liner insert and shims (if used) from the counterbore in the block.

If tool J 1918-02 is unavailable, tap the liner out with a hardwood block and hammer.

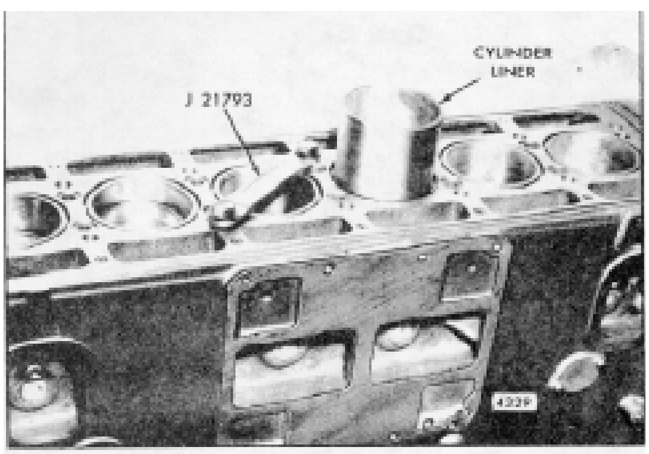


Fig. 3 - Cylinder Liner Hold-Down Clamp

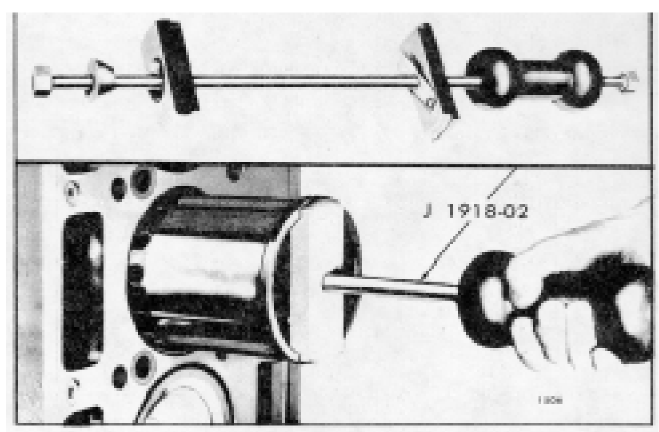


Fig. 4 - Removing Cylinder Liner

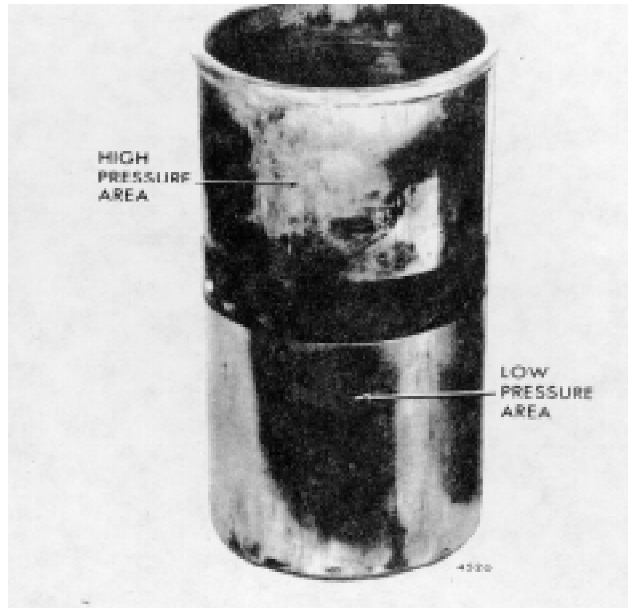


Fig. 6 - High and Low Pressure Contact Areas on Cylinder Liner

Inspect Cylinder Liner

When the cylinder liner is removed from the cylinder block, it must be thoroughly cleaned and then checked for:

Cracks
Scoring
Poor contact on outer surface
Flange irregularities
Inside diameter
Out-of-round
Taper

Cylinder Liner 1.6.3

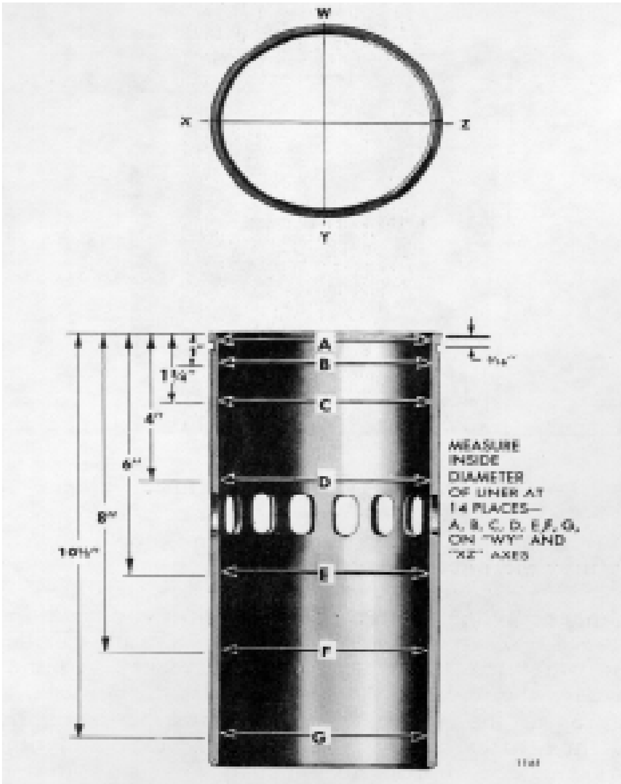


Fig. 7 - Cylinder Liner Measurement Diagram

A cracked or excessively scored liner must be discarded. A slightly scored liner may be cleaned-up and reused.

Excessive liner-to-block clearance or block bore distortion-will reduce heat transfer from the liner to the block and to the engine coolant. Poor contact between the liner and the block bore may be indicated by stains or low pressure areas on the outer surface of the liner (Fig. 6).

Examine the outside diameter of the liner for fretting. Fretting is the result of a slight movement of the liner in the block bore during engine operation, which causes material from the block to adhere to the liner. These metal particles may be removed from the surface of the liner with a coarse, flat stone.

The liner flange must be smooth and flat on both the top and bottom surfaces. Check for cracks at the flange. The liner insert must also be smooth and flat on the top and bottom surfaces. Replace the insert if there is evidence of brinelling.

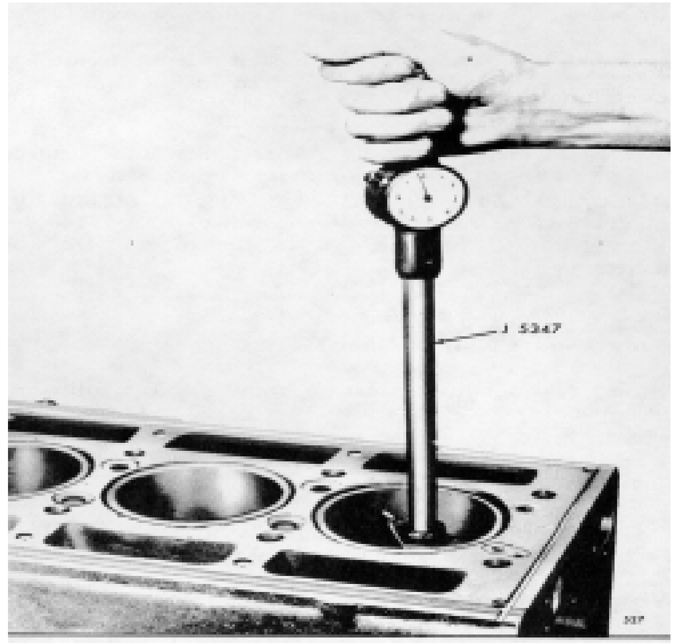


Fig. 8 - Checking Bore of Cylinder Liner

Inspect the block bore and check the liner-to-block clearance whenever a liner is removed. If the clearance exceeds zero to .002" (cast iron block) it will be necessary to bore the block for an oversize liner as outlined in Section 1.1.

Cylinder liners are available in .001 ", .005", .010", .020" and .030" oversize on the outside diameter. When an oversize liner is used, stamp the amount of oversize on top of the cylinder block adjacent to the liner counterbore.

New service liners, standard and oversize, have an inside diameter of 4.2495 " to 4.2511 "

> **NOTE**: Do not modify the surface finish in a new service liner. Since the liner is properly finished at the factory, any change will adversely affect the seating of the piston rings.

Install the liner in the proper bore of the cylinder block and measure the inside diameter at the various points shown in Fig. 7. Use cylinder bore gage J 5347 (Fig. 8), which has a dial indicator calibrated in .0001 " increments, as it is rather difficult to obtain accurate measurements with a micrometer. Set the cylinder bore gage on zero in master ring gage J 5580-1. Also check the liner for taper and out-of-round.

NOTE: Dial bore gage master setting fixture J 23059 may be used in place of the master ring gage.

To reuse the liner, the taper must not exceed .002 “ and the out-of-round must not exceed .0025 “ . In addition, the ridge formed at the top of the ring travel must be removed. If the out-of-round exceeds .0025”, rotate the liner 90°in the block bore and recheck.

Hone Used Cylinder Liner

A used cylinder liner must be honed for the following reasons:

1. To break the glaze (Fig. 9) which results after long periods of operation.

2. To remove the ridge (Fig. 10) formed at the top by the piston ring travel.

When a liner has been in service for a long period, the bore becomes very smooth or glazed due to the rubbing action of the piston rings. Unless this glaze is removed, the time required to seat new piston rings will be lengthened.

The ridge formed at the top of the liner by the travel of the piston rings must also be removed. Otherwise, interference with the travel of the new compression rings may result in ring breakage.

Therefore, even though the taper and out-of-round are within the specified limits, the glaze and ridge must be

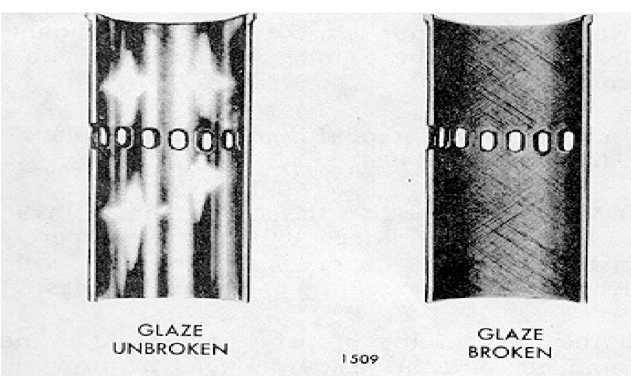


Fig. 9 - Glazed Surface of Cylinder Liner

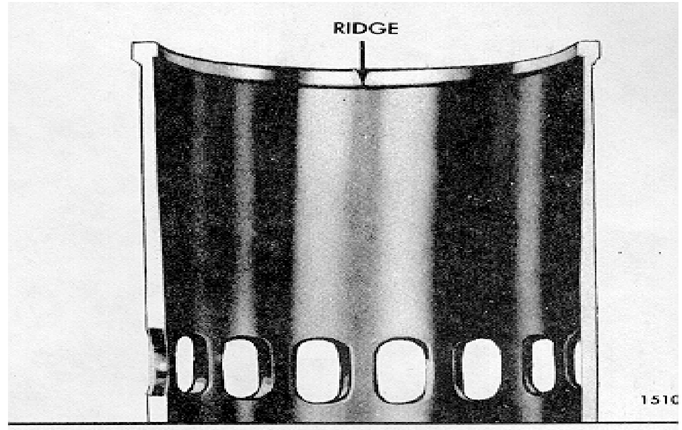


Fig. 10 - Cylinder Liner Ridge Due to Wear

removed by working a hone up and down the full length of the liner a few times.

Whenever a liner is honed, it should be placed in a fixture (a scrap cylinder block makes an excellent honing fixture). However, if it is necessary to hone a liner in the cylinder block that is to be used in i building up the engine, the engine must be dismantled and then, after honing, the cylinder block and other parts must be thoroughly cleaned to ensure that all abrasive material is removed.

The hone J 5902-01, equipped with 120 grit stones J 5902-14, should be worked up and down the full length of the liner a few times in a criss-cross pattern that produces hone marks on a 45 axis. This operation may be performed with emery cloth if a hone is not available.

After the liner has been honed, remove it from the fixture and clean it thoroughly. Then dry it with compressed air and check the entire surface for burrs.

After honing, the liner must conform to the same limits on taper and out-of-round as a new liner and the piston-to-liner clearance must be within the specified limits (Section 1.0).

Fitting Cylinder Liner in Block Bore

1. Wipe the inside and outside of the liner clean and make sure the block bore and counterbore are clean.

2. Place a standard size cylinder liner insert (.1795”-1800” thick) in the block counterbore (Fig. 11).

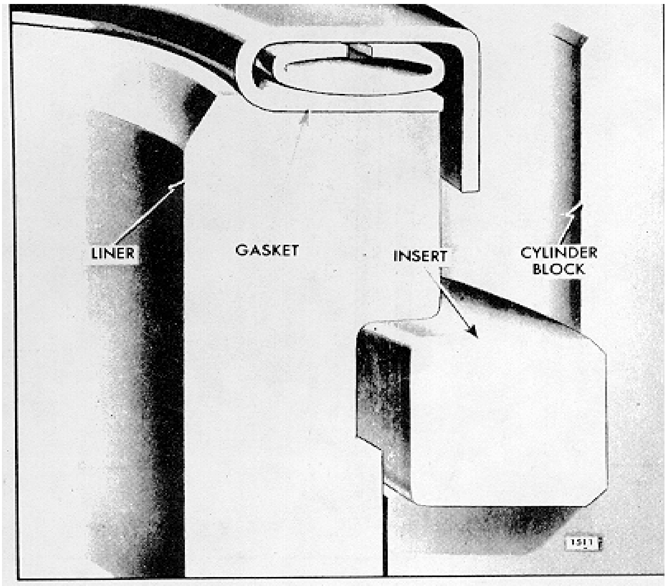


Fig. 11 - Cylinder Liner Mounting in Block

3. Push the cylinder liner into the cylinder block until the liner flange rests on the insert. Do not use excessive force to install the liner. The liner should slide smoothly in place with thumb pressure. If a new liner cannot be pushed in place, light honing of the block bore may be necessary to obtain the desired fit for best heat transfer. Refer to Section 1.0 for the liner-to-block clearance.

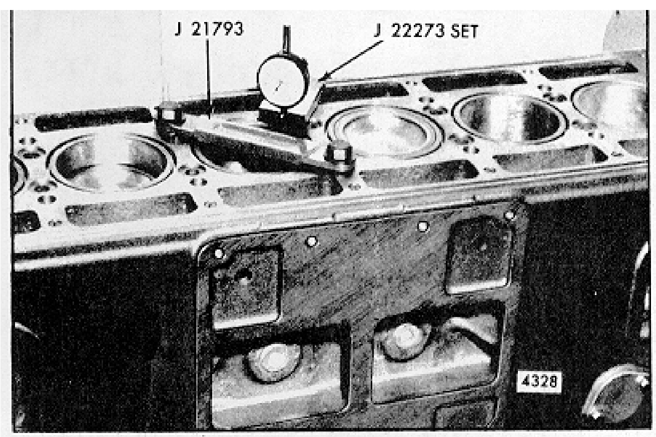


Fig. 12 - Checking Distance of Liner Flange Below Top Face of Block

4. Install a cylinder liner hold-down clamp as illustrated in Fig. 12.

5. Measure the distance from the top of the liner to the top of the block with a dial indicator (Fig. 12). The liner flange must be .045" to .050" below the surface of the block. However, even though all of the liners are within these specifications, there must not be over .002" difference in depth between any two adjacent 'liners when measured along the cylinder longitudinal center line.

> **NOTE**: A .002" thick shim is available for adjusting the liner height (in the current " high" block only). The shim must be installed underneath the liner insert. Do not cut the shim for installation. Liner inserts which are .0015 " thicker or thinner than standard are also available for service. In addition, the .004" and .008" thinner inserts (also available in .0015" thicker and thinner sizes), which are provided for use with re-surfaced cylinder blocks, can also be used to adjust the liner height.

6. Matchmark the liner and the cylinder block with chalk or paint so the liner may be reinstalled in the same position in the same block bore. The match-marks should be toward the blower side of the engine.

7. Remove the hold-down clamp and the cylinder liner.

> **NOTE**: Do not remove the liner insert.

Install Piston and Connecting Rod Assembly

1. With the piston assembled to the connecting rod and the piston rings in place as outlined in Sections 1.6 and 1.6.1, apply Cindol 1705 oil to the piston, rings and the inside surface of the piston ring compressor J 3272-02.

> **NOTE**: Inspect the ring compressor for nicks or burrs, especially at the non-tapered inside diameter end. Nicks or burrs on the inside diameter of the compressor will result in damage to the piston rings.

2. Place the piston ring compressor on a wood block, with the chamfered end of the ring compressor facing up.

3. Position (stagger) the piston ring gaps properly on the piston. Make sure the ends of the oil control ring expanders are not overlapped.

4. Start the top of the piston straight into the ring

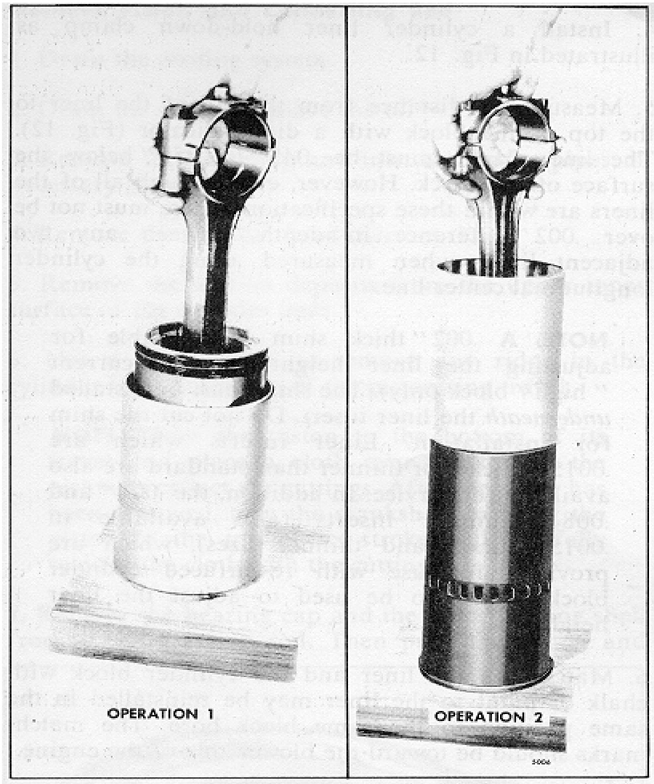


Fig. 13 - Installing Piston and Connecting Rod Assembly in Ring Compressor and Cylinder Liner

compressor. Then push the piston down until it contacts the wood block (Operation I of Fig. 13).

5. Note the position of the matchmark and place the liner, with the flange end down, on the wood block.

6. Place the ring compressor and the piston and connecting rod assembly on the liner so the numbers on the rod and cap are aligned with the matchmark on the liner (Operation 2 of Fig. 13).

> **NOTE**: The numbers on the side of the connecting rod and cap (Fig. 14) identify the rod with the cap and indicate the particular cylinder in which they are used. If a new service connecting rod is to be installed, the same identification numbers must be stamped in the same location as on the connecting rod that was replaced.

7. Push the piston and connecting rod assembly down

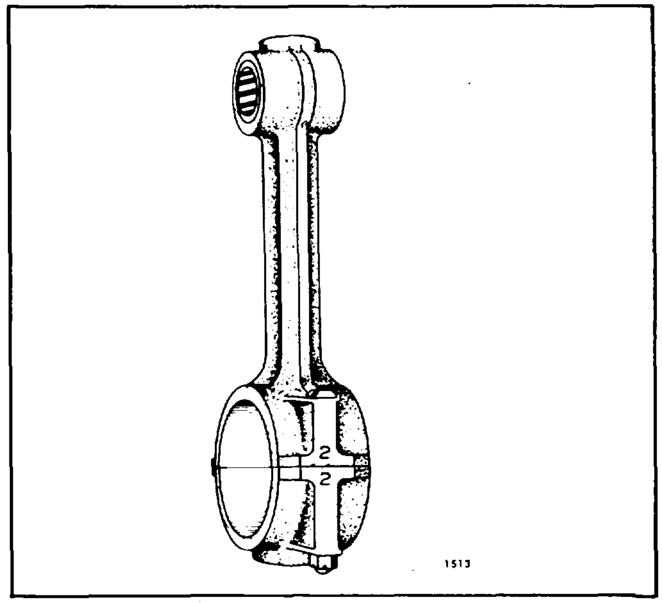


Fig. 14 - Typical Connecting Rod Markings

into the liner until the piston is free of the ring compressor.

> **CAUTION**: Do not force the piston into the liner. The peripheral abutment type expanders apply considerably more force on the oil ring than the standard expander. Therefore, extra care must be taken during the loading operation to prevent ring breakage.

8. Remove the connecting rod cap and the ring compressor. Then push the piston down until the compression rings pass the cylinder liner ports.

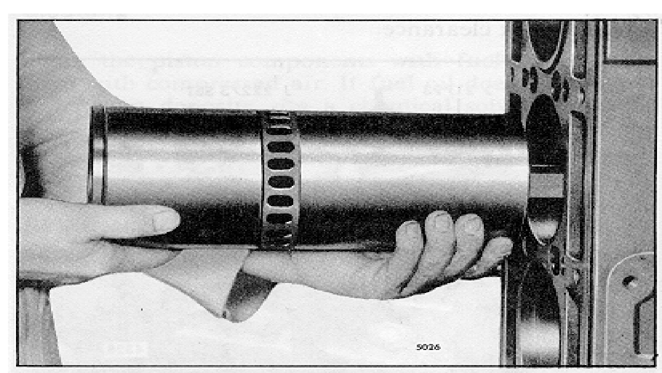


Fig. 15 - Installing Piston, Rod and Liner Assembly in Cylinder Block

Install Cylinder Liner, Piston and Connecting Rod Assembly

After the piston and connecting rod assembly have been installed in the cylinder liner, install the entire assembly in the engine as follows:

1. If any of the pistons and liners are already in the engine, use hold-down clamps to retain the liners in place when the crankshaft is rotated.

2. Rotate the crankshaft until the connecting rod journal of the particular cylinder being worked on is at the bottom of its travel. Wipe the journal clean and lubricate it with clean engine oil.

3. Install the upper bearing shell—the one with a short oil groove at each parting line—in the connecting rod. Lubricate the bearing shell with clean engine oil.

4. Position the piston, rod and liner assembly in line with the block bore (Fig. 15) so the identification number on the rod is facing the blower side of the engine and the matchmarks on the liner and the block are in alignment. Guide the end of the connecting rod through the block bore carefully to avoid damaging or dislodging the bearing shell. Then slide the piston, rod and liner assembly straight into the block bore until the liner flange rests against the insert in the counterbore in the block.

5. Push or pull the piston and connecting rod into the liner until the upper bearing shell is firmly seated on the crankshaft journal.

6. Place the lower bearing shell -- the one with the continuous oil groove from one parting line to the other -- in the connecting rod cap, with the tang on the bearing shell in the notch in the connecting rod bearing cap. Lubricate the bearing shell with clean engine oil.

7. Install the bearing cap and the bearing shell on the connecting rod with the identification numbers on the cap and the rod adjacent to each other. Tighten the connecting rod bolt nuts to 60-70 lb-ft torque (lubrite nut) or 65-75 lb-ft torque (castellated nut).

8. Check the connecting rod side clearance. The clearance must be .006 " to .012".

9. Install the remaining liner, piston and rod assemblies in the same manner. Use hold-down clamps to hold each liner in place.

10. After all of the liners and pistons have been installed, remove the hold-down clamps.

11. Install new compression gaskets and water and oil seals as outlined in Section 1.2. Then install the cylinder head and any other parts which were removed from the engine.

12. After the engine has been completely reassembled, refer to the Lubricating Oil Specifications in Section 13.3 and refill the crankcase to the proper level on the dipstick.

13. Close all of the drains and fill the cooling system.

14. If new parts such as pistons, rings, cylinder liners or bearings were installed, operate the engine on the run-in schedule given in Section 13.2.1.

ENGINE BALANCE AND BALANCE WEIGHTS

Both rotating and reciprocating forces are completely balanced in the engines. The eccentric rotating masses of the crankshaft and connecting rods are balanced by counterweights on the crankshaft cheeks.

The reciprocating masses (the piston and upper end of the rod) produce an unbalanced couple by virtue of an arrangement on the crankshaft in which reciprocating masses, though equal, are not opposite. This unbalanced couple, which tends to rock the engine from end to end, is balanced by an arrangement of rotating counterweights, mounted at the front and rear ends of the camshaft and balance shaft, which produce a couple equal and opposite in magnitude. Consequently the engine will operate smoothly and in balance throughout its entire speed range.

Each set of weights (weights on one shaft comprise a set) rotates in an opposite direction with respect to the other. When the two weights at either end of the engine are in a vertical plane, their centrifugal forces are in the same direction and oppose the unbalanced couple; when they are in a horizontal plane, the centrifugal forces of these balance weights are opposite and are therefore cancelled. The front balance weights are eccentric in a direction opposite to the rear balance weights. Therefore, rotation will result in the desired couple effective only in a vertical plane.

The balance weights consist of two eccentric weights at each end of the engine. On three cylinder engines (through serial number 3A-48439), the weights at the rear are integral with the gears. On three cylinder engines effective with 3A-48440 and four cylinder and six cylinder engines, additional weights are attached to the gears.

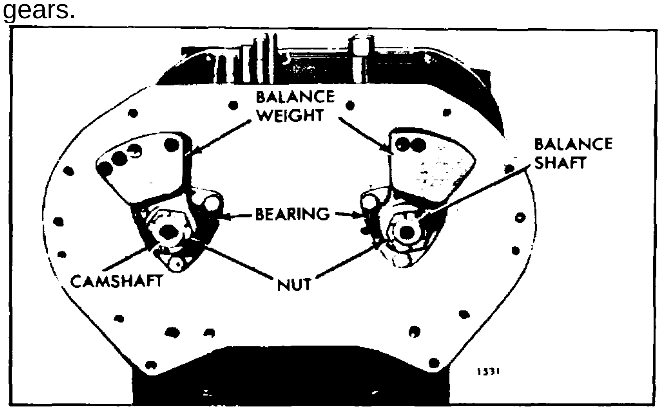


Fig. 1 - Typical Front Balance Weight Mounting.

The front balance weights are keyed to the front end of the camshaft and the balance shaft (Fig. 1). Current balance weights are of one-piece construction. Formerly, spring-loaded balance weights (Fig. 2) were used. The balance weight bushing oscillates on the hardened surface of the hub during engine operation. Torque variations are transmitted from the hub to the weight through the spacer and spring leaves.

Remove Front Balance Weights

1. Remove the balance weight cover.

2. Place a block of Wood between the balance weights to prevent rotation (Fig. 3).

3. Loosen the balance weight retaining nuts on the camshaft and balance shaft with a 1-1/2" socket wrench and remove the nuts and internal tooth lock washers.

4. Force the balance weight off the end of each shaft with two heavy screw drivers or pry bars between the heads of the bearing retaining bolts and the balance weight (Fig. 4).

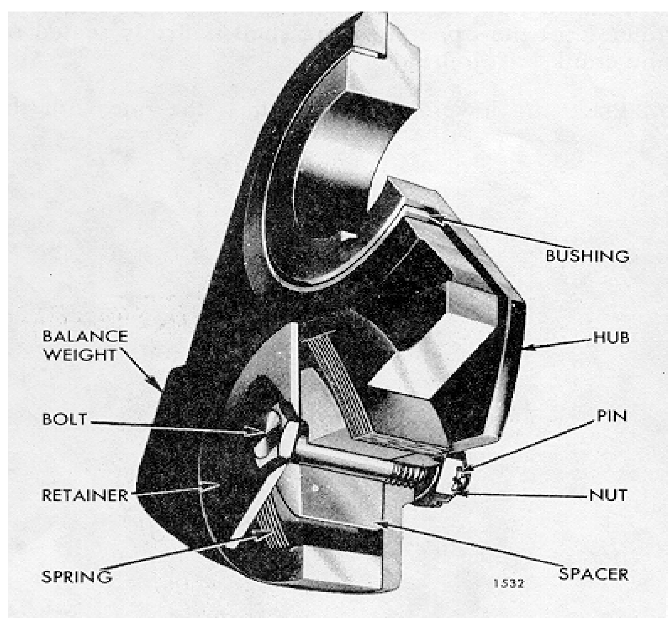


Fig. 2 - Spring-Loaded type Front Balance Weight

1.7 Engine Balance

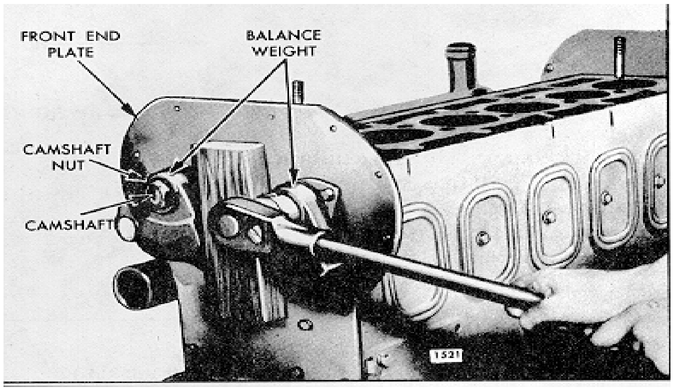


Fig. 3 - Loosening Nut on Camshaft or Balance Shaft

Disassemble Spring-Loaded Balance Weight

1. Remove the cotter pin from the nut (Fig. 5).

2. Remove the bolt and the retainer.

3. Separate the balance weight from the hub.

4. Push the springs and spacer from the balance weight.

5. If the bushing is badly worn, press it out of the weight.

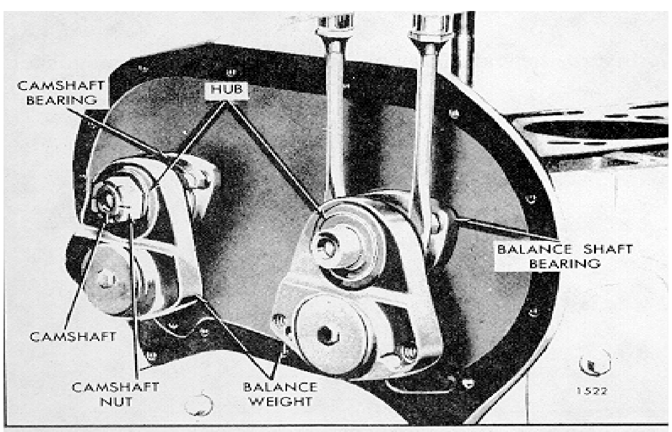


Fig. 4 - Removing Balance Weight Assemblies

Inspection

Clean all of the parts thoroughly with fuel oil and dry them with compressed air.

If the thrust surface (side facing the camshaft or balance shaft thrust washers) of the balance weight hub is damaged, it will be necessary to install a new balance weight.

The clearance between a balance weight bushing and the balance weight hub is from .0005 " to .0035 "with new parts and .006 " with used parts. The clearance between the weight and the hub should be from .010" to .023".

Assemble Spring-Loaded Balance Weight

1. If the old bushing was removed from the balance weight, press a new split bushing into place until the edge of the bushing is flush with the shoulder on the drilled (balancing holes) side of the weight.

2. Select suitable springs (17 per pack) to make four packs, each .251" ± .008" thick. Each spring is .015 " to .016" thick. Measure the pack thickness while the springs are tightly clamped together in a vise or arbor press.

> **CAUTION**: Wash each spring in the packs thoroughly and dry it with compressed air before taking the above measurements.

3. Lay the weight, machined face down, flat on a clean work bench.

4. Dip the spring pack in lubricating oil to completely coat all the springs.

5. Arrange one spring pack on either side of the balance weight spring cavity.

6. Place the spring spacer on the blade of a screw

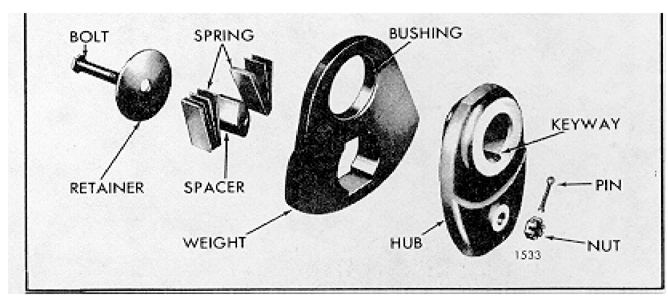


Fig. 5 - Details of Spring-Loaded Type Balance Weight and Hub Assy.

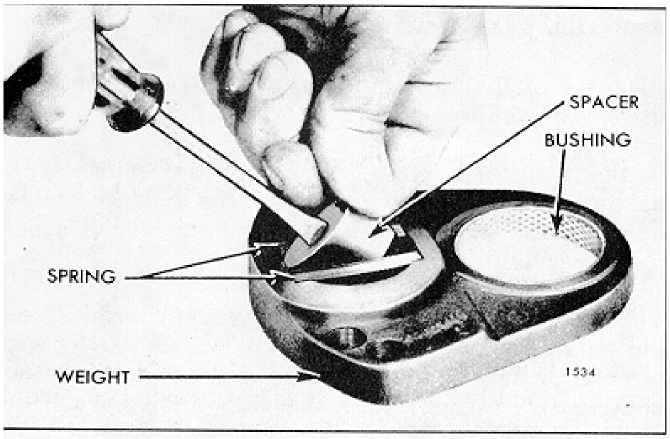


Fig. 6 - Installing Spring Spacer Between Spring Packs

driver and install the spacer, tapered end first, between the spring packs as shown in Fig. 6.

7. Insert the journal of the hub in the bushing of the balance weight. The weight should swing freely on the hub. Burnish the bushing if the clearance is not within the specified .0005 " to .0035 ".

8. Place the retainer against the spring spacer, insert the bolt through the retainer, spacer and hub and secure the bolt with a castellated nut. Tighten the nut to 25-30 lb-ft torque and lock the nut with a cotter pin.

9. Check the clearance between the weight and the hub as shown in Fig. 7. The specified clearance is .010" to .023". Adjust the clearance by loosening or tightening the castellated nut.

Install Front Balance Weights

1. If thrust washers are used ("B" and "C" engines),

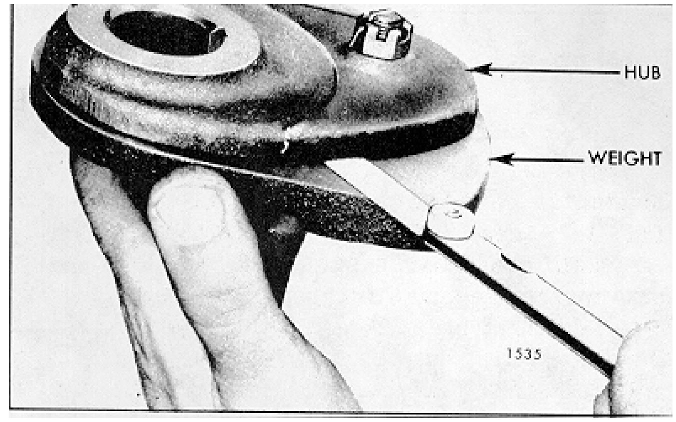


Fig. 7 - Measuring Clearance Between Balance Weight and Hub

apply heavy cup grease to the steel faces of the washers and install the washers up against the camshaft and balance shaft end bearings.

2. Install Woodruff keys in the keyways at the front end of the camshaft and the balance shaft.

3. Align the keyway in the balance weight hub with the key in the shaft and slide the balance weight on the camshaft.

4. Install the balance weight on the balance shaft in the same manner.

5. Slip an internal tooth lock washer over the end of each shaft. Start the nuts on both shafts.

6. Place a block of wood between the balance weights as shown in Fig. 3 and tighten the retaining nuts to 300-325 lb-ft torque.

7. Install the balance weight cover, using a new gasket.

GEAR TRAIN AND ENGINE TIMING

GEAR TRAIN

A completely enclosed train of five helical gears is located at the rear end of the engine, as shown in Fig. 1. A gear bolted to the crankshaft drives the camshaft and balance shaft gears, as well as the blower drive gear, through an idler gear mounted between the crankshaft and balance shaft gears on the RB and RC engines, and between the crankshaft and camshaft gears on the RA and RD engines.

The camshaft gear and balance shaft gear mesh with each other and run at the same speed as the crankshaft. Since these two gears must be in time with each other, and the two as a unit in time with the crankshaft gear, the letter "O" is placed on one tooth of one of the gears with a corresponding mark at the root of the mating teeth of the other gear.

The camshaft and balance shaft gears are keyed to their respective shafts and held securely against the shoulder on the shaft by a nut. Viewing the engine from the flywheel or gear train end, the right-hand gear, whether on the balance shaft, as shown on RA and RD engines, or the camshaft, as shown on RB and RC engines, has left-hand helical teeth (Fig. 1).

The idler gear rotates on a double-row, tapered roller bearing mounted on a stationary hollow hub. This hub is accurately located on the cylinder block end plate, at the left-hand side of the engine, as viewed from the gear train end. A blower drive gear is located on the blower side to transmit power to the blower, governor, fuel pump and water pump. Since, as stated above, the cam and balance shafts must be in time with the crankshaft, identification marks are located on two teeth of the idler gear with corresponding match marks stamped on the crankshaft gear and the camshaft or balance shaft gear, as shown in Fig. 1.

For standard gear train timing, the letter "R" on the idler gear is aligned with the "R" on the crankshaft gear and the camshaft or balance shaft gear. For advanced timing, used on certain engines, the letter "A" on the crankshaft gear is aligned with the letter "R" on the idler gear.

Balance weights, one fastened to the inner face of each camshaft and balance shaft gear, are important in maintaining perfect engine balance. These are in addition to the weights cast integral with the gears.

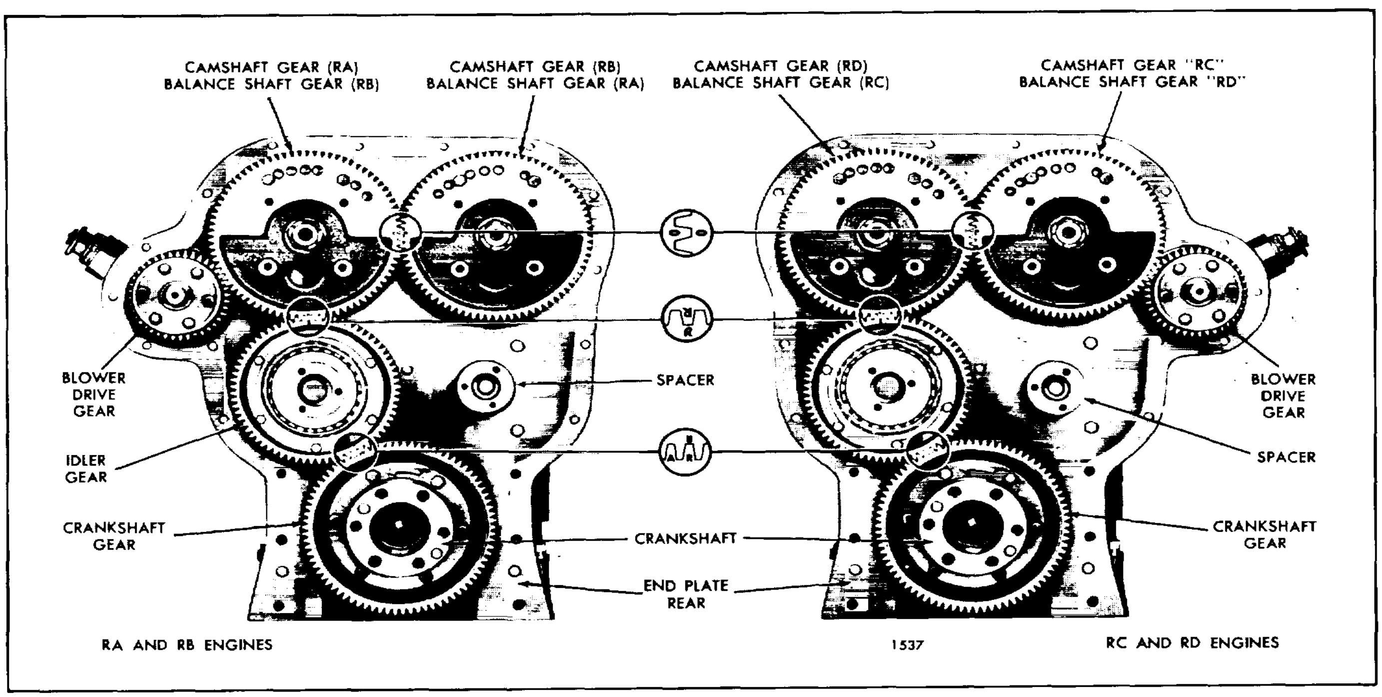


Fig. 1 - Gear Train and Timing Marks - Right Hand Rotation Engines (Standard Timing Shown)

1.7.1 GEAR TRAIN AND TIMING

Gear train noise is usually an indication of excessive gear lash, scoring, pitting or excessive bearing wear. Therefore, when noise develops in a gear train, the flywheel housing should be removed and the gear train and its bearing inspected. A rattling noise usually indicates excessive gear lash whereas a whining noise is a result of too little gear lash.

Excessive wear and scoring may result from abrasive substances or foreign material in the oil, introduced in the engine by such means as removal of the rocker cover without first cleaning away dirt.

The backlash between the various mating gears in the gear train ranges from .003" to .008" with new parts and .010" with used parts.

Since the camshaft and balance shaft gears each have the same number of teeth as the crankshaft gear, they turn at crankshaft speed. However, as the blower drive gear has only about half as many teeth as the camshaft or balance shaft gear, it turns at approximately twice the speed of the crankshaft.

Lubrication

The gear train is lubricated by overflow oil from the camshaft and balance shaft pockets spilling into the gear train compartment. A certain amount of oil also spills into the gear train compartment from the camshaft and balance shaft end bearings, and idler gear bearings. The blower drive gear bearing is lubricated through an external pipe lead-ing from the main cylinder block oil gallery to the gear hub bearing support. The idler gear bearing is pressure lubricated by means of oil passages in the idler gear hub which connect to the oil gallery in the cylinder block.

Checking Engine Timing

The correct relationship between the crankshaft and camshaft must be maintained to properly control fuel injection and the opening and closing of the exhaust valves.

The crankshaft timing gear can be mounted in only one position due to one attaching bolt hole being offset. The camshaft gear can also be mounted in only one position as a result of the location of the keyway relative to the cams. Therefore, when the engine is properly timed, the markings on the various gears will match as shown in Fig. 1.

An engine which is "out of time" may result in pre-ignition, uneven running and a loss of power.
When an engine is suspected of being out of time, due to an improperly assembled gear train, a quick check can be made without having to remove the flywheel and flywheel housing by following the procedure outlined below.

Access to the vibration damper or crankshaft pulley, to mark the top-dead-center position of the selected piston, and to the front end of the crankshaft or flywheel for turning the engine is necessary in performing the timing check. Then, proceed as follows:

1. Remove the valve rocker cover.

2. Select any cylinder for the timing check—it is suggested that a cylinder adjacent to one of the cylinder head cover studs be chosen since the stud may be used for mounting a dial indicator.

3. Remove the fuel jumper lines (at the cylinder selected) and install shipping caps on the injector fuel fittings to prevent the entry of dirt. Make sure that the valve and injector rocker arms are all in the "up" position, then remove-the rocker shaft bracket bolts and swing the rocker arm assemblies back out of the way. Remove the injector assembly.

4. Carefully place (do not drop) a rod approximately 12" long through the injector hole and on top of the piston.

5. With the throttle in the NO-FUEL position, turn the crankshaft slowly in the direction of rotation of the engine, and stop turning when the rod.

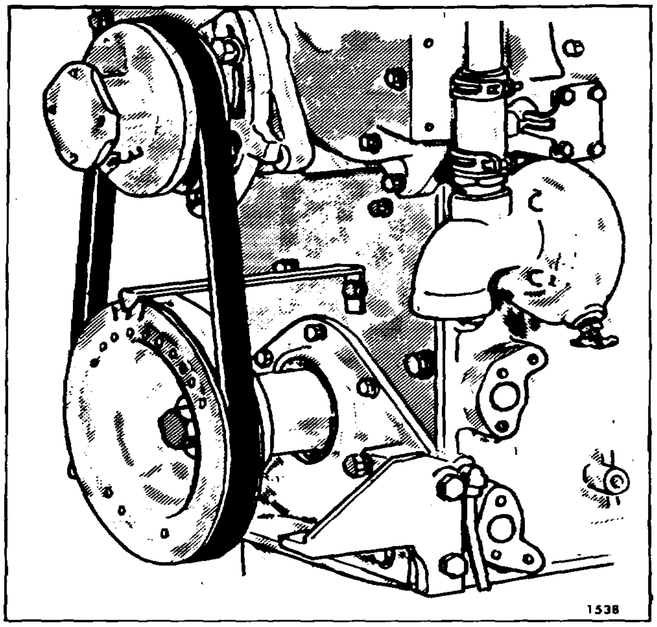


Fig. 2 - Pointer Installation For Marking Top-Dead-Center

reaches the end of its upward travel. Remove the rod and turn the crankshaft opposite the direction of rotation between 1/16 and 1/8 of a turn.

6. Select a dial indicator with .001" graduations and with a spindle movement of at least 1". Use suitable mounting attachments for the indicator so that it can be mounted over the injector hole in the cylinder head. Provide an extension for the spindle of the indicator. The extension must be long enough to contact the piston as it approaches its upper position.

7. Mount the indicator over the injector hole and tighten mountings sufficiently to hold the indicator rigid.

   The mounting leg may be threaded into the rocker cover stud; or the stud may be removed from the cylinder head and the leg threaded into the tapped hole, depending upon the length of the rod used in making up the mounting attachments. Make sure that the spindle extension is free in the injector hole, does not bind, and is free to travel its full 1" movement.

8. Provide a suitable pointer and attach it to the crankshaft front cover or engine front end plate as illustrated in Fig. 2. The pointer should ex-tend over the vibration damper, or crankshaft pulley, whichever is used.

9. Rotate the crankshaft in the direction of rotation slowly until the hand on the dial indicator just stops moving.

10. Rotate the crankshaft in the direction of rotation until the indicator hand just starts to move. Reset dial to "0". Continue turning the crank-shaft slowly until the indicator reading is .010" -- then stop turning.

11. Scribe a line on the damper (or crankshaft pulley) in line with the end of the pointer.

12. Rotate the crankshaft opposite the direction of rotation slowly until the hand on the dial indicator just stops moving.

13. Rotate the crankshaft opposite the direction of rotation until the indicator hand just starts to move. Reset dial to "0". Continue turning the crankshaft slowly until indicator reading is .010"—then stop turning.

14. Scribe a second line on the vibration damper (or crankshaft pulley) in the same manner as in Step 11.

15. Scribe a third line halfway between the first two lines. This is positive top-dead-center. The three scribed lines are shown on the crankshaft pulley in Fig. 2. Remove the indicator from the engine.

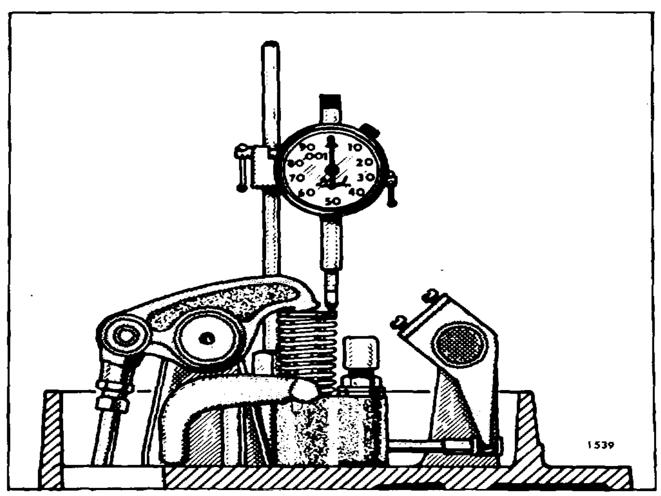


Fig. 3 - Checking Engine Timing By Measuring Injector Depression

1.7.1 GEAR TRAIN AND TIMING

NOTE: Make certain that the crank-shaft pulley retaining bolt is not loosened while turning the crankshaft. The bolt must be tightened to 290-310 lb-ft torque if it becomes loose.

16. Install the injector assembly. Swing the injector and valve rocker arms back into position and install the rocker arm brackets and tighten the bolts to the specified torque. Adjust the valve clearance and time the injector. Rotate the crankshaft until the exhaust valves in the selected cylinder are open.

17. Install the dial indicator again so the spindle of the indicator rests on top of the injector follower as illustrated in Fig. 3. Set the indicator dial to "O(‘. Rotate the crankshaft slowly in the direction of rotation, and stop when the TDC mark on the vibration damper or crankshaft pulley lines up with the pointer.

18. Note the reading on the dial indicator and compare it with the chart.

    After completing the timing check, remove the dial indicator. Remove the shipping caps from injector fuel fittings, and install the injector fuel jumper lines, making sure that they are tightened to prevent any leaks.

    Remove the pointer attached to the front of the engine.

Engine	*INDICATOR READING		
	Standard	Retarded 1-Tooth	Advanced 1-Tooth
	STANDARD TIMING		
(1) 3,4 & 6	.228"	.198"	.248"
(2) 3,4 & 6	.230"	.117"	.262"
ADVANCED TIMING			
(2) 3,4 & 6	.262"	.230"	.289"

* Indicator readings shown are nominal values. The allowable tolerance is + .005 in.

(1) High velocity type injector cam.
(2) Low velocity type injector cam.

19. Reset exhaust valves to .012" cold setting. Time injector and reset exhaust valves to .009" hot after warming up engine as outlined in Section 14.

20. Install the valve rocker cover.

CAMSHAFT, BALANCE SHAFT AND BEARINGS

The camshaft and the balance shaft are located near the top of the cylinder block (Fig. 1) and each may be located on either side of the engine, depending upon the engine model. The camshaft actuates the valve and injector operating mechanism.

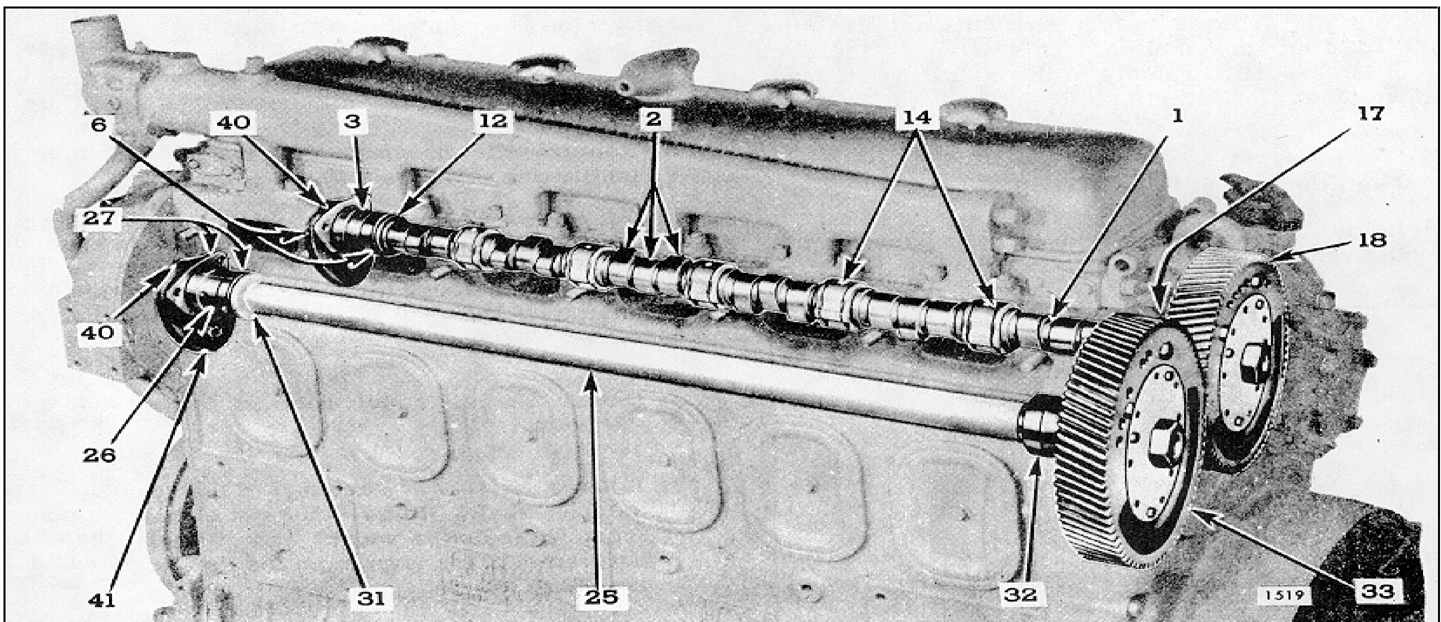
The accurately ground cams on the camshaft ensure efficient, quiet, cam follower roller action, and are heat treated to provide a hard wear surface.

The current engines are equipped with a low velocity, low lift injector cam lobe and a long closing ramp exhaust cam lobe design camshaft. Former engines were equipped with a high lift injector cam lobe camshaft. The two camshafts are interchange-able and only the current camshaft, which can be identified by the numeral "7" stamped on one end of the camshaft, is serviced.

Both ends of the cam and balance shaft are supported by bearing assemblies, each consisting of a flanged housing and two bushings. In addition, intermediate two-piece bearings support the camshaft at uniform intervals throughout its length. The intermediate bearings are secured to the camshaft by lock rings, thereby permitting them to be inserted into the cylinder block with the shafts. Each intermediate bearing is secured in place, after the camshafts are installed, with a lock screw threaded into a counterbored hole in the top of the cylinder block.

On both the camshaft and the balance shafts the gear thrust load is absorbed by two thrust washers, one on each end of the rear bearings of the "A" and "'D" basic engines and at the front end of the "B" and "C" engines. The thrust washers bear against thrust shoulders on the shafts.

A helical drive gear with a counterweight is secured to each shaft with a Woodruff key, nut, nut retainer, retainer bolts and lock washers. The



1.	Camshaft	14.	Bearing--Camshaft--Intermediate	26.	Bearing--Balance Shaft--Front	32.	Bearing--Balance Shaft--Rear
2.	Cam	17.	Bearing--Camshaft--Rear	27.	Washer--Balance Shaft Thrust	33.	Gear--Balance Shaft--R.H Helix
3.	Bearing--Camshaft Thrust	18.	Gear--Camshaft--L.H. Helix	31.	Thrust Shoulder--Balance Shaft	40.	Balance Weight
6.	Washer--Camshaft Thrust	25.	Balance Shaft			41.	Hub--Balance Weight
12.	Thrust Shoulder--Camshaft						

Fig. 1 - Camshaft and Balance Shaft Assemblies

1.7.2 CAMSHAFT, BALANCE SHAFT AND BEARINGS

drive gears are attached to the rear end of the shafts on all engines.

To help maintain engine balance, a balance weight is installed on the front end of each shaft.

Lubrication

Lubricating oil is supplied under pressure to the bearings from the longitudinal main oil gallery through a horizontal transverse passage at each end of the cylinder block, then up the connecting vertical passages in each corner of the block to the camshaft and balance shaft end bearings. The cam-shaft intermediate bearings are lubricated by the oil from the end bearings passing through the drilled passage in the shaft.

The lower halves of the camshaft intermediate bearings are grooved along the horizontal surface that mates with the upper halves of the bearings (Fig. 2). Oil from the passage in the camshaft is forced through the milled slots in the bearing and then out the grooves to furnish additional oil to the cam follower assemblies. This permits the cam pocket to be filled rapidly to the operating oil level immediately after starting the engine.

Remove Camshaft or Balance Shaft

1. Drain the engine cooling system and remove the radiator and all attaching parts.

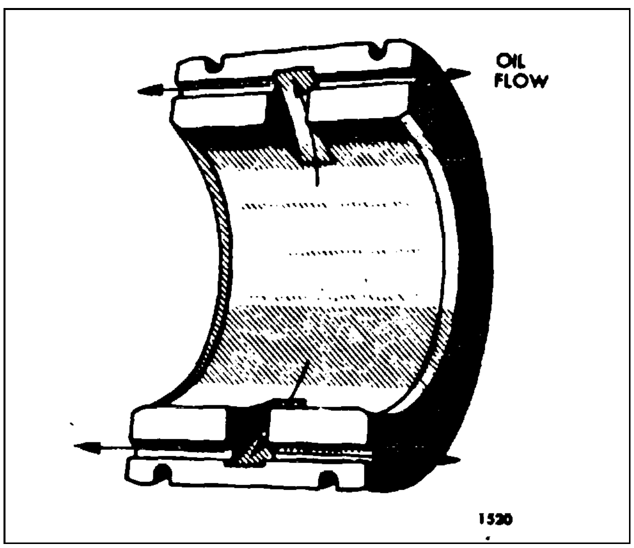


Fig. 2 - Camshaft Intermediate Bearing (Lower Half)

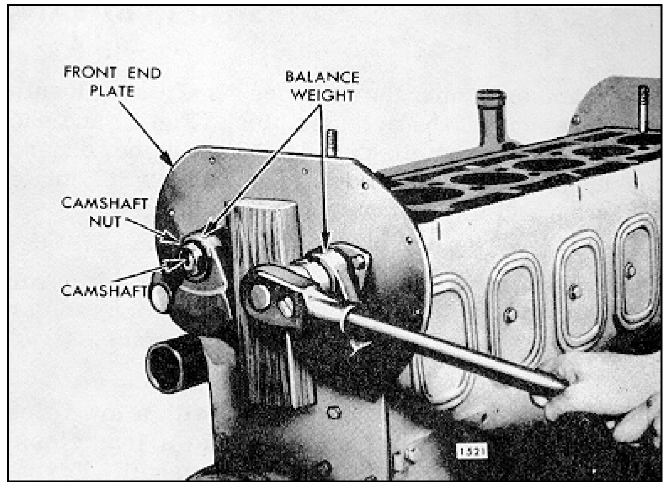


Fig. 3 - Loosening Nut on Camshaft or Balance Shaft

2. Remove all parts, accessories and assemblies that are necessary to facilitate mounting the engine on an overhaul stand.

3. Mount the engine on the overhaul stand. Before releasing the lifting sling, be sure that the engine is mounted securely.

4. Remove the cylinder head.

5. Remove the flywheel and flywheel housing as outlined in Sections 1.4 and 1.5.

6. Remove the front balance weight cover and place a wood block between the balance weights (Fig. 3) or wedge a clean rag between the cam-shaft and balance shaft drive gears on the rear of the engine.

7. Detach the gear nut retainer after removing the bolts.

8. Loosen the nuts on each end of the camshaft and balance shaft. Remove the nut and lock washer from the balance weight end of each shaft. Do not remove the nuts from the drive gear end of the shafts.

9. Remove the front balance weights.

10. Remove the thrust washers between the bear-ings and the balance weight hubs on “B” and “C” engines.

11. Remove the lock screws that secure the cam-shaft intermediate bearings.

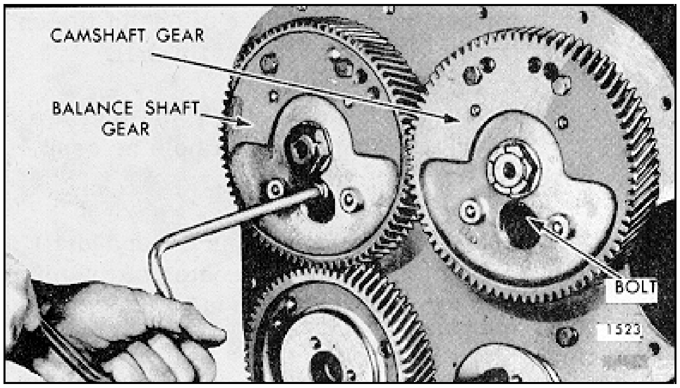


Fig. 4 - Removing or Installing Shaft Bearing Retainer Bolts

12. The three bolts that secure the camshaft and balance shaft bearings to the rear end plate of the engine may be removed by inserting a socket wrench through the hole in the webs of the camshaft and balance shaft drive gears (Fig. 4).

13. Withdraw the camshaft and balance shafts from the rear end of the cylinder block.

    If the thrust washers, located between the bearings and thrust shoulders at the front end of the shafts on "B" and "C" engines are not removed with the shafts, they should be pulled out when removing the bearings.

14. The camshaft and balance shaft front bearings (and thrust washers on "B" and "C" engines) may be removed after taking out the bolts that hold the bearings to the end plate and cylinder block. Pry under the bearing flange with a suitable tool if the bearing cannot be withdrawn by hand.

Remove Camshaft (Flywheel Housing and Transmission in Place)

The camshaft may be removed and replaced without removing the flywheel housing and disconnecting the transmission if there is space enough to slide the shaft out through the front of the engine.

1. Drain the engine cooling system and remove the radiator and all attaching parts.

2. Remove the parts, accessories and assemblies that are necessary to facilitate the removal of the flywheel housing hole cover over the cam-shaft and the front balance weight cover.

3. Remove the cylinder head.

4. Remove the front balance weight cover and place a wood block between the balance-weights (Fig. 3).

5. Detach the gear nut retainer after removing the bolts. Remove the tachometer drive adapt-or, if used.

6. Loosen and remove the nut at each end of the camshaft.

7. Remove the front balance weights.

8. Remove the thrust washer .between the bearing and the balance weight hub ("B" and "C" engines only).

9. Remove the lock screws that secure the cam-shaft intermediate bearings.

10. Remove the three bolts that secure the camshaft bearing to the front end plate.

11. Install the camshaft gear puller J 1902-01, four spacers J 6202-2 and camshaft gear puller adaptor plate J 6202-1 on the camshaft gear (Figs. 5 and 6).

12. Turn the puller center screw clockwise to disengage the camshaft gear.

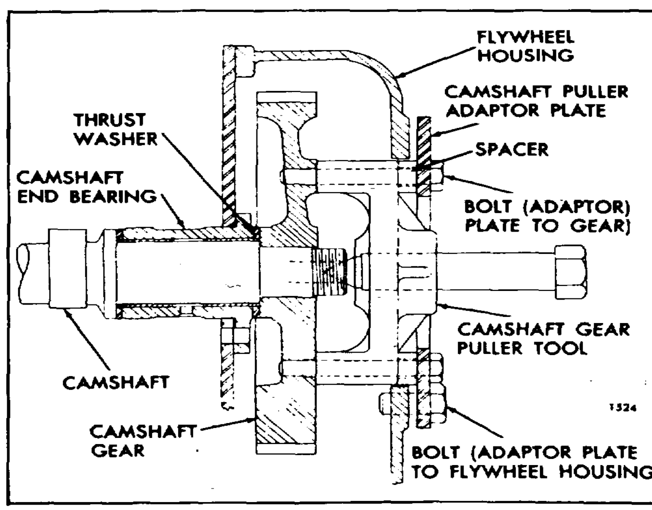


Fig. 5 - Removing Camshaft With Camshaft Gear Puller J 1902-01 and Adaptor Plate Set J 6202

1.7.2 CAMSHAFT, BALANCE SHAFT AND BEARINGS

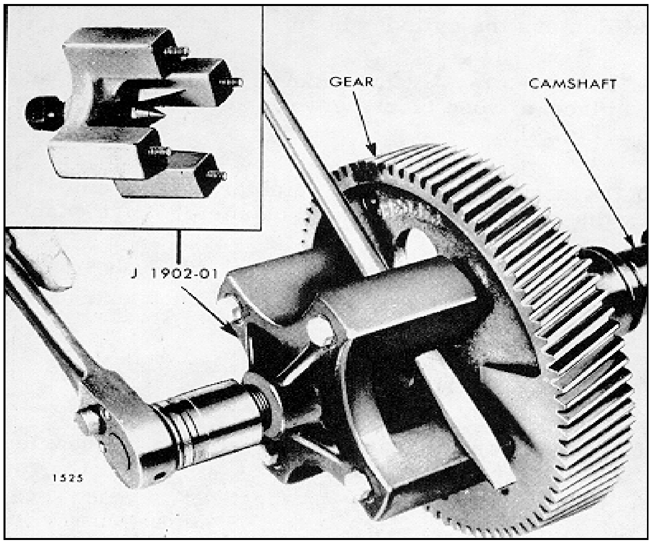


Fig. 6 - Removing Gear (Camshaft or Balance Shaft Gear Puller J 1902-01)

NOTE: Do not remove the puller or adaptor plate until the camshaft is reinstalled. The adaptor plate, se-cured to both the flywheel housing and the camshaft gear will hold the gear (thrust washer also on "A" and "D" engines) securely in place and in alignment which will aid in the reinstallation of the camshaft.

13. Remove the front bearing from the camshaft and pull out the inner thrust washer ("B" or "C" engines). Then, pull the -camshaft and intermediate bearings from the cylinder block.

Disassemble Camshaft or Balance Shaft

1. Remove the gear from the shaft.

2. Slide the rear bearing (and the thrust washer on the "A" and "D" engines) off of the shaft.
3. Remove the lock rings from the camshaft intermediate bearings and free the two halves of each bearing.

4. To facilitate removal of any foreign matter lodged behind the camshaft oil passage end plugs, remove the plugs as follows:

   a. With the camshaft clamped in a vise, make an indentation in the center of one of the end plugs with a 31/64" carboloy tip drill.

   b. To aid in breaking through the hardened surface of the plug, punch a hole as deep as possible with a center punch.

   c. Use a ¼" carboloy tip drill and drill a hole straight through the center of the plug. then, enlarge the hole with a 5/16" carboloy tip drill.

   d. Tap the drilled hole with a 3/8"-16 tap.

   e. Thread the 3/8"-16 adaptor J 6471-2 into the plug and attach the slide hammer J 6471-1 to the adaptor. Remove the plug by striking the weight of the hammer against the handle.

   f. Insert a 3/8" diameter steel rod into the camshaft oil passage and drive the remain-ing plug out.

Inspection

Clean the camshaft, balance shaft and related parts with fuel oil. All foreign matter must be removed from the camshaft oil passage. Dry all parts with compressed air.

Examine the cams and journals. If the surfaces are badly scored or worn replace the camshaft or balance shaft.

Check the runout at the center bearing with the camshaft mounted on the end bearing surface. Runout should not exceed .002".

Check the cam followers if the cam surfaces are scored.

Inspect both faces of each thrust washer. Replace excessively scored or worn washers. New thrust washers are available in standard (.120" to .122" thick) and oversize (.005" or .010"). The clearance between the thrust washer and the thrust shoulder of the shafts is .004" to .012" with new parts, or a maximum of .018 with used parts.

When the thrust surfaces of a camshaft or balance shaft are ground undersize, special care must be taken-as follows:

1. Leave a 1/32" to 3/32" radius between the bearing surface of the thrust collar shoulder and the bearing surface of the camshaft.

2. Leave a .010" to .030" radius between the bearing surface of the thrust collar shoulder and the bearing surface of the balance shaft (Fig. 7).

A fillet radius gage may be used to measure the specified radii.

Examine the faces of the shaft end bearings and any other surface which comes into contact with the thrust washers. Parts that are badly marred must be replaced, slight scratches may be cleaned up with an oil stone.

Inspect the bushings in the shaft end bearings. Replace the bushings or end bearing assemblies if they are worn excessively or the bushings have turned within the bearing. New bushings must be finished bored to a 20 r.m.s. finish after installation and tested for the correct press fit. The correct press fit is indicated if the bushing does not move when a 2000 pound end load is applied. This test is of special importance with engines that operate at high (2300 rpm) speeds. The inside diameter of the bushings must be square with the rear face of the bearing within .0015" total indicator reading, and concentric with the outside diameter of the bearing retainer within .002" total indicator reading. The bushings must project from .045" to .055" from each end of the bearing.

The clearance between the camshaft and balance shaft end journals and the end bearing bushings is .0025" to .004" with new parts, or a maximum of .006" with used parts. End bearings are available in .010" or .020" undersize for use with shafts that are worn or have been reground and the clearances exceed the specified limits.

Replace excessively scored or worn camshaft intermediate bearings. The clearance between the camshaft journals and the intermediate bearings is .0025" to .005" with new parts, or a maximum of .009" with worn parts. Camshaft intermediate bearings are available in .010" and .020" undersize for use with worn or reground shafts in which the clearances exceed the specified limits. Examine the intermediate bearing lock screws and the tapped holes in the block. Damaged holes in the cylinder block may be plugged, redrilled and tapped. Discard lock screws with damaged threads.

Assemble Camshaft and Balance Shaft

1. Install new end plugs in the camshaft.

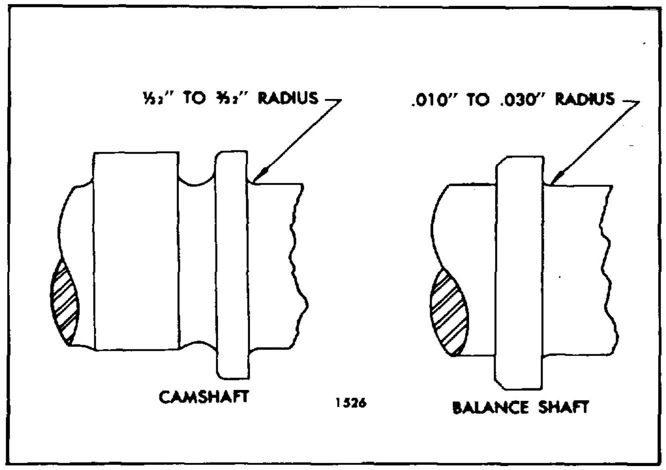


Fig. 7 - Camshaft and Balance Shaft Journal Fillets

2. Apply grease to the steel face of each end thrust washer. Then, place a thrust washer (6 and 27) against each end of the camshaft and balance shaft rear bearings ("A" and "DI' engines). The steel faces of the thrust washers must be towards the bearing.

3. Lubricate the rear camshaft and balance shaft journals and slide the rear bearings on each shaft with the mounting flange of the bearing toward the gear end of the shaft.

4. Install the gears on the shafts.

5. Lubricate the camshaft intermediate bearing journals. Then, place the two halves of each intermediate bearing on a camshaft journal and lock the halves together with the two lock rings. Install each lock ring with the gap over the upper bearing and the ends on equal distance above the split line of the bearing.

> **NOTE:** Two intermediate bearing lock rings are used. The current ring can be identified by the wider gap. The wide gap ring MUST be used with the grooved type lower half bearings and can also be used with the former intermediate bearings.

Install Camshaft and Balance Shaft

1. Insert the front end of the camshaft into the opening on the blower side of the RA, and RC engines and on the opposite side of the RB and RD engines. Push the camshaft into the cylinder block until the camshaft gear teeth

almost engage the teeth of the idler gear. Use care when installing the camshaft to avoid damaging the cam lobes.

NOTE: The right hand gear (viewing the engine from the flywheel end) whether it is attached to the camshaft or balance shaft has left-hand helical teeth.

2. Align the timing marks on the mating gears as shown in Figs. 1 and 2, Section 1.7.1 and slide the camshaft gear in place.

3. Secure the camshaft rear bearing to the cylinder block with the three bolts and lock washers. The camshaft gear may be turned to accommodate the bolts through the hole in the gear web (Fig. 4). Tighten the bolts to 35-40 lb-ft torque.

4. Insert the balance shaft in the bore in the cylinder block and push it in until the teeth of the balance shaft gear almost engage the camshaft gear teeth.

5. Align the timing marks on the mating gears as shown in Figs. 1 and 2, Section 1.7.1 and slide the balance shaft gear into place.

6. Secure the balance shaft rear bearing. Use the same procedure as outlined for the camshaft rear bearing, Step 3.

7. Apply grease to the steel face of each thrust washer. Then, place a thrust washer against the inner end of the camshaft and balance shaft front end bearing (“B” and “C” engines). The steel face of the thrust washer must be against the bearing.

8. Install the camshaft and balance shaft front end bearings with the bolts and lock washers. Tighten the bolts to 35-40 lb-ft torque.

CAUTION: Install the front bearings with care to avoid dislodging the thrust washers. Do not hammer the bearings into the cylinder block.

9. Apply grease to the steel face of each thrust washer (6 and 27) and place them so that the steel faces are against the outer end of the camshaft and balance shaft front bearings (3 and 26) on the "B" and "C" engines.

10. Turn the camshaft intermediate bearings until the holes in the bearings are in alignment with the threaded holes in the cylinder block. In-stall the lock screws and tighten them to 15-20 lb-ft torque.

11. Install the front balance weights on the shafts.

12. Place an internal tooth lock washer on the end of each shaft and start the nuts on both shafts.

13. Use a wood block (Fig. 3) between the balance weights or wedge a clean cloth between the cam and balance shaft gears to prevent their turning. Tighten the nuts to 300-325 lb-ft torque.

14. Install the camshaft and balance shaft gear nut retainers with the bolts and lock washers. Tighten the bolts to 35-39 lb-ft torque.

15. Check the clearance between the thrust washer and the thrust shoulder of both the camshaft and balance shaft. The specified clearance is .004” to .012” with new parts, or a maximum of .018” with used parts.

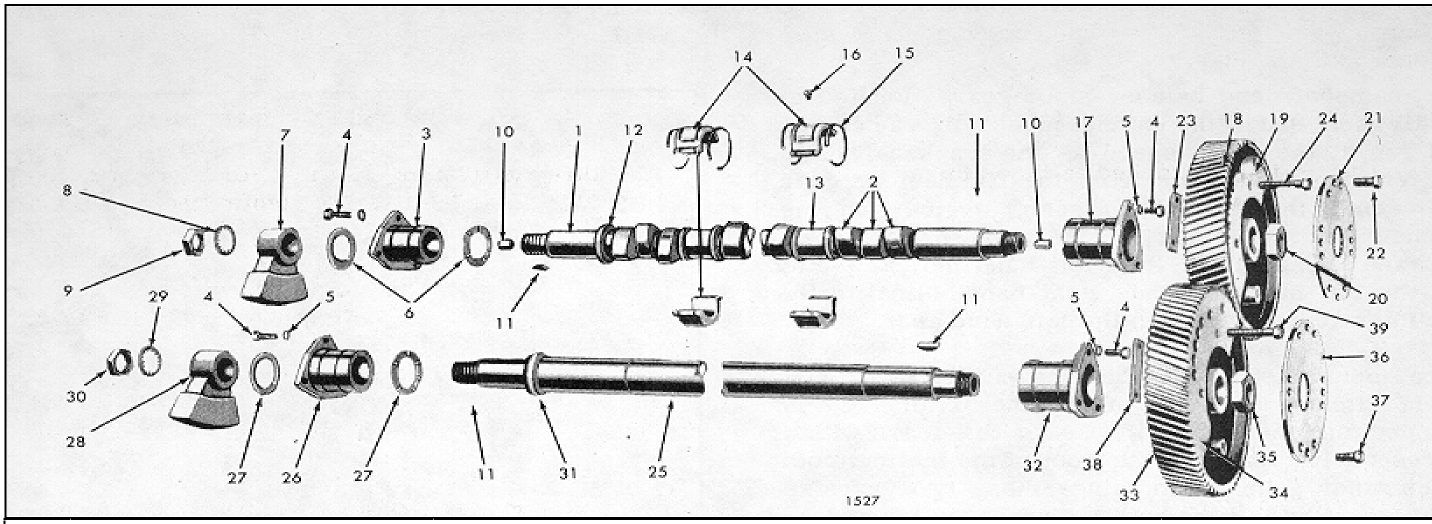
16. Check the backlash between the mating gears.

17. Reinstall the parts, accessories and assemblies that were removed from the engine and refill the cooling system.

Install Camshaft (Flywheel Housing and Transmission in Place)

1. On the “A” and “IY’ engines, apply grease to the steel face of the thrust washer and install it with the steel face against the bearing.

2. Install a Woodruff key in the drive gear end of the camshaft and insert this end into position from the front end of the engine. Push the shaft in until it slides into the rear end bearing. Use care in the installation of the camshaft to pre-vent damage to the cam lobes.



1.	Camshaft	14.	Bearing--Camshaft-	23.	Balance Weight--	32.	Bearing--Balance Shaft-
2.	Cam		Intermediate		Camshaft-Rear		Rear
3.	Bearing--Camshaft-Front	15.	Lock Ring--Intermediate	24.	Bolt--Weight Retainer	33.	Gear--Balance Shaft-
4.	Bolt--Bearing Retainer		Bearing	25.	Balance Shaft		R.H Helix
5.	Lock Washer	16.	Setscrew--Intermediate	26.	Bearing--Balance Shaft-	34.	Weight--integral
6.	Washer--Camshaft Thrust		Bearing		Front		Balance-Balance Shaft
7.	Balance Weight Assy.--	17.	Bearing--Camshaft-Rear	27.	Washer--Balance Shaft	35.	Nut--Balance-Shaft-
	Camshaft-Front	18.	Gear--Camshaft-		Thrust		Rear
8.	Lock Washer--Camshaft Nut		L.H Helix	28.	Balance Weight Assy.--	36.	Retainer--Balance Shaft
9.	Nut--Camshaft-Front	19.	Weight--Integral Balance		Balance Shaft-Front		Gear Nut
10.	Plug--Camshaft		Camshaft	29.	Lock Washer--Balance	37.	Bolt--Gear Nut
11.	Woodruff Key	20.	Nut--Camshaft-Rear		Shaft Nut		Retainer
12.	Thrust Shoulder--Camshaft	21.	Retainer--Camshaft Gear	30.	Nut--Balance Shaft-Front	38.	Balance Weight--
13.	Journal--Camshaft-		Nut	31.	Thrust Shoulder--Balance		Balance Shaft-Rear
	Intermediate	22.	Bolt--Gear Nut Retainer		Shaft	39.	Bolt--Weight Retainer

Fig. 8 - Typical Camshaft and Balance Shaft Details and Relative Location of Parts

3. Align the key in the shaft with the keyway in the camshaft drive gear and start the shaft into the gear. Tap the shaft into the gear with a soft (plastic or rawhide) hammer.

   CAUTION: On the “A” and “ID” engines, make sure the thrust washer is in the correct position to prevent pushing the bushing into the bearing or damage to the bushing.

4. Remove the camshaft gear puller, spacers and adaptor plate. Finger tighten the gear retaining nut on the shaft.
5. Install the front end bearing (and thrustwashers “B” and “C” engines) with the bolts and lock washers. Tighten the bolts to 35-40 lb-ft torque.

   CAUTION: Apply grease to the steel faces of the thrust washers and insure that the steel faces are towards the bearing.

6. Install the balance weight on the front of the camshaft.

7. Start the balance weight retaining nut and lock washer on the camshaft (Fig. 8). Place a wood block between the balance weights (Fig. 3). Tighten the gear retaining nut; then, tighten the balance weight nut to 300-325 lb-ft torque.

8. Align the holes in the camshaft intermediate bearings with the tapped holes in the top of the cylinder block. Install and tighten the lock screws to 15-20 lb-ft torque.

9. Replace the parts, accessories and assemblies that were removed from the engine and refill the cooling system.

CAMSHAFT AND BALANCE SHAFT GEARS

The camshaft and balance shaft gears, located at the flywheel end of the engine, mesh with each other and run at the same speed as the crankshaft (Fig. 1). Viewing the engine from the flywheel or gear train end, the right-hand gear, whether on the balance shaft (RA and RD engines) or camshaft (RB and RC engines), has left-hand helical teeth, and the left-hand gear has right-hand helical teeth. The idler gear mates with the left-hand gear.

Since the camshaft and balance shaft gears must be in time with each other, the letter "O" is stamped on one tooth of one of the gears with a corresponding mark at the root of the mating tooth of the other gear. Also, since these two gears as a unit must be in time with the crankshaft, an identification mark (letter "R" for right-hand rotation) is located on either the camshaft gear or balance shaft gear and the mating idler gear (see Fig. 1 of Section 1.7.2).

The camshaft and balance shaft gears are keyed to their respective shafts and held securely against the shoulder on the shaft by a nut. A gear nut retainer, with a double hexagon hole in the center, fits over the nut and prevents loosening of the nut. The retainer is attached to the gear by bolts threaded into tapped holes in the gear. These tapped holes are also utilized in mounting an accessory drive on the camshaft or balance shaft gear.

The same two gears are used as camshaft and balance shaft gears on three, four and six cylinder engines. A small balance weight is attached to the inner face of each gear. A different size weight is used on three, four and six cylinder engines. The three cylinder engine weight is secured to the gear with two 3/8"-24 x 1-1/8" bolts, the four cylinder engine weight is secured with two 3/8"-24 x 1-3/8" bolts and the six cylinder engine weight is secured with two 3/8"-24 x 1-1/4" bolts. These weights are important in maintaining perfect engine balance.

Remove Camshaft and Balance Shaft Gears

1. Remove camshaft and balance shaft from engine as outlined in Section 1.7.
2. Support the camshaft suitably in soft jaws of bench vise, being careful not to damage cams.
3. Remove nut retaining gear on camshaft.
4. Back out puller screw of tool J 1902-01 and attach puller to outer face of gear with four bolts (Fig. 2).

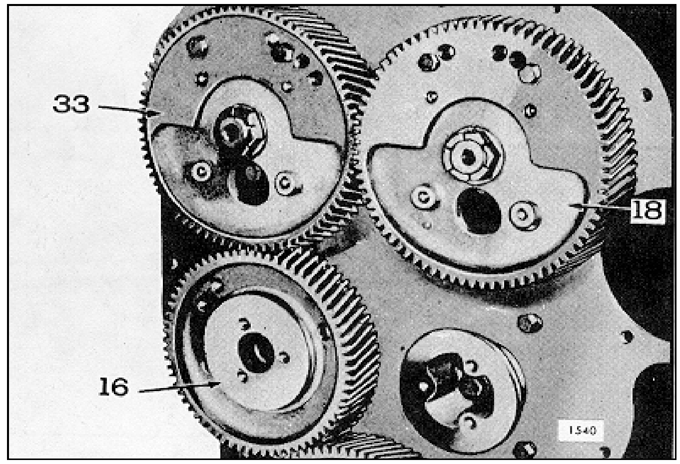


Fig. 1 - Camshaft and Balance Shaft Gear Mounting

16. Gear--Idler
18. Gear--L.H. Helix-Camshaft
33. Gear--R.H. Helix-Balance Shaft

5. Turn puller screw down against end of shaft to remove gear.
6. Remove gear from balance shaft in similar manner.
7. If necessary, remove two weight retaining bolts and remove balance weights from each gear.
8. If necessary, remove keys from camshaft and balance shaft.

Inspection

Clean the gears with fuel oil and dry them with compressed air. Then examine the gear teeth for evidence of scoring, pitting, wear or burning. If severely damaged or worn, install a new gear. Also check the other gears in the gear train.

Install Camshaft and Balance Shaft Gears

1. Install the balance weights on the gears, if removed.
2. Lubricate the shaft journals and place the cam-shaft and balance shaft end bearings in place, with the bolting flanges facing toward the gear ends of the shafts. If the unit being serviced is an "A" or "D" engine, install the thrust

1.7.3 CAMSHAFT AND BALANCE SHAFT GEARS

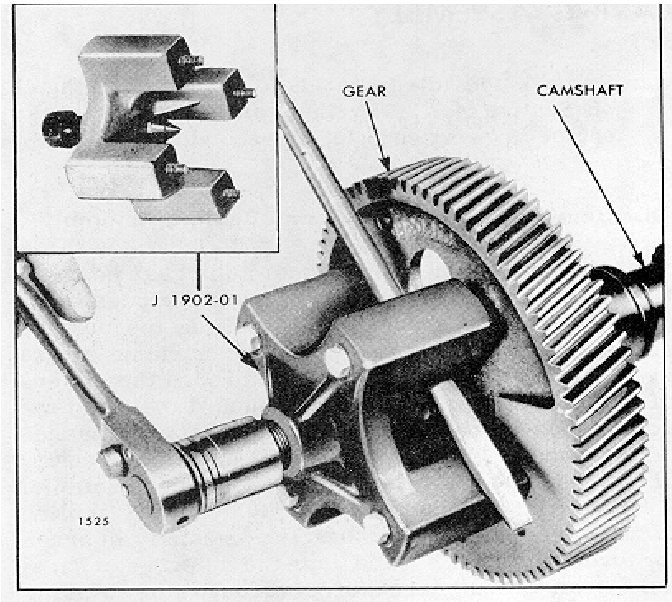


Fig. 2 - Removing Gear (Camshaft or Balance Shaft) with Tool J 1902-01

washers between the end bearings and thrust shoulders of the shafts, and between the end bearings and the gears.

> **NOTE:** Be sure the steel faces of the thrust washers are next to the bearings.

3. Install the Woodruff keys for the gears in both shafts.

4. Note that the teeth on one gear form a right-hand helix and on the other a left-hand helix. When viewing the engine from the flywheel end, the gear with the right-hand helical teeth is located on the left-side and the gear with the left-hand helical teeth is located on the right-side of the engine. With this in mind, rest the non-gear end of camshaft on a wood block and start gear onto the other end of shaft by hand so the keyway aligns with the key and with the flat finished face of the gear away from the bearing.

5. Use gear installer, J 1903, as shown in Fig. 3, to drive the gears on the camshaft and balance shaft tight against the shoulders on the shafts.

6. Start the nuts on their respective shafts by hand. Tighten the nuts after the shafts have been installed in the cylinder block.

7. Install the camshaft and balance shaft in the engine as outlined in Section 1.7.

8. With the shafts and front balance weights in-stalled, wedge a clean cloth between the cam-shaft and balance shaft gears, and tighten the gear retaining nuts to 300-325.1lb-ft torque.

9. Secure the nuts with the retainers, retainer bolts and lock washers.

10. Check the backlash between the mating gears. The backlash should be within .003"-.010".

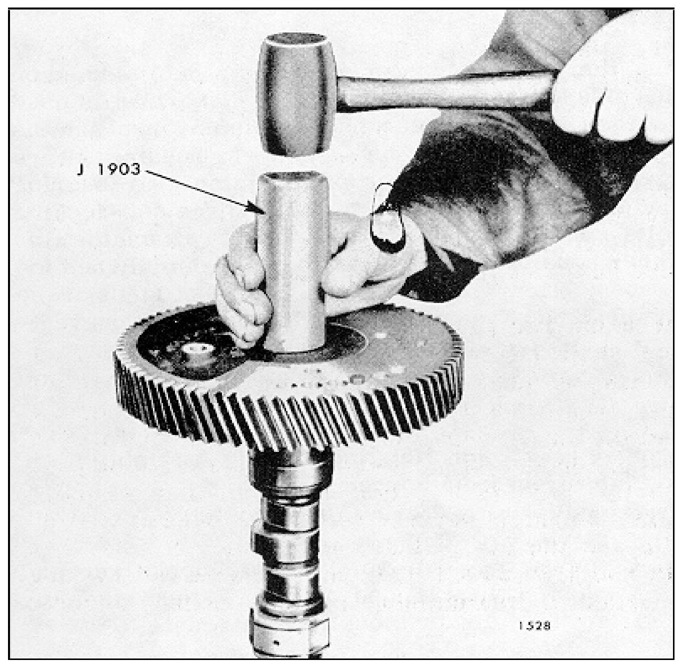


Fig. 3 - Replacing Gear (Camshaft Shown) with Tool J 1903

IDLER GEAR AND BEARING ASSEMBLY

The idler gear mounts on a double row, tapered roller bearing which, in turn, is supported on a stationary hub (Fig. 1). A hollow pin serves a two-fold purpose; first, as a locating dowel it prevents the idler gear hub from rotating and, second, the hollow pin conducts oil under pressure from an oil gallery in the cylinder block through a passage in the gear hub to the roller bearing inner races.

The inner races of the idler gear bearing are pressed onto the gear hub and, therefore, do not rotate since the hub is doweled to the end plate and bolted to the cylinder block and also bolted to the flywheel housing. A spacer separates the two bearing inner races.

The bearing outer race has a light press fit in the idler gear and is held against a flanged lip inside the idler gear on one side and by a retainer se-cured tightly with six bolts on the other side.

An idler gear hole spacer (dummy hub) is used on the side opposite the idler gear. NO gasket is used between the idler gear hub or dummy hub and the flywheel housing. The flywheel housing bears against the inner races of the idler gear bearing and also against the dummy hub. Three self-locking bolts and steel washers are used to attach the fly-wheel housing at the idler gear and dummy hub locations. The washers seat in 7/8” spot faces at the flywheel housing attaching bolt holes, thus preventing oil leakage at these locations.

Remove Idler Gear, Hub and Bearing Assembly and Idler Gear Hole Spacer (Flywheel Housing Previously Removed)

1. Remove the hub to cylinder block bolt and washer (Fig. 1) and withdraw the assembly from the cylinder block rear end plate.

   NOTE: Before removing the idler gear check the idler gear, hub and bearing assembly for any perceptible wobble or shake when pressure is applied; by firmly grasping the rim of the gear with both hands and rocking in relation to the bearing. The bearing must be replaced if the gear wobbles or shakes. If the gear assembly is satisfactory, it is only necessary to check the pre-load before reinstallation.

2. Remove the idler gear hole spacer (23), Fig. 1 of Section 1.7.2, in the same manner if the engine is being completely reconditioned.

Disassemble Idler Gear, Hub and Bearing Assembly

While removing or installing an idler gear bearing, the bearing MUST be rotated to avoid the possibility of damaging the bearing by brinelling the bearing races. Brinelling refers to the marking of the races by applying a heavy load through the rollers of a non-rotating bearing in such a way that the rollers leave impressions on the contact surfaces of the races. These impressions may not be easily discerned during normal inspection. For example, a bearing may be brinelled if a load were applied to the inner race of the bearing assembly in order to force the outer race into the idler gear bore, thus transmitting the force through the bearing rollers. A brinelled bearing may have a very short life.

Refer to Fig. 1 and disassemble the bearing as follows:

1. Remove the six bolts and three bolt locks which secure the bearing retainer to the idler gear.

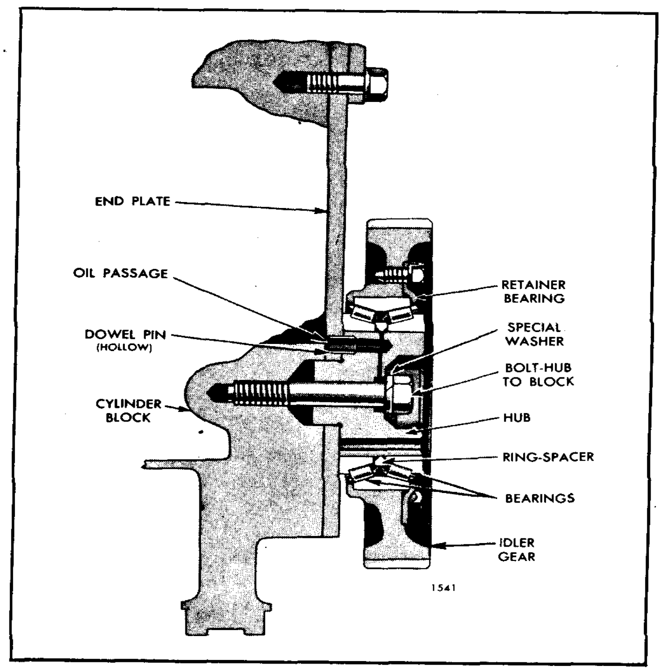


Fig. 1 - Idler Gear Mounting

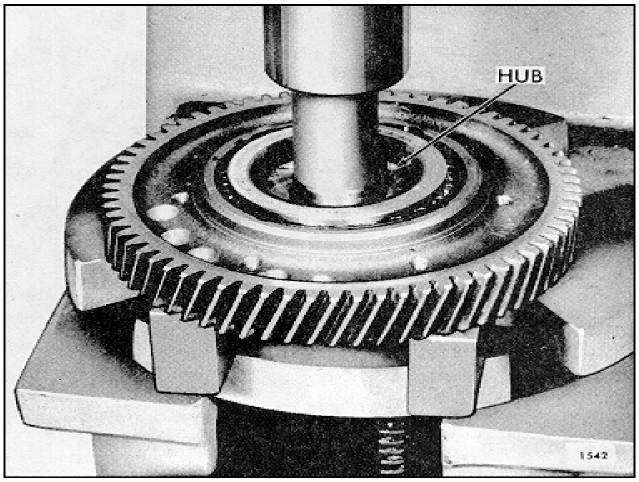


Fig. 2 - Pressing Hub Out of Bearing

2. Clean the idler gear and bearing assembly with fuel oil and dry it with compressed air.

3. Place the idler gear and bearing assembly in an arbor press with the bearing cone or inner race supported on steel blocks as' shown in Fig. 2. While rotating the gear assembly, press the hub out of the bearing. Remove the gear assembly from the arbor press and remove the bearing cones and spacer.

   NOTE: Component parts of the idler gear bearing are mated; therefore, match-mark the parts during disassembly to assure they will be reassembled in their original positions.

4. Tap the bearing cup (outer race) from the idler gear by using a brass drift alternately at four notches provided around the shoulder of the gear.

Inspect Idler Gear and Bearing

Wash the idler gear, hub, and bearing components thoroughly in clean fuel oil and dry with compressed air. Inspect all parts for wear.

Inspect bearings carefully. Wear, pitting, scoring or flat spots on the rollers or races are sufficient cause for rejection and the bearing assembly must be replaced.

Check the idler gear hub and spacer for wear or damage.

Examine the gear teeth for evidence of scoring, pitting and wear. If severely damaged or worn, replace the gear. Also, inspect other gears in the gear train.

Assemble Idler Gear, Hub and Bearing Assembly

Refer to Fig. 3 and assemble bearing components in their original positions (refer to identification marks made during disassembly) as outlined below:

1. Support the idler gear, shoulder down; on the bed of an arbor press and start the outer bearing race squarely into the bore of the gear. Then, press the bearing race tight against the shoulder of the gear, using a steel plate between the ram of the press and the bearing race.

2. Support one bearing cone, numbered side down, on bed of arbor press and lower the idler gear and bearing cup assembly down over the bearing cone.

3. Lay spacer ring on face of bearing cone.

4. Place the second bearing cone, numbered side up, in the idler gear and bearing cup assembly and against the spacer ring.

5. Then, position the idler gear hub over the bearing cones so that the oil hole in the hub is 180° from the gap in the spacer ring.

6. Press the hub into the idler gear bearing cones, while rotating the gear (to seat the rollers properly between the cones) until the face of the hub which will be adjacent to the cylinder block end plate is flush with the corresponding face of the bearing cone. The bearing cones should be supported so as not to load the bearing rollers during this operation (Fig. 4).

7. Prior to installing and securing the bearing retainer, check the preload of the bearing assembly as outlined below.

Check Pre-Load of Bearing

The rollers of the bearing are loaded between the bearing cup and bearing cones in accordance with design requirements to provide a rigid idler gear and bearing assembly. As the bearing cones are moved toward each other in a tapered roller bearing assembly, the rollers will be more tightly held between the cones and cup. In the idler gear bearings, a slight pre-load is applied by means of a

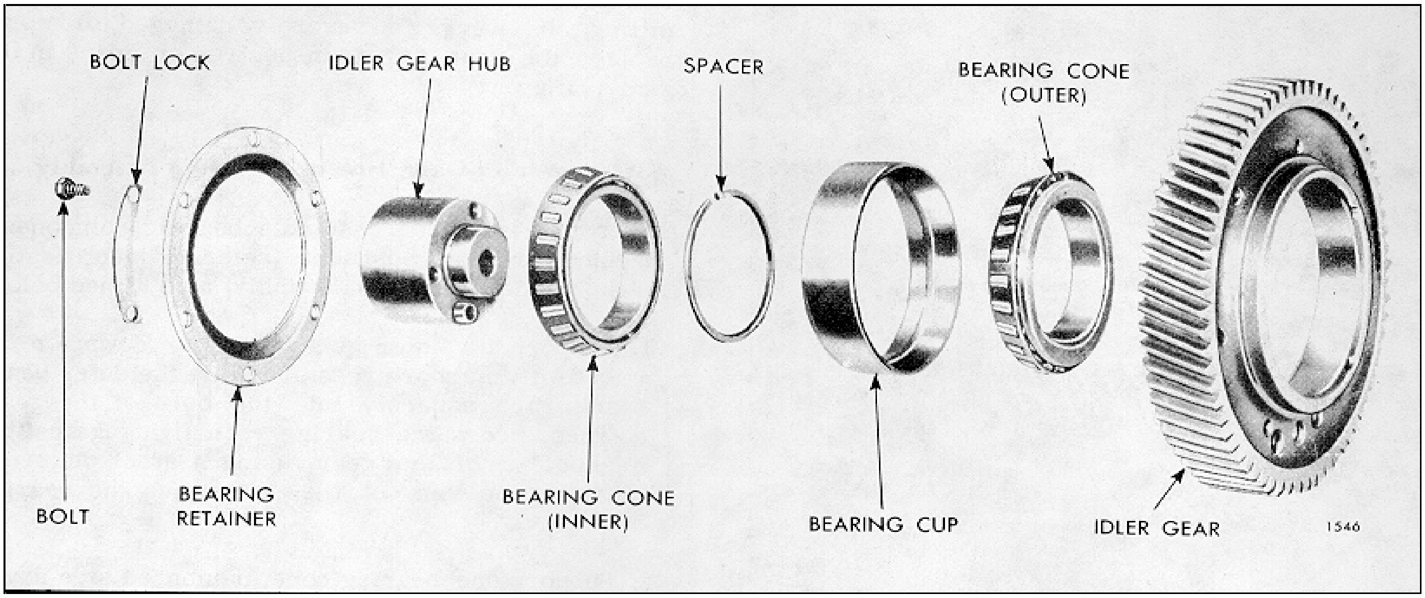


Fig. 3 - Idler Gear Details and Relative Location of Parts

selected spacer ring between the bearing cones, to provide rigidity of the gear and bearing assembly when it is mounted on its hub. This method of pre-loading is measured, in terms of "pounds-pull", by the effort required at the outer diameter of the gear to turn the bearing cup in relation to the bearing cones.

Any time an idler gear assembly has been removed from an engine for servicing or inspection, while performing engine overhaul or other repairs, the pre-load should be measured as part of the operation.

After the idler gear, hub, and bearing are assembled together, the bearing should be checked to ascertain that the gear may be rotated on its bearing without exceeding the maximum torque specifications, nor be so loose as to permit the gear to be moved in relation to the hub by tilting, wobbling or shaking the gear.

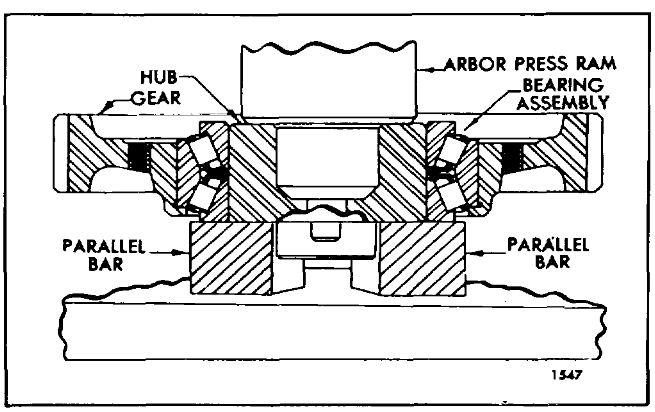


Fig. 4. Pressing Hub into Bearing

If the mating crankshaft and camshaft or balance shaft gears (depending upon engine model) are not already mounted on the engine, the torque required to rotate the idler gear may be checked by mounting the idler gear in position on the engine, using a steel plate 4" square and 3/8" thick against the hub and cone as outlined below.

However, if the gears are on the engine, a suitable fixture, which may be held in a vise, may be made as shown in Fig. 5. Three plates, a ½"-13 x 2 ¾" bolt and a plain washer are used with a ½"-13 nut and plain washer for mounting. One of the plates is used to take the place of the flywheel housing, and the other two plates, the cylinder block. "Engine-mounted" conditions are simulated by tightening the nut to 80-90 lb-ft torque and tightening the three plate-to-hub attaching bolts to 25-40 lb-ft torque. The components of the fixture may be made from steel stock in accordance with the dimensions shown in Fig. 6.

The idler gear bearing must be clean and lubricated with clean light engine oil prior to the pre-load test. Idler gear assemblies which include new bearings should be "worked in" by grasping the gear firmly by hand and rotating the gear back and forth several times.

1.7.4 IDLER GEAR AND BEARING ASSEMBLY

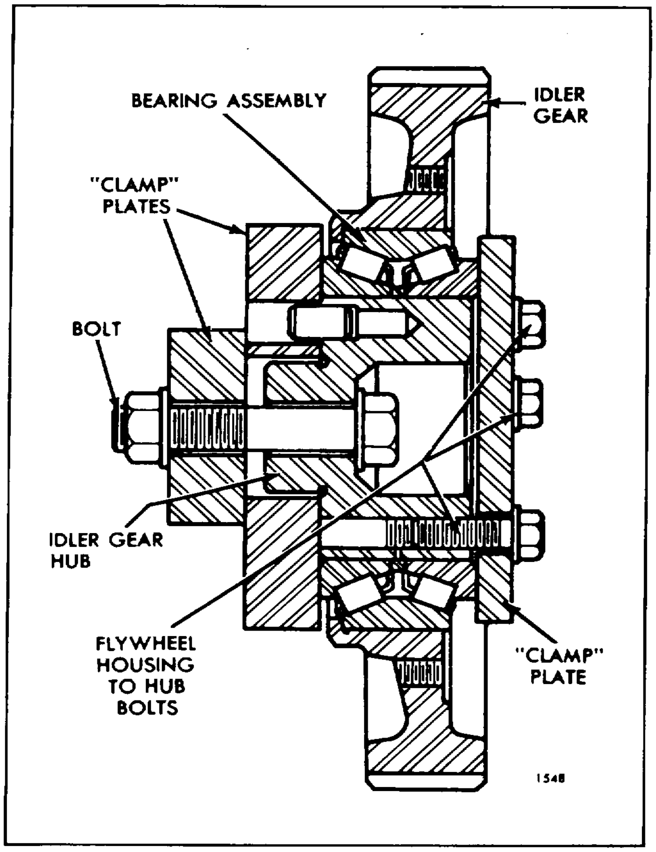


Fig. 5 - Fixture for Testing Bearing Pre-Load

To check the pre-load by the first method:

1. Mount the idler gear assembly on the engine.

2. Install the center bolt and washer through the gear hub and thread into the cylinder block (effective with 3A-48440, 4A-96718, 6A-101509 a ½"-13 x 2 ½" bolt replaced the ½"-13 x 2" bolt). Tighten the bolt to 80-90 lb-ft torque.

3. Place steel plate (lower plate shown in Fig. 6) against hub and bearing. Insert three 3/8"-16 bolts through plate and thread into hub. Tighten the bolts to 25-40 lb-ft torque.

4. Tie one end of a piece of lintless 1/8" cord around a 1/8" round piece of wood (or soft metal stock). Place the wood between the teeth of gear, then wrap the cord around the periphery of the gear several times. Attach the other end of the cord to spring scale, J 8129 (Fig. 7). Maintain a straight, steady pull on the scale, 90° to the axis of the hub, and note the pull, in pounds and ounces, required to start the gear

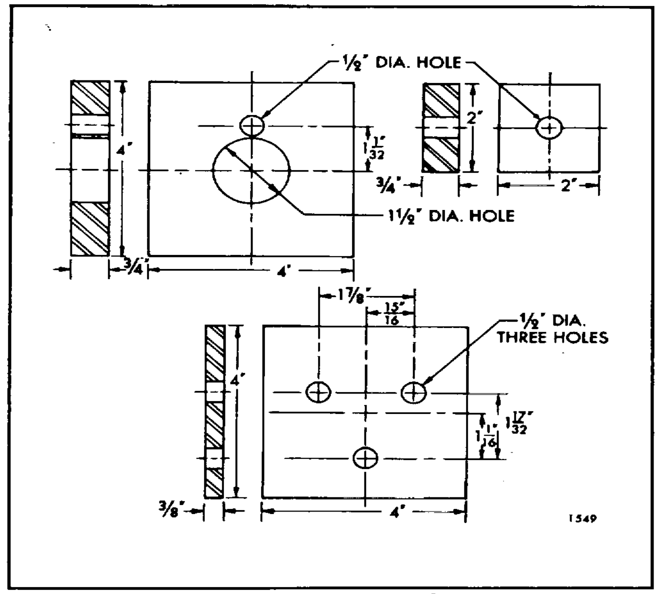


Fig. 6 - Plates for Bearing Test Fixture

rotating. Make several checks to obtain an average reading. If the pull is within 1-1/4 lb. minimum to 6 lbs. 12 ounces maximum and does not fluctuate more than 2 lbs. 11 ounces, the idler gear and bearing assembly are satisfactory for use.

To check the pre-load by the second method:

1. Attach the plates (two upper plates of Fig. 6) to the idler gear with ½"-13 center bolt, washers and nut as shown in Fig. 5. Tighten the bolt to 80-90 lb-ft torque.

2. Attach the other plate to the idler gear with

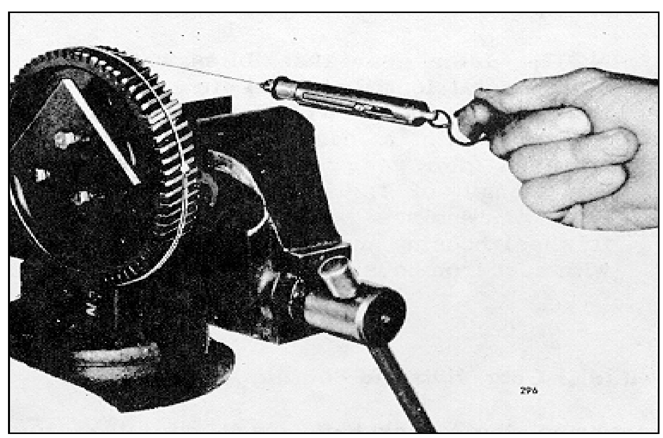


Fig. 7 - Checking Pre-Load of Idler Gear Bearing

three 3/8"-16 bolts. Tighten the bolts to 25-40 lb-ft torque.

3. Clamp the idler gear assembly and fixture in vise as shown in Fig. 7.

4. Attach the cord to the idler gear and spring scale and check the pre-load as outlined in item 4 of the first method.

If the scale reading is within the specified 1-1/4 to 6-3/4 lbs., but fluctuates more than the permissible 2 lbs. 11 ounces, the idler gear and bearing assembly must NOT be installed on the engine. Fluctuations in scale reading may be caused by the races not being concentric to each other, damaged races or rollers, or dirt or foreign material within the bearings. In these cases, the bearing should be inspected for the cause of fluctuation in the scale readings and corrected or a new bearing installed.

A scale reading which exceeds the specified maxi-mum indicates binding of the bearing rollers, or rollers improperly installed. When the scale reading is less than the specified minimum, the bearing is more likely worn and should be replaced.

After the pre-load test is completed, remove the steel plates and attach bearing retainer as follows:

1. Attach the bearing retainer to the idler gear with six bolts and three bolt locks. Tighten the bolts to 24-29 lb-ft torque.

2. Bend the ears of each bolt lock against the flat side of the attaching bolt heads to secure the bolts.

> **NOTE:** Idler gear assemblies which have a total length of 1. 514” to 1. 519” are to be used ONLY on engines equipped with a cast iron flywheel housing. Idler gear assemblies with a total length of 1.509” to 1.514” are used on engines with an aluminum flywheel housing and may also be used with cast iron housings.

Install Idler Gear, Hub and Bearing Assembly

1. Position the crankshaft gear and either the balance shaft or camshaft gear (depending upon engine rotation) so that the match marks will align with those on the idler gear (see Fig. 1 Section 1.7.2).

2. With these marks in alignment, start the idler gear into mesh with the crankshaft gear and either the camshaft or balance shaft gear, and simultaneously rotate the gear hub so that the hollow pin at the inner face of the hub nearly registers with the oil hole in the end plate.

3. Roll the idler gear into position, align the hollow pin with the hole in the end plate, and gently tap the hub until it seats against the end plate. Thus the hollow dowel pin in the hub will conduct oil through the end plate and into the hub where it flows through a drilled passage to the roller bearing.

4. After making sure that the hub is tight against the end plate, secure the idler gear assembly in place with a ½”-13 bolt and special washer. Tighten the bolt to 80-90 lb-ft torque (cast iron cylinder block).

5. If previously removed, install the idler gear hole spacer (dummy hub). Secure the spacer to the cylinder block end plate and cylinder block with a ½”-13 bolt and special washer. Tighten the bolt to 80-90 lb-ft torque (cast iron cylinder block).

> **CAUTION**: Current engines use a new idler gear hub and idler gear hole spacer (dummy hub) which requires ½”-13 x 2 ½” retaining bolts, re-placing the ½”-13 x 2” bolts formerly used.

6. Lubricate the idler gear and bearing liberally with clean engine oil.

7. Check the backlash between the mating gears. The backlash must be .003” to .008” between new gears and must not exceed .010” between used gears.

8. No gasket is used between the idler gear assembly and the flywheel housing.

> **NOTE:** Make sure the oil passage in the cylinder block is plugged at the dummy hub location.

9. Install the flywheel housing as outlined in Section 1.5.

CRANKSHAFT TIMING GEAR

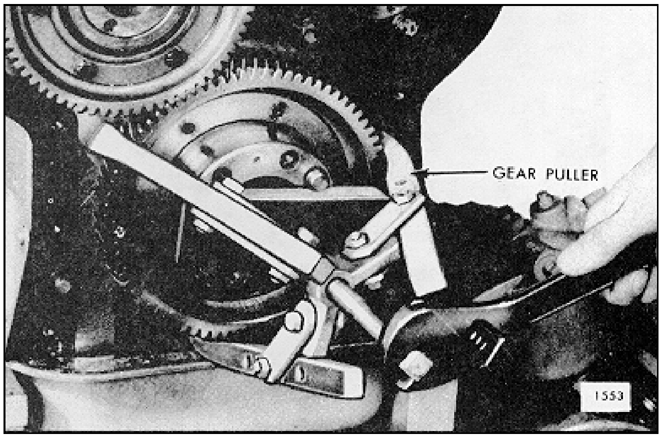


Fig. 1 - Removing Crankshaft Timing Gear

The crankshaft timing gear is bolted to the flange at the rear end of the crankshaft and drives the camshaft gear (RA and RD engines) or balance shaft gear (RB and RC engines) through an idler gear.

Since the camshaft must be in time with the crankshaft, timing marks are located on two teeth of the idler gear with corresponding timing marks stamped on the crankshaft gear and camshaft and balance shaft gears (refer to Section 1.7.1).

Remove Crankshaft Timing Gear (Flywheel Housing Removed)

The crankshaft gear is a press fit on the crankshaft. Remove the gear as follows:

1. Remove the crankshaft rear oil seal sleeve, if used. To remove the sleeve, peen the outside diameter of the sleeve until it stretches sufficiently so it can be slipped off of the crankshaft.

2. Before removing the crankshaft gear, align the timing marks of the gear train and note their location so the gear can be reinstalled in its original position.
3. Remove the six bolts and lock washers securing the gear to the crankshaft.
4. Provide a base for the puller screw by placing a steel plate across the cavity in the end of the crankshaft. Then remove the gear with a suitable puller as shown in Fig. 1.

Inspection

Clean the gear with fuel oil and dry it with compressed air. Examine the gear teeth for evidence of scoring, pitting or wear. If severely damaged or worn, install a new gear. Also check the other gears in the gear train.

Install Crankshaft Timing Gear

1. Position the gear on the rear end of the crankshaft with the flat finished hub of the gear facing toward the cylinder block and with all six bolt holes in the gear aligned with the tapped holes in the crankshaft. One bolt hole is offset so the gear can be attached in only one position.

2. Align the proper timing mark ("R") on the crankshaft gear tooth with the corresponding mark on the idler gear (refer to Section 1.7.1).

   NOTE: When advanced timing is required, align the timing mark "A" with the timing mark on the idler gear.

3. Start the six 3/8"-24 bolts with lock washers through the gear and into the crankshaft. Then draw the gear tight against the shoulder on the crankshaft. Tighten the bolts to 35-39 lb-ft (47-53 Nm) torque.

4. Check the backlash with the mating gear. The backlash should be .003 " to .008" with new gears or .010" maximum with used gears.

5. Install a new crankshaft rear oil seal sleeve, if required, as outlined in Section 1.3.2.

BLOWER DRIVE GEAR AND SUPPORT ASSEMBLY

The blower drive gear is mounted on the blower drive gear support and in addition to driving the blower, drives the governor, water pump and fuel pump. The drive is cushioned by a spring-loaded flexible coupling which insures a uniform rotation of the blower rotors (Figs. 1 and 5).

The left-hand helix blower drive gear is driven by the camshaft gear on RA engines and the balance shaft gear on RB engines. The right-hand helix blower drive gear is driven by the camshaft gear on RC engines, and the balance shaft gear on RD engines see Fig. 1 in Section 1.7.2.

> **NOTE:** The 39 tooth and the 40 tooth blower drive gears are interchange-able, however, the governor will have to be adjusted to compensate for the approximately 2.5 per cent change in the governor drive speed.

A new blower drive support assembly has replaced the former assembly (Fig. 2). The new and former blower drive assemblies are different in that the flanged bearing, which also served as a thrust surface, has been replaced by a new bearing. The inner bearing of the new assembly protrudes slightly from the inner face of the support to facilitate installation of and to serve as a pilot for the thrust washer.

Remove and Install Blower Drive Shaft

If the blower drive shaft is not broken, it may be removed as follows:

1. Remove the six bolts (94 and 95) that secure the flywheel housing small hole cover (92), Fig. 1.

2. Refer to Fig. 4 and remove the snap ring and pull the blower drive shaft out of the drive assembly.

> **NOTE:** Some shafts have a tapped hole in the end which can be used as an aid in removing the shaft.

If the blower drive shaft is broken and it is not possible to remove all of the pieces, it will be necessary to remove the blower, see Section 3.4.

A broken drive shaft indicates an unusual loading which may have been caused by a bearing failure

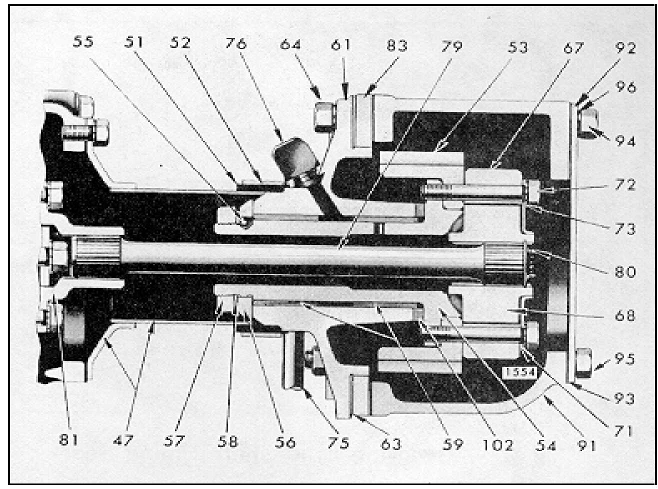


Fig. 1 - Typical Blower Drive Gear and Support Assembly

47	Cover--Blower Drive	73	Lock Washer
51	Seal--Drive Cover	75	Pipe--Drive Bearing Oil
52	Clamp--Cover Seal	76	Elbow--Oil Pipe
53	Gear--Blower Drive	79	Shaft--Blower Drive
54	Hub--Drive Gear	80	Ring--Blower Drive Shaft
55	Lock Ball		
56	Washer--Drive Gear Hub Thrust	81	Hub--Blower Rotor Gear
		83	End Plate--Cylinder Block-Rear
57	Nut--Drive Gear Hub		
58	Lock Washer	91	Housing--Flywheel
59	Bearing--Drive Gear Hub	92	Cover--Flywheel Housing (Small Hole)
61	Support--Drive Gear Hub		
63	Gasket	93	Gasket--Cover
64	Bolt--Drive Gear Hub Support	94	Bolt--3/8"-16 x 7/8"-Cover
67	Support--Drive Coupling	95	Bolt--3/8"-24 x 5"-Cover
68	Cam--Drive Coupling		
71	Retainer--Drive Coupling	96	Lock Washer
72	Bolt--Drive Coupling	102	Thrust Washer

or other malfunction. Inspect the blower drive, blower rotors and the housing before replacing the drive shaft. Refer to the blower inspection procedure in Section 3.4.

Reverse Steps 1 and 2 for the installation of the blower drive shaft.

Remove Blower Drive Gear and Support Assembly (Flywheel Housing Removed)

Removal of the flywheel housing is not necessary when removing the blower drive gear, however, an inspection of the gear train is advisable when any one of the gears requires service. The procedures for the removal of the flywheel and flywheel housing are found in Sections 1.4 and 1.5.

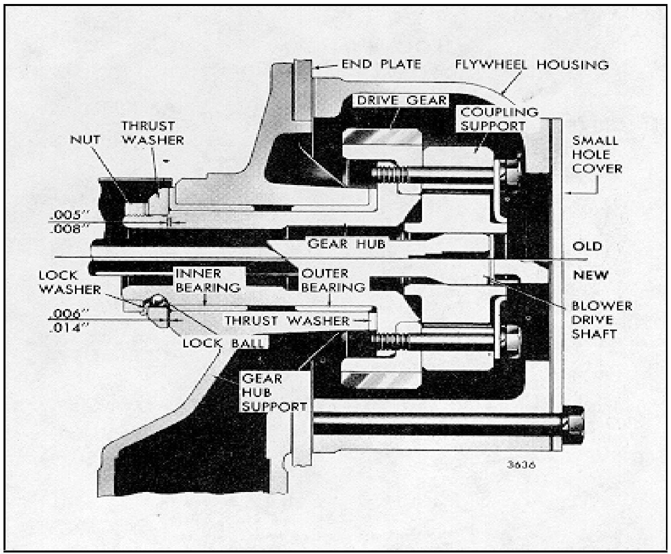


Fig. 2 - Blower Drive Support Assembly

Before removing the blower drive gear, the blower drive shaft must be removed as previously outlined.

1. Remove the blower as outlined in Section 3.4.
2. Remove the blower drive oil line (Fig. 3).
3. Straighten the ears on the lock washer (58) and loosen the drive gear hub nut (57), Fig. 5.
4. Remove the blower drive support attaching bolts.
5. Loosen the blower drive support by tapping it lightly and withdraw the support from the cylinder block rear end plate. Take care to pre-vent damage to the blower drive gear teeth. Discard the gasket.

Disassemble Blower Drive Gear and Support Assembly

1. Secure the blower drive gear and support assembly in a vise with soft jaws.
2. Take out the drive coupling bolts (72) and re-move the retainer (71) and coupling support (67), Fig. 5.
3. Remove the drive gear hub nut (57), lock washer (58), lock ball (55) and thrust washer (56) and withdraw the blower drive gear hub.
4. Remove the thrust washer (Fig. 2) from the blower drive gear hub.
5. Press the gear hub out of the blower drive gear.

Inspection

Clean the parts with fuel oil and dry them with compressed air. Ensure that the oil grooves, oil holes, and cavities are free of dirt.

Replace the thrust washers if they are worn or. scored.

If the bearings are worn or scored excessively the drive gear hub support or bearings will have to be replaced. These bushing type bearings are diamond bored to an inside diameter of 1.6260” to 1.6265”, after installation in the hub.

The clearance between the bearings and the hub is .0010” to .0025” with new parts and a maximum of .0050” with used parts.

The current bearing on the gear end protrudes .045” to .055” above the surface of the face to facilitate the installation of the blower drive thrust

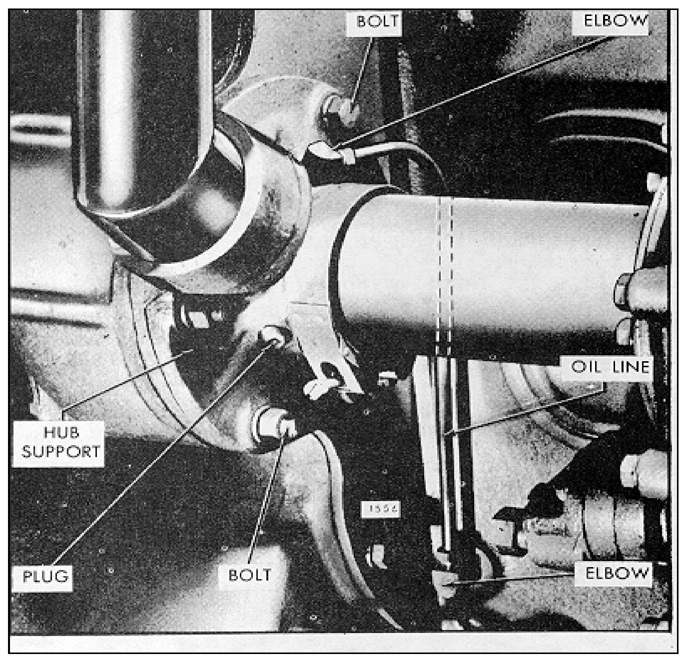


Fig. 3 - Blower Drive Gear and Support Assembly Mounting

washer (Fig. 2). The other bearing is installed with the end flush to .030" below the surface of the face of the support. Each of the former bearings were flanged. Replacement bearings must withstand a 2000 lb. end load without moving, also the bearing bores must be square with the inner and outer faces of the support within .001" total indicator reading.

Replace the blower drive shaft if the serrations are worn or damaged.

Inspect the blower drive coupling support, cam, spring seats and spring packs. Replace worn or damaged parts.

The current blower drive couplings effective with Engine Serial Numbers 3A-38417, 4A-77750 and 6A-84358, incorporate spring seats which prevent pressure and wear from the spring packs on the coupling, thereby prolonging the life of the coupling. Shorter springs are required for use with the spring seats. When a spring replacement is necessary, the new springs and spring seats, available in a kit, must be installed.

Examine the blower drive gear. If the teeth are excessively worn, scored or pitted, the gear must be replaced.

Assemble Blower Drive Gear and Support Assembly

The relative location of the parts is shown in Fig. 5.

1. Secure the blower drive gear support (61) in a vise with soft jaws.
2. Press the drive gear hub (54) into the drive gear (53).
3. Lubricate the drive gear hub, bearings in the support, thrust surfaces and blower drive thrust washer with engine oil.
4. Place the thrust washer (102) on the protruding bearing in the flywheel housing side of the sup-port and insert the blower drive gear hub and gear assembly.
5. Locate the lock ball (55) in its place on the drive gear hub and slide the hub thrust washer (56) into position over the lock ball. The thrust washer must be installed with the tapered face toward the threads on the hub.

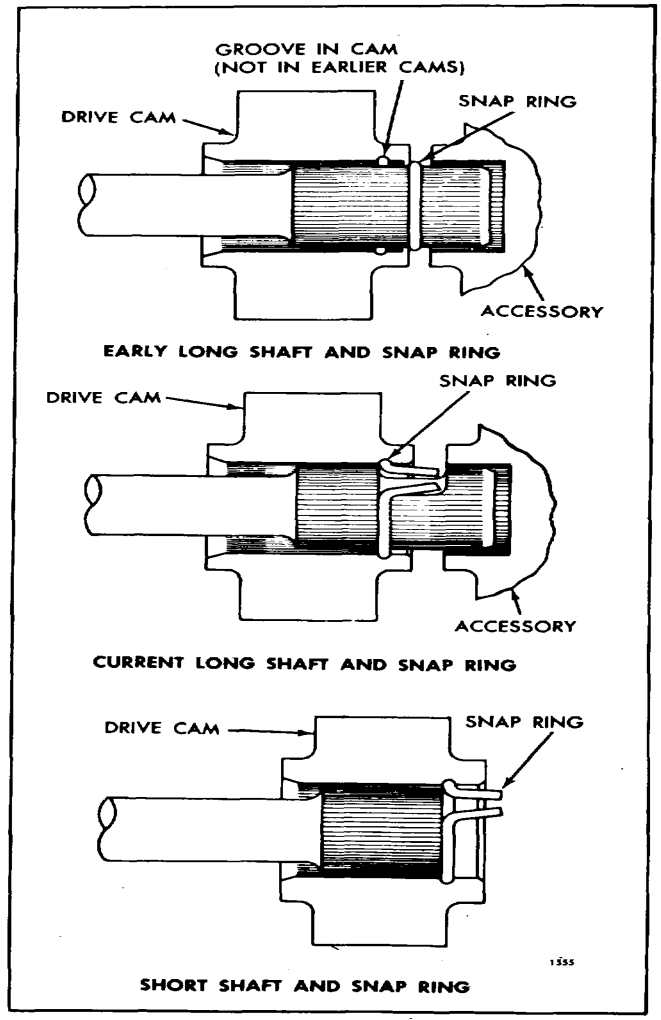


Fig. 4 - Blower Drive Shaft Mounting

6. Install a new lock washer (58) and finger tighten the nut (57) on the hub. Install two bolts into the threaded holes in the drive gear hub. Place a suitable holding bar across the bolts to keep the hub from rotating and tighten the hub nut to 50-60 lb-ft torque. Bend the ears of the lock washer against the nut to lock the nut in place. Remove the two bolts.
7. Assemble the blower drive coupling.
   a. Place the drive coupling support (67) on wood blocks as shown in Fig. 6.
   b. Install the spring end seats (101) and place the spring seats (70) in each corner of the drive coupling support.

1.7.6 BLOWER DRIVER GEAR

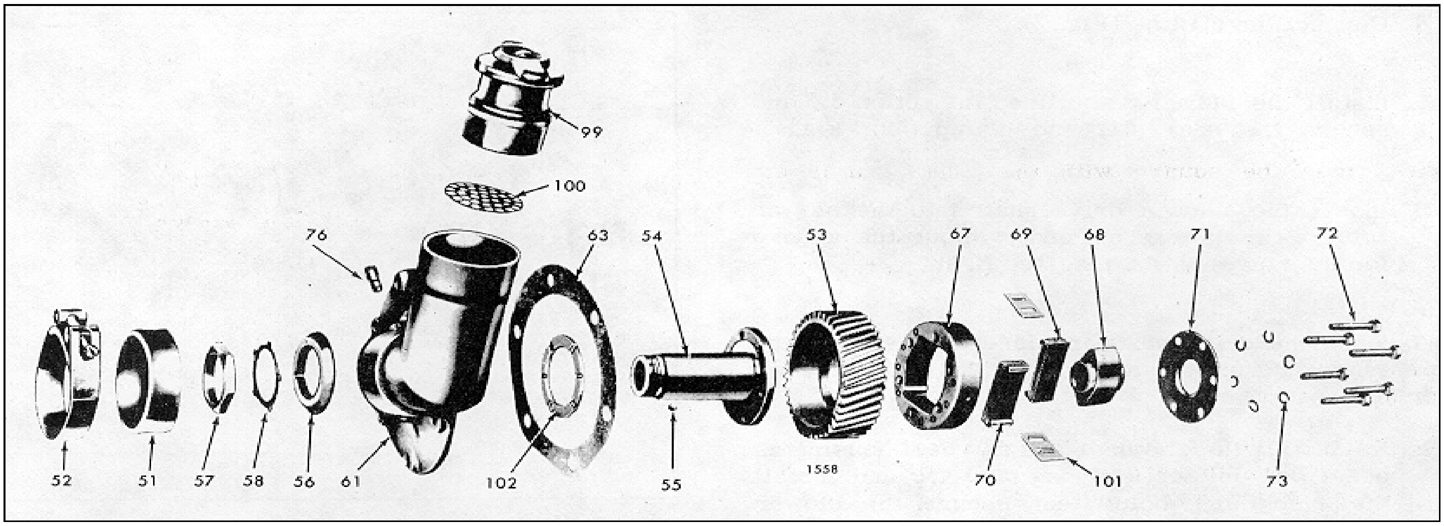


Fig. 5 - Typical Blower Drive Gear Details and Relative Location of Parts

51.	Seal--Drive Cover	57.	Nut--Drive Gear Hub	69.	Spring (Pack)--Drive Coupling	76.	Elbow--Oil Pipe
52.	Clamp--Cover Seal	58.	Lock Washer	70.	Seat--Coupling Spring	99.	Cap--Oil Filler
53.	Gear--Blower Drive	61.	Support--Drive Gear Hub	71.	Retainer--Drive Coupling	100.	Strainer--Oil Filler
54.	Hub--Drive Gear	63.	Gasket	72.	Bolt--Drive Coupling	101.	Seat--Coupling Spring End
55.	Lock Ball	67.	Support--Drive Coupling	73.	Lock Washer	102.	Washer--Thrust
56.	Washer--Drive Gear Hub Thrust	68.	Cam--Drive Coupling				

c. Apply engine oil to the drive coupling springs (there are 21 leaves in each spring pack) and insert them in the coupling support.

d. Place the blower drive cam (68) on the in-staller J 1471, insert the round end of the tool between the spring packs (69) and press the cam into position (Fig. 6).

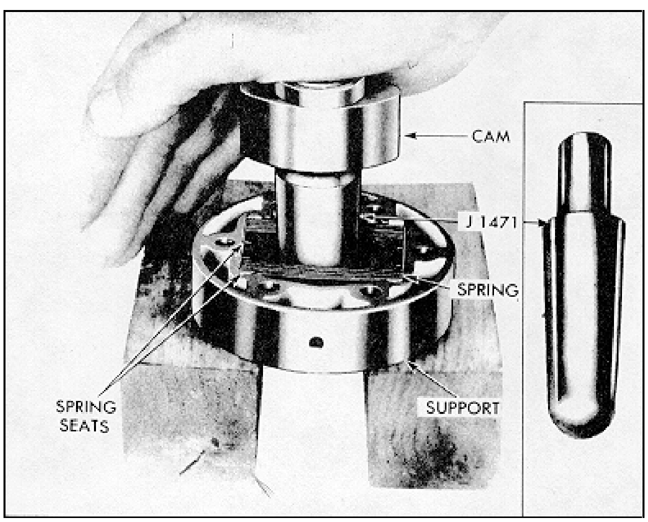


Fig. 6 - Inserting Blower Drive Cam

7. Place the coupling support against the drive gear with the blower drive shaft ring groove in the cam facing away from the drive gear. Then, place the drive coupling retainer (71) against the coupling support with the flared edge away from the support. Revolve the coupling assembly on the hub flange until the cam lobes are in line with the oil grooves in the gear hub (Fig. 7) to ensure proper lubrication.

8. Install the drive coupling bolts.

Install Blower Drive Gear and Support Assembly

1. Check the clearance (Fig. 2) between the drive support and gear hub thrust washer on current engines or between the drive support bearing flange and the gear hub thrust washer on former engines, before installing the blower drive gear support assembly. The clearance on the current engines must be .006” to .014” and on the former engines with the flanged bearing .005” to .008”.

2. Place a new gasket (63) on the mounting face of the hub support (Fig. 5).

3. Attach the blower drive gear and support assembly to the cylinder block rear end plate with the two 3/8”-24 x 7/8 bolts.

4. Connect the oil line (Fig. 3).

5. Install the blower as outlined in Section 3.4 and secure the seal (61) and clamp (52), Fig. 5.

6. Insert the blower drive shaft into the blower rotor gear hub. The end without the groove for the ring must be inserted first.

7. Lock the drive shaft in place by installing the ring in the groove provided in the coupling cam.

8. Re-install the flywheel and flywheel housing as described in Sections 1.4 and 1.5 and install the remaining bolts that secure the blower drive gear and support assembly.

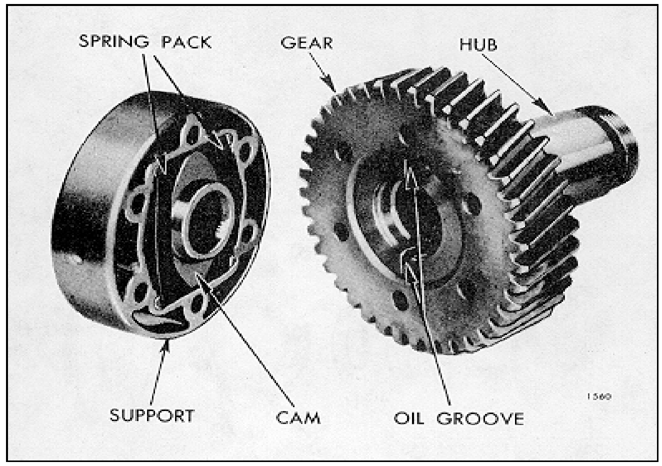


Fig. 7 - Relation of Blower Drive Cam to Oil Grooves in Gear Hub

ACCESSORY DRIVE

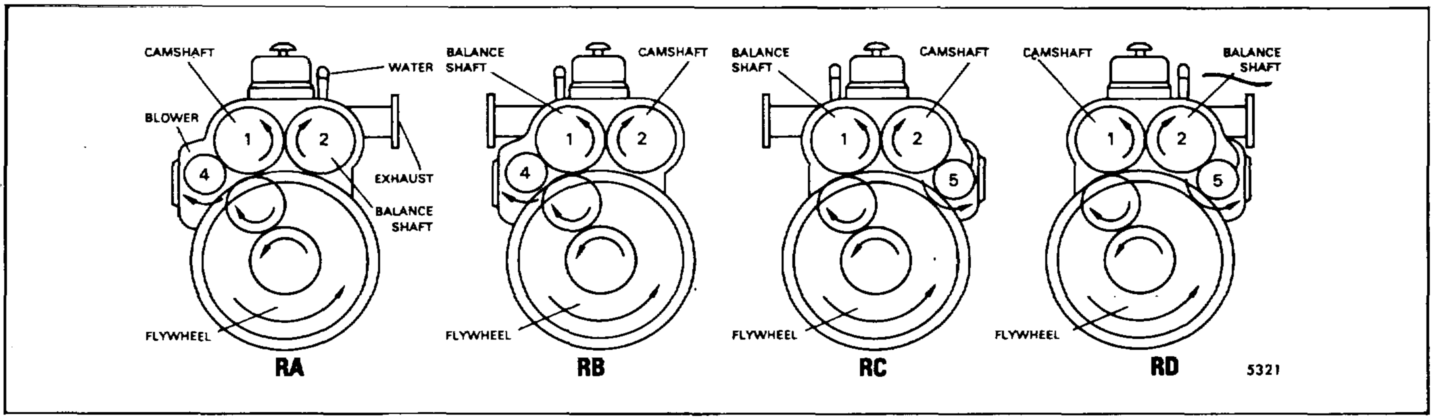


Fig. 1 - Accessory Drive Locations

Accessory drives have been provided on the rear of engines to accommodate both gear driven and belt driven accessories.

For possible accessory drive locations and rotation of the drive at a particular position, refer to Fig. 1.

The drive for direct gear driven accessories, such as air compressors or hydraulic pumps consist of a drive hub, coupling and drive plate (Fig. 2) or a spacer, drive plate and drive coupling (Fig. 3).

The drive plate, and spacer when used, are bolted to the camshaft or the balance shaft gear. The accessory is bolted to the flywheel housing and driven by a drive hub (Fig. 2) or a drive coupling (Fig. 3).

The current drive coupling and plate has 21 external teeth, the former coupling and plate (Fig. 3) had 23 external teeth.

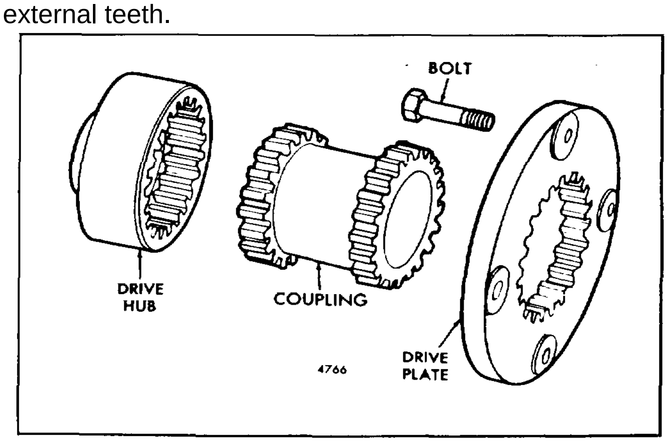


Fig. 2 - Air Compressor Drive

Belt driven accessories, such as battery charging generators or air compressors, are driven off the camshaft or balance shaft gears by a drive hub, and pulley (Fig. 4), or a drive plate, drive shaft, and pulley (Fig. 5).

In the first arrangement, illustrated in Fig. 4, the drive pulley hub is bolted to the camshaft or balance shaft gear. The oil seal retainer is bolted to the flywheel housing, and the pulley is keyed to the drive hub shaft which extends through the oil seal retainer.

In the second arrangement, shown in Fig. 5, the spacer and accessory drive plate are bolted to the balance shaft gear. The accessory drive shaft is splined to the drive plate at one end and supported by a bearing in the accessory drive retainer at the other end. The accessory drive retainer, which

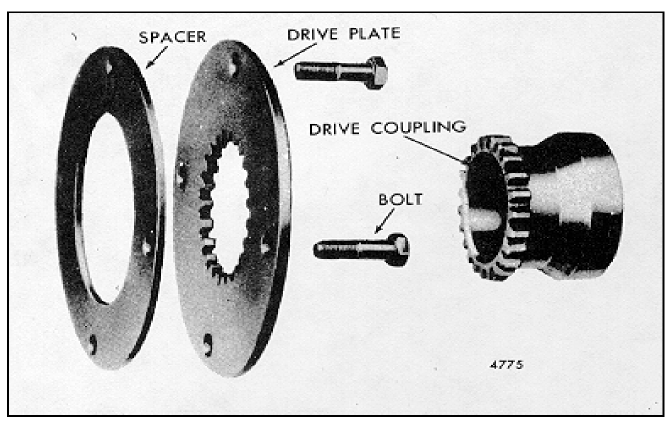


Fig. 3 - Hydraulic Pump Drive

1.7.7 ACCESSORY DRIVE

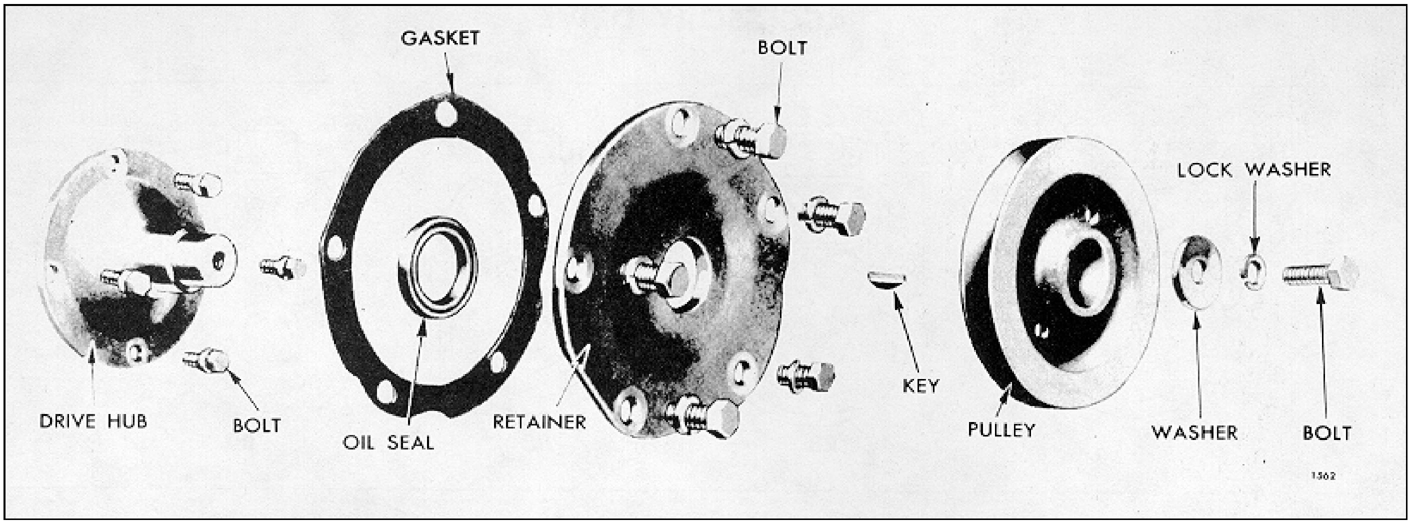


Fig. 4 - Components of Accessory Drive for Belt Driven Accessory (Drive Hub Type)

also incorporates an oil seal, is bolted to the flywheel housing. The pulley is keyed to the drive shaft which extends through the drive retainer assembly.

Remove Accessory Drive

The gear driven type accessory drive may be removed as follows:

1. Remove any external piping or connections to the accessory.
2. Remove five bolts and lock washers attaching the accessory to the flywheel housing. Pull the accessory straight out from the flywheel housing.
3. Remove the drive hub or the drive coupling from the accessory shaft.
4. Place a clean, lintless cloth in the flywheel housing opening, underneath the accessory drive plate, to prevent bolts from accidentally falling into the gear train. Remove the lock wires, if used. Then, remove four bolts (and

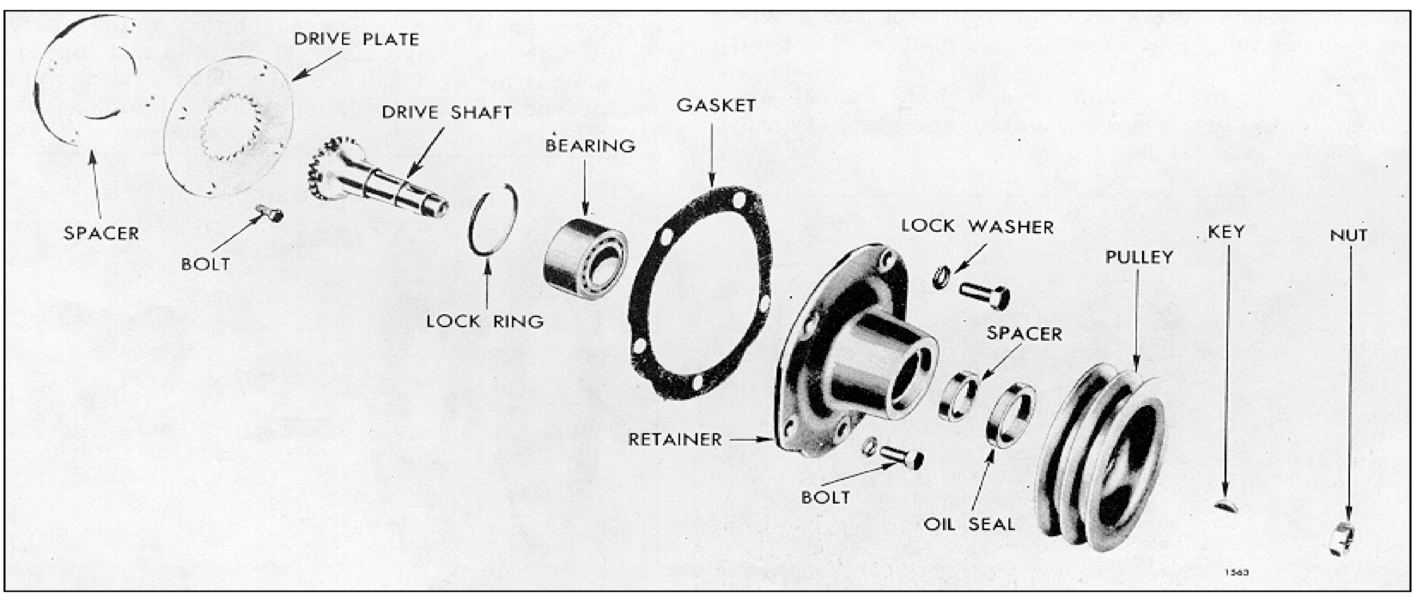


Fig. 5 - Components of Accessory Drive for Belt Driven Accessory (Drive Plate Type)

lock washers if used) and remove the accessory drive plate, and spacer if used.

To remove the drive assembly for a belt driven type accessory, the following procedure may be used:

1. Remove any external piping or connections to the accessory.
2. Loosen the accessory and slide it toward the drive pulley. Then, remove the drive belt and accessory.
3. Remove bolt and washer (Fig. 4), or nut (Fig. 5), retaining the pulley on the drive shaft.
4. Use a suitable gear puller, to remove the pulley from the drive shaft. Remove the Woodruff key.
5. Remove five bolts and lock washers which attach the drive retainer assembly to the flywheel housing. Remove the retainer assembly.
6. Remove the accessory drive shaft, drive plate and spacer (Fig. 5), or drive hub (Fig. 4) in manner similar to that outlined in Steps 3 and 4 under removal of the direct gear driven type accessory drive.
7. Remove the snap ring and ball bearing from the accessory drive shaft retainer assembly shown in Fig. 5.

Inspection

Clean accessory drive parts with clean fuel oil and dry them with compressed air. Examine the gear teeth of the drive shaft, drive coupling, drive hub or drive plate for wear. If worn excessively, re-place with new parts.

Inspect the ball bearing used to support the accessory drive shaft shown in Fig. 5. Shielded bearings must not be washed; dirt may be washed in and the cleaning fluid could not-be entirely removed from the bearing. Wipe the outside of the bearing clean; then hold the inner race and revolve the outer race slowly by hand. If bearing is worn or does not roll freely, replace the bearing.

Check oil seals for wear or damage. Replace if necessary.

Inspect accessory drive hub, shown in Fig. 4, for grooving at area of contact with lip of oil seal. If hub is grooved to a point where the effectiveness of oil seal is lost, a ring type oil seal spacer is available which serves

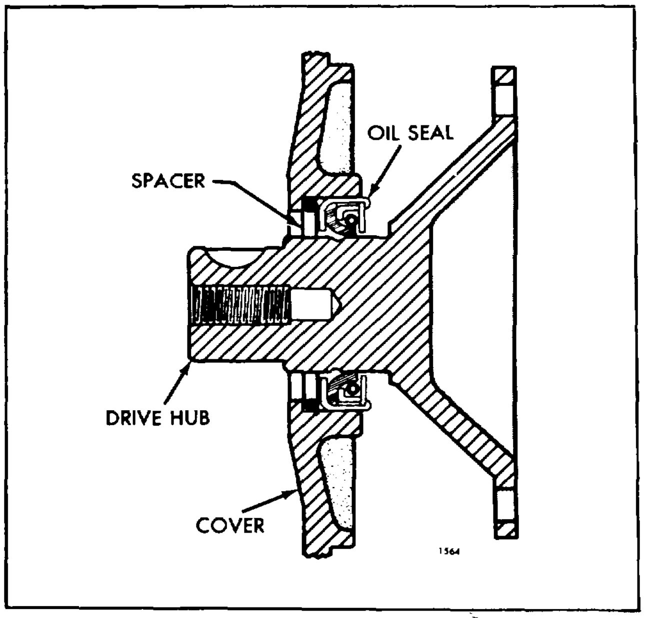


Fig. 6 - Location of Oil Seal Spacer

to reposition the seal, thus providing a new sealing surface for the lip of the seal (Fig. 6).

Install Accessory Drive

1. Remove old gasket material from flywheel housing. Use care so that no gasket material falls into gear train compartment.
2. Insert clean, lintless cloth in flywheel housing opening to prevent bolts from accidentally falling in the gear train. Align bolt holes in accessory drive plate, and spacer if used or accessory drive hub, with tapped holes in cam-shaft or balance shaft gear. Then, secure the plate and spacer, or drive hub, with four bolts (and lock washers or lock wire if used).
3. If a gear driven accessory is used as shown in Figs. 2 and 3, install the accessory drive hub or drive coupling squarely on the accessory shaft, then:
   a. Place a new gasket on the flange and align the holes in the gasket with the bolt holes in the flange. Apply a light coat of grease to retain the gasket in position.
   b. Place the accessory in position against the flywheel housing, rotating it, if necessary, to align the teeth of the drive plate with.

1.7.7 ACCESSORY DRIVE

those in the drive coupling. Secure the accessory to the flywheel housing with five bolts and lock washers.

4. If accessory drive shown in Fig. 5 is used, assemble as follows:

a. Install accessory drive plate and spacer as outlined in Steps 1 and 2 above.

b. Place the drive shaft retainer on bed of arbor press, mounting flange side up. Press ball bearing, with protruding face of inner race towards retainer, straight in until the bearing contacts the shoulder in the bore of the retainer. Install the snap ring.

c. Turn the retainer over and press the oil seal into the bore of the retainer with the lip of the seal towards the bearing.

d. Turn the retainer over again, bearing side up, and press the accessory drive shaft in the bearing until the shoulder on the shaft contacts the bearing.

e. Apply a light coat of grease to the mounting flange of the retainer and place a new gasket in position against the flange. Align the holes in the gasket with the bolt holes in the flange.

f. Place the retainer and drive shaft assembly against the flywheel housing, rotating slightly, if necessary, to permit teeth of the drive shaft to mesh with the teeth in the drive plate. Secure the retainer assembly to the flywheel housing with five bolts and lock washers.

g. Install the Woodruff key in the drive shaft. Start the pulley straight on the shaft, aligning the keyway in the pulley with the key on the shaft. Use a soft hammer to tap the pulley on the shaft.

h. Thread the pulley retaining nut on the end of the drive shaft and draw it up tight.

i. Install the accessory drive on the engine and slip the drive belt over the pulleys. Position the accessory to provide proper tension on the belt and secure it in place.

NOTE: When installing or adjusting an accessory drive belt(s), be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot. Tighten the 7/16"-14 (300M) pivot bolt to 72-77 lb-ft torque. Tighten the 7/16"-14 (280M) pivot bolt to 46-50 lb-ft torque.

5. Assemble the accessory drive shown in Fig. 4 as follows:

a. Press a new oil seal in the retainer, if the seal was removed.

b. Coat the mounting flange of the retainer lightly with grease and place a new gasket against the flange. Align the holes in the gasket with the bolt holes in the flange.

c. With the accessory drive hub in place (see item 2 above), slip the retainer and oil seal assembly over the end of the shaft. Use care not to damage the oil seal. Secure the retainer to the flywheel housing with five bolts and lock washers.

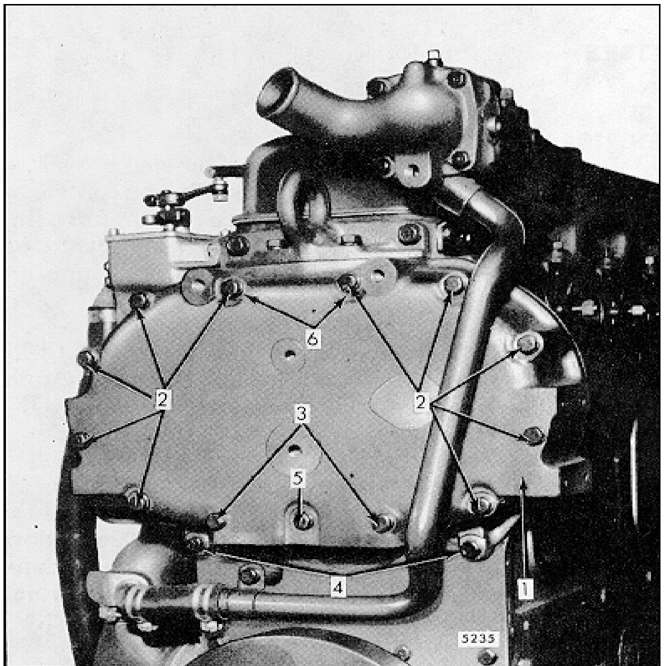
d. Install the Woodruff key. Start the pulley straight on the shaft, aligning keyway in pulley with key on shaft. Use a soft hammer to tap pulley on the shaft.

e. Install washers and pulley retaining bolt and draw the bolt up tight.

f. Install the accessory drive on the engine and slip the drive belt over the pulleys. Position the accessory to provide proper tension on the belt and secure it in place.

NOTE: When installing or adjusting an accessory drive belt(s), be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot. Tighten the 7/16”-14 (300M) pivot bolt to 72-77 lb-ft torque. Tighten the 7/16”-14 (280M) pivot bolt to 46-50 lb-ft torque.

BALANCE WEIGHT COVER



1.	Cover—Balance Weight	4.	Bolt—3/8 16 x 1-7/8 (to cylinder block)
2.	Bolt—3/8-24 x 3 (to end plate)	5.	Bolt—3/28-24 x 1-1/2 (to end plate)
3.	Bolt—3/8-16 x 3-1/2 (to cylinder block)	6.	Washer--Plain

Fig. 1 - Balance Weight Cover Mounting

The front balance weight cover (Fig. 1) encloses the front engine balance weights and also serves as a support for various equipment such as the cooling fan support bracket.

The balance weight cover requires no servicing. However, when an engine is being completely reconditioned or the camshaft, balance shaft or front balance weights need replacing, the balance weight cover must be removed.

Remove Cover

1. Drain the cooling system.

2. Loosen the hose connections between the radiator and the engine.

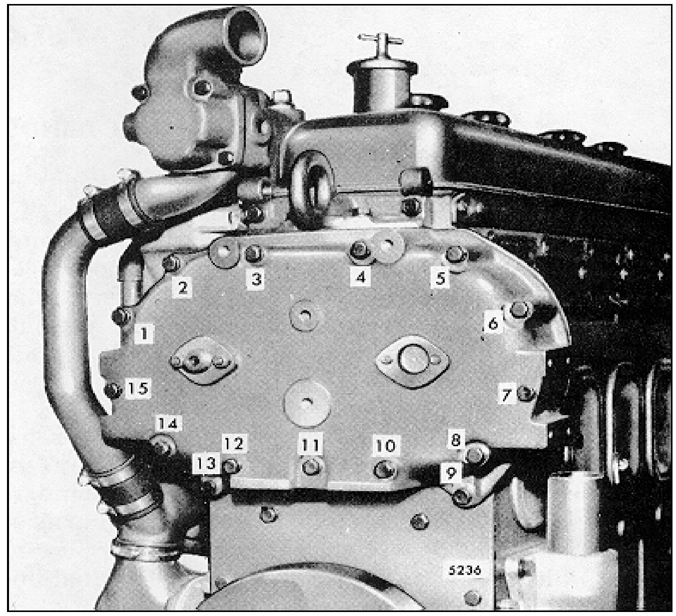


Fig. 2 - Balance Weight Cover Bolt Tightening Sequence

3. Remove the radiator.

4. Remove the fan, fan hub and adjusting bracket.

5. Remove the fifteen bolts, lock washers and plain washers (Fig. I) which secure the balance weight cover to the cylinder block and the front end plate. Remove the cover and gasket.

6. Remove all traces of the old gasket material from the cover and the end plate.

Install Cover

1. Affix a new gasket to the balance weight cover.

2. Install the cover in place and install the fifteen attaching bolts, lock washers and plain washers finger tight.

3. Refer to Fig. 2 and tighten the bolts to 25-30 lb-ft (34-41 Nm) torque.

4. Install the various sub-assemblies that were previously removed.

SHOP NOTES-TROUBLE SHOOTING-SPECIFICATIONS-SERVICE

TOOLS

SHOP NOTES

PISTON AND CYLINDER LINER USAGE

1. "N" pistons are .030" longer than the "E" pistons and approximately .155" longer than the special "E" piston. In addition, the fire ring turbocharged piston is .125" longer than the non-fire ring turbocharged piston. These dimension differences dictate that pistons cannot be mixed in an engine. To do so would result in misfiring and a rough idle condition which could ultimately result in cylinder liner scuffing.

2. The "E" and "turbo" figure 8 cylinder liner has .900 " long ports compared to 1.055 " long ports in the oval port liner and .703" long ports in the standard two valve figure 8 port liner. These port dimension differences prohibit mixing of cylinder liners in an engine which would result in a timing differential and compression ratio changes.

3. Only the oval port cylinder liners can be used with 18.7:1 compression ratio pistons. In addition, only oval port cylinder liners can be used with fire ring turbocharged pistons. The standard figure 8 port cylinder liner should be used only with the non-fire ring two valve piston.

4. Crown valve injectors can be used with the 18.7:1 pistons. Crown valve and needle valve injectors must not be mixed in an engine.

5. When converting to "N" pistons (see Item 1), it is important that the exhaust valve protrusion be measured carefully to assure that when fully closed the exhaust valves do not protrude more than .006 " above the cylinder head fire deck. Only the "thin" exhaust valve inserts (for two valve or four valve heads) which are .247" /.251" thick can be used with the "N" piston.

TEFLON WRAPPED PIPE PLUG

Pipe plugs with a baked teflon coating are available for service. However, pipe plugs can be hand wrapped satisfactorily with teflon tape to provide a better seal and facilitate plug removal. When a teflon wrapped plug is installed, it is extremely important that the specified torque not be exceeded.

Hand wrap a pipe plug with teflon tape as follows:

1. Be sure the pipe plug is thoroughly clean and dry prior to applying the teflon tape. All dirt, grease, oil and scale must be removed.

2. Start the tape one or two threads from the small or leading edge of the plug, joining the tape together with an overlap of approximately 1/8 " .

3. Wrap the tape tightly in the same direction as you would turn a nut. The tape must conform to the configuration of the threads (be pressed into the minor diameter of the threads) without cutting or ripping the tape.

4. Hand tighten and hand torque the pipe plug and *do not exceed the specified torque. Do not use power tools.*

CHECKING BEARING CLEARANCES

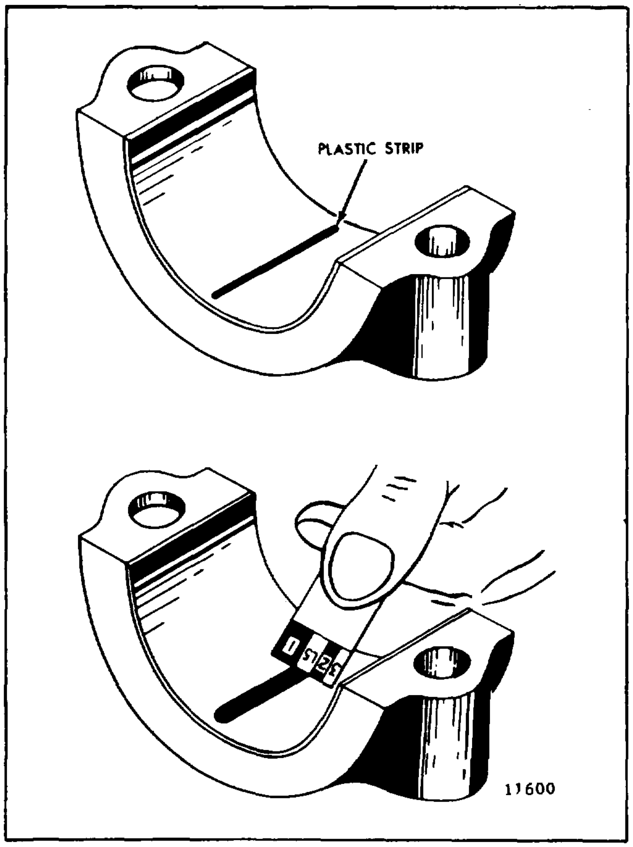


Fig. 2 - Using Plastic Strip to Measure Bearing-to-Crankshaft Clearance

A strip of soft plastic squeezed between the crankshaft journal and the connecting rod bearing or main bearing may be used to measure the bearing clearances.

The strip is a specially molded plastic "wire" manufactured commercially and is available in three sizes and colors. Type PG-I (green) has a clearance range of .001 "to .003", type PR-I (red) has a range of .002 " to .006" and type PB-I (blue) has a range of .004" to .009" .

The plastic strip may be used for checking the bearing clearances as follows:

1. Remove the bearing cap and wipe the oil from the bearing shell and the crankshaft journal.

> **NOTE:** When checking the main bearing clearances with the engine in a position where the main bearing caps are supporting the weight of the crankshaft and the flywheel, an erroneous reading, due to the weight of the crankshaft and flywheel, can be eliminated by supporting the weight of the crankshaft with a jack under the counterweight adjoining the bearing being checked.

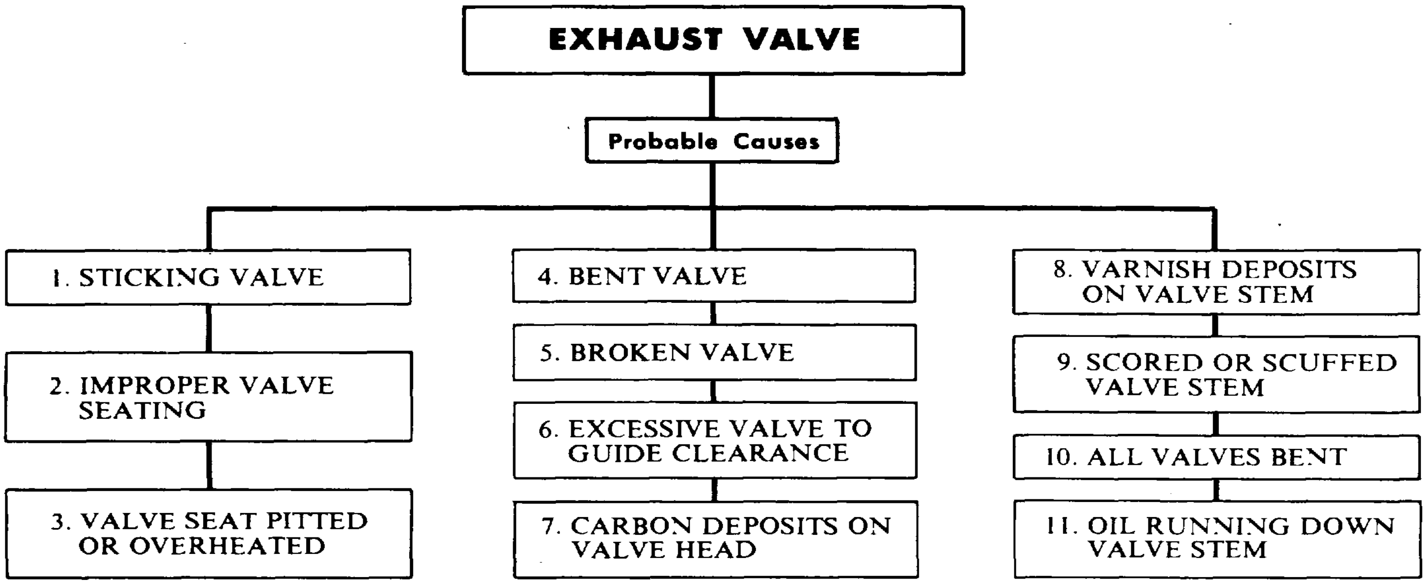
2. Place a piece of the plastic strip the full width of the bearing shell, about ¼ " off center (Fig. 2).

3. Rotate the crankshaft about 30' from bottom dead center and reinstall the bearing cap. Tighten the bolts to the specified torque.

4. Remove the bearing cap. The flattened plastic strip will be found adhering to either the bearing shell or the crankshaft.

5. Compare the width of the flattened plastic strip at its widest point with the graduations on the envelope (Fig. 2). The number within the graduation on the envelope indicates the bearing clearance in thousandths of an inch. Taper may be indicated when one end of the flattened plastic strip is wider than the other. Measure each end of the plastic; the difference between the readings is the approximate amount of taper.

TROUBLE SHOOTING



SUGGESTED REMEDY

1. Check for carbon deposits, a bent valve guide, defective spring or antifreeze (glycol) in the lubricating oil. Replace a bent guide. Clean-up and reface the valve. Replace the valve if necessary.

2. Check for excessive valve-to-guide clearance, bent valve guide or carbon deposits. Replace a bent or worn guide. Clean the carbon from the valve. Reface or replace the valve, if necessary.

3. Check the operating conditions of the engine for overload, inadequate cooling or improper timing. Reface the valve and insert. Replace the valve if it is warped or too badly pitted. Use a harder-face valve if the operating conditions warrant.

4. Check for contact between the valve head and the piston as a result of incorrect valve clearance, an improperly positioned exhaust valve bridge (four valve head) or a defective spring. Check the valve guide, insert, cylinder head and piston for damage. Replace damaged parts.

5. Check for excessive valve-to-guide clearance, a defective valve spring or etching of the valve stem at the weld. Improper valve clearance is also a cause of this type of failure. Check the guide, insert, cylinder head and piston for damage. Replace damaged parts.

6. Replace a worn valve guide. Check and replace the valve, if necessary.

7. Black carbon deposits extending from the valve seats to the guides indicates cold operation due to light loads or to the use of too light a fuel. Rusty brown valve heads with carbon deposits forming narrow collars near the guides indicate hot operation due to overloads, inadequate cooling or improper timing which results in carbonization of the lubricating oil. Clean-up the valves, guides and inserts. Reface the valves and inserts or replace them if they are warped, pitted or scored.

8. Check for a worn valve guide or excessive exhaust back pressure. Replace a worn guide. Check the valve seat for improper seating. Reface the valve and insert or, if necessary, replace.

9. Check for a bent valve stem or guide, metal chips or dirt, or for lack of lubrication. Clean up the valve stem with crocus cloth wet with fuel oil or replace the valve. Replace the guide. When installing a valve, use care in depressing the spring so that the spring cap DOES NOT scrape the valve stem.

10. Check for a gear train failure or for improper gear train timing.

11. Check the operation of the engine for excessive idling and resultant low engine exhaust back pressure. Install valve guide oil seals.

SPECIFICATIONS

Specifications, clearances and wear limits are listed below. It should be specifically noted that the clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" in this chart lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still ensure satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgment of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the text.

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

These limits also apply to oversize and undersize parts

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Cylinder Block			
Block bore:			
Diameter (cast iron block)	4.6260"	4.6270"	
Out-of-round		.0010"	.0020 "
Taper		.0010"	.0020"
Cylinder liner counterbore:			
Diameter	5.0460"	5.0485"	
Depth (cast iron block)	.4770"	.4795"	
Main bearing bore:			
Inside diameter (vertical axis)	3.8120"	3.8130"	
Top surface of block:			
Centerline of main bearing bore to top of block	16.1840"	16.1890"	16.176" min.
Flatness--transverse (3, 4 and 6 cyl.)			.0030"
Flatness--longitudinal (6 cyl.)			.0090"
Depth of counterbores (top surface):			
Cylinder head seal strip groove	.0920"	.1070"	
Large water holes (between cylinders)	.1090"	.1200"	
Small water holes (at ends)	.0870"	.0980"	
Combination water and oil holes	.0870"	.0980"	
Cylinder Liner			
Outside diameter	4.6250"	4.6260"	
Inside diameter	4.2495 "	4.2511 "	
Clearance--liner-to-block:			
Cast iron block	.0000"	.0020"	.0025"
Out-of-round--inside diameter		.0020"	.0025"
Taper--inside diameter		.0010"	.0020"
Depth of flange BELOW block	.0450"	.0500"	.0500"
Variation in depth between adjacent liners		.0020"	.0020"
Insert thickness	.1795"	.1800"	

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
71N Engines			
Piston:			
Height (centerline of bushing to top)	3.5430"	3.5480"	
Diameter (above compression rings)	4.2225"	4.2255"	
Diameter (at skirt)	4.2428"	4.2450".	
Clearance--piston skirt-to-liner	.0045"	.0083"	.0120"
Out-of-round		.0005"	
Taper		.0005"	
Compression rings:			
Gap (top-fire ring) --	.0230"	.0380"	.0600"
Gap (No. 2, 3 and 4)	.0180"	.0430"	.0600"
Clearance--ring-to-groove:			
No 1 (top-fire ring)	.0040"	.0060"	.0100"
No 2	.0100"	.0130"	.6220"
No 3 and 4	.0040"	.0070"	.0130"
Oil control rings:			
Gap	.0080"	.0230"	.0430"
Clearance	.0015"	.0055 "	.0080."

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Cross-Head Pistons and Rings			
71N and 71T Engines			
Piston crown:			
Saddle-to-crown distance:			
piston (18.7:1 compr. ratio)	2.7030"	2.7100"	
T piston (17:1 compr. ratio)	2.6730"	2.6800"	
Diameter:			
At top	4.2226"	4.2256"	
Below both compression rings	4.2391"	4.2421"	
Above and below seal ring groove	.8850"	3.8950"	
Above and below bearing saddle	3.2360"	3.2370"	
Compression rings:			
Gap (top-fire ring)	.0230"	.0380"	.0600"
Compression rings:			
Clearance-ring-to-groove:			
Gap (No. 2 and 3)	.0180"	.0430"	.0600"
*Top (Keystone fire ring)	.0010	.0050"	.0070"
No. 2 (rectangular section)	.0100"	.0130"	.0220"
No. 3 (rectangular section)	.0040"	.0070"	.0130"
Seal ring:			
Gap (in skirt counterbore)	.0020"	.0210"	.0270"
Clearance	.0005"	.0030	.0040"
Piston skirt:			
Diameter section)	4.2428"	4.2450	
Clearance--skirt-to-liner,,,,	.0045"	.0083"	.0120"
Seal ring bore	3.9200	3.9240"	3.9260"
Piston pin bore	.1.5000"	1.5030"	1.5040"
Oil control rings:			
Gap (two rings in lower grooveX71N engine)	.0080"	.0230"	.0430"
Gap (one ring in upper grooveX71N engine)	.0080"	.0230"	.0430"
Clearance (two rings in lower groove)	.0015"	.0055"	.0080"
Clearance (one ring in upper groove)	.0010"	.0035"	.0060"
Connecting Rod (cross-head)			
Length center-to-center of upper and lower bores	10.1230"	10.1260"	
Piston Pins (Cross-Head Piston)			
Length	3.6150"	3.6250."	
Diameter	1.499."	1.5000"	1.4980"
Slipper bearing (bushing):			
Thickness at center	.0870	.0880	.0860"
Clearance (edge of bushing to groove in piston)	.0005"	.0105"	.0120"

*Measured with Keystone fire ring flush with outside diameter of piston crown.
% Diameter above and below the piston pin may be 4.2414"

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Crankshaft			
Journal diameter--main bearing	3.4990"	3.500"	
Journal diameter--conn. rod bearing	2.7490"	2.7500"	
Journal out-of-round		.0.0025"	.0010"
Journal taper		.0005"	.0015
§Runout on journals--total indicator reading:			
6 cylinder (mounted on No. 1 and No. 7 journals):			
At No. 2 and No. 6 journals		.0020"	
At No. 3 and No. 5 journals		.0040"	
At No. 4 journal		.0060"	
Thrust washer thickness	.1190"	.1220"	
End play (end thrust clearance)	.0040"	.0140"	.0180"
Connecting Rod Bearings			
Inside diameter (vertical axis)	2.7514	2.7534"	
Bearing-to-journal clearance	.0014"	.0044"	.0060"
Bearing thickness 90'from parting line	.1548"	.1553"	.153" min.
Main Bearings			
Inside diameter (vertical axis)	3.5014	3.5034"	
Bearing-to-journal clearance	.0014."	.0044"	.0060 "
Bearing thickness 90°from parting line	.1548"	.1553"	.153" min.
Camshaft			
Diameter (at bearing journals):			
Front and rear	1.4970"	1.4975"	
Center and intermediate	1.4980"	1.4985"	
Runout at center bearing (when mounted on end bearings)		.0020"	
Shaft diameter at gear	1.1875"	1.1880"	
Length--thrust bearing end journal	2.8740"	2.8760"	
End thrust	.0040"	.0120"	.0180"
Thrust washer thickness	.1190"	.1220"	
Balance Shaft			
Shaft diameter at bearings	1.4970"	1.4975"	
Shaft diameter at gear	1.1875"	1.1880"	
Length--thrust bearing end journal	2.8740"	2.8760"	
End thrust	.0040."	.0120"	.0180"
Thrust washer thickness	.1190"	.1220"	

§ Runout tolerance given for guidance when regrinding crankshaft. When the runout on adjacent journals is in the opposite direction, the sum must not exceed .003" total indicator reading. When the runout on adjacent journals is in the same direction, the difference must not exceed .003" total indicator reading. When high spots of the runout on adjacent journals are at right angles to each other, the sum must not exceed .004" total indicator reading or .002" on each journal.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Camshaft and Balance Shaft Bearings			
Inside diameter:			
Front and rear	1.5000"	1.5010"	
Center and intermediate	1.5010"	1.5030"	
Clearance--bearing-to-shaft:			
Front and rear	.0025"	.0040"	.0060
Center and intermediate	.0025"	.0050 "	0090."
Outside diameter:			
Front and rear	2.1880"	2.1885"	
Center and intermediate	2.1840"	2.1860"	
Diameter of cylinder block bore	2.1875"	2.1885 "	
Clearance--bearings-to-block:			
Front and rear	.001 press	.0005 loose	
Intermediate (extruded)	.0015"	.0065 "	
Intermediate (die cast)	.0015"	.0105"	
Camshaft and Balance Shaft Gears			
Inside diameter	1.1865	1.1875"	
Clearance--gear-to-shaft	.0015"press	.0.0001"	
Backlash	.0030"	.0080"	.0100"
Idler Gear			
Backlash	.0030"	.0080"	.0100"
Pre-load--Variation on pull 2 lbs. 11 oz	1/2 lb	6 3/4 lb	1/2.6 3/4 lb.
Crankshaft Timing Gear			
Inside diameter	4.7490"	4.7500"	
Clearance--gear-to-shaft	.001 ".press	.001 " loose	
Backlash	.0030"	.0080"	.0100"
Blower Drive Gear			
Backlash	.0030"	.0080"	.0100"
Gear-to-hub fit	.0005" press	.001 " loose	
Support-to-end plate	.0005" press	.0025" loose	
Inside diameter (support bushing)	1.6260"	1.6265"	
Hub diameter (at bearing)	1.6240"	1.6250"	
Hub-to-support bushing clearance	.0010"	.0025"	.0050"
Hub-to-cam clearance	.0020"	.0070"	
End thrust (current bearing)	.0060"	.0140"	
End thrust (former flanged bearing)	.0050"	.0080"	.0100"
Cylinder Head			
Flatness--transverse (6 cyl.)			.0040"
Flatness--longitudinal (6 cyl.)			.0100
Distance between top deck and fire deck	3.5560"	3.5680"	3.5360"
Water nozzles	.0312" recess	Flush	
Cam follower bores	1.0620"	1.0630"	1.0650"
Exhaust Valve Seat Inserts			
Seat width--30 (4-valve)	.0468"	.0937"	.0937"
Valve seat runout		.0020 "	.0020 "

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Exhaust Valves			
Stem diameter (4-valve)	.3100"	.3105"	.3090"
Valve head-to-cylinder head:			
30° (former 2-valve and 4-valve)	002" recess	.028" protr.	
30° (current 2-valve and 4-valve)	023" recess	.006" protr.	
Valve Guides			
Height above cylinder head:			
4-Valve (chamfered guide)	.8800."	.8800"	
4-valve (machined guide)	.6900"	.6900"	
Diameter--inside (4-valve)	.3125."	.3135."	.3.1400"
Clearance--valve-to-guide (4 valve)	.0020"	.0035"	.0050"
Valve Bridge Guides			
Height above cylinder head (4-valve)	2.0400"	2.0400"	
Rocker Arms and Shafts			
Diameter--rocker shaft	.8735"	.8740"	
Diameter--inside (rocker arm bushing)	.8750"	.8760"	
Clearance--shaft-to-bushing	.0010"	.0025"	.0040"
Cam Followers			
Diameter	1.0600"	1.0610"	
Clearance--follower-to-head	.0010"	.0030"	.0060"
Rollers and Pins:			
Clearance--pin-to-bushing	.0013"	.0021"	.010" Horiz.
Side clearance--roller to follower	.0150"	.0230"	.0230"

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	TORQUE (lb-ft)	TORQUE Nm	THREAD SIZE	TORQUE (lb-ft)	TORQUE Nm
1/4 -20	7-9	10-12	9/16-12	90-100	122-136
1/4 -28	8-10	11-14	9/16-18	107-117	146-159
5/16-18	13-17	18-23	5/8 -11	137-147	186-200
5/16-24	15-19	20-26	5/8-18	168-178	228-242
3/8 -16	30-35	41-47	3/4-10	240-250	325-339
3/8 -24	35-39	47-53	3/4 -16	290-300	393-407
7/16-14	46-50	62-68	7/8 -9	410-420	556-569
7/16-20	57-61	77-83	7/8 -14	475-485	644-657
1/2 -13	71-75	96-102	1 - 8	580-590	786-800
1/2 -20	83-93	113-126	1 -14	685-695	928-942

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	C.I. ENG. (lb-ft)
Cam follower guide bolt	1/4 -20	12-15
Injector control shaft bracket bolt	1/4 -20	10-12
Oil pan bolts	5/16-18	10-12
Exhaust valve bridge adjusting screw lock nut	5/16-24	20-25
Blower drive coupling-to-gear hub bolt	5/16-24	20-25
Idler gear bearing retainer bolts	5/16-24	24-29
Injector clamp bolts	3/8 -16	20-25
End plate bolts	3/8 -16	
Air Box cover bolt	3/8 -16	10-15
Crankshaft front cover bolts	3/8 -16	
Flywheel housing bolts	3/8 -16	
* Idler gear hub and spacer bolts	3/8 -16	40-45
§ Idler gear hub and spacer bolts	3/8 -16	25-40
Cam and balance shaft end bearing bolts	3/8 -16	35-40
Balance weight cover bolts	3/8 -16	25-30
Balance weight cover bolts	3/8 -24	25-30
Flywheel housing bolts	3/8. -24	25-30
Crankshaft front cover bolts	3/8 -24	25-30
Camshaft intermediate bearing lock screw	3/8 -24	15-20
Balance weight-to-hub bolt	3/8 -24	25-30
Blower drive gear hub bearing support bolts and nuts	3/8 -24	25-30
Balance weight-to-timing gear bolt	3/8 -24	25-30
Accessory drive-to-gear bolt (steel disc)	3/8 -24	45-50
Accessory drive-to-gear bolt (fiber disc)	3/8 -24	35-39
Injector clamp nut	3/8 -24	20-25
Exhaust manifold outlet flange nuts (brass)	3/8 -24	20-25
Water manifold nuts	3/8 -24	25-30
Fuel pipe nuts	3/8 -24	12-15
Lifter bracket bolt	7/16-14	55-60
#Threaded exhaust valve bridge guide (Nylon insert)	7/16-14	46-50
Air compressor adjusting support pivot bolt (300M)	7/16-14	72-77
Air compressor adjusting support pivot bolt (280M)	7/16-14	46-50
Generator drive bearing retaining bolt	7/16-14	30-35
Generator drive oil seal retaining bolt	7/16-14	30-35
Tachometer drive cover bolt	7/16-14	30-35
Connecting rod nut (Lubrite)	7/16-20	60-70
Connecting rod nut (castellated)	7/16-20	65-75
**Cross-head piston pin to conn. rod bolt	7/16-20	55-60
Exhaust manifold nuts	7/16-20	30-35
Fuel manifold connectors (steel washer)	7/16-20	40-45
#Fuel manifold connectors (Nylon insert)	7/16-20	30-35
Fuel manifold connector nuts	7/16-20	30-35
Crankshaft front cover bolts	1/2 -13	80-90
Flywheel housing bolts	1/2 -13	90-100
@Rocker shaft bolts	1/2 -13	90-100
Generator drive bearing retaining bolt	1/2 -13	30-35
Generator drive oil seal retaining bolt	1/2 -13	30-35
Tachometer drive cover bolt	1/2 -13	30-35
Idler gear and dummy hub bolt	1/2 -13	8b-90
Blower rotor gear retaining nut	1/2 -20	55-65
**Main bearing bolts (assembly)	5/8 -11	18Q-190
**Main bearing bolts (boring)	5/8 -11	165-175

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	C.I. ENG. (lb-ft)
**Cylinder head bolts	5/8 -11	175-185
**Main bearing nuts (assembly)	5/8 -18	155-185
**Main bearing nuts (boring)	5/8 -18	140-155
**Cylinder head nuts	5/8 -18	175-185
**Flywheel bolts	9/16-18	180-190
Accessory drive pulley nut	3/4 -16	80-100
Crankshaft end bolt	1 -14	290-310
Camshaft and balance shaft nut	1 1/8 -18	300-325
Blower drive gear hub nut	1 1/2 -16	50-60

* Self-locking only.
§ Wired head only.
# Lubricate before assembling to cylinder head.
@75-85 lb-ft torque on the two bolts attaching load limit or power control screw bracket (if used) to the rocker arm shaft bracket.
**Lubricate at assembly with International Compound No. 2, or equivalent (refer to Parts Catalog or Microfiche, Section 12.8000A).

STANDARD PIPE PLUG TORQUE SPECIFICATIONS

These specifications apply only to plugs accessible on the outside of a finished engine, However, they do not apply to plugs installed below the surface of the part of which they are a component. Headless plugs to be flush or .0625" below the surface. Use sealing compound on plugs without gaskets or Teflon.

THREAD SIZE	TORQUE (lb-ft)	THREAD SIZE	TORQUE (lb-ft)
1/8	10-12	3/4	33-37
1/4	1416	1	75-85
3/8	18-22	1-1/4	95-105
1/2	23-27	1-12	110-130

SPECIAL PIPE PLUG TORQUE SPECIFICATIONS

APPLICATION	*PLUG	ASSEMBLY
Oil gallery plug	.3/8" Dryseal PTF thread	†Assemble with max. 0.0625" protrusion from surface
Cylinder head (side)	3/8-16"	Assemble flush to 0.0625"protrusion from surface
Cylinder head (top)	1/2"PTF-SAE short	Flush to 1.1250"recessed
Cylinder head (end)	3/4" Dryseal PTF-SAE short	Flush to 0.1250" recessed
Water hole plug	1 " NPTF thread	Assemble 2.000"to 2.250" below machined surface
Core hole plug	1 3/4"-16	150-180 lb-ft torque
Oil drain plug (Nylon washer)	18mm	25-35 b-ft torque

*Apply sealing compound to plugs used without gaskets.
%After installation, a 1.2187" diameter rod inserted in oil line must pass inner face of plug.

STUD TORQUE SPECIFICATIONS

APPLICATION	TORQUE (lb-ft)	HEIGHT
Cylinder head stud ("high")	75 min.	4.3750" ±.0312"
Cylinder head stud ("low")	35-75	4.4375" ±.0312"
Main bearing stud (cast iron block)	35-75	4.000" ±.0312"
Injector clamp stud	10-25	
Water manifold stud	10-25	
Exhaust manifold stud	25-40	

SPRING SPECIFICATIONS

SPRING	REPLACE WHEN LOAD IS LESS THAN:
Cam follower (11 coils - .177"wire)	172 lbs.@2.1250"
Cam follower (11 1/2 coils - .162"wire)	133 lbs.@2.1094"
§Exhaust valve and bridge guide (9 3/4 coils - .135"wire) (former)	79 lbs.@1.4160"
§Exhaust valve (8 3/4 coils - .148"wire) (current)	25 lbs.@1.8000"

§ Four-valve cylinder head

SERVICE TOOLS

TOOL NAME	TOOL NO.
Cylinder Block	
Cylinder Checking Gage and Master Ring Set	J 9353
Cylinder Diameter Checking Gage	J 5347
Master Ring Gage for Block Bore	J 8386-01
Cylinder Hone Set (2 1/2"to 5 3/4")	J 5902-01
Dial Bore Gage Master Setting Fixture	J 23059
Dial Indicator Set	J 22273
Diesel Engine Parts Dolly	J 6387
Engine 'Overhaul Stand	J 6837-01
Engine Overhaul Stand Adapter Plate	J 8196
Special Plug Remover	J 21996-01
Cylinder Head	
Cam Follower Service Fixture	J 5840-01
Cylinder Head Holding Plate Set	J 3087-01
Feeler Gage Set (.0015"to .015")	J 3172
Feeler Stock (.0015")	J 23185
Push Rod Remover (set of 3)	J 3092-01
Slide Hammer	J 2619-01
Socket	J 8932-01
Spring Tester	J 9666
Valve Bridge Holding Fixture	J 21772
Valve Bridge Guide Remover (Broken)	J 7453
Valve Bridge Guide Remover Set (Press Fit)	J 7091-01
Valve Bridge Guide Installer (Press Fit)	J 7482
Valve Bridge Guide Remover and Installer (Threaded - 4 Valve Head)	J 6846
Valve Guide Cleaner	J 5437
Valve Guide Installer (45'4-Valve Head)	J 9729
Valve Guide Installer (Machined 4-Valve Head)	J 21520
Valve Guide Remover (4-Valve Head)	J 6569
Valve Seat Dial Gage	J 8165-3
Valve Seat Grinder	J 8165-01
Valve Seat Grinder Adapter Set (4-Valve Head)	J 6390-01
Valve Seat Insert Installer (4-Valve Head)	J 6568
Valve Seat Insert Remover (454-Valve Head)	J 3091-02
Valve Seat Insert Remover (4-Valve Head)	J 6567-02
Valve Spring Checking Gage	WRE 500-60
Valve Spring Compressor	J 7455
Crankshaft	
Crankshaft and Oil Pump Gear Puller	J 3051
Crankshaft Front Oil Seal Installer	J 9783
Crankshaft Oil Seal Expander	J 22425

TOOL NAME	TOOL NO.
Crankshaft Pulley and Rubber Mounted Balancer Puller	J 5356
Crankshaft Rear Oil Seal Installer	J 9727
Crankshaft Rear Oil Seal Expander (Oversize Seal)	J 4195
Crankshaft Rear Oil Seal Service Sleeve Installer	J 4194
Dial Indicator Set	J 5959-01
Driver Handle	J 3154-1
Driver Handle	J 8092
Micrometer Ball Attachment	J 4757
Universal Bar Type Puller	J 4558-01
Universal Two-Finger Gear Puller	J 4643
Flywheel	
Flywheel Lifting Hook	J 6361-01
Oil Seal Removing and Replacing Tool Set	J 3154-04
Slide Hammer Set	J 5901
Flywheel Housing	
Crankshaft Oil Seal Expander	J 22425
Crankshaft Oil Seal Expander (O.S. Seal)	J 4195
Driver Handle	J 8092
Flywheel Housing Aligning Studs (Set of 4)	J 1927-01
Flywheel Housing Concentricity Gage Set	J 9737-01
Piston, Connecting Rod and Cylinder Liner	
Connecting Rod Bushing Reamer Set	J 1686-03
Connecting Rod Holding Fixture	J 7632
Connecting Rod Spray Nozzle Remover	J 8995
Cylinder Checking Gage and Master Ring Set	J 9353
Cylinder Hone Set (2 1/2" to 5 3/4" range)	J 5902-01
Cylinder Liner Hold-Down Clamp	J 21793-01
Cylinder Liner Remover Set	J 1918-02
Dial Bore Gage Setting Fixture	J 23059
Dial Indicator Set	J 22273
Feeler Gage Set	J 3172
Fire Ring Groove Gage (cross-head piston)	J 24599
Micrometer Ball Attachment	J 4757
Piston and Connecting Rod Bushing Installer and Remover Set	J 1513-02
Piston Bushing Reamer Set	J 3071-01
Piston Pin Retainer Installer (Cross-head piston)	J 23762
Piston Ring Compressor	J 3272-03
Piston Ring Remover and Installer	J 8128
Piston to Liner Feeler Gage Set	J 5438-01
Camshaft	
Blower Drive Cam Installer	J 1471
Camshaft Gear Puller	J 1902-01
Camshaft Gear Puller Adapter Plate Set	J 6202
Camshaft and Oil Pump Gear Replacer	J 1903
Dial Indicator and Attachment Set	J 5959-01
Spring Scale	J 8129

SECTION 2

FUEL SYSTEM AND GOVERNORS

CONTENTS

FUEL SYSTEM

The fuel system (Fig. I) includes the fuel injectors, fuel pipes (inlet and outlet), fuel manifolds (integral with the cylinder head), fuel pump, fuel strainer, fuel filter and fuel lines.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Leaving the pump under pressure, the fuel is forced through the fuel filter and into the inlet fuel manifold, then through fuel pipes into the inlet side of each fuel injector. The fuel manifolds are identified by the words "IN" (top passage) and "OUT" (bottom passage) which are cast in several places in the side of the cylinder head. This aids installation of the fuel lines.

Surplus fuel returns from the outlet side of the injectors to the fuel return manifold and then back to the supply tank.

All engines are equipped with a restrictive fitting in the fuel outlet manifold to maintain the fuel system pressure. Refer to Section 13.2 for the size fitting required.

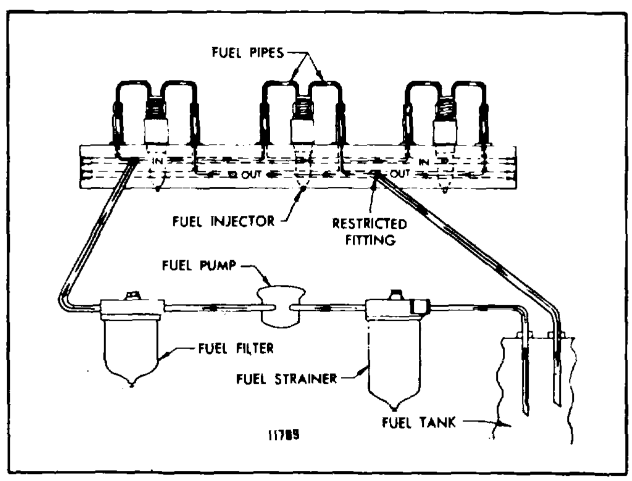


Fig. 1 - Schematic Diagram of Typical Fuel System

FUEL INJECTOR (NEEDLE VALVE)

The fuel injector (Figs. I and 2) is a lightweight compact unit which enables quick, easy starting directly on diesel fuel and permits the use of a simple open type combustion chamber. The simplicity of design and operation provides for simplified controls and easy adjustment. No high pressure fuel lines or complicated air-fuel mixing or vaporizing devices are required.

The fuel injector performs four functions:

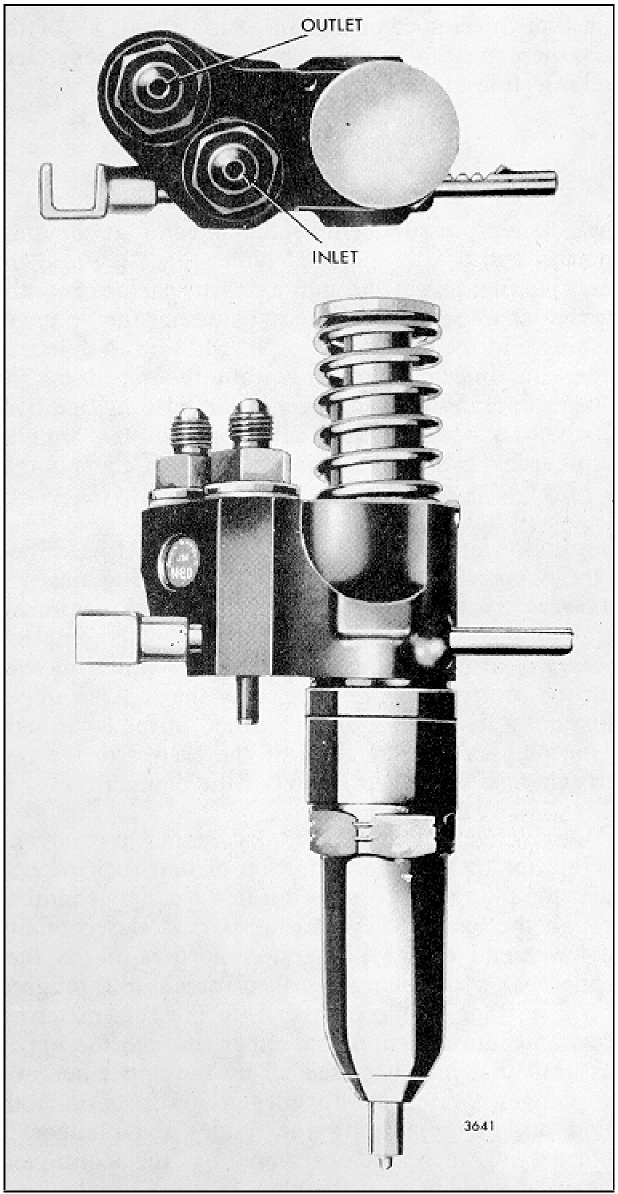


Fig. 1 - Fuel Injector Assembly

1. Creates the high fuel pressure required for efficient injection.

2. Meters and injects the exact amount of fuel required to handle the load.

3. Atomizes the fuel for mixing with the air in the combustion chamber.

4. Permits continuous fuel flow.

Combustion required for satisfactory engine operation is obtained by injecting, under pressure, a small quantity of accurately metered and finely atomized fuel oil into the cylinder.

Metering of the fuel is-accomplished by an upper and lower helix machined in the lower end of the injector plunger. Figure 3 illustrates the fuel metering from no-load to full-load by rotation of the plunger in the bushing.

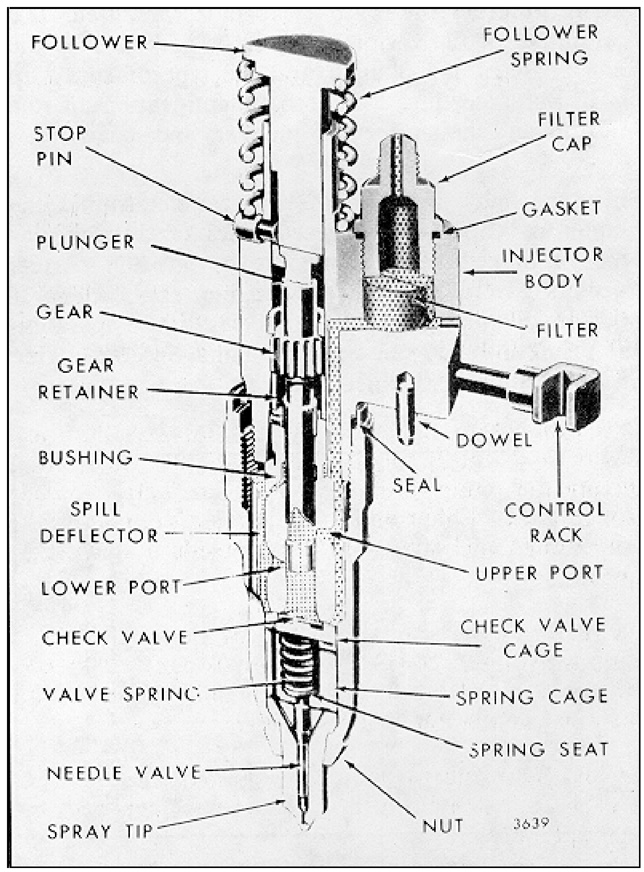


Fig. 2 - Cutaway View of Fuel Injector

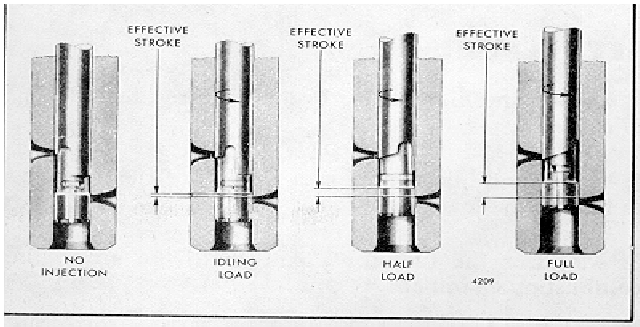


Fig. 3 Fuel Metering from No-Load to Full-Load

Figure 4 illustrates the phases of injector operation by the vertical travel of the injector plunger.

The continuous fuel flow through the injector serves, in addition to preventing air pockets in the fuel system, as a coolant for those injector parts subjected to high combustion temperatures.

To vary the power output of the engine, injectors having different fuel output capacities are used. The fuel output of the various injectors is governed by the helix angle of the plunger and the type of spray tip used. Refer to Fig. 5 for the identification of the injectors and their respective plungers and spray tips.

Since the helix angle on the plunger determines the output and operating characteristics of a particular type of injector, it is imperative that the correct injectors are used for each engine application. If injectors of different types are mixed, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

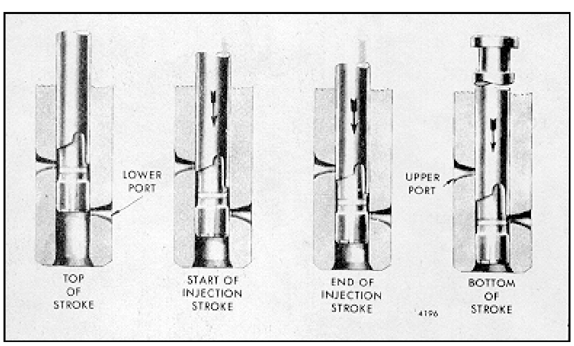


Fig. 4 - Phases of Injector Operation Through Vertical Travel of Plunger

CAUTION: Do not intermix the needle valve injectors with other types of injectors in an engine.

Each fuel injector has a circular disc pressed into a recess at the front side of the injector body for identification purposes (Fig. 5). The identification tag indicates the nominal output of the injector in cubic millimeters.

Each injector control rack (Fig. 2) is actuated by a lever on the injector control tube which, in turn, is connected to the governor by means of a fuel rod. These levers can be adjusted independently on the control tube, thus permitting a uniform setting of all injector racks.

The fuel injector combines in a single unit all of the parts necessary to provide complete and independent fuel injection at each cylinder.

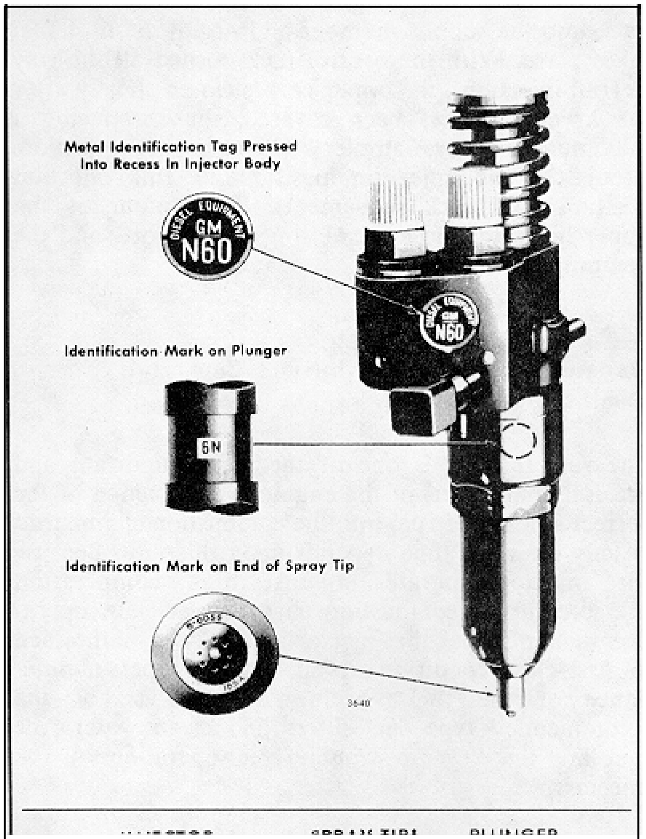
Operation

Fuel, under pressure, enters the injector at the inlet side through a filter cap and filter (Fig. 2). From the filter, the fuel passes through a drilled passage into the supply chamber, that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing. The plunger operates up and down in the bushing, the bore of which is open to the fuel supply in the annular chamber by two funnel-shaped ports in the plunger bushing.

The motion of the injector rocker arm is transmitted to the plunger by the follower which bears against the follower spring (Fig. 6). In addition to the reciprocating motion, the plunger can be rotated, during operation, around its axis by the gear which meshes with the control rack. For metering the fuel, an upper helix and a lower helix are machined in the lower part of the plunger. The relation of the helices to the two ports changes with the rotation of the plunger.

As the plunger moves downward, under pressure of the injector rocker arm, a portion of that fuel trapped under the plunger is displaced into the supply chamber through the lower port until the port is closed off by the lower end of the plunger. A portion of the fuel trapped below the plunger is then forced up through a central passage in the plunger into the fuel metering recess and into the supply chamber through the upper port until that port is closed off by the upper helix of the plunger. 'With the upper and lower ports both closed off, the remaining fuel under the plunger is subjected to increased pressure by the continued downward movement of the plunger.

When sufficient pressure is built up, it opens the flat,



INJECTOR	SPRAY TIP'	PLUNGER
71N5	8-0055--165A	5N
N55	8-0055--165A	55N
N60	8-0055-165A	6N
N65 (brown tog)	8-006-165A	N65
N70	7-006-165	7N
N75	7-006-165	75N
71C5	8--0055-165A	SC
C55	8--0055--165A	55C
C60	8-0055-165A	6C
C65	7--006-165A	65C
C70	7--006- 165	7C
B55	8-006-162	45C
B60	8-006- 162	SC
B65	8-006-165A	65B
71B5	8-006-162	4C
B55E	8 - 006-- 162	B55E
7B5E	8 --006 - 162	7B5E

*First numeral indicates number of spray holes. followed by size of holes and angle formed by spray from holes.

Fig. 5 - Injector Identification Chart

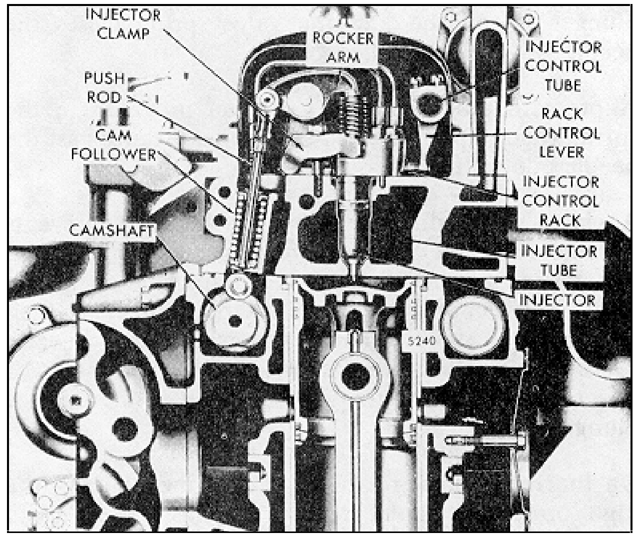


Fig. 6 - Fuel Injector Mounting

non-return check valve. The fuel in the check valve cage, spring cage, tip passages and tip fuel cavity is compressed until the pressure force acting upward on the needle valve is sufficient to open the valve against the downward force of the valve spring. As soon as the needle valve lifts off of its seat, the fuel is forced through the small orifices in the spray tip and atomized into the combustion chamber.

When the lower land of the plunger uncovers the lower port in the bushing, the fuel pressure below the

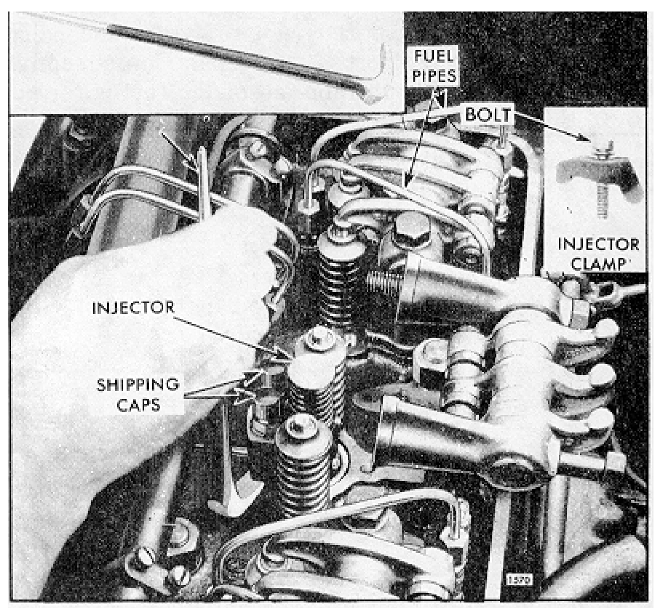


Fig. 7 - Removing Injector from Cylinder Head

plunger is relieved and the valve spring closes the needle valve, ending injection.

A pressure relief passage has been provided in the spring cage to permit bleed-off of fuel leaking past the needle pilot in the tip assembly.

A check valve, directly below the bushing, prevents leakage from the combustion chamber into the fuel injector in case the valve is accidentally held open by a small particle of dirt. The injector plunger is then returned to its original position by the injector follower spring. Figure 4 shows the various phases of injector operation by the vertical travel of the injector plunger.

On the return upward movement of the plunger, the high pressure cylinder within the bushing is again filled with fuel oil through the ports. The constant circulation of fresh cool fuel through the injector renews the fuel supply in the chamber, helps cool the injector and also effectively removes all traces of air which might otherwise accumulate in the system and interfere with accurate metering of the fuel.

The fuel injector outlet opening, through which the excess fuel oil returns to the fuel return manifold and then back to the fuel tank, is directly adjacent to the inlet opening.

Changing the position of the helices, by rotating the plunger, retards or advances the closing of the ports and the beginning and ending of the injection period. At the same time, it increases or decreases the amount of fuel injected into the cylinder. Figure 3 shows the various plunger positions from no-load to full-load. With the control rack pulled out all the way (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with the rack in this position, all of the fuel is forced back into the supply chamber and no injection of fuel takes place. With the control rack pushed all the way in (full injection), the upper port is closed shortly after the lower port has been covered, thus producing a maximum effective stroke and maximum injection.

From this no injection position to full injection position (full rack movement), the contour of the upper helix advances the closing of the ports and the beginning of injection.

General Instructions for Injector Care and Overhaul

The fuel injector is one of the most important and precisely built parts of the engine. The injection of the correct amount of fuel into the combustion chamber at exactly the right time depends upon this unit. Because the injector operates against high compression pressure in the combustion chamber, efficient operation demands that the injector assembly is maintained in first-class condition at all times. Proper maintenance of' the fuel system and the use of the recommended type fuel filters and clean water-free fuel are the keys to trouble-free operation of the injectors.

Due to the close tolerances of various injector parts, extreme cleanliness and strict adherence to service instructions is required.

Perform all injector repairs in a clean, well lighted room with a dust free atmosphere. An ideal injector room is slightly pressurized by means of an electric fan which draws air into the room through a filter. This pressure prevents particles of dirt and dust from entering the room through the doors and windows. A suitable air outlet will remove solvent fumes along with the outgoing air. Also provide a source for 110 volt alternating current electric power.

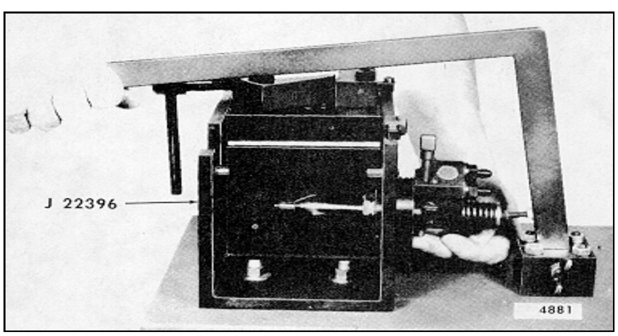


Fig. 8 - Checking Rack and Plunger for Free Movement

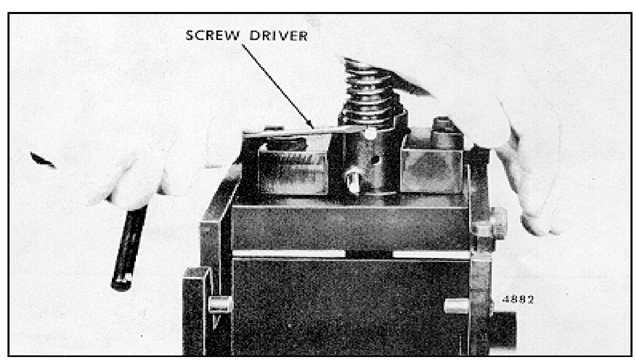


Fig. 9 - Removing Injector Follower Stop Pin

Provide the injector repair room with a supply of filtered, moisture-proof compressed air for drying the injector parts after they have been cleaned. Use wash pans of rust-proof material and deep enough to permit all of the injector parts to be completely covered by the cleaning agent, usually clean fuel oil, when submerged in wire baskets of 16 mesh wire screen. Use baskets which will support the parts so as to avoid contact with the dirt which settles at the bottom of the pans.

Rags should never be used for cleaning injector parts since lint or other particles will clog parts of the injector when it is assembled. A lint-free cleaning tissue is a good, inexpensive material for wiping injector parts.

When servicing an injector, follow the general instructions outlined below:

1. Whenever the fuel pipes are removed from an injector, cover the filter caps with shipping caps to keep dirt out of the injectors. Also protect the fuel pipes and fuel connectors from the entry of dirt or other foreign material.

2. After an injector has been operated in an engine, do not remove the filter caps or filters while the injector is in the engine. Replace the filters only at the time of complete disassembly and assembly of an injector.

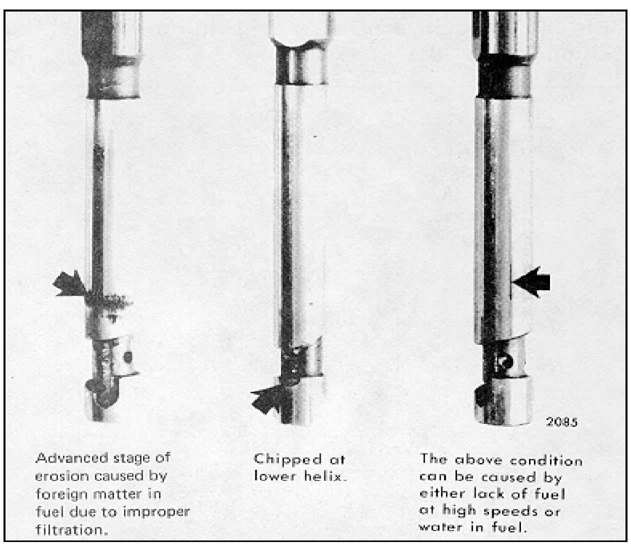


Fig. 10 - Unusable Injector Plungers

NOTE: In the offset injector, a filter is used in the inlet side only. No filter is required on the outlet side (Fig. 34).

3. Whenever an injector has been removed and reinstalled or replaced in an engine, make the following adjustments as outlined in Section 14:

a. Time the injector.

b. Position the injector control rack.

4. Whenever an engine is to be out of service for an extended period, purge the fuel system, then fill it with a good grade of rust preventive (refer to Section 15.3).

5. When a reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. Do not use fuel oil. Install shipping caps on both filter caps immediately after filling. Store the injector in an upright position to prevent test oil leakage.

NOTE: Make sure that new filters have been installed in a reconditioned injector which is to be placed in stock. This precaution will prevent dirt particles from entering the injector due to a possible reversal of fuel flow when installing the injector in an engine other than the original unit.

Remove Injector

1. Clean and remove the valve rocker cover.

2. Remove the fuel pipes from both the injector and the fuel connectors (Fig. 6).

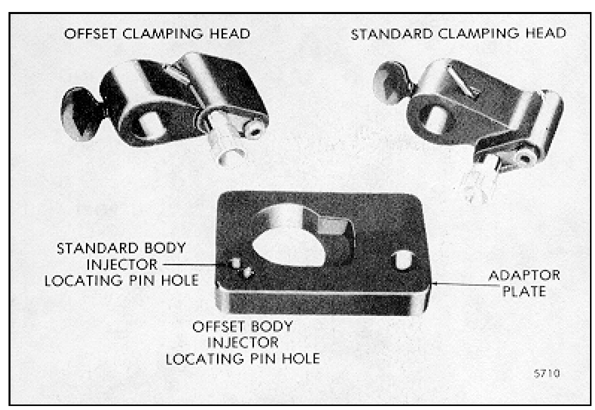


Fig. 11 - Injector Tester J 23010 Clamping Heads

> **NOTE:** Immediately after removal of the fuel pipes from an injector, cover the filter caps with shipping caps to prevent dirt from entering the injector. Also protect the fuel pipes and fuel connectors from entry of dirt or foreign material.

3. Crank the engine to bring the outer ends of the push rods of the injector and valve rocker arms in line horizontally.

4. Remove the two rocker shaft bracket bolts and swing the rocker arms away from the injector and valves (Fig. 7).

5. Remove the injector clamp bolt, special washer and clamp.

6. Loosen the inner and outer adjusting screws (certain engines have only one adjusting screw and lock nut) on the injector rack control lever and slide the lever away from the injector.

7. Lift the injector from its seat in the cylinder head.

8. Cover the injector hole in the cylinder head to keep foreign material out.

9. Clean the exterior of the injector with clean fuel oil and dry it with compressed air.

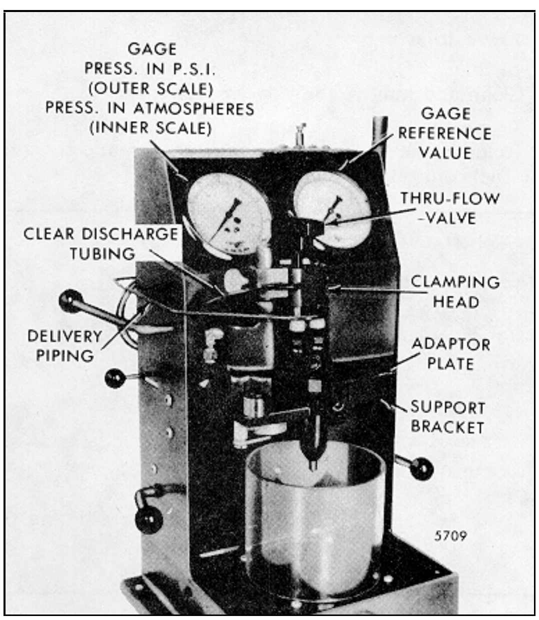


Fig. 12 - Injector Installed in Tester J 23010 with clamping Head

TEST INJECTOR

> **WARNING**: The fuel spray from an injector can penetrate the skin. Fuel oil which enters the blood stream can cause a serious infection. Therefore, follow instructions and use the proper equipment to test an injector.

If inspection does not reveal any external damage, then perform a series of tests to determine the condition of the injector to avoid unnecessary overhauling. Tests must be performed using injector test oil J 26400.

An injector that passes all of the tests outlined below may be considered to be satisfactory for service without disassembly, except for the visual check of the plunger.

However, an injector that fails to pass one or more of the tests is unsatisfactory. Perform all of the tests before disassembling an injector to correct any one condition.

Identify each injector and record the pressure drop and fuel output as indicated by the following tests:

Injector Control Rack and Plunger Movement Test

Place the injector in the injector fixture and rack freeness tester J 22396. Refer to Fig. 8 and place the handle on top of the injector follower.

If necessary, adjust the contact screw in the handle to ensure the contact screw is at the center of the follower when the follower spring is compressed.

With the injector control rack held in the no-fuel position, push the handle down and depress the

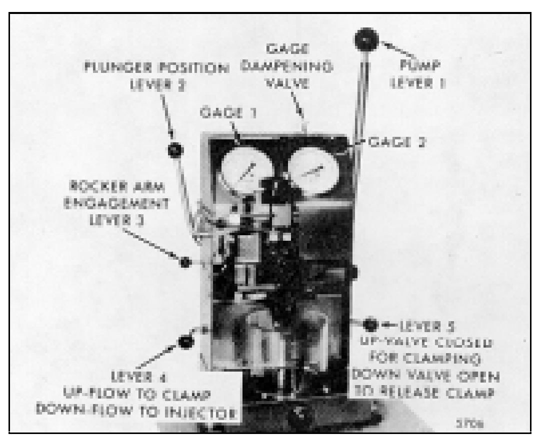


Fig. 13 - Injector in Position for Testing with Tester J 23010

follower to the bottom of its stroke. Then very slowly release the pressure on the handle while moving the control rack up and down as shown in Fig. 8 until the follower reaches the top of its travel. If the rack does not fall freely, loosen the injector nut, turn the tip, then retighten the nut. Loosen and retighten the nut a couple of times if necessary. Generally this will free the rack. Then, if the rack isn't free, change the injector nut. In some cases it may be necessary to disassemble the injector to eliminate the cause of the misaligned parts.

Visual Inspection of Plunger

An injector which passes all of the previous tests should have the plunger checked visually, under a magnifying glass, for excessive wear or a possible chip on the bottom helix. There is a small area on the bottom helix and lower portion of the upper helix, if chipped, that will not be indicated in any of the tests.

Remove the plunger from the injector as follows:

1. Support the injector, right side up, in holding fixture J 22396.

2. Compress the follower spring. Then raise the spring above the stop pin with a screw driver and withdraw the pin (Fig. 9). Allow the spring to rise gradually.

3. Remove the injector from the holding fixture. Turn the injector upside down, to prevent the entry of dirt, and catch the spring and plunger as they drop out.

4. Inspect the plunger. If the plunger is chipped (Fig. 10), replace the plunger and bushing assembly.

5. Reinstall the plunger, follower and spring.

Installing Fuel Injector in Tester J 23010

1. Select the proper clamping head (Fig. 11). Position it on the clamping post and tighten the thumb screw into the lower detent position (Fig. 12).

2. Connect the test oil delivery piping into the clamping head.

3. Connect the test oil clear discharge tubing onto the pipe on the clamping head.

4. Locate the adapter plate on top of the support bracket by positioning the 3/8"diameter hole at the far right of the adapter plate onto the 3/8" diameter dowel pin. This allows the adapter plate to swing out for mounting the fuel injector.

5. Mount the injector through the large hole and insert the injector pin in the proper locating pin hole (Fig. 11).

6. Swing the mounted injector and adapter plate inward until they contact the stop pin at the rear of the support bracket.

Clamping the Fuel Injector

1. Refer to Fig. 13 and position the injector tester levers as follows:

Lever 2 up and to the rear

Lever 3 in the rear detent

Lever 4 up (horizontal)

Lever 5 up (horizontal)

2. Align the clamping head nylon seals over the injector filter caps.

3. Back off the Thru-Flow valve about half-way to allow the self-aligning nylon seals to seat properly during the clamping operation.

4. Hold the clamping head in position over the filter caps and, with the left hand, operate pump lever 1 evenly to move the clamping head down to seal the filter caps.

NOTE: The Thru-Flow valve should still turn freely. If it does not, turn the valve counterclockwise until it rotates freely and re-apply clamping pressure.

CAUTION: Excessive force on lever I during clamping can damage the seals in the valves operated by levers 4 and 5.

Purging Air from the System

Move lever 4 down and operate pump lever I to produce a test oil flow through the injector. When air bubbles no longer pass through the clear discharge tubing, the system is free of air and is now ready for testing.

Injector Valve Opening and Spray Pattern Test

This test determines spray pattern uniformity and the relative pressure at which the injector valve opens and fuel injection begins.

1. Clamp the injector properly and purge the air from the system.

2. Move lever 4 down.

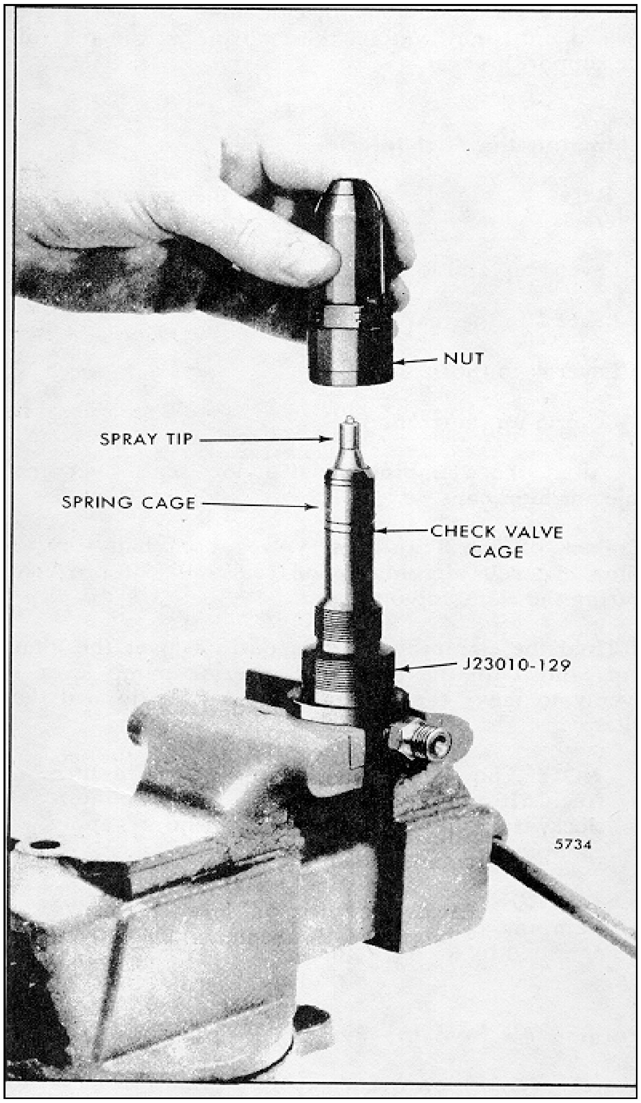


Fig. 14 - Assembling Injector Valve Parts on Tip Tester Adapter J 23010-129

3. Position the injector rack in (he full-fuel position.

4. Place pump lever I in the vertical position.

5. Move lever 3 to the forward detent position.

6. Operate pump lever I uniformly and observe the spray pattern produced.

The highest pressure reference number shown on gage 2 will be reached just before injection ends. Use the following reference values to determine the relative acceptability of the injector. Reference values for Series 71 injectors, except the N-90, 7B5E, B55E and B65 are from 127 minimum to 146 maximum. Reference values for the N-90, 7B5E, B55E and B65 are from 138 minimum to 162 maximum.

NOTE: The reference value obtained when pop testing the needle valve injectors is to be used as a trouble shooting and diagnosis aid. This allows comparative testing of injectors without disassembly. Exact valve opening pressure values can only be determined by the Needle Valve Tip Test using tester J 23010 and tip test adapter J 23010-129 or auxiliary tester J 22640.

Injector High Pressure Test

This test checks for leaks at the filter cap gaskets, body plugs and nut seal ring.

1. Clamp the injector properly and purge the air from the system.

2. Close the Thru-Flow valve, but do not overtighten.

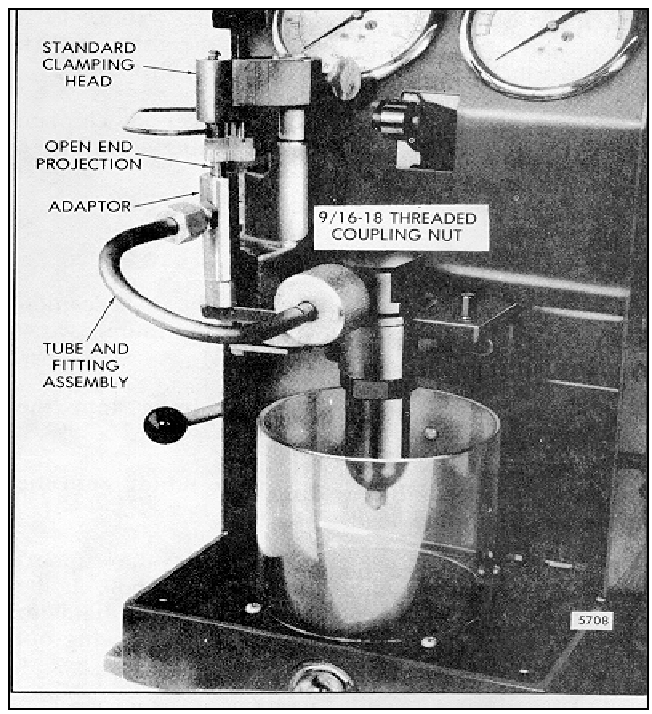


Fig. 15 - Adapter and Tube Assembly on Injector Tester J 23010

CAUTION: Make sure lever 4 is in the down position before operating pump lever 1.

3. Operate pump lever I to build up to 1600 to 2000 psi on gage 1. Check for leakage at the injector filter cap gaskets, body plugs and injector nut seal ring.

Injector Pressure Holding Test

This test determines if the body-to-bushing mating surfaces in the injector are sealing properly and indicates proper plunger-to-bushing fit.

1. Clamp the injector properly and purge the air from the system.

2. Close the Thru-Flow valve, but do not overtighten.

3. Move lever 2 to the rear, horizontal position.

4. Operate pump lever I until gage I reads approximately 700 psi.

5. Move lever 4 to the up position.

6. Time the pressure drop between 450 to 250 psi. If the pressure drop occurs in less than 15 seconds, leakage is excessive.

Refer to the Trouble Shooting Charts in Section 2.0 if the fuel injector does not pass any of the preceding tests.

If the fuel injector passes all of the above tests, proceed with the Fuel Output Test.

Unclamping the Injector

1. Open the Thru-Flow valve to release pressure in the system.

2. Move lever 5 down to release the clamping pressure.

3. Swing out the adapter plate and remove the injector after the nylon seals in the clamping head are free and clear of the injector filter caps.

4. Carefully return lever 5 to the up (horizontal) position.

Needle Valve Tip Test (Using J 23010 Tester and Tip-Test Adapter)

Assemble injector parts on tip test adapter as follows:

1. Clamp the flat sides of the tip test adapter J 23010129 firmly in a vise and assemble the cleaned injector parts including the check valve cage, spring, spring seat, spring cage and spray tip assembly.

2. Carefully pilot the injector nut over the spray tip and valve parts and thread it onto the adapter (Fig. 14).

3. Tighten the injector nut.

4. Mount the adapter and assembled injector parts in the support bracket (adapter plate not needed). Refer to Fig. 15.

5. Install the offset clamping head on the clamping post (on J 23010 testers without serial numbers, use the upper detent position and on J 23010 testers numbered 1051 and higher, use the lower detent position).

6. Select the (larger) 9/16"-18 threaded coupling nut J 23010-20 and thread it on tubing J 23010-75. Install the tubing and fitting to adapter J 23010-167.

7. Connect the tubing to tip test adapter J 23010-129 by threading the coupling nut on the tip test adapter.

Installing Adapter and Tube Assembly on Tester J 23010

1. Position the adapter and tubing assembly with the solid projecting end located in the hole on the left side of the support bracket.

2. Swing the clamping head over the adapter and clamp it with the oil supply outlet aligned over the open projecting end of the adapter (Fig. 15).

NOTE: Use the fuel injector clamping procedure to clamp adapter J 23010-167 in the injector tester.

Spray Tip Test

1. Move lever 4 down and operate pump lever I with even strokes (Fig. 13).

2. Note the pressure at which the needle valve opens on gage 1. The valve should open between 2300 and 3300 psi. The opening and closing action should be sharp and produce a normal, finely atomized spray pattern.

If the valve opening pressure is below 2300 psi and/or atomization is poor, the cause is usually a weak valve spring or a poor needle valve seat.

If the valve opening pressure is within 2300-3300 psi, proceed to check for spray tip leakage as follows:

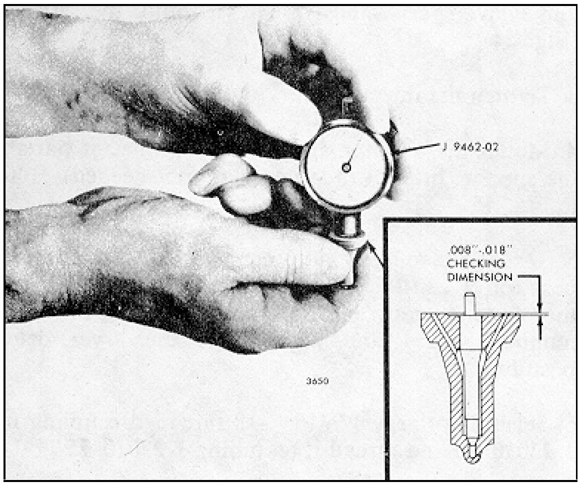


Fig. 16 - Checking Needle Valve Lift

a. Actuate pump lever I several times and hold the pressure at 1500 psi for 15 seconds.

b. Inspect the spray tip for leakage. There should be no fuel droplets, although a slight wetting at the spray tip is permissible.

Needle Valve Lift Test

To measure the needle valve lift, use tool J 9462-01 (Fig. 16) as follows:

1. Zero the indicator by placing the bottom surface of the plunger assembly on a flat surface and zero the indicator dial.

2. Place the spray tip and needle valve assembly tight against the bottom of the gage with the quill of the needle valve in the hole in the plunger.

3. While holding the spray tip and needle valve assembly tight against the gage, read the needle valve lift on the indicator. The lift should be .008" to .018" .

If it exceeds .018", the tip assembly must be replaced.

If it is less than .008", inspect for foreign material between the needle valve and the tip seat.

4. If the needle valve lift is within limits, install a new needle valve spring and recheck the valve opening pressure and valve action. Low valve opening pressure or poor atomization with a new spring and seat indicates the spray tip and needle valve assembly should be replaced.

5. Reassemble the injector as outlined under Assemble Injector and check the injector output with calibrator J 22410.

Needle Valve Tip Test (Using Auxiliary Tester J 22640)

1. Connect the pipe from auxiliary tester J 22640 to the rear of the J 23010 tester at the connection located near the bottom of the tester (Fig.17).
2. Assemble cleaned injector parts, including the check valve cage, spring, spring seat, spring cage and spray tip assembly, on the auxiliary tester J 22640 (Fig. 18).
3. Carefully pilot the injector nut over the spray tip and valve parts and thread it on the auxiliary tester.
4. Tighten the injector nut.
5. Open the valve on the auxiliary tester and place lever 4 in the up (horizontal) position.
6. Install the shield on the auxiliary tester and operate pump lever I until the needle' valve has opened several times to purge the air from the system.
7. Operate pump lever I with smooth, even strokes and note the pressure on gage I when the needle valve opens. The valve should open between 2300 and 3300 psi. The opening and closing action should be sharp and produce a finely atomized spray.

If the valve opening pressure is below 2300 psi and/or atomization is poor, the cause is usually a weak valve spring or poor needle valve seat.

If the valve opening pressure is within 2300-3300 psi, proceed to check for spray tip leakage as follows:

a. Actuate the pump lever several times and hold the pressure at 1500 psi for 15 seconds.

b. Inspect the spray tip for leakage. There should be no fuel droplets although a slight wetting at the spray tip is permissible.

Perform the needle valve lift test.

Fuel Output Test

Perform the injector fuel output test in calibrator J 22410.

When injectors are removed from an engine for fuel output testing and, if satisfactory, reinstalled without disassembly, extreme care should be taken to avoid

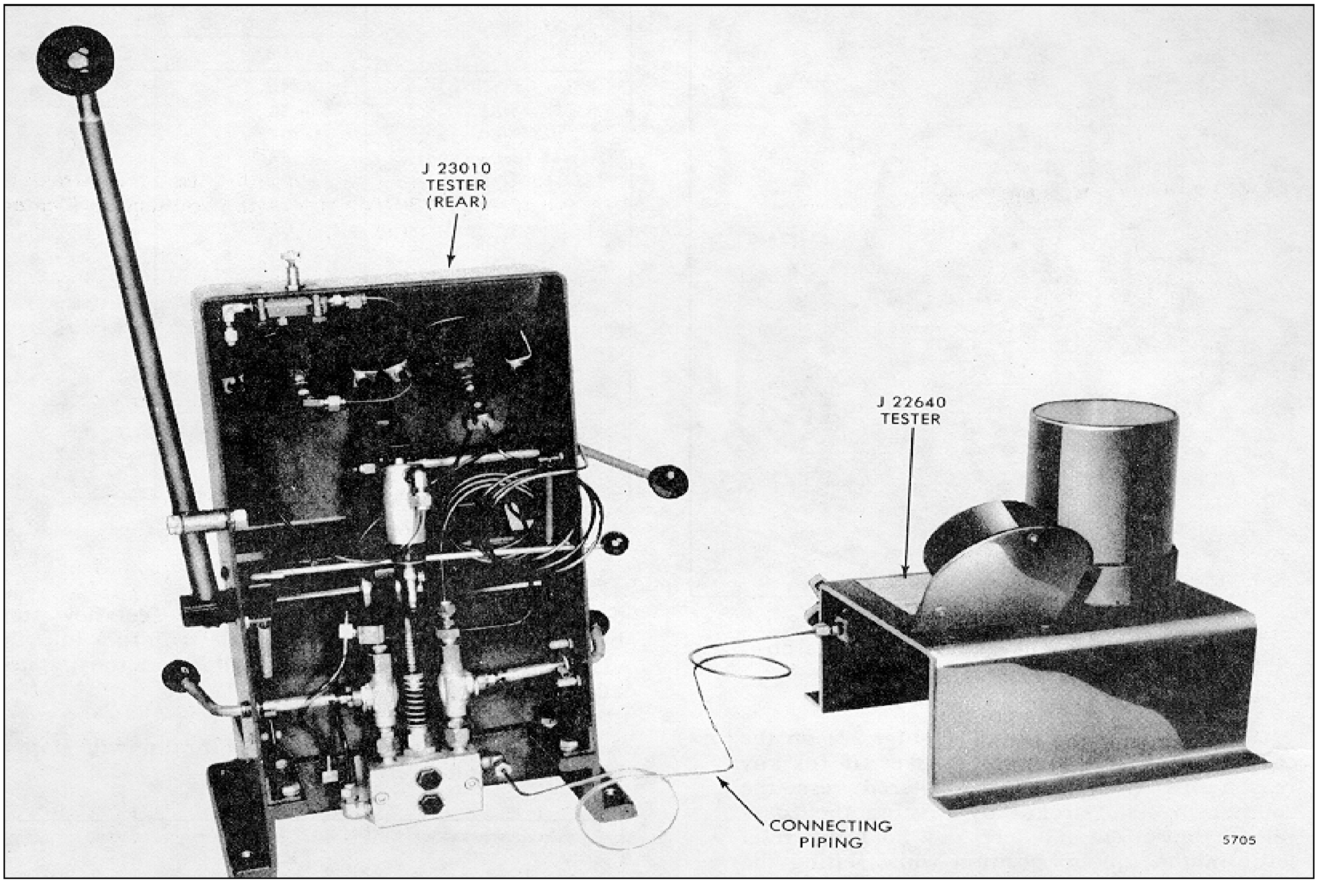


Figure 17 - Injector Needle Valve Tester J 23010 with Auxiliary tester J 22640

reversing the fuel flow. When the fuel flow is reversed, dirt trapped by the filter is back-flushed into the injector components.

Before removing an injector from the engine, note the direction of the fuel flow. To avoid reversing the fuel flow when checking injector fuel output, use the appropriate adapter. The position of the braided fuel inlet tube and the plastic fuel outlet tube on the calibrator (Fig. 20) depends on the adapter being used and the direction of fuel flow through the injector.

Calibrator J 22410

To check the fuel output, operate the injector in calibrator J 22410 (Fig. 21) as follows:

NOTE: Place the cam shift index wheel and fuel flow lever in their respective positions. Turn on the test fuel oil heater switch and preheat the test oil to 95-105°F (35-40°C).

1. Place the proper injector adapter between the tie rods and engage it with the fuel block locating pin. Then slide the adapter forward and up against the fuel block face.

2. Place the injector seat J 22410-226 into the permanent seat (cradle handle in vertical position). Clamp the injector into position by operating the air valve.

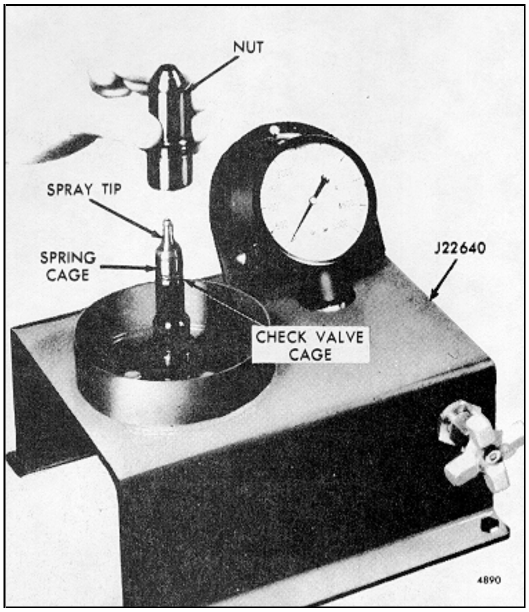


Fig. 18 - Installing Injector Valve Parts on Auxiliary Tester J 22640

NOTE: Make sure the counter (Fig. 22) on the calibrator is preset at 1000 strokes. If for any reason this setting has been altered, reset the counter to 1000 strokes by twisting the cover release button to the left and hold the reset lever in the full up position while setting the numbered wheels. Close the cover. Refer to the calibrator instruction booklet for further information.

3. Pull the injector rack out to the no-fuel position.

4. Turn on the main power control circuit switch. Then start the calibrator by turning on the motor starter switch.

NOTE: The low oil pressure warning buzzer will sound briefly until the lubricating oil reaches the proper pressure.

5. After the calibrator has started, set the injector rack into the full-fuel position. Allow the injector to operate for approximately 30 seconds to purge the air that may be in the system.

Injector	Calibrator J 22410	
	Min	Max,
71N5	50	54
N55	53	57
N60	57	61
N65 (brown tag)	64	68
N70	71	75
N75	75	79
71CS	50	54
CSS	53	57
C60	57	61
C65	64	66
C70	71	75
B55	53	57
B60	57	61
865	64	68
71 B5	50	54
B55E	53	57
7B5E	50	54

Fig. 19 - Fuel Output Chart

6. After the air is purged, press the fuel flow start button (red). This will start the flow of fuel into the vial. The fuel flow to the vial will automatically stop after 1000 strokes.

7. Shut the calibrator off (the calibrator will stop in less time at full-fuel).

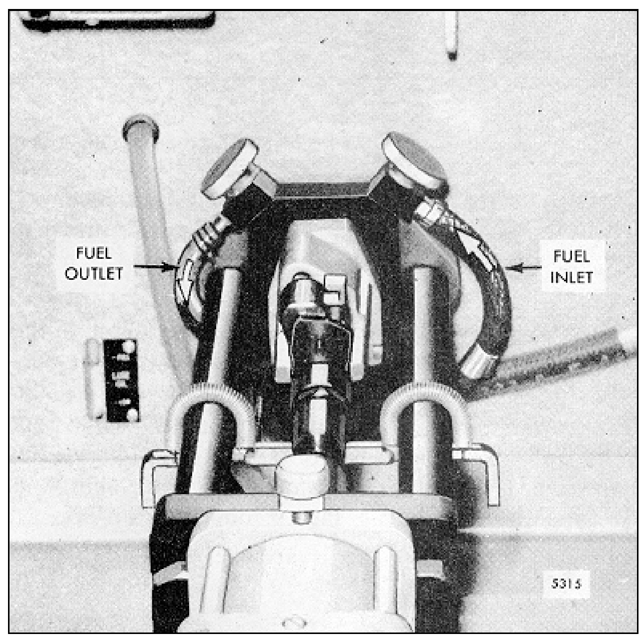


Fig. 20 - Position of Calibrator Fuel Flow Pipes

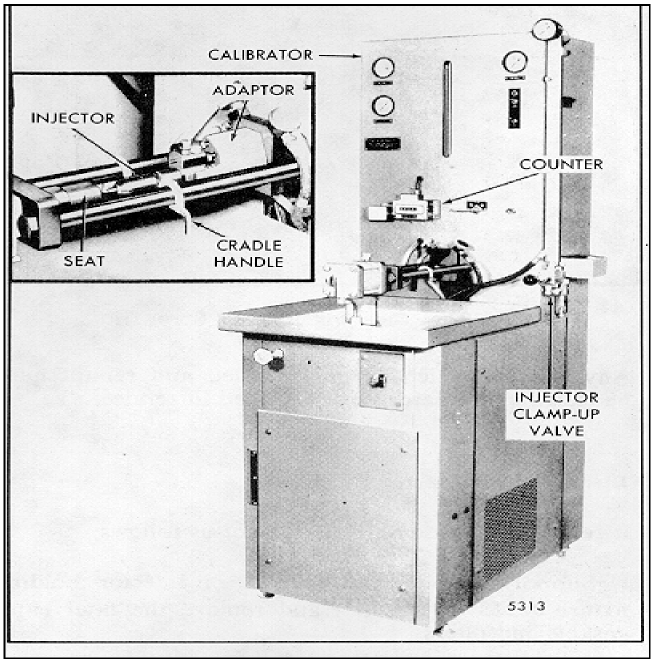


Fig. 21 - Injector in Calibrator J 22410

8. Observe the vial reading and refer to Fig. 19 to determine whether the injector fuel output falls within the specified limits. If the quantity of fuel in the vial does not fall within the specified limits, refer to Trouble Shooting Chart 6 and Shop Notes in section 2.0 for the cause and remedy.

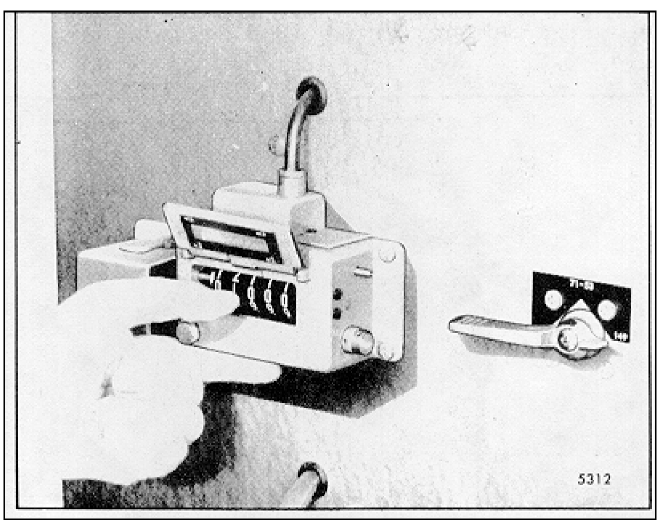


Fig. 22 - Setting Calibrator Stroke Counter

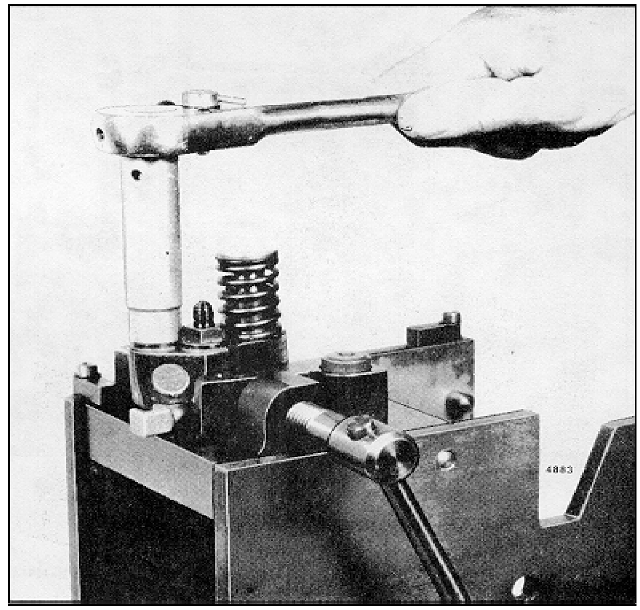


Fig. 23 - Removing or Installing Filter Cap

NOTE: Refer to Section 2.0 for different factors that may affect the injector calibrator output reading.

The calibrator may be used to check and select a set of injectors which will inject the same amount of fuel in

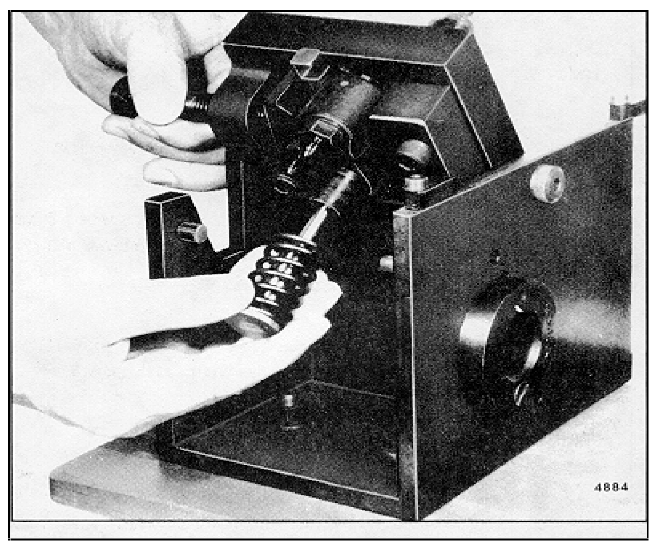


Fig. 24 - Removing or installing Plunger Follower, Plunger and Spring

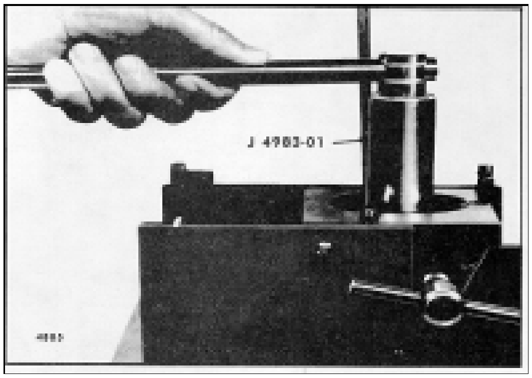


Fig. 25 - Removing Injector Nut

each cylinder at a given throttle setting, thus resulting in a smooth running, well balanced engine.

An injector which passes all of the above tests may be put back into service. However, an injector which fails to pass one or more of the tests must be rebuilt and checked on the calibrator.

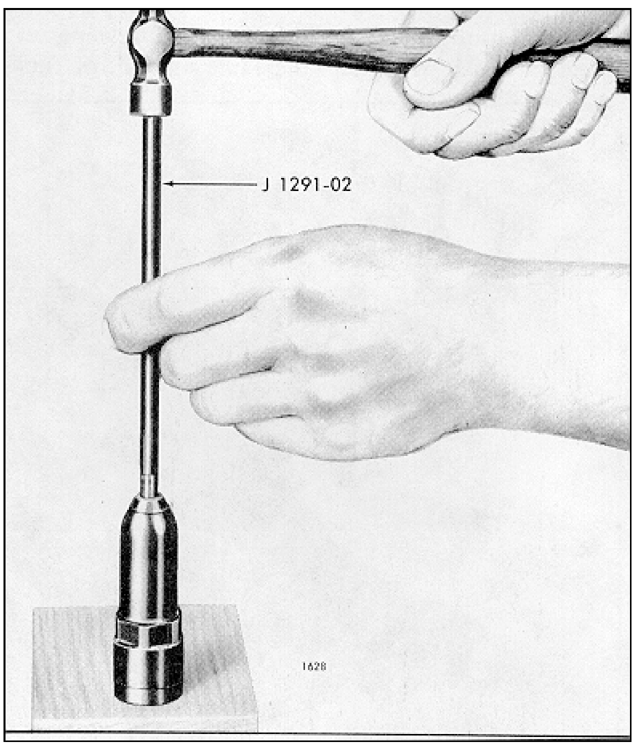


Fig. 26 - Removing Spray Tip from Injector Nut

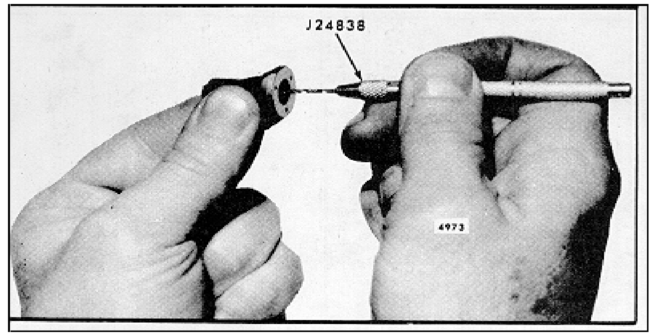


Fig. 27 - Cleaning Injector Spray Tip

Any injector which is disassembled and rebuilt must be tested again before being placed in service.

Disassemble Injector

If required, disassemble an injector as follows:

1. Support the injector upright in injector holding fixture J 22396 (Fig. 23) and remove the filter caps, gaskets and filters.

> **NOTE:** Whenever a fuel injector is disassembled, discard the filters and gaskets and replace with new filters and gaskets. In the offset injector, a filter is used in the inlet side only. No filter is required in the outlet side (Fig. 34).

2. Compress the follower spring as shown in Fig. 11. Then raise the spring above the stop pin with a screw driver and withdraw the pin. Allow the spring to rise gradually.

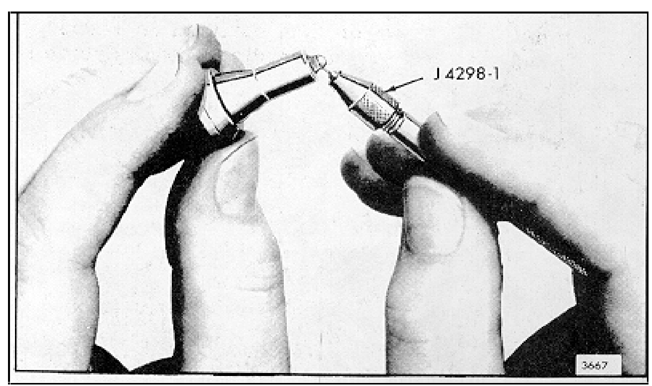


Fig. 28 - Cleaning Spray Tip Orifices

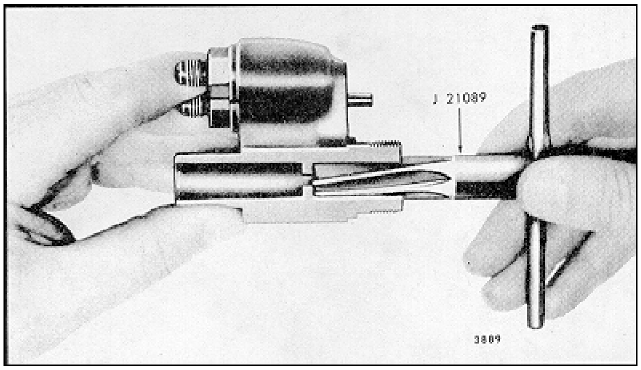


Fig. 29 - Cleaning Injector Body Ring

3. Refer to Fig. 24 and remove the plunger follower, plunger and spring as an assembly.

4. Invert the fixture and, using socket J 4983-01, loosen the nut on the injector body (Fig. 25).

5. Lift the injector nut straight up, being careful not to dislodge the spray tip and valve parts. Remove the spray tip and valve parts from the bushing and place them in a clean receptacle until ready for assembly.

When an injector has been in use for some time, the spray tip, even though clean on the outside, may not be pushed readily from the nut with the fingers. In this event, support the nut on a wood block and drive the tip down through the nut, using tool J 1291-02 as shown in Fig. 26.

6. Refer to Fig. 36 and remove the spill deflector. Then lift the bushing straight out of the injector body.

7. Remove the injector body from the holding fixture. Turn the body upside down and catch the gear retainer and gear in your hand as they fall out of the body.

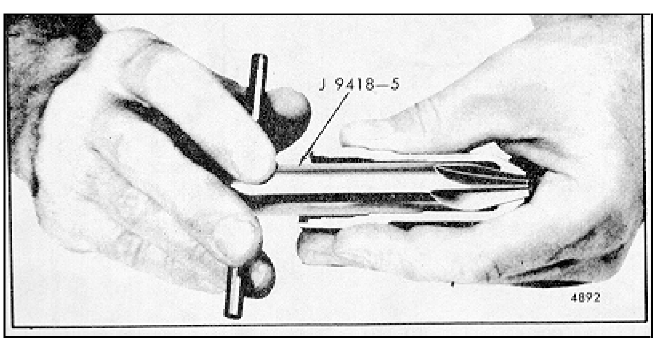


Fig. 30 - Cleaning Injector Nut Spray Tip Seat

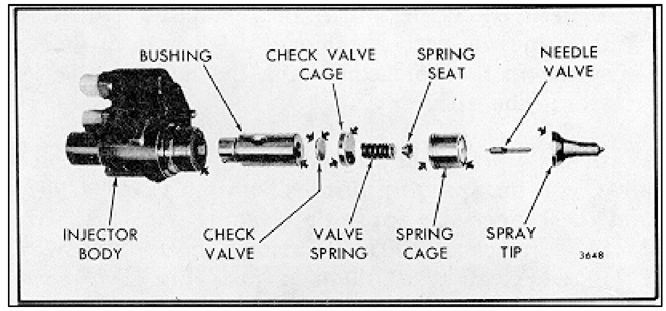


Fig. 31 - Sealing Surfaces which may Require Lapping

8. Withdraw the injector control rack from the injector body. Also remove the seal ring from the body.

Clean Injector Parts

Since most injector difficulties are the result of dirt particles, it is essential that a clean area be provided on which to place the injector parts after cleaning and inspection.

Wash all of the parts with clean fuel oil or a suitable cleaning solvent and dry them with clean, filtered compressed air. Do not use waste or rags for cleaning purposes. Clean out all of the passages, drilled holes and slots in all of the injector parts.

Carbon on the inside of the spray tip may be loosened for easy removal by soaking for approximately 15 minutes in a suitable solution prior to the external cleaning and buffing operation. Methyl Ethyl Ketone J 8257 solution is recommended for this purpose.

Clean the spray tip with tool J 9464-01 (Fig. 27).

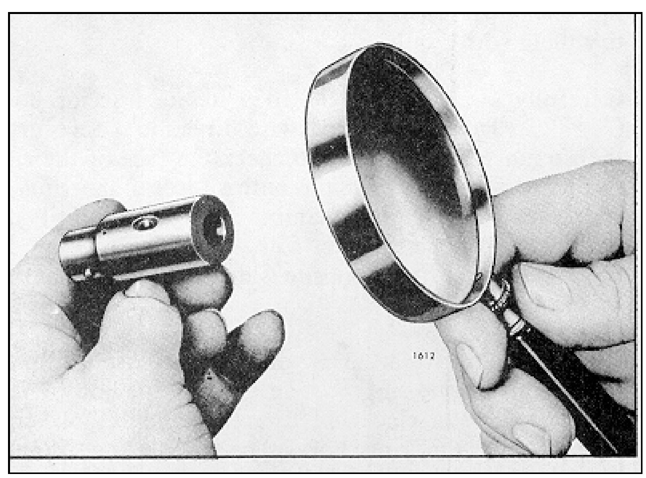


Fig 32 - Examining Sealing Surface with a Magnifying Glass

CAUTION: Care must be exercised when inserting the carbon remover J 946441 in the spray tip to avoid contacting the needle valve seat in the tip.

Wash the tip in fuel oil and dry it with compressed air. Clean the spray tip orifices with pin vise J 4298-1 and the proper size spray tip cleaning wire. Use wire J 21460 to clean .0055"diameter holes and wire J 21461 to clean .006 " diameter holes (Fig. 28).

Before using the wire, hone the end until it is smooth and free of burrs and taper the end a distance of 1/16"with stone J 8170. Allow the wire to extend 1/8" from tool J 4298-1.

The exterior surface of an injector spray tip may be cleaned by using a brass wire buffing wheel, tool J 7944. To obtain a good polishing effect and longer brush life, the buffing wheel should be installed on a motor that turns the wheel at approximately 3000 rpm. A convenient method of holding the spray tip while cleaning and polishing is to place the tip over the drill end of the spray tip cleaner tool J 1243 and hold the body of the tip against the buffing wheel. In this way, the spray tip is rotated while being buffed.

CAUTION: Do not buff excessively. Do not use a steel wire buffing wheel or the spray tip holes may be distorted.

When the body of the spray tip is clean, lightly buff the tip end in the same manner. This cleans the spray tip orifice area and will not plug the orifices.

Wash the spray tip in clean fuel oil and dry it with compressed air.

Clean and brush all of the passages in the injector body, using fuel hole cleaning brush J 8152 and rack hole cleaning brush J 8150. Blow out the passages and dry them with compressed air.

Carefully insert reamer J 21089 in the injector body (Fig. 29). Turn it in a clockwise direction a few turns, then remove the reamer and check the face of the ring for reamer contact over the entire face of the ring. If necessary, repeat the reaming procedure until the reamer does make contact with the entire face of the ring. Clean up the opposite side of the ring in the same manner.

Carefully insert a .375" diameter straight fluted reamer inside the ring bore in the injector body. Turn the reamer in a clockwise direction and remove any burrs inside the ring bore. Then wash the injector body in clean fuel oil and dry it with compressed air.

Remove the carbon deposits from the lower inside diameter taper of the injector nut with carbon remover.

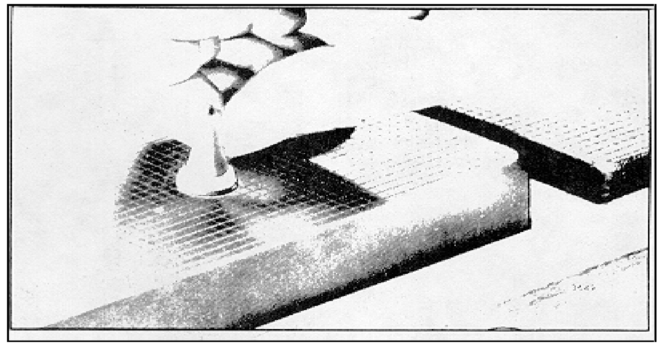


Fig. 33 - Lapping Spray Tip on Lapping Blocks J 22090

J 941l85 Fig. ()i. Use care to minimize removing metal or setting up burrs on the spray tip seat. Remove only enough metal to produce a clean uniform seat to prevent leakage between the tip and the nut. Carefully insert carbon remover J 9418-1 in the injector nut. Turn it clock\fs16 wise to remove the carbon deposits on the flat spray tip seat.

Wash the injector nut in clean fuel oil and dry it with compressed air. Carbon deposits on the spray tip seating surfaces of the injector nut will result in poor sealing and consequent fuel leakage around the spray tip.

When handling the injector plunger, do not touch the finished plunger surfaces with your fingers. Wash the plunger and bushing with clean fuel oil and dry them with compressed air. Be sure the high pressure bleed hole in the side of the bushing is not plugged. If this hole is plugged, fuel leakage will occur at the upper end of the bushing where it will drain out of the injector body vent and rack holes, during engine operation, causing a serious oil dilution problem. Keep

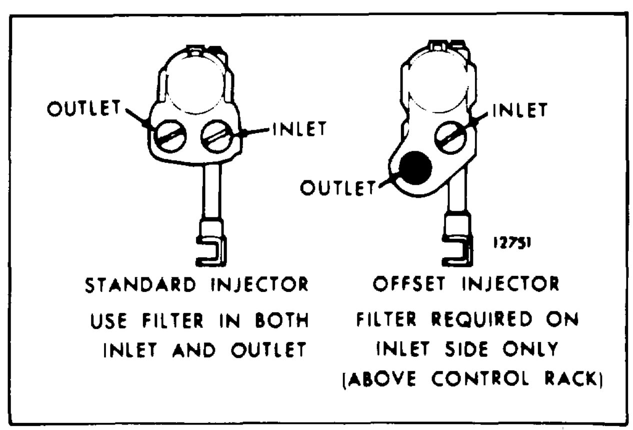


Fig. 34 - Location of Filter in Injector Body

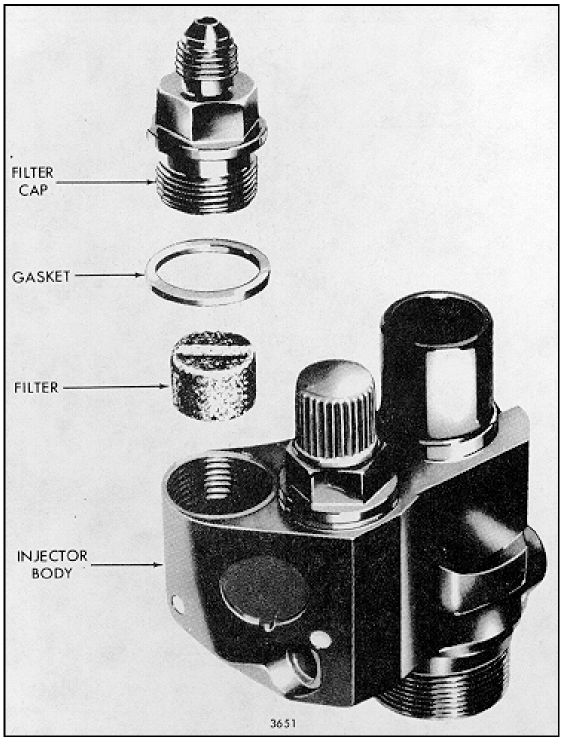


Fig. 35- Details of Injector Filters and Caps and Their Relative Location

the plunger and bushing together as they are mated parts.

After washing, submerge the parts in a clean receptacle containing clean fuel oil. Keep the parts of each injector assembly together.

Inspect Injector Parts

Inspect the teeth on the control rack and the control rack gear for excessive wear or damage. Also check for excessive wear in the bore of the gear and inspect the gear retainer. Replace damaged or worn parts.

Inspect the injector follower and pin for wear. Refer to Section 2.0.

Inspect both ends of the spill deflector for sharp edges or burrs which could create burrs on the injector body or injector nut and cause particles of metal to be introduced into the spray tip and valve parts. Remove burrs with a 500 grit stone.

Inspect the follower spring for visual defects. Then check the spring with spring tester J 9666 and an accurate torque wrench.

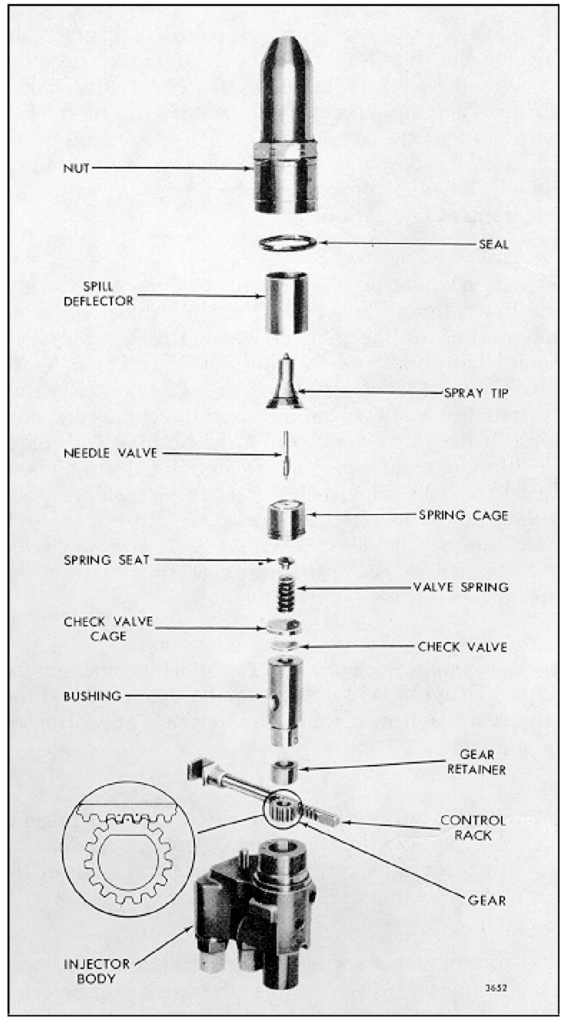


Fig. 36 - Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

The current injector follower spring (.142" diameter wire) has a free length of approximately 1.504" and should be replaced when a load of less than 70 lbs. will compress it to 1.028"

It is recommended that at the time of overhaul, all injectors in an engine be converted to the current spring (.142 "diameter wire) which will provide improved cam roller to shaft follow. However, in the event that one or two injectors are -changed, the remaining injectors need not be reworked to incorporate the current spring.

Check the seal ring area on the injector body for burrs or scratches. Also check the surface which contacts the injector bushing for scratches, scuff marks or other damage. If necessary, lap this surface. A faulty sealing surface at this point will result in high fuel consumption and contamination of the lubricating oil. Replace any loose injector body plugs or a loose dowel pin. Install the proper number tag on a service replacement injector body.

Inspect the injector plunger and bushing for scoring, erosion, chipping or wear. Check for sharp edges on that portion of the plunger which rides in the gear. Remove any sharp edges with a 500 grit stone. Wash the plunger after stoning it. Injector Bushing Inspectalite J 21471 can be used to check the port holes in the inner diameter of the bushing for cracks or chipping. Slip the plunger into the bushing and check for free movement. Replace the plunger and bushing as an assembly if any of the above damage is noted, since they are mated parts. Use new mated factory parts to assure the best performance from the injector.

Injector plungers cannot be reworked to change the output. Grinding will destroy the hardened case at the helix and result in chipping and seizure or scoring of the plunger.

Examine the spray tip seating surface of the injector nut and spray tip for nicks, burrs, erosion or brinelling. Reseat the surface or replace the nut or tip if it is severely damaged.

The injector valve spring plays an important part in establishing the valve opening pressure of the injector assembly. Replace a worn or broken spring.

Inspect the sealing surfaces of the injector parts indicated by arrows in Fig. 31. Examine the sealing surfaces with a magnifying glass as shown in Fig. 32 for even the slightest imperfections will prevent the injector from operating properly. Check for burrs, nicks, erosion, cracks, chipping and excessive wear. Also check for enlarged orifices in the spray tip. Replace damaged or excessively worn parts. Check the minimum thickness of the lapped parts as noted in the chart.

Examine the seating area of the needle valve for wear or damage. Also examine the needle quill and its contact point with the valve spring seat. Replace damaged or excessively worn parts.

Examine the needle valve seat area in the spray tip for foreign material. The smallest particle of such material can prevent the needle valve from seating properly. Polish the seat area with polishing stick J 22964. Coat only the tapered end of the stick with polishing compound J 23038 and insert it directly into the center of the spray tip until it bottoms. Rotate the stick 6 to 12 times, applying a light pressure with the thumb and forefinger.

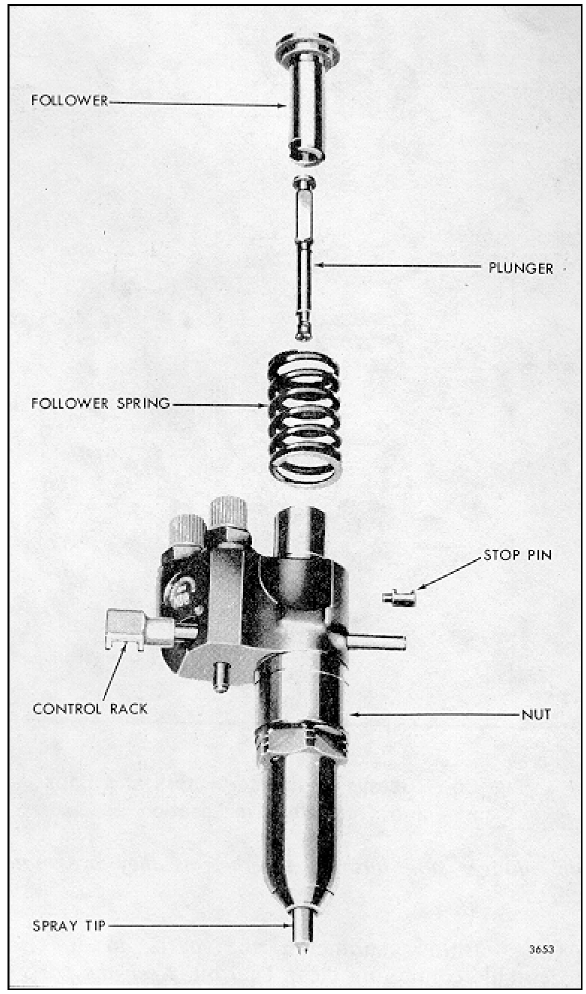


Fig. 37 - Injector Plunger, Follower and Relative Location of Parts

Part Name	Minimum Thickness
Spray Tip (shoulder)	199"
Check Valve Cage	.165"-.163"
Check Valve	022"
Valve Spring Cage	602"

TABLE 1 - Minimum Thickness (Used Parts)

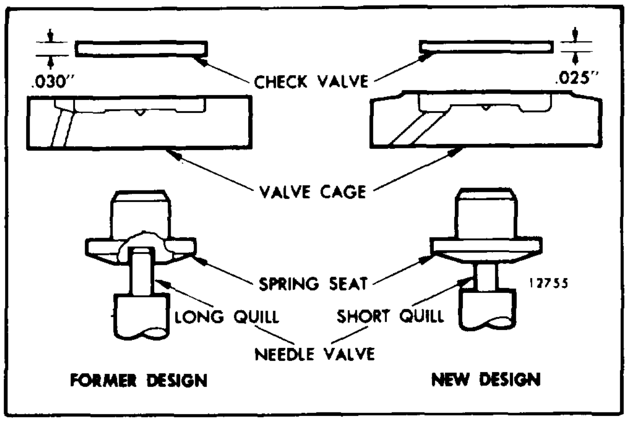


Fig. 38 Comparison of Former and New Design Injector Parts

CAUTION: Be sure that no compound is accidentally placed on the lapped surfaces located higher up in the spray tip. The slightest lapping action on these surfaces can alter the near-perfect fit between the needle valve and tip.

Before reinstalling used injector parts, lap all of the sealing surfaces indicated by the arrows in Fig. 31. It is also good practice to lightly lap the sealing surfaces of new injector parts which may become burred or nicked during handling.

Lapping Injector Parts

Lap the sealing surfaces indicated in Fig. 31 and Table I as follows:

1. Clean the lapping blocks (J 22090) with compressed air. Do not use a cloth or any other material for this purpose.

2. Spread a good quality 600 grit dry lapping powder on one of the lapping blocks.

3. Place the part to be lapped flat on the block as shown in Fig. 33 and, using a figure eight motion, move it back and forth across the block. Do not press on the part, but use just enough pressure to keep the part flat on the block. It is important that the part be kept flat on the block at all times.

4. After each four or five passes, clean the lapping powder from the part by drawing it across a clean piece of tissue placed on a flat surface and inspect the part. Do not lap excessively (refer to Table I).

5. When the part is flat, wash it in cleaning solvent and dry it with compressed air.

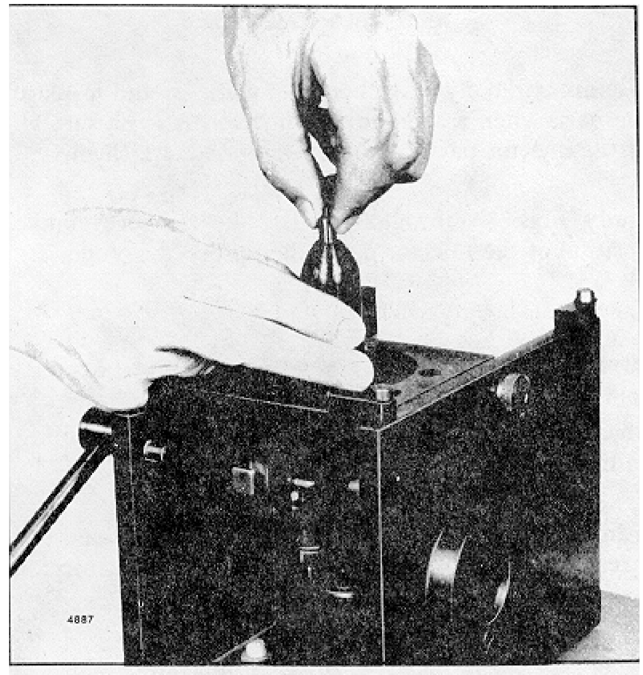


Fig. 39 Tightening Injector Nut by Hand

6. Place the dry part on the second block. After applying lapping powder, move the part lightly across the block in a figure eight motion several times to give it a smooth finish. Do not lap excessively. Again wash the part in cleaning solvent and dry it with compressed air.

7. Place the dry part on the third block. Do not use lapping powder on this block. Keep the part flat and move it across the block several times, using the figure eight motion. Lapping the dry part in this manner gives it the "mirror" finish required for perfect sealing.

8. Wash all of the lapped parts in clean fuel oil and dry them with compressed air.

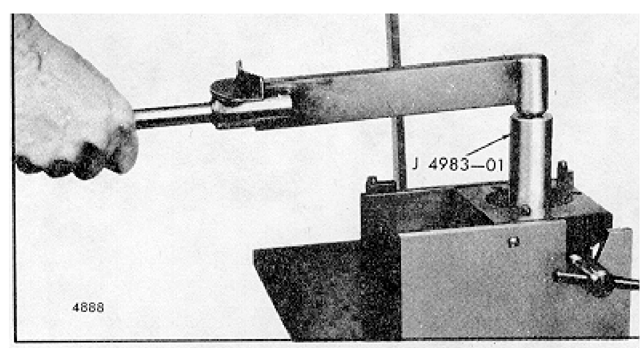


Fig. 40 Tightening Injector Nut With Torque Wrench

ASSEMBLE INJECTOR

Use an extremely clean bench to work on and to place the parts when assembling an injector. Also be sure all of the injector parts, both new and used, are clean.

Study Figs. 34 through 37 for the proper relative position of the injector parts, then proceed as follows:

Assemble Injector Filters

Always use new filters and gaskets when reassembling an injector.

1. Insert a new filter, dimple end down, slotted end up, in each of the fuel cavities in the top of the injector body (Fig. 35).

> **NOTE:** Install a new filter in the inlet side (located over the injector rack) in a fuel injector with an offset body. No filter is required in the outlet side of the offset body injector (Fig. 34).

2. Place a new gasket on each filter cap. Lubricate the threads and install the filter caps. Tighten the filter caps to 65-75 lb-ft (88-102 Nm) torque with a 9/16" deep socket (Fig. 23).

3. Purge the filters after installation by directing compressed air or fuel through the filter caps.

4. Install clean shipping caps on the filter caps to prevent dirt from entering the injector.

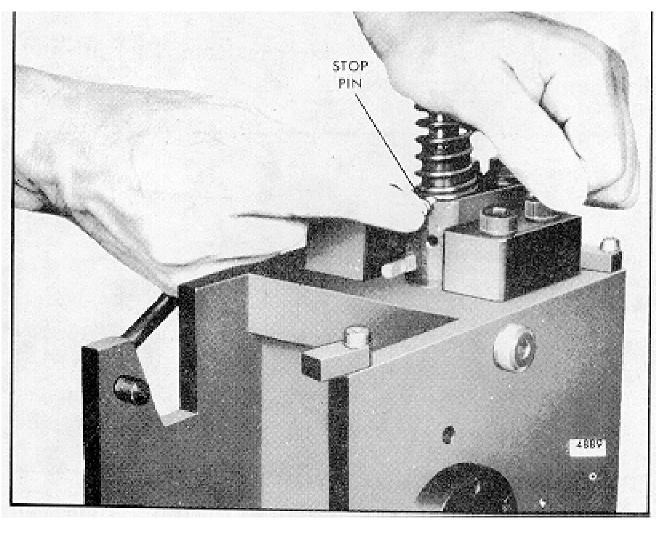


Fig. 41 Installing Injector Follower Stop Pin

Assemble Rack and Gears

Refer to Fig. 36 and note the drill spot marks on the control rack and gear. Then proceed as follows:

1. Hold the injector body, bottom end up, and slide the rack through the hole in the body. Look into the body bore and move the rack until you can see the drill marks. Hold the rack in this position.

2. Place the gear in the injector body so that the marked tooth is engaged between the two marked teeth on the rack (Fig. 36).

3. Place the gear retainer on top of the gear.

4. Align the locating pin in the bushing with the slot in the injector body, then slide the end of the bushing into place.

Assemble Spray Tip, Spring Cage and Check Valve Assemblies

Refer to Fig. 36 and assemble the parts as follows:

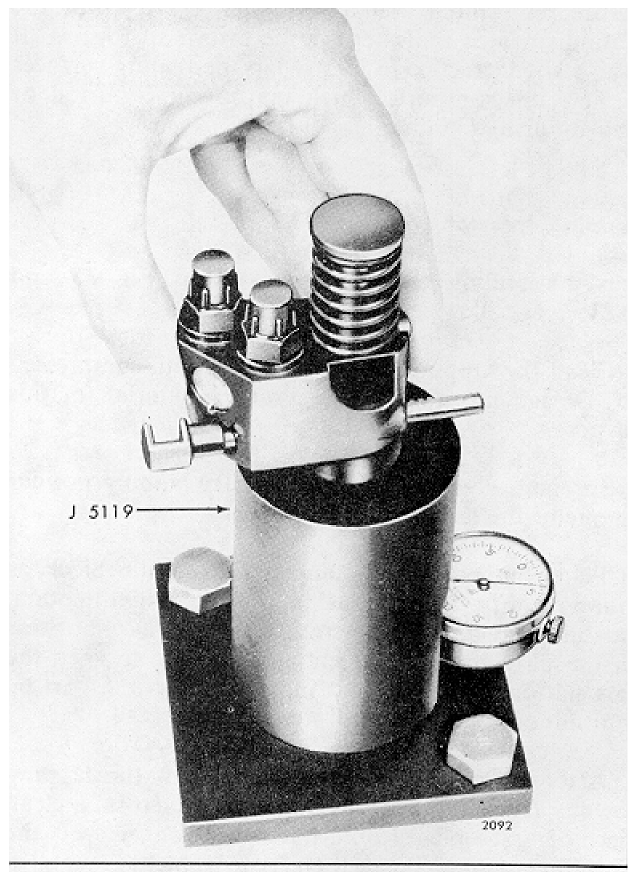


Fig. 42 Checking Injector Spray Tip Concentricity

1. Support the injector body, bottom end up, in injector holding fixture J 22396.

2. Place a new seal ring on the shoulder of the body. Then place the spill deflector over the barrel of the bushing.

3. Place the check valve (without the .010"hole) centrally on the top of the bushing. Then place the check valve cage over the check valve and against the bushing.

> **CAUTION:** The former and new check valve and check valve cage are not separately interchangeable in a former injector (Fig,. 38).

4. Insert the spring seat in the valve spring, then insert the assembly into the spring cage, spring seat first.

> **CAUTION:** Install a new spring seat (Fig. 38) in a former injector if a new design spray tip assembly is used.

5. Place the spring cage, spring seat and valve spring assembly (valve spring down) on top of the check valve cage.

> **CAUTION:** When installing a new spray tip assembly in a former injector, a new valve spring seat must also be installed. The current needle valve has a shorter quill.

6. Insert the needle valve, tapered end down, inside of the spray tip (Fig. 2). Then place the spray tip and needle valve on top of the spring cage with the quill end of the needle valve in the hole in the spring cage.

7. Lubricate the threads in the injector nut and carefully thread the nut on the injector body by hand. Rotate the spray tip between your thumb and first finger while threading the nut on the injector body (Fig. 39). Tighten the nut as tight as possible by hand. At this point there should be sufficient force on the spray tip to make it impossible to turn with your fingers.

8. Use socket J 4983-41 and a torque wrench to tighten the injector nut to 75-85 lb-ft (102-115 Nm) torque (Fig. 40).

> **NOTE:** Do not exceed the specified torque. Otherwise, the nut may be stretched and result in improper sealing of the lapped surfaces in a subsequent injector overhaul.

Assemble Plunger and Follower

1. Refer to Fig. 37 and slide the head of the plunger into the follower.

2. Invert the injector in the assembly fixture (filter cap end up) and push the rack all the way in. Then place the follower spring on the injector body.

3. Refer to Fig. 41 and place the stop pin on the injector body so that the follower spring rests on the narrow flange of the stop pin. Then align the slot in the follower with the stop pin hole in the injector body. Next align the flat side of the plunger with the slot in the follower. Then insert the free end of the plunger in the injector body. Press down on the follower and at the same time press the stop pin into position. When in place, the spring will hold the stop pin in position.

Check Spray Tip Concentricity

To assure correct alignment, check the concentricity of the spray tip as follows:

1. Place the injector in the concentricity gage J 5119 as shown in Fig. 42 and adjust the dial indicator to zero.

2. Rotate the injector 360° and note the total runout as indicated on the dial.

3. If the total runout exceeds .008", remove the injector from the gage. Loosen the injector nut, center the spray tip and tighten the nut to 75-85 lb-ft (102115 Nm) torque. Recheck the spray tip concentricity. If, after several attempts, the spray tip cannot be positioned satisfactorily, replace the injector nut.

Test Reconditioned Injector

Before placing a reconditioned injector in service, perform all of the tests (except the visual inspection of the plunger) previously outlined under Test Injector.

The injector is satisfactory if it passes these tests. Failure to pass any one of the tests indicates that defective or dirty parts have been assembled. In this case, disassemble, clean, inspect, reassemble and test the injector again.

install Injector

Before installing an injector in an engine, remove the carbon deposits from the beveled seat of the injector tube in the cylinder head. This will assure correct alignment of the injector and prevent any undue stresses from being exerted against the spray tip.

Use injector tube bevel reamer J 5286-9, Section 2.1.4, to clean the carbon from the injector tube. Exercise care to remove ONLY the carbon so that the proper clearance between the injector body and the cylinder head is maintained. Pack the flutes of the reamer with grease to retain the carbon removed from the tube.

Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter cap until it runs out of the outlet filter cap.

Install the injector in the engine as follows:

1. Refer to Fig. 6 and insert the injector into the injector tube with the dowel pin in the injector body registering with the locating hole in the cylinder head.

2. Slide the injector rack control lever over so that it registers with the injector rack.

3. Install the injector clamp, special washer (with curved side toward injector clamp) and bolt. Tighten the bolt to 20-25 lb-ft (27-34 Nm) torque. Make sure that the clamp does not interfere with the injector follower spring or the exhaust valve springs.

> **NOTE:** Check the injector control rack for free movement. Excess torque can cause the control rack to stick or bind.

4. Move the rocker arm assembly into position and secure the rocker arm brackets to the cylinder head by tightening the bolts to the torque specified in Section 2.0.

> **CAUTION:** On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridge is not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Therefore, note the position of the exhaust valve bridge before, during and after tightening the rocker shaft bolts.

5. Remove the shipping caps. Then install the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-41 to tighten the connections to 12-15 lb-ft (16-20 Nm) torque.

> **CAUTION:** Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared end of the fuel line and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

6. Perform a complete engine tune-up as outlined in Section 14. However, if only one injector has been removed and replaced and the other injectors and the governor adjustment have not been disturbed, it will only be necessary to adjust the valve clearance and time the injector for the one cylinder, and to position the injector rack control lever.

FUEL INJECTOR TUBE

The bore in the cylinder head for the fuel injector is directly through the cylinder head water jacket as shown in Fig. 1. To prevent coolant from contacting the injector and still maintain maximum cooling of the injector, a tube is pressed into the injector bore. This tube is sealed at the top with a neoprene ring and upset into a flare on the lower side of the cylinder head to create water-tight and gas-tight joints at the top and bottom.

Remove Injector Tube

When removal of an injector tube is required, use injector tube service tool set J 22525 as follows

1. Remove, disassemble and clean the cylinder head as outlined in Section 1.2.

2. Place the injector tube installer J 5286-4 in the injector tube. Insert the pilot J 5286-5 through the small opening of the injector tube and thread the pilot into the tapped hole in the end of the installer (Fig. I).

3. Tap on the end of the pilot to loosen the injector tube. Then lift the injector tube, installer and pilot from the cylinder head.

Install Injector Tube

Thoroughly clean the injector tube hole in the cylinder head to remove dirt, burrs or foreign material that may prevent the tube from seating at the lower end or sealing at the upper end. Then install the tube as follows:

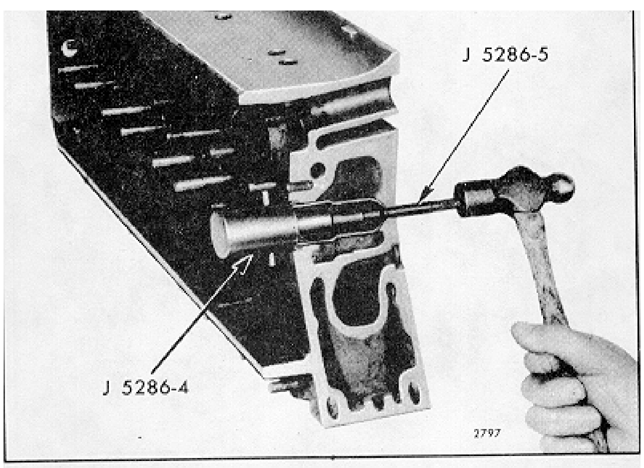


Fig. 1 - Removing Injector Tube

1. Place a new injector tube seal 'ring in the counterbore in the cylinder head.

2. Place the installer J 5286-4 in the injector tube. Then insert the pilot J 5286-5 through the small opening of the injector tube and thread it into the tapped end of the installer (Fig. 2).

3. Slip the injector tube into the injector bore and drive it in place as shown in Fig. 2. Sealing is accomplished between the head counterbore (inside diameter) and outside diameter of the injector tube. The tube flange is merely used to retain the seal ring.

4. With the injector tube properly positioned in the cylinder head, upset (flare) the lower end of the injector tube as follows:

   a. Turn the cylinder head bottom side up, remove the pilot J 5286-5 and thread the upsetting die J 5286-6 into the tapped end of the installer J 5286-4 (Fig. 3).

   b. Then, using a socket and torque wrench, apply approximately 30 lb-ft (41 Nm) torque on the upsetting die.

   c. Remove the installing tools and ream the injector tube as outlined below.

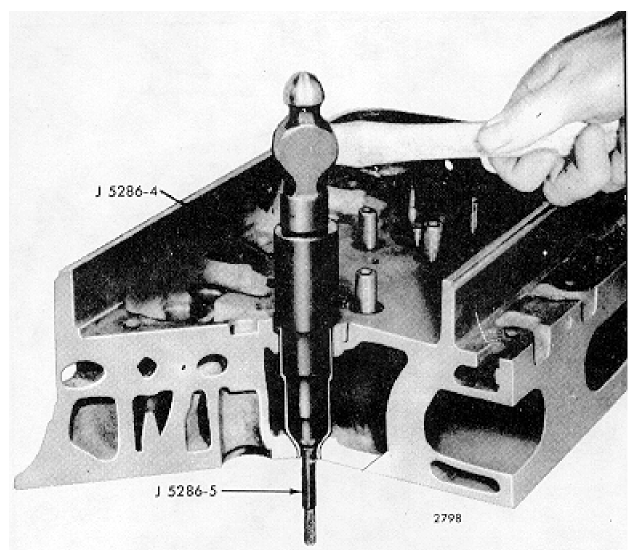


Fig. 2 - Installing Injector Tube

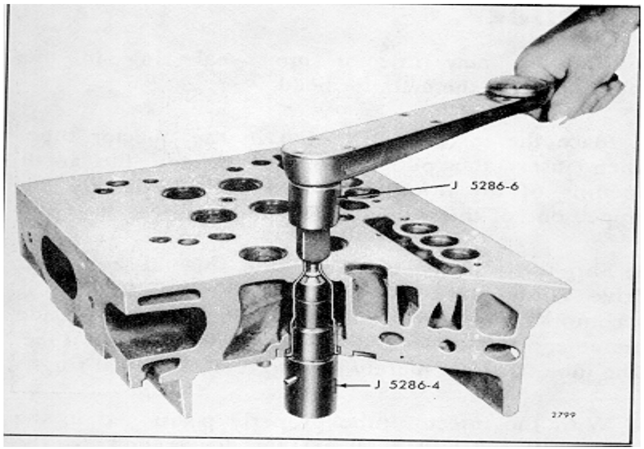


Fig. 3 - Upsetting Injector Tube

Ream Injector Tube

After an injector tube has been installed in a cylinder head, it must be finished in three operations: First, hand reamed, as shown in Fig. 4, to receive the injector body nut and spray tip; second, spot-faced to remove excess stock at the lower end of the injector tube; and third, hand reamed, as shown in Fig. 5, to provide a good seating surface for the bevel or the lower end of the injector nut. Reaming must be done carefully and without undue force or speed so as to avoid cutting through the thin wall of the injector tube.

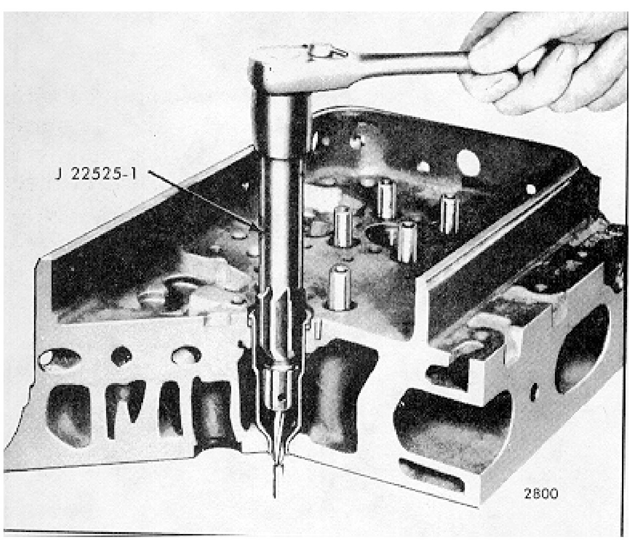


Fig. 4 Reaming Injector Tube for Injector Body Nut and Spray Tip

NOTE: The reamer should be turned in a clockwise direction only, both when inserting and when withdrawing the reamer, because movement in the opposite direction will dull the cutting edges of the flutes.

1. Ream the injector tube for the injector nut and spray tip. With the cylinder head right side up and the injector tube free from dirt, proceed with the first reaming operation as follows:

   a. Place a few drops of light cutting oil on the reamer flutes, then carefully position the reamer J 22525-1 in the injector tube.

   b. Turn the reamer in a clockwise direction (withdrawing the reamer frequently for removal of chips) until the lower shoulder of the reamer contacts the injector tube (Fig. 4). Clean out all of the chips.

2. Remove excess stock:

   a. With the cylinder head bottom side up, insert the pilot of cutting tool J 5286-8 into the small hole of the injector tube.

   b. Place a few drops. of cutting oil on the tool. Then, using a socket and a speed handle, remove the excess stock so that the lower end of the injector tube is from flush to .005" below the finished surface of the cylinder head.

3. Ream the bevel seat in the injector tube: The tapered lower end of the injector tube must provide a smooth and true seat for the lower end of

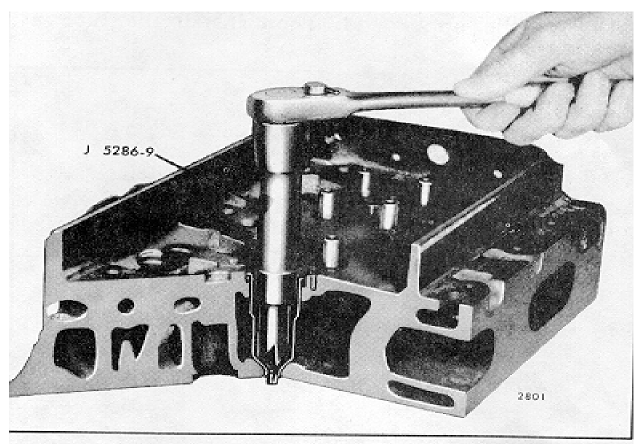


Fig. 5 - Reaming Injector Tube for Injector Nut

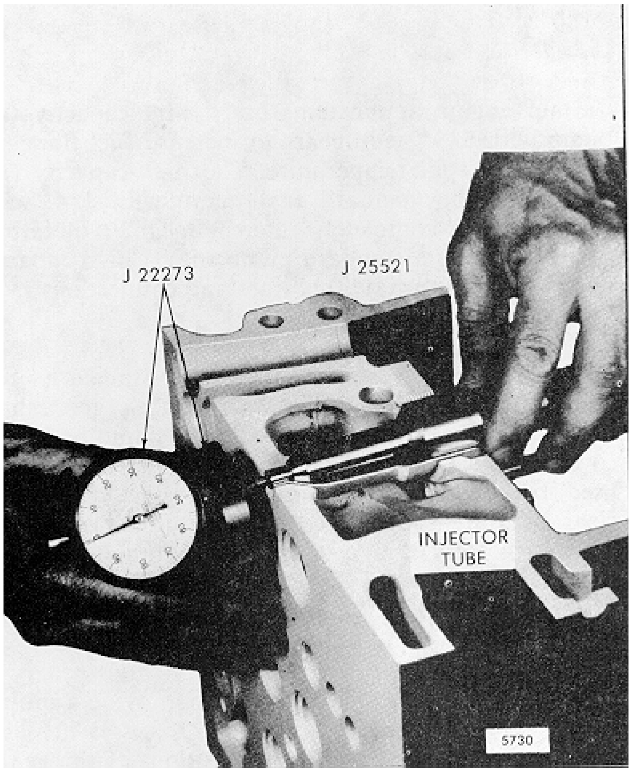


Fig. 6 Measuring Relationship of Bevel Seat in Injector Tube to Fire Deck of Cylinder Head

the injector nut to effectively seal the cylinder pressures and properly position the injector tip in the combustion chamber. Therefore, to determine the amount of stock that must be reamed from the seat of the tube, refer to Fig. 6.

Install gage J 25521 in the injector tube. Zero the sled gage dial. indicator J 22273 to the fire deck. Gage J 25521 should be flush to i.014"with the fire deck of the cylinder head (Fig. 7).

> **NOTE:** Any fire deck re-surfacing work must be done prior to final injector tube seat gaging.

With the first reaming operation completed and the injector tube spot-faced, wash the interior of the injector tube with clean solvent and dry it with

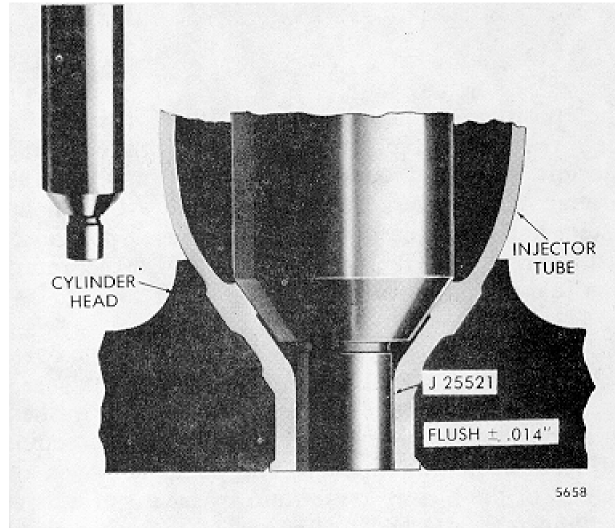


Fig. 7 Measuring Relationship of Gage to Fire Deck of Cylinder Head

compressed air. Then perform the second reaming operation as follows:

a. Place a few drops of cutting oil on the bevel seat of the tube. Carefully lower the reamer J 5286-9 into the injector tube until it contacts the bevel seat.

b. Make a trial cut by turning the reamer steadily without applying any downward force on the reamer. Remove the reamer, blow out the chips and look at the bevel seat to see what portion of the seat has been cut.

c. Proceed carefully with the reaming operation, withdrawing the reamer occasionally to observe the reaming progress.

d. Remove the chips from the injector tube and, using gage J 25521, continue the reaming operation until the shoulder of the spray tip is flush to .014"with the fire deck of the cylinder head as shown in Fig. 7. Then wash the interior of the injector tube with clean solvent and dry it with compressed air.

FUEL PUMP

The positive displacement gear-type fuel pump (Fig. 1) transfers fuel from the supply tank to the fuel injectors. The pump circulates an excess supply of fuel through the injectors which purges the air from the system and cools the injectors. The unused portion of fuel returns to the fuel tank by means of a fuel return manifold and fuel return line.

The fuel pump is attached to the rear end plate cover of the blower assembly with three bolt and seal assemblies. The seals are flat, soft copper washers which prevent the oil in the blower cover from seeping out around the bolt threads. The pump is driven off the end of the blower lower rotor by means of a drive coupling fork attached to the end of the pump drive shaft and mating with a drive disc attached to the blower rotor as shown in Fig. 2.

On certain applications, the fuel pump is attached to a special flywheel housing large hole cover. It is driven off of the balance shaft gear by means of a drive coupling fork attached to the end of the pump drive shaft and mating with a drive adapter bolted to the balance shaft gear.

Fuel pumps are furnished in left-hand or right-hand rotation, according to the engine model, and are stamped "LH IN" or "RH IN". The left-hand pumps are used on LA-LB-RA-RB engines while the right-hand pumps are used on LC-LD-RC-RD engines. These pumps are not interchangeable, nor can a pump made for one rotation be rebuilt for the other rotation since the relief valve can be installed in only one position in the pump body.

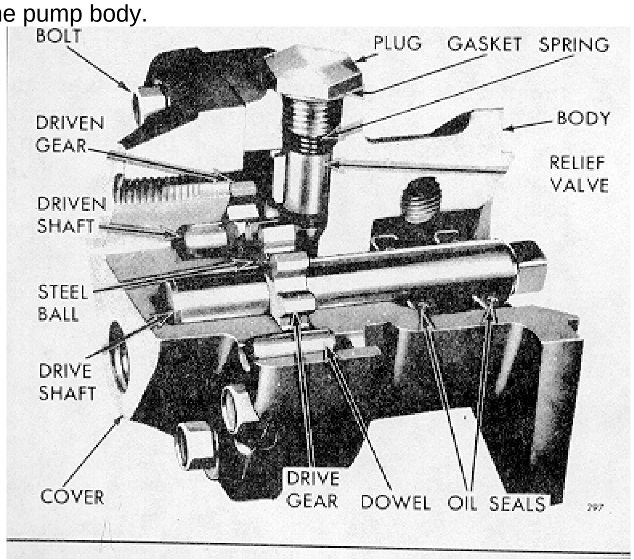


Fig. 1 Typical Fuel Pump Assembly

Certain engine applications use a high-capacity fuel pump with 3/8 "wide gears to increase fuel flow and reduce fuel spill temperature. The high-capacity fuel pump and the standard fuel pump with 1/4"wide gears are not completely interchangeable; therefore, when replacing a standard pump with a high-capacity pump, the appropriate fuel lines and connections must be used.

The fuel pump cover and body are positioned by two dowels. The dowels aid in maintaining gear shaft alignment. The mating surfaces of the pump body and cover are perfectly flat ground surfaces. No gasket is used between the cover and body since the pump clearances are set up on the basis of metal-to-metal contact. A very thin coat of sealant provides a seal against any minute irregularities in the mating surfaces. Cavities in the pump cover accommodate the ends of the drive and driven shafts.

The fuel pump body is recessed to provide running space for the pump gears (Fig. 3). Recesses are also provided at the inlet and outlet positions of the gears. The small hole "A" permits the fuel oil in the inlet side of the pump to lubricate the relief valve at its outer end and to eliminate the possibility of a hydrostatic lock which would render the relief valve inoperative. Pressurized fuel contacts the relief valve through hole "B" and provides for relief of excess discharge pressures. Fuel re-enters the inlet side of the pump through hole "C" when the discharge pressure is great enough to move the relief valve back from its seat. Part of the relief valve may be seen through hole "C". The cavity "D" provides escape for the fuel oil which is squeezed out of the gear teeth as they mesh together on the discharge side of the pump. Otherwise, fuel trapped at the root of the teeth would tend to force the gears apart, resulting in undue wear on the gears, shafts, body and cover.

Two oil seals are pressed into the bore in the flanged side of the pump body to retain the fuel oil in the pump and the lubricating oil in the blower timing gear compartment. The oil seals are installed with the lips of the seals facing toward the flanged end of the pump body. A small hole "E" (Fig. 3) serves as a vent passageway in the body, between the inner oil seal and the suction side of the pump, which prevents building up any fuel oil pressure around the shaft ahead of the inner seal.

Some fuel oil seepage by the fuel pump seals can be expected, both with a running engine and immediately after an engine has been shut down. This is especially true with a new fuel pump and/or new pump seals, as the seals have not yet conformed to the pump drive

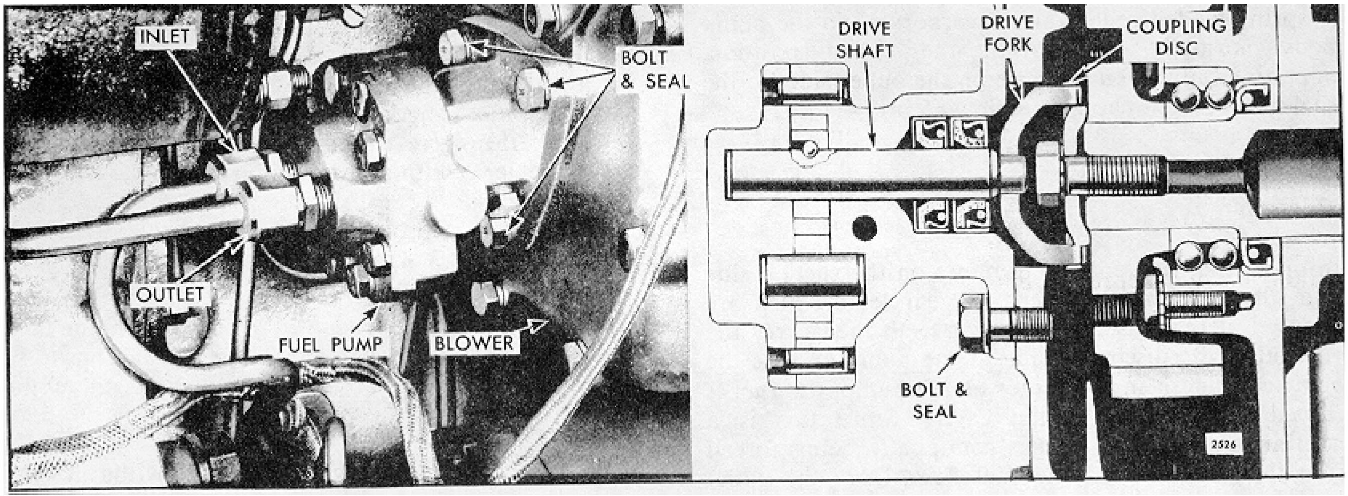


Fig. 2 - Typical Fuel Pump Mounting and Drive

shaft. Fuel pump seals will always allow some seepage. Tapped holes in the pump body are provided to prevent fuel oil from being retained between the seals. Excessive fuel retention between the seals could provide enough pressure to cause engine oil dilution by fuel, therefore, drainage of the excess fuel oil is mandatory. However, if leakage exceeds one drop per minute, replace the seals.

The drive and driven gears are a line-to-line to .001 "press fit on their shafts. The drive gear is provided with a gear retaining ball to locate the gear on the shaft (Fig. 2).

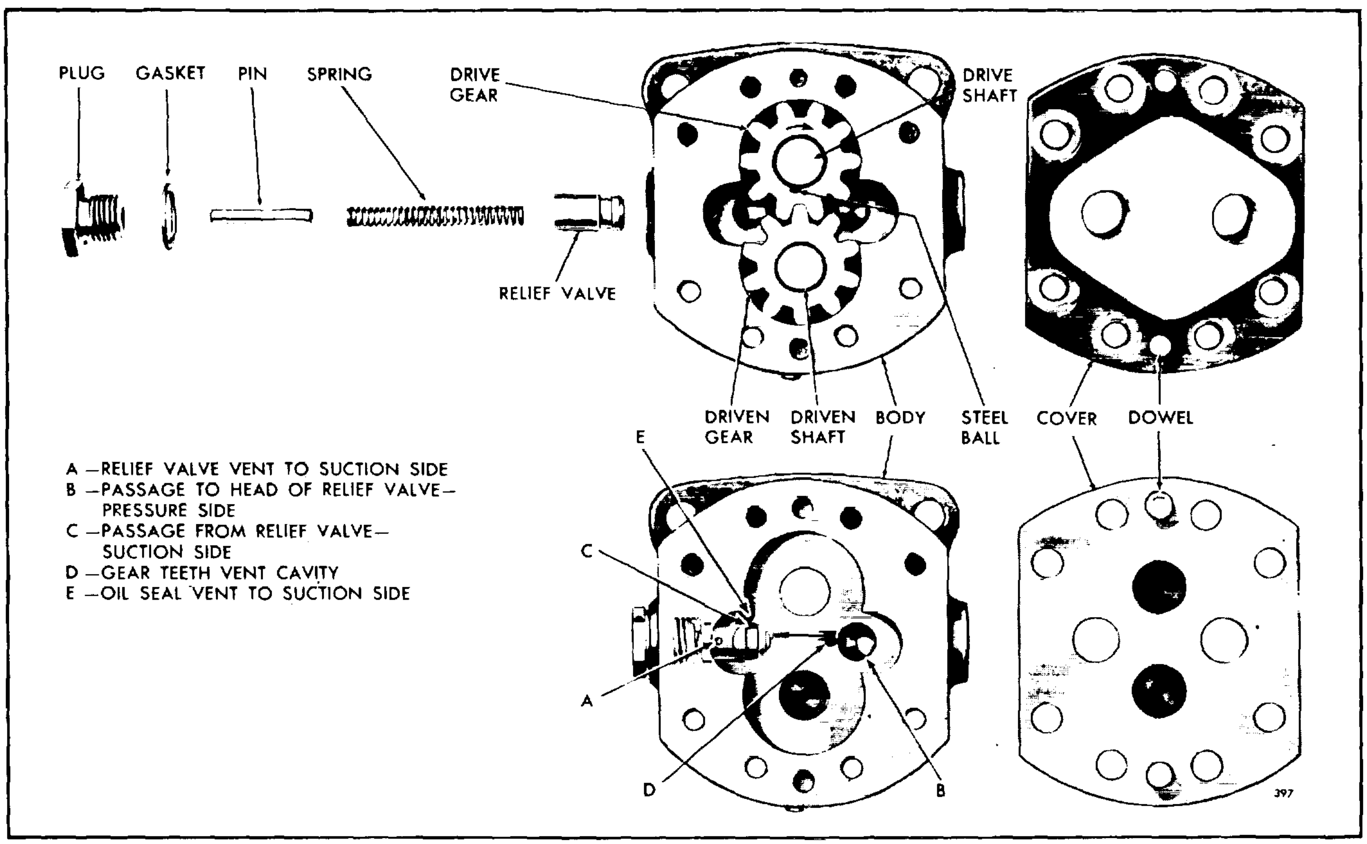


Fig. 3 - Fuel Pump Valving and Rotation (Right-Hand Pump)

A spring-loaded relief valve incorporated in the pump body normally remains in the closed position, operating only when pressure on the outlet side (to the fuel filter) reaches approximately 65 psi (448 kPa).

Operation

In operation, fuel enters the pump on the suction side and fills the space between the gear teeth which are exposed at that instant. The gear teeth then carry the fuel oil to the discharge side of the pump and, as the gear teeth mesh in the center of the pump, the fuel is forced out into the outlet cavity. Since this is a continuous cycle and fuel is continually being forced into the outlet cavity, the fuel flows from the outlet cavity into the fuel lines and through the engine fuel system under pressure.

The pressure relief valve relieves the discharge pressure by by-passing the fuel from the outlet side of the pump to the inlet side when the discharge pressure reaches approximately 65 to 75 psi (448 to 517 kPa).

The fuel pump should maintain the fuel pressure at the fuel inlet manifold as shown in Section 13.2.

Remove Fuel Pump

1. Disconnect the fuel lines from the inlet and outlet openings of the fuel pump.

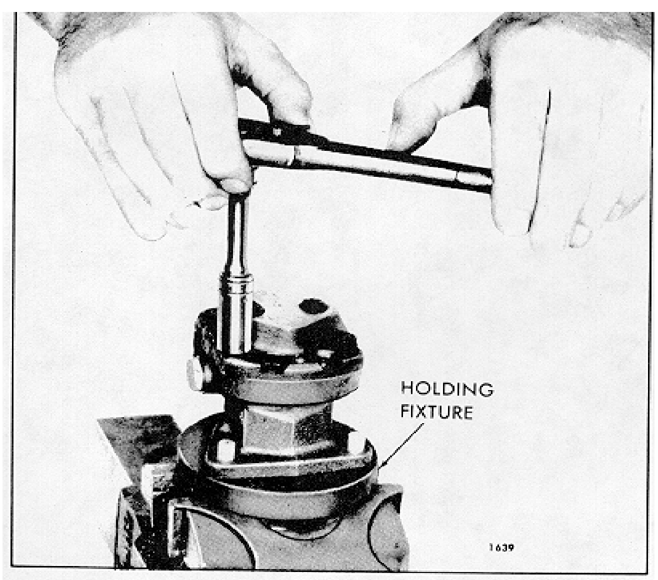


Fig. 4 Removing Fuel Pump Cover 2.

2. Remove the three pump attaching bolt and seal assemblies, using wrench J 4242, and withdraw the pump from the blower.

3. Check the drive coupling fork and, if broken or worn, replace it with a new coupling.

Disassemble Fuel Pump

With the fuel pump removed from the engine and mounted in holding fixture J 1508-10 as shown in Fig. 4, refer to Figs. I and 6 and disassemble the pump as follows:

1. Remove the eight cover bolts and withdraw the pump cover from the pump body. Use care not to damage the finished faces of the pump body and cover.

2. Withdraw the drive shaft, drive gear and gear retaining ball as an assembly from the pump body.

3. Press the drive shaft just far enough to remove the steel locking ball. Then invert the shaft and gear assembly and press the shaft from the gear. Do not misplace the steel ball. Do not press the squared end of the shaft through the gear as slight score marks will damage the oil seal contact surface.

4. Remove the driven shaft and gear as an assembly from the pump body. Do not remove the gear from the shaft. The driven gear and shaft are serviced only as an assembly.

5. Remove the relief valve plug and copper gasket.

6. Remove the valve spring, pin and relief valve from the valve cavity in the pump body.

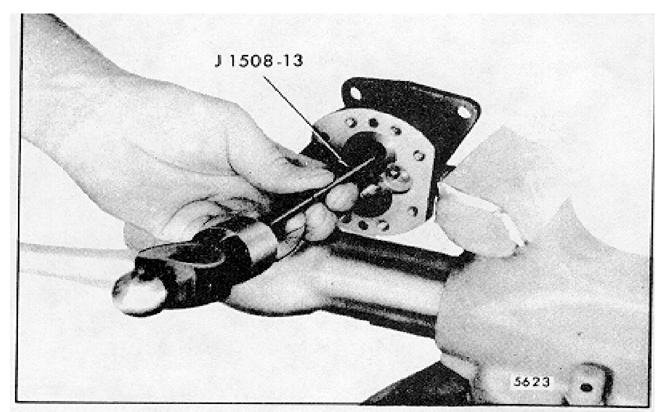


Fig. 5 - Removing Oil Seals

7. If the oil seals need replacing, remove them with oil seal remover J 1508-13 (Fig. 5). Clamp the pump body in a bench vise and tap the end of the tool with a hammer to remove the outer and inner seals.

> **NOTE:** Observe the position of the oil seal lips before removing the old seals to permit installation of the new seals in the same position.

Inspection

Clean all of the parts in clean fuel oil and dry them with compressed air.

Oil seals, once removed from the pump body, must be discarded and replaced with new seals.

Check the pump gear teeth for scoring, chipping or wear. Check the ball slot in the drive gear for wear. If necessary, replace the gear.

Inspect the drive and driven shafts for scoring or wear. Replace the shafts if necessary. The driven shaft is serviced as a gear and shaft assembly only.

The mating faces of the pump body and cover must be flat and smooth and fit tightly together. Any scratches or slight damage may result in pressure leaks. Also check for wear at areas contacted by the gears and shafts. Replace the pump cover or body if necessary.

The relief valve must be free from score marks and burrs and fit its seat in the pump body. If the valve is scored and cannot be cleaned up with fine emery cloth or crocus cloth, it must be replaced.

Current standard fuel pumps (with 1/4"wide gears) incorporate a 1/8" shorter pump body with three drain holes, a 1/8" shorter drive shaft and a cover with a 3/8"inlet opening. When replacing a former pump, a 3/8"x 1/4" reducing bushing is required for the inlet opening and the unused drain holes must be plugged.

Assemble Fuel Pump

Refer to Figs. 1, 3 and 6 and assemble the pump as follows:

I. Lubricate the lips of the oil seals with a light coat of

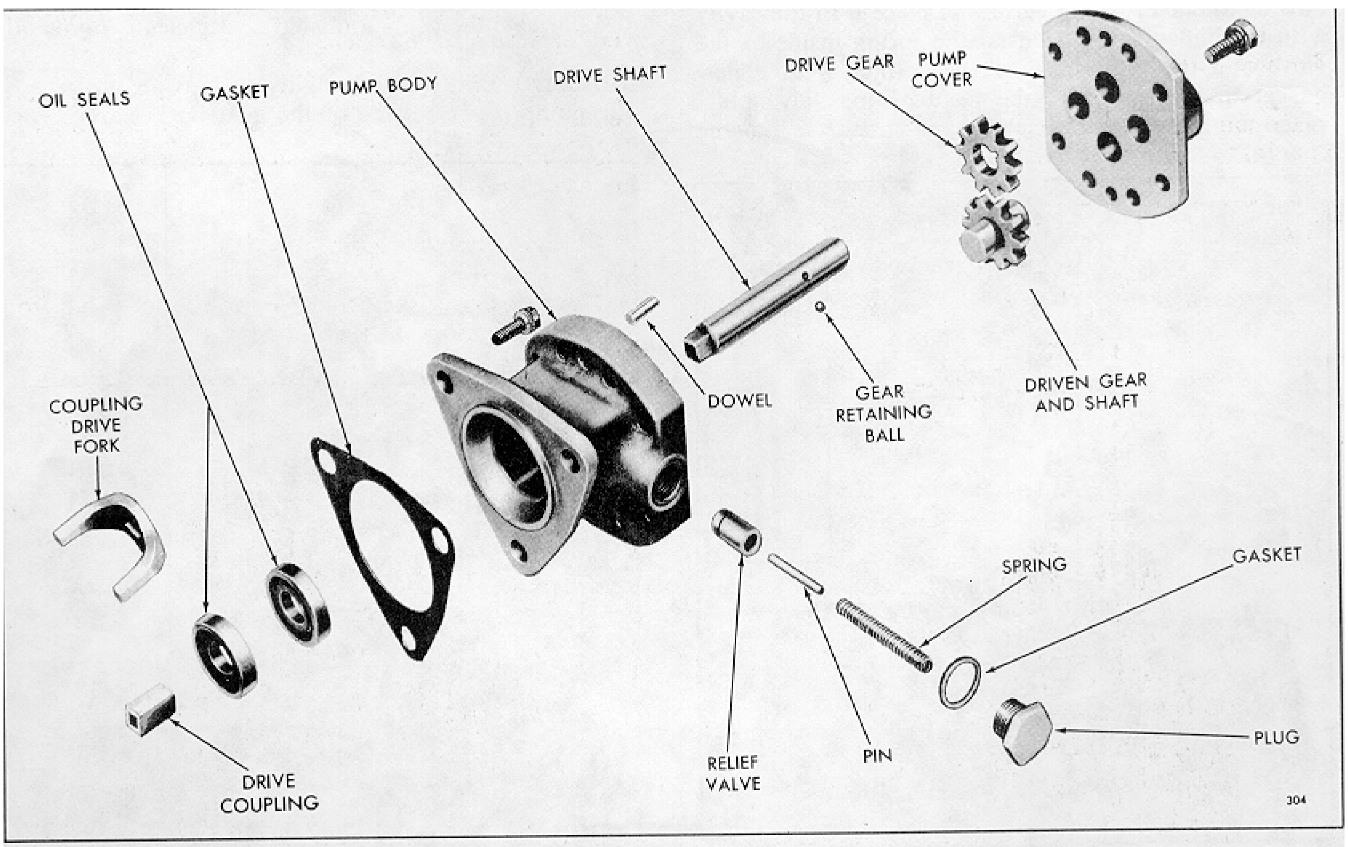


Fig. 6 - Fuel Pump Details and Relative Location of Parts

vegetable shortening, then install the oil seals in the pump body as follows:

a. Place the inner oil seal on the pilot of the installer handle J 1508-8 so that the lip of the seal will face in the same direction as the original seal which was removed.

b. With the pump body supported on wood blocks (Fig. 7), insert the pilot of the installer handle in the pump body so the seal starts straight into the pump flange. Then drive the seal in until it bottoms.

c. Place the shorter end of the adapter J 1508-9 over the pilot and against the shoulder of the installer handle. Place the outer oil seal on the pilot of the installer handle with the lip of the seal facing the adapter. Then insert the pilot of the installer handle into the pump body and drive the seal in (Fig. 8) until the shoulder of the adapter contacts the pump body. Thus the oil seals will be positioned so that the space between them will correspond with the drain holes located in the bottom of the pump body.

2. Clamp the pump body in a bench vise (equipped with soft jaws) with the valve cavity up. Lubricate the outside diameter of the valve and place it in the cavity with the hollow end up. Insert the spring inside of the valve and the pin inside of the spring. With a new gasket in place next to the head of the valve plug, place the plug over the spring and thread it into the pump body. Tighten the 1/2"-20 plug to 18-24 Ib-ft (24-33 Nm) torque.

3. Install the fuel pump drive gear over the end of the drive shaft which is not squared (so the slot in the gear will face the plain end of the shaft). This operation is very important, otherwise fine score marks caused by pressing the gear into position from the square end of the shaft may cause rapid wear of the oil seals. Press the gear beyond the gear retaining ball detent. Then place the ball in the detent and press the gear back until the end of the slot contacts the ball.

4. Lubricate the pump shaft and insert the square end of the shaft into the opening at the gear side of the pump body and through the oil seals as shown in Fig. 9.

5. Place the driven shaft and gear assembly in the pump body.

> **CAUTION:** The driven gear must be centered on the shaft to give proper end clearance. Also, the chamfered end of the gear teeth of the production gear must face the pump body. If a service replacement gear with a slot is used, the slot must face toward the pump cover.

6. Lubricate the gears and shafts with clean engine oil.

7. Apply a thin coat of quality sealant on the face of the pump cover outside of the gear pocket area. Then

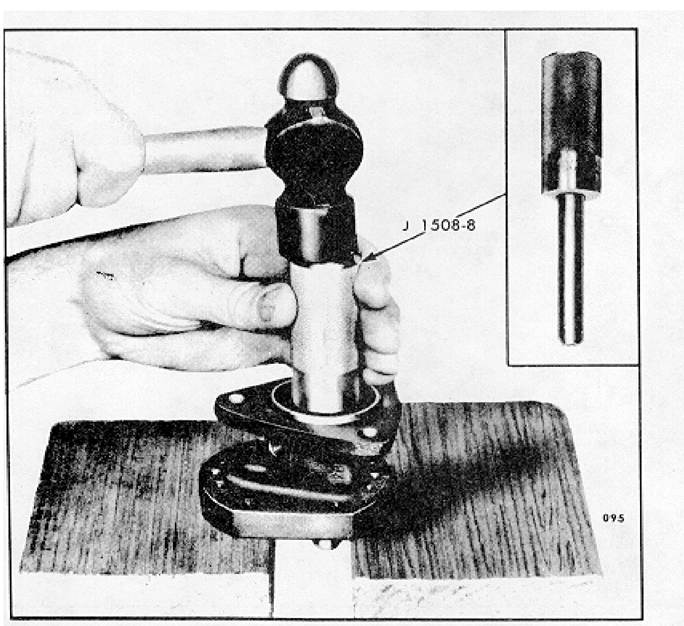


Fig. 7 Installing Inner Oil Sea

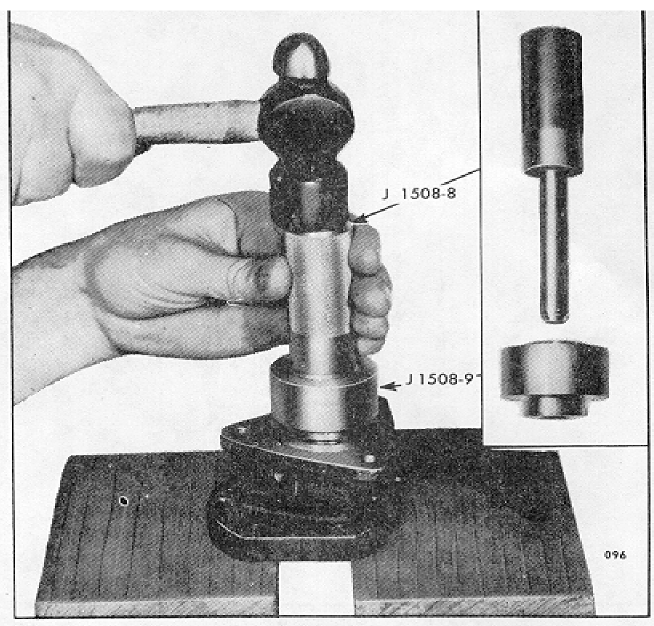


Fig. 8 - Installing Outer Oil Seal

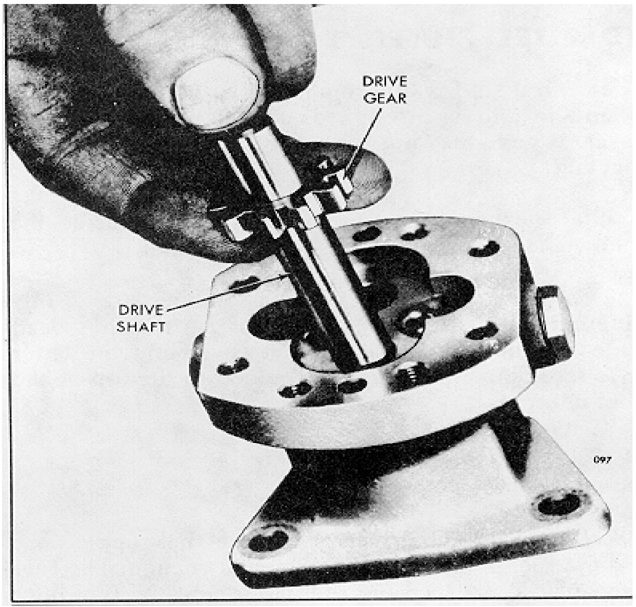


Fig. 9 Installing Fuel Pump Drive Shaft and Gear Assembly

place the cover against the pump body with the two dowel pins in the cover entering the holes in the pump body. The cover can be installed in only one position over the two shafts.

> **CAUTION:** The coating of sealant must be extremely thin since the pump clearances have been set up on the basis of metal-to-metal contact. Too much sealant could increase the clearances and affect the efficiency of the pump. Use care that sealant is not squeezed into the gear compartment, otherwise damage to the gears and shafts may result.

8. Secure the cover in place with eight bolts and lock washers, tightening the bolts alternately and evenly.

9. After assembly, rotate the pump shaft by hand to make certain that the parts rotate freely. If the shaft does not rotate freely, attempt to free it by tapping a corner of the pump.

10. Install 1/8 " pipe plugs in the upper' unused drain holes.

11. If the pump is not to be installed immediately, place plastic shipping plugs in the inlet and outlet openings to prevent dirt or other foreign material from entering the pump.

Install Fuel Pump

The left-hand pump is used on "A" and "B" engines and the right-hand pump is used on "C" and "D" engines. The pumps are not interchangeable and cannot be rebuilt to operate in an opposite direction. The pump must always be installed with the inlet opening in the pump cover (marked "LH IN" or "RH IN") on the side toward the cylinder block. Note in Fig. 2 that the fuel pump is bolted to the blower. The pump is driven by a drive disc at the rear of the blower lower rotor. Install the pump as follows:

1. Affix a new gasket to the pump body mounting flange. Then place the drive coupling fork on the square end of the drive shaft.

2. Place the fuel pump against the blower, being certain that the drive coupling fork registers with the slots in the drive disc on the blower rotor shaft.

3. Secure the pump to the blower with three nylon patch bolts.

> **NOTE:** To provide improved sealing against leakage, nylon patch bolts are used in place of the former bolt and seal assemblies.

4. If removed, install the fuel inlet and outlet fittings in the pump cover.

5. Connect the inlet and outlet fuel lines to the fuel pump.

6. If the fuel pump is replaced or rebuilt, prime the fuel system before starting the engine. This will prevent the possibility of pump seizure upon initial starting.

FUEL STRAINER AND FUEL FILTER

A fuel strainer (primary) and fuel filter (secondary), Fig. I are used to remove impurities from the fuel.

The fuel strainer is located between the fuel tank and the fuel pump. The replaceable density-type element is capable of filtering out particles of 30 microns (a micron is approximately .00004"). The fuel filter is installed between the fuel pump and the fuel inlet manifold. The replaceable paper-type element (Fig. 2) can remove particles as small as 10 microns.

> **CAUTION:** A fuel tank of galvanized steel should never be used for fuel storage, as the fuel oil reacts chemically with the zinc coating to form powdery flakes which quickly clog the fuel filter and cause damage to the fuel pump and the fuel injectors.

The fuel strainer and fuel filter are essentially the same in construction and operation, and they will be treated as one in this section.

The filter and strainer, illustrated in Figs. 3 and 4, consist basically of a shell, a cover, and a replaceable filtering element. The assembly is made oil tight by a shell gasket, a cover nut or bolt, and a cover nut or bolt gasket.

The central stud is a permanent part of the shell and, when the unit is assembled, extends up through the cover where the nut or bolt holds the assembly together.

A filter element sets over the central stud inside the shell and is centered in the shell by the stud.

The former and current cover assemblies are visibly different by a cast letter "P" (primary) that has been added to the top of the strainer cover and the letter "S" (secondary) that has been added to the top of the filter cover.

Operation

Since the fuel strainer is between the fuel supply tank and the fuel pump, it functions under suction. The fuel filter. placed between the fuel pump and the fuel inlet manifold in the cylinder head, operates under pressure Fuel enters through the inlet passage in the cover and into the-shell surrounding the filter element. Pressure or suction created by the pump causes the fuel to flow through the filter element where dirt particles are removed. Clean fuel flows to the interior of the filter element, up through the central passage in the cover and into the outlet passage, then to the fuel inlet manifold in the cylinder head.

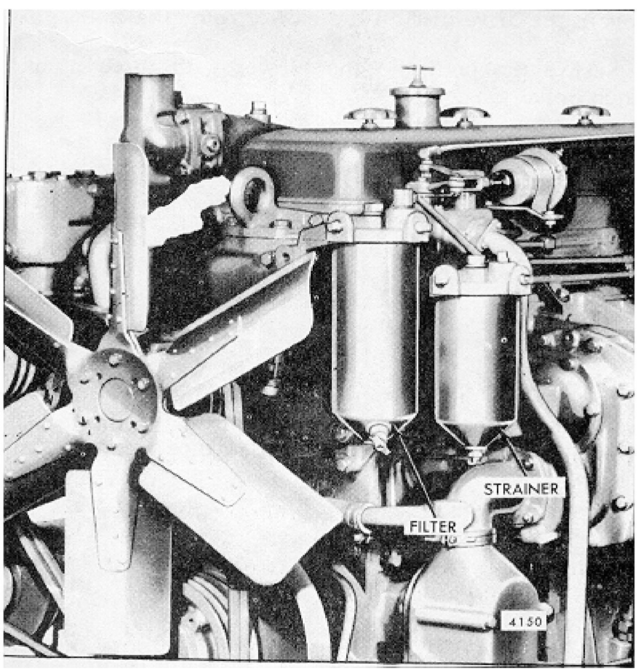


Fig. 1 Typical Mounting of Fuel Filter and Fuel Strainer

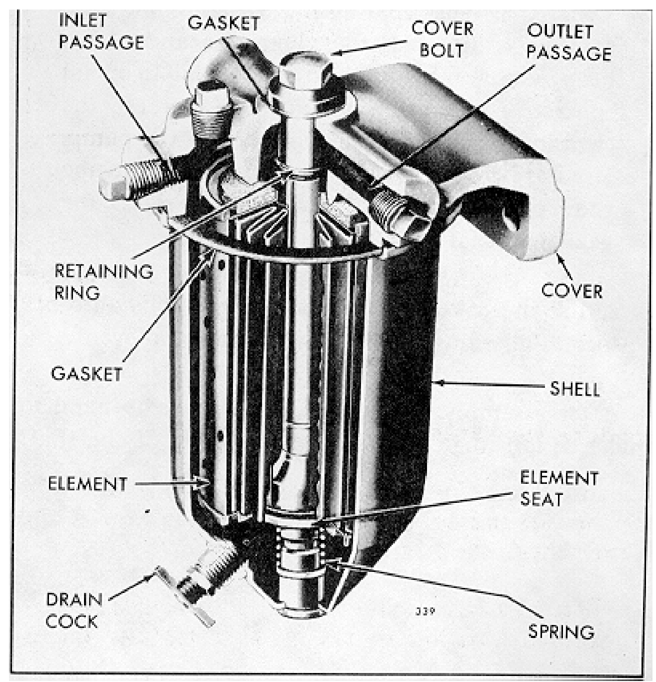


Fig. 2 - Fuel Filter Assembly

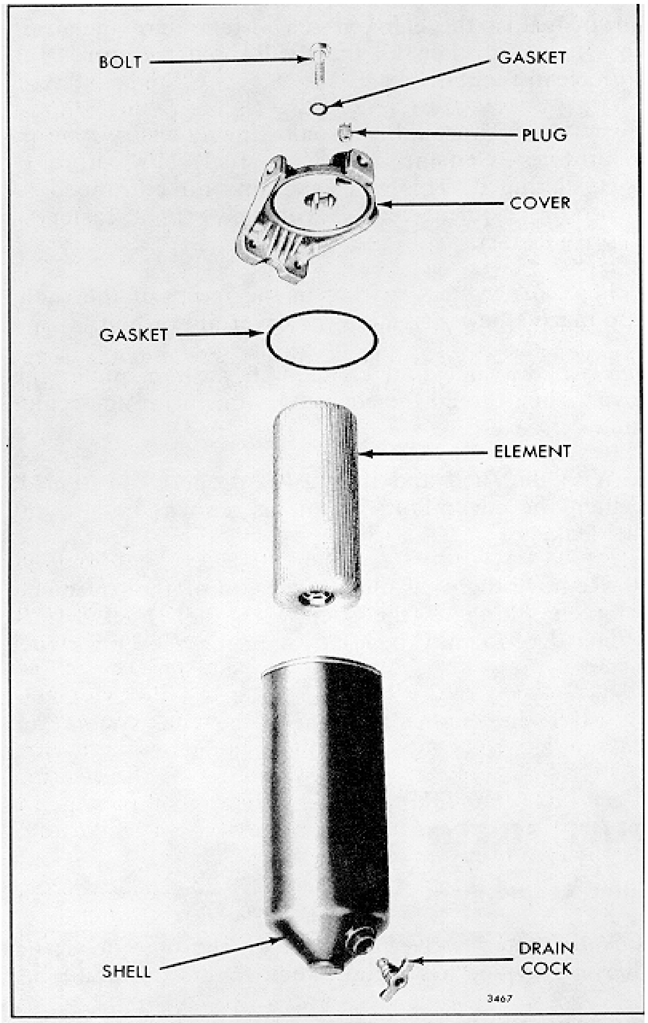


Fig. 3 Fuel Strainer Details and Relative Location of Parts

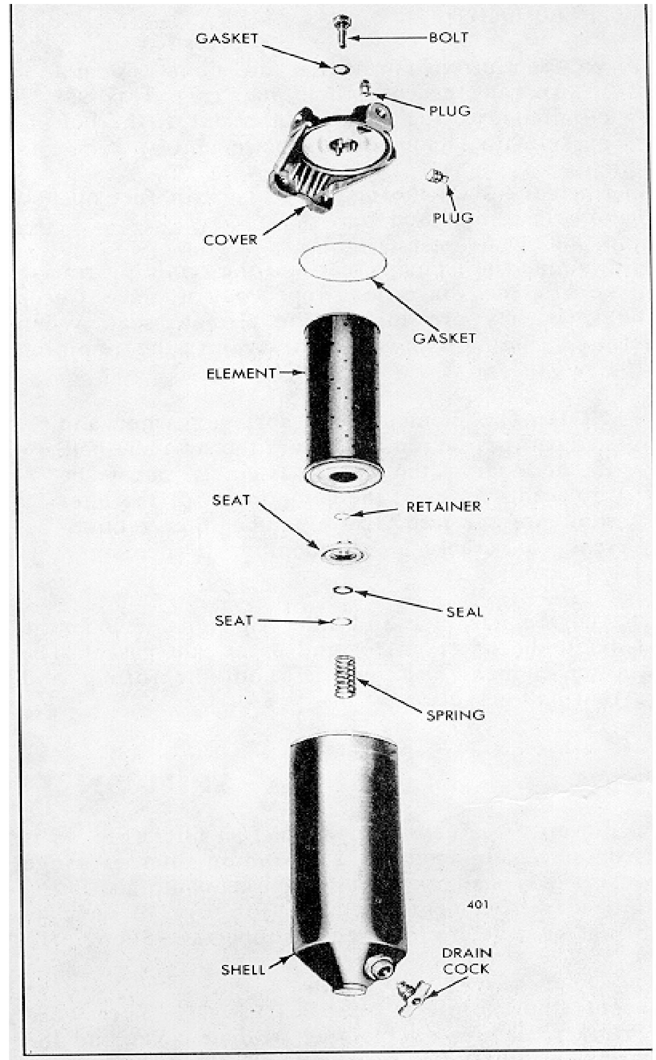


Fig. 4 Fuel Filter Details and Relative Location of Parts

If engine operation is erratic, indicating shortage of fuel or flow obstructions, refer to Trouble Shooting in Section 15.2 for corrective measures.

Replace Fuel Strainer or Filter Element

The procedure for replacing an element is the same for the fuel strainer or fuel filter. Refer to Figs. 3 and 4 and replace the element as follows:

> **CAUTION:** Only filter elements designed for fuel oil filtration should be used to filter the fuel.

1. With the engine stopped, place a container under the strainer or filter and open the drain cock. Loosen the cover nut or bolt just enough to allow the fuel oil to drain out freely. Then close the drain cock.

> **CAUTION:** The wiring harness, starting motor or other electrical equipment must be shielded during the filter change, since fuel oil can permanently damage the electrical insulation.

2. While supporting the shell, unscrew the cover nut or bolt and remove the shell and element. Also remove and discard the cover nut retaining ring, if used.

3. Remove and discard the filter element and shell

gasket, the cover nut or bolt gasket, and, if used, the cover bolt snap ring.

> **NOTE:** Current strainers and filters do not incorporate the cover bolt snap ring. This was eliminated to facilitate replacement of the bolt gasket with each element replacement.

4. Wash the shell thoroughly with clean fuel oil and dry it with compressed air.

5. Examine the element seat and the retaining ring to make sure they have not slipped out of place. Check the spring by pressing on the element seat. When released, the seat must return against the retaining ring.

> **NOTE:** The element seat, spring, washer and seal can not be removed from the strainer shell. If necessary, the shell assembly must be replaced. However, the components of the filter shell are serviced. Examine the filter retainer seal for cracks or hardening. If necessary, replace the seal.

The current strainer and filter elements include the element, the cover gasket and cover bolt gasket. The strainer element also includes both the former and current bolt gaskets.

6. Place a new element over the center stud and push it down against the element seat. Make sure the drain cock is closed, then fill the shell about two-thirds full with clean fuel oil.

> **NOTE:** Thoroughly soak the density-type strainer element in clean fuel oil before installing it. This will expel any air entrapped in the element and is conducive to a faster initial start.

7. Place a new shell gasket in the recess of the shell; also place a new gasket on the cover nut or bolt.

8. Place the shell and element in position under the cover. Then thread the cover bolt (or nut) in the center stud.

9. With the shell and the gasket properly positioned, tighten the cover bolt or nut just enough to prevent fuel leakage.

10. Remove the pipe plug at the top of the cover and complete filling of the shell with fuel. Fuel system primer J 5956 may be used to prime the entire fuel system.

11. Start the engine and check the fuel system for leaks.

SPIN-ON TYPE FUEL FILTER

A spin-on type fuel strainer and fuel filter (Fig. 5) is used on certain engines. The spin-on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly (Fig. 6). No separate springs or seats are required to support the filters.

The filter covers incorporate a threaded sleeve to accept the spin-on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification.

No drain cocks are provided on the spin-on filters. Where water is a problem, it is recommended that a water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

Filter Replacement

A 1 " diameter twelve-point nut on the bottom of the filter is provided to facilitate removal and installation.

Replace the filter as follows

1. Unscrew the filter (or strainer) and discard it.

2. Fill a new filter replacement cartridge about two thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.

3. Install the new filter assembly and tighten it to twothirds of a turn beyond gasket contact.

4. Start the engine and check for leaks.

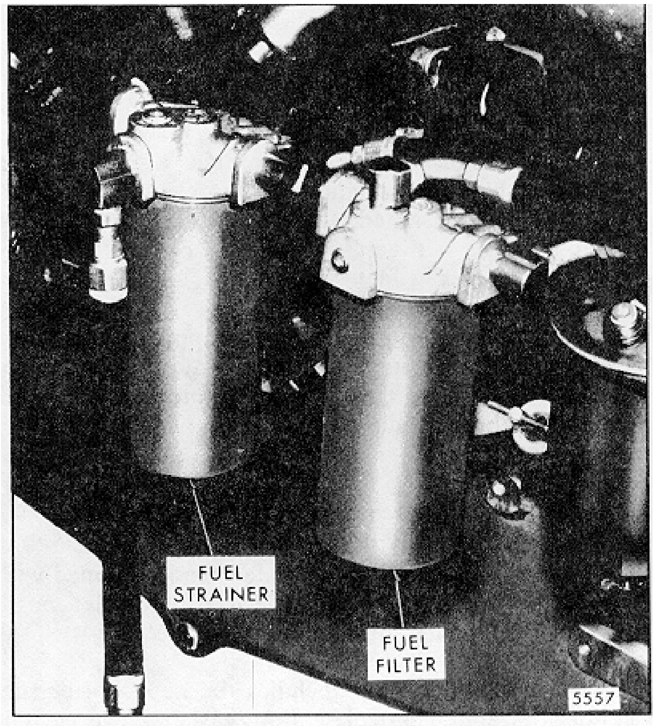


Fig. 5 - Typical Spin-On Filter Mounting

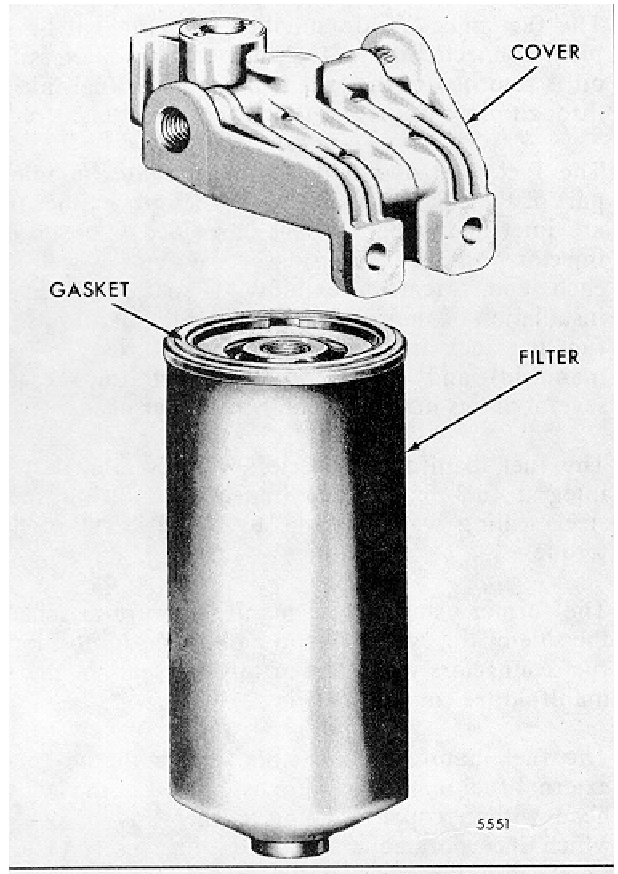


Fig. 6 - Spin-On Filter Details

FUEL MANIFOLD

The fuel injectors are supplied with fuel oil through pipes connected to the fuel inlet manifold. Excess fuel oil is returned to the fuel tank from the fuel injectors through pipes connected to the fuel outlet manifold.

The fuel inlet and outlet manifolds are an integral part of the current cylinder heads (Fig. I). Since there are inlet and outlet passages provided opposite each injector position in the side of the head as well as at each end, greater flexibility is permitted in the installation of the fuel lines to the fuel manifolds. The fuel passages are identified by the words "IN" (top manifold) and "OUT" (bottom manifold) cast in several places in the side of the cylinder head.

The fuel manifold connectors are assembled to the integral fuel manifold cylinder head, using special steel sealing washers, and tightened to 40-45 lb-ft torque.

The former external fuel manifolds were attached to the side of the cylinder head and locked in position by fuel connectors which set in tapered seats in the fuel manifold tee connectors (Fig. 2).

The fuel manifold connectors used with the former external fuel manifolds were assembled to the cylinder head with a copper sealing washer and a lock nut which incorporated a threaded fibre insert (Fig. 3). Later, an unthreaded fibre insert was used and the nut was installed with the fibre end down. Threads were cut into the insert when the nut was assembled to the connector and provided a more effective seal against leakage of lubricating oil to the outside of the cylinder head. In a later change, the staking operation, which secured the insert in place, was omitted from the nut.

This provided a smooth sealing surface on the nut and the copper washer was eliminated. However, a one piece connector which incorporated a nylon insert replaced the former connector and nut. When the connector is installed, the nylon insert effects a complete seal between the threads of the connector and the cylinder head.

A special fitting with a restricted opening is used in the fuel outlet manifold to maintain the proper pressure within the fuel system. Refer to Section 13.2 for the size of restriction used.

Service

When replacing a former cylinder head equipped with external fuel manifolds by a current cylinder head, discard the old fuel manifolds and connectors.

A service cylinder head includes the new shorter fuel connectors and the steel sealing washers. The current and former fuel connectors are not interchangeable. A length of flexible hose and two hose fittings are also provided. Since the fuel inlet can be located at any one of the inlet passages in the side of the head, the flexible hose can be cut to the required length for connecting the fuel filter to the fuel inlet manifold.

The direction of flow of the fuel will, in most cases, be reversed when replacing a cylinder head with the external fuel manifolds by one with the integral manifolds. Therefore, replace the filters before the injectors are reinstalled in the replacement head. Otherwise, damage to the injectors will result due to foreign particles in the filter entering the injector.

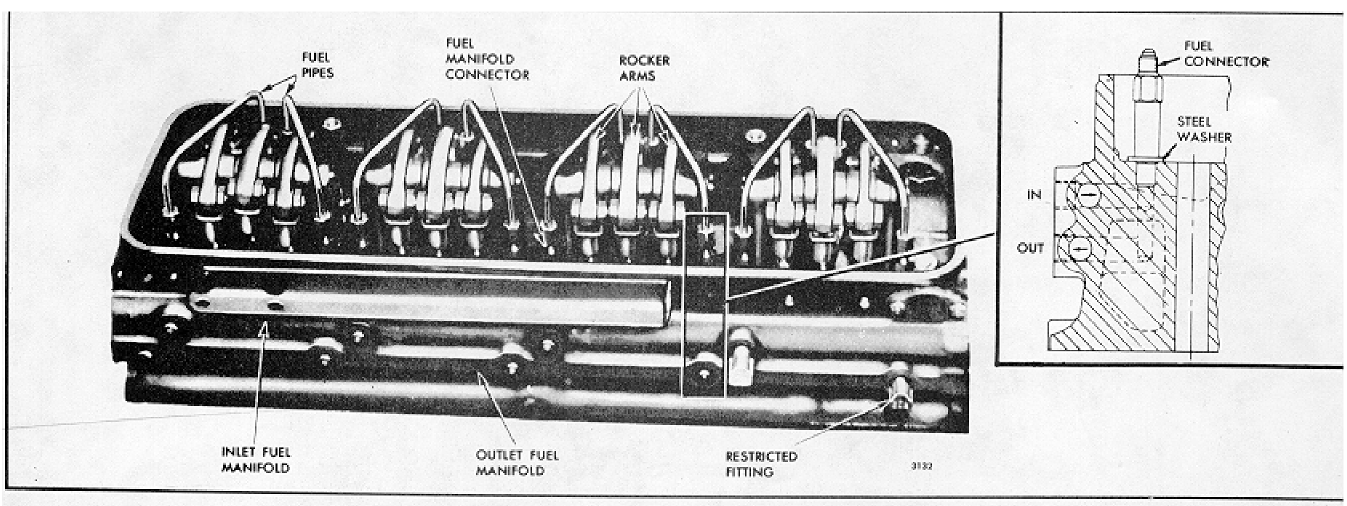


Fig. 1 - Cylinder Head with Integral Fuel Manifolds

2.4 Fuel Manifold

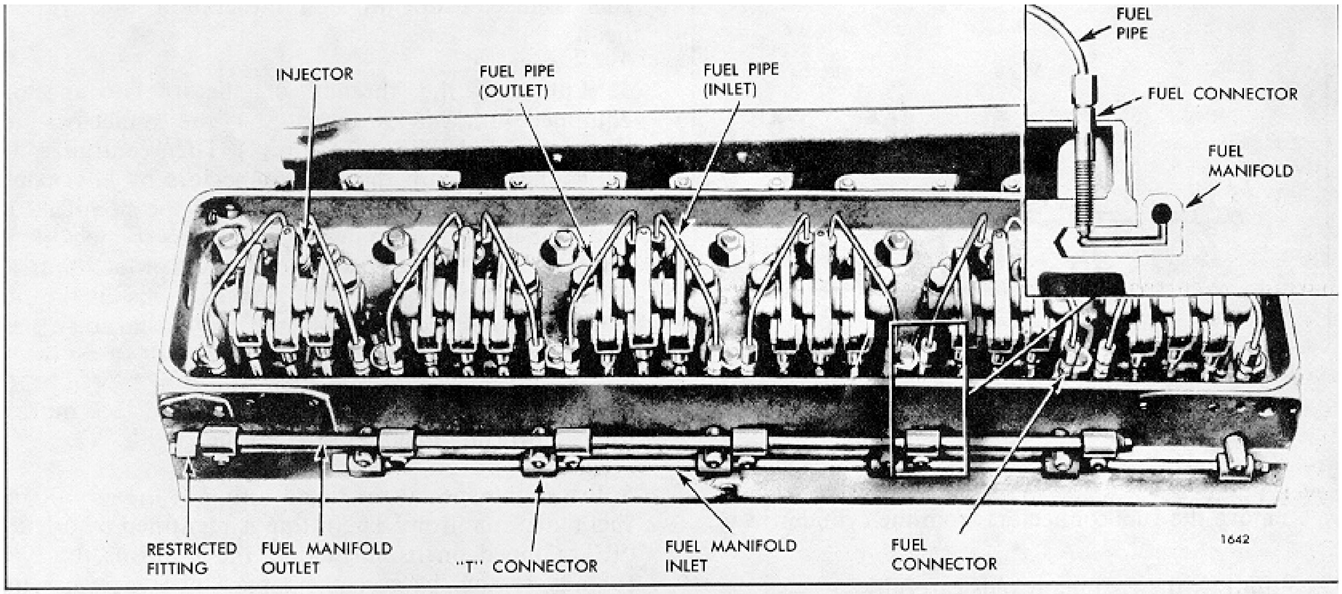


Fig. 2 - Former Cylinder Head with External Fuel Manifolds

Remove External-Type Fuel Manifolds

Remove the fuel manifolds as follows:

1. Clean and remove the valve rocker cover.

2. Refer to Fig. 2 and disconnect the fuel oil pipes from the injectors and the fuel connectors.

3. Disconnect the fuel lines from the fittings at the ends of the manifolds.

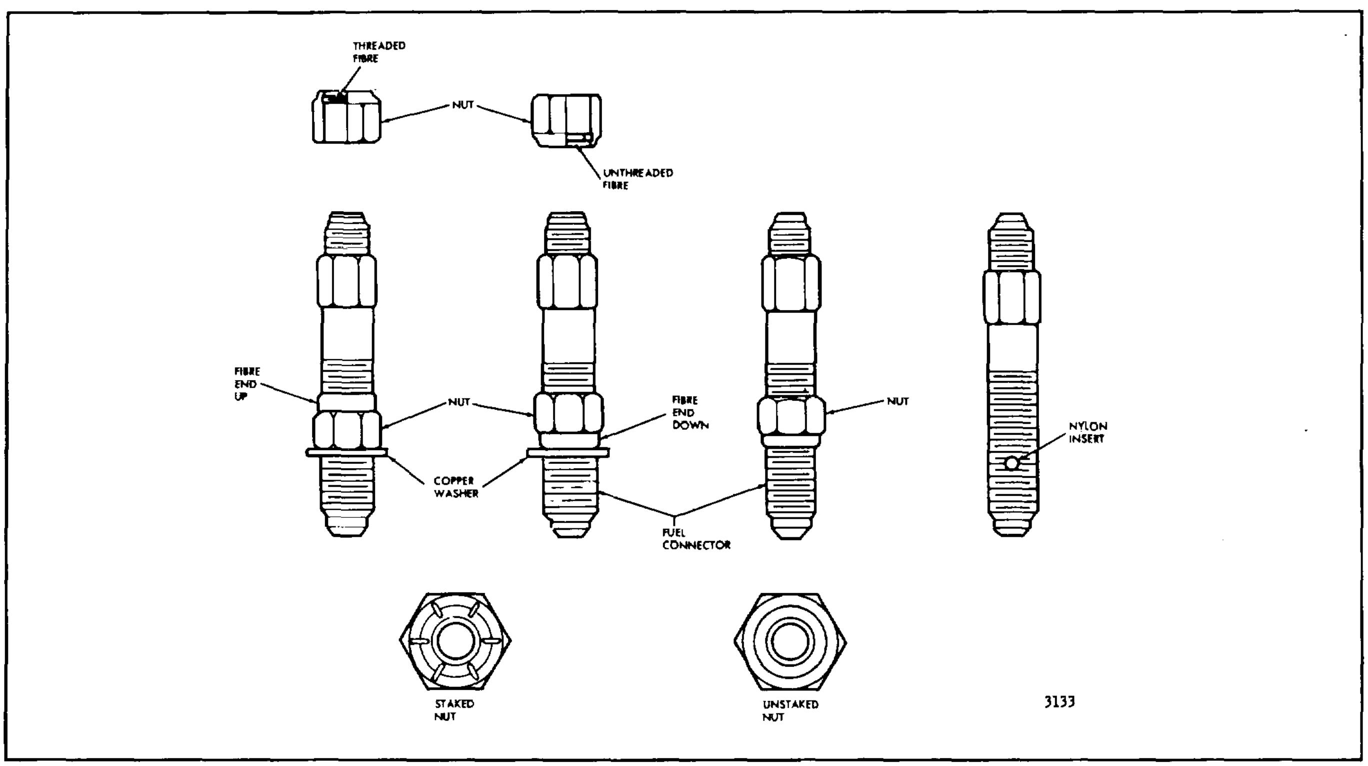


Fig. 3 - Fuel Connectors Used with External Fuel Manifolds

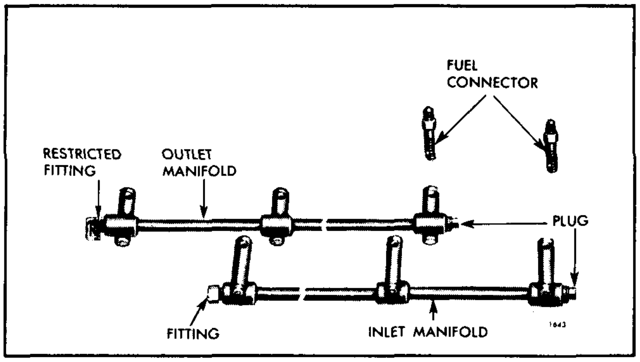


Fig. 4 External Type Fuel Manifold Details and Relative Location of Parts

4. Remove the fuel connectors from the cylinder head.

5. Withdraw the fuel manifolds carefully.

Inspection

Since the former external fuel manifolds are positioned and locked in place by the fuel connectors, be sure the tapered seats in the manifold tee connectors and the tapered ends of the fuel connectors are clean and free of score marks. If scored surfaces cannot be cleaned up, replace the parts.

Install Former External-Type Fuel Manifolds

Refer to Figs. 2 and 4 and note that the tee connectors on the manifolds are on the top side of the lower manifold and on the bottom side of the upper manifold. The upper and lower manifolds are not interchangeable. Install the manifolds as follows:

1. Clean out the cylinder head openings for the fuel connectors and fuel manifold fittings.

2. Guide the tee connectors of the manifolds into the openings in the side of the cylinder head so that the tapered seats are in approximate alignment with the fuel connector openings in the top of the cylinder head.

3. Lubricate the threads of the fuel connectors equipped with a nylon insert. Start the connectors into the tapped holes (inset in Fig. 2). Then centralize the tee connectors with the fuel connectors by alternately turning the connectors while moving the manifold in arid out slightly. Centering the tee connectors is important and necessary to ensure leakproof joints. If a lock nut is used with the connector, install the nut with the fibre end down. If the nut is staked, a new copper sealing washer must also be used.

4. Tighten all of the fuel connectors (and lock nuts, if used) uniformly to 30-35 lb-ft torque.

5. Install the special restricted fitting at the end of the fuel outlet manifold. The fitting is identified by a letter "R" stamped on its surface. If the fitting is replaced for any reason, be sure the replacement part has the same size orifice as the one removed. It is very important that the correct size fitting be installed to maintain the proper fuel pressure and an adequate flow of fuel within the system.

6. Attach the fuel oil pipes to the fuel connectors and the fuel injectors. Be sure the flared ends of the fuel pipes are properly seated before tightening the connections. Use socket J 8932-01 and a torque wrench to tighten the connections to 12-15 Ib-ft torque.

> **CAUTION:** Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening can twist or fracture the flared ends of the fuel pipes and result in fuel leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

7. Connect the fuel lines to the fuel manifolds.

8. Start the engine and check all of the fuel connections for leaks. Lubricating oil diluted with fuel oil can cause serious damage to the engine bearings.

> **NOTE:** Any leakage between the fuel connectors and the tapered 'seats of the manifold tee connectors would be observed at the side of the cylinder head.

9. Install the valve rocker cover, using a new gasket.

MECHANICAL GOVERNORS

Horsepower requirements on an engine may vary due to fluctuating loads; therefore, some method must be provided to control the amount of fuel required to hold the engine speed reasonably constant during load fluctuations. To accomplish this control, a governor is introduced in the linkage between the throttle control and the fuel injectors. The governor is mounted on the front end of the blower and is driven by the upper blower rotor. The following types of mechanical governors ate used:

1. Limiting Speed Mechanical Governor. (Grove Crane Application)

2. Variable Speed Mechanical Governor.

Engines requiring a minimum and maximum speed control, together with manually controlled intermediate speeds, are equipped with a limiting speed mechanical governor.

Engines subjected to varying load conditions that require an automatic fuel compensation to maintain a near constant engine speed, which may be changed manually by the driver, are equipped with a variable speed mechanical governor.

Each type of governor has an identification plate located on the control housing, containing the governor assembly number, type, idle speed range and drive ratio. The maximum engine speed, not shown on the identification plate, is stamped on the option plate attached to the valve rocker cover.

Check Governor Operation

Governor difficulties are usually indicated by speed variations of the engine; however, it does not necessarily mean that all such speed fluctuations are caused by the governor. Therefore, when improper speed variations are present, check the engine as follows:

1. Make sure the speed changes are not the result of excessive load fluctuations.

2. Check the engine to be sure that all of the cylinders are firing properly (refer to Section 15.2). If any cylinder is not firing properly, remove the injector, test it and, if necessary, recondition it as outlined in Section 2.1 or 2.1.1.

3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and the injector control tube.

With the fuel rod connected to the injector control tube lever, the mechanism should be free from bind throughout the entire travel of the injector racks. If friction exists in the mechanism, it may be located and corrected as follows:

1. If an injector rack sticks or moves too hard, it may be due to the injector hold-down clamp being too tight or improperly positioned. To correct this condition, loosen the injector clamp, reposition it and tighten the clamp bolt to 20-25 lb-ft torque.

2. An injector which is not functioning properly may have a defective plunger and bushing or a bent injector rack. Recondition a faulty injector as outlined in Section 2.1 or 2.1.1.

3. An injector rack may bind as the result of an improperly positioned rack control lever. Loosen the rack control lever adjusting screws. If this relieves the bind, relocate the lever on the control tube and position the rack as outlined in Section 14.

4. The injector control tube may bind in its support brackets, thus preventing free movement of the injector racks to their no-fuel position due to tension of the return spring. This condition may be corrected by loosening and realigning the control tube supporting brackets. If the control tube support brackets were loosened, realigned and tightened, the injector racks must be repositioned as outlined in Section 14.

5. A bent injector control tube return spring may cause friction in the operation of the injector control tube. If the spring has been bent or otherwise distorted, install a new spring.

6. Check for bind at the pin which connects the fuel rod to the injector control tube lever; replace the pin, if necessary.

If, after making these checks, the governor fails to control the engine properly, remove and recondition the governor.

LIMITING SPEED MECHANICAL GOVERNOR

The limiting speed mechanical governor, illustrated in Fig. 1, performs the following functions:

1. Controls the engine idling speed.

2. Limits the maximum operating speed of the engine.

The governor is mounted on the front end of the blower and is driven by the upper blower rotor, (Fig. 2). The governor consists of three subassemblies:

1. Control Housing Cover.

2. Control Housing.

3. Weights and Housing.

The governor provides full fuel for starting when the speed control lever is in the idle position.
Immediately after starting, the governor moves the injector racks to that position required for idling.

Grove Crane Application
Governor Operation

The centrifugal force of the revolving governor weights (272 and 273) is converted into linear motion which is transmitted through the riser (67) and operating shaft (26) to the operating shaft lever (27). One end of lever (27) operates against the high and low speed springs (48 and 46) through the spring cap (47), while the other end provides a moving fulcrum on which the differential lever (23) pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low speed spring (depending on the speed range), the governor stabilizes the engine speed for a given setting of the governor control lever.

In the low speed range, the centrifugal force of the low speed weights operates against the low speed spring. As the engine speed increases, the centrifugal force of the low speed weights compresses the low speed spring until the weights are against their stops, thus limiting their travel, at which time the low speed spring is fully compressed and the low speed cap is against the high speed plunger.

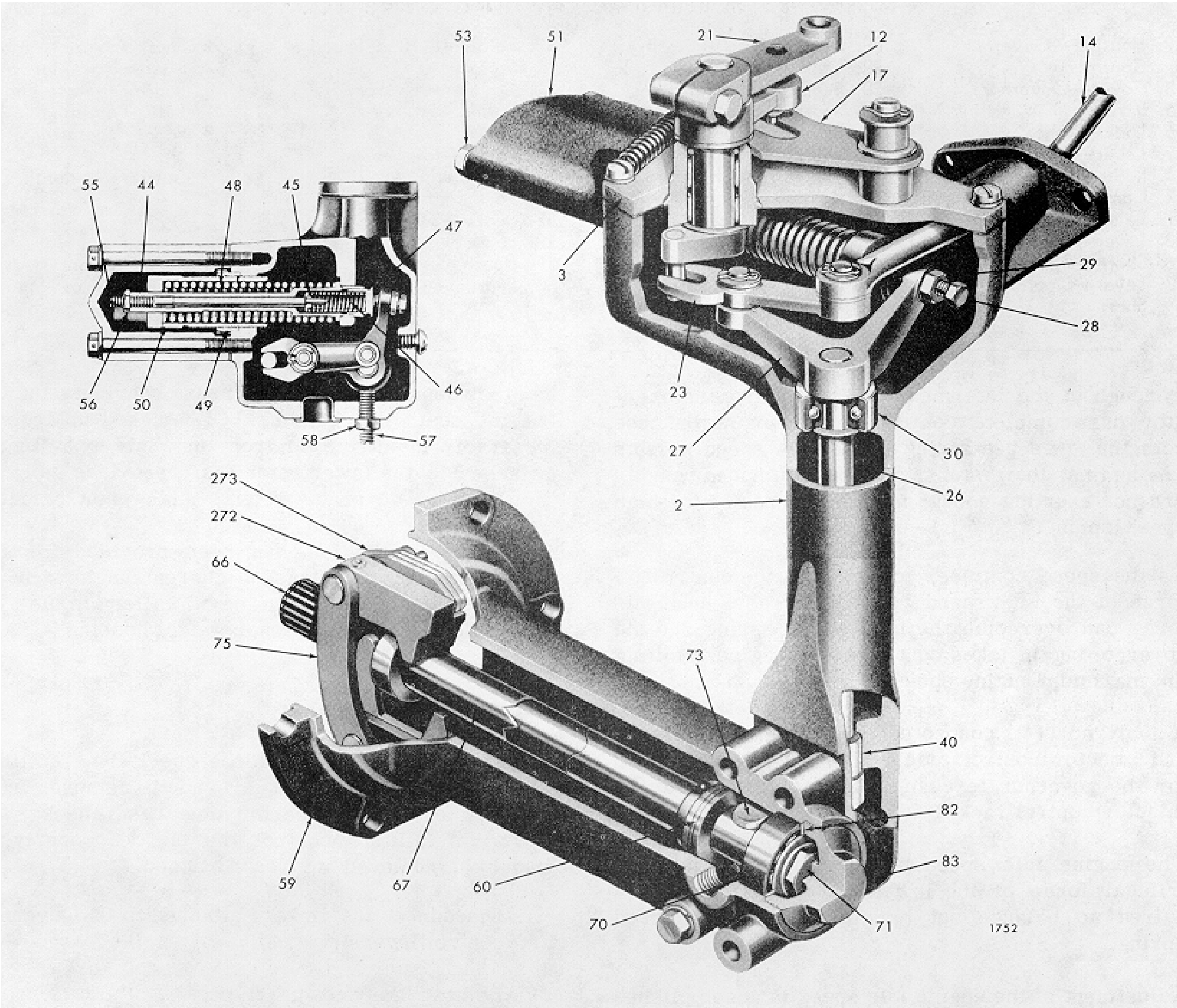


Fig. 1 - Limiting Speed Mechanical Governor

Fig. 1 - Limiting Speed Mechanical Governors

2. Housing--Governor Control
3. Cover--Governor
5. Screw
6. Lock Washer
12. Lever--Throttle Shaft
14. Rod--Fuel
17. Cam
21. Lever--Speed Control
23. Lever--Differential
26. Shaft--Operating
27. Lever--Operating Shaft
28. Screw--Gap Adjusting
29. Lock Nut
30. Bearing--Operating Shaft
40. Bushing--Operating Shaft
44. Plunger--High Speed Spring
45. Seat--Low Speed Spring
46. Spring--Low Speed
47. Cap--Low Speed Spring
48. Spring--High Speed
49. Lock Nut--Retainer
50. Retainer--High Speed Spring
51. Cover--High Speed Spring Retainer
53. Bolt
55. Screw--Idle Speed Adjusting
56. Lock Nut
57. Screw--Buffer
58. Lock Nut
59. Housing--Weight
60. Bearing--Riser Thrust
66. Shaft Assy.--Weight
67. Riser--Governor
70. Bearing--Shaft End
71. Bolt--Retaining
73. Fork--Operating Shaft
75. Carrier--Weight
82. Gasket
83. Plug--W7eight Housing
272. Weights--Low Speed
273. Weights--High Speed

Throughout the intermediate speed range the operator has complete control of the engine because both the low speed spring and the low speed weights are against their stops, and the high speed weights are not exerting enough force to overcome the high speed spring.

As the speed continues to increase, the centrifugal force of the high speed weights increases until this force can overcome the high speed spring and the governor again takes control of the engine, limiting the maximum engine speed.

A fuel rod (14), connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The engine idle speed is determined by the centrifugal force of the low speed weights (272) required to balance out tension on the low speed spring.

Adjustment of the engine idle speed is accomplished by changing the tension on the low speed spring by means of the idle adjusting screw (55). Refer to Section 14 for the idle speed adjustment.

The maximum no-load speed is determined by the centrifugal force of the high speed weights (273) required to balance out the tension on the high speed spring.

Adjustment of the maximum no-load speed is accomplished by the high speed spring retainer (50). Movement of the high speed spring retainer nut will increase or decrease the tension on the high speed spring. Refer to Section 14 for the maximum no load speed adjustment.

Lubrication

Surplus oil returning from the cylinder head provides lubrication for the parts in the governor control housing, the riser thrust bearings, and the weight shaft end bearing. Oil, picked up from a reservoir in the blower front end plate by a slinger attached to the lower rotor shaft, provides lubrication for the governor weights and weight carrier.

Pressure lubrication has been provided for the weight housing bearings on current engines by an oil tube attached between the oil gallery in the cylinder block and the governor weight housing.

Remove Governor

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Disconnect the linkage attached to the governor control levers (Fig. 2).
2. Remove the breather tube.
3. Remove four screws and lock washers and lift the governor cover (Fig. 3) and gasket from the governor housing.
4. Refer to Figs. 1 and 2 and disconnect the fuel rod from the differential lever (23) and the injector control tube lever.
5. Disconnect the oil tube at the governor weight housing or cover and remove the cover, if used.
6. Remove the two governor-to-cylinder head bolts.
7. Remove the control housing from the cylinder head and weight housing.
8. Use tool J 4242, to remove the six governor, weight housing-to-blower bolts; then withdraw the housing from the blower.

2.7.1 LIMITING SPEED GOVERNOR

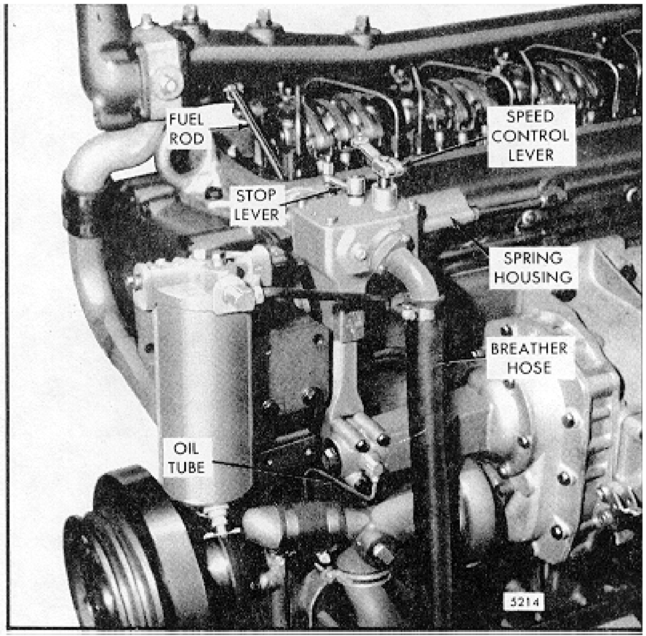


Fig. 2 Typical Limiting Speed Governor Mounting

Disassemble Governor

1. Disassemble governor cover:

   a. Remove the plug from the throttle shaft (Fig. 3).

   b. Loosen the speed control lever bolt, and lift the speed control lever from the throttle shaft.

   c. Remove the tapered pin from the throttle shaft lever. Lift the lever and the seal ring retainer from the throttle shaft. Withdraw the throttle shaft from the cover.

   d. Remove the cam retainer and plain washer from the cam pin. Lift the cam and the stop lever off the pin.

   e. Remove the seal ring from the governor cover.

   f. Wash the cover assembly (containing needle bearings) thoroughly in clean fuel oil and inspect the needle bearings for wear or damage. If the bearings are satisfactory for further use, removal is unnecessary.

   g. If needle bearing removal is necessary, place the inner face of the cover over the opening in the bed of the press. Place remover J 21967 on top of the bearing and under the ram of the press; then press both bearings out of the cover (Fig. 4).

2. Disassemble the governor control housing:

   a. Place the control housing in a soft jawed vise.

   b. Remove two bolts (53), Fig. 9, and withdraw the high speed spring retainer cover (51).

   c. Loosen the lock nut (49) with tool J 5345-5. Remove the high speed spring retainer (50), idle adjusting screw (55), high speed spring (48), spring plunger (44), low speed spring (46), spring seat (45), and spring cap (47) as an assembly.

   d. Remove the spring retainer (25) and washer, then lift the differential lever (23) from the pin of the operating shaft lever (27).

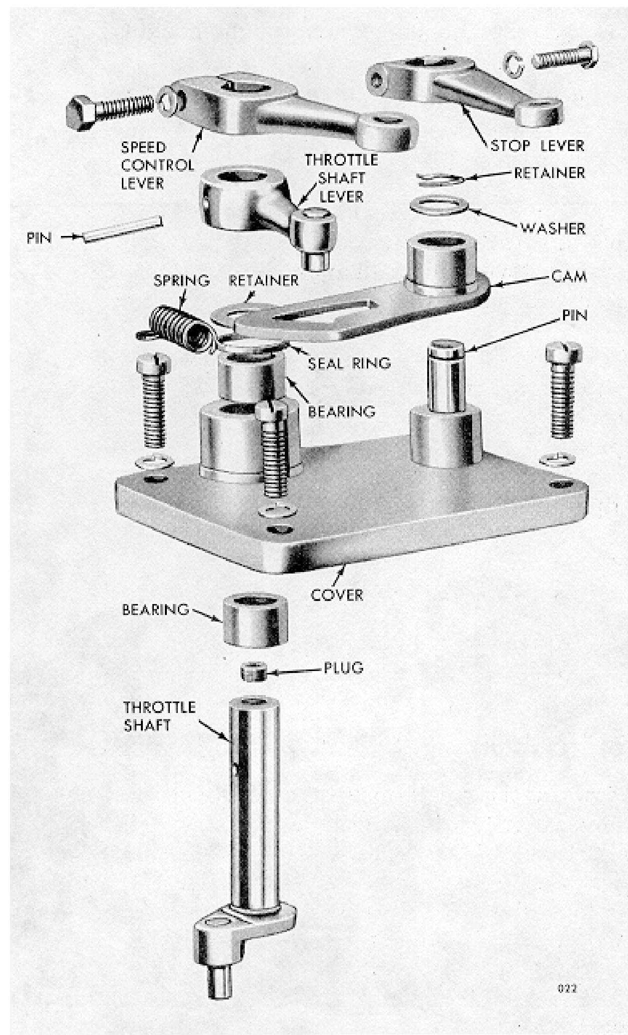


Fig. 3 Governor Cover Details and Relative Location of Parts

e. Remove the expansion plug (41) out of the lower end of the control housing.

f. Remove the bearing retaining screw (32), flat washer (33), and lock washer.

g. Loosen the operating fork set screw, if used.

h. Support the control housing as shown in Fig. 5. Press the operating shaft (26) from the operating fork (73) using a brass rod. Withdraw the operating shaft, operating lever (27), and bearing (30) as an assembly from the control housing.

i. Support the operating shaft and lever on bed of press as shown in Fig. 6. Press the shaft from the operating lever and bearing with a brass rod.

3. Disassemble governor weight housing:

a. Place the weight housing (59), Fig. 9, in a soft jawed vise. Remove the plug (83) and gasket (82).

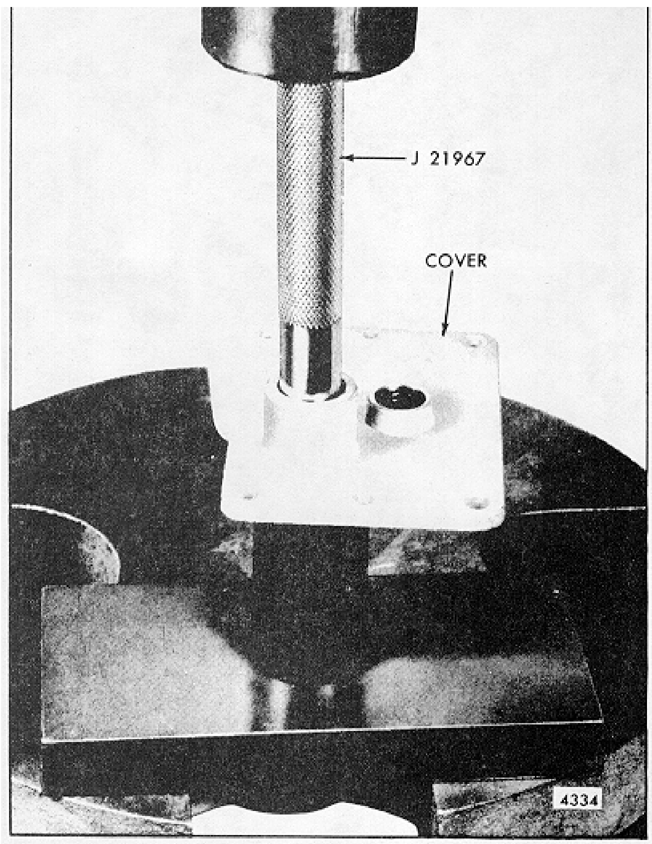


Fig. 4 - Removing Needle Bearing from Governor Cover

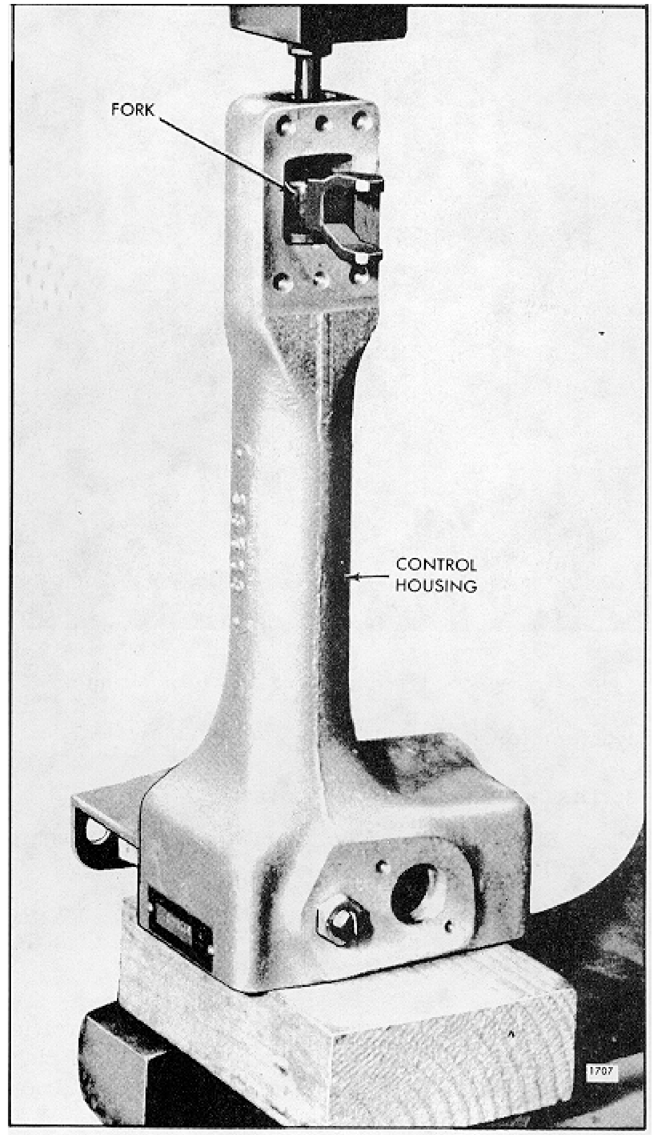


Fig. 5 Removing Operating Fork from Operating Shaft

b. Straighten the tang of the lock washer and remove the bearing retaining bolt (71).

c. Thread a 5/16"-24 x 3" bolt into the tapped end of the weight shaft (66). Support the weight housing (59) on the bed of the press as shown in Fig. 7 and press the shaft from the bearing.

d. Slide the riser thrust bearing (60) and governor riser (67) from the shaft (66).

f. This bearing is specially designed to absorb thrust loads; therefore, looseness between the mating parts does not indicate excessive wear.

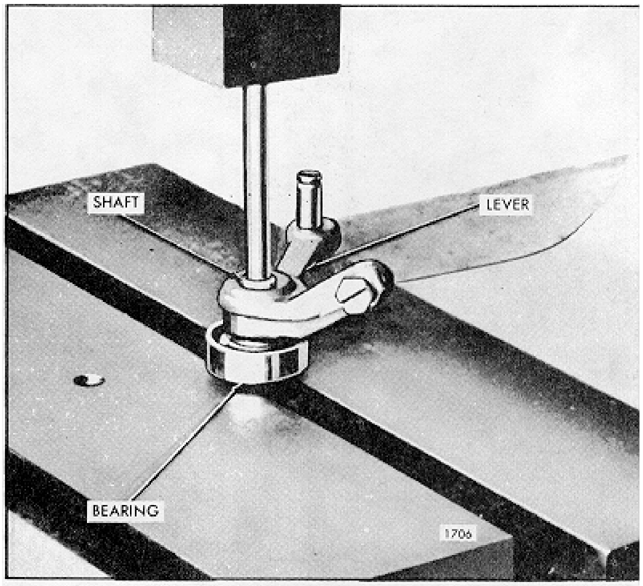


Fig. 6 Removing Operating Shaft from Operating lever

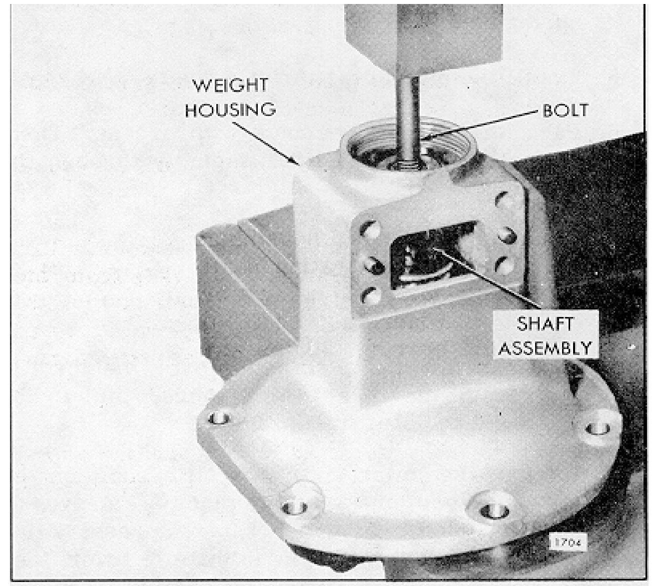


Fig. 7 Removing Governor Weight and Shaft Assy.

e. Remove the bearing (70) from the weight housing.

f. Mark the weights (76 or 272 and 273) and carrier (75) with a center punch for identification, also note position of the thin washers (78) between the weights so that the parts can be replaced in their original position.

g. Remove the Allen set screw (274) from the low speed weights. Withdraw the pins and governor weights.

NOTE: If necessary the needle bearing in the high speed weights may be removed at this time.

h. If required, the weight carrier (75), Fig. 9, may be pressed from the governor weight shaft and a new carrier installed.

Inspection

Clean all of the parts with fuel oil, and dry them with compressed air.

Revolve the ball bearings slowly by hand. Replace bearings which indicate rough or tight spots. Also replace bearings which are corroded or pitted.

Examine the riser thrust bearings for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and bearing assembly.

Examine the governor or weights at the riser contact for excessive wear. If this condition exists install a new governor or weight.

Inspect the weight carriers, and retaining pins for wear.

Inspect the bushings in current weights and replace if worn excessively. In former weights inspect the needle bearings for wear and replace if necessary.

Inspect the operating shaft and bushing for excessive wear. If excessive wear is noted, a new bushing and shaft must be installed.

Assemble Governor Cover

1. If the needle bearings were removed from the governor cover, place the governor cover on the bed of an arbor press with inner face of the cover down. Start the upper bearing straight into the bearing bore of the cover with the number on the bearing up. Insert the bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 8).

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

   NOTE: Do not use impact tools to install needle bearings.

3. Apply lubricant to the retaining pin and place the cam (Fig. 3) over the pin with the boss of the cam up. Install the stop lever.

4. Place the washer over pin and secure with the spring retainer.

5. Install the plug in the throttle shaft.

6. Pack the needle bearings with grease. Then, slide the throttle shaft assembly through the bearings.

7. Insert the seal ring over the shaft and into the counterbore against the upper bearing. Place the retainer over the shaft and against seal ring.

8. Start the throttle shaft lever over the throttle shaft with the holes (for tapered pin) in the lever and the shaft in alignment.

9. Support the lower end of throttle shaft on the bed of arbor press, then place a sleeve on throttle lever and under ram of press. Align the slot in cam with pin in throttle lever, then press the lever down on the shaft until hole in the lever is in line with the hole in the shaft.

10. Insert the tapered pin in the hole of the lever, then support the lever and cover assembly on a steel block and drive the pin into place.

11. Position the speed control lever on the throttle shaft and tighten the retaining bolt.

12. Attach one end of the spring in small hole of cam.

Assemble Governor Control Housing

1. Place the washer (31), Fig. 9, over short finished end of the operating shaft (26). Start the bearing (30) over end of the shaft. Support the opposite end of the shaft on the bed of a press. Press the bearing on the shaft tight against the washer with a sleeve which has the same diameter as the bearing inner race.

2. With the pivot pin in the operating lever (27) up, start the lever over the end of shaft with the flat on the shaft registering with the flat surface in the lever. Press the lever on the shaft tight against the bearing (30).

3. Lubricate the bearing and operating shaft bushing (40) in the housing with clean engine oil. Insert the lever and operating shaft assembly in the control housing.

4. Position the operating fork (73) over the lower end of the operating shaft, Fig. 9, so the finished side of the fork finger will rest against

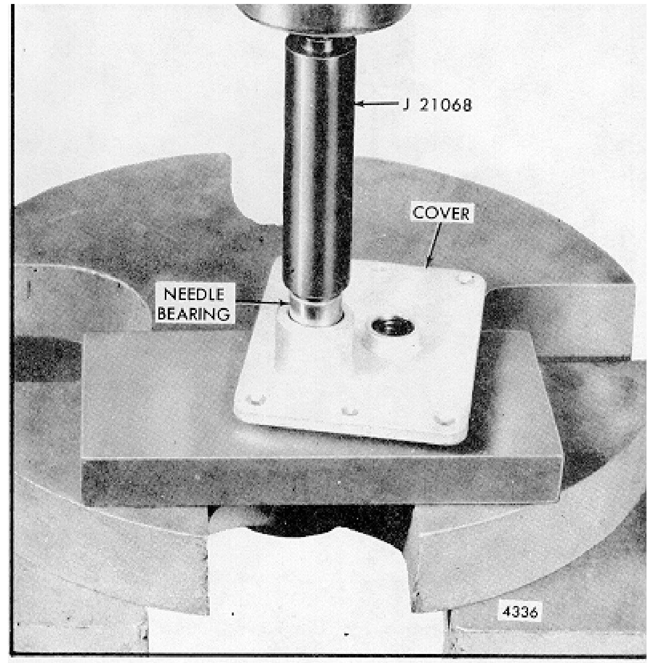


Fig. 8 Installing Needle Bearings in Governor Cover

the thrust bearing (60) when assembled as shown in Fig. 1.

5. Support the operating shaft and control housing in an arbor press with the upper end of the operating shaft resting on a steel block. Align the flat in the operating fork with the flat on the operating shaft; then, place a sleeve over the end of the shaft and rest it on the fork. Bring the ram of the press down on the sleeve and press the fork straight down and tight against the shoulder on the shaft.

6. Tighten the fork set screw, if used.

7. Apply a good quality sealant around the periphery of the expansion plug (41), Fig. 9, and press the plug into the lower end of the control housing.

8. Place a lock washer and flat washer over the retaining screw (32). Thread the screw in the control housing to secure the operating shaft bearing (30).

9. Place the differential lever (23) over the pivot pin of the operating lever. Install a plain washer and spring retainer (25).

Assemble Governor Springs, Plungers and Adjusting Screws

1. Thread the lock nut (58), Fig. 9, on the buffer

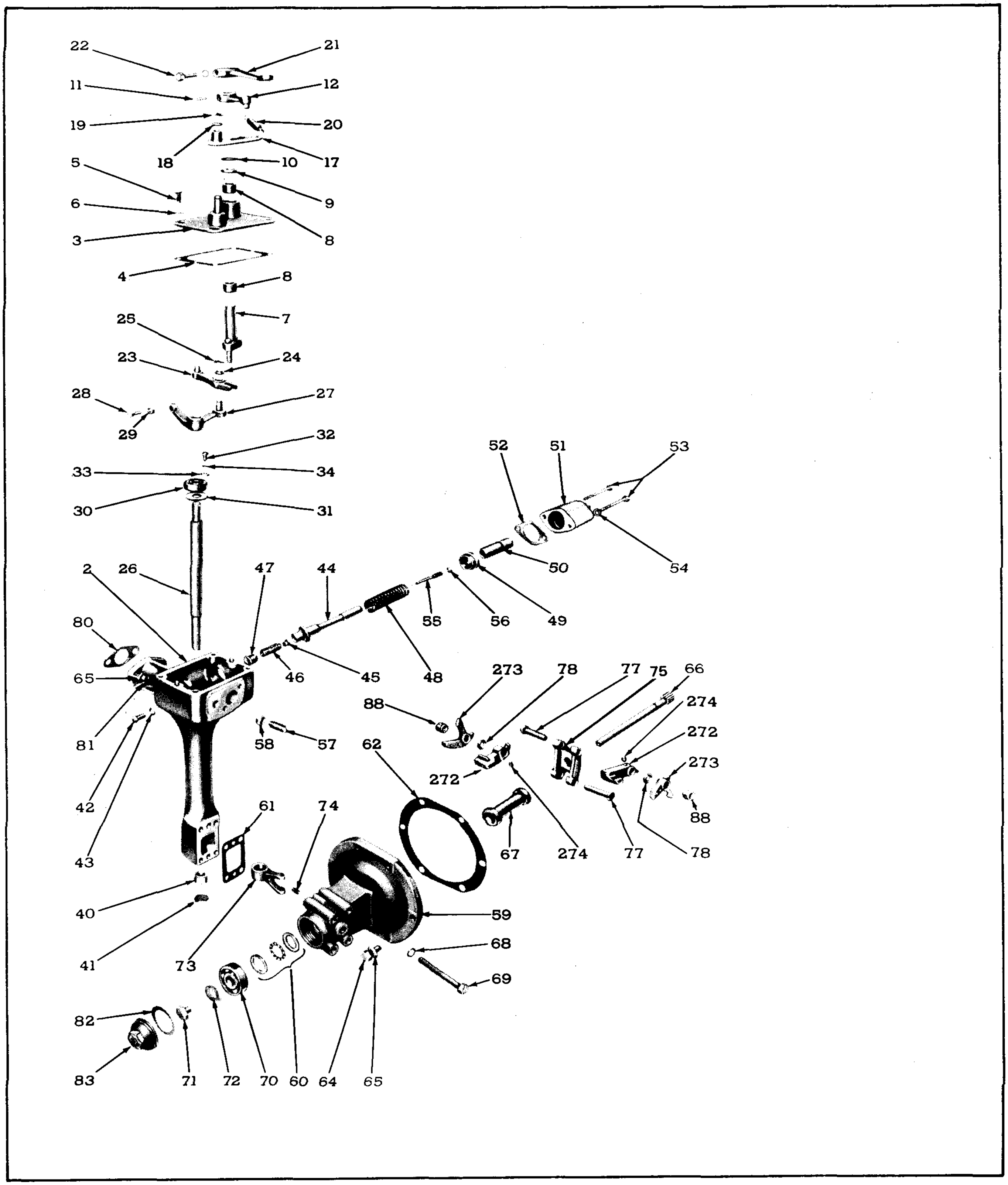


Fig. 9 - Limiting Speed Governor Details and Relative Location of Parts

Fig. 9 - Limiting Speed Governor Details and Relative Location of Parts

2. Housing--Governor Control
3. Cover--Governor
4. Gasket
5. Screw
6. Lock Washer
7, Shaft--Throttle
8. Bearing--Throttle Shaft
9. Ring--Seal
10. Retainer--Seal Ring
11. Pin--Tapered
12. Lever--Throttle Shaft
17. Cam
18. Washer--Plain
19. Retainer--Spring
20. Spring--Cam Control
21. Lever--Speed Control
22. Bolt
23. Lever--Differential
24. Washer--Lever Pin
25. Retainer--Spring
26. Shaft--Operating
27. Lever--Operating Shaft
28. Screw--Gap Adjusting
29. Lock Nut
30. Bearing--Operating Shaft
31. Washer--Bearing
32. Screw
33. Washer--Flat
34. Lock Washer
40. Bushing--Operating Shaft
41. Plug--Expansion
42. Screw
43. Washer
44. Plunger--High Speed Spring
45. Seat--Low Speed Spring
46. Spring--Low Speed
47. Cap--Low Speed Spring
48. Spring--High Speed
49. Lock Nut-Retainer
50. Retainer--High Speed Spring
51. Cover--High Speed Spring Retainer
52. Gasket
53. Bolt
54. Lock Washer
55. Screw--idle Speed Adjusting
56. Lock Nut
57. Screw--Buffer
58. Lock Nut
59. Housing--Weight
60. Bearing--Riser Thrust
61. Gasket--Weight Housing Cover
62. Gasket--Governor to Blower
64. Bolt
65. Copper Washer
66. Shaft Assy.--Weight
67. Riser--Governor
68. Lock Washer
69. Bolt
70. Bearing--Shaft End
71. Bolt--Retaining
72. Lock Washer
73. Fork--Operating Shaft
75. Carrier--Weight
77. Pin--Weight
78. Washer--Plain
80. Gasket--Governor to Cylinder Head
81. Bolt
82. Gasket
83. Plug--Weight Housing
88. Bearing--Governor Weight
272. Weight--Low Speed
273. Weight--High Speed
274. Screw--Set

screw (57) and thread the buffer screw into the control housing.

2. Thread the lock nut (49), Fig. 1, on the high speed spring retainer (50) approximate 1-1/2". Place the high speed spring (48) over the high speed spring plunger (44) with the tightly wound end of the spring against the shoulder of the plunger.

3. Insert the plunger and spring assembly in the high speed spring retainer. Thread the idle screw (55) approximately 1" into the tapped end of the plunger. Thread the lock nut (56 over the idle screw.

4. Insert the low speed spring (46) in the low speed spring cap (47) and the small end of the spring seat (45) in the opposite end of the low speed spring.

5. Insert the low speed spring seat and low speed spring and cap assembly in the high speed spring plunger (44) with the spring seat (45) against the shoulder of the idle screw (55).

6. Start the governor high speed spring assembly into the opening of the control housing and thread the high speed spring retainer (50) in the housing approximately 1".

7. Installation of the high speed spring retainer cover (51) is not required until after the governor has been installed on the engine and the tune-up procedures outlined in Section 14 have been completed.

Assemble Governor Weight Housing

1. Start the weight pin (77) through the opening in the weight carrier (75), Fig. 9.

   Place the low speed weight (272) on the pin and slide the pin through.

2.7.1 LIMITING SPEED GOVERNOR

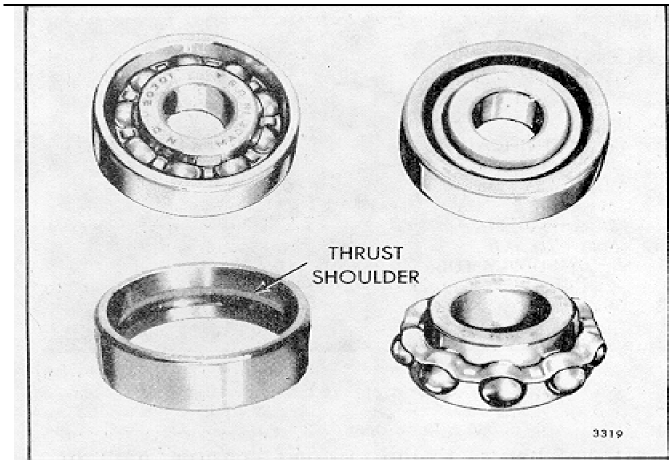


Fig. 10 - Governor Weight Shaft Bearing

Place two flat washers (78) on the pin next to the low speed weights.

Install the high speed weights (273) on their shafts after installing the needle bearings or bushings.

Place the high speed weight on the pin and slide the pin through the weight.

Place two more flat washers on the pin between the high speed weights and the carrier. Slide the pin through the washers and into the carrier.

Align the indentation in the pin with the set screw hole in the low speed weights. Apply a sealant such as Loctite grade C or CV or equivalent on the threads of the set screw (274). Insert the set screw and tighten it to 20 lb-in minimum. Be sure to stake the set screw in two places after tightening the screws.

NOTE: Before applying the sealant to a new set screw immerse the set screw in Loctite Primer T or equivalent.

2. Slide the riser (67) over the shaft (66) and against the finished surfaces of the governor weights (Fig. 1).
3. Assemble the riser thrust bearing (60) on the weight shaft (66) with the bearing race with the smallest inside diameter against the thrust riser. Incorrect installation of the bearing will result in erratic operation of the governor.
4. Insert the weight carrier and shaft assembly (66) in the weight housing.
5. Support the splined end of the shaft on the bed of an arbor press. Start the shaft end bearing (70) in the housing and over the end of the shaft with the numbered side of the bearing facing away from the shaft. Press the bearing in place with a sleeve that bears against the inner race.

   CAUTION: This bearing has thrust capacity in one direction only. Be sure to install the bearing so that the thrust shoulder (Fig. 10) is toward the governor weights. Otherwise, the force exerted by the weights will pull the inner race and ball assembly away from the outer race and result in damage to the bearing and erratic governor operation.
6. Place the washer (72), Fig. 9, over the bearing retaining bolt (71). Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang on the washer against the head of the bolt.
7. Place a gasket (82) in the housing, against the bearing. Apply Loctite sealant grade HV or equivalent to the full 360° circumference of the plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb-ft torque.

Install Governor

1. Affix a new gasket (62), Fig. 9, to the governor weight housing. Start the splined end of the weight shaft in the upper blower rotor and position the housing against the blower end plate (Fig. 2).
2. Place a new copper gasket on each weight housing-to-blower bolt and thread the bolts into the blower end plate, finger tight only.
3. Place a new gasket (61), Fig. 9, over the dowels and against the side of the weight housing facing the engine.
4. Move the thrust bearing assembly and riser toward the weight end of the shaft.
5. Position the lower end of the control housing over the dowel pins in the weight housing.

   NOTE 1: The finished surface of the operating fork must be placed against the outer side of the thrust bearing as shown in Fig. 1.

   NOTE 2: Current weight housings have two ribs cast on the inner surface of the housing to prevent any part of the riser thrust bearing from sliding forward to where the operating fork could be inserted on the wrong side of one or more parts of the bearing. For ease in assembling the governor control housing to the interim weight housings (no identification mark), Fig. 11, place a 3/8"-24 x 3/4" or 7/8" bolt, from which the outer 1/2" of thread down to a diameter of 5/16" to 1/4" has been removed, in the 1/8" NPTF oil hole to prevent the thrust bearing from moving too far forward in the weight housing.

After the control housing is installed,' remove the bolt and install the oil tube fitting.

6. Affix a new gasket (80), Fig. 9, to the governor control housing; then attach the governor control housing to the cylinder head with two bolts, (Fig. 2). Tighten the bolts.

7. Tighten the governor-to-blower bolts with wrench J 4242.

8. Affix a new gasket to the weight housing cover (former governors only) and place the cover in position. Install the four weight housing-to- control housing bolts (69) with lock washers and tighten the bolts.

9. Connect the oil tube to the fitting on the weight housing, or on the cover (if used).

10. Refer to Figs. 1 and 2 and position the fuel rod (14) over the differential lever pin. Place a

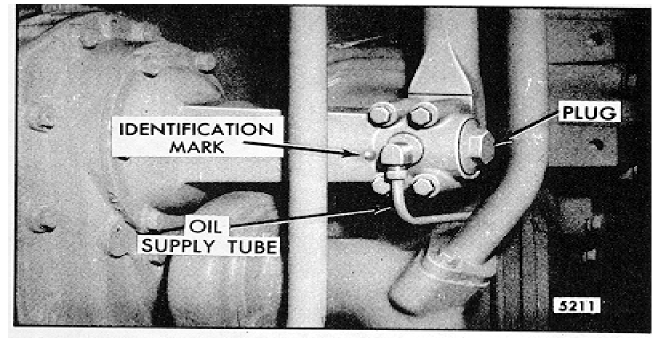


Fig. 11 - Governor Weight Housing

flat washer over the pin and secure it with the retainer.

11. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.

12. Place a new gasket (4), Fig. 9, on the governor control housing and mount the governor cover on the housing with the pin on the throttle shaft (7) registering with the machined slot in the differential lever (23) as shown in Fig. 1.

13. Install the four cover screws with lock washers. Connect one end of the cam spring to one of the cover screws as shown in Fig. 2.

14. Connect throttle linkage.

15. Attach the breather tube to the governor housing.

16. Tune-up the engine as outlined in Section 14.3.

The limiting speed mechanical fuel modulating governor is a double weight type and performs the following functions:

1. Controls the engine idle speed.

2. Limits the maximum operating speed of the engine.

3. Regulates the fuel input at part throttle.

The governor is mounted on the front end of the blower and is driven by the upper blower rotor.

The governor consists of three subassemblies:

1. Control Housing Cover.

2. Control Housing.

3. Weights and Housing.

The governor provides full fuel for starting when the speed control lever is in the idle position. Immediately after the engine starts, the governor moves the injector racks to that position required for idling.

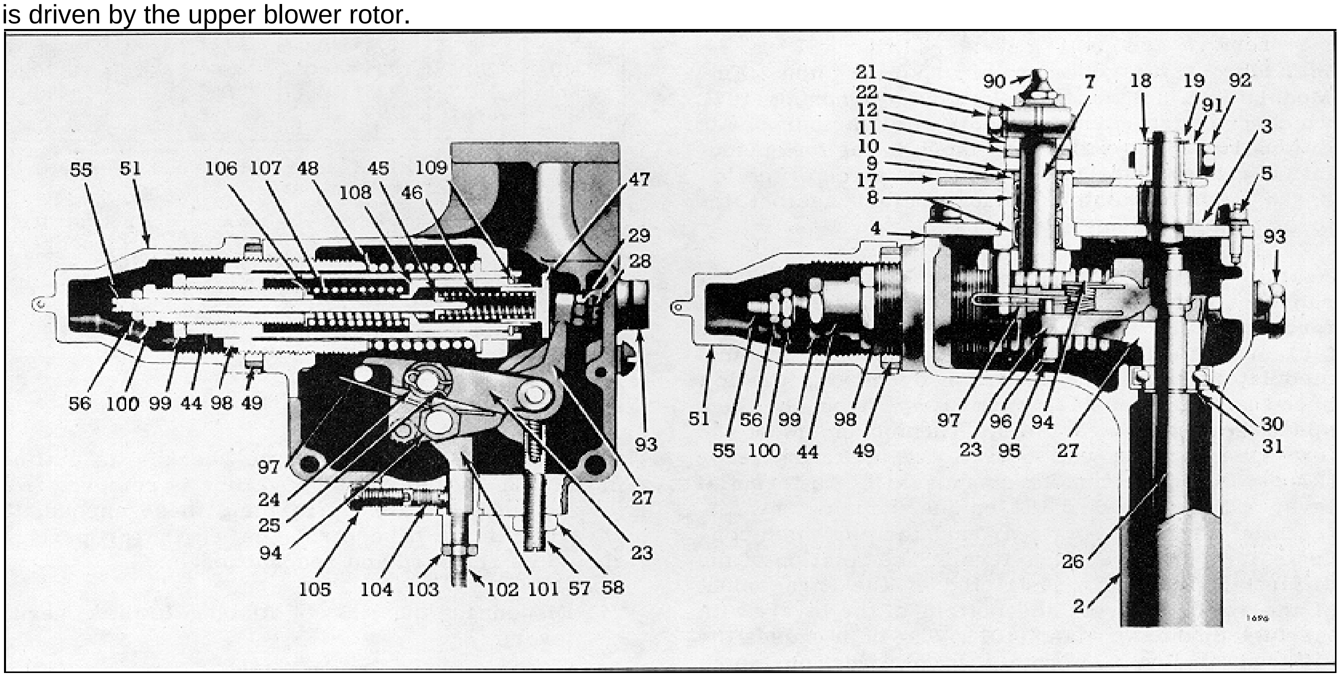


Fig. 1 - Fuel Modulating Governor

2	Housing--Control	25	Spring Retainer	49	Lock Nut--High Speed	98	Screw--High Speed Adjusting
3	Cover--Governor	26	Shaft--Operating	51	Cover--Adjustment	99	Lock Nut--Modulating Screw
4	Gasket--Cover	27	Lever--Operating Shaft	55	Screw--idle Speed Adjusting	100	Screw--Modulating Speed Adjusting
5	Screw	28	Screw--Low Speed Gap Adjusting	56	Locknut--Idle Speed Screw	101	Cam--Modulating
7	Shaft--Throttle	29	Lock Nut	57	Screw--Buffer	102	Screw--Cam Adjusting
8	Roller Bearings	30	Bearing--Operating Shaft	58	Lock Nut--Buffer Screw	103	Lock Nut
9	Seal	31,	Washer--Bearing	90	Lubrication Fitting	104	Lock Screw--Cam
10	Seal Washer	44	Plunger--High Speed Spring	91	Lever--Stop	105	Plugging Screw
11	Pin--Taper	45	Seat--Low Speed Spring	92	Bolt	106	Seat--Modulating Spring
12	Lever--Throttle Shaft	46	Spring--Low Speed	93	Plug-Control Housing	107	Spring--Modulating
17	Cam-Control	47	Cap--Low Speed Spring	94	Screw--Torsion Spring	108	Plunger--Modulating Spring
18	Washer	48	Spring--High Speed	95	Pin--Roller	109	Retainer Ring
19	Spring Retainer			96	Roller		
21	Lever--Speed Control			97	Spring--Torsion		
22	Bolt						
23	Lever--Differential						
24	Washer--Lever Pin						

2.7.1.1 LIMITING SPEED GOVERNOR

Operation (Fuel Modulating Governor)

The fuel-modulating governor (Fig. 1) has been developed to improve combustion and fuel economy during low-speed full-throttle operation. The "Fuel-Modulator" incorporated with the mechanical limiting speed governor automatically controls the fuel input to assure complete combustion, thus providing maximum fuel economy, clean exhaust, and longer engine life. This control is assured regardless of the throttle setting maintained by the operator.

The governor includes a low speed spring (46), a high speed spring (48), a set of low speed weights, and a set of high speed weights, similar to those included in the limiting speed mechanical governor.

In addition, the governor incorporating the "Fuel Modulator" includes a fuel modulator spring (107), which provides governor control for the purpose of gradually reducing the fuel input in the fuel modulating range. Over this speed, the force of the low speed and modulator springs react against the force of the high speed weights.

As the engine speed decreases below top modulator range, the gradual reduction in high speed weight force permits the force of the low speed spring (46) and modulating spring (107) to open the fuel modulator gap in the governor by moving the low speed spring cap (47) back away from the high speed spring plunger (44). The movement of the low speed spring cap moves the operating lever (27) -- the operating lever moves the differential lever (23) -- toward the engine, causing the differential lever to rotate around the pin which connects it to the operating lever. The rotation of the differential lever is restricted by the engagement of the roller (96), on the bottom of the lever, with the fuel modulator cam (101). The cam causes the differential lever to rotate in a direction which pulls the governor link back into the governor and thus pulls the injector racks out from the full fuel position.

During this time, the differential lever torsion spring (97) opposes the above rotation with a light tension and maintains the roller (96) in its proper position against the fuel modulator cam (101). It is this differential lever torsion spring which allows the "Fuel-Modulator" to operate regardless of the throttle position maintained by the operator.

The fuel modulator spring tension is set so that the injector racks start to leave the "full in" position as the engine speed is reduced. The engine speed at which this occurs is controlled by the rate and tension of the modulating spring used. Fuel modulating action begins at approximately 200 rpm below the fuel modulating gap closing speed with 80 cu. mm. injectors, and approximately 300 rpm below fuel modulating gap closing speed with 70 cu. mm. injectors. Delay in modulating action with 70 cu. mm. injectors is due to the helix design on the injector plunger, which does not reduce the fuel input until after .075" rack movement.

The following chart specifies proper fuel modulating and high speed spring combination to be used at the desired full load engine rpm.

RPM		Modulator Spring	High Speed Spring	Injector
Max.	Min.			
2300	1975	175# (G)	55# (Y)	70
2300	2075	225# (W)	55# (Y)	70
2300	2075	225# (W)	55# (Y)	80
2300	1865	150# (B)	55# (Y)	70

*RPM given is full load; to obtain no-load (floor setting) speed, add 125 RPM.

When engine is equipped with a rubber damper full load speed must not exceed 2000 RPM. When full load speed in excess of 2000 RPM is desired, engine must be equipped with a fluid (viscous) damper.
Color stripe -- (W) white, (G) green, (B) brown and (Y) yellow.

Remove Governor

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Disconnect the linkage attached to the governor levers.
2. Remove the breather tube from the governor.
3. Remove four cover screws and lock washers and lift the governor cover (3) and gasket (4) from the governor control housing (3).
4. Disconnect the fuel rod from the differential lever (23) and the injector control tube lever.
5. Disconnect the oil tube at the governor weight housing or cover. Remove the cover, if used.
6. Remove two governor-to-cylinder head bolts
7. Remove the control housing from the cylinder head and the weight housing.
8. Remove the six governor weight housing-to- blower bolts using wrench J 4242 and withdraw the housing from the blower.

Disassemble Governor Cover

1. Remove the plug from the throttle shaft (Fig. 2).
2. Loosen the clamping bolt and lift the speed control lever from the throttle shaft.
3. Loosen the clamping bolt and remove the stop lever, if used.
4. Remove the tapered pin from the throttle shaft lever. Lift the lever and seal ring retainer from the throttle shaft. Withdraw the throttle shaft from the cover.
5. Remove the cam retainer and plain washer from the cam pin. Lift the cam off the pin.
6. Remove the seal ring from the governor cover.
7. Wash the cover assembly (containing needle bearings) thoroughly in clean fuel oil and inspect the needle bearings for wear or

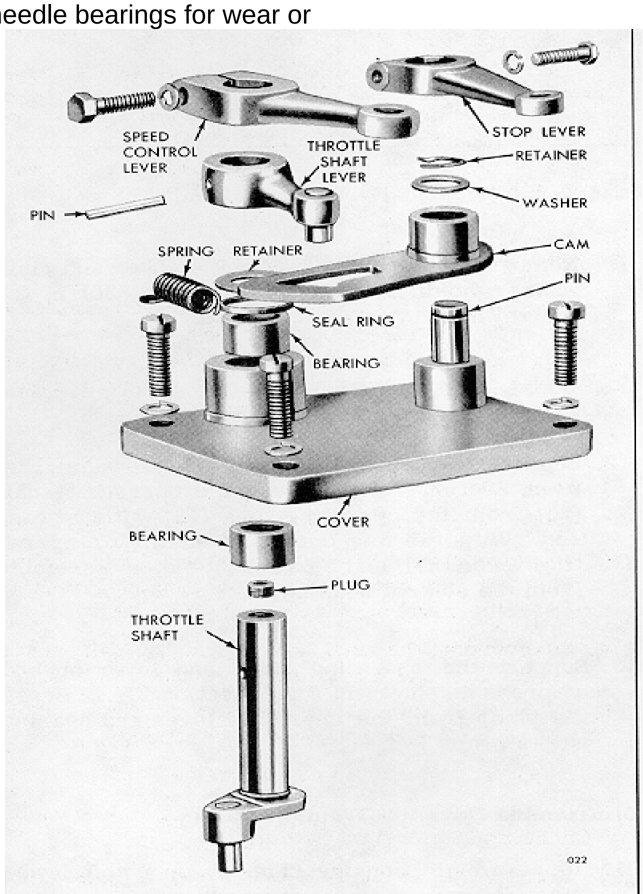


Fig. 2 - Governor Cover Details and Relative Location of Parts

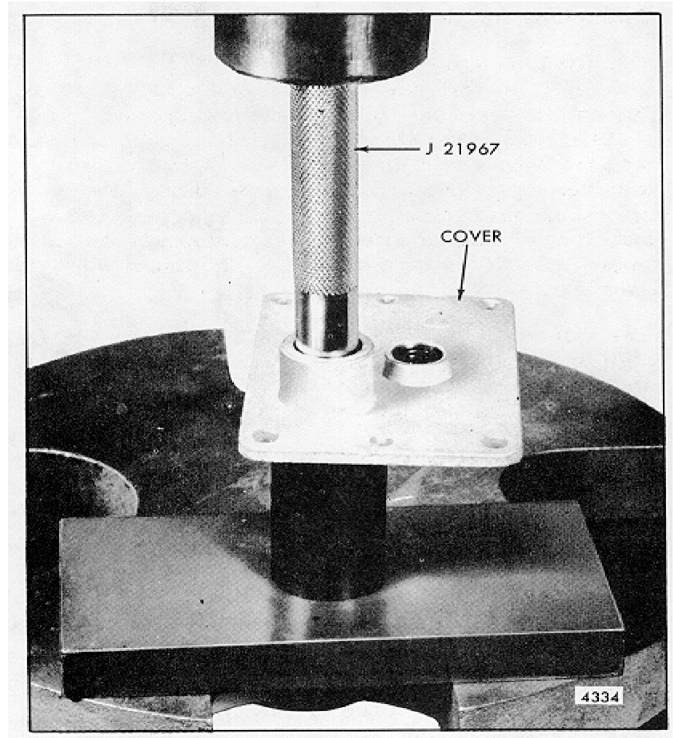


Fig. 3 - Removing Needle Bearing from Governor Cover

damage. If bearings are satisfactory, removal is unnecessary.

8. If needle bearing removal is necessary, place the inner face of the cover over the opening in the bed of the arbor press (Fig. 3). Place the bearing remover J 21967 on top of the bearing and under the ram of the press, then press both bearings out of the cover.

Disassemble Governor Control Housing

1. Refer to Fig. 1 and remove the adjustment cover (51). Loosen the high speed adjusting screw lock nut (49) using a spanner wrench. Use an end wrench to thread the high speed adjusting screw (98) out of the control housing. When the adjusting screw is free of the housing, the entire assembly of springs and plungers can be removed and placed on a bench for further disassembly.
2. Remove the low speed spring cap (47), low speed spring (46), and low speed spring seat (45).
3. Loosen the idle speed adjusting screw lock nut (56), also the modulating speed spring adjusting screw lock nut (99).

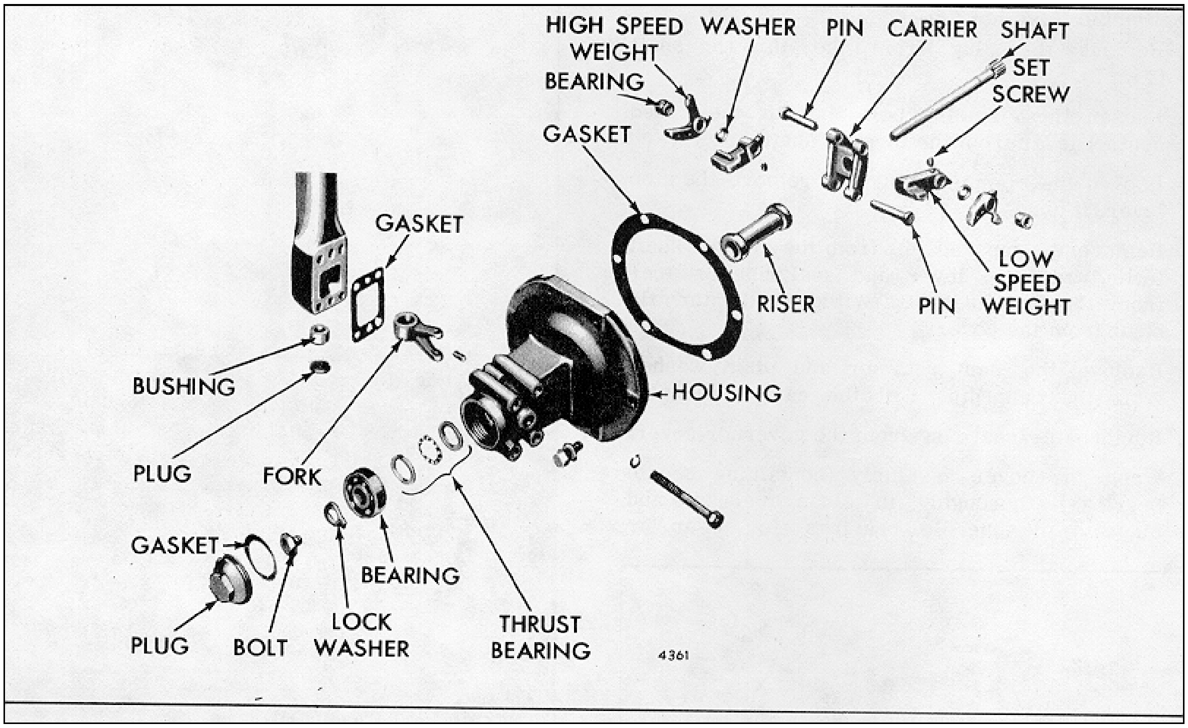


Fig. 4 - Fuel Modulating Governor Weight Housing Details and Relative Location of Parts

2.7.1.1 LIMITING SPEED GOVERNOR

4. Remove the idle speed adjusting screw (55), also the modulating spring adjusting screw (100).

5. Remove modulating spring plunger retainer ring (109) from high speed spring plunger with sharp-nosed pliers.

6. Remove the modulating spring plunger (108), modulating spring (107) and modulating spring seat (106) from inside the high speed spring plunger.

7. Remove the spring retainer (25) and washer.

Lift the differential lever (23) from the pin on the operating shaft lever (27).

8. Remove the special screw (94) retaining the torsion spring (97) to the differential lever, then remove the spring from the screw.

9. Remove the expansion plug out of the lower end of the control housing.

10. Remove the lock screw, lock washer and plain washer holding the upper bearing (30) in the control housing.

11. Loosen the operating fork set screw, if used.

12. Support the control housing as shown in Fig. 6 in Section 2.7.1. Press the operating shaft (26) from the operating fork (73) with a brass rod. Withdraw the operating shaft (26), operating lever (27), and bearing (30) as an assembly from the control housing.

13. Support the operating shaft and lever on bed of press as shown in Fig. 7 Section 2.7.1. Press the shaft from the operating lever and bearing with a brass rod.

Disassemble Governor Weight Housing

1. Place weight housing (Fig. 4) in a soft jawed vise. Remove the plug and gasket.

2. Straighten the tang on the lock washer and remove the bearing retaining bolt.

3. Thread a 5/16"-24 x 3" bolt into the tapped end of the weight shaft. Support the weight housing on bed of press as shown in Fig. 8 in Section 2.7.1. Press the shaft from the bearing.

4. Slide the riser thrust bearing and governor riser from the shaft.

   This bearing is specially designed to absorb thrust loads; therefore, looseness between the mating parts does not indicate excessive wear.

5. Remove the bearing from the weight housing.

6. Mark the low and high speed weights and carrier with a center punch for identification, also note the position of the thin washer between the weights so that the parts can be replaced in their original position.

7. Remove Allen set screw from the low speed weights. Withdraw the pins and the governor weights.

   NOTE: If necessary the needle bearings in the high speed weights may be removed at this time.

8. If required, the weight carrier (Fig. 4) may be pressed from governor weight shaft and a new carrier installed.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

Revolve the ball bearings slowly by hand. Replace the bearings which indicate rough or tight spots. Also replace bearings which are corroded or pitted.

Examine the riser thrust bearings for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and bearing assembly.

Examine the governor weights at the riser contact area for excessive wear. If this condition exists install a new governor weight.

Inspect the weight carriers and retaining pins for wear.

Inspect the bushings in current weights and replace them if they are worn excessively. In former weights inspect the needle bearings for wear and replace if necessary.

Inspect the operating shaft and bushing for excessive wear. If excessive wear is noted, a new bushing and shaft must be installed.

Assemble Governor Cover

1. If the needle bearings were removed from the governor cover place the governor cover on the bed of an arbor press with the inner face of the cover down. Start the upper bearing straight into the bearing bore of the cover with the number on the bearing up. Insert bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 5).

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

   NOTE: Do not use impact tools to install needle bearings.

3. Apply lubricant to the cam pin and referring to Fig. 2 place the cam over the pin with the boss of the cam up. Install the stop lever.

4. Place washer over the pin and secure it with the spring retainer.

5. Install the plug in the throttle shaft.

6. Pack the needle bearings with grease. Then, slide the throttle shaft through the bearings.

7. Insert the seal ring over the shaft and into the counterbore against the upper bearing. Place the retainer over the shaft and against the seal ring.

8. Start the throttle control lever over the throttle shaft with the holes (for the tapered pin) in the lever and the shaft in alignment.

9. Support the lower end of the throttle shaft on the bed of an arbor press, then place a sleeve

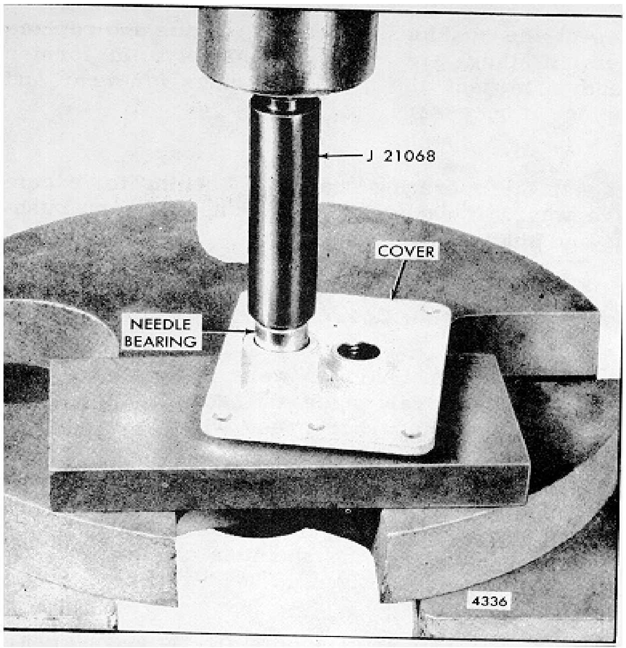


Fig. 5 - Installing Needle Bearings in Governor Cover

on the throttle lever and under the ram of the press. Align the slot in the cam with the pin in the throttle lever, then press the lever down on the shaft until the hole in the lever is in line with the hole in the shaft.

10. Insert the tapered pin in the hole in the lever, then support the lever and cover assembly on a steel block and drive the pin into place.

11. Position the speed control lever on the throttle shaft and tighten the retaining bolt.

Assemble Governor Control Housing

1. Place the washer (31), Fig. 1 over the short finished end of the operating shaft (26). Start the bearing (30) over the end of the shaft. Support the opposite end of the shaft on the bed of the press. Press the bearing on the shaft tight against the washer with a sleeve which has the same diameter as the bearing inner race.

2. With the pivot pin in the operating lever (27) up, start the lever over the end of the shaft with the flat on shaft registering with the flat surface in the lever. Press the lever on the shaft tight against the bearing (30).

3. Lubricate the bearing and the operating shaft bushing (40) in the housing with clean engine oil. Insert the lever and the operating shaft assembly in the control housing.

4. Position the operating fork (73) over the lower end of the operating shaft, Fig. 4, so the finished side of the fork finger will rest against the thrust bearing when assembled as shown in Fig. 1 in Section 2.7.1.

5. Support the operating shaft and control housing in an arbor press with the upper end of the operating shaft resting on a steel block. Align the flat in the operating fork with the flat on the operating shaft; then, place a sleeve over the end of the shaft and rest it on the fork. Bring the ram of the press down on the sleeve and press the fork straight down and tight against the shoulder on the shaft.

6. Tighten the fork set screw, if used.

7. Apply a good quality sealant around the periphery of the expansion plug (Fig. 4) and press the plug into the lower end of the control housing.

8. Place a lock washer and flat washer over the retaining screw (32). Thread the screw in the control housing to secure the operating shaft bearing (30).

9. Install the torsion spring (97) Fig. 1, to the differential lever (23) with special screw (94). Tighten the screw securely.

10. Refer to Fig. 1 and place the differential lever (23) over the pivot pin of the operating lever. Install a plain washer and spring retainer (25).

Assemble Governor Springs, Plungers, and Adjusting Screws

1. Thread the idle speed adjusting screw into the modulating spring adjusting screw; then, thread these two pieces into the high speed spring plunger (Fig. 6).

2. Install the modulating spring seat, the modulating spring, and the modulating spring plunger into the high speed spring plunger. The spring seat shoulder must be toward the spring.

3. With the modulating spring seat, spring, and plunger installed in the high speed spring plunger, install the retainer ring in the groove near the end of the high speed spring plunger. Be sure the ring is fully seated in the groove.

4. Install the low speed spring seat, low speed spring and low speed spring cap into the high speed spring plunger. The spring seat shoulder must be toward the spring.

5. Slide the high speed spring and high speed adjusting screw over the high speed spring plunger.

6. Hold the assembly while positioning it in the control housing, with the high speed spring plunger against the support in the housing. Thread the high speed spring adjusting screw into the housing sufficiently to retain the assembly.

7. Thread the high speed adjusting screw into the housing until the end of the screw is approximately 3/4" from the spanner lock nut. Thread the modulating spring adjusting screw in until the end of the screw is approximately 1 1/2" from the spanner lock nut.

Assemble Governor Weight Housing

1. Refer to Fig. 4 and start the pin through the opening in the weight carrier.

   Place the low speed weight on the pin and slide the pin through.

   Place two flat washers on the pin next to the low speed weights.

   Install the high speed weights on their shafts after installing the needle bearings or bushings.

   Place the high speed weight on the pin and slide the pin through the weight.

   Place two more flat washers on the pin between the high speed weights and the carrier. Slide the pin through the washers and into the carrier.

   Align the indentation in the pin with the set screw hole in the low speed weights. Apply a sealant such as Loctite grade C or CV or equivalent on the threads of the set screw Insert the set screw and tighten it to 20 lb-in minimum. Be sure to stake the set screw in two places after tightening the screws.

   > **NOTE**: Before applying the sealant to a new set screw immerse the set screw i n Loctite P rim e r T or equivalent.

2. Slide the riser over the shaft and against the finished surfaces of the governor weights as shown in Fig. 4.

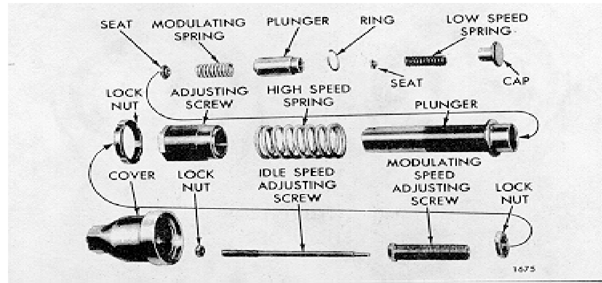


Fig. 6 - Governor Springs, Plungers and Adjusting Screws (Fuel Modulating Governor)

3. Assemble the riser thrust bearing on the weight shaft with the bearing race with the smallest inside diameter against the thrust riser. Incorrect installation of the bearing will result in erratic operation of the governor.

4. Insert the weight carrier and shaft assembly in the weight housing.

5. Support the splined end of the shaft on the bed of an arbor press. Start the shaft end bearing in the housing and over the end of the shaft with the numbered side of the bearing facing away from the shaft. Press the bearing in place with a sleeve that bears against the inner race.

   > **CAUTION:** This bearing has thrust capacity in one direction only. Be sure to install the bearing so that the thrust shoulder (Fig. 7) is toward the governor weights. Otherwise, the force exerted by the weights will pull the inner race and ball assembly away from the outer race and result in damage to the bearing and erratic governor operation.

6. Place the washer, Fig. 4, over the bearing retaining bolt. Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang on the washer against the head of the bolt.

7. Place a gasket in the housing, against the bearing. Apply a Loctite sealant grade HV or equivalent to the full 360’ circumference of the plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb-ft torque with either flat or point of head on a horizontal line.

2.7.1.1 LIMITING SPEED GOVERNOR

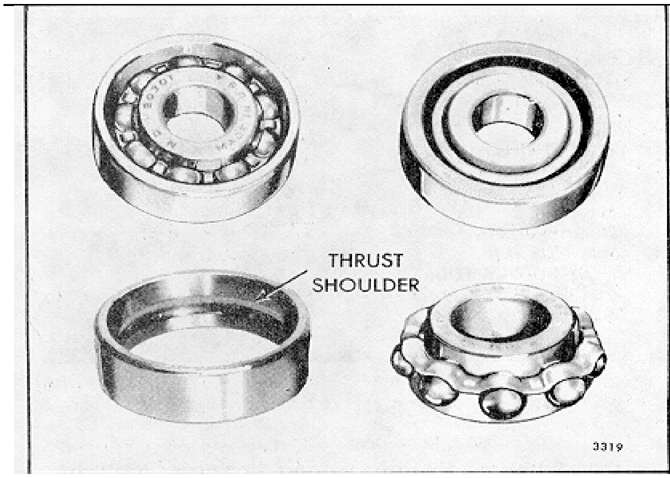


Fig. 7 - Governor Weight Shaft Bearing

Install Governor

1. Affix a new gasket, (Fig. 4) to the governor weight housing. Start the splined end of the weight shaft in the upper blower rotor and position the housing against the blower end plate.

2. Place a new copper gasket on each weight housing-to-blower bolt and thread the bolts into the blower end plate, finger tight only.
3. Place a new gasket (Fig. 4) over the dowels and against the side of the weight housing facing the engine.
4. Move the thrust bearing assembly and riser toward the weight end of the shaft.
5. Position the lower end of the control housing over the dowel pins in the weight housing.

   NOTE 1: The finished surface of the operating fork must be placed against the outer side of the thrust bearing as shown in Fig. 1in Section 2.7.1.

   NOTE 2: Current weight housings have two ribs cast on the inner surface of the housing to prevent any part of the riser thrust bearing from sliding forward to where the operating fork could be inserted on the wrong side of one or more parts of the bearing. For ease in assembling the governor control housing to the interim weight housings (no identification mark), Fig. 8, place a 3/8"-24 x 3/4" or 7/8" bolt, from which the outer 1/2" of thread down to a diameter of 5/16" to 1/4" has been removed, in the 1/8" NPIYF oil hole to prevent the thrust bearing from moving too far forward in the weight housing.

After the control housing is installed, remove the bolt and install the oil tube fitting.

6. Affix a new gasket to the governor control housing, then attach the governor control housing to the cylinder head with two bolts. Tighten the bolts.
7. Tighten the governor-to-blower bolts with wrench J 4242.
8. Affix a new gasket to the weight housing cover (former governors only) and place the cover in position. Install the four weight housing-to-control housing bolts with lock washers and tighten the bolts.
9. Connect the oil tube to the fitting on the weight housing or on the cover (if used).
10. Position the fuel rod (14) over the differential lever pin (Fig. 1 in Section 2.7.1). Place a flat washer over the pin and secure it with the retainer (25).
11. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.
12. Place a new gasket (4), Fig. 1, on the governor control housing and mount the governor cover on the housing with the pin on the throttle shaft (7) registering with the machined slot in the differential lever (23).
13. Install the four cover screws (5) with lock washers. One end of the cam spring (20) is anchored to one of the cover screws (Fig. 2).
14. Connect throttle linkage.
15. Attach the breather tube to the governor housing.
16. Tune-up the engine as outlined in Section 14.5.

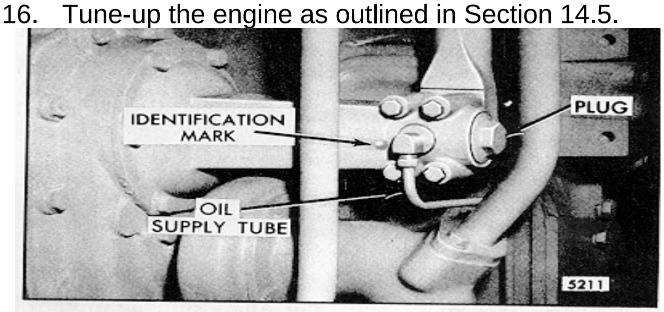


Fig. 8-Governor Weight Housing

LIMITING SPEED MECHANICAL GOVERNOR (DUAL HIGH SPEED RANGE)

The limiting speed mechanical double weight dual range governor is similar to the limiting speed governor shown in Fig. 1 in Section 2.7.1 except for the spring and piston assemblies illustrated in Figs. 1 and 2.

The dual range governor is used on highway vehicle engines that require a high maximum speed part of the time and a low maximum speed the remainder of the time.

Due to the governors dual speed feature, it permits a high engine speed in the lower gear ratios for maximum vehicle acceleration while providing a conservative vehicle speed in the higher gears. The valve for controlling the high and low speed ranges of the governor is usually connected to the transmission. Shifting the transmission from a lower gear to a higher gear will automatically shift the governor from its high maximum speed range to the low maximum speed range. This two speed operation is accomplished by the use of air pressure behind a piston (Figs. 1 and 2) to increase the tension on the governor high speed spring. The removal of air pressure from behind the piston permits the governor high speed spring to force the piston against the low maximum speed adjusting screw that retains enough tension in the governor high speed spring to operate the engine at the desired lower speed.

Lubrication

Surplus oil returning from the cylinder head provides lubrication for the parts in the governor

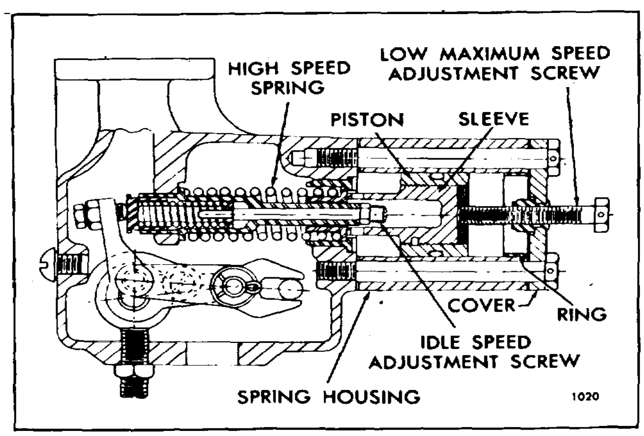


Fig. 1 - Spring and Piston Assembly of Former Dual Range Governor

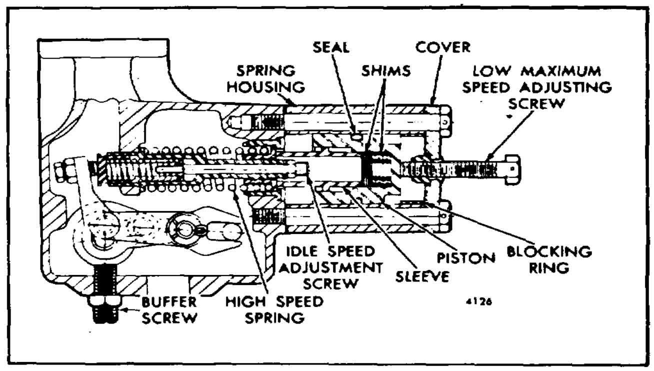


Fig. 2 - Spring and Piston Assembly of Current Dual Range Governor

control housing, the riser thrust bearings and the weight shaft end bearing. Oil picked up from a reservoir in the blower front end plate by a slinger attached to the lower rotor shaft, provide lubrication for the governor weights and weight carrier.

Pressure lubrication has been provided for the weight housing bearings on current engines by an oil tube attached between the oil gallery in the cylinder block and the weight housing.

Remove Governor

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Disconnect linkage attached to the governor levers.
2. Remove breather tube.
3. Remove four screws and lock washers and lift the governor cover and gasket from the control housing.
4. Disconnect the fuel rod from the differential lever and the injector control tube lever.
5. Disconnect the oil tube at the governor weight housing or cover and remove the cover, if used.
6. Remove both governor-to-cylinder head bolts.
7. Remove the governor control housing from the cylinder head and governor weight housing.

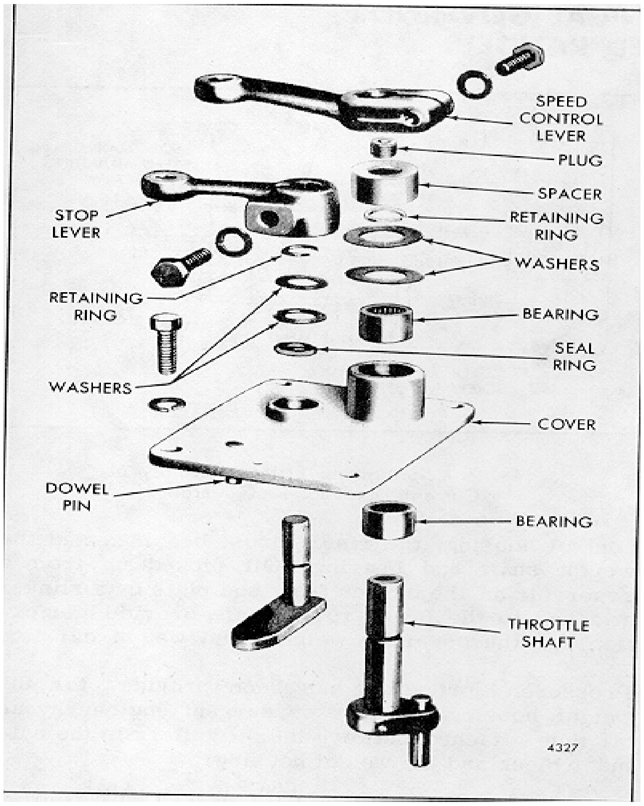


Fig. 3 - Exploded View of Governor Cover

8. Remove six weight housing-to-blower bolts, using wrench J 4242, and withdraw the housing from the blower.

Disassemble Governor Cover

1. Loosen the lever bolts and remove the speed control lever and stop lever from their respective shafts.

2. Remove the plug from the throttle shaft.

3. Remove the seal retaining ring and spacers from the stop lever shaft and withdraw the shaft from the cover.

4. Remove the seal ring from the governor cover.

5. Remove the spacer (if used) and the retaining ring and washers from the throttle shaft and withdraw the shaft from the cover.

6. Wash the cover assembly thoroughly in clean

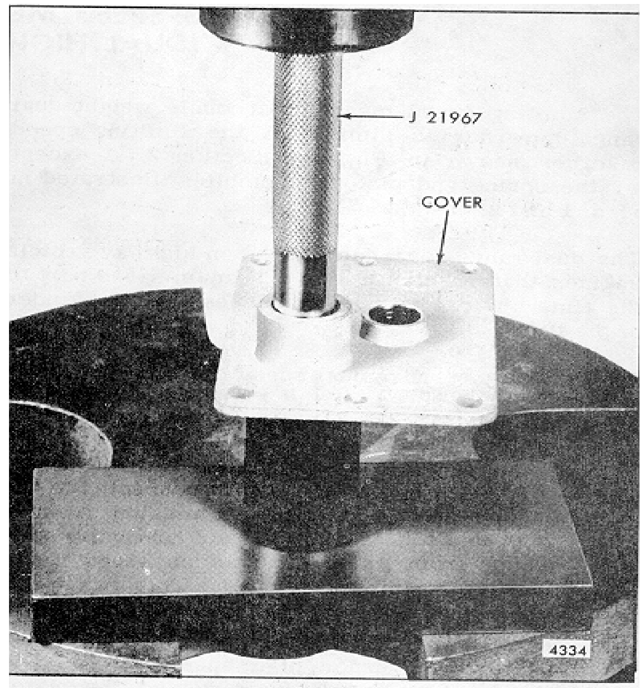


Fig. 4 - Removing Needle Bearing from Governor Cover

fuel oil and inspect the needle bearings for wear or damage. If bearing removal is necessary, place the inner face of the cover over the opening in the bed of the press. Place remover tool J 21967 on top of bearing (Fig. 4) and under ram of press, then press both bearings out of the cover.

Disassemble Governor Control Housing

1. Remove the two bolts securing the spring housing cover and withdraw the cover, piston, sleeve and low maximum speed adjustment screw as an assembly (Figs. 1 and 2).

   NOTE: Current governors have a blocking ring in the spring housing to prevent removal of the seal from the rear end (cover end) of the spring housing, thus preventing seal ring damage.

2. Remove the spring retainer and washer, then lift the differential lever from the pin of the operating shaft lever (Fig. 5).
3. Remove the expansion plug from the lower end of the control housing.

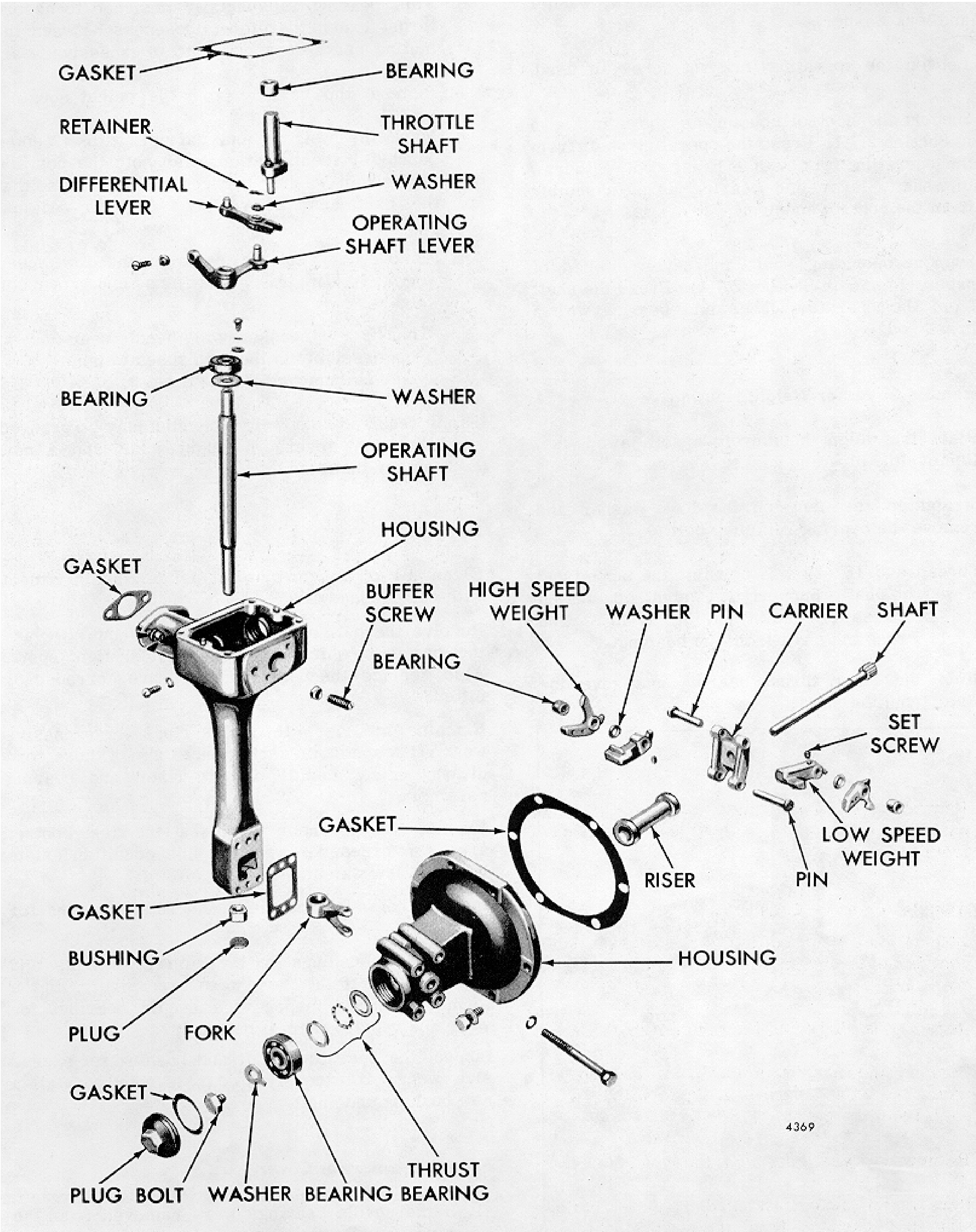


Fig. 5 - Exploded View of Governor Control and Weight Housings

4. Remove the bearing retaining screw, washer and lock washer.

5. Loosen the operating fork set screw, if used.

6. Support the control housing as shown in Fig. 5 in Section 2.7.1. Press the operating shaft from the operating fork with a brass rod. Withdraw the shaft, lever and bearing as an assembly from the control housing.

7. Support operating shaft and lever on bed of press (Fig. 6 in Section 2.7.1). Press the shaft from the operating lever and bearing with a brass rod.

Disassemble Governor Weight Housing

1. Place the weight housing in a soft jawed vise. Remove the plug and gasket.

2. Straighten the tang on the lock washer and remove the bearing retaining bolt.

3. Thread a 5/16"-24 x 3" bolt into the tapped end. of weight shaft. Support the weight housing on bed of press as shown in Fig. 7 in Section 2.7.1. Press the shaft from the bearing.

4. Slide the riser thrust bearing and governor riser from the shaft.

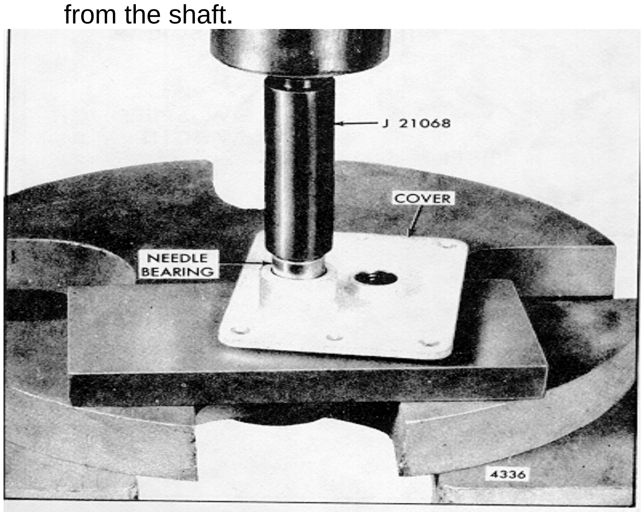


Fig. 6 - Installing Needle Bearings in Governor Cover

This bearing is specially designed to absorb thrust loads; therefore, looseness between the mating parts does not indicate excessive wear.

5. Remove the bearing from the weight housing.

6. Mark the weights and carrier with a center punch for identification, also note the position of the thin washer between the weights so that the parts can be replaced in their original position.
7. Remove the set screw from the low speed weights. Withdraw the pins and governor weights.

   NOTE: If necessary the needle bearing assembly in the high speed weights may be removed at this time.

8. If required, the weight carrier may be pressed from the governor weight shaft and a new carrier installed.

Inspection

Clean all of the parts with fuel oil, and dry them with compressed air.
Revolve the ball bearings slowly by hand. Replace the bearings which indicate rough or tight spots.
Also replace the bearings which are corroded or pitted.
Examine the riser thrust bearings for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and bearing assembly.
Examine the governor weights at the riser contact area for excessive wear. If this condition exists install a new weight.
Inspect the weight carriers and retaining pins for wear.
Inspect the bushings in the current weights and replace them if they are worn excessively. In the former weights inspect the needle bearings for wear and replace them if necessary. Inspect the operating shaft and bushing for excessive wear. If excessive wear is noted, install a new bushing and shaft.

Assemble Governor Cover

1. If the needle bearings were removed from the governor cover, place the governor cover on the bed of an arbor press with the inner face of the cover down. Start the upper bearing straight into the bearing bore of the cover with

the number on the bearing up. Insert bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 6).

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

NOTE: Do not use impact tools to install needle bearings.

3. Install the plug in the throttle shaft.
4. Pack the needle bearings with grease. Then, slide the throttle shaft assembly through the bearings.
5. Install two retaining washers and retaining ring on the throttle shaft.
6. Install the spacer on the shaft (slip fit) against the retaining washers and over the snap ring.

    NOTE: Prior to September 1970 a spacer was not used. When assembling a governor cover on an engine built prior to September 1970 include a .440" thick spacer.

7. Lubricate the stop lever shaft with engine oil and slide the shaft through the cover.
8. Install a new seal ring over the shaft and in the cover, then install two seal retaining washers and a retaining ring.
9. Install the stop lever and speed control lever and tighten the clamping bolts.

Assemble Governor Control Housing

1. Place a washer (Fig. 5) over' the short finished end of the operating shaft. Start the bearing over the end of the shaft. Support the opposite end of the shaft on the bed of a press. Press the bearing on shaft tight against washer with a sleeve which has the same diameter as the bearing inner race.
2. With the pivot pin in the operating lever up, start the lever over the end of shaft with the flat on shaft registering with flat surface in the lever. Press the lever on the shaft tight against bearing.
3. Lubricate the bearing and operating shaft bushing in the housing with clean engine oil. Insert the lever and operating shaft assembly in the control housing.
4. Position the operating fork over the lower end of the operating shaft (Fig. 5) so the finished side of the fork finger will rest against the thrust bearing when assembled as shown in Fig. 1 of Section 2.7.1.

5. Support the operating shaft and control housing in an arbor press with the upper end of the operating shaft resting on a steel block. Align the flat in the operating fork with the flat on the operating shaft; then, place a sleeve over the end of the shaft and rest it on the fork. Bring the ram of the press down on the sleeve and press the fork straight down and tight against the shoulder on the shaft.

6. Tighten the fork set screw, if used.

7. Apply a good quality sealant around the periphery of the expansion plug (Fig. 5) and press the plug into the lower end of the control housing.

8. Place a lock washer and flat washer over the retaining screw. Thread the screw in the control housing to secure the operating shaft bearing.

9. Place the differential lever over the pivot pin of the operating lever (Fig. 5). Install a plain washer and spring retainer.

Assemble Governor Springs, Plungers, and Adjusting Screws

1. Thread the lock nut on the buffer screw and thread the buffer screw into the governor control housing.

2. Thread the idle speed adjusting screw into the high speed spring plunger; then, thread the lock nut on the end of the adjusting screw.

3. Slip the high speed spring, spring guide, and governor spring retainer over the end of the plunger.

4. Insert the low speed spring seat, low speed spring, and spring cap in the other end of the plunger.

5. Slip the low speed spring end of the assembly through the control housing. Then, thread the high speed spring retainer into the control housing, using tool J 1652-01.

6. Apply P.O.B. No. 3 sealant, or its equivalent, on the threads of the piston sleeve; then, thread the sleeve into the piston until the sleeve extends approximately 25/32" from the piston.
7. Install a seal ring in the groove of the piston.
8. Position the blocking ring in the spring housing so the opening in the ring is in line with the threaded hole. If the spring housing did not incorporate a blocking ring, the installation of a blocking ring is recommended. This ring will prevent the piston and seal ring from sliding out the cover end of the spring housing, and possible damage to the seal ring by the sharp edges of the threaded hole.
9. Lubricate the inside surface of the spring housing with an all purpose grease and insert the piston and sleeve assembly inside the spring housing at the end opposite to the pipe plug boss.
10. Use a new gasket at each end of the spring housing and attach the cover to the end of the housing (end with the boss for the pipe plug) and install the spring housing on the control housing.
11. Install the low maximum speed adjustment screw and lock nut in the spring housing cover.

Assemble Governor Weight Housing (Double Weight)

1. Start the weight pin through the opening in the weight carrier (Fig. 5).

   Place the low speed weight on the pin and slide the pin through.

   Place two flat washers on the pin next to the low speed weights.

   Install the high speed weights on their shafts after installing the needle bearings.

   Place the high speed weight on the pin and slide the pin through the weight.

   Place two more flat washers on the pin between the high speed weights and the carrier. Slide the pin through the washers and into the carrier.

   Align the indentation in the pin with the set screw hole in the low speed weights. Apply a sealant such as Loctite grade C or CV or equivalent on the threads of the screw.

   Insert the set screw and tighten it to 20 lb-in minimum. Be sure to stake the set screw in two places after tightening the screws.

   NOTE: Before applying the sealant to a new set screw immerse the set screw in Loctite Primer T or equivalent.

2. Slide the riser over the shaft and against the finished surfaces of the governor weights as shown in Fig. 1 in Section 2.7.1.

3. Assemble the riser thrust bearing on the weight shaft with the bearing race having the smaller inside diameter against the thrust riser. Incorrect installation of the bearing will result in erratic operation of the governor.

4. Insert the weight carrier and shaft assembly in the weight housing.

5. Support the splined end of the shaft on the bed of an arbor press. Start the shaft end bearing in the housing and over the end of the shaft with the numbered side of the bearing facing away from the shaft. Press the bearing in place with a sleeve that bears against the inner race.

   CAUTION: This bearing has thrust capacity in one direction only. Be sure to install the bearing so that the thrust shoulder (Fig. 10 in Section 2.7.1) is toward the governor weights. Otherwise, the force exerted by the weights will pull the inner race and ball assembly away from the outer race and result in damage to the bearing and erratic governor operation.

6. Place the washer (Fig. 5) over the bearing retaining bolt. Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang on the washer against the head of the bolt.

7. Place a gasket in the housing, against the bearing. Apply a Loctite Sealant grade HV or equivalent to the full 360° circumference of the plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb-ft torque.

Install Governor

1. Affix a new gasket (Fig. 5) to the governor weight housing. Start the splined end of the weight shaft in the upper blower rotor and position the housing against the blower end plate.

2. Place a new copper gasket on each weight housing-to-blower bolt and thread the bolts into the blower end plate, finger tight only.

3. Place a new gasket (Fig. 5) over the dowels and against the side of the weight housing facing the engine.

4. Move the thrust bearing assembly and riser toward the weight end of the shaft

5. Position the lower end of the control housing over the dowel pins in the weight housing.

   NOTE 1: The finished surface of the operating fork must be placed against the outer side of the thrust bearing as shown in Fig. 1 in Section 2.7.1.

   NOTE 2: Current weight housings have two ribs cast on the inner surface of the housing to prevent any part of the riser thrush bearing from sliding forward to where the operating fork could be inserted on the wrong side of one or more parts of the bearing. For ease in assembling the governor control housing to the interim weight housings (no identification mark), Fig. 7, install a 3/8"-24 x 3/4" or 7/8" bolt, from which the outer 1/2" of thread down to a diameter of 5116" to 1/4" has been removed, in the 1/8" NPTF oil hole to prevent the thrust bearing from moving too far forward in the weight housing.

After the control housing is installed remove the bolt and install the oil tube fitting.

6. Affix a new gasket (Fig. 5) to the governor control housing then, attach the governor control housing to the cylinder head with two bolts. Tighten the bolts.

7. Tighten the governor-to-blower bolts with wrench J 4242.

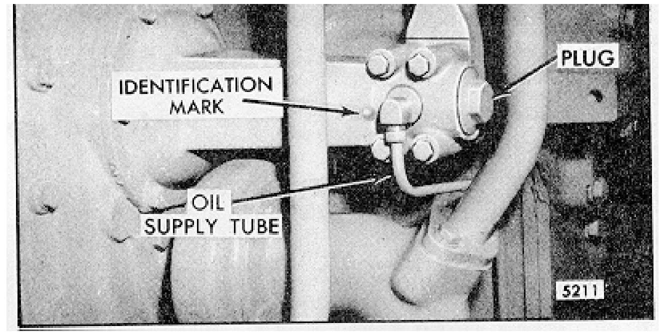


Fig. 7 - Governor Weight Housing

8. Affix a new gasket to the weight housing cover (former governors only) and place the cover in position. Install the four weight housing-to-control housing bolts with lock washers and tighten the bolts.

9. Connect the oil tube to the fitting on the weight housing or the cover (if used).

10. Refer to Fig. I in Section 2.7.1 and position the fuel rod over the differential lever pin. Place a flat washer over the pin and secure it with the retainer.

11. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.

12. Place a new gasket (Fig. 5) on the governor control housing and mount the governor cover on the housing with the pin on the throttle shaft registering with the machined slot in the differential lever.

13. Install the four cover screws with lock washers.

14. Connect throttle linkage.

15. Attach breather tube to governor housing.

16. Tune-up the engine as outlined in Section 14.3.2.

LIMITING SPEED MECHANICAL GOVERNOR
(Variable Low-Speed)

The variable low-speed limiting speed mechanical governor is used on highway vehicle engines where the same engine powers both the vehicle and auxiliary equipment and a high idle speed range is desired during the auxiliary operation.

The current governor is a single-weight type and provides an idle speed range of 550 to 1800 rpm. The former governor was a double-weight type and provided an idle speed range of 450 to 1300 rpm.

The governor is mounted on the front end of the blower and is driven by the upper blower rotor.

Governor identification is provided by a name plate attached to the governor housing. The letters V.L.S.L.S. stamped on the name plate denote a variable low-speed limiting speed mechanical governor.

Operation

During highway operation the governor functions as a limiting speed governor, controlling the engine idling speed and limiting the maximum operating speed. At the unloading area, the throttle is left in the idle speed position and the remote control knob is turned to the speed required within the above range to operate the auxiliary equipment. The governor then functions as a variable speed governor, maintaining a constant speed when the load is continuously changing during the unloading operation. Before resuming highway operation, the remote control knob must be turned all the way back.

Lubrication

The governor is lubricated in the same manner as the limiting speed governor (Section 2.7.1).

Check Governor Operation

Governor difficulties should be checked out in the same manner as outlined in Section 2.7. If, after making the checks, the governor fails to control the engine or auxiliary equipment properly, it should be removed and reconditioned.

Remove Governor From Engine

1. Disconnect the manual control flexible shaft from the governor spring housing.
2. Remove the governor following the same procedures outlined in Section 2.7.1.

Disassemble Governor

The variable low-speed limiting speed governor is similar to the limiting speed governor with the

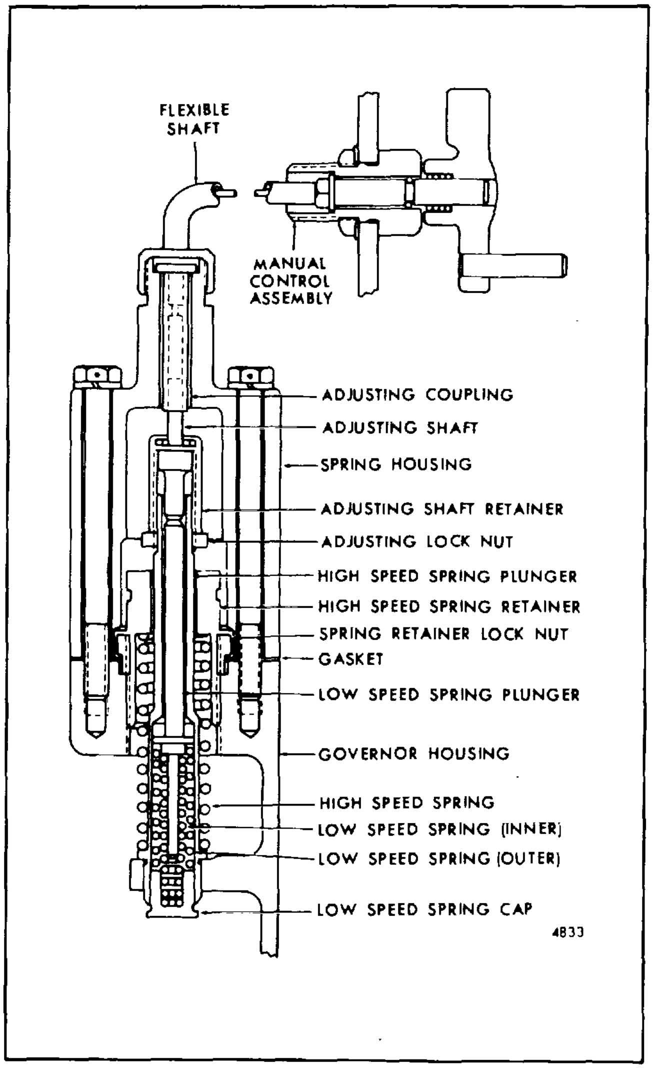


Fig. 1 - Governor Spring Housing and Components

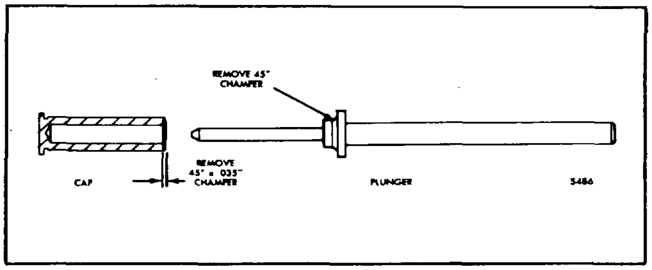


Fig. 2 - Rework Former Plunger and Cap

exception of the spring housing and its components. Therefore, disassemble the governor as outlined in Section 2.7.1, then disassemble the spring housing and its components (Fig. I) as follows:

1. Clamp the flange of the governor housing in a vise equipped with soft jaws.

2. Remove the two bolts and lock washers securing the spring housing to the governor housing and withdraw the spring housing and gasket.

3. Remove the adjusting coupling from the adjusting shaft.

4. Hold the adjusting lock nut with a wrench and back off the retainer and adjusting shaft.

5. Unscrew the adjusting shaft from the retainer.

6. Unscrew the idle speed adjusting lock nut from the end of the high-speed spring plunger.

7. Unscrew the high-speed spring retainer lock nut and remove the high-speed spring retainer, plunger and spring along with the low-speed spring plunger, inner and outer springs and low-speed spring cap as an assembly from the governor housing.

8. Remove the high-speed spring retainer and spacer assembly and spring from the high-speed spring plunger. Remove the low-speed spring cap from the opposite end of the high-speed spring plunger and remove the low-speed spring plunger along with the inner and outer low-speed springs.

NOTE: The high-speed spring retainer on early engines did not include a spacer. If the shaft sticks in the retainer, replace it with the current retainer and spacer assembly.

Inspect Governor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air, then inspect them as outlined in Section 2.7.1.

Assemble Governor

NOTE: During assembly, lubricate all spring housing components and needle bearing assemblies with MIL. G3278A, Aero Shell 7A grease, or equivalent (special grease for high and low temperature operations).

Assemble the governor as outlined in Section 2.7.1, then assemble the spring housing and components (Fig. 1).

To assure a 550 rpm idle speed for certain on highway vehicle engines, the spring seat chamfer has been removed from the low-speed spring plunger and cap. The internal chamfer has been removed from both ends of the coil of the outer low-speed spring. A high idle condition could be the result if an unchamfered spring did not seat properly due to the chamfer on the former plunger and cap. To correct this condition, install a current (modified) plunger and cap, or remove the 45° chamfer from the spring seat area of the plunger and also the 45 ° x .035 " chamfer on the cap (shaded area, Fig. 2).

CAUTION: A chamfered spring should not be used with an unchamfered plunger and cap, because a severe wear condition will result.

1. Thread the spring retainer lock nut on the high-speed spring retainer approximately 1-1/2 ".
2. Place the high-speed spring on the high-speed spring plunger.
3. Insert the high-speed spring and plunger assembly in the high-speed spring retainer.
4. Insert the low-speed spring plunger into the high-speed spring plunger.
5. Place the inner and outer springs in the lower end of the high-speed spring plunger, over the low-speed spring plunger.
6. Install the low-speed spring cap over the end of the inner low-speed spring and into the end of the high-speed spring plunger and install the assembly in the governor housing.

CAUTION: Place the spring housing gasket in position before installing the assembly.

7. Thread the idle speed adjusting lock nut on the threaded end of the high-speed spring plunger approximately 1/2 ".
8. Screw the adjusting shaft into the adjusting shaft retainer all the way in as shown in Fig. 1.
9. Install the adjusting retainer and shaft onto the high-speed spring plunger. Turn down the adjusting retainer against the idle speed adjusting lock nut.
10. Install the adjusting coupling and spring housing after the governor adjustments (Section 14.3.3) have been performed.

Install Governor

Install the governor as outlined in Section 2.7.1, then connect the manual control flexible shaft to the governor spring housing (Fig. 1).

Adjust the governor as outlined in Section 14.3.3.

LIMITING SPEED MECHANICAL GOVERNOR
(Fast Idle Cylinder)

The double-weight limiting speed governor equipped with a fast idle air cylinder is used on vehicle engines where the engine powers both the vehicle and auxiliary equipment.

The fast idle system consists of a fast idle air cylinder installed in place of the buffer screw and a throttle locking air cylinder mounted on a bracket fastened to the governor cover (Fig. 1). An engine shutdown air cylinder, if used, is also mounted on the governor cover.

For operation and adjustment of the fast idle air cylinder, refer to Section 14.3.4.

Lubrication

The governor is lubricated in the same manner as the limiting speed governor (Section 2.7.1).

Check Governor Operation

Governor difficulties should be checked in the manner outlined in Section 2.7. If, after making the checks, the governor fails to control the engine or auxiliar
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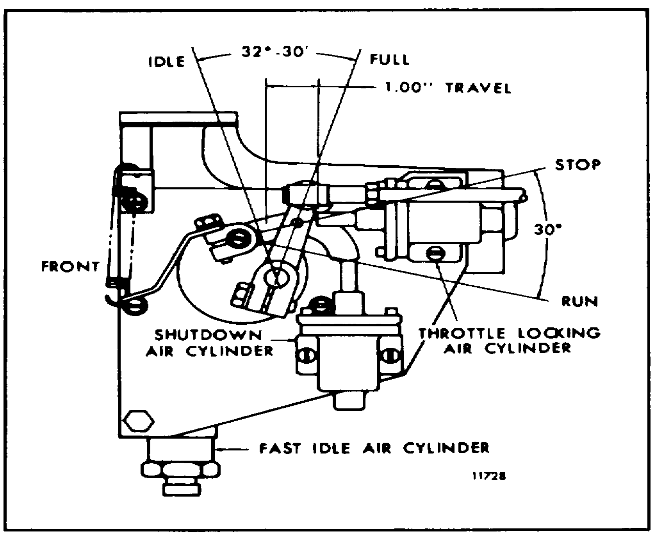


Fig. 1 - Governor with Fast Idle Cylinder

equipment properly, it should be removed and reconditioned.

Remove Governor

1. Release any air in the system and disconnect the air

2. Remove the governor by following the procedure outlined in Section 2.7.1.

Disassemble Governor

1. Disassemble the governor as outlined in Section 2.7.1.
2. Refer to Fig. 2 and disassemble the fast idle cylinder as follows:
   a. Pull the plunger out of the buffer spring and cylinder.
   b. Clamp the air cylinder in a vise equipped with soft jaws.
   c. Apply pressure on the end of the air inlet plug and remove the plug retaining ring from the groove in the air cylinder.
   d. Pull the air inlet plug and seal ring assembly from the air cylinder. Remove the seal ring from the groove in the plug.
   e. Insert a 3/32" diameter steel rod in the plunger opening in the air cylinder and push the piston, seal ring, dual idle spring and spring follower out

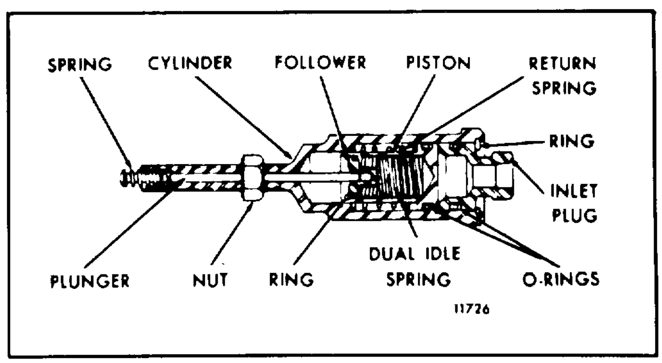


Fig. 2-Fast Idle Air Cylinder

of the air cylinder as an assembly. Then remove the air cylinder spring from the cylinder.

f. Remove the seal ring from the groove in the piston. Apply pressure on the spring follower and remove the follower retaining ring from the groove in the piston. Remove the follower and spring.

Inspection

Wash all of the governor components in clean fuel oil and dry them with compressed air. Then inspect them as outlined in Section 2.7.1.

Examine the fast idle air cylinder components for wear or any defects. Replace worn or damaged parts.

Assemble Governor

1. Assemble the governor as outlined in Section 2.7.1.

2. Assemble the fast idle cylinder as follows:

   a. Refer to Fig. 2 and insert the dual idle spring inside of the fast idle air cylinder. Place the spring follower, with the small diameter end down, inside of the spring. Apply pressure on the spring follower and compress the spring enough to expose the retaining groove. Then install the retaining ring in the groove.

   b. Install a new seal ring in the groove in the piston. Then install the air cylinder spring over the small diameter end of the piston.

   c. Lubricate the seal ring on the piston with engine oil. Then insert the piston and spring assembly, with the small diameter end of the piston first, straight into the air cylinder spring seats on the shoulder in the cylinder.

   d. Install a new seal ring in the groove of the air cylinder air inlet plug.

   e. Lubricate the seal ring with engine oil. Then insert the air inlet plug straight into the air cylinder and against the piston.

   f. Clamp the air cylinder in a vise equipped with soft jaws. Apply pressure on the end of the air inlet plug and compress the spring enough to expose the retaining ring groove. Then install the retaining ring.

   g. If removed, thread the lock nut on the air cylinder. Then insert the plunger through the buffer spring and into the air cylinder.

3. Install the fast idle air cylinder assembly in the governor housing buffer screw hole.

Install Governor

1. Install the governor on the engine as outlined in Section 2.7.1.
2. Install the throttle locking and engine shutdown air cylinders.
3. Connect the air hoses to the air cylinders.
4. Adjust the governor as outlined in Section 14.3.4.

SHOP NOTES - TROUBLE SHOOTING - SPECIFICATIONS

SERVICE TOOLS

SHOP NOTES

INJECTOR COMPARATOR AND CALIBRATOR READINGS

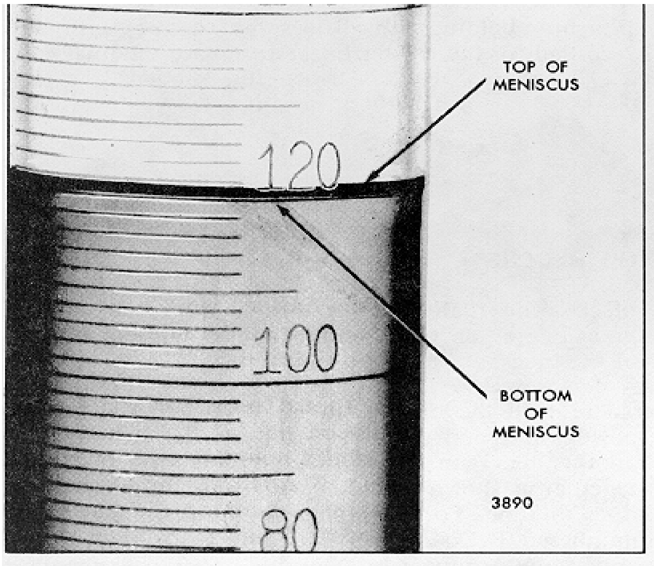


Fig. 1 - Checking Fuel Output

Several factors affect the injector comparator or calibrator output readings. The four major items are:

1. Operator Errors: If the column of liquid in the vial is read at the top of the meniscus instead of at the bottom, a variation of I or 2 points will result. Refer to Fig. 1.
2. **Air In Lines:** This can be caused by starting a test before the air is purged from the injector and lines, or from an air leak on the vacuum side of the pump.
3. **Counter Improperly Set**: The counter should be set to divert the injector output at 1,000 strokes.
This should not be confused with counter overrun that will vary from 2 to 6 digits, depending upon internal friction. The fuel diversion is accomplished electrically and will occur at 1,000 strokes (if properly set) although the counter may overrun several digits.
4. **Test Oil**: A special test oil is supplied with the comparator and the calibrator and should always be used. If regular diesel fuel oil (or any other liquid) is used, variations are usually noted because of the effect of the oil on the solenoid valve and other parts.

The fuel oil introduced into the test oil when the fuel injector is placed in the comparator or calibrator for a calibration check contaminates the test oil. Therefore, it is important that the test oil and test oil filter be changed every six months, or sooner if required.

In addition, other malfunctions such as a slipping drive belt, low level of test oil, a clogged filter, a defective pump or leaking line connections could cause bad readings. A frequent check should be made for any of these tell-tale conditions.

CHECKING INJECTOR TESTER J 9787

The injector tester J 9787 should be checked monthly to be sure that it is operating properly. The following check can be made very quickly using test block J 9787-49.

Fill the supply tank in the injector tester with clean injector test oil J 8130. Open the valve in the fuel supply line. Place the test block on the injector locating plate and secure the block in place with the fuel inlet connector clamp. Operate the pump handle until all of the air is out of the test block, then clamp the fuel outlet connector onto the test block. Break the connection at the gage and operate the pump handle until all of the air bubbles in the- fuel system disappear. Tighten the connection at the gage. Operate the pump handle to pressurize the tester fuel system to 2400-2500 psi. Close the valve on the fuel supply line. After a slight initial drop, the pressure should remain steady. This indicates that the injector tester is operating properly. Open the fuel valve and remove the test block.

If there is a leak in the tester fuel system, it will be indicated by a drop in pressure. The leak must be located, corrected and the tester rechecked before checking an injector.

Occasionally dirt will get into the pump check valve in the tester, resulting in internal pump valve leakage and the inability to build up pressure in the tester fuel system. Pump valve leakage must be corrected before an injector can be properly tested.

When the above occurs, loosen the fuel inlet connector clamp and operate the tester pump handle in an attempt to purge the dirt from the pump check valve. A few quick strokes of the pump handle will usually correct a dirt condition. Otherwise, the pump check valve must be removed, lapped and cleaned, or replaced.

If an injector tester supply or gage line is damaged or broken, install a new replacement line (available from the tester manufacturer). Do not shorten the old lines or the volume of test oil will be altered sufficiently to give an inaccurate valve holding pressure test. If it is suspected that the lines have been altered, i.e. by shortening or replacing with a longer line, check the accuracy of the tester with a master injector on which the pressure holding time is known. If the pressure holding time does not agree with that recorded for the master injector, replace the lines.

REFINISH LAPPING BLOCKS

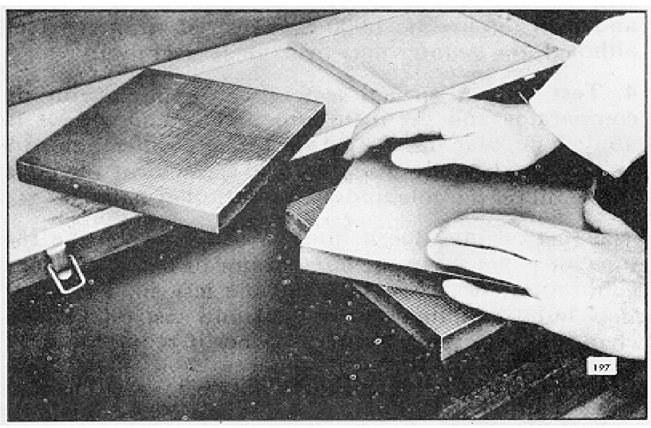


Fig. 2 - Refinishing Lapping Blocks

As the continued use of the lapping blocks will cause worn or low spots to develop in their lapping surfaces, they should be refinished from time to time.

It is good practice, where considerable lapping work is done, to devote some time each day to refinishing the blocks. The quality of the finished work depends to a great degree on the condition of the lapping surfaces of the blocks.

To refinish the blocks, spread some 600 grit lapping powder of good quality on one of the blocks. Place another block on top of this one and work the blocks together as shown in Fig. 2. Alternate the blocks from time to time. For example, assuming the blocks are numbered 1, 2 and 3, work I and 2 together, then 1 and 3, and finish by working 2 and 3 together. Continue this procedure until all of the blocks are perfectly flat and free of imperfections.

Imperfections are evident when the blocks are clean and held under a strong light. The blocks are satisfactory when the entire surface is a solid dark grey. Bright or exceptionally dark spots indicate defects and additional lapping is required.

After the surfaces have been finished, remove the powder by rinsing the lapping blocks in trichloroethylene and scrubbing with a bristle brush.

When not in use, protect the lapping blocks against damage and dust by storing them in a close fitting wooden container.

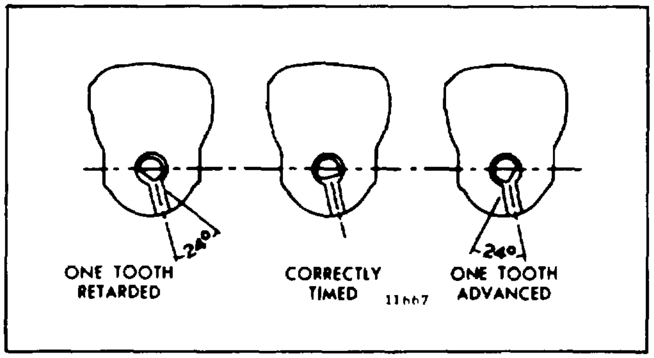


Fig. 3 - Injector Rack-to-Gear Timing

If it is suspected that a fuel injector is "out of time", the injector rack-to-gear timing may be checked without disassembling the injector.

A hole located in the injector body, on the side opposite the identification tag, may be used to visually determine whether or not the injector rack and gear are correctly timed. When the rack is all the way in (full-fuel position), the flat side of the plunger will be visible in the hole, indicating that the injector is "in time". If the flat side of the plunger does not come into full view (Fig. 3) and appears in the "advanced" or "retarded" position, disassemble the injector and correct the rack-to-gear timing.

INJECTOR SPRAY TIPS

Due to a slight variation in the size of the small orifices in the end of each spray tip, the fuel output of an injector may be varied by replacing the spray tip.

Flow gage J 21085 may be used to select a spray tip that will increase or decrease fuel injector output for a particular injector after it has been rebuilt and tested on the comparator or calibrator.

EFFECT OF PRE-IGNITION ON FUEL INJECTOR

Pre-ignition is due to ignition of fuel or lubricating oil in the combustion chamber before the normal injection period. The piston compresses the burning mixture to excessive temperatures and pressures and may eventually cause burning of the injector spray tip and lead to failure of the injectors in other cylinders. When pre-ignition occurs, remove all of the injectors and check for burned spray tips or enlarged spray tip orifices.

Before replacing the injectors, check the engine for the cause of pre-ignition to avoid recurrence of the problem. Check for oil pull-over from the oil bath air cleaner, damaged blower housing gasket, defective blower oil seals, high crankcase pressure, plugged air box drains, ineffective oil control rings or dilution of the lubricating oil.

INJECTOR PLUNGERS

The fuel output and the operating characteristics of an injector are, to a great extent, determined by the type of plunger used. Three types of plungers are illustrated in Fig. 4. The beginning of the injection period is controlled by the upper helix angle. The lower helix angle retards or advances the end of the injection period. Therefore, it is imperative that the correct plunger is installed whenever an injector is overhauled.

If injectors with different type plungers (and spray tips) are mixed in an engine, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

Injector plungers cannot be reworked to change the output or operating characteristics. Grinding will destroy the hardened case and result in chipping at the helices and seizure or scoring of the plunger.

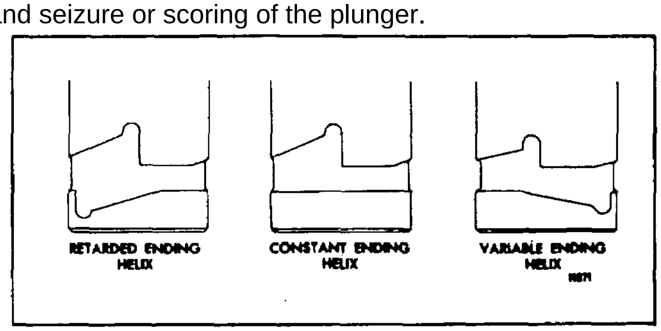


Fig. 4 - Types of Injector Plungers

REPLACING INJECTOR FOLLOWER SPRING

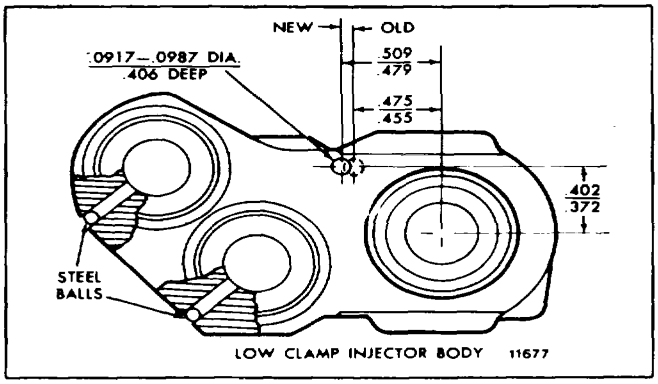


Fig. 5 - Relocating Timing Pin Hole in Injector Body

When replacing the injector follower spring (.120" diameter wire) in a low clamp body injector built prior to June, 1965 with a new injector follower spring (.142" diameter wire), it will be necessary to relocate the timing pin holes as illustrated in Fig. 5, or grind .022" from the side of the injector timing gage shank, to permit continued use of the injector timing gage.

REFINISHING INJECTOR FOLLOWER FACE

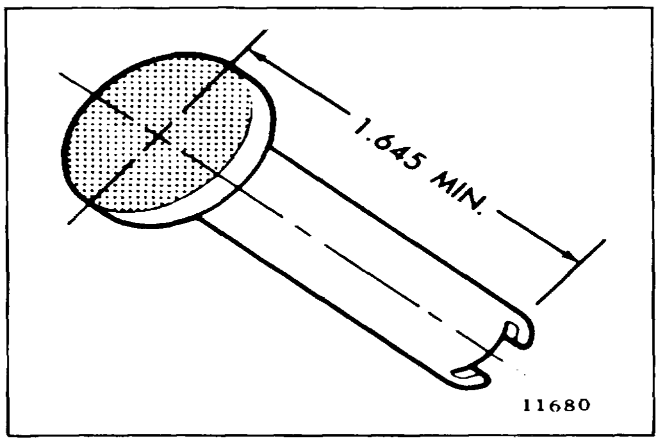


Fig. 6-Injector Follower

When refinishing the face of an injector follower, it is extremely important that the distance between the follower face and the plunger slot is not less than 1.645 " minimum as shown in Fig. 6. If this distance is less than specified, the height of the injector follower in relation to the injector body will be altered and proper injector timing cannot be realized.

NOTE: The maximum amount of metal that can be removed from the injector follower face, and still ensure a sufficiently hardened surface for contact with the rocker arm, is .010 ".

The appearance of the injector body and nut of a rebuilt injector can be enhanced with an oxide finish obtained through a dipping process known as bluing. Pre-mixed compounds are available commercially for preparing the necessary solutions. Detailed instructions are usually provided with the commercial compounds. An effective bluing solution can be prepared in the service shop by mixing the following materials:

6 lbs. of sodium hydroxide per gallon of water, 3-1/2 lbs. of sodium nitrite per gallon of water I ounce of phosphoric acid per gallon of water.

The procedure usually follows five (5) steps in sequence:

1. An alkaline solution bath (180-212°F or 82-100°C) to pre-clean.

2. A hot or cold water rinse.

3. The bluing solution bath.

4. A cold water rinse.

5. An engine lubricating oil bath (180-212°F or 82-100' C) to rust proof the parts. The bluing tank should be a double walled, 1-1/2" insulated type of 10 gage steel.

The temperature of the bluing solution should be 295'F to 305°F or 146°C to 152°C. The boiling point of the solution is directly related to its concentration. Therefore, when the boiling point is too high, the solution is too concentrated and the volume of water is probably low. When this occurs, the boiling point can be reduced to 300'F (149' C) by water: The parts should be placed in the solution for 15 to 30 minutes.

It is extremely important that the parts be free of oil before placing them in the bluing bath. Oil will produce a varied color part.

There are several important safety precautions to be followed for preparing and using the solutions. Protective clothing such as rubber gloves, rubber arm covers, rubber apron and protective face shield contribute to the safety- of personnel carrying out the procedures. When preparing the solutions, the compounds should be added to the water and not water added to the compounds. The dipping tanks should be properly vented and all fumes exhausted to the outside atmosphere. Since temperatures of the caustic solutions exceed the boiling point of water, any splashing encountered while adding make-up water can cause serious burns. Always add water slowly and with extreme care. When the parts to be dipped are cold, caution should be taken to avoid splashing that might occur when the cold parts come in contact with the hot solutions. A heavy wire-screen type basket, suitable for holding a quantity of injector bodies, is recommended for dipping the parts in the solutions.

FUEL LINES

Flexible fuel lines are used to facilitate connection of lines leading to and from the fuel tank, and to minimize the effects of any vibration in the installation.

Be sure a restricted fitting of the proper size is used to connect the fuel return line to the fuel return manifold. Do not use restricted fittings anywhere else in the fuel system.

When installing fuel lines, it is recommended that connections be tightened only sufficiently to prevent leakage of fuel; thus flared ends of the fuel lines will not become twisted or fractured because of excessive tightening. After all fuel lines are installed, run the engine long enough to determine whether or not all connections are sufficiently tight. If any leaks occur, tighten the connections only enough to stop the leak. Also check the filter cover bolts for tightness.

LOCATING AIR LEAKS IN FUEL LINES

Air drawn into the fuel'system may result in uneven running of the engine, stalling when idling, or a loss of power. Poor engine operation is particularly noticeable at the lower engine speeds. An opening in the fuel suction lines may be too small for fuel to pass through but may allow appreciable quantities of air to enter.

Check for loose or faulty connections. Also check for improper fuel line connections such as a fuel pump suction line connected to the short fuel return line in the fuel tank which would cause the pump to draw air. Presence of an air leak may be detected by observing the fuel filter contents after the filter is bled and the engine is' operated for 15 to 20 minutes at a fairly high speed. No leak is indicated if the filter shell is full when loosened from its cover. If the filter shell is only partly full, an air leak is indicated.

TROUBLE SHOOTING

FUEL PUMP

The fuel pump is so constructed as to be inherently trouble free. By using clean, water-free fuel and maintaining the fuel filters in good condition, the fuel pump will provide long satisfactory service and require very little maintenance.

However, if the fuel pump fails to function satisfactorily, first check the fuel level in the fuel tank, then make sure the fuel supply valve is open. Also check for external fuel leaks at the fuel line connections and filter gaskets. Make certain that all fuel lines are connected in their proper order.

Next, check for a broken pump drive shaft or drive coupling. Insert the end of a wire through the pump flange drain hole, then crank the engine momentarily and note whether the wire vibrates. Vibration will be felt if the pump shaft rotates.

All fuel pump failures result in no fuel or insufficient fuel being delivered to the fuel injectors and may be indicated by uneven running of the engine, excessive vibration, stalling at idling speeds or a loss of power.

The most common reason for failure of a fuel pump to function properly is a sticking relief valve. The relief valve, due to its close fit in the valve bore, may become stuck in a fully open or partially open position due to a small amount of grit or foreign material lodged between the valve and its bore or seat. This permits the fuel to circulate within the pump rather than being forced through the fuel system.

Therefore, if the fuel pump is not functioning properly, remove the relief valve plug, spring and pin and check the movement of the valve within the valve bore. If the valve sticks, recondition it by using fine emery cloth to remove any scuff marks. Otherwise, replace the valve. Clean the valve bore and the valve components. Then lubricate the valve and check it for free movement throughout the entire length of its travel. Reinstall the valve.

After the relief valve has been checked, start the engine and check the fuel flow at some point between the restricted fitting in the fuel return manifold at the cylinder head and the fuel tank.

CHECKING FUEL FLOW

1. Disconnect the fuel return hose from the fitting at the fuel tank and hold the open end in a convenient receptacle (Fig. 7).
2. Start and run the engine at 1200 rpm and measure the fuel flow. Refer to Section 13.2 for the specified quantity per minute.

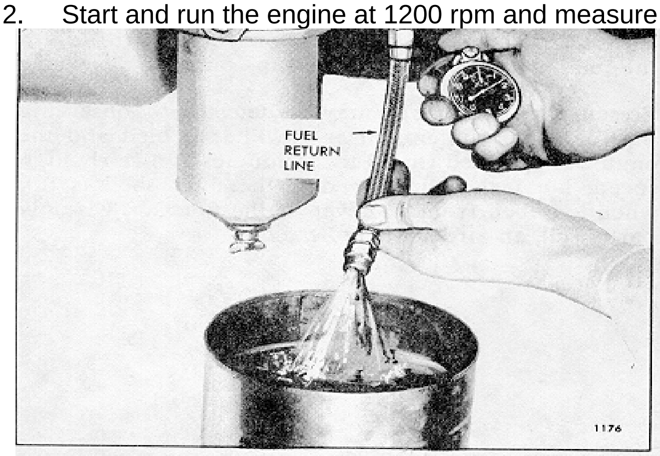


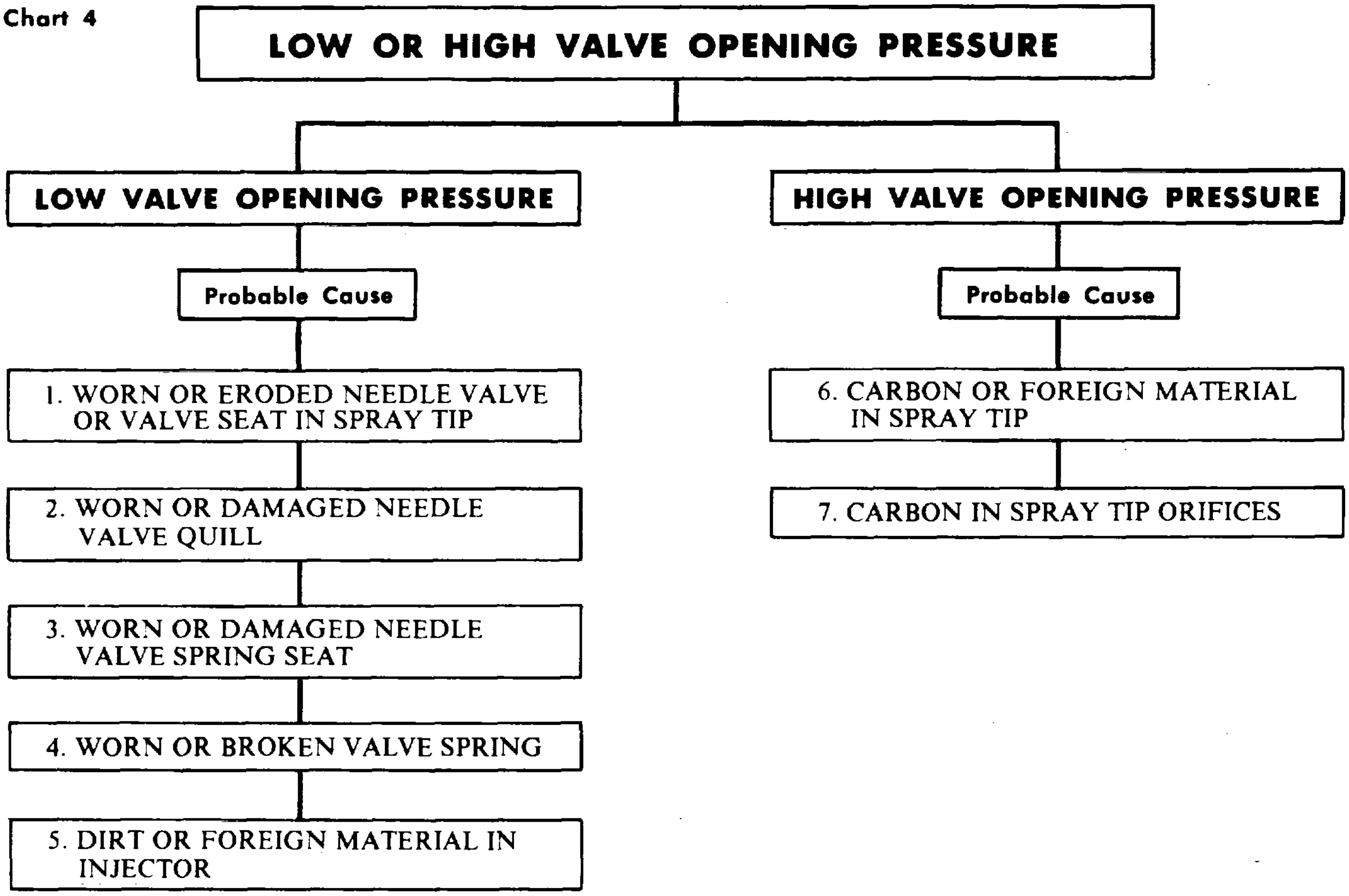
Fig. 7 - Measuring Fuel Flow

3. Immerse the end of the fuel hose in the fuel in the container. Air bubbles rising to the surface of the fuel will indicate air being drawn into the fuel system on the suction side of the pump. If air is present, tighten all fuel line connections between the fuel tank and the fuel pump.
4. If the fuel flow is insufficient for satisfactory engine performance, then:
   a. Replace the element in the fuel strainer. Then start the engine and run it at 1200 rpm to check the fuel flow. If the flow is still unsatisfactory, perform Step "b" below:
   b. Replace the element in the fuel filter. If the flow is still unsatisfactory, do as instructed in Step "c".
   c. Substitute another fuel pump that is known to be in good condition and again check the fuel flow. When changing a fuel pump, clean all of the fuel lines with compressed air and be sure all fuel line connections are tight. Check the fuel lines for restrictions due to bends or other damage.

If the engine still does not perform satisfactorily, one or more fuel injectors may be at fault and may be checked as follows:

1. Run the engine at idle speed and cut out each injector in turn by holding the injector follower down with a screw driver. If a cylinder has been misfiring, there will be no noticeable difference in the sound and operation of the engine when that particular injector has been cut out.
2. Stop the engine and remove the fuel pipe between the fuel return manifold and the injector.
3. Hold a finger over the injector fuel outlet and crank the engine with the starter. A gush of fuel while turning the engine indicates an ample fuel supply; otherwise, the injector filters are clogged and the injector must be removed for service.

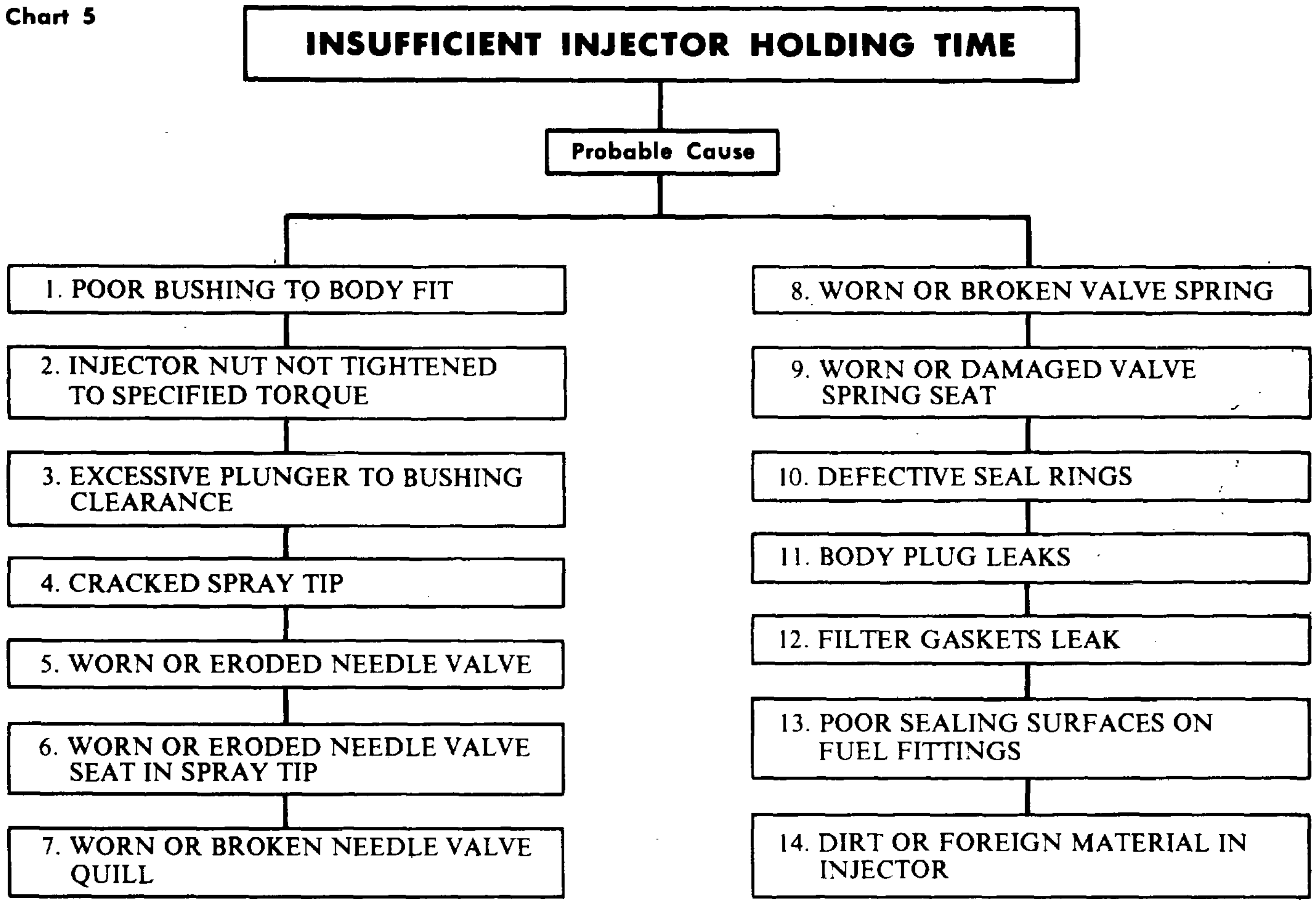
Chart 4



SUGGESTED REMEDY

1. Replace the needle valve and spray tip assembly.
2. Replace the needle valve and spray tip assembly.
3. Replace the spring seat.
4. Replace the valve spring.
5. Disassemble the injector and clean all of the parts.
6. Remove the carbon in the spray tip with tip reamer J 9464 which is especially designed and ground for this purpose.
7. Check the size of the spray tip orifices. Then, using tool J 4298-1 with the proper size wire, clean the orifices.

Chart 5



1. Lap the injector body.
2. Tighten the injector nut to 75-85 lb-ft (102-115 Nm) torque. Do not exceed the specified torque.
3. Replace the plunger and bushing. 4, 5, 6 and 7. Replace the needle valve and spray tip assembly.
8. Replace the valve spring.
9. Replace the valve spring seat.

10. Replace the seal rings.

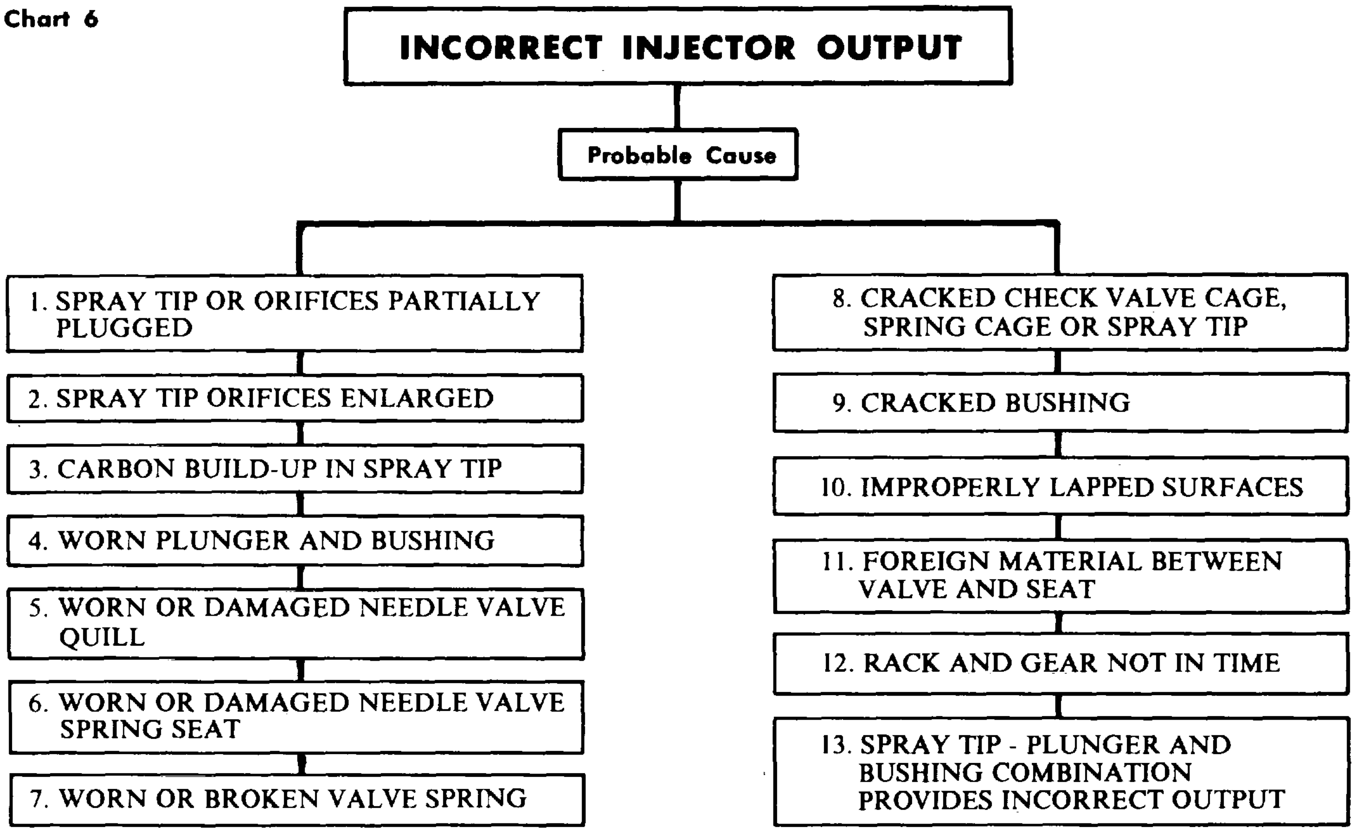
11. Install new body plugs.

12. Replace the filter cap gaskets and tighten the filter caps to 65-75 Ib-ft (88-102 Nm) torque.

13. Clean up the sealing surfaces or replace the filter caps, if necessary. Replace the filter if a cap is replaced.

14. Disassemble the injector and clean all of the parts.

Chart 6



SUGGESTED REMEDY

1.Clean the spray tip as outlined under Clean Injector Parts.

2.Replace the needle valve and spray tip assembly.

3.Clean the spray tip with tool J 1243.

4.After the possibility of an incorrect or faulty spray tip has been eliminated and the injector output still does not fall within its specific limits, replace the plunger and bushing with a new assembly.

NOTE: The fuel output of an injector varies with the use of different spray tips of the same size due to manufacturing tolerances in drilling the tips. If the fuel output does not fall within the specified limits of the Fuel Output Check Chart, try changing the spray tip. However, use only a tip specified for the injector being tested.

5.Replace the needle valve and spray tip assembly.
6.Replace the spring seat.
7.Replace the valve spring.
8.Replace the cracked parts.
9.Replace the plunger and bushing assembly.
10.Lap the sealing surfaces.
11.Disassemble the injector and clean all of the parts.
12. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth on the rack.
13.Replace the spray tip and the plunger and bushing assembly to provide the correct output.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	TORQUE (lb-ft)	Nm	THREAD SIZE	TORQUE (lb-ft)	Nm
1/4 -20	7-9	10-12	9/16-12	90-100	122-136
1/4 -28	8-10	11-14	9/16-18	107-117	146-159
5/16-18	13-17	18-23	5/8 -11	137-147	186-200
5/16-24	15-19	20-26	5/8 -18	168-178	228-242
3/8 -16	30-35	41-47	3/4 -10	240-250	325-339
3/8 -24	35-39	47-53	3/4 -16	290-300	'393-407
7/16-14	46-50	62-68	7/8 -9	410-420	556-569
7/16-20	57-61	77-83	7/8 -14	475-485	644-657
1/2 -13	71-75	96-102	1-8	580-590	786-800
1/2 -20	83-93	113-126	1-14	685-695	928-942

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	C.1 ENGINE (Ib-ft)	ALUM ENG. (Ib-ft)
Limiting speed low weight set screw	10-32	20 in-lb	
Injector clamp stud	3/8 -16	10-25	10-25
Injector clamp bolt	3/8 -16	20-25	20-25
Injector clamp nut	3/8 -24	20-25	20-25
Fuel pipe nut	3/8 -24	12-15	12-15
*Fuel manifold connector (nylon insert)	7/16-20	30-35	30-35
*Fuel manifold connector (steel washer)	7/16-20	40-45	
Fuel manifold connector nut	7/16-20	30-35	30-35
tRocker arm bracket bolt	1/2 -13	90-100	
Injector filter cap	5/8 -24	65-75	65-75
Injector nut (needle valve)	15/16-24	75-85	75-85

t75-85 Ib-ft torque on the two bolts attaching load limit or power control screw bracket (if used) to the rocker arm shaft
*Lubricate before assembly. brackets.

SERVICE TOOLS

TOOL NAME	TOOL NO.
INJECTOR	
Auxiliary injector tester ("N" injectors)	J 22640
Fuel pipe socket	J 8932-01
Fuel system primer	J 5956
Injector body reamer	J 21089
Injector body thread reconditioning set	J 22690
Injector bushing Inspectalite	J 21471
Injector calibrator	J 22410
Injector comparator	J 7041
Injector service set (includes *tools)	J 1241-07
Injector service set ("N" injectors - includes §tools)	J 23435
*Deburring tool	J 7174
§*Fuel hole brush	J 8152
§*Injector nut socket wrench	J 4983-01
§*Injector nut and seat carbon remover set	J 9418
§*Injector spray tip driver	J 1291-02
*Injector tip cleaner	J 1243
§*Pin vise	J 4298-1
§*Rack hole brush	J 8150
§*Spray tip carbon remover	J 9464-01
*Spray tip seat remover	J 4986-01
*Spray tip wire (.005 ")	J 21459-01
§*Spray tip wire (.0055")	J 21460-01
§*Spray tip wire (.006")	J 21461-01
§*Wire sharpening stone	J 8170
Injector test oil (five gallons)	J8130
Injector tester	J 9787
Injector tip concentricity gage	J 5119
Injector vise and rack freeness tester	J 22396
Injector vise jaws (offset body)	J 8912
Injector vise jaws (standard body)	J 1261
Lapping Block set	J 22090
Methyl Ethyl Ketone cleaning fluid	J 8257
Polishing compound ("N" injectors)	J 23038
Polishing stick set ("N" injectors)	J 22964
Spray tip flow gage	J 21085
Spray tip gage ("N" injectors)	J 9462-01
Spring tester	J 9666
Wire brush (brass)	J 7944
INJECTOR TUBE	
Cylinder head holding plates	J 3087-01
Injector tube service tool set	J 22525
Injector tube service tool set (for power equipment)	J 22515

TOOL NAME	TOOL NO.

FUEL PUMP

Fuel pump tool set	J 1508-02
Fuel pump wrench	J 4242

MECHANICAL GOVERNOR

Adjustable spanner wrench	J 5345-5
Governor cover bearing installer	J 21068
Governor cover bearing remover/installer	J 21967-01
High-speed spring retainer nut wrench	J 1652-01
Variable speed spring housing bearing installer set	J 9196

SECTION 3

AIR INTAKE SYSTEM

CONTENTS

AIR INTAKE SYSTEM

In the scavenging process employed in the 71 In-Line engines, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burned gases through the exhaust valve ports. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, therefore, each cylinder is filled with fresh, clean air which provides for efficient combustion.

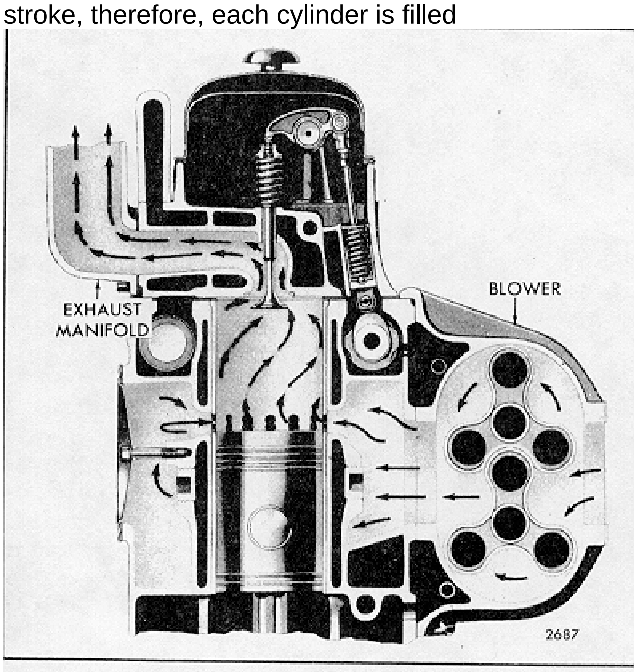


Fig. 1 - Air Flow Through Blower and Engine

The air, entering the blower from the air cleaner, is picked up by the blower rotor lobes and carried to the discharge side of the blower as indicated by the arrows in Fig. 1. The continuous discharge of fresh air from the blower creates an air pressure of approximately seven pounds per square inch in the air chamber of the cylinder block at maximum engine speed. This air sweeps through the intake ports, which start to open as the piston approaches the end of its downward travel and close after the compression stroke begins.

The angle of the ports in the cylinder liners creates a uniform swirling motion to the intake air as it enters the cylinders. This motion. persists throughout the compression stroke and facilitates scavenging and combustion.

AIR CLEANER

The air cleaners are designed to remove the foreign matter from the air, pass the required volume of air for proper combustion and scavenging, and maintain their efficiency for a reasonable period of time before requiring service.

Air cleaners have been classified as light duty or heavy duty according to their application and dirt holding capacity.

The importance of keeping dust and grit-laden air out of an engine cannot be overemphasized since clean air is so essential to satisfactory engine operation and long engine life. The air cleaner must be able to remove fine materials such as dust and blown sand as well as coarse materials such as chaff, sawdust, or lint from the air. It must also have a reservoir capacity large enough to retain the material separated from the air to permit operation for a reasonable period before cleaning and servicing are required.

Dust and dirt entering an' engine will cause rapid wear of the piston rings, cylinder liners, pistons and the exhaust valve mechanism with a resultant loss of power and high lubricating oil consumption. Also, dust and dirt which is allowed to build-up in the air cleaner passages will eventually restrict the air supply to the engine and result in heavy carbon deposits on the pistons and valves due to incomplete combustion.

Light Duty Oil Bath Type Air Cleaner

Light duty oil bath type air cleaners, Fig. 1, consists essentially of a wire screen element supported inside a cylindrical housing which contains an oil bath directly below the element. Air drawn through the cleaner passes over the top of the oil bath. The air stream direction reverses when the air impinges on the oil in the sump and is then directed upwards by baffles. During this change in the direction of air flow, much of the foreign matter is trapped by the oil and is carried to the sump where it settles out. The air passes upward through the metal-wool elements where more dust and the entrained oil are removed. A second change of air direction, at the top of the cleaner directs the air downward through the center tube and into the blower inlet housing.

Heavy Duty Type Air Cleaner

In all heavy duty air cleaners, Fig. 2 air is drawn through the air inlet hood, which acts as a cleaner,

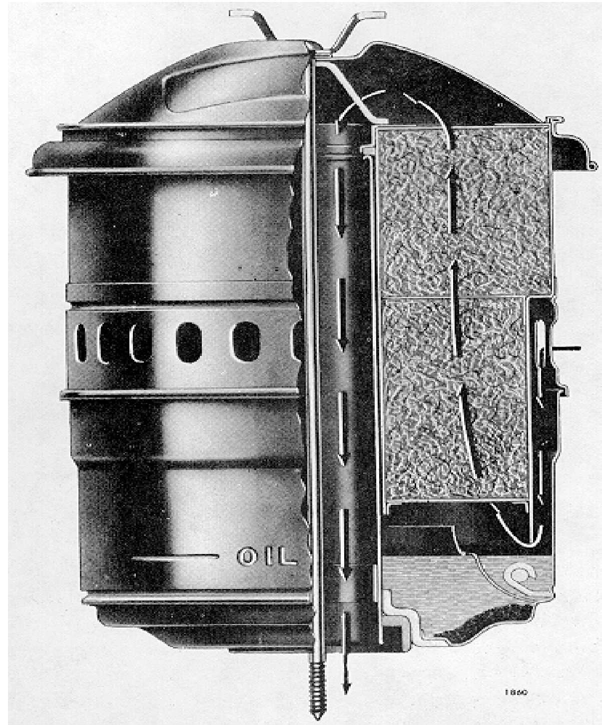


Fig. 1 - Light Duty Oil Bath Air Cleaner and Silencer Assembly

down through the center tube. At the bottom of the tube, the direction of air flow is reversed and oil is picked up from the oil reservoir cup. The oil laden air is carried up into the separator screen where the oil which contains the dirt particles is separated from the air by collecting on the separator screen.

A low pressure area, (Fig. 3), is created toward the center of the air cleaner as the air passes a cylindrical opening formed by the outer perimeter of the central tube and the inner diameter of the separator screen. This low pressure is caused by the difference in air current velocity across the opening. The low pressure area, plus the effect of gravity and the inverted cone shape of the separator screen, causes the oil and dirt mixture to drain to the center of the cleaner cup. This oil is again picked up by the incoming air causing a looping cycle of the oil, however, as the oil is carried toward another cycle,

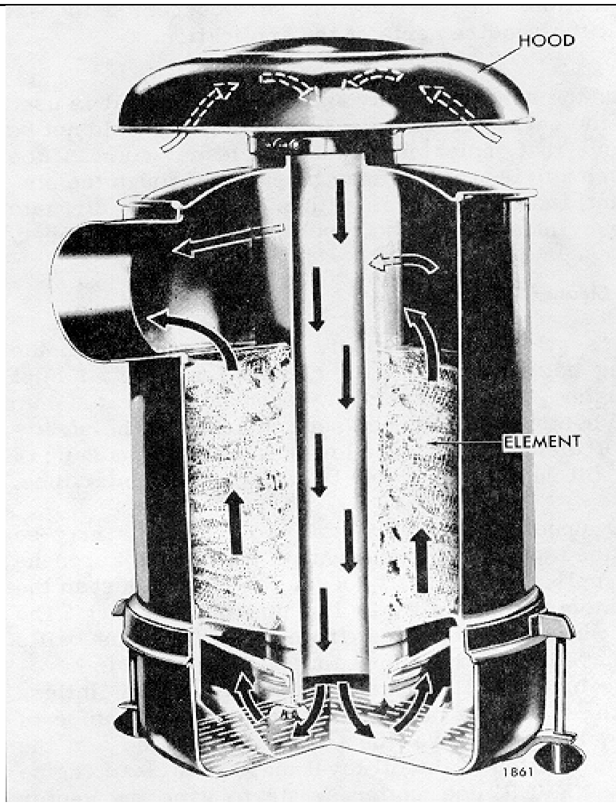


Fig. 2 - Oil Bath Air Cleaner and Silencer Assembly - Heavy Duty

some of the oil will overflow the edge of the cup carrying the dirt with it. The dirt will be deposited in the outer area surrounding the cup. Oil will then flow back into the cup through a small hole located in the side of the cup. Above the separator screen, the cleaner is filled with a wire screen element which will remove any oil which passes through the separator screen. This oil will also drain to the center and back into the pan. The clean air then leaves the cleaner through a tube at the side and enters the blower through the air inlet housing.

Air Cleaner Mounting

Air cleaner mountings vary in accordance with the air cleaner installation and the engine units on which they are employed. The light duty air cleaners are mounted on the air inlet housing. Heavy duty air cleaners are remotely mounted from the air inlet housing and are connected to it by air tight ducts.

Air Cleaner Maintenance

Although air cleaners are highly efficient, this efficiency depends upon the proper maintenance and **periodic servicing. If the cleaners are not properly maintained, the oil sump will become filled with sludge and the screens or elements will not remove dust properly. This would result in dust and dirty oil entering the engine and also increase the restriction to air flow through the cleaner.**

Should dust in the air supply enter the engine, it would be carried directly into the cylinders and, due to its abrasive properties, cause premature wear of moving parts, which would materially shorten engine life. Should the air flow through the cleaner be restricted, it would eventually be impossible for the engine to burn all of the fuel injected into its cylinders and carbon formation would progress at a greatly increased rate.

The efficiency of the air cleaner may be offset by leaks in the duct work, loose hose connections, or damaged gaskets which permit dust-laden air to completely by-pass the cleaner and enter the engine directly.

The following maintenance procedure will assure efficient air cleaner operation:

1. Keep the air cleaner tight on the air intake to engine.

2. Keep the air cleaner properly assembled so the joints are strictly oil and air tight.

3. In case of damage to the air cleaner, intake or connections, repair it at once.

4. In dusty areas, inspect the air cleaner frequently for dirt deposits in the oil bath or thickened oil.

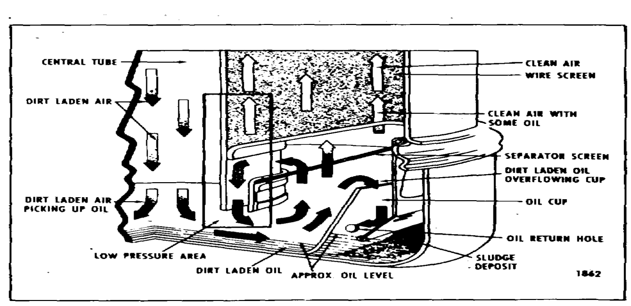


Fig. 3 - Air Flow Through Heavy Duty Oil Bath Air Cleaner

Thoroughly clean the oil bath cleaner often enough to prevent the oil from becoming excessively thick with sludge, and be sure to use the proper kind and quantity of oil. Keep the oil at the level mark in the cup. In replacing the cup, be sure it fits snugly to form a tight joint.

5. Where a rubber hose from the cleaner to the blower is employed, remove the hose connections and cement them in place. Use a new hose and clamps, if necessary, to obtain an air-tight connection.

6. After servicing the air cleaner, remove the air inlet housing and clean the accumulated dirt deposits from the blower air inlet screen and the air inlet housing. Make sure all air intake passages and the air box are kept clean.

7. Make a careful periodic inspection of the entire air system. Enough dust-laden air will pass through an almost invisible crack to eventually cause serious damage to. an engine.

No hard fast rule for servicing any air cleaner can be given since it depends upon the type of cleaner, and air conditions. A cleaner operating in severe dust conditions will require more frequent service than a cleaner operating in clean air. The most satisfactory service period should be determined by frequently inspecting the cleaners, under normal operation, then setting the service period to best suit the requirements of the application.

Use the same viscosity and grade of oil that is used in the engine crankcase. The oil level should not be above that indicated on the air cleaner sump. If too much oil is used, it may be pulled through the element and into the engine, thus carrying the dirt into the cylinders and also resulting in excessive speed.

Air Cleaner Service

To service the light duty air cleaner, loosen the wing bolt and remove the cleaner from the air inlet housing. The cleaner may then be separated into two sections. The upper section contains the metal-wool elements and the lower section is made up of the oil sump, removable baffle, and the center tube.

The upper shell and metal-wool elements may be cleaned by soaking the entire section in kerosene or fuel oil. This will loosen the oil and dust in the elements and facilitate flushing out the dirt. The oil should be emptied from the sump, the baffle removed, and the sump and baffle cleaned in kerosene or fuel oil to remove all sediment. A lintless cloth should be pushed through the center tube of the cleaner before the baffle is installed and the sump refilled to the oil level mark with clean engine oil. NEVER use cotton waste to wipe the center

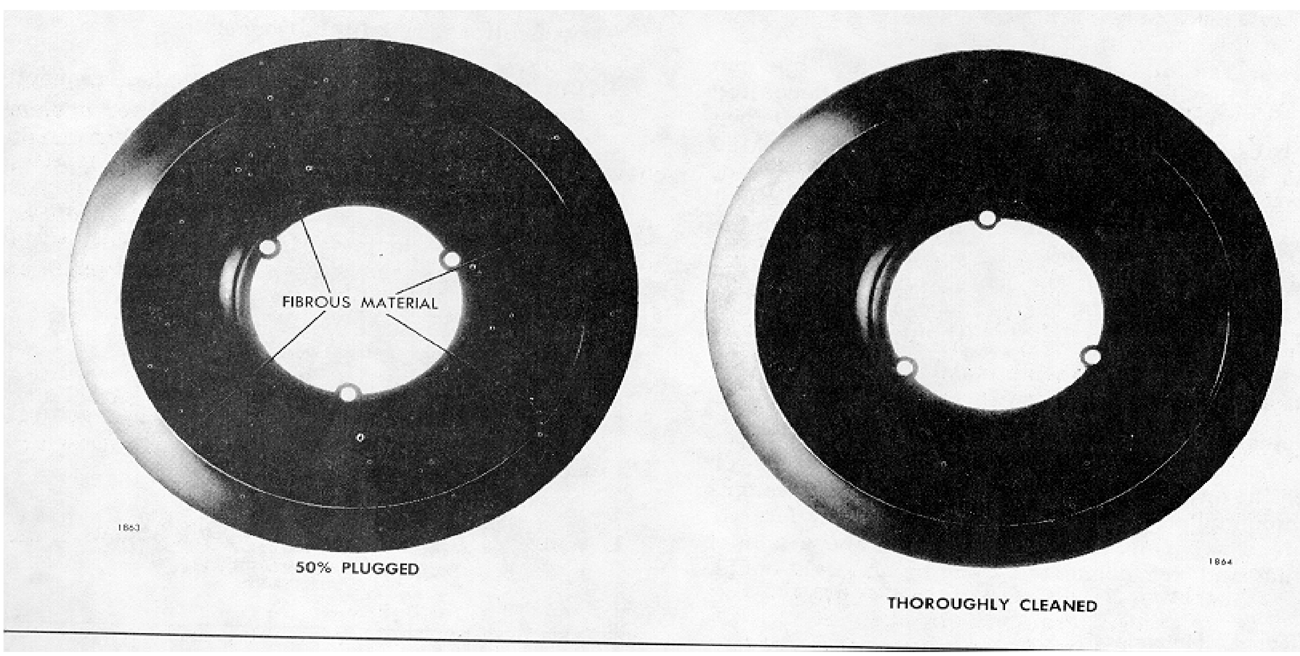


Fig. 4 - Comparison of Air Cleaner Trays

tube. Use the same viscosity and grade of oil that is used in the engine crankcase. All gaskets and sealing surfaces should be checked and cleaned to ensure air-tight seals.

After the filter element has been thoroughly drained of the flushing fluid, the cleaner should be assembled. However, before installing the cleaner on the engine, the air inlet housing and blower in-let screen should be checked for the presence of dirt accumulations. If the service period has been too long, or dust-laden air has been leaking past the seals, the inlet housing and screen will be dirty. This will serve as a good check on the maintenace of the air cleaner installation. When installing the cleaner (and its seal) on the inlet housing, be sure that the cleaner seats properly, then tighten the wing bolt securely until the cleaner is rigidly mounted.

The air inlet hoods used on heavy-duty air cleaners are not intended to do any cleaning. However, some dirt will collect on the heavy screens and in the hood itself. Therefore, it will be necessary to remove the hood occasionally for cleaning by brushing or with compressed air.

When the oil sump is removed on some heavy-duty air cleaners, a tray type screen attached to the tube will be visible. It may be removed by loosening the wing nuts and rotating the tray so that it unlocks from the tube. On other heavy duty models, the tray rests on the lip of the inner oil cup of the sump and is not retained by wing nuts.

The efficiency of the tray type oil bath air cleaner can be greatly reduced unless the fibrous material caught in the tray is removed. It is extremely important that the tray be cleaned regularly and properly.

If a tray is plugged with lint or dirt, (Fig. 4), wash the tray in a solvent or similar washing solution and blow out with high velocity compressed air or steam. And even pattern of light should be visible through the screens when a clean tray is held up to the light, (Fig. 4). It may be necessary, as a last resort, to burn off the lint. Extreme care must be taken not to melt the galvanized coating in the tray screens. Some trays have equally spaced holes in the retaining baffle. Check to make sure that they are clean and open.

It is advisable to have a spare tray on hand to replace the tray that requires cleaning. Having an extra tray available makes for better servicing and the plugged tray can be cleaned thoroughly at

Check for dirt accumulation in the air cleaner center tube. Remove the dirt by passing a lintless cloth through the center tube. Some tubes have a restricted portion at the lower end and care must be exercised not to damage this end.

Check the oil sump for any dirt accumulation in both the inner and outer cups and clean if necessary.

At some regular period of engine service, remove the entire air cleaner from the engine and clean the fixed element. This can be done by passing a large quantity of clean solvent through the air outlet and down into the fixed element. When clean, allow the element to dry thoroughly before installing the cleaner.

When all of the components have been cleaned, the cleaner is ready for assembly. The removable screen should be installed and the oil sump should be filled with clean engine oil to the indicated level and installed on the cleaner. Care should be exercised that all gaskets and joints are tight. All connections from the cleaner to the engine should be checked for air leaks to prevent any air by-passing the air cleaners.

If it is found that unfiltered air is being admitted into the engine through the duct work of an air cleaner installation, the following procedure may be used for finding air leaks in an air duct system. The air cleaning system does not have to be dismantled, thus effecting a saving in time.

To make this check it is necessary that suitable plugs be provided to block the air cleaner system inlet and outlet. The air cleaner inlet plug should contain a suitable air connection and shut-off valve to maintain two pounds pressure in the air duct system. The outlet plug need only be of sufficient size to form a completely air-tight seal at the outlet end of the system. Then check the system as follows:

1. Remove the air inlet hood.
2. Insert the plug (with the fitting for the air hose) in the air cleaner inlet to form an air- tight seal.
3. Insert the other plug in the outlet end of the system to form an air-tight seal.
4. Attach an air hose to the plug in the air cleaner inlet and regulate the pressure not to exceed 2 psi.

5. Brush a soap-suds solution on all of the air duct connections. Any opening which would allow dust to enter the engine can then be detected by the escaping air causing bubbles in the soap-suds solution. All leaks thus discovered should be remedied until the system checks "air-tight".

6. Remove the plugs and install the air inlet hood.

The design and function of the heavy duty air cleaners is such that the fixed elements tend to be self-cleaning. However, it may be necessary, occasionally, to remove the entire cleaner from its mountings and clean these elements. If the fixed elements require too frequent cleaning, it is advisable to relocate the air intake to provide a cleaner air supply.

AIR SHUT-DOWN HOUSING

The air shut-down housing, mounted on the side of the blower, serves as a mounting for the air cleaner or for air cleaner ducting. The air shut- down housing contains an air shut-down valve that shuts off the air supply and stops the engine whenever abnormal operating conditions require an emergency shut-down (Section 7.4.1).

Remove Shut-Down Housing

1. Remove the air cleaner or air cleaner ducts.

2. Disconnect the Bowden wire assembly from the air shut-off cam pin handle.

3. Remove the bolts and washers that retain the housing to the blower and remove from blower. Remove air shut-down housing gasket from blower.

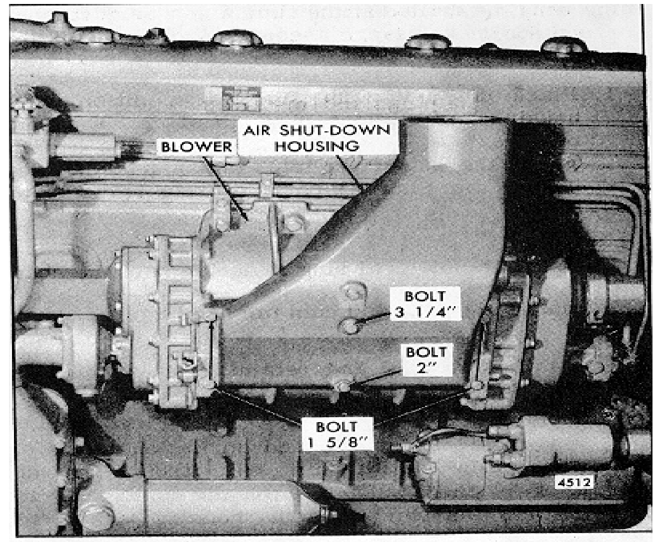


Fig. 2 - Air Shut-down Housing Mounting and Bolt Location

Disassemble Shut-Down Housing

If necessary, the emergency shut-down valve may be disassembled after the air shut-down housing has been removed from the blower.

Refer to Fig. 1 and dissemble the shut-down valve as follows:

1. Use a small punch to remove the pin from the shut-down valve shaft. Remove the washer from the shaft. Remove and discard the seal ring from the housing.

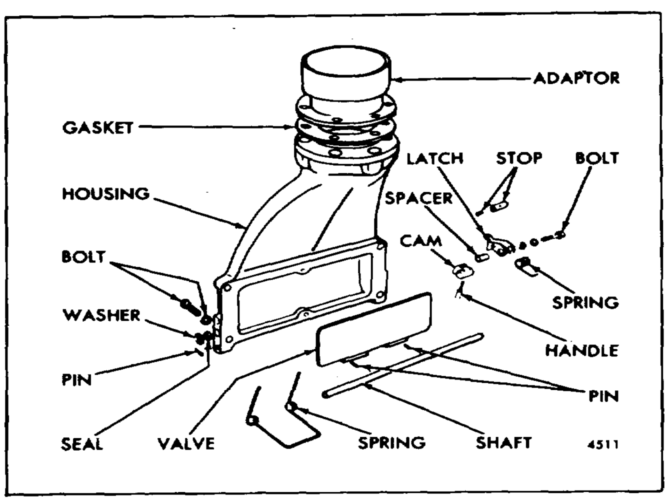


Fig. 1 - Typical Air Shut-down Housing Detail and Relative Location of Parts

2. Remove the pins that secure the shut-down valve to the shaft.

3. Note the position of the air shut-down spring and the valve; then, withdraw the shaft from the housing to release the valve and spring in the housing. Remove and discard the seal ring from the housing.

4. Remove the bolt, lock washer and plain washer from the housing and remove the latch, latch spring and spacer.

Inspection

Clean all of the parts thoroughly, including the blower screen, with fuel oil and dry them with compressed air. Inspect the parts for wear or damage. The face of the shut-down valve must be perfectly flat to assure a tight seal when it is in the shut-down position.

Assemble Air Shut-Down Assembly

The holes for the cam pin handle and the retaining pins must be drilled at the time a new service shaft or shut-down valve are assembled. Refer to Fig. 1 and proceed as follows:

1. Place the valve and spring in position in the housing and slip the shaft in place. The shaft must extend 76" from the side of the housing where the shut-down latch is assembled. Then, install the pins which retain the valve to the shaft.

2. Install a new seal ring at each end of the shaft.

3. Install the cam and cam pin handle on the shaft.

4. Install a washer and retaining pin at the other end of the shaft.

5. Assemble the spacer and spring on the latch. Then, slip the attaching bolt through the lock washer, plain washer, latch and spacer. Attach the latch assembly to the housing and tighten the bolt.

Install Air Shut-Down Housing

1. Place the blower screen and gasket assembly in position with the screen side of the assembly toward the blower.
2. Refer to Fig. 2 and mount the air shut-down housing together with the striker plate gasket and striker plate (if used) on the blower with bolts and lock washers and tighten the bolts to 16-20 lb-ft torque.

   NOTE: The 3/8"-16 x 3-1/4" bolt and the 3/8"-16 x 2" bolt must be installed, as shown in Fig. 2. The four 1-5/8" bolts are installed in the four corner bosses of the housing.

3. Connect the Bowden wire assembly to the air shut-off cam pin handle.

4. Start and run the engine at idle speed and no- load. Trip the air shut-down. If the engine does not stop, check it for air leakage between the valve(s) and the striker plate. If necessary, reposition the valve(s).

5. Install the air cleaner or air cleaner ducts.

BLOWER

The blower, designed especially for efficient Diesel operation, supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow three- lobe rotors revolve with very close clearances in a housing bolted to the cylinder block. To provide continuous and uniform displacement of air, the rotor lobes are made with a helical (spiral) form, (Figs. 1 and 2).

Two timing gears, located on the drive end of the rotor shafts, space the rotor lobes with a close tolerance; therefore, as the lobes of the upper and lower rotors do not touch at any time, no lubrication is required.

Oil seals located in the blower end plates prevent air leakage and also keep the oil used for lubricating the timing gears and rotor shaft bearings from entering the rotor compartment.

Lip type oil seals or metal ring type oil seals are installed in the blower end plates. Each ring type oil seal consists of a carrier pressed onto the rotor shaft, a collar pressed into the end plate, and a seal ring contained in a groove of the carrier.

The outside diameter of the seal ring seals against the collar to prevent leakage of air or oil. Each rotor is supported in the doweled end plates of the blower housing by a roller bearing at the front end and a two row pre-loaded radial and thrust ball bearing at the gear end.

The blower upper rotor is driven by the blower drive shaft which is coupled to the upper rotor timing gear by means of a flexible drive hub (20) Fig. 1.

Currently a standard and a small diameter rotor blower are used on In-line 71 engines. The small diameter rotor blower with a 2.00:1 blower to engine speed ratio is employed in the 71E and 71N engines and a 1.95:1 blower to engine speed ratio is employed in the 71T engines. When higher pressures are required, such as for bulk unloading, a large bearing 2.00:1 ratio (P) blower with metal ring type oil seals is used. The former 71E and 71N engines used a 1.69:1 ratio blower and the former 71T engines used a 1.55:1 ratio blower. Early engines employ the 2.00:1 ratio standard blower.

The ratio between the blower speed and the engine speed, and the number of teeth in the blower drive gears and reduction gears is given in the following chart.

Engine Type	Blower Type	Ratio Blower-to-Engine Speed	No. Teeth (Blower Drive Gear)	No. Teeth (Reduction Gear)
CURRENT 71, 71E, 71N, 71T AND 71P ENGINES				
71,	Standard	2.00:1	39	No Reduction Gears
71E,71N	Small dia. Rotor	2.00:1	39	No Reduction Gears
71T	Small dia. Rotor	1.95:1	40	No Reduction Gears
71P	Large Bearing	2.00:1	39	No Reduction Gears
FORMER 71E, 71N and 71T ENGINES				
71E,71N	Standard	1.69:1	39	33 (Drive) 39 (Driven)
71T	Standard	1.55:1	39	45 (Drive) 58 (Driven)

Reduced blower speed on the former 71E, 71N and 71T reduction blowers is accomplished by the use of an additional pair of gears mounted on the rotor shafts. The upper drive gear (140), Fig. 2, is mounted on a double row ball bearing and is driven by the blower drive shaft by means of a flexible drive hub attached to the gear. The drive gear mates with a lower driven gear (142) that is splined to the lower blower rotor shaft. Since the lower rotor (timing) gear (14) is also splined to the lower rotor shaft, it drives the upper rotor (timing) gear (13).

A flexible coupling, formed by an elliptical cam driven by two bundles of leaf springs which ride on four semi-cylindrical supports and spring seats is attached to the blower drive gear (42) (Fig. 1), and prevents the transfer of torque fluctuations to the blower.

The blower rotors are timed by the two rotor gears (13) and (14) at the rear end of the rotor shafts. This timing must be correct, otherwise the required clearance, obtained by the use of shims behind the gears, between the rotor lobes will not be maintained.

Normal gear wear causes a decrease in the rotor to-rotor clearance between the leading edge of the upper rotor lobes and the trailing edge of the lower rotor lobes of the standard blower and the small diameter rotor blower. In the former 71E, 71N and 71T reduction blowers, the lower rotor is the leading. rotor and the upper rotor is the trailing rotor; therefore, gear wear will cause a decrease in the rotor-to-rotor clearance between the leading edge of the lower rotor lobes and the trailing edge of the upper rotor lobes. Clearance between the opposite sides of the rotor lobes is increased correspondingly.

While the rotor lobe clearance may be corrected by adjustment, gear backlash cannot be corrected. When gears have worn to the point where the back-lash exceeds .004", the gears must be replaced.

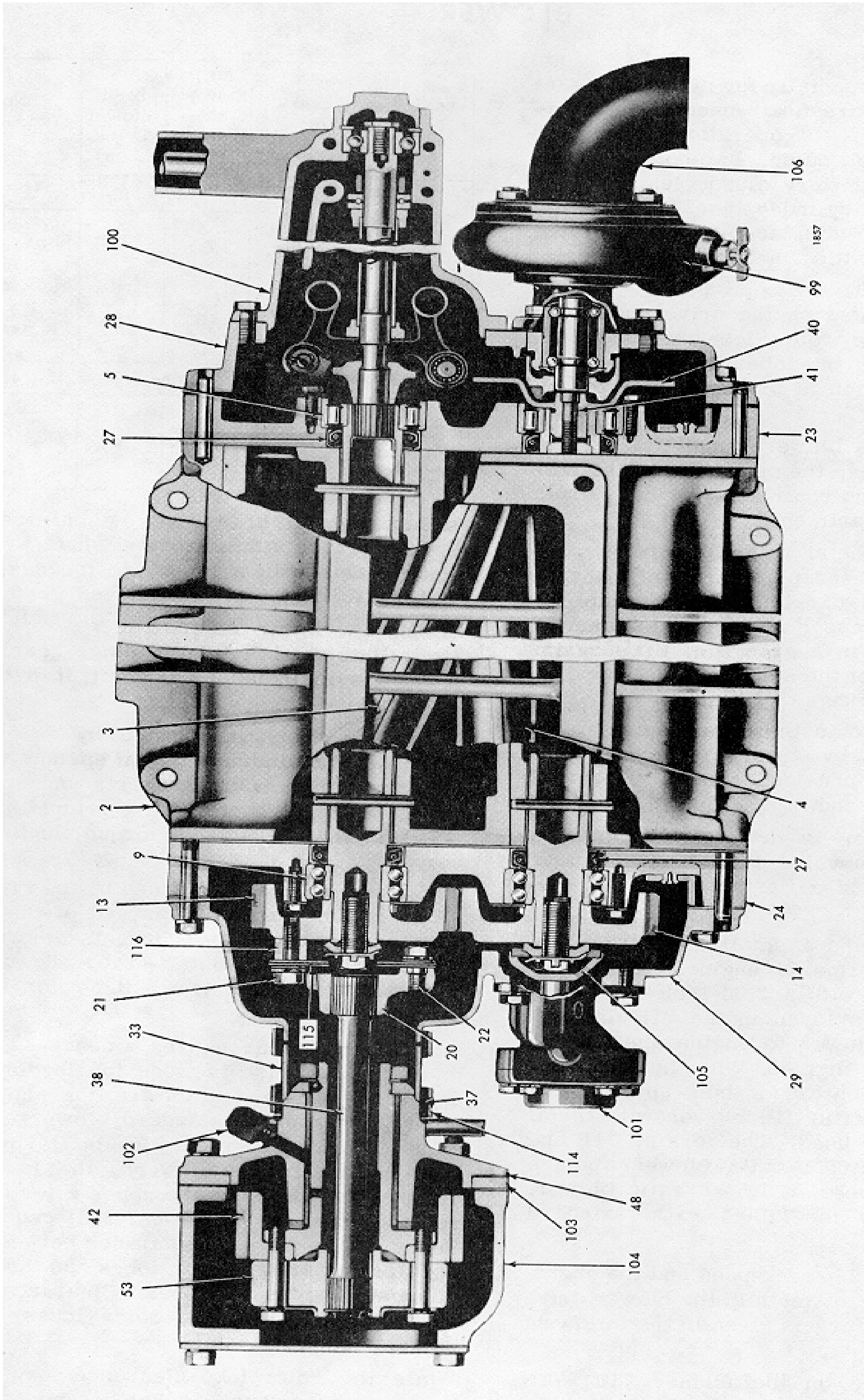


Fig. 1 - Blower and Drive Assembly and Accessories Including Mechanical Governor Attached to Standard Blower or Small Diameter Rotor Blower (71 Engines)

Fig 1 - Blower and Drive Assembly and Accessories Including Mechanical Governor Atta ched to Standard Blower or Small Diameter Rotor Blower (71 Engines)

2	Housing--Blower	20	Hub--Rotor Drive Gear	40	Coupling Assy.--	102	Elbow (900)--Oil Line
3	Rotor--Blower--Upper	21	Bolt--Plate to Gear		Water Pump Drive		to Blower Drive
	R.H. Helix	22	Bolt--Plate to Hub	41	Bolt--Allen Head--	103	End Plate--Cylinder
4	Rotor--Blower--Lower	23	End Plate--Front		Coupling		Block--Rear
	L.H Helix	24	End Plate--Rear	42	Gear--Blower	104	Housing--Flywheel
5	Bearing (Roller)-	27	Oil Seal--End Plate		Drive	105	Fork--Fuel Pump Drive
	Front	28	Cover--End Plate--Front	48	Support--Blower Drive	106	Cover--Water Pump
9	Bearing (Ball)--Rear--	29	Cover--End Plate--Rear		Gear Hub		Inlet
	Double Row Thrust	33	Cover--Blower Drive	53	Coupling Assy.--	114	Clamp--Drive Cover
13	Gear--Rotor--Upper		Shaft		Blower Drive		Seal
	R.H Helix	37	Seal--Drive Shaft	99	Pump--Fresh fater	115	Plate--Blower Rotor
14	Gear--Rotor--Lower		Cover	100	Governor		Drive Hub
	L.H Helix	38	Shaft--Blower Drive	101	Pump--Fuel	116	Spacer--Plate to Gear

Lubrication

Oil drains from the valve operating mechanism on the cylinder head into the camshaft pocket (A and C engines) or balance shaft pocket (B and D engines) in the cylinder block; then, when it reaches a certain level, the oil flows from the pocket into cavities at the upper corners of the blower and through passages in the blower and end plates to lubricate the bearings, governor and water pump drives at the front end, and bearings and gears at the rear end of the blower. A slinger attached to the front end of the lower rotor shaft throws oil into the front roller bearings and governor weights. A dam in the blower end plates maintains oil at a level adequate to submerge the lower portion of the slinger and the driven gear.

Surplus oil overflows the dams in the end plates and returns through two drilled holes in the cylinder block to the engine crankcase. On the former blower, the oil dam was located in the blower end plate cover.

Inspection of Blower

The blower may be inspected for any of the following conditions without being removed from the engine. However, the air shut-down housing must be removed.

> **CAUTION:** When inspecting a blower on an engine with the engine running, keep fingers and clothing away from the moving parts of the blower and run the engine at low speeds only.

Dirt or chips, drawn through the blower, will make deep scratches in the rotors and housing and throw up burrs around such abrasions. If burrs cause interference between the rotors or between the rotors and the housing, the blower should be removed from the engine and the parts dressed down to eliminate the interference, or the rotors must be replaced if they are too badly scored.

Leaky oil seals are usually manifested by the presence of oil on the blower end plates and rotors or the inside surfaces of the housing. This condition may be checked by running the engine at low speed and directing a light into the rotor compartment at the end plates and the oil seals. A thin film of oil radiating away from the seals is indicative of an oil leak.

A worn blower drive, resulting in a rattling noise inside the blower, may be detected by grasping the top rotor firmly and attempting to rotate it. Rotors may move from 3/8" to 5/8", measured at the lobe crown, with a springing action. When released, the rotors should move back at least 1/4". If the rotors cannot be moved as directed above, or if the rotors move too freely, the flexible blower drive coupling should be inspected and replaced if necessary.

If the drive coupling is worn, the blower drive gear assembly may be removed from the cylinder block end plate after the blower has been removed from the engine and the drive gear hub bearing support to cylinder block end plate bolts are removed, see Section 1.7.6.

Loose rotor shafts or damaged bearings will cause rubbing and scoring between the crowns of the rotor lobes and the mating rotor roots, between the rotors and the end plates, or between the rotors and the housing. Generally, a combination of these conditions exists. A loose shaft usually causes rubbing between the rotors and the end plates. Worn or damaged bearings will cause rubbing between the mating rotor lobes at some point or perhaps allow the rotor assemblies to rub the blower housing. This condition will usually show up at the end where the bearings have failed.

Excessive back-lash in between the blower timing gears usually results in the rotor lobes rubbing throughout their entire length.

To correct any of the above conditions, the blower must be removed from the engine and either repaired or replaced.

3.4 BLOWER

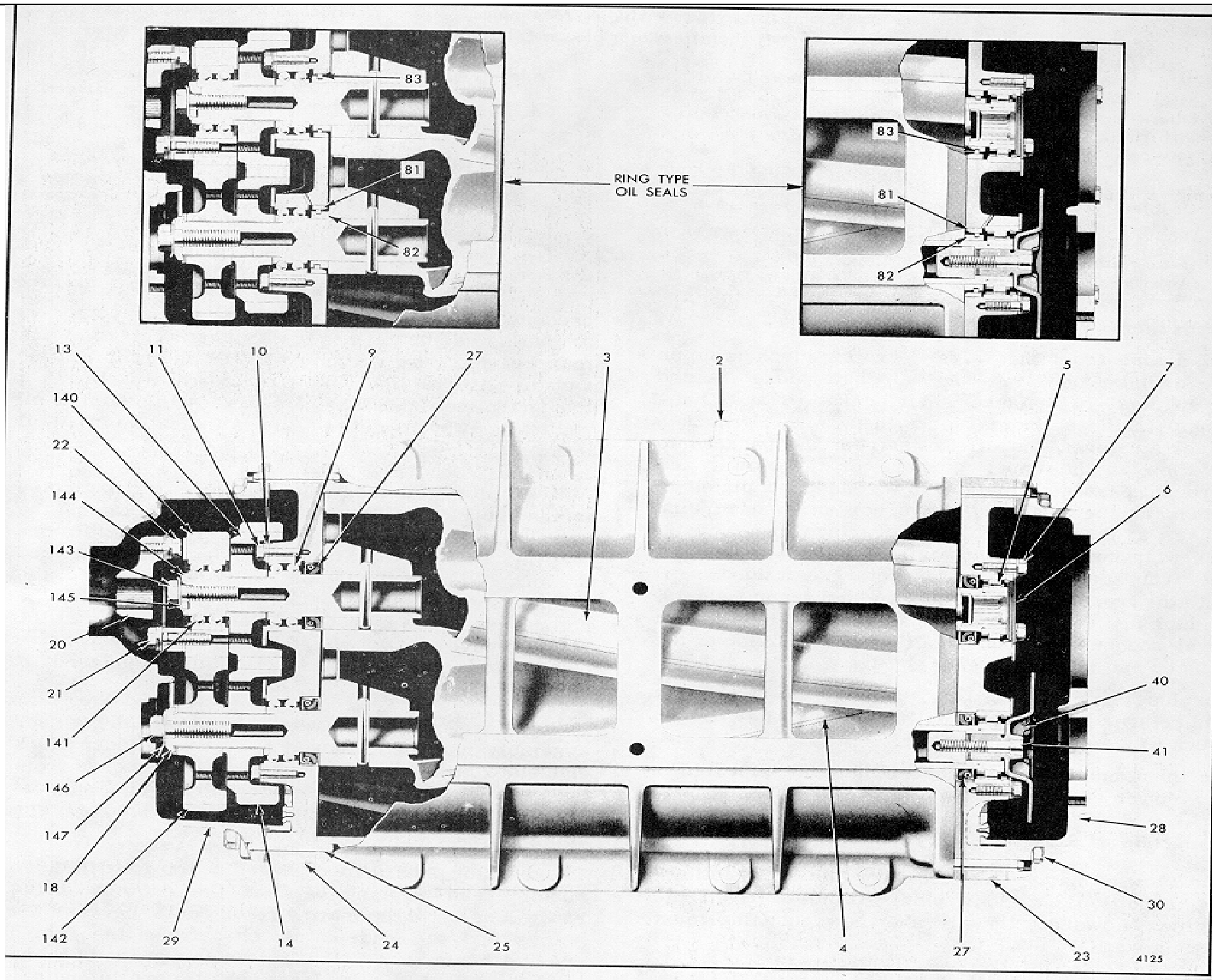


Fig. 2 - Former Reduction Blower Assembly (71E, 71N and 71T)

2	Housing--Blower
3	Rotor--Upper R.H Helix
4	Rotor--Lower L.H Helix
5	Bearing (Roller)--Front
6	Retainer--Bearing--Front
7	Bolt--Bearing Retainer--Front
9	Bearing (Boll)--Rear--Double Row Thrust
10	Retainer--Beoring--Reor
11	Bolt--Bearing Retainer--Rear
13	Gear--Rotor--Upper R.H Helix
14	Gear--Rotor--Lower L.H Helix
18	Disc--Fuel Pump Coupling
20	Hub--Rotor Drive
21	Bolt--Plate to Gear
22	Bolt--Plate to Hub
23	End Plate--Front
24	End Plate--Rear
25	Pin (Dowel)--Housing to End Plate
27	Oil Seal--End Plate
28	Cover--End Plate--Front
29	Cover--End Plate--Rear
30	Bolt--End Plate Cover
40	Coupling Assy.--Water Pump Drive
41	Bolt--Allen Head--Coupling
81	Collar--Blower End Plate
82	Carrier--Seol Ring
83	Ring--Seol (Piston Type)
140	Gear--Drive--R.H Helix
141	Bearing (Ball)--Drive Gear
142	Gear--Driven--L.H. Helix
143	Bolt--Drive Gear Retaining
144	Retainer--Drive Gear Bearing
145	Lock Washer--Bolt to Drive Gear
146	Bolt--Driven Gear Retaining
147	Lack Washer--Bolt to Driven Gear

The blower inlet screen should be inspected periodically, as noted in Section 15.1, for an accumulation of dirt which, after prolonged operation, may affect the air flow. Servicing of the screen consists of thoroughly washing it in fuel oil and cleaning with a stiff brush until the screen is free of all the dirt deposits.

Remove Blower

In most cases, removal of the blower, together with the governor drive, fresh water pump, fuel oil pump, and the blower drive shaft cover, will be found most advantageous. For removal of this assembly, refer to Figs. 3 and 4 and proceed as follows:

1. Drain the cooling system.
2. Remove the governor control housing assembly as outlined under "Remove Governor" in Section 2.7.1 for a limiting speed governor.
3. Disconnect the fuel lines at the fuel pump.
4. Loosen the water pump connections at the pump cover (inlet) and the cylinder block.

7. If the engine is equipped with a manual operating shut-down, disconnect the Bowden wire from

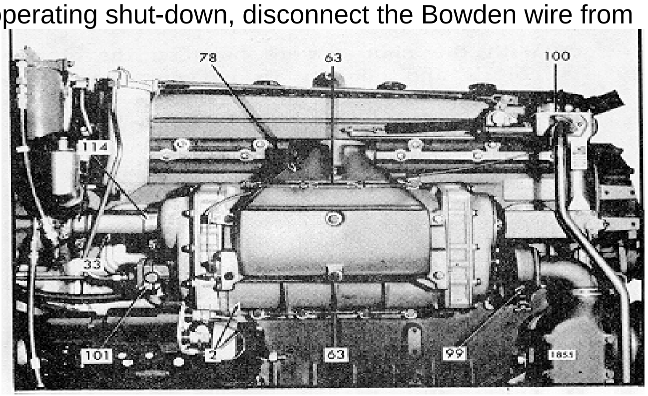


Fig. 3 - Typical Blower Mounting (71 Engine)

2	Housing--Blower	100	Governor
33	Cover--Blower Drive Shaft	101	Pump--Fuel
63	Bolt--Blower Mounting	114	Clamp--Blower Drive Cover Seal
78	Housing--Air Shut-down		
99	Pump--Fresh Water		

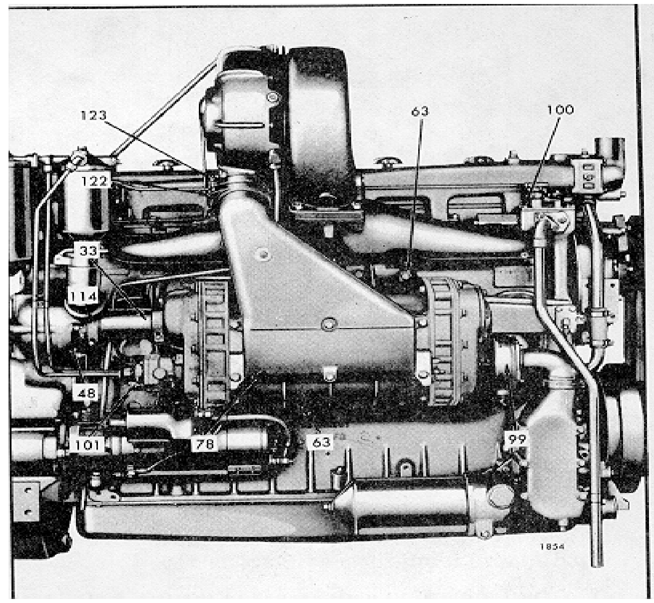


Fig. 4 - Typical Blower Mounting (71T Engine)

33	Cover--Blower Drive Shaft	100	Governor
		101	Pump--Fuel
48	Support--Blower Drive Gear Hub	114	Clamp--Blower Drive Cover Seal
63	Bolt--Blower Mounting	122	Hose--Air Inlet
78	Housing--Air Inlet	123	Clamp--Hose
99	Pump--Fresh Water		

the air shut-down valve shaft lever, then remove the bolt securing the Bowden wire clip to the air shut-down housing.

8. Remove the air cleaner (non-turboed engines), then remove the air inlet housing, gasket, striker plate and air inlet screen from the blower.
9. Remove the blower drive shaft as outlined in Section 1.7.6.
10. Loosen the blower drive shaft cover seal clamp (114) at the blower drive gear hub support.

11. Remove the bolts and plain washers securing the blower to the cylinder block. Slide the blower slightly forward, withdraw the blower drive shaft cover from the seal, then lift the blower away from the cylinder block.

Remove Accessories from Blower

1. Remove the three bolts and seal washer assemblies securing the fuel pump to the blower rear end plate cover, then remove the fuel pump, gasket and drive coupling fork.

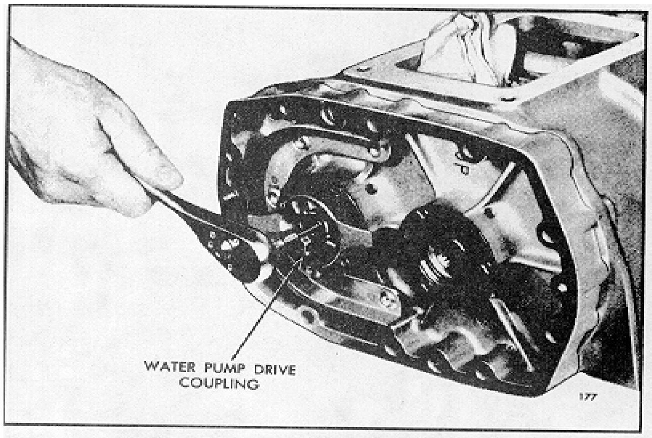


Fig. 5 - Removing Water Pump Drive Coupling Bolt from Blower Rotor Shaft

2. On the current blower, loosen the seal clamp securing the blower drive shaft cover to the blower end plate cover, then remove cover, seal and clamp from the end plate cover. On the former blower, remove the six bolts and seal washer assemblies securing the blower drive shaft cover to the blower end plate cover, then remove the cover and gasket.
3. Remove the three bolts and seal washer assemblies securing the fresh water pump to the blower front end plate cover, then remove the water pump and gasket. If necessary, tap the pump with a plastic hammer to loosen it.
4. Remove the six bolts and seal washer assemblies securing the governor weight housing to the blower front end plate cover, then remove the weight housing and gasket.

Disassemble Blower

Refer to Figs. 1, 2, 11 and 12 and disassemble the blower as follows:

1. Remove the ten bolts and lock washers securing the end plate covers (28) and (29) to the blower front and rear end plates. Tap the ends of the end plate covers with a plastic hammer to loosen the covers from the gaskets and dowel pins in the end plates. Then, remove the covers and gaskets from the end plates.
2. Place a clean folded shop towel between the rotors and a towel between the rotor and the housing to prevent the rotors from turning. Then, remove the bolt securing the water pump drive coupling to the blower rotor shaft as shown in Fig. 5.
3. Thread adaptor J 6471-4 (1/2"-20 threads) or adaptor J 6471-10 (9/16"-18) into the water pump drive coupling, then attach slide hammer and shaft J 6471-1 to the adaptor and pull the drive coupling from the blower rotor shaft
4. Refer to Figs. 11 and 12 and remove the bolts (21), lock washers and plain washers securing the blower rotor drive hub (20) and drive hub plates (115) to the blower rotor timing gear (13) or drive gear (140), then remove the drive hub, plates and spacers (116) (and bearing retainer (117) or former 71E, 71N and 71T blowers) from the gear. If necessary, remove the three bolts (22), lock washers and plain washers securing the drive plates to the drive hub.

5. Remove the reduction drive gears (if used), and the blower rotor timing gears as follows:
   a. Remove bolt, lock washer and retainer securing the timing gear, or the reduction drive gear (if used) to the right-hand helix rotor shaft. Then remove the bolt, lock washer and fuel pump coupling disc (18)securing the other timing gear, or the reduction driven gear (if used), to the left-hand helix rotor shaft. If used, slide the right-hand helix reduction drive gear with bearing off the upper rotor shaft. Remove the reduction driven gear from the lower rotor.
   b. Back out the center screw of both pullers J 6270-1 and secure the pullers to the gears with 5/16"-24 x 1-1/2" bolts.

NOTE: Both gears must be pulled from the rotor shafts at the same time.

   c. With the shop towels between the blower rotors and housing to prevent them from turning, turn the puller screws uniformly clockwise and pull the gears from the rotor shafts (Fig. 6).

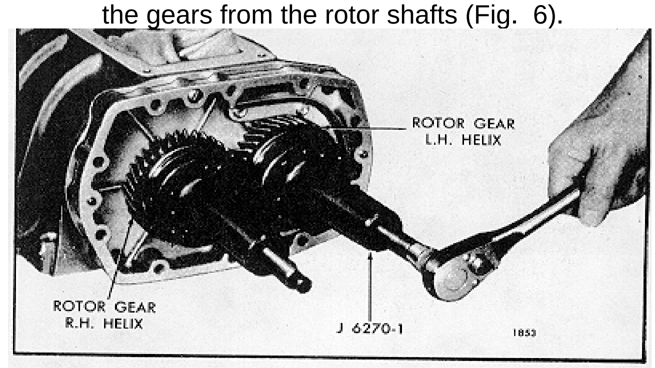


Fig. 6 - Removing Blower Rotor Gears from Blower Rotor Shafts

d. Remove the shims from the rotor shafts or the inner face of the gears, and note the number and thickness of the shims.

6. Remove the bolts and lock washers securing the rotor shaft bearing retainers (6) to both the front and rear end plates. Remove the retainers.

7. Remove the blower rear end plate and bearing assembly from the blower housing and rotors with the two pullers J 6270-1 as follows:

a. Remove the two fillister head screws (26) securing the rear end plate (24) to the blower housing, and loosen the two fillister head screws securing the front end plate (23) to the housing approximately three turns.

b. Back out the center screws of the pullers. far enough to permit the flange of each puller to lay flat on the face of the end plate.

c. Secure the pullers to the end plate with six 1/4"-20 x 1-1/4" bolts.

NOTE: Be sure that the 1/4"-20 bolts are threaded all the way into the tapped holes in the end plate to eliminate possible damage to the end plate.

d. Turn the two pullers screws uniformly clockwise and withdraw the end plate and bearings from the blower housing and rotors as shown in Fig. 7.

8. Remove the blower front end plate in the same manner as described above.

9. Withdraw the blower rotors from the housing.

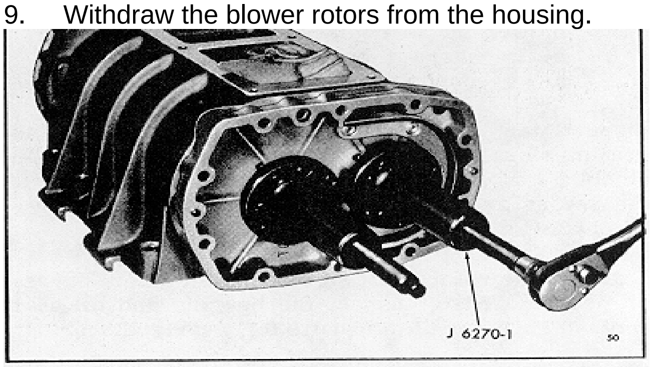


Fig. 7- Removing Blower End Plate

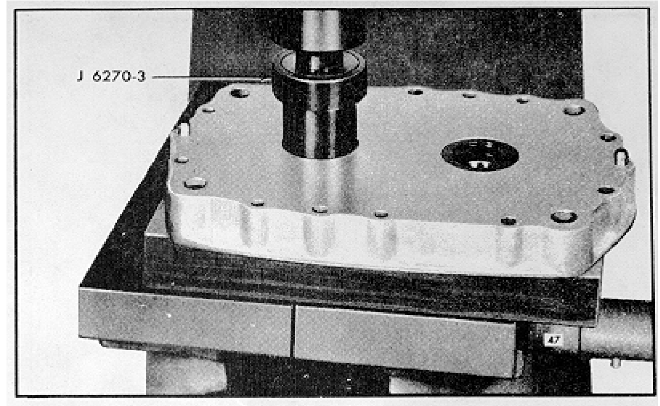


Fig. 8 - Removing Oil Seal (or Seal Ring Collar) and Bearing from End Plate

10. Remove the bearings and the lip type oil seals from the 71 and 71E blower end plates as follows:

a. When performing a major overhaul, discard the oil seals, otherwise inspect the oil seals. If the seals are scored, or hard, new seals must be installed. If necessary, remove the seals from the end plates at the same time the individual bearings are removed.

b. Support the outer face of the end plate on wood blocks on the bed of an arbor press.

c. Place the long end of the oil seal remover and installer J 6270-3 down through the oil seal and into the bearing, with the opposite end of the remover under the ram of the press (Fig. 10). Then, press the bearing and oil seal out of the end plate.

d. Remove the remaining bearings and oil seals from the end plates in the same manner.

11. Remove the bearings and ring type oil seals (if used) carriers, and collars from the blower rotor shafts and end plates as follows:

a. Clamp one lobe of the rotor in a bench vise equipped with soft jaws (Fig. 9). Tighten the vise just enough to hold the rotor stationary.

b. If used remove .005" shims (spacer) on the 71P blower.

c. Remove the oil seal ring from the seal ring carrier on each blower rotor shaft with a

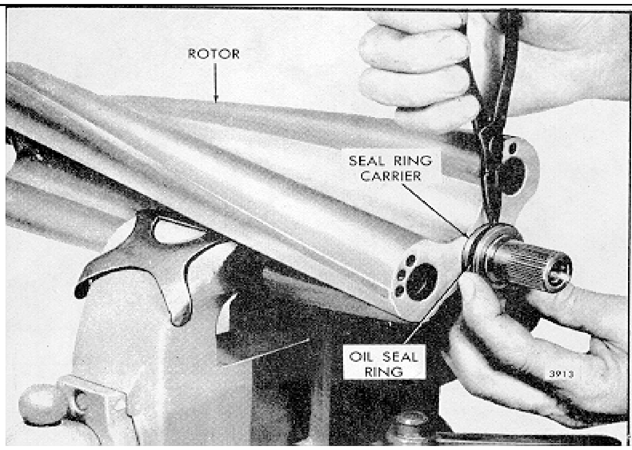


Fig. 9 - Removing Oil Seal Ring from Carrier

pair of snap ring pliers J 4880 as shown in Fig. 9.

d. Refer to Fig. 10 and place the seal ring carrier remover adaptor J 6270-2 over the carrier. Make sure the adaptor is seated in the groove of the carrier.

e. Back out the center screw of puller J 6270- 1 far enough to permit the puller flange to lay flat against the adaptor J 6270-2.

f. Place the puller over the end of the rotor shaft and against the adaptor on the oil seal ring carrier. Then, secure the puller to the adaptor with two bolts.

g. Turn the puller screw clockwise and pull the oil seal ring carrier from the rotor shaft (Fig. 10).

h. Remove the remaining oil seal ring carriers from the rotor shafts in the same manner.

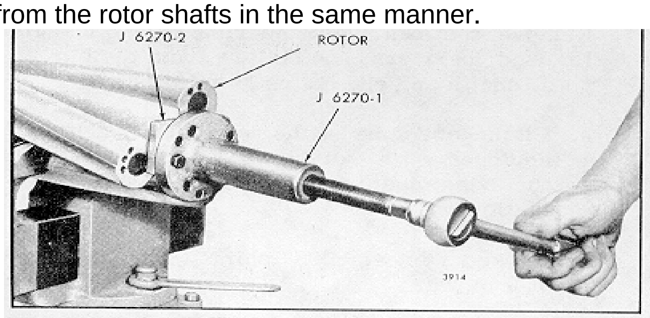


Fig. 10 - Removing Oil Seal Ring Carrier from Blower Rotor Shaft

i. Refer to Fig. 8 and support the outer face of the blower end plate on wood blocks on the bed of an arbor press.

j. Place the long end of the oil seal remover and installer J 6270-3 down through the oil seal ring collar and into the bearing, with NW the opposite end of the remover under the ram of the press (Fig. 8). Then, press the bearing and oil seal ring collar out of the end plate.

k. Remove the remaining bearings and oil seal ring collars from the end plates in the same manner.

Inspection

Wash all of the blower parts in clean fuel oil and dry them with compressed air.

Examine the bearings for any indications of corrosion or pitting. Lubricate each bearing with light engine oil; then, while holding the bearing inner race from turning, revolve the outer race slowly by hand and check for rough spots.

The double-row ball bearings are pre-loaded and have no end play. A new double-row bearing will ILI seem to have considerable resistance to motion when revolved by hand.

Check the oil seal rings, carriers and collars for wear and scoring. If worn excessively, they must be replaced. Inspection of the lip type oil seal is covered in item "a" under Step 10.

NOTE: When a blower with lip type oil seals is being reconditioned, the
installation of new seals is recommended. Oversize oil seals and oil seal spacers are available in the blower kit to replace the standard oil seals where the blower rotor shafts are grooved.

Inspect the blower rotor lobes, especially the sealing ribs, for burrs and scoring. Rotors must be smooth for efficient operation of the blower. If he rotors are slightly scored or burred, they may be cleaned up with emery cloth.

Examine the rotor shaft serrat onus for wear, burrs, or peening. Also, inspect the bearing and oil seal contact surfaces of the shafts for wear and scoring.

Inspect the inside surface of the blower housing for burrs and scoring The inside surface must he

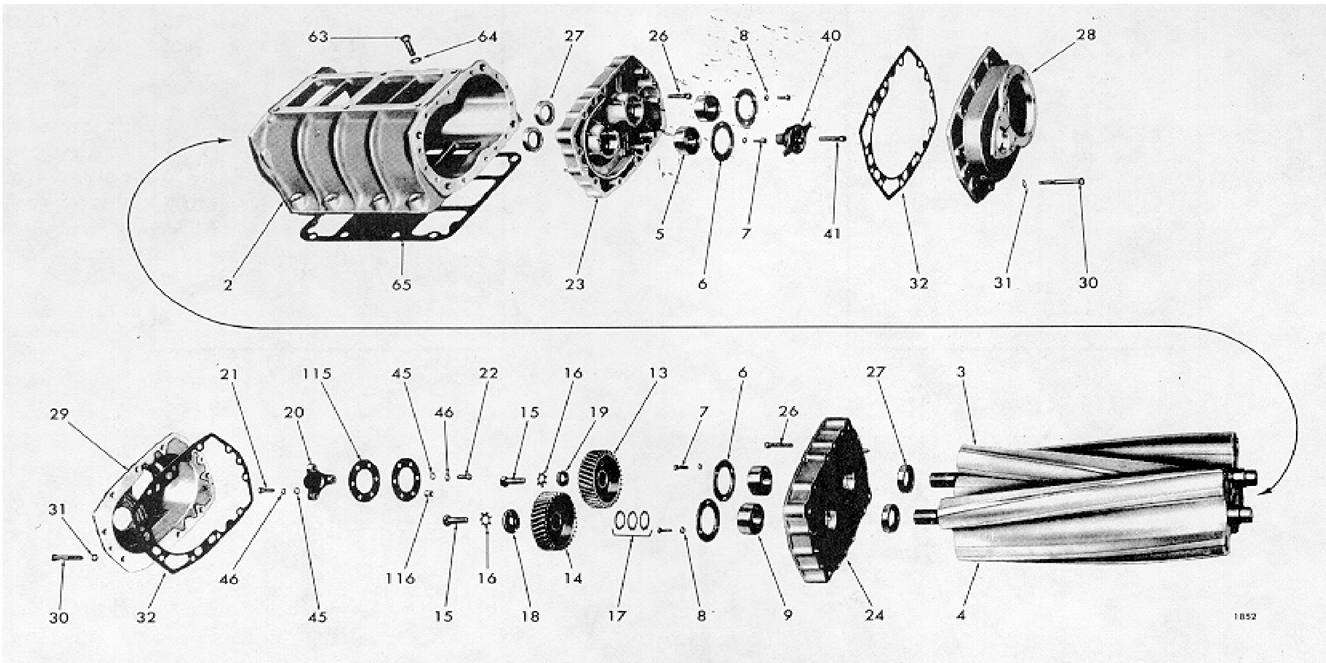


Fig. 11 - Typical Details and Relative Location of Parts - Standard and Small Diameter Rotor Six Cylinder 71 Blowers

2	Housing--Blower	14	Gear--Rotor--Lower--	22	Bolt--Plate to Hub	40	Coupling Assy.-- Water
3	Rotor--Blower--Upper--		L.H Helix	23	End Plate--Front		Pump Drive
	R.H Helix	15	Bolt--Rotor Gear	24	End Plate--Rear	41	Bolt--Allen Head
4	Rotor--Blower--Lower-- Plain Washer	16	Lock		Washer--Bolt to	25	Pin (Dowel)-- 45
	L.H Helix		Rotor Gear		Housing to End Plate	46	Lock Washer
5	Bearing (Roller)--Front	17	Shim--Gear to Bearing	26	Bolt--End Plate	63	Bolt--Blower Mounting
6	Retainer--Bearing		(For Timing Rotors)	27	Oil Seal--End Plate	64	Plain Washer--Blower
7	Bolt--Bearing--Retainer	18	Disc--Fuel Pump	28	Cover--End Plate--Front		Mounting
8	Lock Washer		Coupling	29	Cover--End Plate--Rear	65	Gasket--Blower Housing
9	Bearing (Ball)--Rear	19	Washer--Rotor Gear	30	Bolt--End Plate Cover	115	Plate--Blower Rotor
	Double Row Thrust		Retaining	31	Lock Washer		Drive Hub
13	Gear--Rotor--Upper--	20	Hub--Rotor Drive	32	Gasket--End Plate	116	Spacer--Plate to Gear
	R.H Helix	21	Bolt--Plate to Gear		Cover		

smooth for efficient operation of the blower. If the inside surface of the housing is slightly scored or burred, it may be cleaned up with emery cloth.

Check the finished ends of the blower housing, for flatness and burrs. The end plates must set flat against the blower housing.

The finished inside face of each end plate must be smooth and flat. If the finished face is slightly scored or burred, it may be cleaned up with emery cloth.

Examine the serrations in the blower timing gears for wear and peening; also check the teeth for wear, chipping or damage. If the gears are worn to the point where the backlash between the. gear teeth exceeds .004", or damaged sufficiently to require replacement, both gears must be replaced as a set.

Check the blower drive shaft serrations for wear or peening. Replace the shaft if it is bent.

Inspect the blower drive coupling springs (pack) and the cam for wear.

Replace all worn or excessively damaged blower parts.

Assemble Blower

The lobes on the upper blower rotor and the teeth on its gear form a right-hand helix while the lobes and teeth of the lower rotor and gear form a left- hand helix. Therefore, a rotor with right-hand helix

3.4 BLOWER

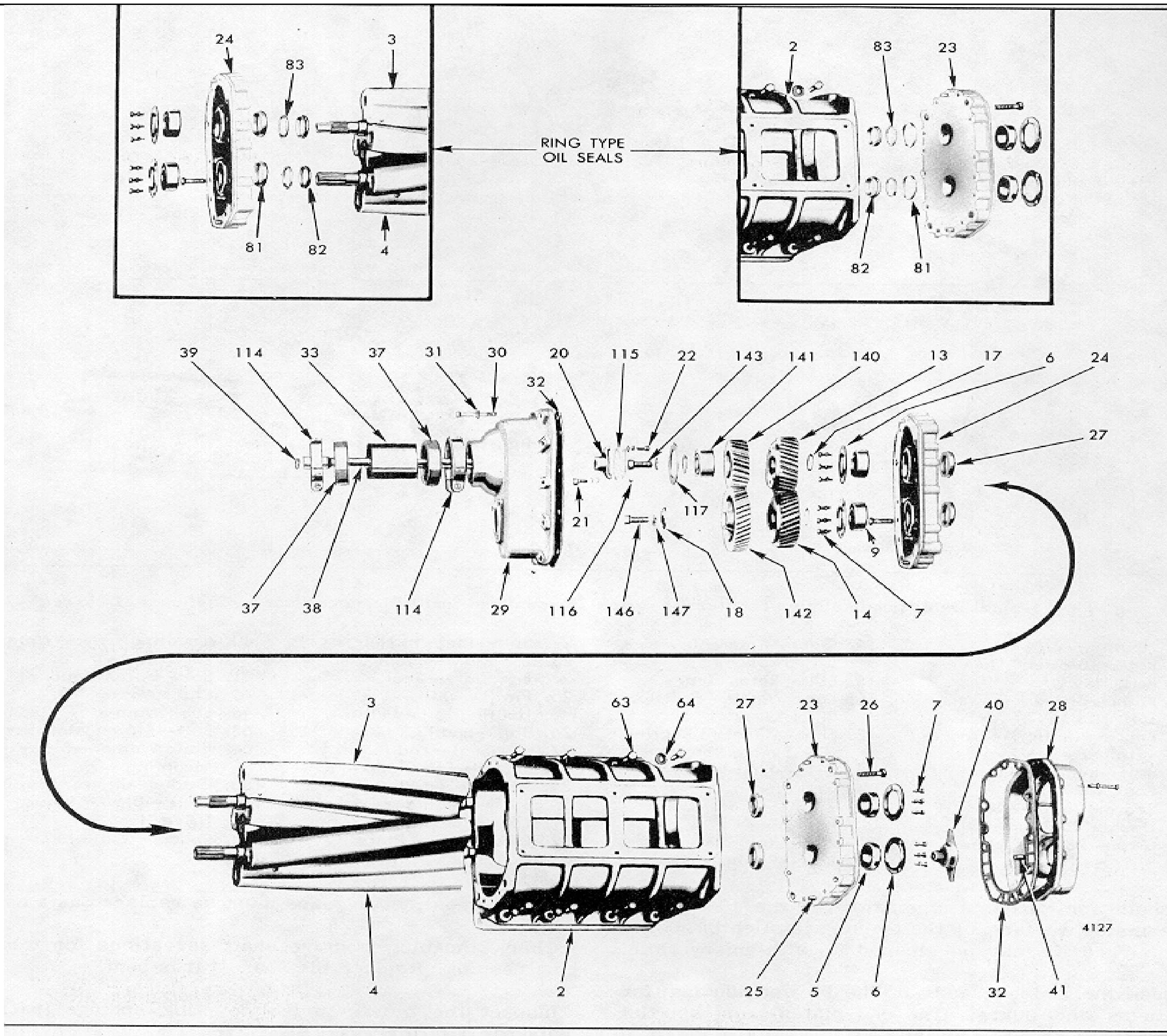


Fig. 12-Typical Details and Relative Location of Parts- Six Cylinder Former Reduction Blowers

lobes must be used with a gear having right-hand helix teeth and vice versa (Fig. 13).

With this precaution in mind, proceed with blower assembly, referring to Figs. 11 through 24 as directed in the text.

1. Install the lip type oil seals (Fig. 15) as follows:

a. Support the blower end plate, finished surface facing up, on wood blocks on the bed of an arbor press (Fig. 14).

NOTE: If oversize oil seals are being used in the blower end plates, use installer J 1682-13 to install the over-size oil seal spacers on the rotor shafts.

Fig. 12 - Typical Details and Relative Location of Parts - Six Cylinder Former Reduction Blowers

2	Housing--Blower	20	Hub--Rotor Drive	33	Cover--Blower Drive	83	Ring--Seal (Piston Type)
3	Rotor Assy.--Upper--	21	Bolt--Plate to Gear		Shaft	114	Clamp--Blower Drive
	R.H Helix	22	Bolt--Plate to Hub	34	Bolt--Drive Shaft		Cover Seal
4	Rotor Assy.--Lower--	23	End Plate--Front		Cover	315	Plate--Blower Rotor
	L.H Helix	24	End Plate--Rear	35	Lock Washer		Drive Hub
5	Bearing (Roller)--Front	25	Pin (Dowel)--	36	Gasket--Drive Shaft	116	Spacer--Plate to Gear
6	Retainer--Bearing		Housing to End Plate		Cover	117	Retainer--Bearing
7	Bolt--Bearing Retainer	26	Bolt--End Plate	37	Seal--Blower Drive	140	Gear--Drive--R.H.
9	Bearing (Ball)--Rear--	27	Oil Seal--End Plate		Cover		Helix
	Double Row Thrust	28	Cover--End Plate--	38	Shaft--Blower Drive	141	Bearing (Ball)--Drive
13	Geor--Rotor--Upper--		Front	39	Snap Ring--Drive Shaft		Gear
	R.H Helix	29	Cover--End Plate--	40	Coupling Assy.--	142	Gear--Driven--L.H.
14	Gear--Rotor--Lower--		Rear		Water Pump Drive		Helix
	L.H Helix	30	Bolt--End Plate	41	Bolt--Allen Head	143	Bolt--Drive Gear
17	Shim--Gear to Bearing		Cover	63	Bolt--Blower Mounting		Retaining
	(For Timing Rotors)	31	Lock Washer	64	Plain Washer	146	Bolt--Driven Gear
18	Disc--Fuel Pump	32	Gasket--End Plate	81	Collar--Blower End Plate		Retaining
	Coupling		Cover	82	Carrier--Seal Ring	147	Lock Washer

b. Start the oil seal straight into the bore in the end plate with the sealing edge facing down (toward the bearing bore).

c. Place the short end of oil seal remover and 'installer J 6270-3 iii the oil seal and under the ram of the press (Fig. 14). Then, press the oil seal into the end plate until the shoulder on the installer contacts the end plate.

NOTE: A step under the shoulder of the installer will position the oil seal approximately .005" below the finished face of the end plate. This is within the .002" to .008" specified.

d. Install the remaining oil seals in the end plates in the same manner.

2. If used, install the ring type oil seal, carriers, and collars on the rotor shafts and in the end plates as follows:

a. Support one of the rotor assemblies on wood blocks on the bed of an arbor press as shown in Fig. 16.

b. Lubricate the inside diameter of the oil seal ring carrier a with engine oil; then start the carrier straight over the end of the rotor shaft with the chamfered inside diameter end facing the rotor.

c. Place the oil seal ring carrier installer J 6270-4 over the end of the rotor shaft and against the carrier with the end of the installer under the ram of the press. Then, press the carrier down tight against the rotor.

d. Install the remaining oil seal ring carriers on the rotor shafts in the same manner.

e. Install an oil seal ring in the ring groove of

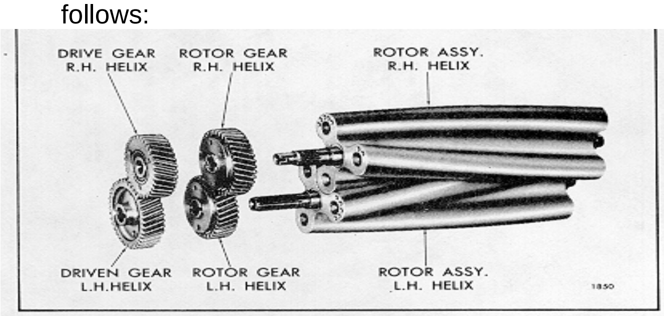


Fig. 13 - Upper and Lower Rotors and Gears (Former Reduction Blowers)

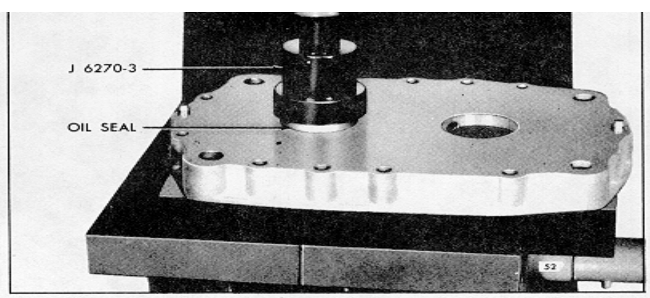


Fig. 14 - Installing Oil Seal (or Seal Ring Collar) in Blower End Plate

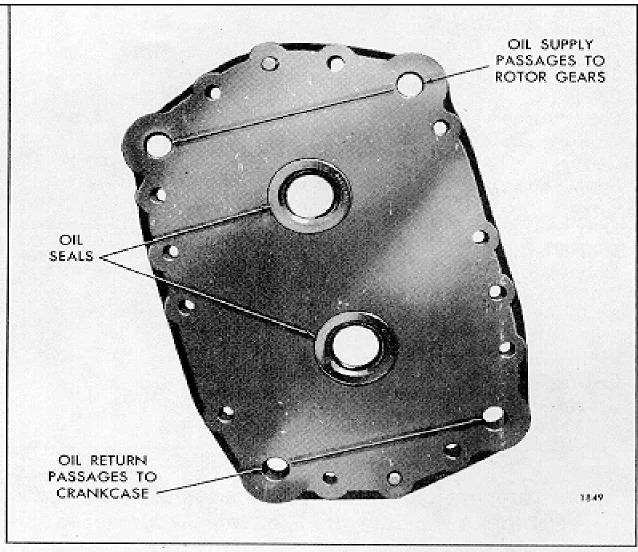


Fig. 15 - Blower End Plate and Oil Seal Location (Standard 71 and 71E Blowers)

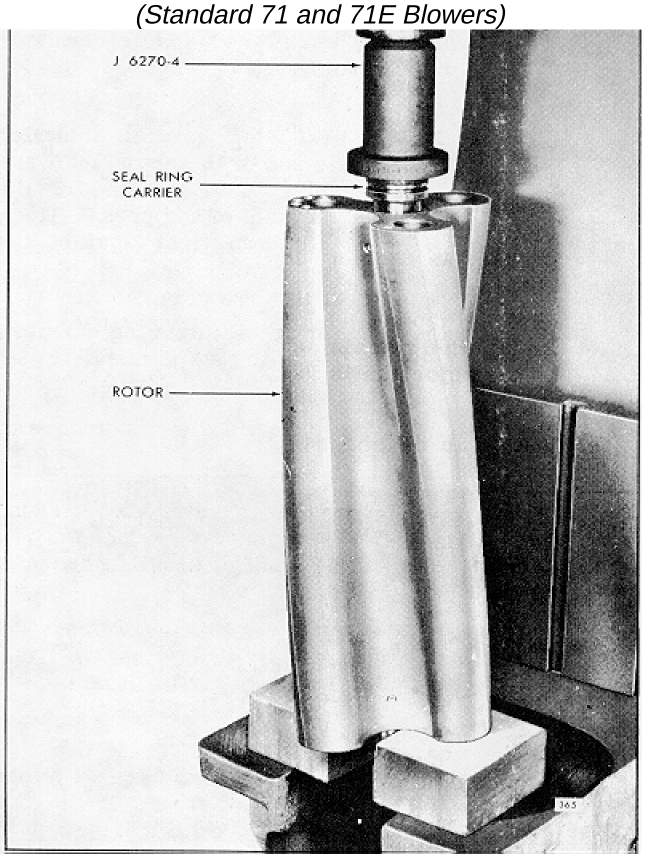


Fig. 16 - Installing Oil Seal Ring Carrier on Blower Rotor Shaft

each carrier with a pair of snap ring pliers J 4880 in the same manner as shown in Fig. 9.

> **CAUTION:** To avoid breaking the oil seal rings, do not spread them any more than necessary to place them over the end of the carrier.

Support one of the blower end plates, inner face up, on wood blocks on the bed of an arbor press as shown in Fig. 14.

Lubricate the outside diameter of a seal ring collar with engine oil; then start the chamfered outside diameter end of the collar straight into the bore in the end plate.

Place the oil seal ring collar installer J 6270-4 on top of the seal ring collar and under the ram of the press in the same manner as shown in Fig. 14. Then, press the collar into the end plate until the shoulder on the installer contacts the end plate.

> **NOTE**: A step under the shoulder of the installer will position the collar approximately .005" below the finished face of the end plate. This is within the .002" to .008" specified.

Install the remaining oil seal ring collars in the end plates in the same manner.

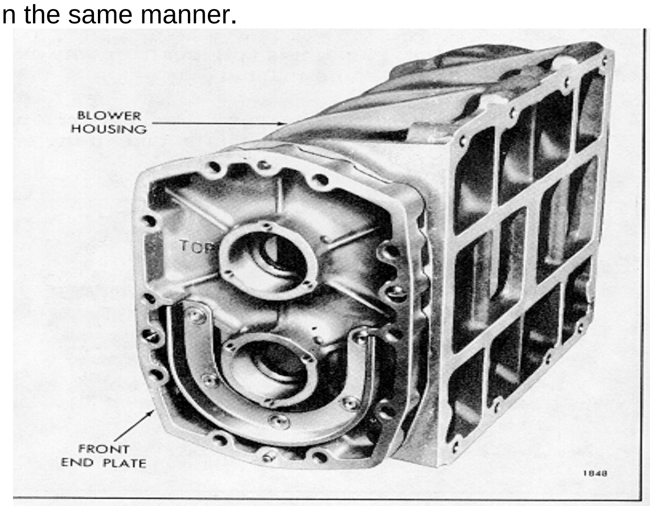


Fig. 17 - Position of Blower Front End Plate on Housing

Assemble Rotors and End Plates (With Lip Type Oil Seals)

1. Install the blower front end plate, making sure the mark TOP on the outer ribbed side is at the top of the blower housing, identified by the flange which supports the housing on the top edge of the cylinder block (Fig. 17).

The front and rear end plates of the blower are inter changeable.

One end plate should be assembled to the front end of the blower housing first and the other plate should be assembled to the rear of the blower housing after the rotors are in place. Attach an end plate to the front of the blower housing as follows:

a. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the front end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

b. Place the blower housing on a bench with the top of the housing up, and the front end of the housing facing the outside of the bench.

c. Position the end plate in front of the blower housing with the flat finished face of the end plate facing the housing and the end marked TOP facing the flanged side of the housing. Then, start the dowel pins straight into the dowel pin holes in the housing. Push or tap the end plate against the housing.

Note that gaskets are not used between the end plates and the housing; therefore, the

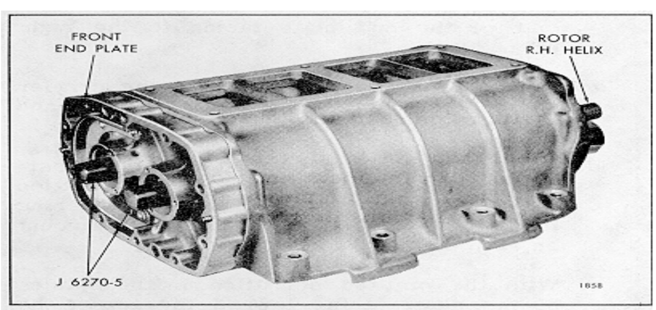


Fig. 18 - Assembling Blower Rotors into Housing and Front End Plate (Lip Type Oil Seals)

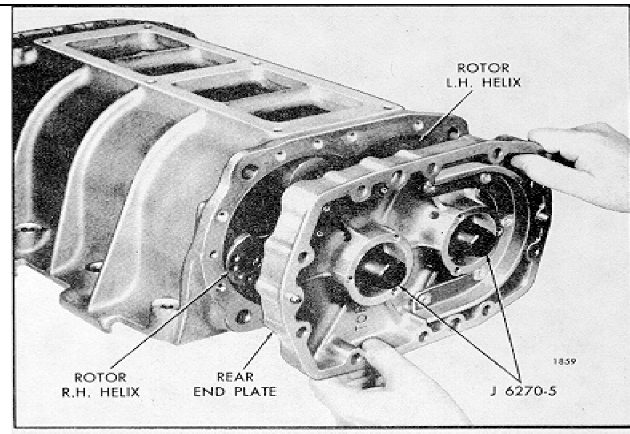


Fig. 19 - Installing Blower Rear End Plate (Lip Type Oil Seals)

mating surfaces must be flat and smooth.

d. Insert the two fillister head screws through the end plate and thread them into the housing. Tighten the screws securely. Do not use lock washers on these screws.

2. Assemble the blower rotors in the blower housing and front end plate as follows:

The rotors must be assembled in the blower housing with the omitted serrations in the rotor shafts aligned as shown in Fig. 28.

NOTE: The housing used in E, T and P blower assemblies are stamped for identification with the letters "E", "T" or "P" near the top of the housing. The "N" engines are also stamped "E".

a. Place an oil seal pilot J 6270-5 on the short (non-splined) end of each rotor shaft. Then, place the rotors in mesh with the omitted serrations in the shafts in alignment as shown in Fig. 28.

NOTE: When oversize oil seals are used in the blower end plate, use oil seal spacer installers J 6270-28 for the oil seal pilots in place of J 6270-5.

b. Insert the blower rotors with oil seal pilots straight into the blower housing with the right-hand helix rotor at the top, flange, side of the housing. Then, push the rotor shafts and oil seal pilots on through the oil seal in the front end plate as shown in Fig. 18.

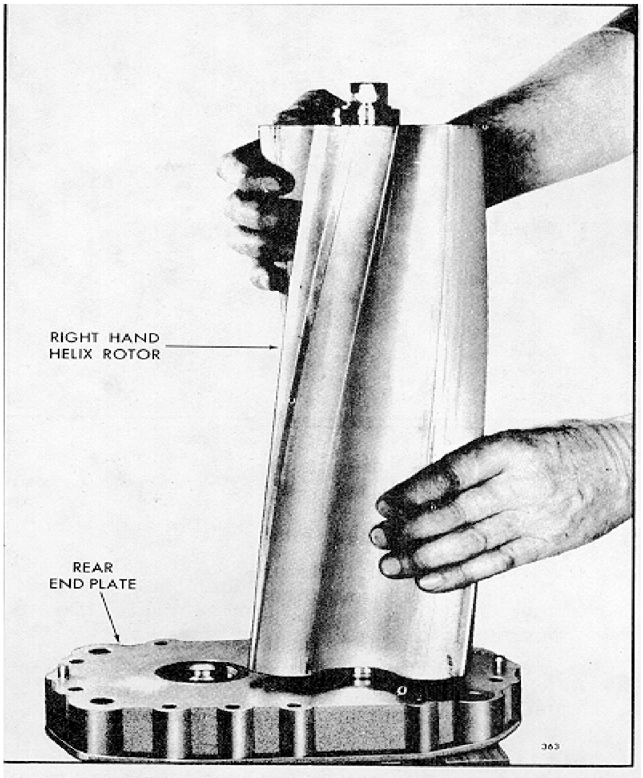


Fig. 20 - Installing Blower Rotor in Rear End Plate (Ring Type Oil Seals)

c. Remove the oil seal pilots from the rotor shafts.

3. Attach the blower rear end plate to the blower housing as follows:
   a. Reverse the blower housing on the bench (rear end of housing facing the outside of the bench).

   b. Place an oil seal pilot J 6270-5 on the serrated end of each rotor shaft.

   NOTE: When oversize oil seals are used in the blower end plate, use oil seal spacer installers J 6270-28 for the oil seal pilots in place of J 6270-5.

   c. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the rear end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

   d. Place the rear end plate in position in front of the oil seal pilots with the flat finished face of the end plate facing the blower housing and the mark TOP on the end plate at the top flange side of the housing.

   e. Place the rear end plate over the oil seal pilots (Fig. 19) and start the dowel pins straight into the dowel pin holes in the housing. Push or tap the end plate against the housing.

   f. Insert the two fillister head screws through the end plate and thread them into the housing. Tighten the screws securely. Do not use lock washers on these screws.

   g. Remove the oil seal pilots from the rotor shafts.

Assemble Rotors and End Plates
With Ring Type Oil Seals)

Install the blower rotors in the blower rear end plate as outlined below:

The front and rear blower end plates are inter changeable. Note that gaskets are not used between the end plates and the housing; therefore, mating surfaces must be flat and smooth.

a. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the rear end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

b. Support the rear end plate on two wood blocks, approximately 4" high, with the inner face of the end plate facing up and the TOP end of the end plate facing to the right (Fig. 20).

c. Lubricate the oil seal ring in the carrier on the rear (splined) end of the right-hand helix rotor shaft with engine oil.

d. Hold the right-hand rotor in a vertical position, rear (splined) end down, and position the seal ring in the carrier so the ring protrudes from its groove the same amount on each side.

e. With the omitted serration in the spline, of the shaft facing toward the top of the end plate, start the splined end of the rotor shaft straight into the right-hand shaft opening in the end plate as shown in Fig. 20.

Continue to lower the rotor until the oil seal ring contacts the seal ring collar in the end plate; then carefully work the oil seal ring into the collar until the rotor contacts the end plate.

f. Perform Steps "c" and "d" above on the left-hand helix rotor.

g. Position the two rotors together so the lobes are in mesh and the omitted serration in splines of both shafts face toward the top of the end plate; then, start the splined end of the shaft straight into the left-hand shaft opening in the end plate. Continue to lower the rotor in place as outlined in Step "e".

2. Determine the rotation of the blower being assembled, then install the blower housing over the rotors as follows:
   a. Position the blower housing above the rotors with its mounting flange facing toward the right-hand helix rotor. Lower the housing over the rotors until it contacts the dowel pins in the end plate.
   b. Align the dowel pin holes in the blower housing with the pins and push the housing tight against the end plate. If necessary, tap the housing lightly with a plastic hammer.
3. Install the blower front end plate on the rotors and housing as outlined below:

   a. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the front end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

   b. Lubricate the oil seal rings in the carriers on the rotor shaft with engine oil.

   c. Position the oil seal rings in the carriers so the ring protrudes from its groove the same amount on each side.

   d. Position the front end plate over the top of the rotor shafts with the inner face of the end plate facing the rotors and the mark "TOP" on the end plate at the flange side of the housing as shown in Fig. 21.

   e. Lower the end plate straight over the rotor shafts until the dowel pins in the end plate contact the blower housing (Fig. 21); then carefully work the dowel pins into the dowel pin holes in the housing and the oil seal rings into the collars. Push the end plate tight against the housing. If necessary, tap the end plate lightly with a plastic hammer.

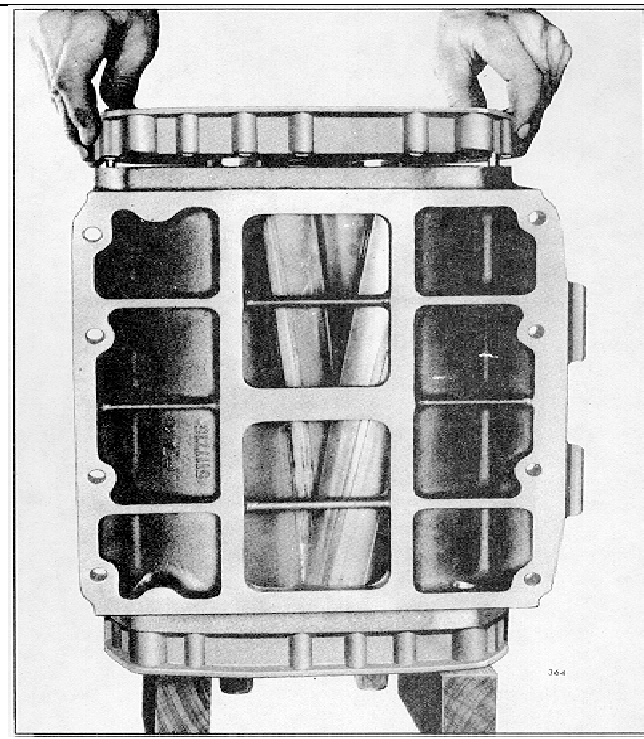


Fig. 21 - Installing Front End Plate on Blower Rotors and Housing (Ring Type Oil Seals)

   f. Insert the two fillister head screws through the front end plate and thread them into the housing. Tighten the screws securely. Do not use lock washers on these screws.

Install Blower Rotor Shaft Bearings and Gears.

1. With the blower housing, rotors and end plates still supported in a vertical position on the two wood blocks, install the roller bearings on the rotor shafts and in the front end plate as follows:

   a. Lubricate one of the roller bearings with engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

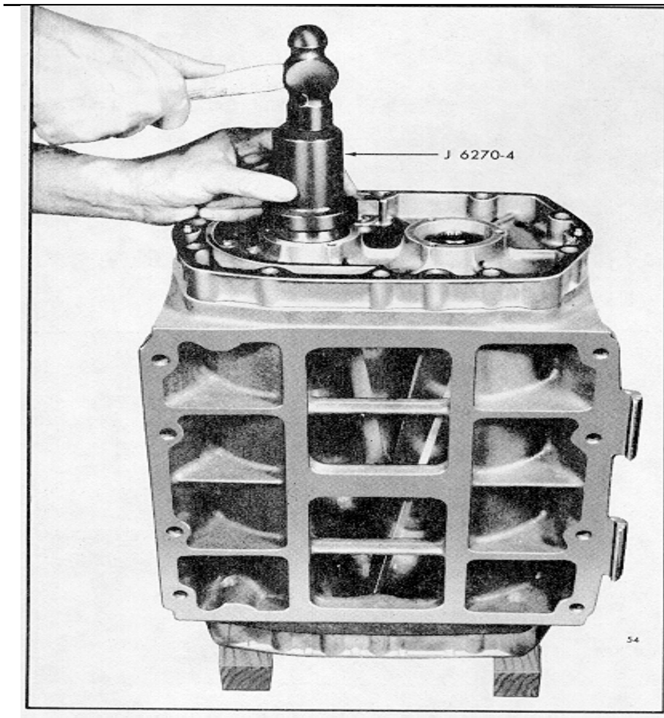


Fig. 22 - Installing Roller Bearing on Rotor Shaft and in Front End Plate

b. Place installer J 6270-4 on top of the bearing and tap the bearing on the shaft and into the front end plate as shown in Fig. 22.

c. Install the second roller bearing on the remaining rotor shaft in the same manner.

d. Place the bearing retainers on top of the bearings and the end plate; then, install the retainer bolts and lock washers. Tighten the bolts to 7-9 lb-ft torque.

2. Start the end of the water pump drive coupling straight into the left-hand helix rotor shaft. Then, place a clean shop towel between the blower rotors to prevent them from turning. Install the drive coupling retaining bolt and draw the coupling and slinger tight against the end of the shaft, then tighten the bolt to 18 lb-ft torque.

3. Affix a new gasket (32) to the blower front end plate cover (38).

NOTE: The former blower end plate cover is not interchangeable with the current blower end plate cover.

4. Position the end plate cover over the end plate dowel pins, with the large hole in the cover toward the top of the end plate, then push the cover against the end plate. Install the ten bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

5. Install the ball bearings on the rotor shafts and in the rear end plate as follows:
   a. Reverse the position of the blower housing on the two wood blocks (Fig. 23).

   b. On a blower with ring type oil seals, insert the two fillister head screws through the

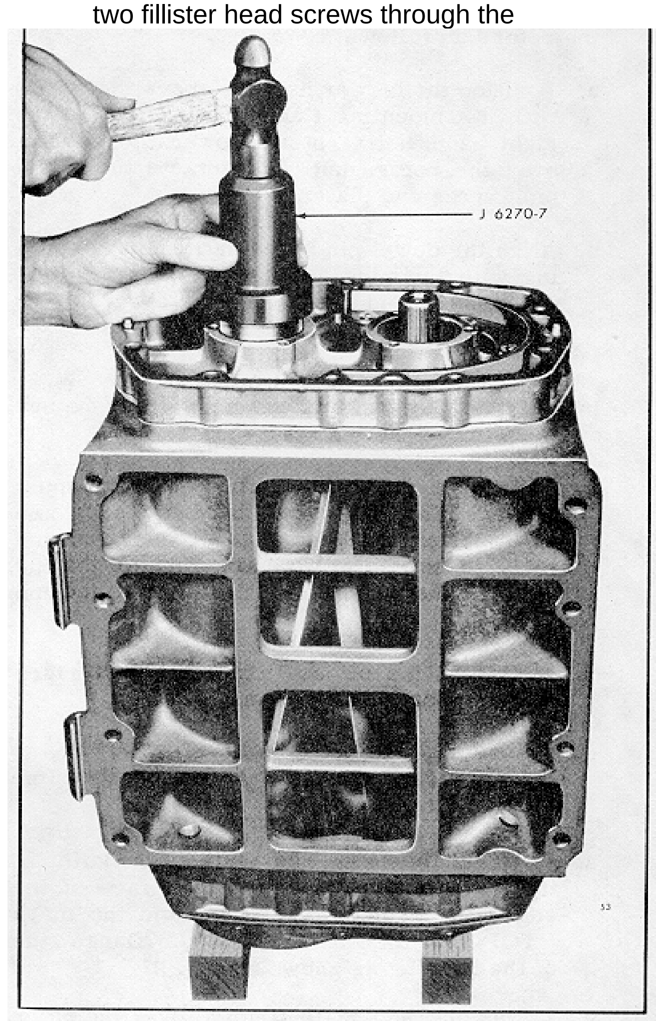


Fig. 23 - Installing Ball Bearing on Rotor Shaft and in Rear End Plate

rear end plate and thread them into the housing. Tighten the screws securely. Do not use lock washers on these screws.

c. Lubricate one of the ball bearings with engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

d. Place installer J6270-7 on top of the bearing and tap the bearing straight on the shaft and into the rear end plate as shown in Fig. 23.

e. Install the second ball bearing on the remaining rotor shaft in the same manner.

f. Place the bearing retainers on top of the bearings and the end plate; then, install the retainer bolts and lock washers. Tighten the bolts to 7-9 lb-ft torque.

6. Make a preliminary check of the rotor-to-end plate and rotor-to-housing clearances at this time with a feeler gage as shown in Fig. 29. Refer to Figs. 26 and 27 for minimum blower clearances.

7. Install the blower rotor timing gears on a standard blower or a smaller diameter rotor blower as follows:

One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alignment.

a. Place the blower housing and rotor assembly on the bench with the air inlet side of the housing facing up and the rear end (serrated end of rotor shafts) of the blower facing the outside of the bench.

b. Rotate the rotors to bring the omitted serrations on the shafts in alignment and facing the top of blower housing (Fig. 28).

c. Install the same number and thickness of shims on the rotor shafts that were removed at the time of disassembly.

NOTE: When rebuilding a blower with new rotors or new gears, first install the gears on the rotor shafts without the shims, then check clearances between rotors to determine location and thickness of shims to be used (Fig. 28).

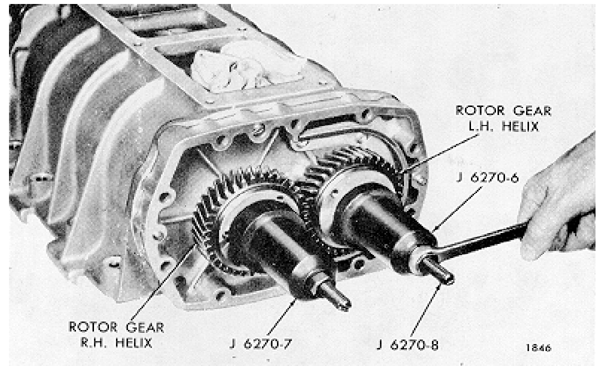


Fig. 24. Installing Rotor Gears on Rotor Shafts for Preliminary Check of Clearances

d. Lubricate the serrations of the rotor shafts with engine oil.

e. Place the teeth of the rotor gears in mesh so that the omitted serrations inside the gears are in alignment and facing the same direction as the serrations on the shafts.

NOTE: A center punch mark placed in the end of each rotor shaft at the omitted serrations will assist in aligning the gears on the shafts.

f. Start both rotor gears straight on the rotor shafts with the right-hand helix gear on the right-hand helix rotor and the left-hand helix gear on the left-hand helix rotor, and the omitted serrations in the gears in line with the omitted serrations on rotor shafts.

g. Thread an installer screw J 6270-8 in the end of each rotor shaft until it bottoms. Place gear installer J 6270-7 over the installer screw and against the right-hand helix gear, and gear installer J 6270-6 over the installer screw and against the left-hand helix gear; then, thread a nut on each installer screw (Fig. 24).

h. Place a clean shop towel between the rotors, and another one between the rotor and the housing to prevent the rotors from turning. Then turn the nuts on the installer screws clockwise as shown in Fig. 24 and press the gears into position tight against the shims and bearing inner races.

NOTE: Both gears must be pressed on the rotor shafts at the same time.

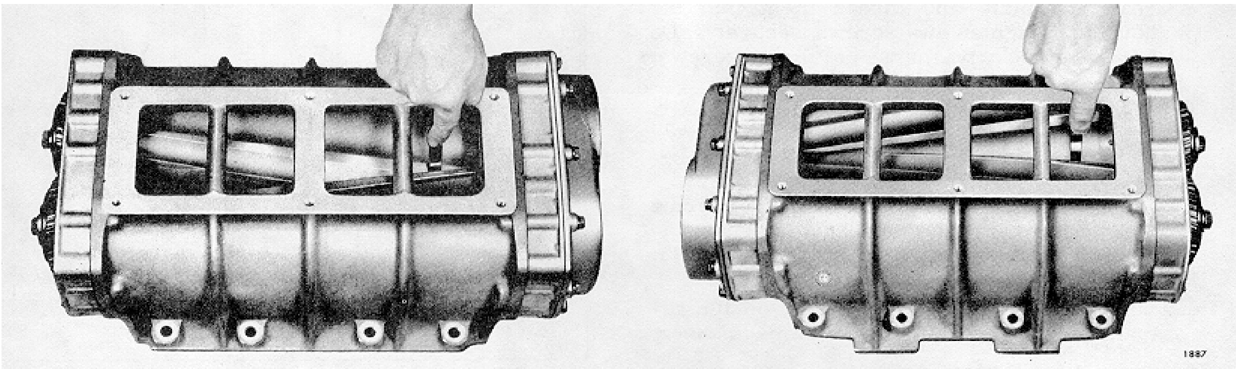


Fig. 25. Measuring "CC" and "C" Clearances Between Blower Rotor Lobes

i. Remove the rotor timing gear installers from the rotor shafts.

j. Place a lock washer (16) and the gear retaining washer (19) on one of the gear retaining bolts (15). Thread the bolt into the right hand helix rotor shaft, and guide the lugs on the retaining washer in the slots in the gear hub, then bend one of the tangs on the lock washer over into the slot of the retaining washer. Tighten the gear retaining bolt to 55-65 lb-ft torque.

k. Place a lock washer (16) and the fuel pump drive coupling disc (18) on the remaining gear retaining bolt. Thread the bolt into the left-hand helix rotor shaft and guide the lugs on the disc in the slots in the gear hub, then bend one of the tangs on the lock washer over into the slot in the disc. Tighten the gear retaining bolt to 55-65 lb-ft torque.

l. Bend one of the tangs of each lock washer over against head of gear retaining bolt.

8. Install the blower rotor timing gears on the former reduction blower (Fig. 12) as follows:

One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alignment.

a. Place the blower housing and rotor assembly, air inlet side of housing facing up, on the bench with the rear end (serrated end of rotor shaft) of the blower facing the outside of the bench.

b. Rotate rotors to bring omitted serrations on the shaft in alignment and facing the top of the blower housing (Fig. 28).

c. Install the same number and thickness of shims on the rotor shafts that were removed at the time of disassembly.

NOTE: When rebuilding a blower with new rotors or new gears, first install the gears on the rotor shafts without the shims, then check the clearances between the rotors to determine the location and thickness of shims to be used; refer to Fig. 28.

d. Lubricate the serrations of the rotor shafts with engine oil.

NOTE: A center punch mark placed in the end of each rotor shaft at the omitted serrations will assist in aligning the gears on the shafts.

e. Start the left-hand helix gear on shaft of left-hand helix rotor with omitted serrations in the gear and the shaft in alignment.

f. Thread an installer screw J 6270-8 in the end of the rotor shaft until it bottoms. Place the installer J 6270-6 over the screw and against the gear, and thread a nut on the installer screw.

g. Place a clean shop towel between the rotors, and another one between the rotor and the housing to prevent the rotors from turning. Then, turn the nut on the installer screw clockwise and press the gear on the shaft until the outer face of the gear is flush or slightly below the end of the shaft.

h. Start the right-hand helix gear on the shaft of the right-hand helix rotor with the gear teeth in mesh and the omitted serrations in the gear and the shaft in alignment.

i. Thread an installer screw J 6270-8 in the end of the rotor shaft until it bottoms. Place the installer J 6270-6 over the screw and against the gear, and thread a nut on the installer screw. Then, turn the nuts on the installer screws uniformly clockwise and press the gears into position tight against the shims and bearings as shown in Fig. 24.

NOTE: Both gears must be pressed on the rotor shafts at the same time.

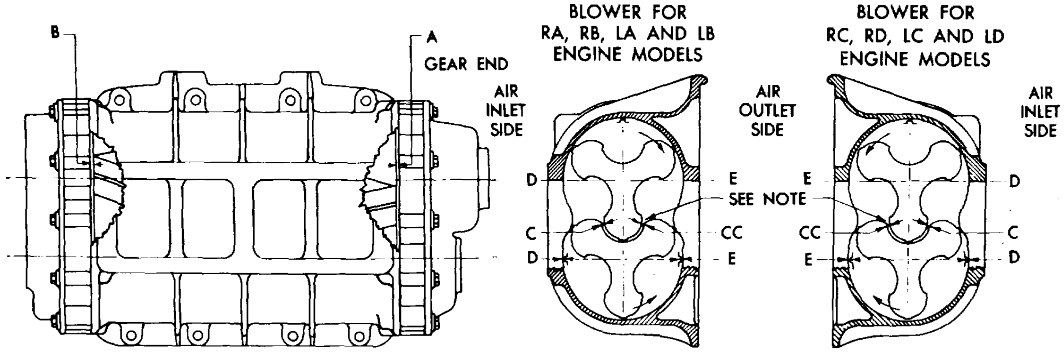
j. Remove the rotor timing gear installers from the rotor shafts.

Timing Blower Rotors

After the blower rotors and timing gears are installed, the blower rotors must be timed.

The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

If the right-hand helix gear is moved out, the right-hand helix rotor will turn counterclockwise when viewed from the gear end. If the left-hand helix gear is moved out,



		A	B	C	CC	D	E
3-71	MIN.	.007	.007	.012	.002	.015	.004
	MAX.				.006		
4-71	MIN.	.007	.009	.012	.002	.015	.004
	MAX.				.006		
6-71	MIN.	.007	.014	.012	.002	.015	.004
	MAX.				.006		
6-71P	MIN.	.012	.019	.014	.002	.030	.004
	MAX.				.006		

TIME ROTORS TO DIMENSIONS ABOVE

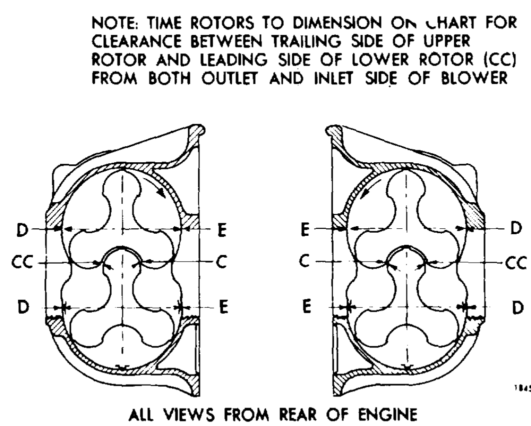


Fig.26. Chart of Minimum Clearances for Standard Blowers, Smaller Diameter Rotor Blowers and Large Bearing (P) Blowers

the left-hand helix rotor will turn clockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.

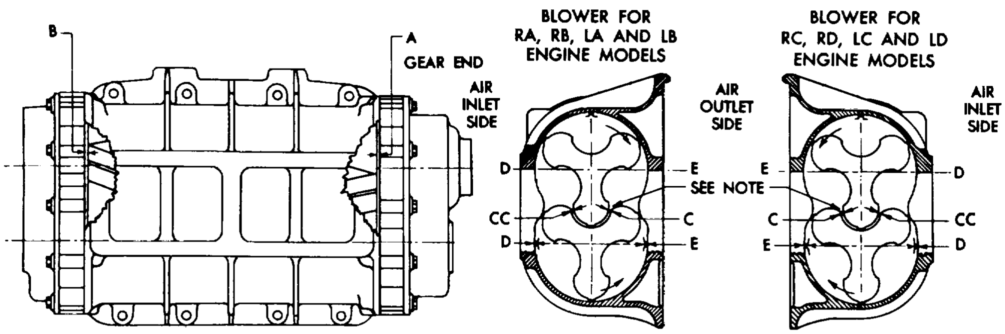
Moving the gears OUT or IN on the rotor shafts is accomplished by adding or removing shims between the gears and the bearings.

The clearance between the rotor lobes should be checked with 1/2" feeler gages in the manner shown in Fig. 25. When measuring clearances of more than .005", laminated feeler gages that are made up of .002", .003" or .005" feeler stock are more practical and suitable than a single feeler gage. Clearances should be measured from both the inlet and outlet sides of the blower.

A specially designed feeler gage set J 1698-02 for the blower clearance operation is available. Time the rotors as follows:

1. 71 Blower - Time the rotors to have .002" to .006" clearance between the TRAILING edge of the UPPER rotor and LEADING edge of the LOWER rotor ("cc" clearance) measured from both the inlet and outlet sides as shown in Figs. 25 and 26. If possible, keep this clearance to the minimum (.002"). Then check the clearance between the LEADING edge of the UPPER and the TRAILING edge of the LOWER rotors ("c" clearance) for the minimum clearance shown in Fig. 26. Rotor-to-rotor measurements should be taken 1" from the governor end, at the center, and 1" from the drive end.

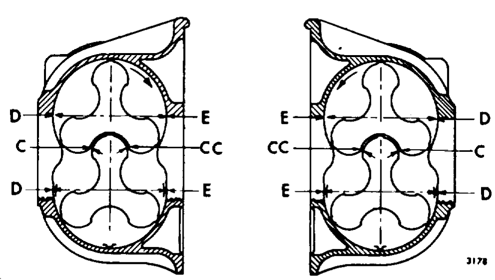
   Former Reduction Blowers--Time the rotors to have .002" to .006" clearance between the TRAILING edge of the LOWER rotor and the LEADING edge of the UPPPER rotor ("cc" clearance) measured from both the inlet and outlet sides as shown in Figs. 25 and 27. If possible keep this clearance to the minimum



		A	B	C	CC	D	E
4-71	MIN.	.007	.009	.014	.002	.015	.004
	MAX.				.006		
6-71E & T	MIN.	.007	.014	.014	.002	.015	.004
	MAX.				.006		

TIME ROTORS TO DIMENSIONS ABOVE

NOTE: TIME ROTORS TO DIMENSION ON CHART FOR CLEARANCE BETWEEN TRAILING SIDE OF LOWER ROTOR AND LEADING SIDE OF UPPER ROTOR (CC) FROM BOTH OUTLET AND INLET SIDE OF BLOWER



ALL VIEWS FROM REAR OF ENGINE

Fig. 27. Chart of Minimum Clearances for Former Reduction Blowers

(.002"). Then check the clearance between the LEADING edge of the LOWER and the TRAILING edge of the UPPER rotors ("c" clearance) for the minimum clearance shown in Fig. 27. Rotor-to-rotor measurements should be taken one inch from the governor end, at the center, and one inch from the drive end.

2. After determining the amount one rotor must be revolved to obtain the proper clearance, add shims back of the proper gear as shown in Fig. 28 to produce the desired result. When more or less shims are required, both gears must be removed from the rotors. Placing a .003" shim in back of a rotor gear will revolve the rotor .001".

3. Install the required thickness of shims back of the proper gear and next to the bearing inner race and reinstall both gears. Recheck the clearances between the rotor lobes.

4. Determine the minimum clearances at points "A" and "B" shown in Figs. 26 and 27. Insert the feeler gages, as shown in Fig. 29, between the end plates and the ends of the rotors. This operation must be performed at the ends of each lobe, making twelve measurements in all. See Figs. 26 and 27 for the minimum clearances.

5. Check the clearance between each rotor lobe and the blower housing at both the inlet and outlet side - twelve measurements in all. See Figs. 26 and 27 for the minimum clearances.

After the blower rotors are timed, complete the assembly of the blower as outlined below.

1. On the former reduction blowers, install the rotor drive and driven gears on the rotor shafts as follows:

   a. Place the blower housing and rotor assembly, air inlet side of housing facing up, on the bench with the timing gear end of the blower facing the outside of the bench.

   b. Start the left-hand helix driven gear on the shaft of the left-hand helix rotor with the omitted serrations in the gear and the shaft in alignment. Then, tap the gear on the shaft and against the timing gear with a plastic hammer, or install the gear with the gear installers J 6270-6, 7 and 8.

   c. If removed, install the drive gear bearing in the right-hand helix drive gear with the number on the race of the bearing facing the outside face of the gear.

   d. Lubricate the bearing in the drive gear with engine oil, then place the drive gear on the rotor shaft with the numbered side of the bearing facing out.

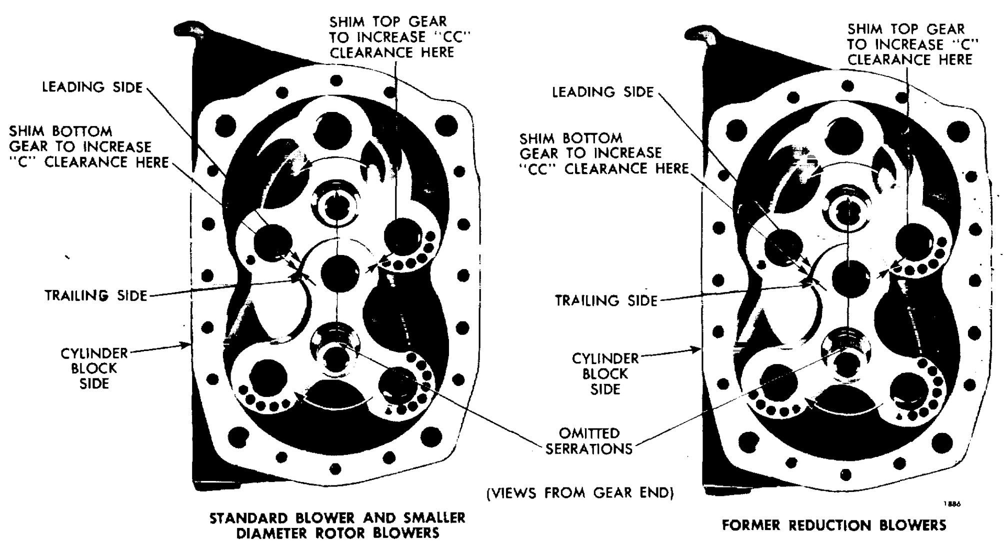


Fig. 28. Diagram Showing Proper Location of Shims for Correct Rotor Lobe Clearances

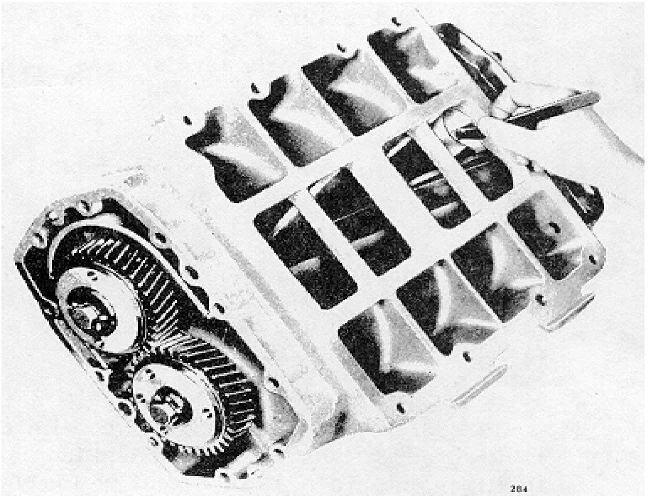


Fig. 29. Measuring End Clearance Between Blower Rotors and Housing

e. Place the lock washer and the bearing retainer (117) on the 7/16-20 x 1-1/4" drive-gear retaining bolt (143). Thread the bolt into the right-hand helix rotor shaft and guide the lugs on the rear face of the retainer in the slot in the end of the rotor shaft, then bend one of the tangs on the lock washer over into slot in the retainer. Tighten the bolt to 55-65 lb-ft torque.

f. Place the lock washer (147) and the fuel pump drive coupling disc (18) on the 1/2" 20 x 1-1/4" driven gear retaining bolt (146). Thread the bolt into the left-hand helix rotor shaft, and guide the lugs on the disc in the slots in the gear hub, then bend one of the tangs on the lock washer over into the slot in the disc. Tighten the bolt to 55-65 lb-ft torque.

g. Bend one of the tangs of each lock washer over against the head of each gear retaining bolt.

2. Refer to Figs. 11 and 12 and attach the blower rotor drive hub (20) and drive hub plates (115) to the blower gears as follows:

a. If removed, attach rotor drive hub plates (115) to the drive hub (20) with three bolts (22), lock washers and plain washers. Tighten the bolts to 25-30 lb-ft torque.

b. Attach the rotor drive hub and drive plates to the right-hand helix rotor timing gear with three bolts (21), lock washers, plain washers and three spacers (116) on the standard blower and smaller diameter rotor blower, or drive gear (140) on the former reduction blowers, along with three spacers (116) and bearing retainer (117) between the plates and the face of the gear. Tighten bolts to 25-30 lb-ft torque.

c. Check runout of splines in the rotor drive hub with an indicator. Spline runout must not exceed .020" total indicator reading.

3. Affix a new gasket (32) to the blower rear end plate cover (29).

NOTE: The former blower end plate cover is not interchangeable with the current blower end plate cover.

4. Position the end plate cover over the end plate dowel pins, then push the cover against the end plate. Install the ten bolts and lock washers. Tighten the bolts to 13-17 lb-ft torque.

Attach Accessories to Blower

Refer to Fig. 1 and attach the fuel pump, water pump, blower drive shaft cover and governor weight housing assembly to the blower as follows:

1. Attach fuel pump to the blower as outlined under "Attach Fuel Pump to Blower" in Section 2.2.

2. Attach the water pump to the blower as outlined under "Install Fresh Water Pump" in Section 5.1. To convert the former water pump drive coupling to the current coupling refer to Section 3.0.

3. Attach the governor weight housing assembly to the blower as outlined under "Install Governor" in Section 2.7.1 for limiting speed governor, and Section 2.7.2 for the variable speed governor.

4. On the current blower, attach the blower drive shaft cover (33) to the blower rear end plate cover (29) with cover seal (37) and seal clamp (114) as shown in Fig. 1.

5. On a former blower, affix a new gasket to the bolting flange of the blower drive shaft cover (33) and attach it to the blower rear end plate cover with six bolts and seal washers, finger tight only.

Attach Blower to Engine

Refer to Figs. 3 and 4 and attach the blower assembly to the engine as follows:

Before attaching the blower assembly to the engine, check the inside of the blower for any foreign material and revolve the rotors by hand to be sure they turn freely.

1. Affix a new blower to block gasket to the cylinder block with Scotch Grip Rubber Adhesive No. 4300 or equivalent to prevent the gasket from shifting when placing the blower against the block.

2. Place a new drive shaft cover seal (37) and seal clamp (114) over the end of the drive shaft cover (33).

3. Place the water pump outlet packing flange, flat face toward pump body, and slide a new packing ring over the pump outlet. Then, place a new water pump cover seal and clamp on top of the oil cooler housing outlet opening.

4. Place the blower assembly into position against the cylinder block, being careful not to dislodge the blower gasket.

5. Install the eight blower to cylinder block bolts and plain washers, and tighten the bolts to 55-60 lb-ft torque (cast iron block).

6. Slide the blower drive shaft cover seal (37) into position against the blower drive gear hub support and tighten the seal clamp.

7. On a former blower, tighten the bolts securing the blower drive shaft cover (33) to the blower rear end plate cover.

8. Install the blower drive shaft (38) by pushing the plain end, without squared hole, of the shaft through the blower drive coupling from the rear of the engine, then into the blower drive gear hub. If necessary, rotate the blower rotors slightly to align the splines of the drive shaft with those in the gear hub (20). Then, install the lock ring in the blower drive cam.

9. Install the flywheel housing small hole cover.

10. Connect the water pump outlet packing flange to the cylinder block. Also, tighten the seal clamp connecting the water pump cover to the oil cooler housing.

11. Place the blower air inlet housing, together with the striker plate gasket, striker plate (if used) and screen and gasket assembly against the blower (with the screen side of the gasket assembly toward the blower). Then secure in place with bolts and lock washers. Tighten the bolts to 16-20 lb-ft torque.

12. If the engine is equipped with an automatic shutdown solenoid, install the solenoid and connect the wires to the solenoid.

13. If the engine is equipped with a manual shutdown assembly, connect the control wire to the air shutdown valve shaft lever and attach the control wire clip under the head of the air inlet housing attaching bolt.

14. Install the governor control housing assembly as outlined under "Install Governor" in Section 2.7.1 for the limiting speed governor.

15. Install the air cleaners (non-turbocharged engines).

16. Connect the fuel lines to the fuel pump.

18. Fill the cooling system with clean fresh water plus rust inhibitor (or sufficient quantity of high boiling point antifreeze) and check the system for leaks.

SHOP NOTES - TROUBLE SHOOTING -

SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

INSTALLING WATER PUMP DRIVE AND ROTOR SHAFT KIT

The current design water pump intermediate drive coupling is designed to minimize wear, thereby increasing service life.

To convert the former drive coupling to the current coupling, a "Water Pump Drive and Rotor Shaft Kit" must be used.

> **NOTE:** Before the kit can be installed, refer to Section 3.4 and remove and disassemble the blower.

Remove Rotor Stub Shaft

Refer to Fig. 1 for identification and location of the parts.

1. Use a sharp screwdriver or similar tool to punch a hole in the center of the core plug, opposite the visible drilled hole in the rotor, and pry out plug.
2. Drive the groove pin down through the shaft with a punch until it reaches the position shown by the dotted line.
3. Bend the groove pin with the punch until it is almost "L" shaped as shown by the solid line. This operation is necessary because the length of the pin is greater than the corresponding width of the rotor cavity.
4. Drive the groove pin in until it drops into the rotor cavity.

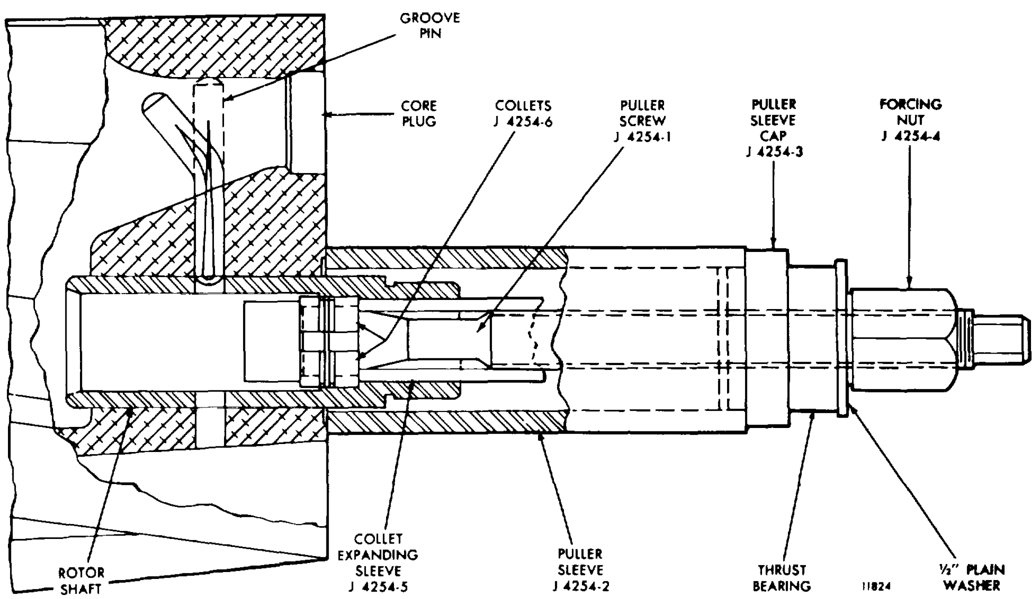


Fig. 1. Removing Rotor Stub Shaft

5. Remove the plug from the inside of the rotor shaft by driving it out of the shaft and into the rotor body.

6. Clamp the rotor firmly in a vise with soft wood blocks between the rotor and the vise jaws.

7. Insert the puller screw (J 4254-1) with the collets (J 4254-6) in the retracted position into the rotor shaft until the collets are beyond the shoulder on the internal surface of the shaft.

8. Push the collets on to the larger diameter of the puller screw as shown. Remove the collet expanding sleeve (J 4254-5).

9. Coat the threads of the puller screw with an extreme pressure lubricant.

10. Pull the puller screw outward by hand until the collets seat against the internal shoulder of the rotor shaft and maintain tension on the puller screw.

11. While holding the puller screw in this position, place the following tool components, in the order named, over the puller screw: puller sleeve (J 4254-2), puller sleeve cap (J 4254-3), thrust bearing, 1/2" plain washer and forcing nut (J 4254-4).

12. Tighten the forcing nut until it is finger tight.

13. Thread the forcing nut on the puller screw to remove the shaft from the rotor.

14. Remove the rotor from the vise and shake the rotor shaft plug and groove pin from the rotor cavity.

Install Service Rotor Front Stub Shaft

1. Coat the new blower rotor front shaft with lubriplate, or equivalent.

2. Use a suitable press arrangement, align the rotor shaft with its hole in the rotor and press the shaft into the rotor to the height of the spacer (J 4254-8).

3. Drill and ream a new .250" diameter, 2-1/2"' deep pin hole in the rotor 120° from the existing pin hole.

4. Drive the new groove pin into the new hole. The end of the pin must be 1/16" below the rotor surface.

5. Install a new core plug.

6. Stake the pin and the core plug after installation and remove all raised burrs.

After the modified lower blower rotor assembly has been used in the re-assembly of the blower up to the point where the water pump intermediate drive coupling is to be installed, install the new water pump intermediate drive coupling in accordance with the following procedure.

Attach Water Pump Intermediate Drive Coupling to Blower Rotor

1. Install the splined end of the water pump intermediate drive coupling into the lower blower rotor front stub shaft.

2. Insert the 5/16" bolt through the water pump coupling and thread it into the rotor shaft and plug assembly.

3. Tighten the bolt to 15-19 lb-ft (20-26 N•m) torque.

TROUBLE SHOOTING

CONDITION	PROBABLE CAUSE	SUGGESTED REMEDY
NOISY OPERATION OR VIBRATION	WHEEL SHAFT BEARINGS ARE NOT BEING LUBRICATED	Supply required oil pressure. Clean or replace oil line.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.
ENGINE WILL NOT DELIVER RATED POWER	CLOGGED AIR INTAKE SYSTEM	Check air cleaner and clean air intake ducts.
	EXCESSIVE DIRT BUILD-UP IN COMPRESSOR	Thoroughly clean compressor assembly. Clean air cleaner and check for leaks.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.

SPECIFICATIONS

Specifications, clearances and wear limits are listed below. It should be specifically noted that the clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" in this chart lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still ensure satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgement of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the text.

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

These limits also apply to oversize and undersize parts.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Blower (71)			
Backlash (timing gears)	.0005"	.0025"	.0040"
Backlash (reduction gears)	.0020"	.0060"	.0080"
Oil seal or seal collar (below end plate surface)	.0020"	.0080"	
Dowel pin (projection beyond inside face of end plates)	.3800"		

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	TORQUE (lb-ft)	TORQUE N•m	THREAD SIZE	TORQUE (lb-ft)	TORQUE N•m
1/4 -20	7-9	10-12	9/16-12	90-100	122-136
1/4 -28	8-10	11-14	9/16-18	107-117	146-159
5/16-18	13-17	18-23	5/8 -11	137-147	186-200
5/16-24	15-19	20-26	5/8 -18	168-178	228-242
3/8 -16	30-35	41-47	3/4 -10	240-250	325-339
3/8 -24	35-39	47-53	3/4 -16	290-300	393-407
7/16-14	46-50	62-68	7/8 - 9	410-420	556-569
7/16-20	57-61	77-83	7/8 -14	475-485	644-657
1/2 -13	71-75	96-102	1 - 8	580-590	786-800
1/2 -20	83-93	113-126	1 -14	685-695	928-942

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE (lb-ft)
Blower lower front bearing retaining bolt (Allen head)	5/16-24	18
Blower drive plate-to-drive hub bolt	5/16-24	25-30
Blower drive hub-to-blower rotor gear bolt	5/16-24	25-30
Air inlet housing-to-blower housing bolt	3/8 -16	16-20
Blower housing-to-cylinder block bolt (C.I. block)	7/16-14	55-60
Blower rotor timing gear bolt	7/16-20	55-65
Blower rotor timing gear bolt	1/2 -20	55-65
Fuel pump drive disc bolt	1/2 -20	55-65

SERVICE TOOLS

TOOL NAME	TOOL NO.
Blower	
Blower clearance feeler set	J 1698-02
Snap ring pliers (external type)	J 4880
Blower service tool set	J 6270-02
Slide hammer set	J 6471-02

SECTION 4

LUBRICATION SYSTEM

CONTENTS

LUBRICATION SYSTEM

Figure 1 schematically illustrates the flow of oil through a typical Series 71 lubricating system including the various components such as the oil pump, oil cooler, by-pass and full-flow filters, the pressure regulator valve and by-pass valve.

The lubricating oil is circulated by a gear-type pressure pump mounted on the No. 1 and No. 2 main bearing caps and gear driven from the crankshaft.

All the oil leaving the pump is forced through the full-flow oil filter to the cooler and then into the oil gallery in the cylinder block from where it is distributed to the various engine bearings. The drain from the cylinder head and other engine parts leads back to the oil pan.

A spring-loaded integral plunger-type relief valve, located in the oil pump body, by-passes excess oil from the discharge to the intake side of the pump when the pressure in the engine oil gallery exceeds approximately 105 psi (724 kPa).

If the oil cooler should become clogged, the oil will flow from the pump through a spring-loaded by-pass valve directly into the oil gallery.

Clean engine oil is assured at all times by the use of a replaceable element type full-flow oil filter incorporated in the engine lubrication system. With this type filter, which is installed in the lubricating system between the pump and the cooler, all of the oil is filtered before entering the engine.

A by-pass type filter with replaceable element is available as optional equipment. A portion of the oil is continually by-passed through the filter and the filtered oil is returned to the engine oil pan.

Stabilized oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by means of a regulator valve located between the pump outlet and the inlet to the cylinder block. When the oil pressure at the valve exceeds 50 psi (345 kPa), the regulator valve opens and remains open until the pressure is less than the opening pressure.

Oil Distribution

Oil from the cooler is conducted by a vertical passage to a longitudinal main oil gallery on the blower side of the cylinder block. As shown in Fig. 1, this gallery distributes the oil, under pressure, to the main bearings and to a horizontal, transverse passage at each end of the cylinder block. From each of these two horizontal passages, oil flows through two vertical bores (one at each end of the cylinder block) to the end bearings of the camshaft and balance shaft. In addition, oil is forced

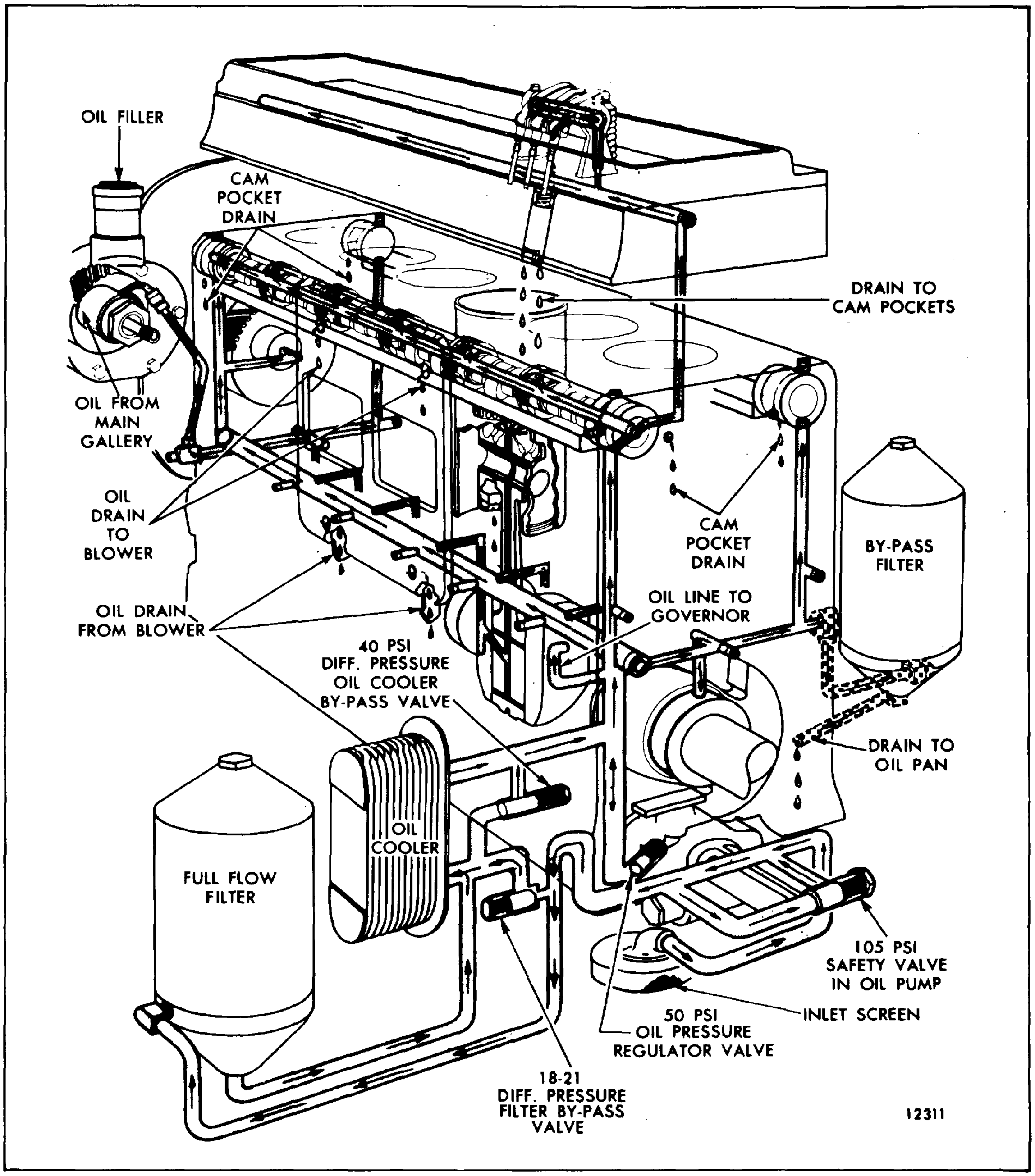


Fig. 1. Schematic Diagram of Typical Lubrication System

through an oil passage in the camshaft which lubricates the camshaft intermediate bearings. Oil for lubricating the connecting rod bearings, piston pins and for cooling the piston head is provided through the drilled crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of oil from the camshaft pocket through a communicating passage into the flywheel housing. Some oil spills into the flywheel

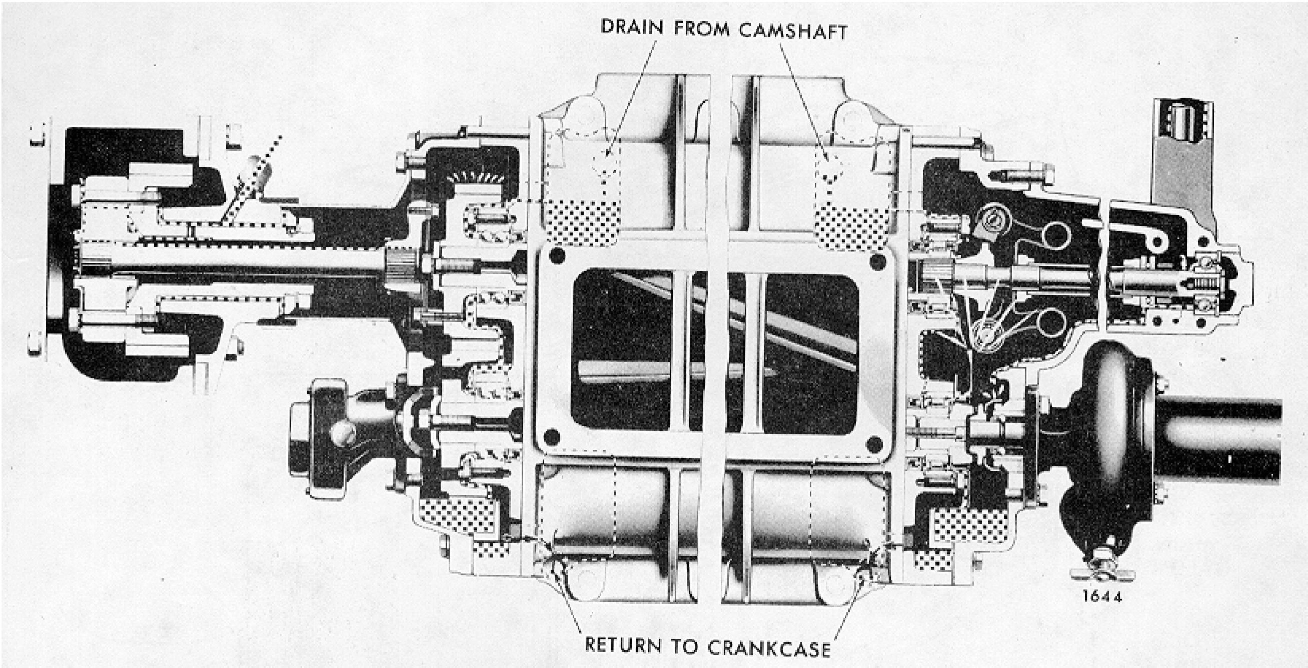


Fig. 2. Blower Lubrication

housing from the bearings of the camshaft, balance shaft and idler gear.

The blower drive gear bearing is lubricated through an external pipe from the rear horizontal oil passage of the cylinder block.

A longitudinal oil gallery on the camshaft side of the cylinder head is supplied with oil from one of the vertical bores located at each end of the cylinder block. Oil from this gallery enters the drilled rocker arm shafts through the rocker shaft brackets at the lower ends of the drilled bolts and lubricates the rocker arm bearings and push rod clevis bearings.

Excess oil from the rocker arms lubricates the ends of the valve push rods, injector push rods and the cam followers, and then drains to cam pockets in the top of cylinder block from which the cams are lubricated. When these pockets are filled, the oil overflows through two holes, one at each end of the blower housing, as shown in Figs. 1 and 2, and thus provides lubrication for the blower drive gears at the rear end and for the governor mechanism at the front end. A dam in the blower rear end plate cover maintains an oil level in which the teeth of the lower blower rotor timing gear run. A slinger at the forward end of lower rotor throws oil from the dam onto the governor weight assembly. Surplus oil overflows the dam in the end plate covers and passes through drilled holes in the cylinder block to the oil pan.

Lubrication System Maintenance

Use the proper viscosity grade and type of *heavy duty* oil as outlined in the *Lubricating Oil Specifications* in Section 13.3. Change the oil and replace the oil filter elements at the periods recommended by the oil supplier (based on his analysis of the drained engine oil) to ensure trouble-free lubrication and longer engine life.

The oil level should never be allowed to drop below the *low* mark on the dipstick. Overfilling the crankcase may contribute to abnormal oil consumption, high oil temperature, and also result in oil leaking past the crankshaft rear oil seal.

To obtain the true oil level, the engine should be stopped and sufficient time (approximately twenty minutes) allowed for the oil to drain back from the various parts of the engine. If more oil is required, add only enough to bring the level to the *full* mark on the dipstick.

Cleaning Lubrication System

Thorough flushing of the lubrication system is required at times. Should the engine lubrication system become contaminated by ethylene glycol antifreeze solution or other soluble material, refer to Section 5 for the recommended cleaning procedure.

OIL PUMP

The gear type oil pump shown in Figs. 1 and 2 is mounted on the first and second main bearing caps and is gear driven from the front end of the crankshaft.

The oil pump helical gears rotate inside a housing (Fig. 1). The drive gear (23) is keyed to the drive shaft which is supported inside the housing on two bushings with a drive-driven gear keyed to the outer end of the shaft. The driven gear (24) is supported on the driven gear shaft which is pressed into the pump body.

An integral plunger-type relief valve (4) by-passes excess oil to the inlet side of the pump when the pressure in the oil lines exceeds 105 pounds per square inch.

An inlet pipe (19), attached to the inlet opening in the pump body, leads to the inlet screen (2) which is mounted with brackets to a main bearing cap.

The inlet screen is located below the oil in the pan and serves to strain out any foreign material which might damage the pump.

The oil pump inlet screen should be removed and cleaned periodically in addition to the cleaning it receives each time the engine is reconditioned.

When required certain engines are equipped with a duel type pump which incorporates a scavenging

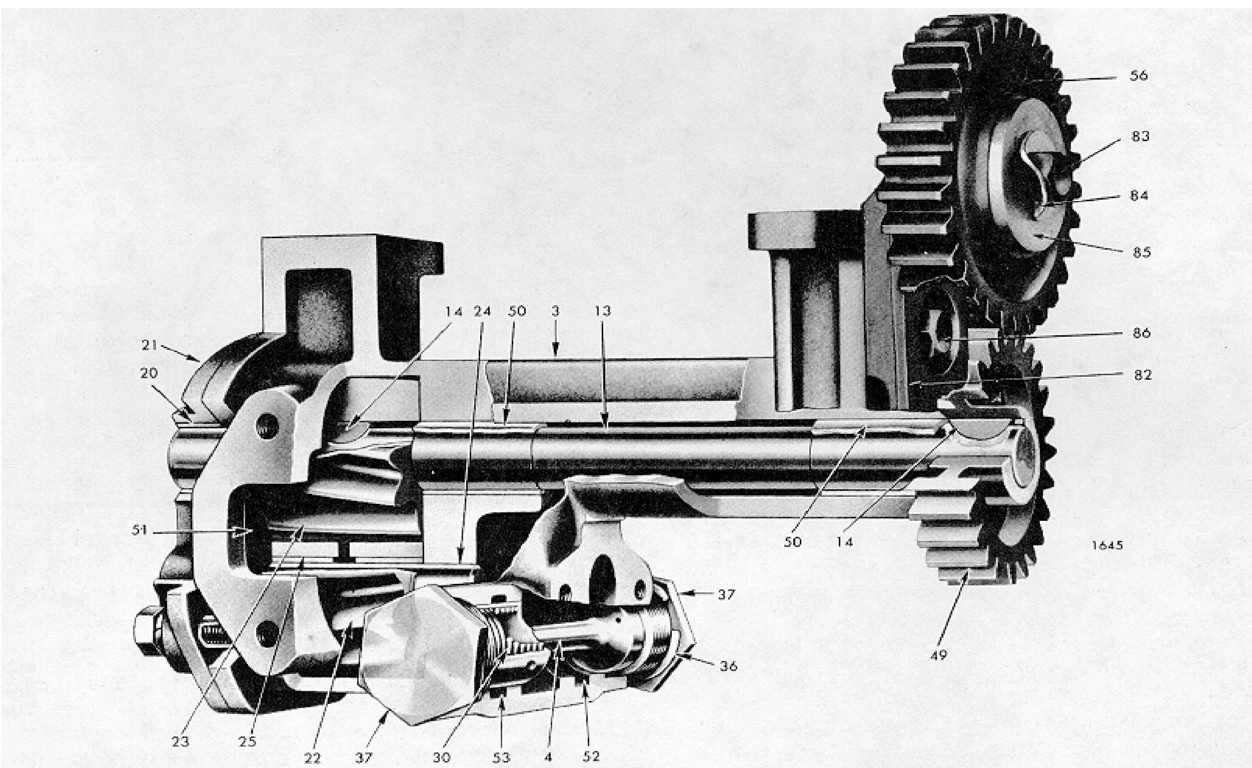


Fig. 1. Oil Pump Assembly

3. Body--Oil Pump
4. Valve--Oil Pressure Relief
13. Shaft--Drive
14. Woodruff Key
20. Bushing--Drive Shaft (Short)
21. Cover--Pump
22. Gear--Driven
23. Gear--Drive
24. Shaft--Driven Gear
25. Bushing
30. Spring--Relief Valve
36. Copper Gasket
37. Plug--Relief Valve
49. Gear--Drive-Driven
50. Bushing--Drive Shaft (Long)
51. Gear Cavity (Intake Side)
52. Oil Passage (Gear Cavity to Pump Outlet)
53. Oil Passage (By-pass to Intake Side of Gear Cavity)
56. Gear--Idler
82. Support--Idler Gear
83. Bolt--Idler Gear-to-Support
84. Lock Washer
85. Thrust Washer--Idler Gear-to-Support Bolt
86. Bolt--Support-to-Pump

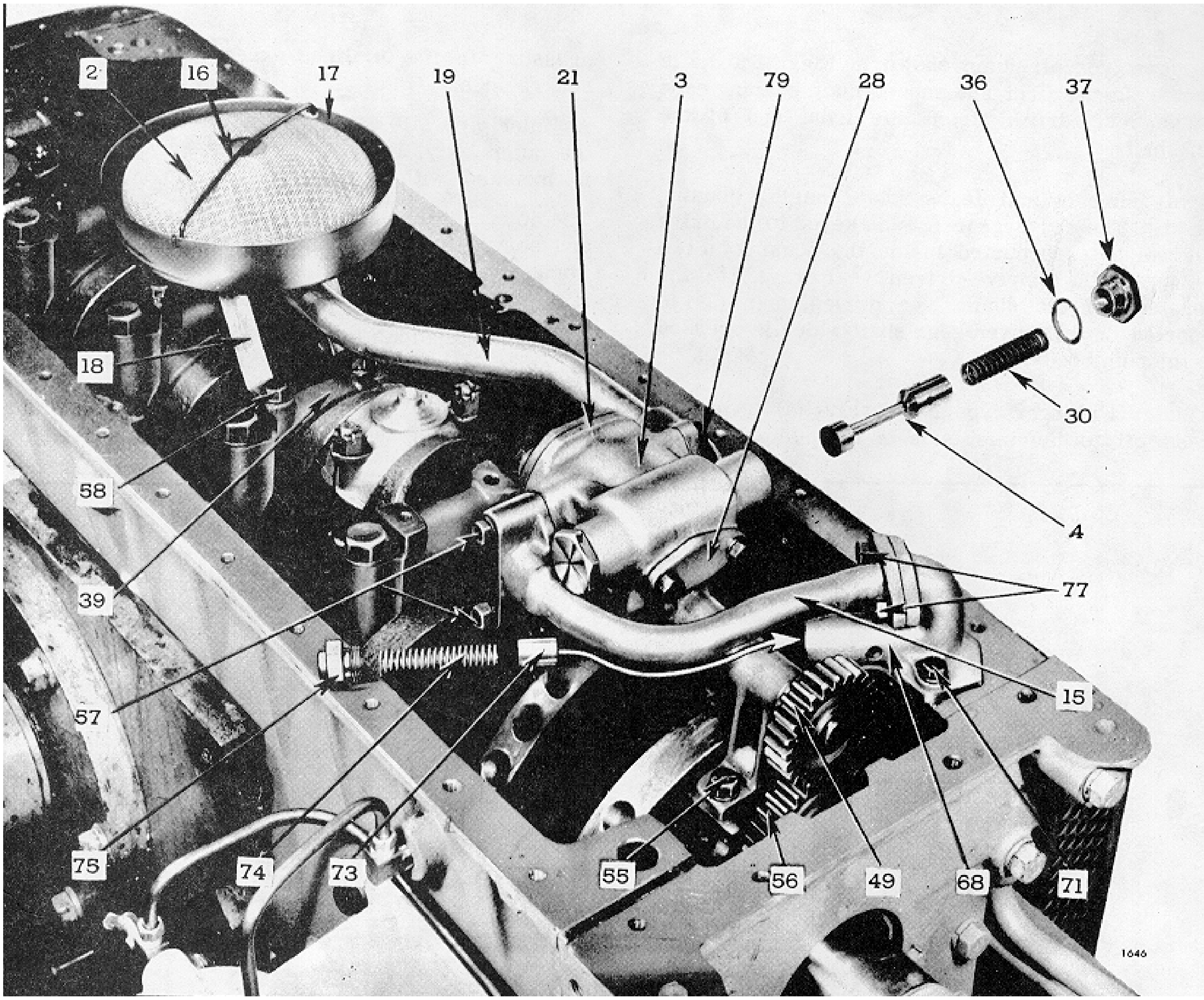


Fig. 2. Typical Oil Pump Mounting

2. Screen--Oil Pump Intake
3. Body--Oil Pump
4. Valve--Oil Pressure Relief
15. Pipe--Pump Outlet
16. Retainer--Screen
17. Cover--Screen
18. Bracket--Screen
19. Pipe--Pump Inlet
21. Cover--Pump
28. Cover--Pump Inlet Pad
30. Spring--Relief Valve
36. Gasket—Copper
37. Plug--Relief Valve
39. Cap—Main Bearing
49. Gear--Drive-Driven
55. Bolt--Pump to Bearing Cap
56. Gear--Idler
57. Bolt--Outlet Pipe to Pump
58. Bolt--Screen Bracket to Bearing Cap
68. Oil Pressure Regulator Assy.
71. Bolt--Regulator to Cylinder Block
73. Valve--Regulator
74. Spring--Regulator
75. Plug--Regulator
77. Bolt--Outlet Pipe to Regulator
79. Bolt--Inlet Pipe to Pump

pump. The scavenging pump consists of a spacer, two gears, and a pump body (see inset in Fig. 3). Oil which normally flows to the front of the engine during inclined operation of the engine is transferred to the rear of the pan by the scavenging pump and is then picked up by the oil pump for distribution throughout the engine.

An idler gear (56) is mounted on a support bracket which is attached to the pump body (Fig. 1).

Pressure lubrication of the idler gear bushing is provided by means of a drilled passage in the pump body and a connecting passage in the idler gear support bracket.

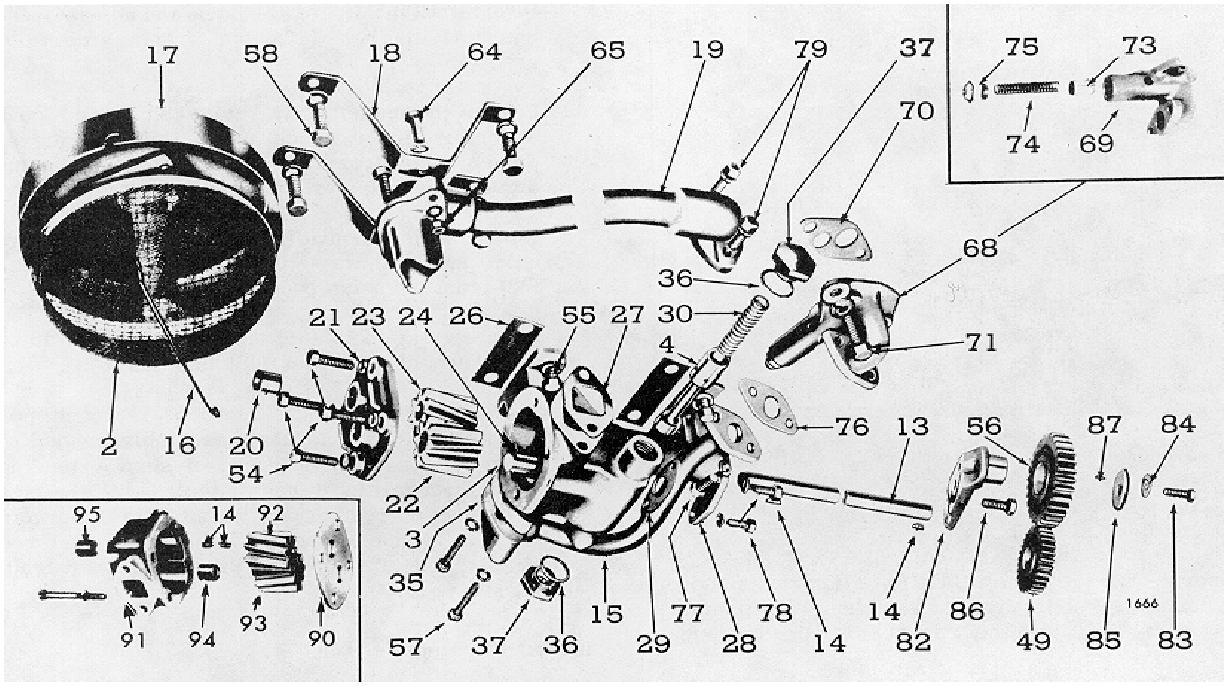


Fig. 3. Oil Pump Details and Relative Location of Parts

2. Screen—Pump
3. Body--Oil Pump
4. Valve--Oil Pressure Relief
13. Shaft--Drive
14. Woodruff Key
15. Pipe--Pump Outlet
16. Retainer--Screen
17. Cover--Screen
18. Bracket--Screen
19. Pipe--Pump Inlet
20. Bushing--Drive Shaft (Short)
21. Cover--Pump
22. Gear--Driven
23. Gear--Drive
24. Shaft--Driven Gear
26. Shim
27. Gasket--Inlet Pipe to Pump
28. Cover--Pump Inlet Pad
29. Gasket--Pad Cover
30. Spring--Relief Valve
35. Gasket--Outlet Pipe to Pump
36. Gasket--Copper
37. Plug--Relief Valve
49. Gear--Drive-Driven
54. Bolt--Pump Cover
55. Bolt--Pump to Bearing Cap
56. Gear--Idler
57. Bolt--Outlet Pipe to Pump
58. Bolt--Screen Bracket to Bearing Cap
64. Bolt--Inlet Pipe and Cover to Bracket
65. Nut
68. Regulator Assy.--Oil Pressure
69. Regulator Body
70. Gasket--Regulator to Cylinder Block
71. Bolt--Regulator to Cylinder Block
73. Valve--Regulator
74. Spring--Regulator
75. Plug—Regulator
76. Gasket--Outlet Pipe to Pressure Regulator
77. Bolt--Outlet Pipe to Pressure Regulator
78. Bolt--Inlet Pad Cover
79. Bolt--Inlet Pipe to Pump
82. Support--Idler Gear
83. Bolt--Idler Gear to Support
84. Lock Washer--Idler Gear-to-Support Bolt
85. Washer--Idler Gear-to-Support Bolt
86. Bolt--Idler Gear Support-to-Pump
87. Locating Pin--Idler Gear Washer
88. Dowel--Idler Gear Support
90. Spacer--Pump Body
91. Body--Scavenging Pump
92. Gear--Scavenging Drive
93. Gear--Scavenging Driven
94. Bushing--Scavenging Driven Gear
95. Bushing--Scavenging Pump Body
96. Bolt--Scavenging Pump Body

Remove Oil Pump

1. Remove the drain plug from the oil pan and drain the oil.

2. Remove the oil pan bolts and remove the oil pan.

3. Remove attaching bolts and lock washers securing the oil pump, regulator body and oil outlet tube and oil inlet tube support (including scavenging pump tube supports if used) from the main bearing caps, and cylinder block (Fig. 2).

NOTE: Remove and save the shims, if used between the oil pump mounting feet and the bearing caps.

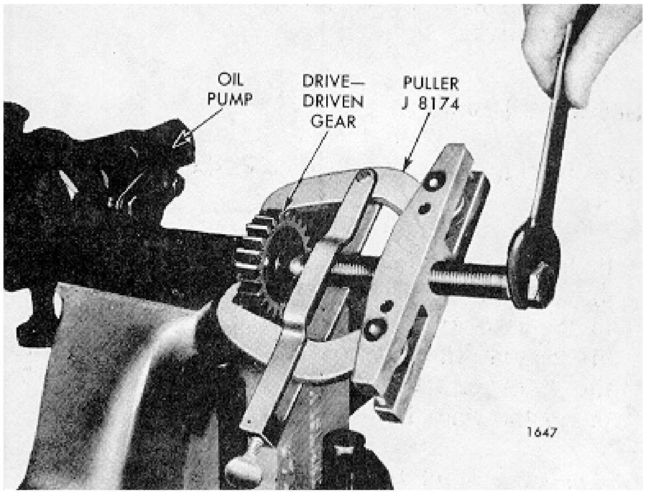


Fig. 4. Removing Oil Pump Drive-Driven Gear from Shaft

Disassemble Oil Pump

Observe carefully the position of all parts including the oil inlet and outlet pipes during disassembly so as to facilitate the reassembly of the pump.

1. Remove the scavenging pump inlet pipe together with the inlet screen, if so equipped, from the scavenging pump body.

2. Remove the scavenging pump outlet pipe, if so equipped.

3. Remove the oil pump inlet pipe (19) with the screen cover and mounting brackets.

4. Remove the oil pressure regulator and the oil pump outlet pipe (15) as an assembly from the pump body (3).

5. Remove the four bolts and lock washers securing the scavenging pump body or the cover to the oil pump body (3).

6. Remove the scavenging pump drive and driven gears from the oil pump drive and driven shafts, if so equipped.

7. Remove the Woodruff keys from the drive shaft and slide the spacer off the end of the shafts, if Step 6 performed.

8. Remove the valve plugs (37) and copper gaskets (36) from each side of pump body, and jar the relief valve parts from the body (Fig. 3).

9. Remove the pump driven gear (22) from the driven gear shaft (24).

10. Straighten the lip of the lock washer (84) and unscrew the bolt (83) thus freeing the idler gear (56).

11. Clamp the pump body, drive shaft and gear assembly in a bench vise. Pull the drive-driven gear from the outer end of the pump drive shaft as shown in Fig. 4.

12. Remove the Woodruff key (14) from the drive shaft and withdraw the shaft and driven gear (22) from the pump body.

13. Unscrew the bolt (86) and remove the idler gear support (82) from the pump body.

14. If the drive gear (23) is to be replaced, position the gear and shaft assembly on bed of arbor press with long end of shaft extending down through slot in bed plate and with the face of the gear resting on the plate as shown in Fig. 5. Place a short 1/2" round steel rod on the end of shaft, and press the shaft from the gear.

Inspect Oil Pump Parts

Wash all parts in clean fuel oil and dry them with compressed air.

Examine the gear cavity in the pump body and the drive shaft bushings. If the gear teeth are scored or worn, install new gears. If the driven gear bushings are worn, replace the bushings. Service replacement bushings in the driven gears must be reamed after assembly. Bushings used with the .499" diameter driven gear shaft must be reamed to .500" $\pm$.0005" and bushings used

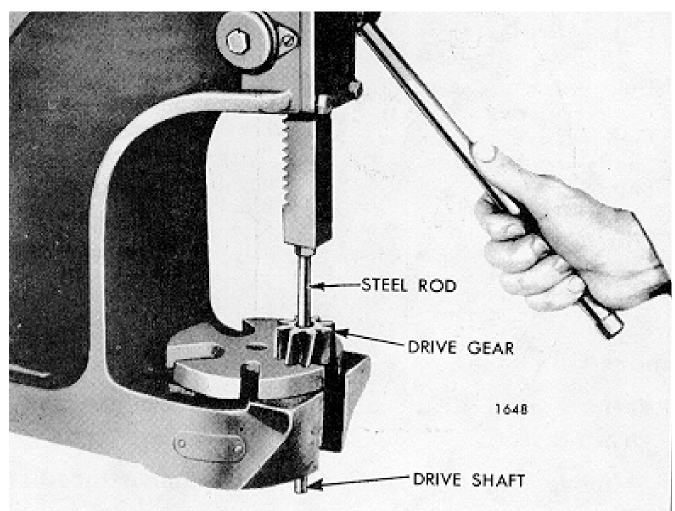


Fig. 5. Removing Oil Pump Drive Gear from Shaft

with the .623" diameter shaft must be reamed to .625" ±.0005".

Inspect the bushings in the pump body and cover or scavenging pump body. If the bushings are worn excessively, replace the pump and cover or scavenging pump body assemblies unless suitable boring equipment is available for finishing the new bushings. When installing new bushings, replace all of the bushings. The bushings must be located and positioned as shown in Fig. 6. Also, the gear bore and the bushing bore in both the pump body and cover or scavenging pump body must be concentric within .001". The shaft-to-pump body-bushing clearance with new parts is .0008" to .0025". The shaft-to-pump cover or scavenging pump body bushing clearance with new parts is .0010" to .0027".

CAUTION: When installing the spacer between the oil pump body and the scavenging pump body, be sure the bleed hole is located on the discharge side of the oil pump assembly. Refer to Fig. 3.

In an efficient oil pump, the gears should have a free-running fit (with no perceptible looseness) in the pump housing. The use of excessively worn gears will result in low engine oil pressure which, in turn, may lead to serious damage throughout the engine.

Inspect the pressure relief valve spring, relief valve and its seat in the pump body. If necessary, install new parts.

Assemble Oil Pump

Refer to Fig. 3, and assemble the oil pump as follows:

1. If the drive gear (23) was removed from the drive shaft (13), insert the Woodruff key (14) in the keyway and apply a light coat of engine oil on the shaft. Start the shaft squarely into the bore of the gear and, as shown in Fig. 5, press the shaft into the gear.

   The gear must be 6-15/16" on 3 and 4 cylinder engines, or 6-15/32" on 6 cylinder engines, from the keyway end of the drive shaft (Fig. 7).

2. Press the dowel (88) into the pump body, if removed.

3. Place the idler gear support (82) in position against the forward end of the pump body (Fig. 3) and secure the support to the body with bolt (86).

4. Install the drive gear and shaft assembly in the pump body and slide the driven gear (22) onto the shaft (24).

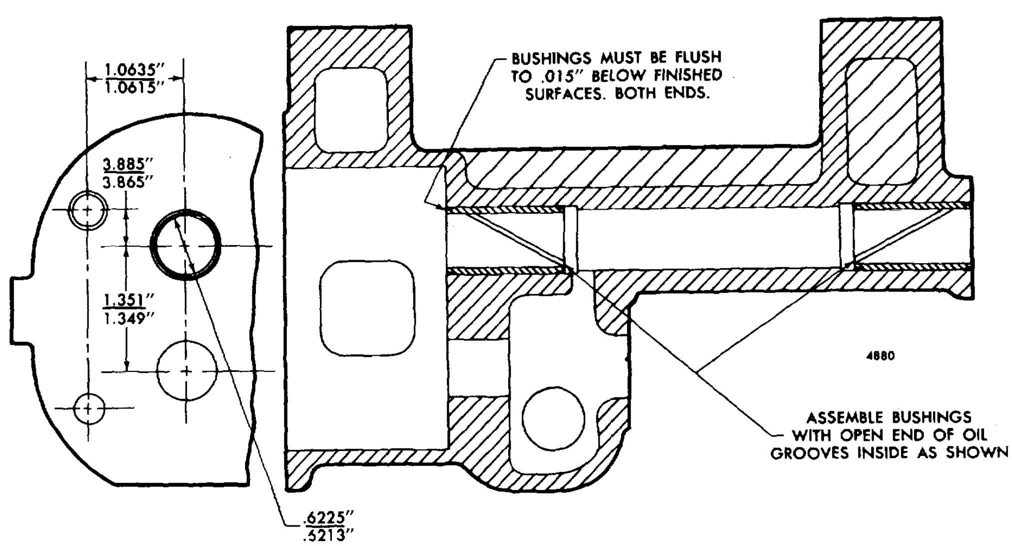


Fig. 6. Diameter and Location of Bushing in Oil Pump

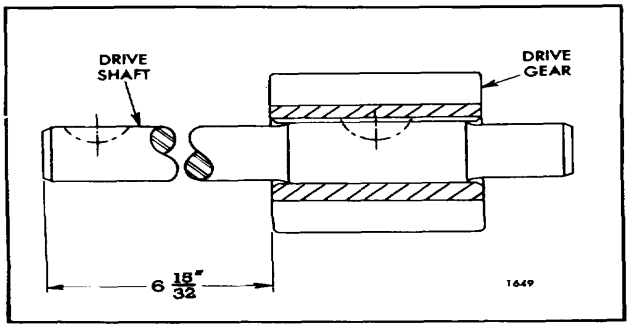


Fig. 7. Oil Pump Drive Shaft and Gear Assembly-Six Cylinder Engine

5. If the engine is equipped with a scavenging pump, install the oil pump spacer (90) over the end of the drive and driven gear shafts flush against the oil pump body.

6. Insert two Woodruff keys in the keyway and slide the drive gear (gear with keyway) (92) against the spacer.

7. Slide the driven gear (93) on the driven shaft against the spacer.

8. Secure the pump cover (21) or scavenging pump body (91) to the oil pump body with four bolts (54) and lock washers.

9. Support the drive gear end of the drive shaft (13) on the bed of an arbor press and insert the Woodruff key (14) in the keyway of the shaft. Position the drive-driven gear (49) on the end of the drive shaft with the extended hub side up away from the pump body. Insert a .005" feeler ribbon between the driven gear and the pump body and press the gear on the shaft until the clearance between the gear and the body is .005".

   NOTE: A suitable sleeve and a brass hammer may be used for positioning the gear if an arbor press is not available.

10. If the locating pin (87) was removed, install it in the idler gear support (82), then lubricate the bearing surface with engine oil and place the gear (56) in position on the support (82) with the flat side of gear facing the support.

11. Place the lock washer (84) on the bolt (83) and the special washer (85) next to the lock washer and start the bolt into the idler gear support. Then rotate the special washer and lock washer so that the slot in each washer engages the locating pin (87).

12. Tighten the idler gear bolt so one hex of the bolt head is over the end of the locating pin (87). Then bend the lock washer against the flat of the bolt head.

13. Screw the relief valve plug (37), with copper gasket (36), into place in the side of the pump body opposite the inlet opening. Then place the valve (4) and spring (30) in the bore at the inlet side of the pump body as shown in Fig. 2, and while compressing the spring, start the second relief valve plug (37), with gasket (36), into the body. Tighten the plugs.

14. If the cover (28) and gasket (29) were removed from the pump body, reinstall and secure them with the two bolts (78) and lock washers.

The oil pump must turn freely after assembly. Any bind in the pump must be removed before it is installed on the engine.

Remove Oil Pump Driving Gear from Crankshaft

With the oil pan and lubricating oil pump removed, the oil pump driving gear may be removed from the crankshaft as follows:

1. Support the front end of engine and remove the crankshaft front cover (Section 1.3.5).

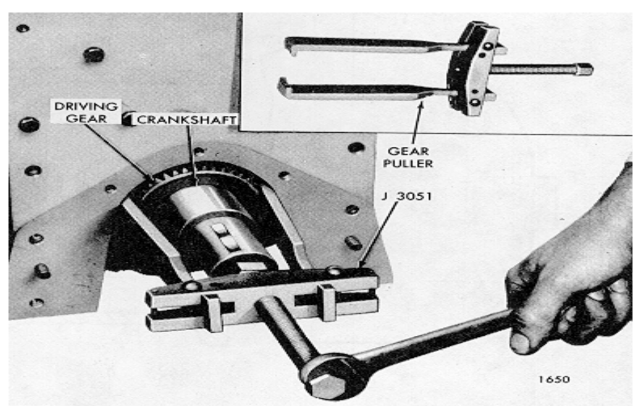


Fig. 8. Removing Oil Pump Driving Gear from Crankshaft

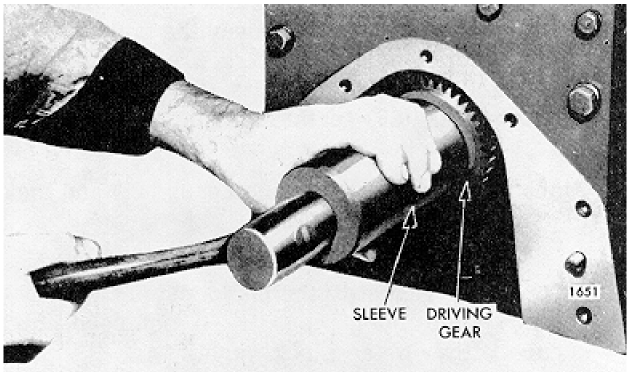


Fig. 9. Installing Oil Pump Driving Gear on Crankshaft

2. Remove the oil slinger.

3. If required use puller J 3051, as illustrated in Fig. 8 to pull the pump driving gear from the front end of the crankshaft as follows:

   a. Screw crankshaft pulley or cap retaining bolt into the end of the crankshaft.

   b. Attach the jaws of the puller behind the gear and locate the point of puller screw in the center of the retaining bolt.

   c. Turn the puller screw clockwise and draw the gear from the crankshaft.

4. Remove the Woodruff key from the crankshaft.

Install Oil Pump Driving Gear on Crankshaft

1. Install the Woodruff key in the crankshaft.

2. Position the gear (80) so the chamfer on the gear hub is toward the main bearing cap and start the gear on the shaft and over the key.

3. Slide the gear on the crankshaft or use a sleeve if required, as illustrated in Fig. 9, and drive the gear tight against the shoulder on the crankshaft.

4. Install the oil slinger with dished side away from the gear as illustrated in Fig. 1 in Section 1.3.6.

5. Install the crankshaft front cover as outlined in Section 1.3.5.

Install Oil Pump

Refer to Fig. 2 and install the oil pump on the main bearing caps as follows:

1. Hold the pump assembly against the main bearing caps so the idler gear (56) meshes with the driving gear on the crankshaft.

2. Insert the four bolts (55) with lock washers through the mounting feet of the pump and into the bearing caps (39). Align the pump so that the teeth of crankshaft gear and the idler gear are parallel; then tighten the bolts to 35-39 lb-ft cast iron cylinder block and check clearance between gear teeth with a feeler gage. Proper clearance between crankshaft gear and idler gear is .005" minimum, .012" maximum (Fig. 10).

   CAUTION: Always check the clearance between the crankshaft gear and the oil pump idler gear with the engine in the upright or running position.

If shims were used between the pump mounting feet and the bearing caps and new gears are <u>not</u> installed, the same shims (cleaned) or the same number of new (identical) shims should be installed and the number then adjusted to obtain the proper clearance between gear teeth. However, if new gears have been installed, a larger number of shims will be required under the mounting feet. In either event, the pump must be tightened on the bearing cap <u>before</u> the clearance between the gear teeth is measured.

NOTE: When adjusting for gear tooth clearance by installing or removing shims, the same number of shims must be changed under each foot so that the pump will always be level on the main bearing caps. The insertion or removal

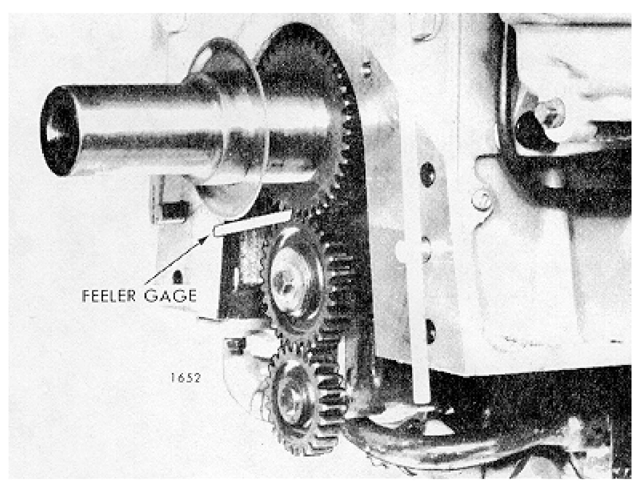


Fig. 10. Measuring the Clearance Between the Teeth of the Oil Pump Driven Gears

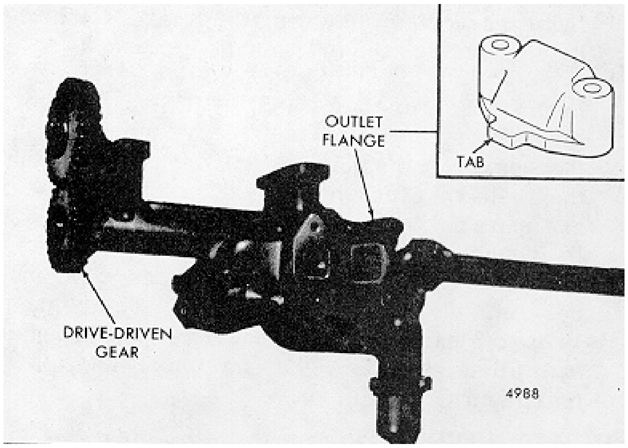


Fig. 11. Position of Scavenging Pump Outlet Flange

of one .005" shim will change the gear tooth clearance by .0035".

3. Place a new gasket (76) between the outlet pipe and the pressure regulator and bolt the two parts together loosely. Use a new gasket (35) and secure the outlet pipe (15) to the oil pump body (3) with the bolts not over 7/8" long. Attach the pressure regulator (68) to the cylinder block using a new gasket (70).

   When attaching the pump outlet and the pressure regulator, none of the bolts should be tightened until all the bolts have been started. After all bolts are started, the outlet pipe bolts (57) should be tightened alternately, then the pressure regulator bolts (71) should be tightened, and finally the pipe-to-regulator bolts (77) should be secured. This procedure prevents twisting the outlet pipe.

4. Attach the pump screen brackets (18) to the main bearing caps with lock washers and the bolts (58). Do not tighten bolts.

5. Affix a new gasket (27) to the pump end of the inlet pipe (19), then attach the pipe to the oil pump.

6. Set the screen cover (17) over the outer end of the oil inlet pipe (19) and secure it to the pipe and brackets (18) with bolts (64). Tighten the bracket bolts (58) to the bearing caps (Fig. 2).

7. Place the screen (2) in the cover (17) and lock in place with retainer (16).

8. Affix a new gasket to the pump end of the scavenging pump inlet pipe, if so equipped, and secure with bolts and lock washers.

   On 3 and 4 cylinder engines equipped with the scavenging pump section the scavenging pump screen is part of the oil inlet tube, however, on 6 cylinder engines a separate screen is used. Install scavenging pump screen, if used.

9. Affix a new gasket to the scavenging pump outlet pipe, then secure the pipe to pump body with lock washers and bolts.

   NOTE: When installing an outlet flange of the type illustrated in Fig. 11, be sure the opening in the flange is toward the front of the pump (toward the drive-driven gear).

10. Re-check all bolts for tightness to assure there will be no leaks in the oil pump and pipe mounting connections.

11. Place a new gasket on the oil pan and install the oil pan on the cylinder block. All the oil pan bolts should be started before any are tightened. Bolts should be tightened snugly but not excessively, starting with the center bolts and working toward each end of the oil pan. Excessive tightening of the bolts will crush the oil pan gasket unnecessarily.

12. Fill the crankcase to the proper level with the oil viscosity recommended in the Lubricating Oil Specifications in Section 13.

LUBRICATING OIL PRESSURE REGULATOR

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by an oil pressure regulator installed between the oil pump outlet pipe and the cylinder block.

The regulator assembly consists of a regulator body, a hollow piston-type valve, a spring and a plug to retain the valve and spring (Fig. 1).

The valve is held on its seat, by the spring, which is compressed by the plug threaded into the valve opening in the regulator body. The entire assembly is bolted to the lower flange of the cylinder block and sealed against oil leaks by a gasket between the two members. When the oil pressure at the valve exceeds 50 psi (345 kPa), the valve is forced from its seat and oil from the engine oil gallery is by-passed to the oil pan.

Under normal conditions, the pressure regulator should require very little attention. If sludge accumulates in the lubrication system, the valve may not work freely, thereby remaining open or failing to open at the normal operating pressure.

Whenever the lubricating oil pump is removed for inspection, the regulator valve and spring should also be removed, thoroughly cleaned in fuel oil and inspected.

Remove Oil Pressure Regulator

1. Remove the two oil pump outlet pipe to regulator attaching bolts and lock washers.

2. Remove the two regulator body-to-cylinder block bolts and lock washers.

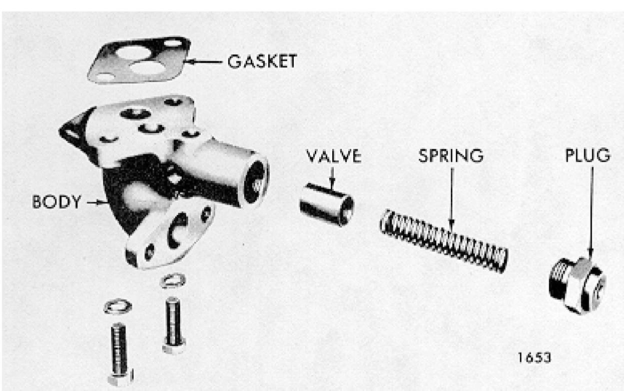


Fig. 1. Lubricating Oil Pressure Regulator Details and Relative Location of Parts

3. Tap the lower end of the regulator body lightly to loosen the body from the gasket and cylinder block. Remove the gasket.

Disassemble Oil Pressure Regulator

1. Clamp the flange of the regulator body in a bench vise with soft jaws and remove the plug from the body.

2. Remove the spring and valve from the regulator body.

Inspection

Clean all of the regulator components in fuel oil and dry them with compressed air. Then inspect the parts for wear or damage.

The regulator valve must move freely in the valve body. If the valve or regulator body is scored and cannot be cleaned up with crocus cloth, they must be replaced.

Replace a fractured or pitted spring.

Assemble Oil Pressure Regulator

Refer to Fig. 1 and assemble the regulator as follows:

1. Apply clean engine oil to the outer surface of the valve and slide it into the regulator body, closed end first.

2. Insert the spring in the valve and, while compressing the spring, start the plug into the regulator body. Tighten the plug.

Install Oil Pressure Regulator

1. Remove all traces of the old gasket from the regulator body, cylinder block and pump outlet pipe flange.

2. Affix a new gasket to the regulator body with the oil passage holes in the gasket in alignment with the oil passages in the body and secure the regulator to the cylinder block with two bolts.

3. Place a new gasket between the regulator and the pump outlet pipe and connect these parts together with two bolts.

LUBRICATING OIL FILTERS

Series 71 engines are equipped with a full-flow type lubricating oil filter. A by-pass type oil filter may be used in addition to the full-flow type filter when additional filtration is desired.

Full-Flow Oil Filter

The full-flow type lubricating oil filter is installed ahead of the oil cooler in the lubrication system. The filter may be remotely mounted or mounted on the engine as shown in Fig. 1.

The filter assembly consists of a replaceable element enclosed within a shell which is mounted on an adapter or base. When the filter shell is in place, the element is restrained from movement by a coil spring.

All of the oil supplied to the engine by the oil pump passes through the filter before reaching the various moving parts of the engine. The oil is forced by pump pressure through a passage in the filter adapter to the space surrounding the filter element. Impurities are filtered out as the oil is forced through the element to a central passage surrounding the center stud and out through another passage in the filter adapter and then to the oil cooler.

A valve, which opens at approximately 18-21 psi, is located in the filter adapter or base and will by-pass the oil directly to the oil cooler should the filter become clogged.

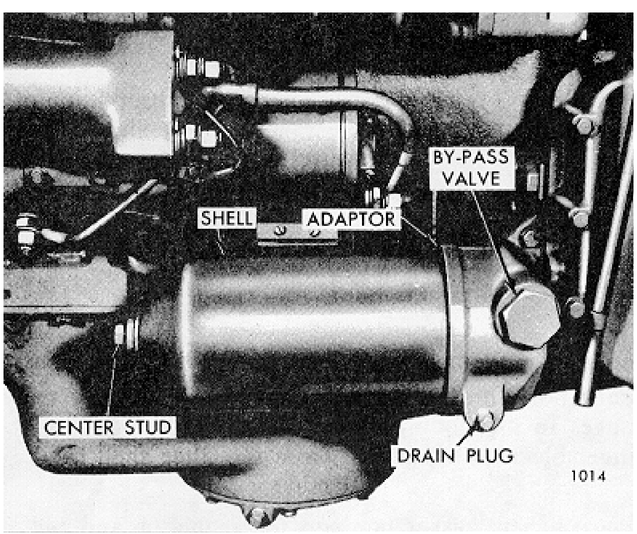


Fig. 1. Typical Full-Flow Oil Filter Mounting

By-Pass Oil Filter

When additional filtration is desired, an oil filter of the by-pass type (Fig. 2) may also be installed on the engine. However, *the size of the orifice on the discharge side of the filter must not exceed .062"* to control the oil flow rate and to provide sufficient oil pressure when the engine is running at idle speed.

When the engine is running, a portion of the lubricating oil is bled off the oil gallery and passed through the by-pass filter. Eventually all of the oil passes through the filter, filtering out fine foreign particles that may be present.

The by-pass filter assembly consists of a replaceable element contained in a shell mounted on a combination base and mounting bracket. When the shell is in place, the filter element is restrained from

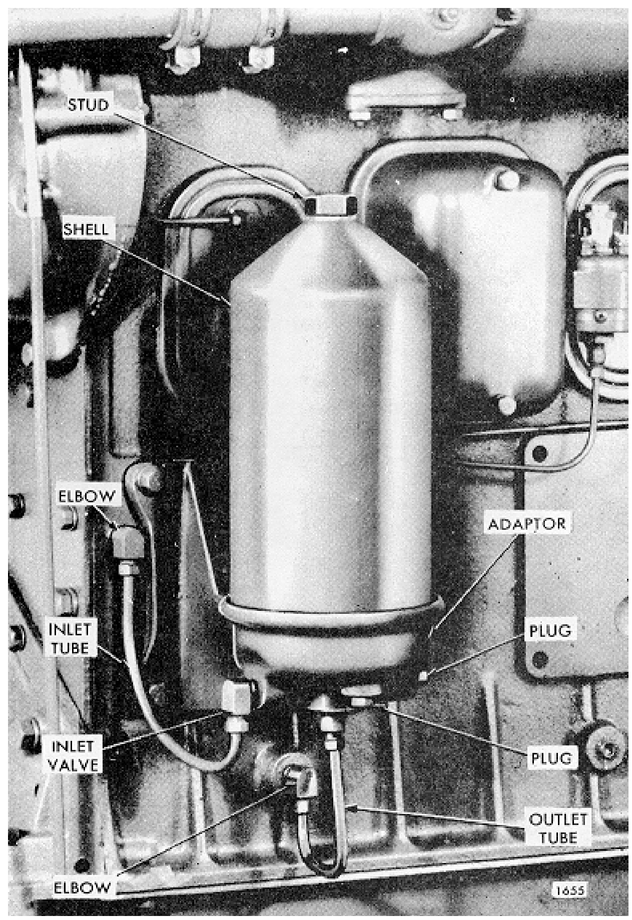


Fig. 2. Typical By-Pass Oil Filter Mounting

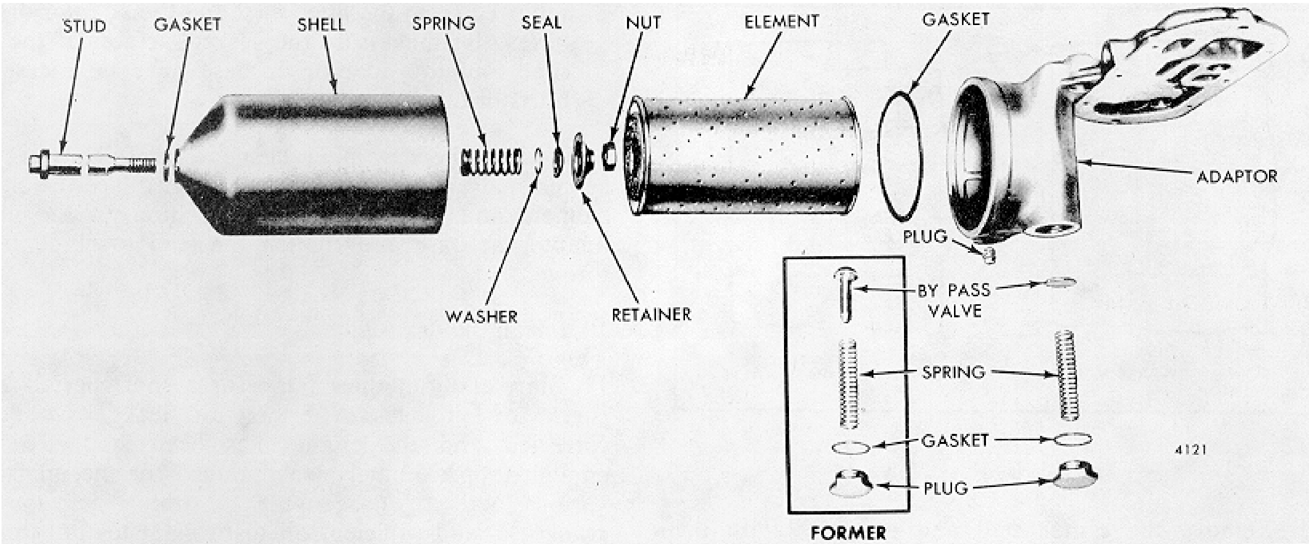


Fig. 3. Full-Flow Oil Filter Details and Relative Location of Parts

movement by a coil spring at the top. A hollow center stud serves as the outlet passage from the filter as well as securing the shell in place.

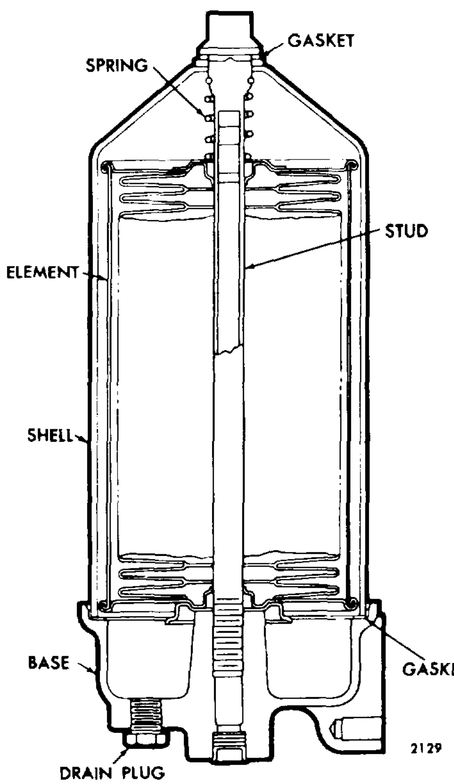


Fig. 4. By-Pass Oil Filter Details

Oil Filter Maintenance

With the use of detergent lubricating oils, the color of the lubricant has lost value as an indicator of oil cleanliness or proper filter action. Due to the ability of the detergent compounds to hold minute carbon particles in suspension, heavy duty oils will always appear dark colored on the oil level dipstick.

Heavy sludge deposits found on the filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. The removal of abrasive dust, metal particles and carbon must be ensured by replacement of the oil filter elements at the time the engine oil is changed.

Selection of a reliable oil supplier, strict observation of his oil change period recommendations and proper filter maintenance will ensure trouble-free lubrication and longer engine life.

Replace Oil Filter Element

Replace the element in either the full-flow or by-pass type oil filter assembly (Figs. 3 and 4) as follows:

1. Remove the drain plug from the filter shell or the filter adapter or base and drain the oil.

2. Back out the center stud and withdraw the shell, element and stud as an assembly. Discard the filter element and the shell gasket.

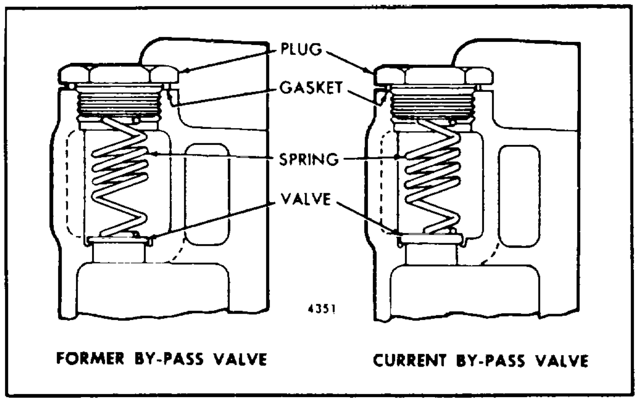


Fig. 5. By-Pass Valve

3. Remove the center stud and gasket. Retain the gasket unless it is damaged and oil leaks occurred.

4. Remove the nut or snap ring on the full-flow filter center stud.

   NOTE: The center stud on the current full-flow oil filter has been revised by removing the snap ring groove and increasing the 5/8"-18 thread length approximately 1/2". To conform with this change, a 5/8"-18 nut replaces the snap ring formerly used to retain the filter spring and seal.

5. Examine the element retainer seal (Fig. 3) for hardening or cracks. If necessary, replace the seal.

6. Clean the filter shell and the adapter or base.

7. Install the center stud gasket and slide the stud (with the spring, washer, seal and retainer installed on the full-flow filter stud) through the filter shell.

8. Install a new shell gasket in the filter adapter or base.

   NOTE: Before installing the filter shell gasket, be sure all of the old gasket material is removed from the filter shell and the adapter or base. Also make sure the gasket surfaces of the shell and the adapter or base have no nicks, burrs or other damage.

9. Position the new filter element carefully over the center stud and within the shell. Then place the shell, element and stud assembly in position on the filter adapter or base and tighten the stud to 50-60 Ib-ft torque.

10. Install the drain plug.

11. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected and the engine has been stopped long enough (approximately ten minutes) for the oil from various parts of the engine to drain back to the crankcase, add sufficient oil to bring it to the proper level on the dipstick.

Remove and Install By-Pass Valve

1. If necessary, remove the filter adapter from the engine.

2. Remove the plug and gasket and withdraw the spring and by-pass valve (Fig. 3).

3. Wash all of the parts in clean fuel oil and dry them with compressed air.

4. Inspect the parts for wear. If necessary, install new parts.

5. Reassemble and install the by-pass valve. Use only the current by-pass valve and spring (Fig. 5) for service. The current thicker valve and stiffer spring increase the by-pass pressure from 13-18 psi to 18-21 psi to permit more efficient filtration.

   NOTE: The current and early design (inset, Fig. 3) by-pass valves are not interchangeable.

6. Use a new gasket and install the filter adapter.

OIL COOLER

In order to perform its functions satisfactorily, the lubricating oil must be kept within the proper temperature limits. If the oil is too cold, it will not flow freely. If the oil is too hot, it cannot support the bearing loads, it cannot carry away enough heat, and it may result in too great an oil flow. As a consequence, oil pressure may drop below acceptable limits and oil consumption may become excessive.

In performing its lubricating and cooling functions, the oil absorbs a considerable amount of heat and this heat must be dissipated by an oil cooler.

The oil cooler is located on the side of the engine just below the water pump (Fig. 1).

To assure proper lubrication, if the oil cooler core becomes clogged, a valve located between the oil inlet and the element, by-passes the oil around the cooler directly to the oil gallery in the cylinder block.

The by-pass valve, spring, plug and gasket are housed in the oil cooler adapter (Fig. 1).

The by-pass valve should be removed, cleaned, and reassembled whenever the cooler element is cleaned or replaced. However, if required, the by-pass valve can be removed without removing oil cooler.

Remove By-Pass Valve

Remove the plug and lift the gasket, valve and spring from the adapter (Fig. 1).

Inspection

Clean the by-pass valve components with fuel oil and dry them with compressed air.

Inspect the valve and spring for wear or damage and replace them if necessary.

Install By-Pass Valve

1. Apply clean engine oil to the outside surface of the by-pass valve and place the valve in the adapter, closed end first.

2. Slide the valve spring into the valve and screw the plug with gasket, into the adapter.

Remove Oil Cooler

1. Drain cooling system by opening the drain cock (Fig. 1) at the bottom of the oil cooler housing.

2. Remove the bolts and lock washers that attach the water inlet connector to the oil cooler housing.

3. Loosen the clamp, breaking the connection between the water pump and oil cooler housing.

4. Remove the bolts attaching the oil cooler housing to the adapter, and remove the housing and element as an assembly. Be careful when withdrawing the assembly not to drop or damage the cooler core.

5. If the adapter is to be removed, remove the bolts that hold the adapter to the cylinder block and remove the adapter and gaskets. Do not lose the copper washer off lowest bolt.

6. Remove all traces of gasket material from the cylinder block and the oil cooler components.

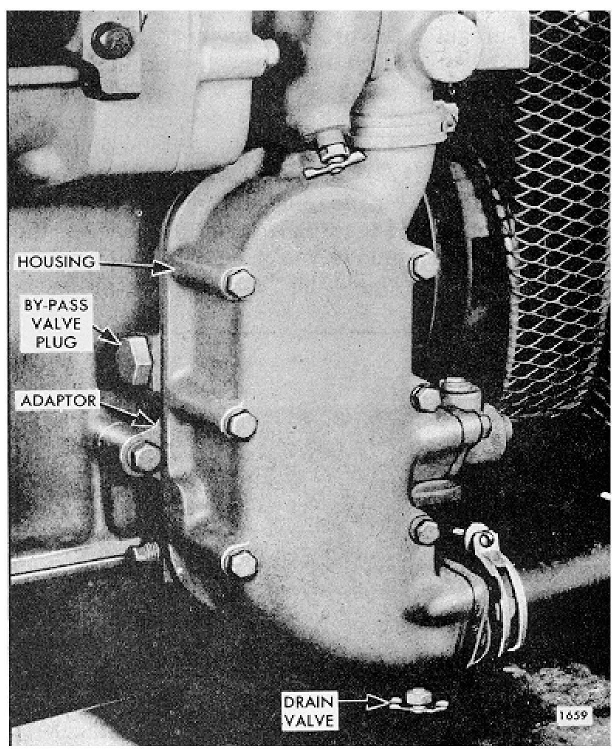


Fig. 1. Typical Lubricating Oil Cooler Mounting

7. If the openings are not marked IN and OUT on the oil cooler it is suggested that they be marked before reinstalling the oil cooler.

Clean Oil Cooler Core

1. Clean the oil passages in the oil cooler core by circulating a solution of trichloroethylene through the passages with a force pump.

   CAUTION: Perform this operation in the open or in a well ventilated room. Avoid breathing the fumes or direct contact of the chemicals with the skin.

   Clean the oil cooler core before the sludge hardens. If the oil passages are badly clogged, circulate an Oakite or alkaline solution through the oil cooler core and flush it thoroughly with clean, hot water.

   NOTE: Do not attempt to clean an oil cooler core when an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. In this instance, replacement of the oil cooler core is strongly recommended.

2. After cleaning the oil passages, clean the water side of the oil cooler core by immersing it in a solution made as follows: add one-half (1/2) pound of oxalic acid to each two and one-half (2-1/2) gallons of a solution composed of one-third (1/'3) muriatic acid and two-thirds (2/3) water. The cleaning action is evident by the bubbling and foaming. Carefully observe the process and remove the oil cooler core from the solution when the bubbling stops (this usually takes from 30 to 60 seconds). Then, thoroughly flush the oil cooler core with clean, hot water. After cleaning, dip the oil cooler core in light oil.

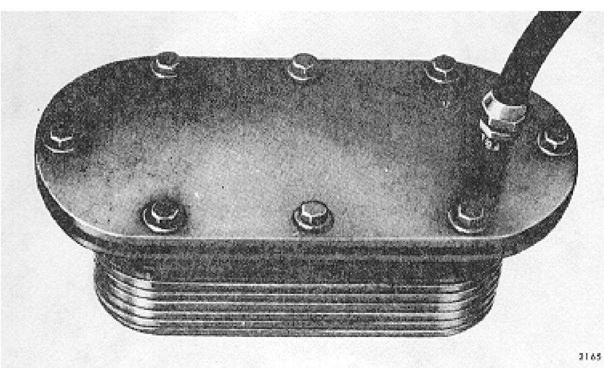


Fig. 2. *Oil Cooler Core Prepared for Pressure Check*

   CAUTION: Protect the eyes and avoid breathing the fumes or direct contact of the acid with the skin.

Pressure Check Oil Cooler Core

1. Make a suitable plate and attach it to the flanged side of the oil cooler core. Use a gasket made from rubber to ensure a tight seal. Drill and tap the plate to permit an air hose fitting to be attached at inlet side of oil cooler core (Fig. 2).

2. Attach an air hose and apply 75-150 psi air pressure. Then, submerge the oil cooler core and plate assembly in a tank of heated water (180°F.). Any leaks will be indicated by air bubbles in the water.

   CAUTION: When making pressure test, be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of a fitting, hose or the oil cooler core.

3. After the pressure check is completed, remove the plate and air hose and dry the oil cooler core with compressed air. Replace the oil cooler core if leaks were indicated.

   NOTE: In cases where a leaking oil cooler core has caused contamination of the engine, the engine must be immediately flushed to prevent serious damage (refer to Section 5).

Install Oil Cooler

The lubricating oil cooler may be installed by reversing the sequence of operations given for removal as follows (Fig. 3).

1. If the oil cooler adapter was removed from the cylinder block, remove the old gaskets from bosses where the adapter sets against the block. Affix new gaskets and then secure the adapter to the cylinder block with bolts, lock washers, and copper washer.

   NOTE: Copper washer must be installed on the lower right hand adapter-to-block bolt to prevent leakage of oil from adapter.

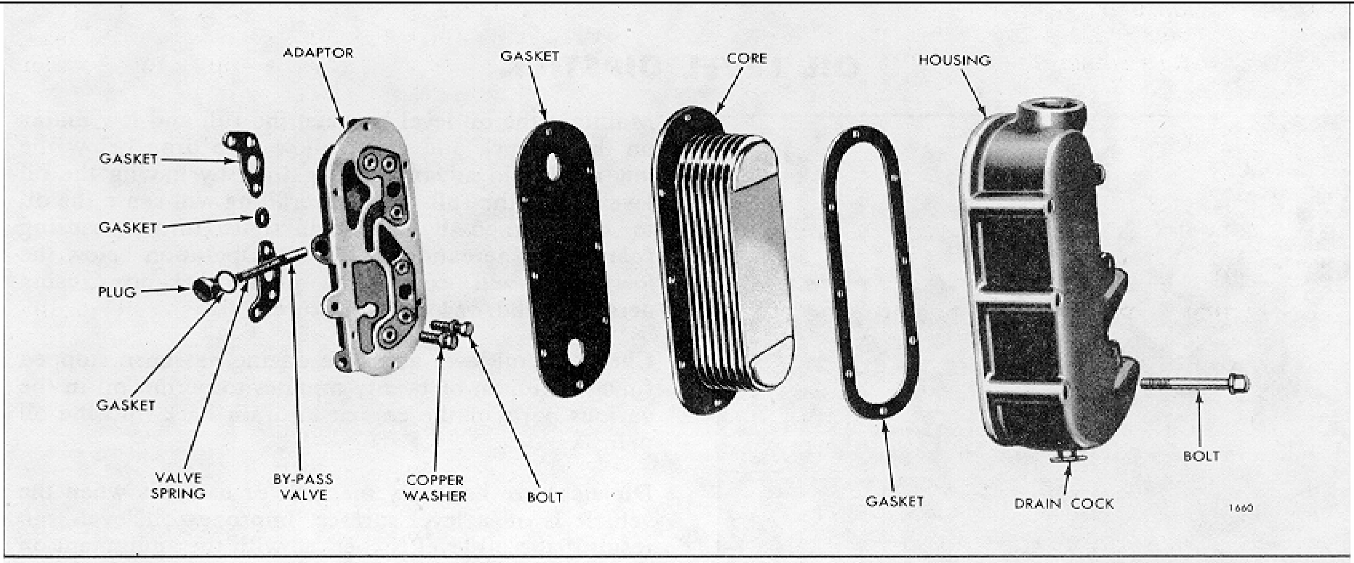


Fig. 3 - Lubricator Oil Cooler and By-Pass Valve Details and Relative Location of Parts.

2. Affix new gaskets to each side of the core, and position the core inside the housing.

3. Set the housing with cooler core against the adaptor and secure with bolts and lock washers at the same time locating the seal and clamp. Tighten the clamp (Fig. 1).

4. Affix a new gasket to the oil cooler water inlet connector and secure with bolts and lock washers.

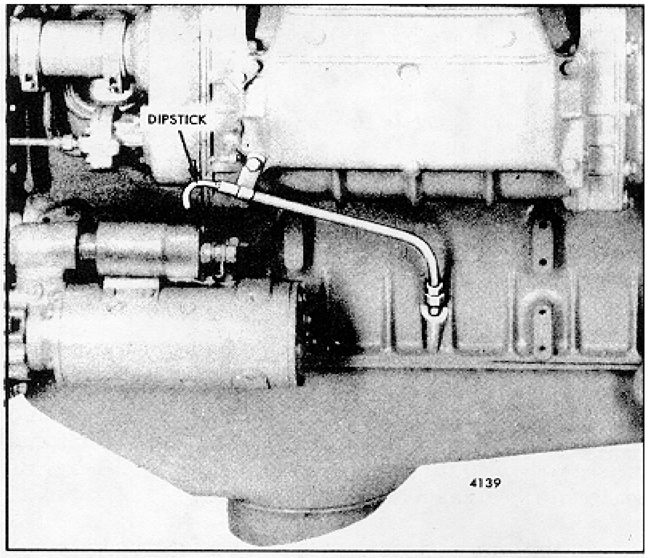


Fig. 1 - Typical Dipstick Mounting

A steel ribbon-type oil level dipstick is used to check the quantity of oil in the engine oil pan. The dipstick is located in an adaptor attached, by means of a guide, to an opening in the cylinder block or the oil pan.

Maintain the oil level between the full and low marks on the dipstick and never allow it to drop below the low mark. No advantage is gained by having the oil level above the full mark. Overfilling will cause the oil to be churned by the crankshaft throws causing foaming or aeration of the oil. Operation below the low mark will expose the pump pick-up causing aeration and/or loss of pressure.

Check the oil level after the engine has been stopped for a minimum of twenty minutes to permit oil in the various parts of the engine to drain back into the oil pan.

Dipsticks are normally marked for use only when the vehicle is on a level surface. Improper oil levels can result if the oil level is checked with the equipment on a grade.

Fill the crankcase with oil as follows:

1. Fill the oil pan to the full mark on the dipstick.
2. Start and run the engine for approximately ten minutes.
3. Stop the engine and wait a minimum of twenty minutes. Then add the required amount of oil to reach the full mark on the dipstick.

OIL PAN

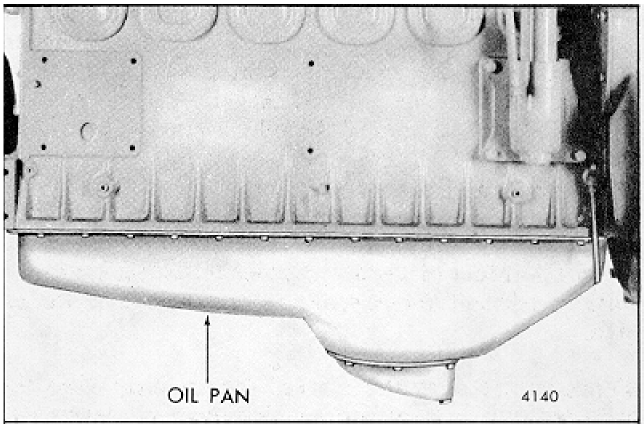


Fig. 1 - Typical Oil Pan Installation

The engine is equipped with a stamped steel oil pan (Fig 1). The oil sump is located at the rear of the pan. A one piece gasket is used with the steel pan.

Remove and Install Oil Pan

1. Remove the drain plug and drain the oil.
2. Remove the bolt and washer assemblies. Then remove the oil pan and gasket.
3. Clean all of the old gasket material from the cylinder block and the oil pan. Then clean the oil pan with fuel oil and dry it with compressed air.
4. Check a stamped oil pan for dents or breaks in the metal which may necessitate repair or replacement. Check for misaligned flanges or raised surfaces surrounding the bolt holes by placing the pan on a surface plate or other large flat surface.
5. When installing the oil pan, use a new gasket and, starting with the center bolt on each side and working alternately toward each end of the pan, tighten the bolts to 15-20 lb-ft (20-27 Nm) torque.
6. Install and tighten the drain plug (refer to Section 4.0).
7. Fill the oil pan with new oil (refer to Sections 4.6 and 13.3) to the full mark on the dipstick. Then start and run the engine for a short period to check for oil leaks.
8. Stop the engine and, after approximately twenty minutes, check the oil level. Add oil, if necessary.

VENTILATING SYSTEM

Harmful vapors which may be formed within the engine are removed from the crankcase, gear train, and valve compartments by a continuous, automatic ventilating system.

A slight pressure is maintained in the engine crankcase by the seepage of a small amount of air from the air box past the piston rings. This air sweeps up through the flywheel housing, and is admitted to the valve compartment through cavities in the lifter brackets. Ventilating air in the valve compartment is drawn off via the governor control housing (Fig. 1) or through a breather attached to the side of the cylinder block (Fig. 2) or to the oil pan adaptor (Fig. 3).

Service

Inspect and clean the breather tube and breather and baffle if necessary to eliminate the possibility of clogging. This can best be done by removing the breather tube from the governor and the breather and baffle from the cylinder block, washing them with a suitable solvent and drying them with compressed air.

Clean the breather element (Fig. 3):

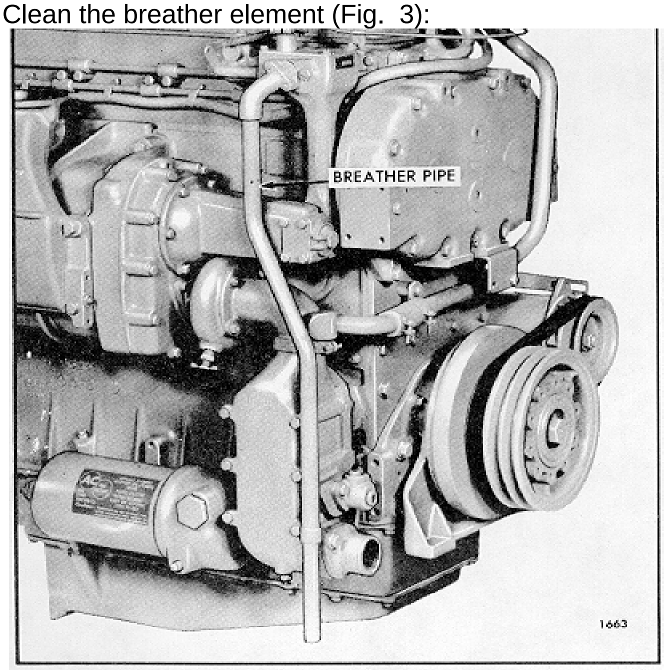


Fig. 1 - Typical Breather Pipe Mounting

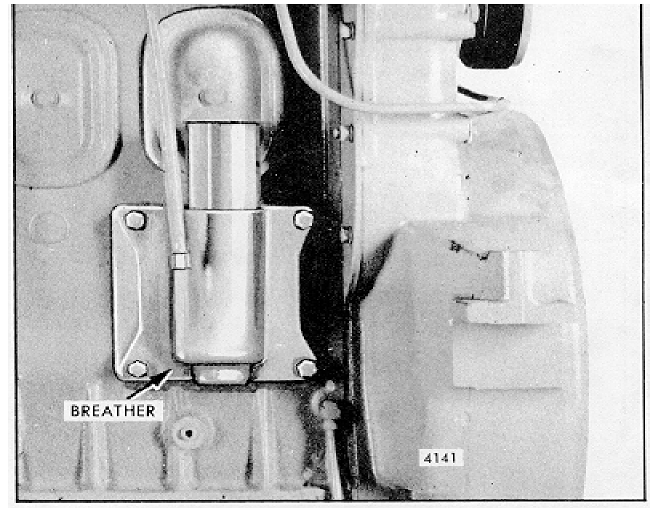


Fig. 2 - Typical Breather Mounting

1. Loosen the clamp and remove the breather cover.

2. Remove the four bolts and lock washers which attach the breather adaptor to the oil pan adaptor and remove the breather and gasket.

3. Loosen the bolt which fastens the element to the breather body and remove the element and screen. Do not lose the spring retaining clip which holds the bolt in place.

4. Wash the element thoroughly in clean fuel oil and dry it with compressed air.

5. Install the breather, using new gaskets, by reversing the procedure for removal.

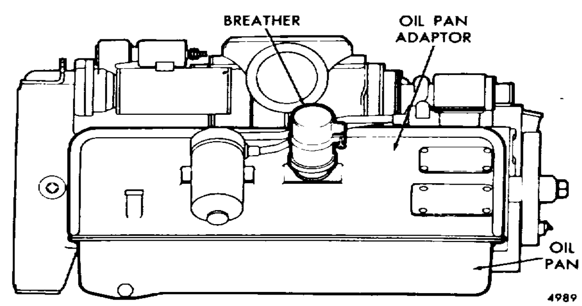


Fig. 3 - Breather Mounting (Horizontal Engine)

SPECIFICATIONS - SERVICE TOOLS

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5-7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2-20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4-10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-0	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483494	7/8-14	475485	644657
1 - 8	435-443	59.-600	1 -8	580-590	786-800
1-14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE C.I ENGINE	
		Ib-ft	Nm
Oil pan bolts	5/16-18	10-12	14-16
Oil pump-to-bearing cap bolt	3/8 -24		
Oil pump drive idler gear nut	1/2 -20	60-70	81-95
Oil filter center stud	5/8 -18	50-60	68-81
Oil pump relief valve plug	7/8 -18	15-25	20-34
Oil pan drain plug (nylon washer)	18 mm	25-35	34-47

STUD TORQUE SPECIFICATIONS

APPLICATION	TORQUE	
	Ib-ft	Nm
Oil filter center stud	40-50	54-68

SERVICE TOOLS

TOOL NAME	TOOL NO.
Crankshaft gear and oil pump gear puller	J 3051
Spring tester	J 9666
Two-arm steel grip puller	J 8174

SECTION 5
COOLING SYSTEM

CONTENTS

COOLING SYSTEM

To effectively dissipate the heat generated by the engine a radiator and cooling fan are provided to protect the engine and prevent severe damage. A centrifugal type water pump, attached to and driven by the blower, circulates the engine coolant through the lubricating oil cooler, cylinder block, cylinder head, and water manifold. A thermostat is utilized to maintain a normal engine operating temperature range of 1600F. to 185°F.

The engine coolant is circulated through the radiator (Fig. 1) where the heat is absorbed in the air stream developed by either a blower or suction fan which is belt driven from the crankshaft. The water pump draws the coolant through the oil cooler and discharges it into the lower part of the cylinder block. Openings in the water jacket around the cylinder bores connect with corresponding openings in the cylinder head through which the liquid rises to circulate around the valves and fuel injectors. Then the coolant passes through a water manifold, bolted to the cylinder head, past the thermostat and into the radiator.

upon starting a cold engine or when the coolant is below operating temperature (thermostat closed) the coolant is by-passed from the water manifold directly to the pump, thus providing water circulation within the engine during the warm-up period.

Engine Cooling System Maintenance

A properly maintained and clean cooling system will reduce engine wear and increase the satisfactory engine operating time between engine overhauls. This is accomplished by the elimination of hot spots within the engine. Thus, when operating within the proper engine temperature range and when not exceeding the recommended horsepower output of the unit, all engine parts will be within their operating temperature ranges and at their proper operating clearances.

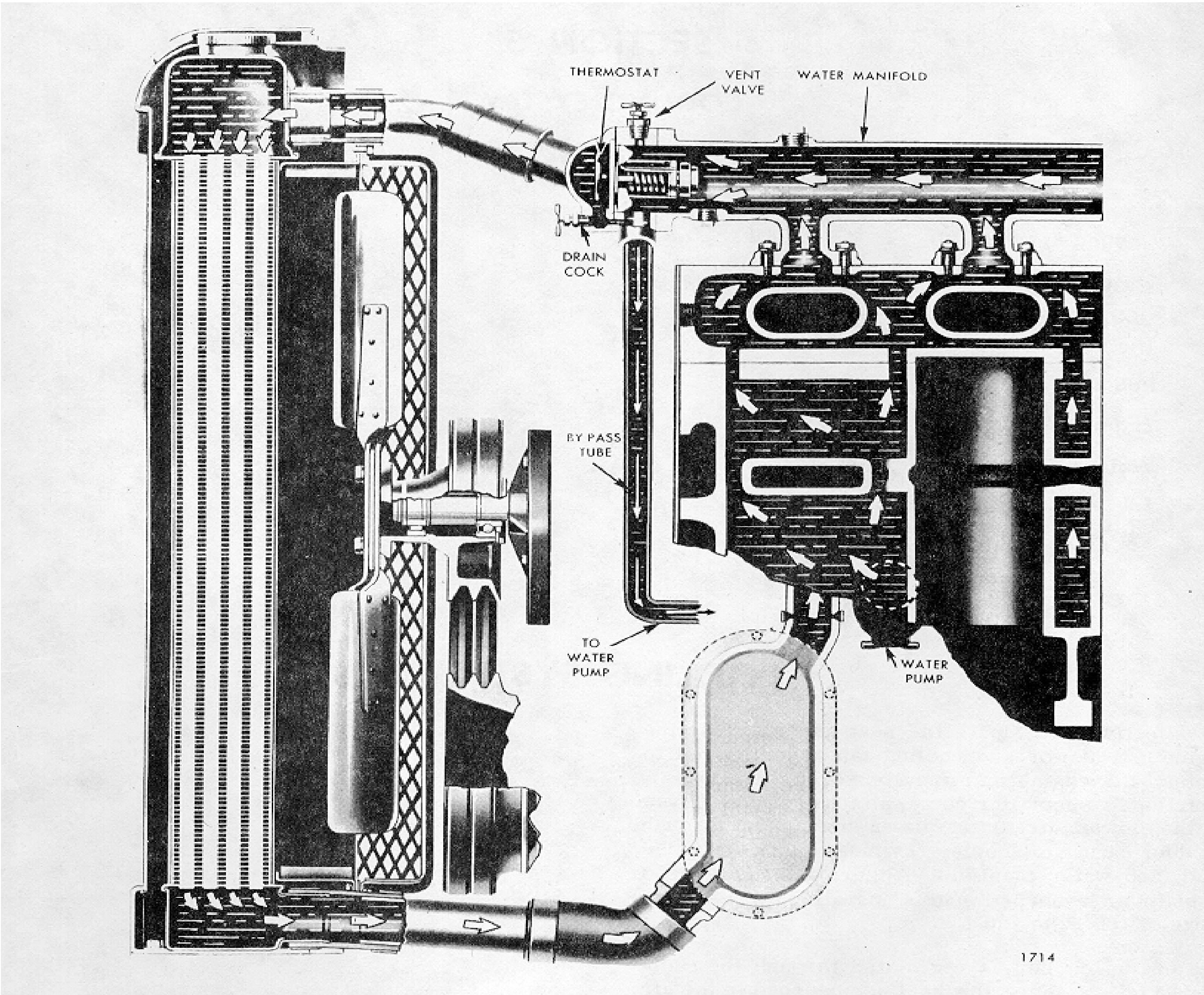


Fig. 1-Typical Cooling System with Radiator Fan

Engine Coolant

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinders, from the component parts such as exhaust valves, cylinder liners, and pistons which are surrounded by water jackets. In addition, the heat absorbed by the oil is also removed by the engine coolant in the oil-to-water oil cooler. Refer to Section 13.3 for coolant recommendations.

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, cylinder head, thermostat housings, and oil cooler housing) is shown in the following chart.

COOLING SYSTEM CAPACITY CHART (Basic Engine)	
ENGINE	CAPACITY (Gallons)
6-71	5 1/2

To ascertain the complete amount of coolant in the cooling system, the additional capacity of the radiator, hoses, and accessories such as a heater must be added to the capacity of the basic engine. The capacity of the radiator and related equipment should be obtained from the equipment supplier, or the capacity of a particular cooling system may be determined by filling the system with water, then draining and measuring the amount required.

Drain Cooling System

Drain the coolant by opening the drain cocks in the water outlet elbow, oil cooler housing, the fresh water pump, the radiator and, on certain engines, the water hole cover located on the blower side toward the rear of the cylinder block. Components of the cooling system that do not have a drain cock, are drained through the oil cooler housing drain cock.

Remove the cooling system filler cap to permit the coolant to drain completely from the system.

To ensure that all of the coolant is drained completely from a engine, all cooling system drains should be opened. Should any water that may be trapped in the cylinder block or radiator freeze, it will expand and may cause damage. When freezing weather is expected, drain a unit not adequately protected by antifreeze. Leave all drain cocks open until refilling the cooling system.

Fill Cooling System

Before starting the engine, close all of the drain cocks and fill the cooling system with water. The use of clean, soft water will eliminate the need for descaling solutions to clean the cooling system. A hard, mineral-laden water should be made soft by using water softener chemicals before it is poured into the cooling system. These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

Start the engine and, after the normal operating temperature has been reached, allowing the coolant to expand to its maximum, check the coolant level. The coolant level should be within 2" of the top of the filler neck.

Should a daily loss of coolant be observed, and there are no apparent leaks, there is a possibility of gases leaking past the cylinder head water seal rings into the cooling system. The presence of air or gases in the cooling system may be detected by connecting a rubber tube from the overflow pipe to a water container. Bubbles in the water in the container during engine operation will indicate this leakage. Another method for observing entrained air in the cooling system is by inserting a transparent tube in the water outlet line.

Flush Cooling System

If a coolant filter is used and properly maintained the cooling system need not be flushed. Otherwise the cooling system should be flushed each spring and fall. The flushing operation cleans the system of antifreeze solution in the spring and removes the summer rust inhibitor in the fall, preparing the cooling system for a new solution. The flushing operation should be performed as follows:

1. Drain the previous season’s solution from the unit.
2. Refill the cooling system with soft, clean water. If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.
3. Start the engine and operate it for 15 minutes to thoroughly circulate the water.
4. Drain the cooling system completely.
5. Refill the system with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats and the fan belt tension and water level are satisfactory, it will be necessary to clean and flush the entire cooling system. Scale formation should be removed by using a quality descaling solvent. Immediately after using the solvent, neutralize the system with a neutralizer. It is important that the directions printed on the container of the descaling solvent be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and flush it with clean water. Then, fill the system with the proper cooling solution.

> **CAUTION**: Whenever water is added to a hot engine, it must be done slowly to avoid rapid cooling which may cause distortion and possible cracking of engine castings.

Reverse Flushing

After the engine and radiator have been thoroughly cleaned, they should be reverse-flushed. The water pump should be removed and the radiator and engine reverse-flushed separately to prevent dirt and scale deposits clogging the radiator tubes or being forced through the pump. Reverse-flushing is accomplished with hot water, under air pressure, being forced through the cooling system in a direction opposite to the normal flow of coolant, thus loosening and forcing the scale deposits out.

Reverse-flush the radiator as follows:

1. Remove the radiator inlet and outlet hoses and replace the radiator cap.

2. Attach a hose at the top of the radiator to direct the water away from the engine.

3. Attach a hose to the bottom of the radiator and insert a flushing gun in the hose.

4. Connect the water hose of the gun to a water outlet and an air hose to the compressed air outlet.

5. Turn on the water and, when the radiator is full, turn on the air in short blasts.

> **CAUTION**: Apply air gradually. Do not exert more than 30 pounds (p.s.i.) air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until only clean water is expelled from the radiator.

Reverse-flush the cylinder block and cylinder head water passages as follows:

1. Remove the thermostat and the water pump.

2. Attach a hose to the water inlet of the cylinder block to drain the water away from the engine.

3. Attach a hose to the water outlet at the top of the engine and insert a flushing gun in the hose.

4. Block the bottom opening and fill the coolant passages with water; then unblock the bottom opening and blow the water from the engine with full air pressure from the flushing gun.

5. Again fill the engine cooling system with water and blow clean with full air pressure. Repeat this procedure until the flushing water runs clean.

If the scale deposits in the radiator cannot be removed by chemical cleaners or reverse-flushing, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate water through the radiator core from the bottom to the top during this operation.

Miscellaneous Cooling System Checks

In addition to the above cleaning procedures, the other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The thermostat and the radiator pressure cap should be checked and replaced, if found defective. The cooling system hoses should be inspected and any hose that feels abnormally hard or soft should be replaced immediately.

When water connection seals and hoses are installed be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamp. All external leaks should be corrected as soon as detected. The fan belt must be adjusted to provide the proper tension, and the fan shroud must be tight against the radiator core to prevent recirculation of air which may lower cooling efficiency.

Contaminated Engine

When the cooling system or lubricating system becomes contaminated, it should be flushed thoroughly to remove the contaminants before the engine is seriously damaged. One possible cause of such contamination is a cracked oil cooler core. In such a case, oil will be forced into the cooling system while the engine is operating, and coolant will leak into the lubricating system when the engine is stopped.

Coolant contamination of the lubricating system is especially harmful to an engine during the cold season when the cooling system is normally filled with an ethylene glycol antifreeze solution. If mixed with the oil in the crankcase, this antifreeze forms a varnish which quickly immobilizes moving engine parts.

To remove such contaminants from the engine, both the cooling system and the lubricating system must be thoroughly flushed as outlined below:

COOLING SYSTEM

If the engine has had a failure resulting in the contamination of the cooling system with lubricating oil, the following flushing procedure is recommended:

1. Prepare a mixture of Calgon, or its equivalent, and water at the rate of two ounces (dry measure) to one gallon of water.
2. Remove the engine thermostat to permit Calgon and water mixture to circulate through the engine and the radiator.
3. Fill the cooling system with the Calgon solution.

4. Run the engine for five minutes.

5. Drain the cooling system.

6. Repeat Steps 3, 4, and 5.

7. Fill the cooling system with clean water.

8. Let the engine run for five minutes.

9. Drain the cooling system completely.

10. Install the engine thermostat.

11. Close all of the drains and refill the cooling system with fresh coolant.

LUBRICATION SYSTEM

When the engine lubricating system has been contaminated by an ethylene glycol antifreeze solution, or other soluble material, the following cleaning procedure, using Butyl Cellosolve, or its equivalent, is recommended.

CAUTION: Use extreme care in the handling of these chemicals to prevent serious injury to the person or damage to finished surfaces. Wash off spilled fluid immediately with clean water.

If the engine is still in running condition, proceed as follows:

1. Drain all the lubricating oil.

2. Remove and discard the oil filter element. Clean and dry the filter shell and install a new element.

3. Mix two parts of Butyl Cellosolve, or its equivalent, with one part of SAE 10 engine oil. Fill the crankcase of the engine to the proper operating level with the mixture.

4. Start and run the engine at a fast idle (1000 to 1200 rpm) for 30 minutes to one hour. Check the oil pressure frequently.

5. After the specified time, stop the engine and immediately drain the crankcase and the filter. Sufficient time must be allowed to drain all of the fluid.

6. Refill the crankcase with SAE 10 engine oil after the drain plug is replaced, and run the engine at the same fast idle speed for ten or fifteen minutes. Then, stop the engine and drain the oil thoroughly.

7. Remove and discard the filter element, clean the filter shell, and install a new element.

8. Install the drain plug and fill the crankcase to the proper ’level with the oil recommended for normal engine operation.

9. To test the effectiveness of the cleaning procedure, it is recommended that the engine be started and run at a fast idle (1000 to 1200 rpm) for approximately 30 minutes. Then, stop and immediately restart the engine. There is a possibility that the engine is not entirely free of contaminant deposits if the starting speed is slow.

10. If the procedure for cleaning the lubricating oil system was not successful, it will be necessary to disassemble the engine and to clean the affected parts thoroughly.

MAKE CERTAIN THAT THE CAUSE OF THE INTERNAL COOLANT LEAK HAS BEEN CORRECTED BEFORE RETURNING THE ENGINE TO SERVICE.

The centrifugal type water pump illustrated in Fig. 1 circulates the engine coolant through the cylinder block, cylinder head, radiator, and the oil cooler. The drive end of the pump shaft is supported by a sealed double-row combination radial and thrust ball bearing. The pump shaft serves as the inner race of the bearing.

A spring-loaded seal assembly and a water slinger, located between the seal and the bearing, prevent the coolant from passing along the shaft to the bearing. The carbon washer in the seal assembly bears against a steel insert that is pressed into the pump body. The insert may be replaced when worn.

The impeller is a press fit on one end of a tapered stainless steel shaft. Former pump assemblies used a taper pin to hold the impeller on the shaft.

The pump is mounted at the front end of the blower (Fig. 2) and is driven by the lower blower rotor shaft. The drive coupling, pressed on the end of the pump shaft, has an integral oil thrower that shrouds the flange end of the pump body and deflects the oil away from the bearing.

Lubrication

The sealed type ball bearing is filled with lubricant at the time it is assembled to the pump shaft, and no further lubrication is required.

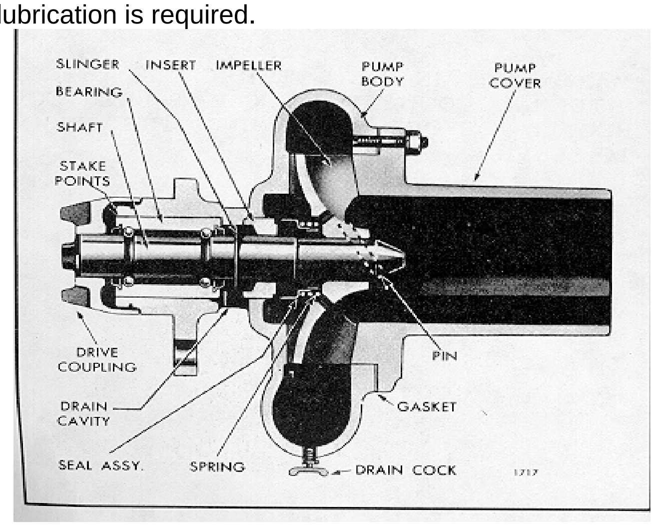


Fig. I - Typical Water Pump Assembly

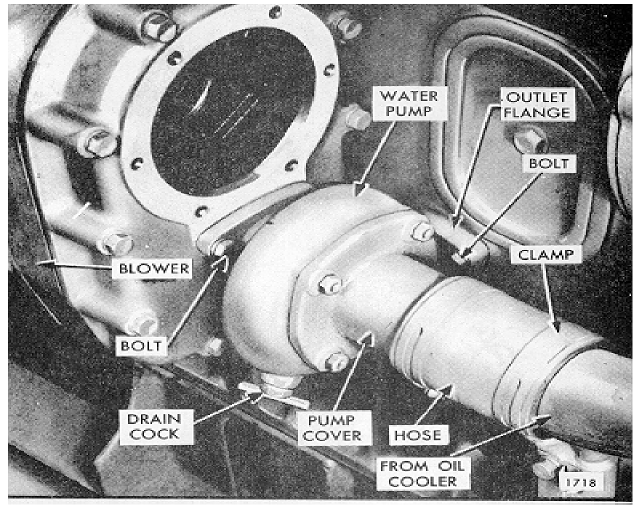


Fig. 2 - Water Pump Mounting

Remove Water Pump

Refer to Figs. 2 and 3 and remove the pump as follows:
1. Open the drain cock in the pump body and drain the cooling system.
2. Loosen the hose clamps and slide the water pump inlet hose back against the pump cover.
3. Remove the two bolts and lock washers that attach the pump outlet flange to the cylinder block. Remove the flange and packing ring.
4. Remove the three bolt and seal assemblies that attach the pump to the blower assembly.
5. Withdraw the pump and remove the gasket.

Disassemble Water Pump
1. Remove the pump cover and gasket.
   NOTE: Clean the corrosion from around the impeller and shaft before separating the shaft and bearing assembly from the impeller, seal and water pump body.

2. Support the pump on its mounting flange in an arbor press as shown in Fig. 4. Place a short rod on the end of the shaft and press the shaft and bearing assembly from the impeller, seal

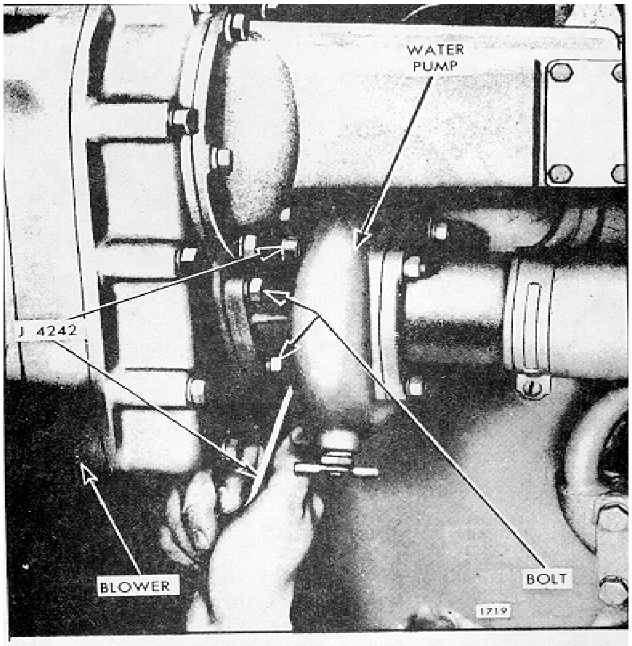


Fig. 3 - Loosening Inner Water Pump-to-Blower Attaching Bolt with Tool J 4242

and pump body. If the impeller is pinned to the shaft considerably more pressure will be required to shear the pin.

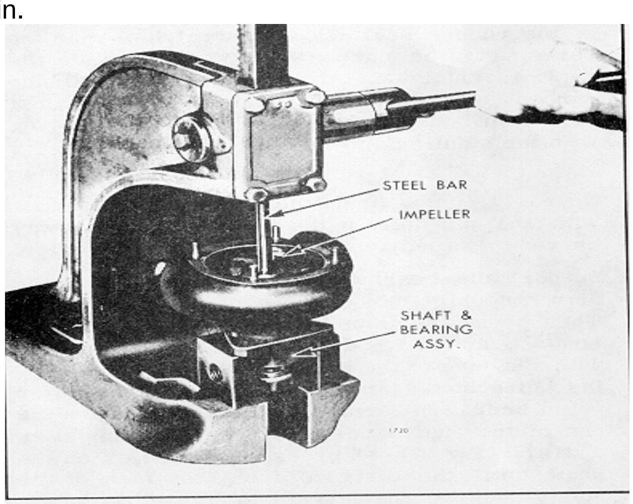


Fig. 4 - Pressing Water Pump Shaft from Impeller

3. Remove the impeller and seal assembly from the pump body.
4. If the steel insert is worn or scratched excessively, tap or press it out of the pump body.
5. Remove the water slinger from the shaft.
6. If the impeller was pinned to the shaft remove the sheared taper pin from the shaft and impeller by tapping against the small end of the pin with a punch and hammer.
7. If necessary, remove the pump drive coupling from the shaft with tool J 1930 as shown in Fig. 5.

Inspection

Clean all of the parts except the shaft and bearing assembly. The sealed type pump shaft bearing must not be immersed in a cleaning fluid since dirt may be washed in and the fluid cannot be entirely removed.

Revolve the pump shaft bearing slowly by hand. If rough spots are detected, replace the shaft and bearing assembly and seal assembly. A water pump reconditioning kit includes a shaft and bearing assembly.

Examine the impeller and seal components for wear, and replace them if necessary. The seal is

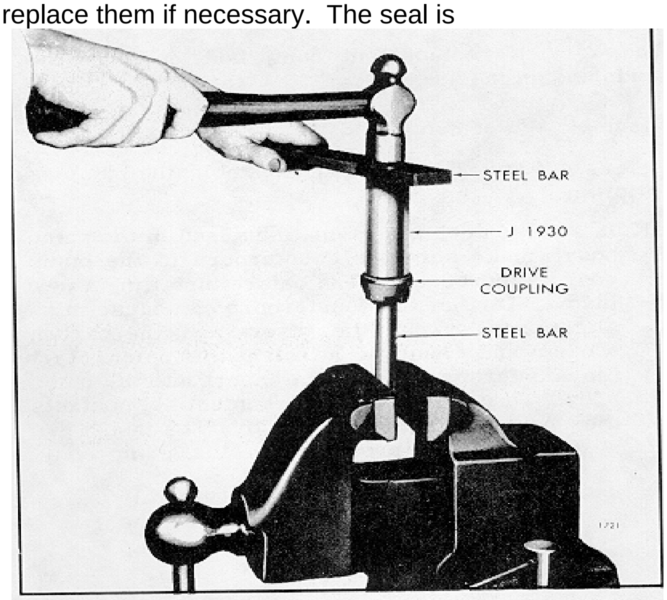


Fig. 5 - Removing Water Pump Drive Coupling from Shaft with Tool J 1930

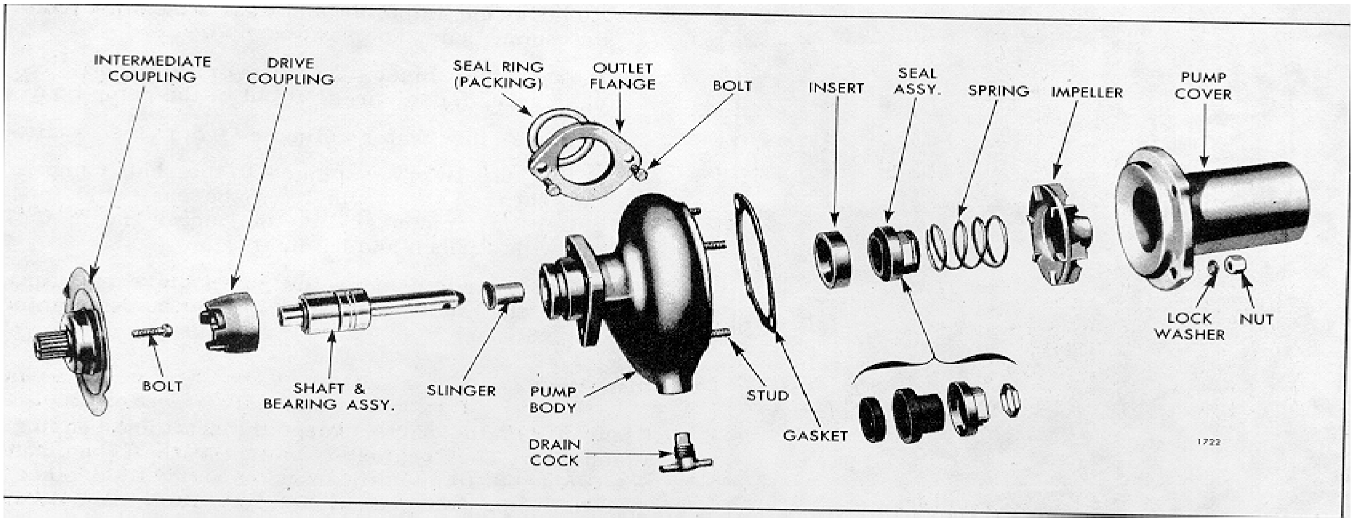


Fig. 6-Water Pump Details and Relative Location of Parts

available as an assembly only and includes the carbon washer, seal, ring, guide, and the spring. A seal assembly is also included with a service replacement impeller.

Examine the studs in the pump body. If it is necessary to replace a stud, use a good grade of sealant on the threads and drive the stud in to 6-8 lb-ft torque.

The service replacement pump body includes the studs and an insert.

Assemble Water Pump

Refer to Figs. 1 and 6 and assemble the pump as follows:

1. If a new steel insert is to be used in the pump body, make sure the counterbore in the pump body is thoroughly clean before installing a new insert. Dirt in the counterbore can cause misalignment between the insert and the carbon washer and result in a leak at this point. Start the counterbored end of the insert into the pump body. Then, press the insert in until it contacts the shoulder in the pump body. The insert has a .0015"-.0035" press fit in the pump body.

> **CAUTION:** Do not mar the highly finished seal contact surface of the insert when pressing it into the pump body.

2. Install the water slinger on the pump shaft with the flange of the slinger approximately 3/16" from the end of the outer race of the bearing.

3. Support the impeller end of the pump body on an arbor press, and insert the coupling end of the shaft and bearing assembly into the pump body. Then, press against the outer race of the bearing until the bearing contacts the shoulder in the pump body. Stake the end of the pump body in three places to prevent the bearing from moving endwise.

4. With the surface of the water seal clean and free from dirt and metallic particles, apply a thin coat of liquid soap on the inside diameter of the rubber seal. Do not scratch or mar the surface of the carbon seal washer. Slide the seal assembly on the pump shaft until the carbon seal washer is seated firmly against the pump body insert. Then, install the spring with the small end toward the seal.

5. On early pumps place the impeller on the shaft with the pin hole in the shaft aligned midway between two adjacent blades of the impeller.

6. Support the bearing end of the shaft (not the driven coupling) on the bed of an arbor press. Then press the impeller on the shaft. On current engines the end of the shaft must be flush with the face of the impeller hub with the bearing being held against the shoulder in the water pump body. On former engines which have the end of the shaft tapered, use impeller installer J 21971 (Fig. 7), to press the impeller on the shaft until the distance from the face of the pump body to the face of the impeller hub is .052"-.072", with the bearing being held against the shoulder in the water pump body.

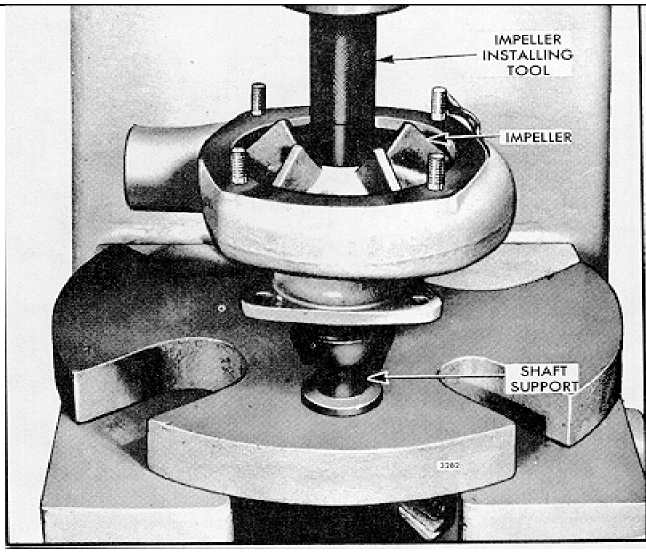


Fig. 7 - Installing Water Pump Impeller

7. If the impeller was previously pinned to the shaft and the old parts are reassembled, insert a .184" drill in the pin hole in the shaft and drill a new hole in the impeller hub. Install a new 3/16" x 7/8" groove pin. However, if a new impeller is installed on either a new or old shaft, it will not be necessary to pin it to the shaft since the impeller bore diameter has been decreased to permit a press fit.

8. Support the impeller end of the pump shaft on an arbor press and, press the coupling onto the shaft. The drive coupling must be flush with the end of the shaft. Make sure the drive coupling is tight on the shaft.

9. Rotate the shaft by hand to be sure the rear face of the impeller blades do not rub the pump body.

10. Place a new pump cover gasket against the bolting flange of the pump body. Slide the pump cover over the studs and secure it to the pump body with four lock washers and nuts.

11. If previously removed, install the drain cock in the pump body.

Install Water Pump

Refer to Fig. 2 and install the water pump on the engine as follows:

1. To convert the former intermediate drive coupling to the current coupling, refer to Section 3.0.

2. Make sure the intermediate shaft coupling is secure. If it was previously removed, insert the splined end of the coupling into the mating splines in the blower rotor shaft. Then, draw the coupling in place with the 5/16"-24 x 1-1/2" bolt. Tighten the bolt to 15-19 lb-ft torque.

3. Place the pump outlet flange over the pump outlet with the flat side of the flange facing the pump body. Slip the packing ring over the pump outlet and next to the flange.

4. Affix a new gasket to the bolting flange and place the pump against the blower end plate cover so that the lugs on the drive coupling mesh with the lugs on the intermediate shaft coupling. Secure the pump to the blower with the three bolts and seal washers.

5. Slide the pump outlet packing ring and packing flange against the cylinder block and secure the flange with two bolts and lock washers.

6. Slide the water pump inlet hose in place and secure it with the hose clamps.

7. Close the pump drain cock, and fill the engine cooling system.

> **NOTE**: When filling the cooling system of certain models, it is necessary to open the vent valve at the top of the thermostat housing.

HIGH CAPACITY FRESH WATER PUMP

Certain six-cylinder engines (effective with engine 6A-5987), are equipped with a fresh water pump of greater capacity to provide increased circulation of the coolant. Six-cylinder turbocharged engines also require the high capacity pump to compensate for reduced pump speed; the ratio of blower speed (pump speed) to engine speed is 1.55:1 for the turbocharged engines and 1.95:1 for the nonturbocharged engines. However, the standard pump provides sufficient circulation of the coolant for the four-cylinder turbocharged engines.

The current pump assembly, effective with engine 6A-59447, incorporates a new seal assembly and impeller (Fig. 8). The shaft and bearing assembly and seal assembly are the same as used in the current standard pump assembly.

Service

The high capacity pump (Fig. 8) is serviced in the same manner as the standard pump. However, on current engines, press the impeller on the shaft using impeller installer J 22437 until the distance

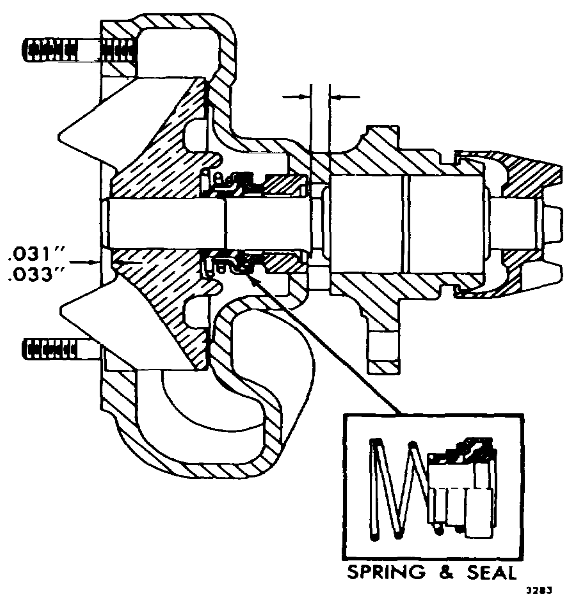


Fig. 8 - High Capacity Fresh Water Pumps

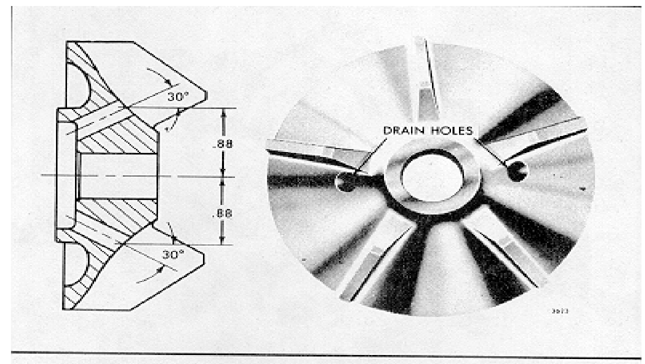


Fig. 9 - Reworking Diagram of Water Pump Impeller

between the end of the shaft and the face of the impeller hub is .031"-.033", with the bearing being held against the shoulder in the water pump body.

On former engines which have the end of the shaft tapered press the impeller on the shaft using impeller installer J 9303 until the distance between the end of the shaft and the face of the impeller hub is .099"-.101" with the bearing being held against the shoulder in the water pump body.

Effective with Engine 6A-98234, two 1/4" holes were added to the water pump impeller (Fig. 9) to vent the seal chamber and eliminate the possibility of foreign material build-up between the impeller and the seal, which could result in a seal leakage. In cases where pump seal difficulties are encountered, on pumps with former impellers, it is recommended that the holes be incorporated.

> **NOTE**: Remove any rough edges and burrs from the impeller after drilling the holes.

The old seal assembly is available for service. However, if the impeller requires replacement, the current seal assembly and impeller must be used together. The shaft with the milled flat must also be replaced if a current impeller and seal are installed.

> **NOTE:** The current shaft and bearing assembly, seal assembly, seal spring, drive coupling, and pump body insert are the same for both the standard and high capacity fresh water pump.

Coolant leaving the cylinder head through an opening over each exhaust port, enters the water manifold which is attached to the head with two nuts and lock washers at each of the water openings (Fig. 1). A separate gasket is used at each attaching flange between the manifold and cylinder head.

A gradually increasing area in the cast manifold from the rear end terminates in a mounting flange to which the thermostat housing is attached by means of bolts and lock washers.

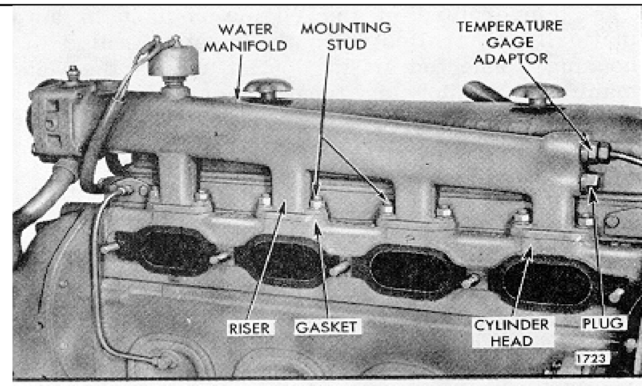


Fig. 1 - Typical Water Manifold Mounting

Remove Water Manifold

Remove the water manifold as follows:

1. Drain the cooling system to level necessary by opening valve in bottom of fresh water pump and valve in thermostat housing.

2. Loosen the bolts which secure the outlet elbow and thermostat housing to the water manifold.

3. Remove the cooling water temperature gage, adaptor from the rear end of water manifold.

4. Remove the water manifold stud nuts and lock washers and lift the manifold straight up off studs. Remove the manifold to cylinder head gaskets.

Install Water Manifold

Remove all the old gaskets and install the manifold using new gaskets.

1. With new gaskets in place, lower the water manifold down over studs and secure to cylinder head with two nuts and lock washers at each riser.

2. Install temperature gage adaptor in end of manifold.

3. Attach the thermostat housing and outlet elbow to the water manifold with bolts and lock washers.

4. Fill the cooling system to proper level.

> **NOTE:** When filling cooling system on certain models, it is necessary to open the vent valve at the top of thermostat housing.

The temperature of the engine coolant is automatically controlled by a thermostat located in a housing connected to the outlet end of the water manifold. A blocking type thermostat (Fig. 1) is used when a standard cooling system is employed; a semi-blocking type thermostat (Fig. 2) is used with a rapid warm-up cooling system.

At coolant temperatures below approximately 170°F., the thermostat valves remain closed and block the flow of coolant to the radiator, During this period, all of the coolant in the standard system is circulated through the engine and is directed back to the suction side of the water pump via the by-pass tube. In the rapid warm-up system, enough coolant to vent the system is by-passed to the radiator top tank by means of a separate external deaeration line and then back to the water pump without going through the radiator cores. As the coolant temperature rises above 170'F., the thermostat valves start to open, restricting the by-pass system, and permit a portion of the coolant to circulate through the radiator. When the coolant temperature reaches approximately 185'F., the thermostat valves are fully open, the by-pass system is partially blocked off, and most of the coolant is directed through the radiator.

A properly operating thermostat is essential for efficient operation of the engine. If the engine operating temperature deviates from the normal range of 160" to 185"F., remove the thermostat and check it.

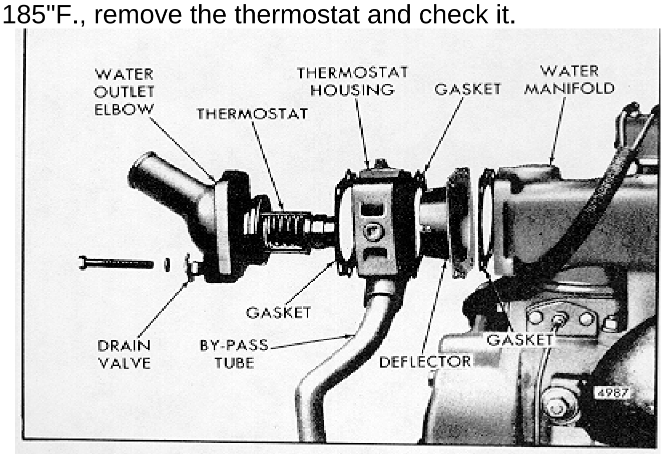


Fig. 1 - Typical Thermostat Housing Mounting

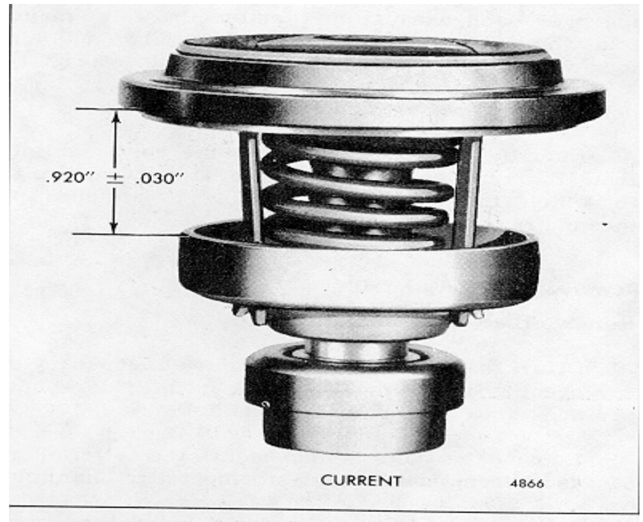


Fig. 2 - Semi-Blocking (Shielded) Type Thermostat

Remove Thermostat

1. Drain the cooling system to the necessary level by opening the drain valve.
2. Remove the bolts which secure the outlet elbow and the thermostat housing (by-pass tube) to the water manifold (Fig. 1).

3. Remove the thermostat and the deflector (if used) and clean the seat for the thermostat in the outlet elbow.

Inspect Thermostat

If the action of the thermostat has become impaired due to accumulated rust and corrosion from the engine coolant so that it remains closed, or only partially open, thereby restricting the flow of water, overheating of the engine will result. A thermostat which is stuck in the wide open position may not permit the engine to reach its normal operating temperature, thus resulting in incomplete combustion of fuel and in build-up of carbon deposits on the pistons, rings and valves.

The operation of the thermostat may be checked by immersing it in a container of hot water (Fig. 3). Place a thermometer in the container, but do not allow it to touch the bottom of the container. Agitate

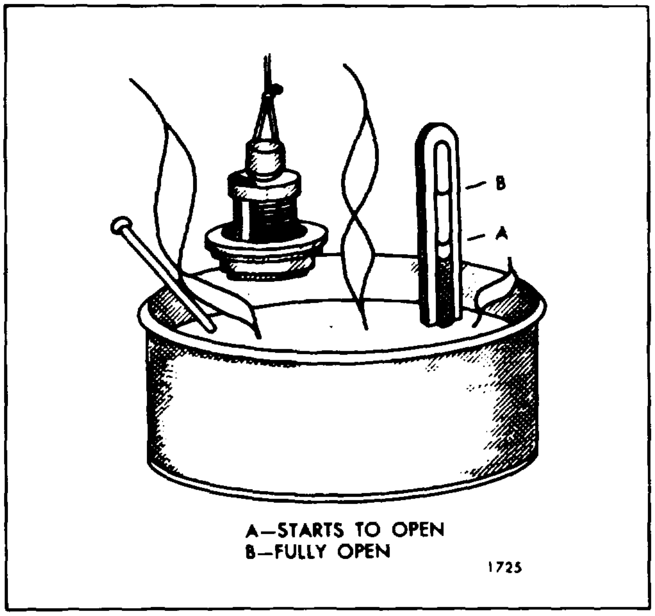


Fig. 3 - Method of Checking Thermostat Operation

the water to maintain an even temperature throughout the container. As the water is heated, the thermostat should begin to open when the water temperature reaches approximately 170°F. (the opening temperature is usually stamped on the thermostat). The thermostat should be fully open at approximately 185°F.

Install Thermostat

1. Affix a new gasket to each side of the thermostat housing.

2. Install the deflector, if used, and a new gasket.

3. Set the thermostat in the housing and attach the outlet elbow and the thermostat housing to the water manifold.

> **NOTE:** The openings in the side of the thermostat body (former service thermostat) must be fully open before the thermostat is installed. If the openings are partially closed in handling, they can be opened by grasping the body flange and turning the body.

4. Connect any other piping which may have been disconnected.

5. Fill the cooling system and check for leaks.

RADIATOR

The temperature of the coolant circulating through the engine is lowered by the action of the radiator and the fan. The radiator is mounted in front of the engine so that the fan will draw air through it, thereby' lowering and maintaining the coolant temperature to the degree necessary for efficient engine operation.

The life of the radiator will be considerably prolonged if the coolants used are limited to either clean, soft water with a rust inhibitor or a mixture of water and a high boiling point type antifreeze. The use of any other type antifreeze is not recommended.

To increase the cooling efficiency of the radiator, a metal shroud is placed around the fan. The fan shroud must be fitted airtight against the radiator to prevent re-circulation of the hot air drawn through the radiator. Hot air which is permitted to pass around the sides or bottom of the radiator and is again drawn through the radiator will cause overheating of the engine.

Another cause of overheating is slippage of the fan drive belts which is caused by incorrect belt tension, worn belts or worn fan belt pulley grooves, or the use of fan belts of unequal length when two or more belts are used. The belt tension and condition of the belts should be checked periodically.

A radiator that has a dirty, obstructed core or is leaking, a leak in the cooling system, or an inoperative thermostat will also cause the engine to overheat. The radiator must be cleaned, the leaks eliminated, and defective thermostats replaced immediately to prevent serious damage from overheating.

The external cleanliness of the radiator should be checked if the engine overheats and no other causes are apparent.

Cleaning Radiator

The radiator should be cleaned whenever the foreign deposits are sufficient to hinder the flow of air or the transfer of heat to the air. In a hot dusty area, periodic cleaning of the radiator will prevent a decrease in efficiency and add life to the engine.

The fan shroud and grille should be removed, if possible, to facilitate the cleaning of the radiator core.

An air hose with a suitable nozzle is often sufficient to remove loose dust from the radiator core. Occasionally, however, oil may be present requiring the use of a solvent, such as oleum, to loosen the dirt. The use of gasoline, kerosene, or fuel oil is NOT recommended as a solvent. A spray gun is an f effective means of applying the solvent to the radiator core. Use air to remove the remaining dirt. Repeat this process as many times as necessary, then rinse the' radiator with clean water and dry it with air.

Another method of cleaning the radiator is the use of steam or a steam cleaning device, if available. If the foreign deposits are hardened, it may be necessary to apply solvents.

The scale deposit inside the radiator is a result of using hard, high mineral content water in the cooling system. The effect of heat on the minerals in the water causes the formation of scale, or hard coating, on metal surfaces within the radiator, thereby reducing the transfer of heat. Some hard water, instead of forming scale, will produce a silt-like deposit which restricts the flow of water. This must be flushed out at least twice a year --more often if necessary.

To remove the hardened scale, a direct chemical action is necessary. A flushing compound such as salammoniac, at the specified rate of 1/4 pound per each gallon of radiator capacity, should be added to the coolant water in the form of a dissolved solution while the engine is running. Operate the engine for at least 15 minutes, then drain and flush the system with clean water.

Other flushing compounds are commercially available and should be procured from a reliable source. Most compounds attack metals and should not remain in the engine for more than a few minutes. A neutralizer should be used in the cooling system immediately after a de-scaling solvent is used.

For extremely hard, stubborn coatings, such as lime scale, it may be necessary to use a stronger solution. The corrosive action of a stronger solution will affect the thin metals of the radiator, thereby reducing its operating life. A complete flushing and rinsing is mandatory and must be accomplished skillfully.

After the solvent and neutralizer have been used and the cooling system is flushed, completely drain the entire system again and fill it with clean, soft water plus a rust inhibitor or high boiling point type antifreeze. After filling the cooling system, inspect the radiator and engine for water leaks.

NOTE: When draining or filling, the cooling system must be vented.

After the radiator core has been thoroughly cleaned and dried, reinstall the fan shroud and grille, if removed.

Inspection

Examine the radiator for cracks or other damage. The core fins should be straight and evenly spaced to permit a full flow of cooling air. The core tubes should be clean inside and outside and have no leaks.

If repainting the radiator core becomes necessary, it is recommended that a thin coat of dull black radiator paint or another high quality flat black paint be used. Ordinary oil paints have an undesirable glossy finish and do not transmit heat as well.

Check all radiator hoses and clamps. Replace cracked and deteriorated hoses and damaged clamps.

Radiator Pressure Control Cap

The radiator has a pressure control cap with a normally closed valve. The cap is designed to permit a pressure of approximately seven pounds in the cooling system before the valve opens. This pressure raises the boiling point of the cooling liquid and permits somewhat higher engine operating temperatures without loss of any coolant from boiling. To prevent the collapse of the hoses and other parts which are not internally supported, a second valve in the radiator cap opens under vacuum when the system cools.

CAUTION: Always remove the radiator cap slowly and carefully to avoid a possible flash of hot cooling liquid.

To ensure against possible damage to the cooling system from either excessive pressure or vacuum, check both valves periodically for proper opening and closing pressures. Replace the radiator cap if necessary.

ENGINE COOLING FAN

The engine cooling fan is belt driven from the crankshaft pulley (Fig. 1).

The fan is bolted to a hub and pulley which is carried on two bearings. The bracket and shaft is mounted on the fan support which is in turn attached to the balance weight cover. The bracket is slotted to permit adjustment of the fan belt tension by moving the bracket and shaft on the attaching bolts (Fig. 2). Formerly the bracket and shaft were separate pieces and the rear end of the shaft was supported in the bracket and retained by a snap ring.

At major overhaul the fan bearing hub assembly should be discarded. Pack the hub assembly, using a new b, straight, or tapered roller bearing, with Lithium base multipurpose grease. The fan blades should run in a vertical plane parallel with and a sufficient distance away from the rear face of the radiator core to ensure the blades will not damage the core. Bent fan blades reduce the efficiency of the cooling system and tend to throw the fan out of balance.

Adjust Fan Belt

The belt tension and condition of the belts should be checked as outlined in Section 15.1.

Remove and Install Fan Blades

Remove the fan blades from the hub by removing the bolts, nuts and lock washers, providing enough clearance exists between the fan blades and the inner face of the radiator core with the belt guard and fan guard removed (Fig. 1). If the blades cannot be removed in this manner, the fan, hub and bracket may be removed as an assembly from the support on the balance weight cover, and then the blades removed from the hub, see Remove Fan, Hub and Bracket below. The fan blades may be installed by reversing the procedure used for removal.

Remove Fan, Hub and Bracket from Engine

1. Remove the two adjusting bolts, lock washers and plain washers, thus freeing the fan belts from the hub.

2. Loosen the bracket pivot or adjusting bolts until the bracket is free. Remove the fan, hub and bracket as an assembly from the engine.

Disassemble Fan, Hub and Bracket (Former)

With the fan, hub and adjusting bracket removed from the engine, refer to Figs. 2 and 5 and disassemble as follows:

1. Remove the bolts, nuts, and lock washers securing the fan to the hub. Remove the fan.

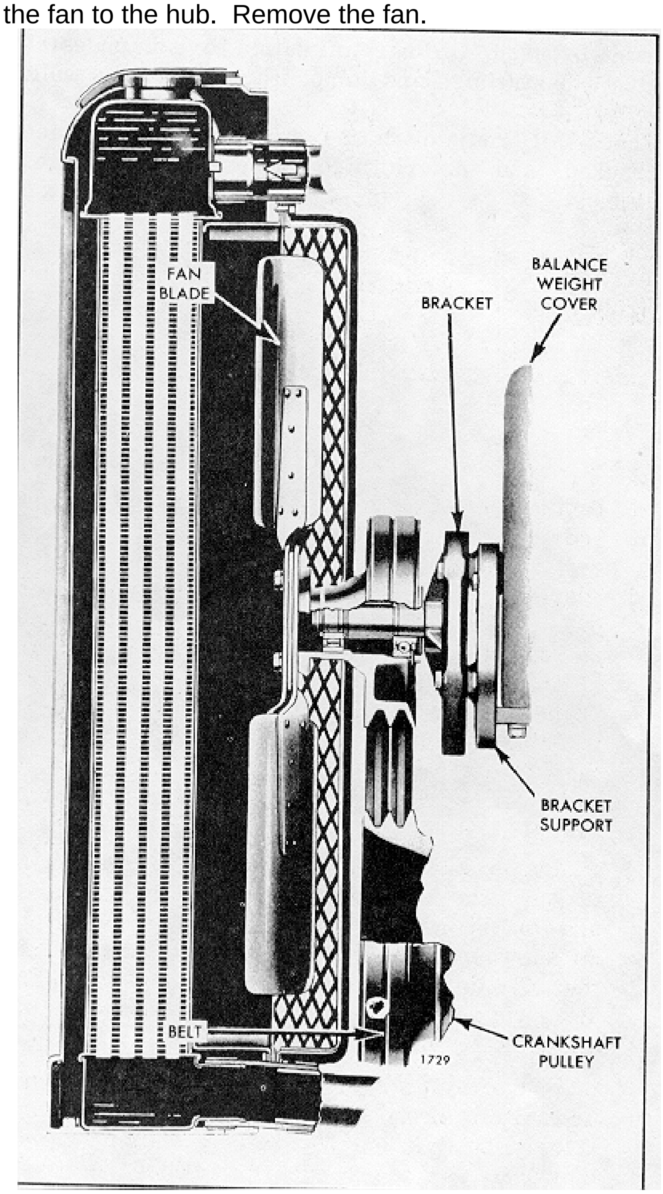


Fig. 1 - Typical Fan and Hub Assembly

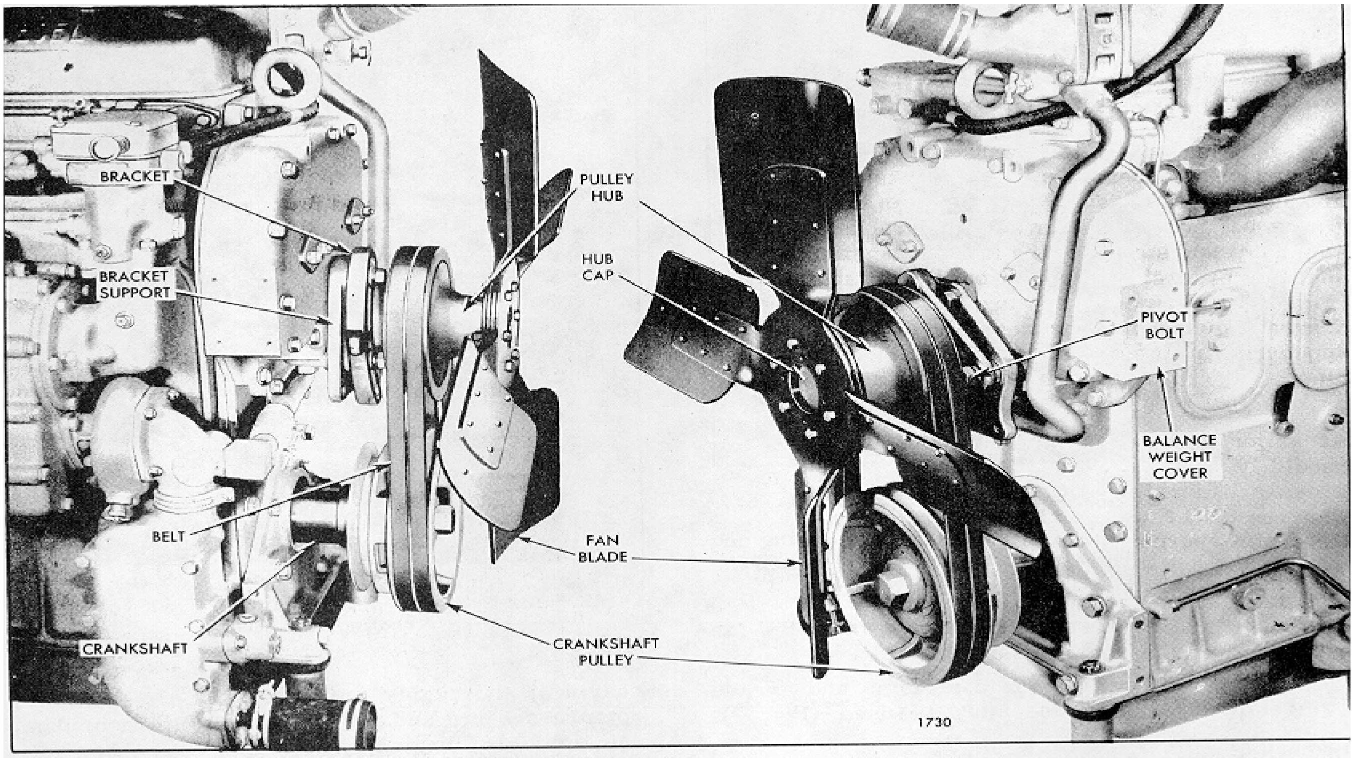


Fig. 2-Fan Mounting

2. Remove the bracket retaining ring from the rear end of the shaft.

3. Place the hub and bracket assembly in an arbor press with the front face of the bracket supported on split plates so that the hub is clear of the bed of the press, as shown in Fig. 3. Place a brass rod between the end of the shaft and the ram of the press, press the shaft from the bracket. When the bracket is free, the bolt and lock washer may be removed from the bracket.
4. Place the hub in an arbor press with the shaft in line with the opening in the bed of the press and the opposite end under the ram of press, as shown in Fig. 4. Place a brass rod between the ram of the press and the end of the shaft and press the shaft, front roller bearing and cap from the hub (Fig. 4).
5. Slide the roller bearing from the shaft. If the inner race of the bearing is in good condition it may be left on the shaft. If, however, removal of the inner race is necessary, first remove the retaining ring, then split the inner race and remove it from the shaft.
6. Remove the retaining ring from the hub and tap the rear ball bearing from the hub, using a brass rod against the rear of the bearing.

Disassemble Fan, Hub and Bracket (Current)

With the fan, hub and adjusting bracket removed from the engine, refer to Figs. 2 and 8 and disassemble as follows:

1. Remove the attaching bolts and lock washers holding the fan and the spacer (if used) to the hub. Remove the fan.
2. Loosen the fan hub adjusting bracket bolts and remove the drive belts. Then withdraw the bolts and washers and remove the hub and bracket assembly from the engine.
3. Remove the fan hub cap (if a spacer and cap assembly were not used).
4. Remove the hub bolt and washer (Fig. 7). Also remove the shims if the former hub assembly (Fig. 7) is used.
5. Withdraw the hub and bearing assembly from

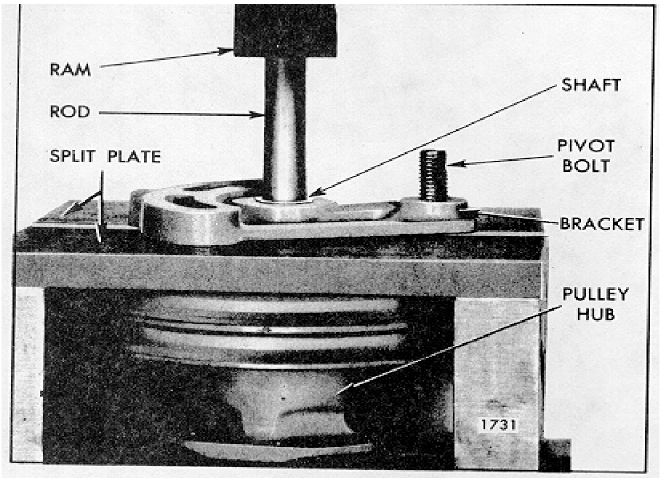


Fig. 3 - Removing Fan Shaft from Fan Adjusting Bracket

the shaft. It may be necessary to tap the end of the shaft with a soft hammer to loosen the- hub assembly.

6. Remove the oil seal and bearing from the fan hub.
7. Remove the bearing spacer shims and grease retainer if new assembly is used (Fig. 7).

Inspection

Wash the fan and fan hub parts (except shielded

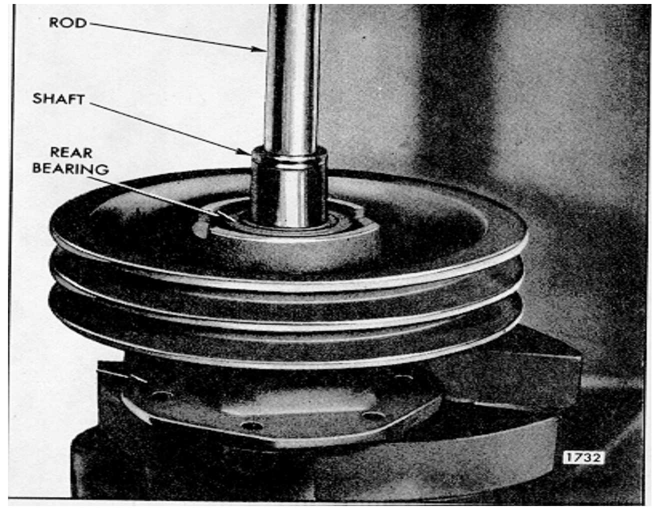


Fig. 4 - Removing Fan Shaft and Front Roller Bearing from Hub

bearings) thoroughly with fuel oil, dry them with compressed air and inspect them for wear or damage. <u>Shielded bearings must not be washed</u>; dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Hold the

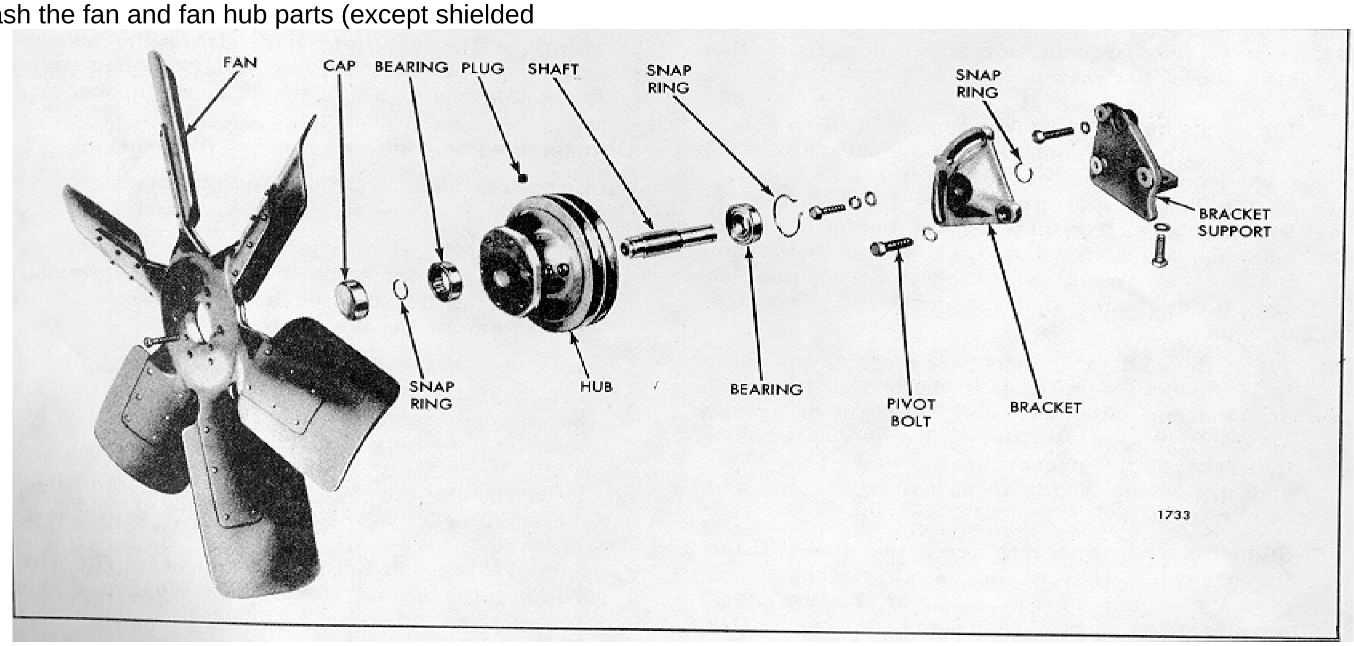


Fig. 5 - Fan, Hub and Adjusting Bracket Details and Relative Location of Parts

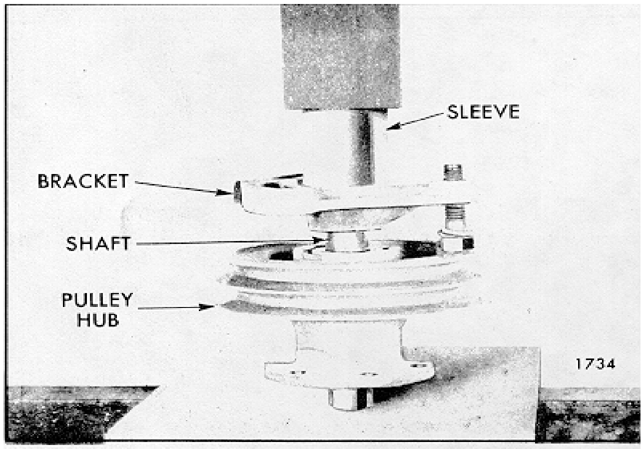


Fig. 6 - Installing Adjusting' Bracket and Bolt on Fan Shaft

inner race and revolve the outer race of each bearing slowly by hand. If rough or tight spots are detected replace the bearing. Examine the fan blades for cracks. Replace the fan if the blades are badly bent, since straightening may weaken the blades, particularly' in the hub area.

Remove any rust or rough spots in the grooves of the fan pulley and crankshaft pulley. If grooves are damaged or severely worn replace the pulley.

Assemble Fan, Hub and Bracket (Former)

Lubricate ball, straight or tapered roller bearings with Chevron BRB No. 2 grease or an equivalent Lithium base multi-purpose grease.

1. If the inner race of roller bearing was removed, start a new bearing straight on the short journal end of the shaft.

Then press the bearing inner race tight against the shoulder on the shaft.

2. Install the snap ring.
3. Insert the shaft and roller bearing into the flanged end of pulley hub and pack the cavity with grease.
4. Start the ball bearing shaft straight on the long journal end of the shaft. Place the hub in an arbor press with the forward end of the shaft resting on plate and, using a sleeve over rear end of the shaft, press the bearing tight against shoulder on the shaft.

5. Install the retaining ring in hub.

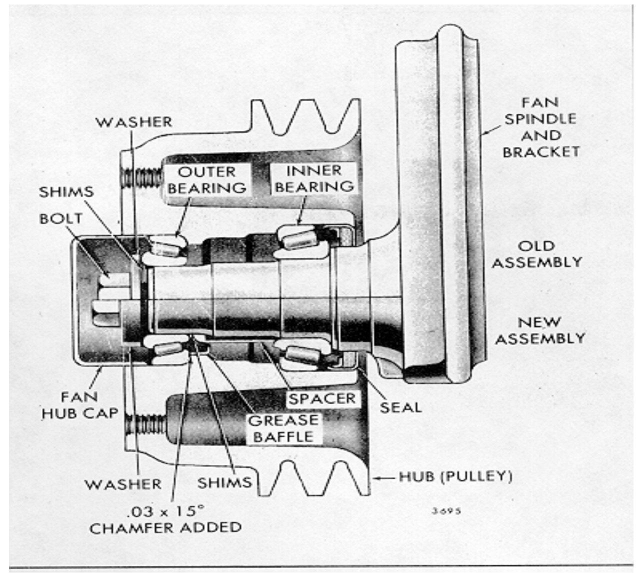


Fig. 7 - Shaft Type Fan Hub Assembly

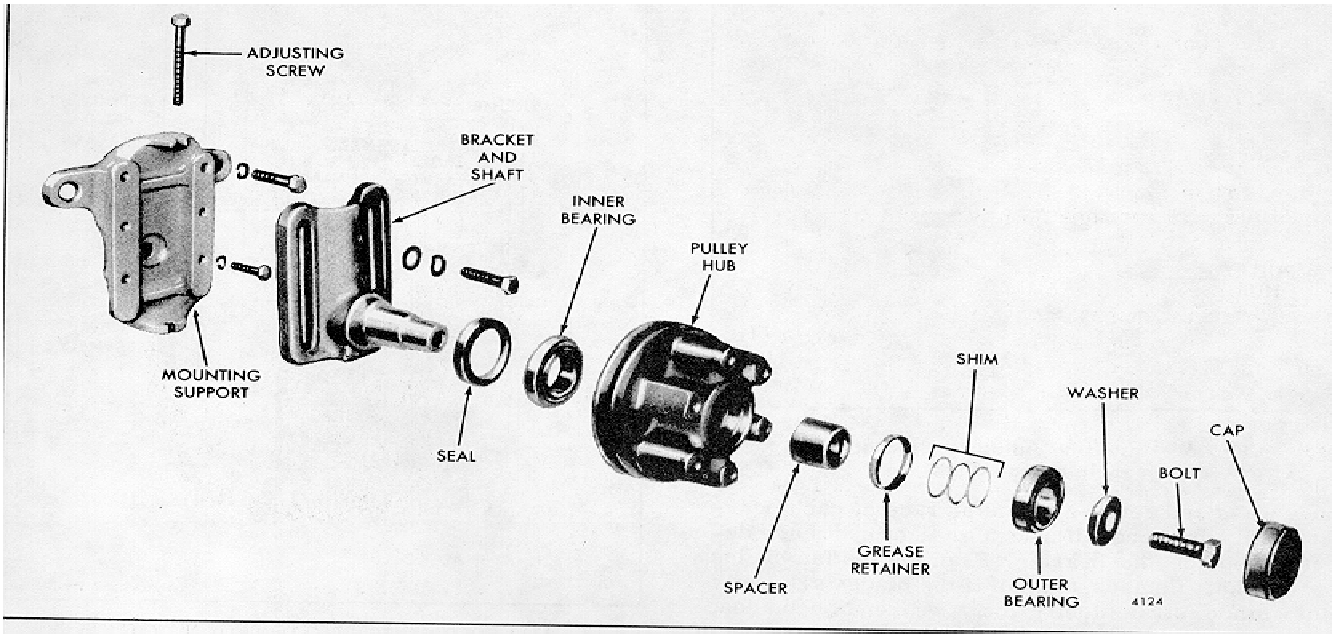
6. Insert the bracket pivot bolt with lock washer through 21/32" hole in the bracket with head of bolt at the front side of bracket (Fig. 6).
7. Support the forward end of shaft on the plate of the arbor press. Start the bracket straight on the shaft and, using a sleeve, press the bracket into place in manner as shown in Fig. 6.
8. Install the retaining ring on the end of the shaft.
9. Install the cap in the fan hub.
10. Secure the fan blade to the hub with the six bolts, nuts and lock washers.

Assemble Fan, Hub and Bracket (Current)

Lubricate ball, straight or tapered roller bearings with Chevron BRB No. 2 grease or an equivalent Lithium base multi-purpose grease.

Assemble the fan hub and bracket shown in Figs. 7 and 8 as follows:

1. Apply grease to the rollers of both bearings before installing them in the fan hub (pulley).



2. Install the inner bearings with the protruding face of the inner race facing outward from the hub.
3. Install a new oil seal with the felt-side flush with the outer edge of the hub.
4. Place the hub over the shaft and install the bearing spacer (if used).
5. Pack the cavity approximately 1/4 full with grease and install the grease retainer.
6. Place the shims against the bearing spacer. Then, install the outer bearing with the protruding face of the inner race facing outward from the hub.
7. Secure the hub with the retaining washer and bolt. Tighten the 1/2"-20 bolt to 83-93 lb-ft torque while rotating the pulley.
8. Check the end play in the assembly with the shaft in a horizontal position. The end play must be .001" to .006". If necessary, remove the bolt, washer, and outer bearing and adjust the number and thickness of the shims to obtain the required end play. Shims are available in .015", .020", and .025" thickness. Then, reassemble the fan hub and check the end play.
9. Fill fan hub cap 3/4 full of grease and install it in the end of the fan hub (pulley).

NOTE: The cap must not protrude beyond the face of the hub.

Install Fan, Hub and Bracket on Engine (Former)

1. Place the fan belts on the pulley.
2. Position the bracket against the bracket support and thread the pivot or adjusting bolt into the support.
3. Thread the two adjusting bolts with lock washers and plain washers into the support. Bolts are tightened when making the fan belt adjustment.

Install Fan, Hub and Bracket (Current)

1. Attach the fan hub and adjusting bracket assembly to the bracket support on the engine with bolts, lock washers, and plain washers. Do not tighten the bolts.
2. Install the drive belts, adjust the bracket to provide the proper tension, and tighten the bolts. If used, install the adjusting bracket, bolt and plain washer shown in Fig. 7.
3. Install the fan (and fan spacer and cap, if used) on the hub and secure it with the bolts and lock washers.

WATER FILTER AND CONDITIONER

The engine cooling system water filter and conditioner (Fig. 1) is a compact by-pass type unit with a replaceable element.

A correctly installed and properly maintained water filter and conditioner provides a cleaner engine cooling system, greater heat dissipation, increased engine efficiency through improved heat conductivity, and contributes to longer life of engine parts.

The filter provides mechanical filtration by means of a closely packed element through which the water passes. Any impurities such as sand and rust particles suspended in the cooling system will be removed by the straining action of the element. The removal of these impurities will contribute to longer water pump life and proper operation of the thermostat.

The filter also serves to condition the coolant by softening the water to minimize scale deposits, maintain an acid-free condition and act as a rust preventive.

Corrosion inhibitors are placed in the element and dissolve into the water, forming a protective rust-proof film on all of the metal surfaces of the cooling system (refer to Section 13.3). The other components of the element perform the function of cleaning and preparing the cooling passages while the corrosion inhibitors protect them.

Filter Installation

If a water filter and conditioner is to be installed on an engine which has been in service, drain and flush the cooling system prior to installation of the filter.

Filter Maintenance

Replace the chemically activated element periodically and buff the lower corrosion resistor plate on the former filter each time (discard the plate if excessive metal loss or pitting is evident) to ensure effective protection of the cooling system.

If the water filter is installed on an engine which has previously been in service, it may be necessary to change the filter element two or three times at intervals of approximately 6,000 miles or less to clean up accumulations of scale and rust in the cooling system. It is advisable to drain and flush the system during these initial change intervals.

Change the filter element periodically as outlined in Section 15.1.

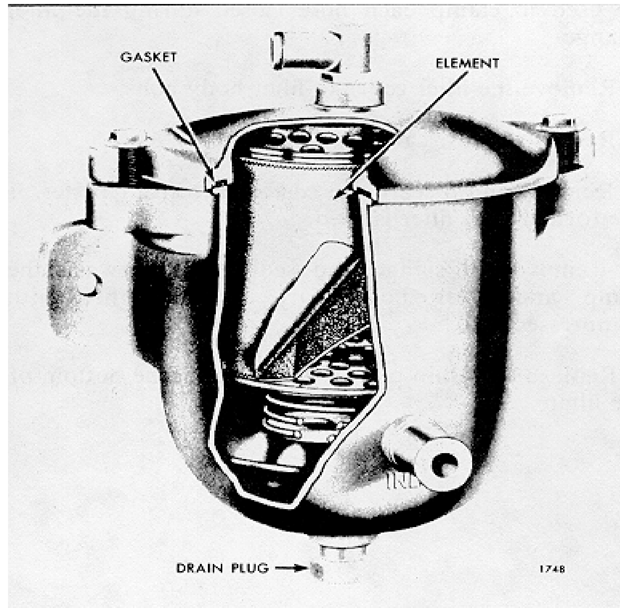


Fig. 1 - Water Filter and Conditioner

Make-up water up to approximately 40% of the total capacity of the cooling system may safely be added before a filter element change is required.

If it is necessary for any reason to drain the cooling system before an element change, the treated water should be saved and re-used. If the treated water is discarded, a new filter element must be installed since the protective agents in the used filter will have been partially consumed in treating the discarded water.

Service

Whenever the water filter is removed and reinstalled, the filter must have metal-to-metal contact (grounded), either directly with the mounting surface or through the mounting bolts.

The current water filter includes a non-chromate type element. This element can be used in place of either of the former water filter elements (permanent type antifreeze or plain water type) and thus provides year around cooling system protection. The current and the former water filter elements are completely interchangeable in the former filter can (refer to Section 13.3).

Replace the element and service the water filter and conditioner as follows:

1. Close the water filter inlet and outlet shut-off valves.

If shut-off valves are not provided, vise grip pliers can be used to clamp each hose closed during the filter change.

2. Remove the filter cover-to-filter body bolts.

3. Remove and discard the element.

4. Remove and discard the corrosion resistor plates, if the former type filter is used.

5. Remove the sludge and sediment and wash the sump and filter body. Dry it thoroughly with compressed air.

6. Replace the drain plug, if removed, in the bottom of the filter.

7. Insert the new element.

8. Use a new filter cover gasket, install the filter cover and tighten the bolts evenly.

9. Open the inlet and outlet lines by opening the shutoff valves or removing the vise grip plier clamps.

10. Operate the engine and check for leaks. The top of the filter and the outlet line should feel warm to the touch with the rise in coolant temperature. If not, disconnect the filter outlet line at the end opposite the filter connection to bleed the air from the system and reconnect the line. Use caution to minimize coolant loss.

SPECIFICATIONS-SERVICE TOOLS

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

SIZE NUT OR BOLT	TORQUE (lb-ft)	SIZE NUT OR BOLT	TORQUE (lb-ft)	SIZE NUT OR BOLT	TORQUE (lb-ft)
¼ -20	7-9	76 - 20	57-61	¾ - 10	240-250
¼ 28	8-10	1/2 - 13	71-75	¾ - 1'6	290-300
5/16 - 18	13-17	1/2 - 20	83-93	7/8 - 9	410-420
5/16 -24	15-19	9/16 - 12	90-100	7/8 - 1 4	475-485
3/8 - 16	30-35	9/16 - 18	107-117	1 - 8	580-590
3/8 -24	35-39	5/8 - 11	137-147	1 - 14	685-695
7/16 - 14	46-50	5/8 - 18	168-178		

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	SIZE NUT OR BOLT	TORQUE (lb-ft) C. I. ENGINE	
Water Pump Coupling Bolt (current)	5/16 - 24	18 min.	
Water Manifold Nut	3/8 - - 24	25-30	
Water Pump Coupling Bolt (former tapered end)	7/16 - 24	25-30	

STUD TORQUE SPECIFICATIONS

APPLICATION	TORQUE (lb-ft)
Water Manifold Stud	10-25

SERVICE TOOLS

TOOL NO	TOOL NAME
J 1930	Water Pump Drive Coupling Remover
J 21971	Water Pump Impeller Installer (.052"-.072")
J 22437	Water Pump Impeller Installer (.031"-.033")
J 4242	Water Pump & Fuel Pump Wrench
J 8499	Thermostat Seal Replacer
J 9303	Water Pump Impeller Installer (.099"-.101")

SECTION 6

EXHAUST SYSTEM

CONTENTS

EXHAUST MANIFOLD

An air-cooled exhaust manifold (Fig. I) is attached to the cylinder head. The location and angle of the exhaust outlet of the manifold varies with the engine model. The exhaust manifold is secured to studs, located between the exhaust ports and at the outer sides of the end ports of the cylinder head, with bevel washers and nuts. A exhaust manifold three-piece gasket is used on the 6-71 engine.

Remove Exhaust Manifold

1. Disconnect the exhaust pipe from the exhaust manifold.

2. If the exhaust manifold is mounted on the blower side of the engine (Fig. 1), remove the air inlet housing from the blower. Cover the air inlet opening to prevent entry of foreign material. Then remove the air compressor (if used) and the governor control housing.

3. Remove the nuts, bevel washers and end crabs that attach the exhaust manifold to the cylinder head. It is suggested that, as a safety measure, the nut be loosened but left on the center stud until all of the other nuts and washers have been removed.

4. Support the manifold and remove the nut and washer from the center stud.

5. Lift the manifold away from the cylinder head.

6. Remove the manifold gaskets.

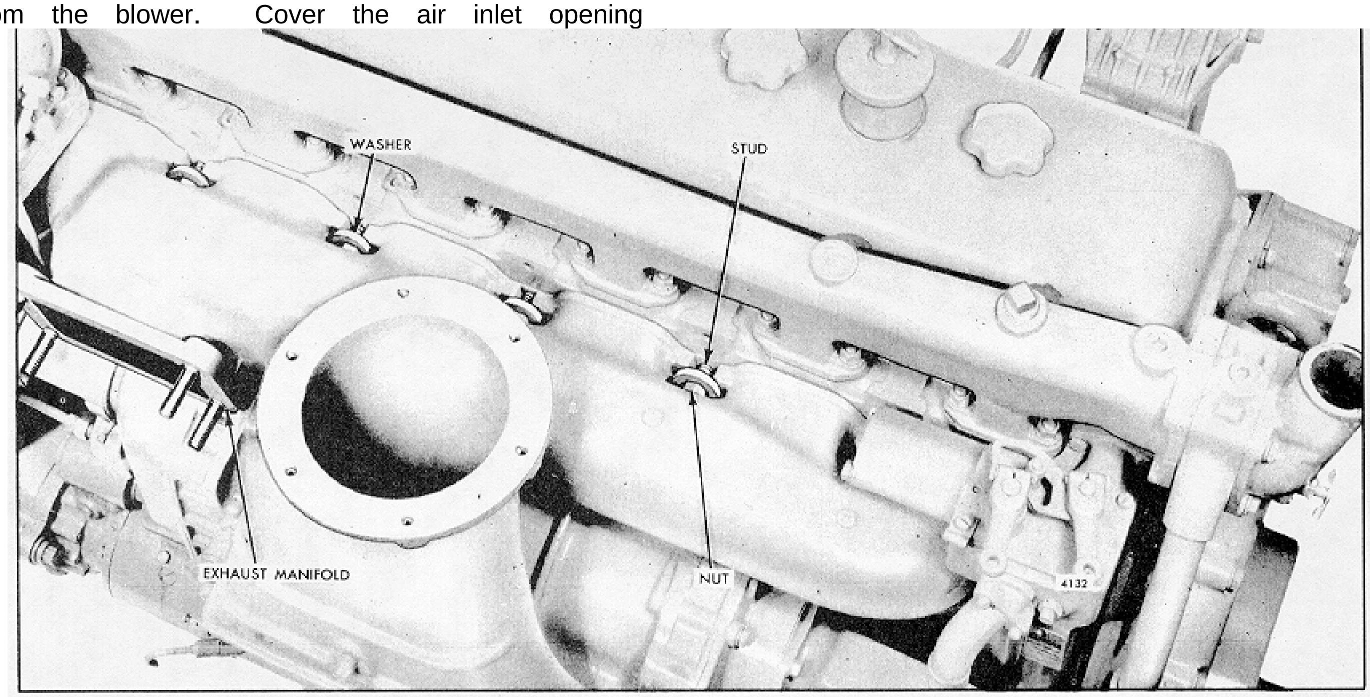


Fig. 1. - Typical Exhaust Manifold Mounting

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold.

Examine the exhaust manifold studs for damage. If necessary, replace the studs. New studs are driven in to 25-40 lb-ft torque.

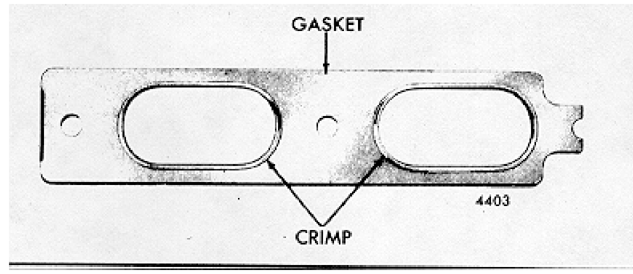


Fig. 2 - Metal Clad Exhaust Manifold Gasket

Install Exhaust Manifold

1. Place a new gasket(s) over the studs and up against the cylinder head.

   CAUTION: When installing the metal clad exhaust manifold gasket(s), be sure the crimped side of the gasket (Fig. 2) faces the cylinder head.

2. Position the exhaust manifold over the studs and against the gasket(s).

3. Install the bevel washers, end crabs and nuts on the studs.

   NOTE: Install the bevel washers with the crowned sides toward the nuts.

4. Then, starting with the center nut and working alternately toward each end, tighten the manifold nuts to 30-35 lb-ft torque (cast iron head) or 25-30 lb-ft torque (aluminum head).

   NOTE: If the cylinder head was removed from the engine, do not tighten the manifold nuts until AFTER the head is reinstalled. Otherwise, interference may be encountered between the manifold and the cylinder block bosses which serve as a support for the manifold when the cylinder head is installed.

5. If the exhaust manifold is mounted on the blower side of the engine (Fig. 1), install the governor control housing, air compressor and the air inlet housing.

6. Connect the exhaust pipe to the manifold. When brass nuts are used to secure an outlet flange to the manifold, tighten the nuts to 20-25 lb-ft torque.

SECTION 7

ELECTRICAL EQUIPMENT, INSTRUMENTS AND

PROTECTIVE SYSTEMS

CONTENTS

ELECTRICAL SYSTEM

A typical engine electrical system generally consists of a starting motor, a battery-charging generator (alternator), a transistor combination voltage regulator, current regulator and cutout relay to protect the electrical system, a storage battery and the necessary wiring.

Detailed information on maintenance and repair of the specific types of electrical equipment used can be found in the service manuals and bulletins issued by the equipment manufacturer. Information regarding equipment manufactured by the Delco-Remy Division of General Motors Corporation may be obtained from their electrical equipment operation and service manuals. The manuals may be obtained from United Delco Division, or from the Technical Literature Section, Delco-Remy Division of General Motors Corporation, Anderson, Indiana.

BATTERY-CHARGING GENERATOR (D.C. and A.C.)

The battery-charging circuit consists of a generator (alternator), regulator, battery and the wiring. The battery-charging generator (Fig. 1) is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the generator.

Direct current generators (Fig. 2) are manufactured in a wide range of sizes and types, but the basic design of all D.C. generators is the same. The size and type of generator applied to a particular engine depends on many factors, including maximum electrical load, type of service, percentage of engine idling to running time, type of drive, drive ratio (engine speed to generator speed), generator mounting and environmental conditions.

The alternating current self-rectifying generator (alternator), Figs. 3 and 4, is especially beneficial on an engine with extra electrical accessories and one that has to operate for extended periods at idle speeds. Diodes, built into the slip ring end frame, rectify the three phase A.C. voltage to provide D.C. voltage at the battery terminal of the generator, thereby eliminating the need for an external rectifier. The alternator is also available in a variety of sizes and types.

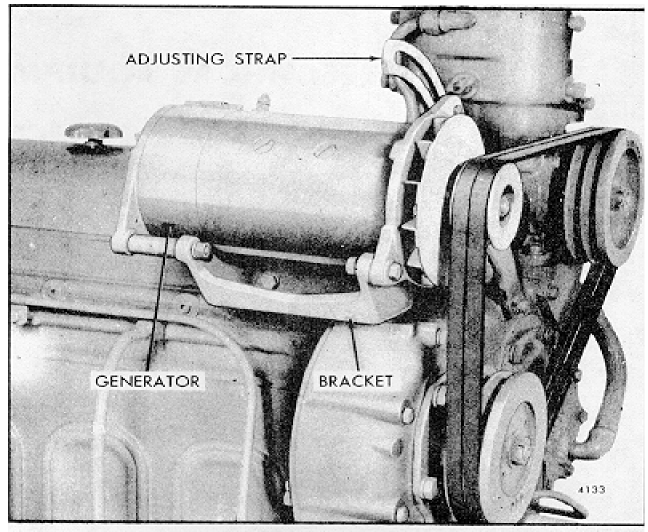


Fig. 1 - Typical Generator Mounting

The proper selection of a generator which will meet the needs of the battery-charging circuit on :ie particular engine is mandatory. This, together with adherence to the recommended maintenance procedures, will reduce generator troubles to a minimum. Since most generators adhere to the same basic design, the maintenance, removal and installation procedures for all are similar.

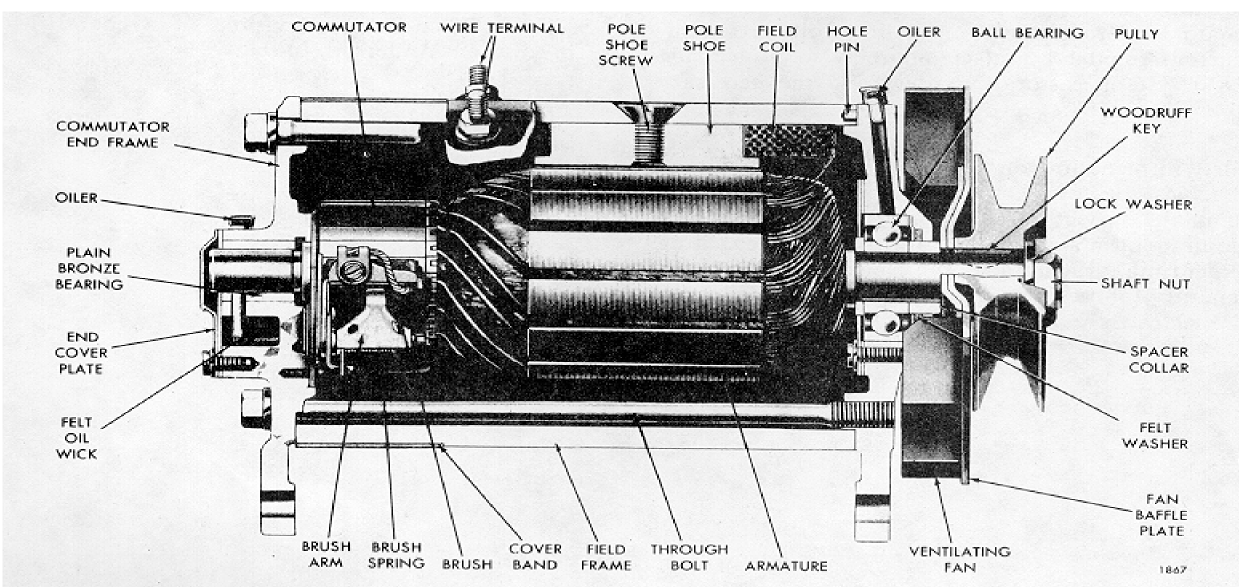


Fig. 2 - Typical Direct Current Generator

7.1 Battery-Charging Generator

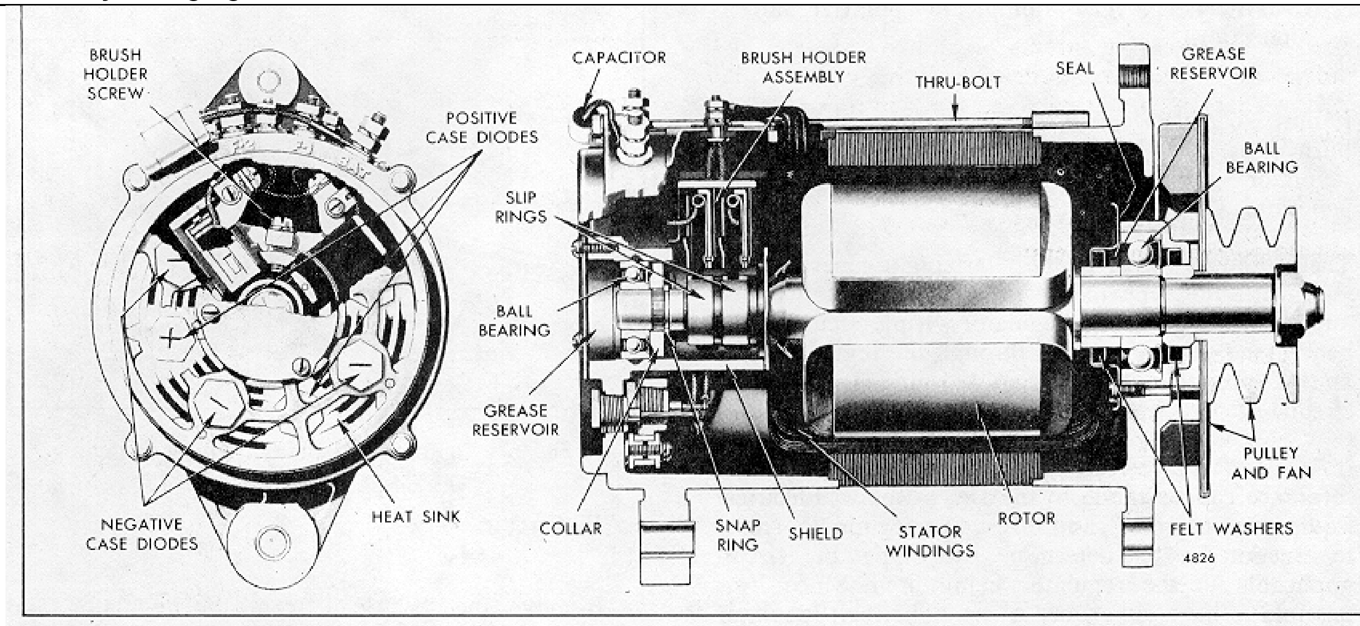


Fig. 3- 30 DN Type 250 A.C. Self-Rectifying Generator (Alternator)

Generator Maintenance

1. Maintain the proper drive belt tension. Replace worn or frayed belts. Belts should be replaced as a set when there is more than one belt on the generator drive.

2. Lubricate the generator bearings as outlined in the Lubrication and Preventive Maintenance Chart in Section 15.1.

Remove Generator

1. Disconnect all of the leads from the generator and tag each one to ensure correct re-installation.

2. Loosen the generator mounting bolts and nuts and the adjusting strap bolt. Then remove the generator drive belts.

3. While supporting the generator, remove the adjusting strap bolt and washers and the mounting bolts. washers and nuts. Then remove the generator.

4. Remove the pulley assembly if the generator is to be replaced.

Install Generator

1. Install the generator drive pulley, if it was removed. Tighten the pulley retaining nut to 50-60 lb-ft torque (Fig. 5)

NOTE: If the pulley was not removed, check the retaining nut for proper torque.

2. Position the generator on the mounting brackets and start the bolts, with lock washers, through the bolt holes in the generator end frames. If nuts are used, insert the bolts through the bolt holes and then install the lock washers and nuts.
3. Align the threaded hole in the extension ear of the drive end frame with the slot in the adjusting strap. Start the bolt, with the lock washer and plain washer, through the slot of the adjusting strap and into the threaded hole in the generator end frame.
4. Place the drive belts in the grooves of the pulleys.
5. Adjust the generator belt tension as outlined in Section 15.1.
6. Attach the wires and cables. Be sure that each one is correctly installed in accordance with its previous location on the generator. Keep all connections clean and tight.

Polarizing D.C. Generator

After each check or adjustment of the voltage regulator or generator, particularly after the leads have been disconnected and then reconnected, it is necessary to polarize the D.C. generator before starting the engine. This is to ensure correct polarity with respect to the battery.

CAUTION: Never attempt to polarize an alternator.

Failure to polarize a D.C. generator will result in burned or stuck cutout relay contact points in the regulator, a rundown battery and damage to the generator.

The procedure for correctly polarizing a generator will vary with the type of electrical equipment installed and upon the generator regulator wiring circuit. If the generator field is grounded through the regulator, it is an "A" circuit; if it is internally grounded, it is a "B" circuit.

If Delco-Remy electrical equipment is installed, reference can be made to the Delco-Remy "Electrical Equipment Manual" and "Test Specifications" (refer to Section 7) to determine the type of circuit applicable to the regulator being used. Since it is possible to have either an "A" or "B" circuit regulator with any given generator, the polarizing procedures must be carefully adhered to. Use of the wrong polarizing procedure or neglecting to polarize will result in reversed generator polarity and serious damage to electrical components.

After ascertaining the correct circuit used, polarize the generator as outlined below:

1. "A" Circuit:

   Connect a jumper lead momentarily between the "BAT" and "GEN" terminals of the regulator.

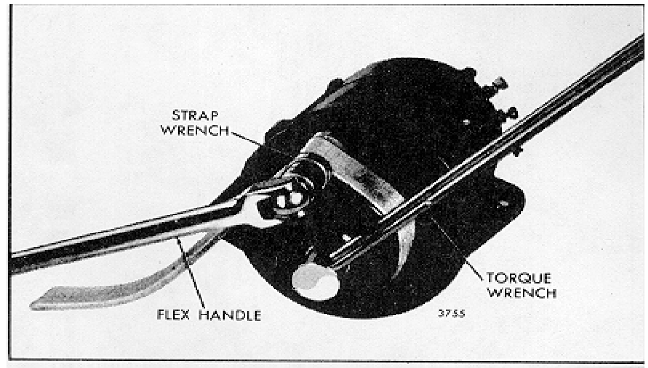


Fig. 5 - Tightening Generator Pulley Retaining Nut

2. "B" Circuit:

Remove the "F" lead from the regulator and momentarily connect it to the "BAT' terminal of the regulator.

A momentary surge of current to the generator correctly polarizes it with respect to the battery.

Alternator Precautions
Precautions must be taken when working on or around alternators. The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

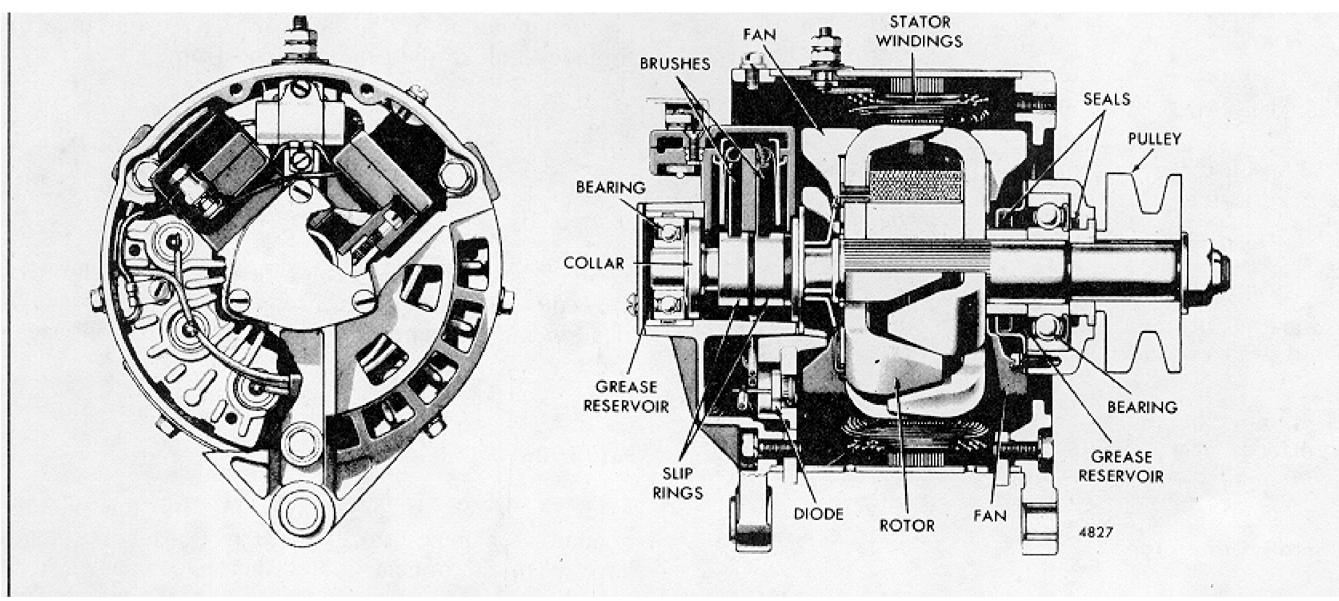


Fig. 4 · 20DN Type 250 A.C. Self-Rectifying Generator (Alternator)

Avoid grounding or shorting the output wires or the field wires between the generator and the regulator. Never run an alternator on an open circuit.

Grounding an A.C. generator's output wire or terminals, which are always "hot" regardless of whether or not the engine is running, or accidental reversing of the battery polarity will destroy the diodes. Grounding the field circuit will also result in the destruction of the diodes. Some voltage regulators provide protection against some of these circumstances. However, it is recommended that extreme caution be used.

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery may result in damage to the generator diodes due to the momentary high voltage and current generated by the rapid collapse of the magnetic field surrounding the field windings.

If a booster battery is to be used, the batteries must be connected correctly (negative to negative and positive to positive).

Never use a fast charger with the battery connected or as a booster for battery output. Never attempt to polarize the alternator.

The alternator diodes are also sensitive to heat and care must be exercised to prevent damage to them from soldering irons, etc.

If faulty operation of an alternator occurs on an engine equipped with an insulated starting motor, check to be sure that a ground strap is present and is correctly installed.

STANDARD REGULATOR FOR BATTERY-CHARGING GENERATOR (DC Charging Circuit)

To regulate the voltage and current output of the battery-charging generator, and to maintain a fully charged storage battery, several protective devices are employed, depending upon the type of electrical system. The most representative of these devices is the "three-unit" regulator.

These regulators are identified as:

a. A "Circuit B" unit in which the generator field circuit passes through the regulator and returns to ground inside the generator itself. This regulator must be used only with "Circuit B" generators in which the field is internally grounded.

b. A "Circuit A" unit in which the generator field circuit is connected to ground within the regulator, and is used only with generators having an externally grounded field circuit.

The regulators are dust and moisture-proofed. On most applications, it is necessary to use shock mounts which insulate the regulator against vibration but necessitates the installation of a ground lead.

The three-unit regulator consists of a cutout relay, a voltage regulator, and a current regulator mounted in a single assembly as shown in Fig. 1. These three units are basic and generally apply to most regulators in a DC generator system.

CUTOUT RELAY

The cutout relay has two windings assembled on one core, a series winding of a few turns of heavy wire and a shunt winding of many turns of fine wire. The relay core and windings are assembled into a frame. A flat steel armature is attached to the frame by a hinge so it is centered just above the center of the core. The armature has two or more contact points which are located just above a similar number of stationary contact points.

Operation

When the engine is not running, the armature contact points of the relay are held away from the stationary points by tension of a leaf spring.

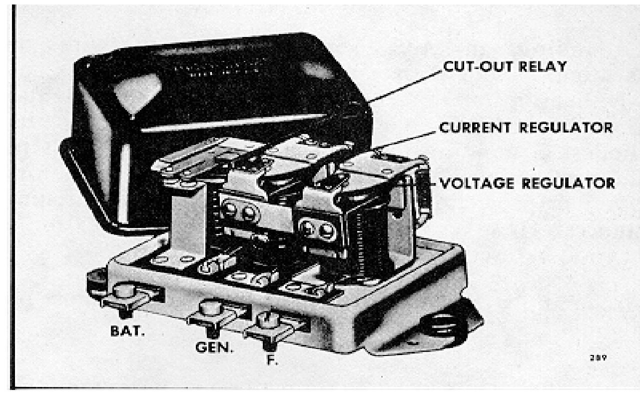


Fig. 1 - Typical Regulator Assembly

As the engine starts and the generator speed increases, the current flowing through the shunt winding builds up until it reaches the value for which the relay has been set. At this point, sufficient magnetism overcomes the armature spring tension, the contact points close, and the current flows to the battery. Then, the current which flows through the series winding is in the right direction to add to the magnetic force holding the armature down and the points closed.

When the engine is slowed down or stopped, current will begin to flow from the battery to the generator. This reverses the direction of current flow through the series winding, causing a reversal of the series winding magnetic field. The magnetic field of the shunt winding does not reverse. Therefore, the two windings now oppose each other magnetically and the resultant magnetic field is not strong enough to hold the armature down. The leaf spring pulls the armature away from the core and the points separate, opening the circuit between the generator and the battery.

> **CAUTION**: The DC generator regulator cutout relay contact points must never be closed by hand with the battery connected. This would cause a high current flow through the units and damage them.

VOLTAGE REGULATOR

The voltage regulator has two windings on a single core. One is a shunt winding consisting of many turns of fine wire which, in series with a resistor, is shunted across the generator at all times. The second winding is a field current winding which is connected between the generator field circuit and ground whenever the regulator contact points are closed. In addition to the core frame, armature and contact points, the unit has a spiral spring which holds the armature away from the core so the two contact points are touching when the voltage regulator is not operating.

Operation

When the generator voltage reaches the value for which the voltage regulator is adjusted, the combined magnetic field produced by the shunt winding and the field current winding overcomes the armature spring tension, pulls the armature down, and separates the voltage regulator contact points. This introduces resistance into the generator field circuit so the generator field current and generator voltage are reduced. The lowering of the output of the generator causes the points to again close, thereby removing the resistance and increasing the generator output. The complete cycle, of opening and closing of the points and the alternate inserting and removing of the resistance in the generator field circuit, is done rapidly, thus limiting the generator voltage to a predetermined maximum value. With the generator voltage limited, the generator supplies varying amounts of current to meet the requirements of varying states of battery charge and electrical loads.

CURRENT REGULATOR

The current regulator contains two windings assembled on one core, a series winding and a field current winding. The series winding, consisting of a few turns of heavy wire, is connected into the charging circuit so the full output of the generator passes through it. The field current winding is connected in series with the generator field circuit so the field current flows through it when the regulator contact points are closed.

The outward appearance of the current regulator is similar to that of the voltage regulator.

Operation

The magnetism produced by current flowing through the series winding overcomes the armature spring tension, and the contact points open when the current reaches the value for which the current regulator is adjusted. This inserts a resistance into the generator field circuit, resulting in a drop in generator output. Immediately, the magnetic field of the series winding is weakened, the contact points close, the generator output starts to increase and the cycle is repeated. This action prevents the generator from exceeding its rated output.

Therefore, when the load demand is heavy, generator output will increase until it reaches the current value for which the current regulator is set; then, the current regulator will begin to operate and pre-regulate the current output from the generator.

After any check or adjustment of the voltage regulator, it is necessary to polarize the generator before starting the engine to assure correct polarity with respect to the battery.

HEAVY DUTY REGULATOR FOR BATTERY-CHARGING GENERATOR
(DC Charging Circuit)

The carbon pile regulator (Fig. 2) is a heavy duty unit designed for use with a high output DC generator.

Compared with the vibrating-contact regulators, the carbon pile regulator functions on a different principle which should be clearly understood before adjustments of the regulator are attempted. In the carbon pile regulator, a stack or pile of small flat carbon disks is connected in series electrically with the generator field circuit. Control of the generator output is obtained by varying the pressure on the carbon stack which, in turn, varies its resistance without interrupting the field circuit.

The regulator (Fig. 2) contains an actuating relay, a circuit breaker relay, a voltage regulator, a current regulator, and an overload circuit breaker relay. In addition to these operating units, a system voltage rheostat is connected in series with the voltage regulator shunt winding.

In the carbon pile regulator, the units named in Fig. 2 perform the following functions. The actuating relay and circuit breaker relay operate together to close and open the charging circuit. The

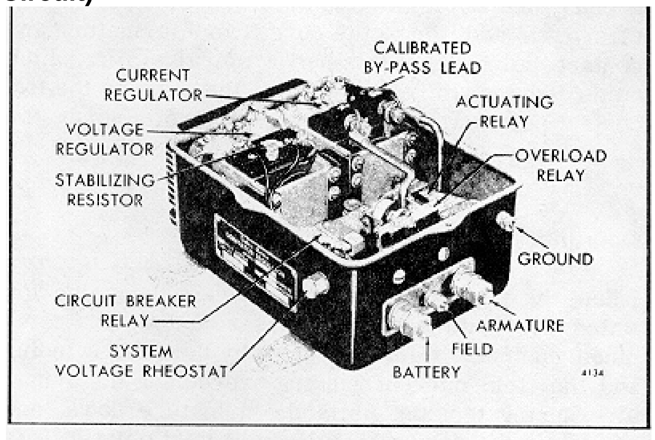


Fig. 2 - Carbon Pile Regulator Assembly

voltage regulator limits the generator voltage to a safe operating value. The current regulator limits the generator current output to its rated maximum. The system voltage rheostat provides an external means of adjusting the voltage regulator setting. The reverse current overload relay is a safety device which will cause the circuit breaker relay
contact points to open on excessive reverse current.

REGULATOR FOR BATTERY-CHARGING GENERATOR
(AC Charging Circuit)

There are two types of regulators being used with self-rectifying AC generators in the battery-charging circuit. One is a transistorized regulator which contains a vibrating voltage regulator unit and a field relay unit. The other is a transistor regulator which contains no moving parts and is used with a separately mounted field relay.

TRANSISTOR REGULATOR

The transistorized regulator (Fig. 3), for use on a negative ground circuit, contains a vibrating voltage regulator unit and a field relay unit. The regulator uses a single transistor and two diodes. The transistor works in conjunction with the conventional voltage unit having a vibrating contact point to limit the generator voltage to a pre-set value. A field discharge diode reduces arcing at the voltage regulator contacts by dissipating the energy created in the generator field windings when the contacts separate. A suppression diode prevents damage from transient voltages which may appear in the system.

Certain transistorized regulators are equipped with a choke coil to permit the installation of a capacitor between the regulator and the "BAT" terminal on installations experiencing radio interference. The capacitor suppresses the radio noise and the choke coil acts to prevent oxidation of the voltage regulator contacts. Regulators incorporating the choke coil are identified by a spot of green paint on the regulator base, next to the single mounting bolt-hole.

CAUTION: A capacitor must not be installed unless the transistorized

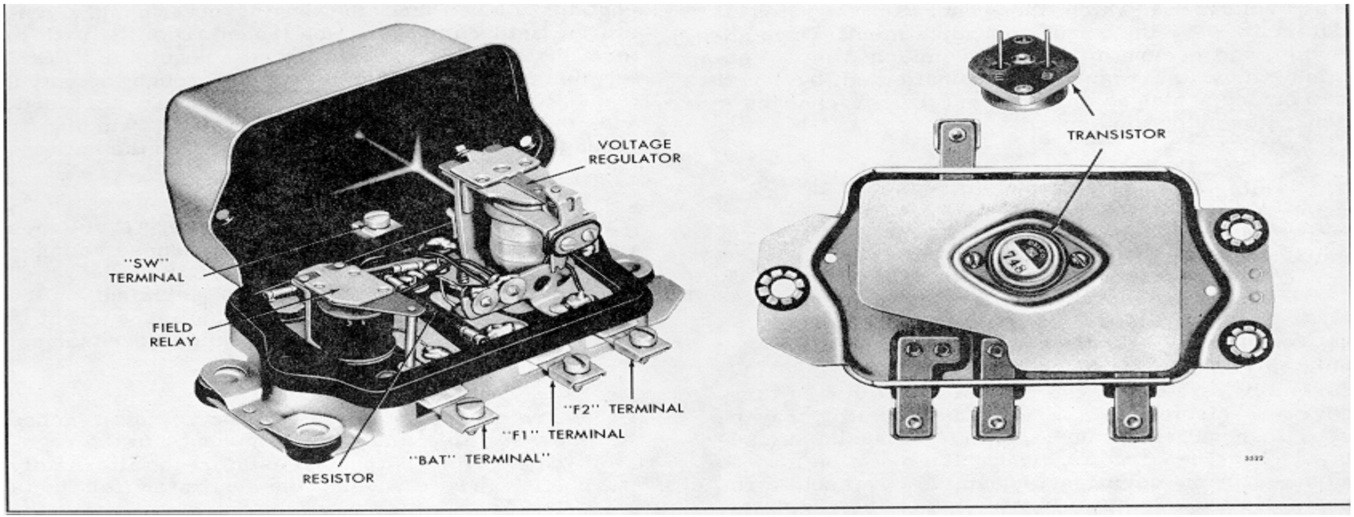


Fig. 3 - Transistorized Regulator

regulator incorporates the choke coil.

Operation

When the engine starting switch is closed, the field relay winding is energized and causes the contacts to close. Current then flows from the battery through the relay contacts to the regulator "'F2" terminal. From this point, the current flows through the generator field winding and then through the transistor and voltage contact points to ground.

As the generator speed increases, the increased voltage from the generator "BAT" terminal is impressed through the field relay contacts across the regulator shunt winding. The magnetism created in the winding causes the voltage contacts to open, thus causing the transistor to shut off the field current. The generator voltage then decreases, and the voltage contacts re-close. This cycle repeats many times per second, thereby limiting the generator voltage to the value for which the regulator is set.

The magnetism produced in an accelerator winding, when the voltage contacts are closed, aids the shunt winding in opening the contacts. When the contacts are open, the absence of the magnetism in the accelerator winding allows the spring to immediately re-close the contacts. This action speeds up the vibration of the contacts.

CAUTION: Do not short across or ground any of the terminals on the regulator or the generator and do not attempt to polarize the generator.

TRANSISTOR REGULATOR

The transistor regulator is composed principally of transistors, diodes, capacitors, and resistors to form a completely static electrical unit containing no moving parts.

The transistor is an electrical device which limits the generator voltage to a pre-set value by con- trolling the generator field current. The diodes, capacitors, and resistors act together to aid the transistor in performing this function, which is the only function that the regulator performs in the charging circuit.

The voltage at which the generator operates is determined by the regulator adjustment. Once adjusted, the generator voltage remains almost constant, since the regulator is unaffected by length of service, changes in temperature, or changes in generator output and speed.

The voltage regulator illustrated in Fig. 4 is designed for negative ground battery-charging circuits only. It has two exposed terminals. The voltage setting may be adjusted by relocating a screw in the base of the regulator.

The voltage regulator shown in Fig. 5 has shielded plug-in connections and .requires a cable and plug assembly to connect the regulator into the battery-charging circuit. This type of regulator may be used in negative ground, positive ground and insulated charging circuits. The voltage setting may be adjusted by removing a plug in the cover and turning a slotted adjusting button inside the regulator.

Operation

A separately mounted field relay connects the regulator "POPS" terminal and the generator field windings to the battery when the engine starting switch is closed.

In the negative ground circuit, with the field relay contacts closed and the engine not running, generator field current can be traced from the battery through the relay contacts to the regulator "POS" terminal. Current then continues through the output transistor of the regulator, to the "FLD" terminal, and then through the generator field winding to ground, completing the circuit back to the battery.

When the generator begins to operate, AC voltages are induced in the stator windings. These voltages are changed, or rectified, to a DC voltage which appears at the output, or "BAT," terminal on the generator. The generator then supplies current to charge the battery and operate vehicle accessories.

As generator speed increases, the voltage reaches the pre-set value and the components in the regulator cause the output transistor to alternately "turn off" and "turn on" the generator field voltage. The regulator thus operates to limit the generator output voltage to the pre-set value.

In the positive ground circuit, when the switch is closed and the engine is not running, field current can be traced from the battery positive ground to generator ground, and then to the regulator "POS" terminal. The current continues through the output transistor, to the regulator "FLD" terminal, and then through the field winding and field relay contacts back to the battery, thus completing the circuit. Except - for this primary difference this

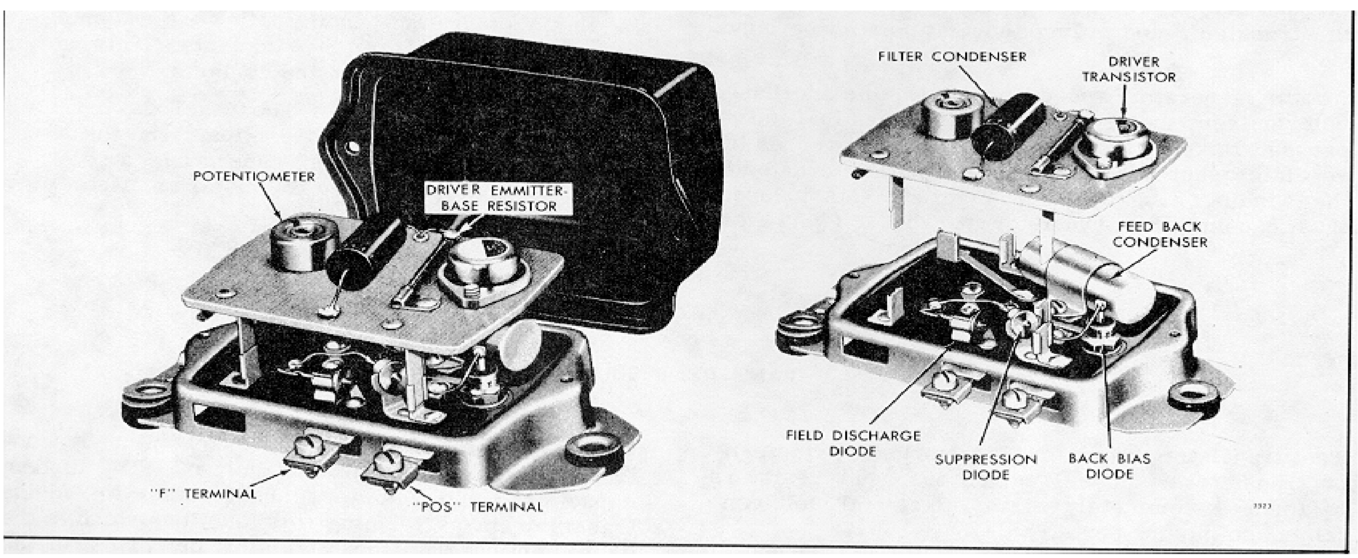


Fig. 4 - Former Transistor Regulator (Negative Ground Circuits Only)

7.1.1 REGULATOR FOR BATTERY-CHARGER GENERATOR

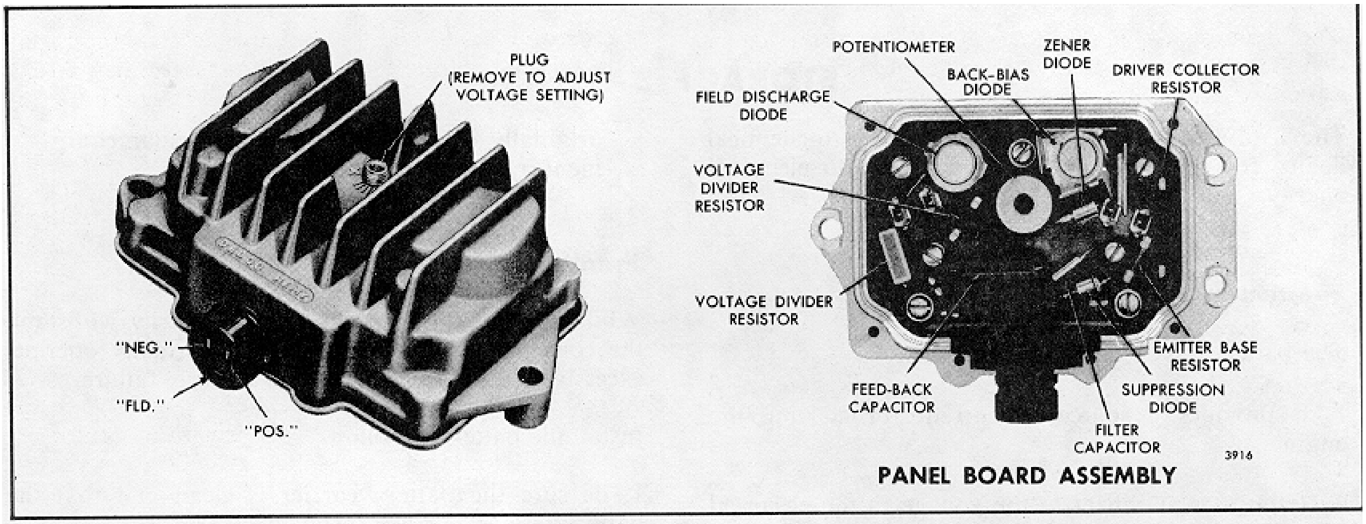


Fig. 5 -Current Transistor Regulator with Plug-In Connections.

circuit operates in the same manner as that described for the negative ground circuit.

Regulator Precautions

Never short or ground the regulator terminals; do not attempt to polarize the circuit.

Make sure all connections in the charging circuit are tight to minimize resistance.

Refer to "AC Generator Precautions" in Section 7.1.

STORAGE BATTERY

The lead-acid storage battery is an electro-chemical device for converting chemical energy into electrical energy.

Function of Battery

The battery has three major functions:

1. It provides a source of current for starting the engine.

2. It acts as a stabilizer to the voltage in the electrical system.

3. It can, for a limited time, furnish current when the electrical demands exceed the output of the generator.

Types of Batteries

There are two types of batteries in use today.

1. The dry charge battery contains fully charged positive plates and negative plates separated by separators. The battery contains no electrolyte until it is activated for service in the field and therefore leaves the factory dry. Consequently, it is called a dry charge battery.

2. If the battery has been manufactured as a wet battery, it will contain fully charged positive and negative plates plus an electrolyte. This type of battery will not maintain its charged condition during storage and must be charged periodically to keep it ready for service.

> **NOTE**: In the selection of a replacement battery, it is always good practice to select one of an "electrical size" at least equal to the battery originally engineered for the particular equipment by the manufacturer.

Install Battery

While the battery is built to satisfactorily withstand the conditions under which it will normally operate, excessive mechanical abuse leads to early failure.

Install the battery as follows:

1. Be sure the battery carrier is clean and that the battery rests level when installed.
2. Tighten the hold-down clamps evenly until snug. However, do not draw them down too tight or the battery case will become distorted or will crack.
3. Attach the cable clamps after making sure the cables and terminal clamps are clean and in good condition. To make the cable connections as corrosion resistant as possible, place a felt washer at the base of each terminal beneath the cable clamps. Coat the entire connection with a heavy general-purpose grease. Be sure the ground cable is clean and tight at the engine block or frame.
4. Check the polarity to be sure the battery is not reversed with respect to the generating system.
5. Connect the grounded terminal of the battery last to avoid short circuits which will damage the battery.

Servicing the Battery

A battery is a perishable item which requires periodic servicing. Only when the battery is properly cared for as described below can long and trouble-free service be expected.

1. Check the level of the electrolyte regularly. Add water if necessary, but do not overfill. Overfilling can cause poor performance or early failure.

2. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and re-apply a coat of grease when needed. Replace corroded or damaged parts.

4. Use the standard battery test as the regular service test to check the condition of the battery.

5. Check the electrical system if the battery becomes discharged repeatedly.

Many electrical troubles caused by battery failures can be prevented by systematic battery service. In general, the care and maintenance recommendations for storage batteries are the same today as they have always been.

Battery Safety Precautions
When batteries are being charged, an explosive gas mixture forms beneath the cover of each cell. Part of this gas escapes through the holes in the vent plugs and may form an explosive atmosphere around the battery itself if ventilation is poor. This explosive gas may remain in or around the battery for several hours after it has' been charged. Sparks or flames can ignite this gas causing an internal explosion which could shatter the battery.

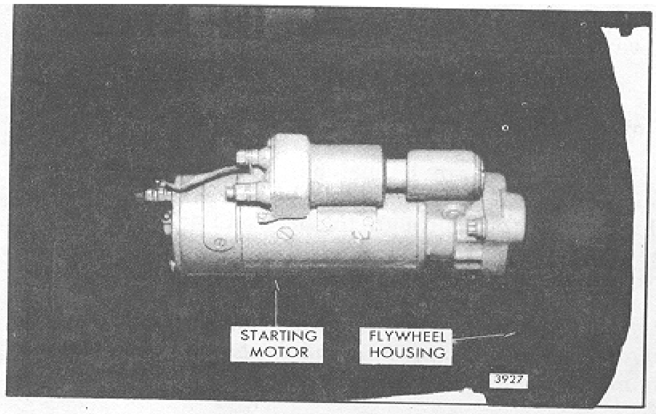


Fig. 1 - Sprag Overrunning Clutch Type Starting Motor Mounting (Current)

The starting motor is mounted on the flywheel housing as illustrated in Fig. 1. When the starting circuit is closed, a small drive pinion on the armature shaft engages with the teeth on the engine flywheel ring gear to crank the engine. When the engine starts, it is necessary to disengage the drive pinion to prevent the armature from overspeeding and damaging the starting motor. To accomplish this, the starting motor is equipped with a heavy-duty sprag overrunning clutch or a Dyer drive.

Sprag Overrunning Clutch Type Starting Motor

A solenoid switch, mounted on the starting motor housing, operates the current sprag type overrunning clutch drive by linkage and a shift lever (Fig. 2). When the starting switch is engaged, the solenoid is energized and shifts the starting motor pinion into mesh with the flywheeel ring gear and closes the main contacts within the solenoid. Once engaged, the clutch will not disengage during intermittent engine firing. To protect the armature from excessive speed when the engine starts, the clutch "overruns", or turns faster than the armature, which permits the pinion to disengage itself from the flywheel ring gear.

The solenoid plunger and shift lever on this type of starting motor is totally enclosed to protect them from dirt, water and other foreign material.

An oil seal, between the shaft and the lever housing, and a linkage seal (Fig. 2) prevents the entry of transmission oil into the main frame of the starting motor and solenoid case, allowing the motor to be used on wet clutch applications.

The nose housing on the sprag clutch type starting motor can be rotated to obtain a number of different solenoid positions with respect to the mounting flange. The nose housing, on starters equipped with the heavy-duty clutch, is attached to the lever housing by

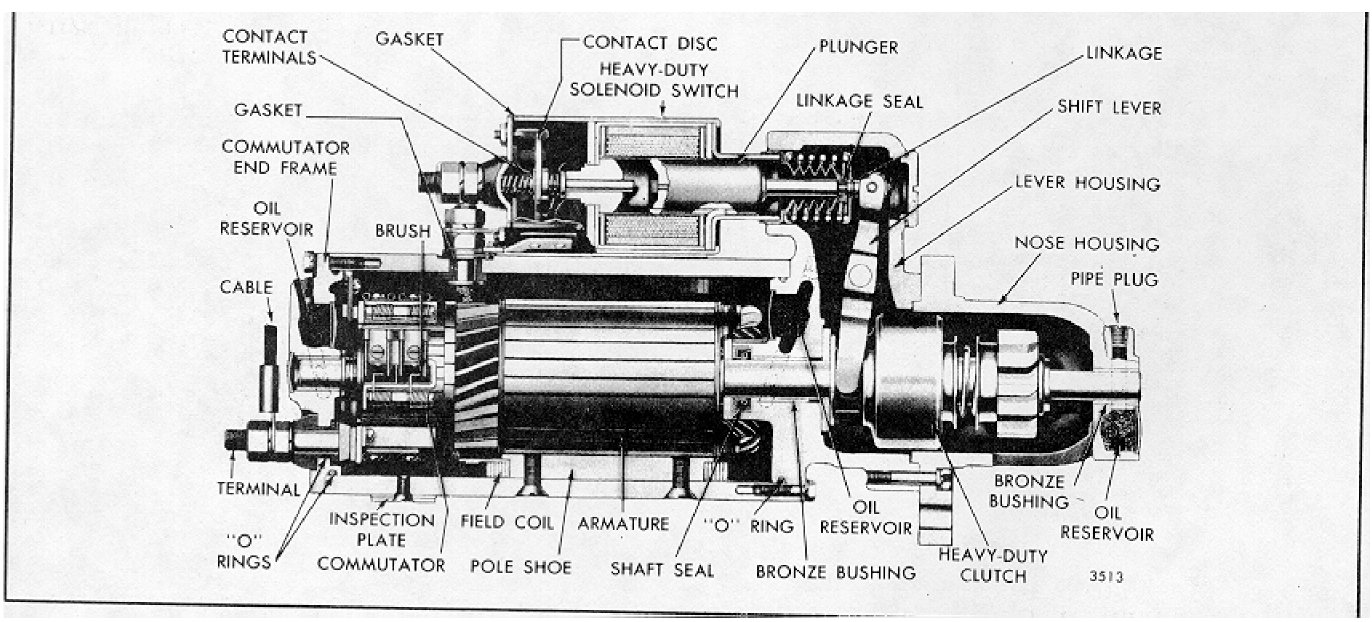


Fig. 2 - Cross-section of Starting Motor with Sprag Heavy-Duty Clutch Drive

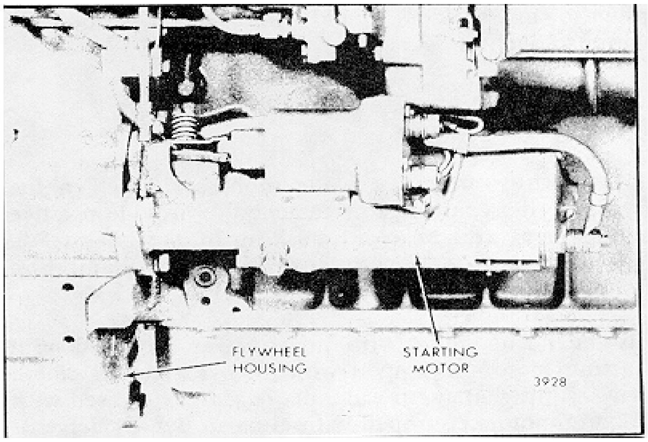


Fig. 3 - Dyer Drive Type Starting Motor Mounting (Former)

six bolts located around the outside of the housing (Fig. 2).

NOTE: When installing a current flywheel housing on an early engine, the starting motor nose housing may have to be indexed to reposition the solenoid.

When repositioning of the solenoid is required on a service replacement starting motor, proceed as follows:

1. Remove the six socket head screws (I short and 5 long) and six neoprene plugs, if a twelve hole starter mounting flange is used.

2. Turn the nose housing to the required position.

NOTE: The solenoid must never be located below the centerline of the starter or dust, oil, moisture and foreign material can collect and cause solenoid failures.

3. Install the six socket head screws, with the short screw in the shallow hole nearest the solenoid and six neoprene plugs, if a twelve hole starter mounting flange is used.

4. Tighten the screws to 13-17 lb-ft torque.

High-Output Starting Motor

A high-output 12 volt starting motor, with a sprag overrunning clutch type drive, is provided for certain vehicle applications which require the equivalent of 24 volts for starting the engine and 12 volts for lighting and operation of electrical accessories. The same total battery capacity recommended for use with a 24 volt starter (two 205 ampere-hour batteries) must be retained and connected in parallel for the high-output 12 volt starter.

Dyer Drive Type Starting Motor

The former Dyer drive type starting motor (Fig. 3) is operated through a solenoid starting shift lever and switch mounted on the motor. The Dyer drive mechanism provides positive engagement of the starting motor pinion with the engine flywheel ring gear before the starting motor switch is closed and the armature begins to rotate.

When the engine starting switch is closed, the starter

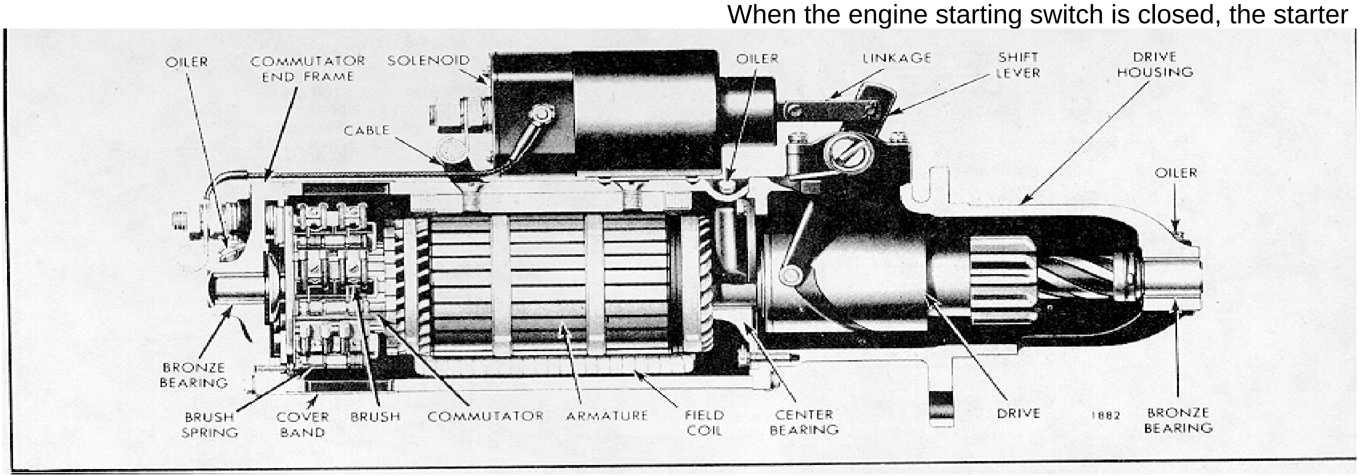


Fig. 4 - Cross-section of Starting Motor with Dyer Drive

solenoid (Fig. 4) is energized and the solenoid plunger pulls the pinion into mesh with the flywheel ring gear. Continued movement of the plunger then closes the solenoid switch contacts and permits the starting motor to crank the engine. As soon as the engine starts, the pinion is automatically de-meshed by the reversal of torque so the armature will not be subjected to excessive speeds.

> **NOTE:** When a current flywheel housing is installed on an early engine, it may be necessary to replace the Dyer drive starting motor with a sprag clutch type motor.

Lubrication

Starting motors which are provided with lubrication fittings (hinge cap oilers, oil tubes sealed with pipe plugs, or grease cups) should be lubricated periodically (refer to Section 15.1).

Flywheel Ring Gears

The starting motor drive pinion and the engine flywheel ring gear must be matched to provide positive engagement and to avoid clashing of the gear teeth. Flywheel ring gear teeth have either no-chamfer, a Bendix chamfer or a Dyer chamfer (Fig. 5).

Flywheel ring gears with no chamfer are used with starting motors equipped with an overrunning clutch drive. Ring gears with a Bendix chamfer are used with starting motors equipped with either a Bendix drive or an overrunning clutch drive. Ring gears with the Dyer chamfer, used with Dyer drive type starting motors, may be reversed and used with the overrunning clutch drive type starting motors.

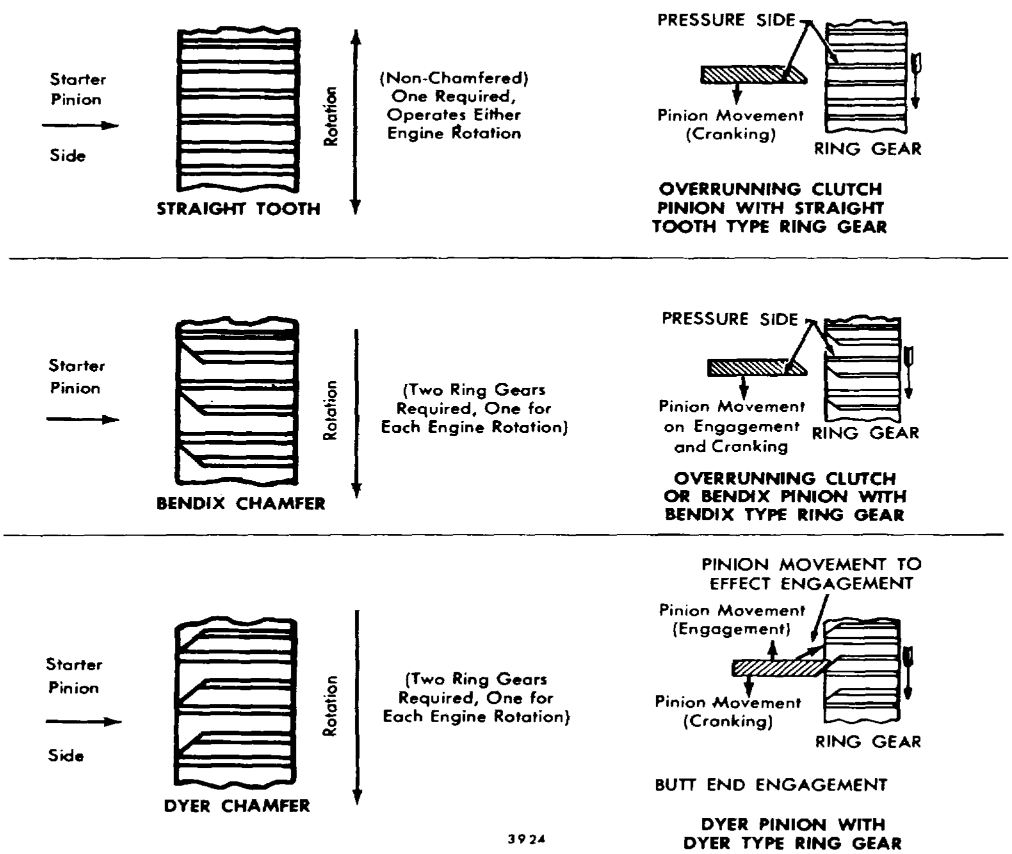


Fig. 5 - Types of Flywheel Ring Gears

If the wrong type of ring gear is used, repeated starting attempts will be required for engagement of the drive pinion and burring of the gear teeth will result.

Remove Starting Motor
Failure of the starting motor to crank the engine at normal cranking speed may be due to a defective battery, worn battery cables, poor connections in the cranking circuit, defective engine starting switch, low temperature, condition of the engine or a defective starting motor.

If the engine, battery and cranking circuit are in good condition, remove the starting motor as follows:

1. Remove the ground strap or cable from the battery or the cable from the starting motor solenoid. Tape the end of the cable to prevent discharging the battery from a direct short.
2. Disconnect the starting motor cables and solenoid wiring.

NOTE: Tag each lead to ensure correct connections when the starting motor is reinstalled.

3. Support the motor and remove the three bolts and lock washers which secure it to the flywheel housing. Then pull the motor forward to remove it from the flywheel housing.

Check the starting motor in accordance with the Delco-Remy "Cranking Circuit" maintenance handbook.

Install Starting Motor
To install the starting motor, reverse the procedure outlined for removal. Tighten the 5/8 "-11 starter attaching bolts to 137-147 lb-ft torque.

Keep all of the electrical connections clean and tight. When installing wiring terminal leads to the starting motor and the solenoid switch, tighten the No. 10-32 connections to 16-30 lb-in torque and the 1/2 "-13 connections to 20-25 lb-ft torque.

A solenoid switch is included in the starting system on a Series 71 engine using a Bendix drive starter to provide a means of opening and closing the circuit between the starting motor and the battery during the cranking operation. The switch is mounted on a plate which in turn may be mounted on or near the starting motor.

Specifications of a typical starting switch are as follows:

"Pull-In" Voltage potential of 15 volts, plus or minus one volt, is required to pull the plunger into operating position.

"Hold-In" Voltage potential of not less than 3.5 volts is required to hold the plunger in its opening position.

Resistance of Solenoid Winding is from 3.8 to 4.0 ohms.

Four terminals are provided on the switch, two of which are at the lower end for the connection of the battery and motor leads. Two smaller terminals, one on each side of the switch, are provided for the connection of the lead from the starting switch on the instrument panel and the lead from the fuse which is grounded to the engine base. Insulating bushings and washers are used to completely insulate the terminals from the switch body.

The starting motor-battery circuit is opened and closed inside the switch body by means of a contact disc (circular plate) which is attached to, but insulated from, a plunger which is free to move up or down within the body. When in the non-operating position, the contact disc is held away from the terminals by the tension of a spring, bearing against a cap attached to the upper end of the plunger.

Operation

When the instrument panel starting switch contacts are closed, a circuit is completed across the solenoid switch terminals (377) and (378) and through the coil (373), Fig. 1. The resultant magnetic field created in the core of the coil overcomes the tension of the return spring (380), Fig. 1, and the plunger (374) is drawn downward into the magnetic field, carrying the contact disc (375) with it. When the contact disc touches the contacts (376) and

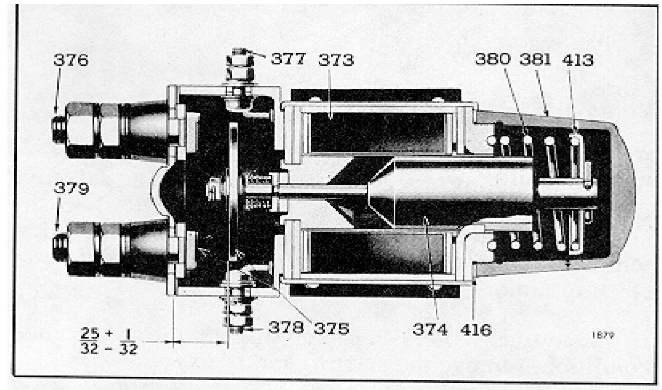


Fig. 1 - Typical Solenoid Switch Assembly

373	Coil	378	Stud--Terminal
374	Plunger and Rod Assy Cable Terminal	379	Stud--Starting Motor
375	Disc--Contact Return	380	Spring--Plunger
376	Stud--Battery Cable Terminal Spring	381	Cover--Plunger
		413	Cup--Plunger
377	Stud--Terminal Cover	416	Gasket--Plunger

(379), the circuit between the motor and battery is completed and the cranking operation begins.

The cranking operation continues until the circuit is broken by releasing the starting switch on the instrument panel. When this happens, the circuit through the coil is broken and the magnetic field collapses. This allows the return spring (380) to pull the plunger out of the coil core and the contact disc away from the battery and starting motor (studs) contacts.

Starting Cautions

1. Press starting button firmly.
2. If the engine fails to start after first attempt, do not press starting button again until engine has stopped rotating.

Serious damage may result to the starting motor if the above rules are not followed.

Periodically, inspect all terminals to make sure connections are clean and tight.

Remove Solenoid Switch

1. Disconnect the battery cable and the starter switch wire from the terminal stud (376), also disconnect starting motor cable from terminal stud (379).

2. Remove wires from switch terminals (377) and (378). Tag wires for identification.
3. Remove four nuts, lock washers, plain washers, and bolts, and remove solenoid switch.

Install Solenoid Switch

The switch may be reinstalled on the engine as outlined below:

1. Attach the switch to the mounting plate with four bolts, plain washers, lock washers and nuts.

2. Connect the battery cable and the starter switch wire to the terminal (376) and connect the starting motor cable to the terminal (379).

3. Connect the wires to the switch terminals (377) and (378).

INSTRUMENT PANEL AND INSTRUMENTS

The instruments generally required in the operation of a diesel engine consist of an oil pressure gage, water temperature gage, ammeter, and a mechanical tachometer. Instruments with slotted cases are available for use with lighted dashes. Also, closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine starting switch, and engine stop. knob, and an emergency stop knob.

Oil Pressure Gage
The oil pressure gage registers the pressure of the lubricating oil in 'the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed in the "Operating Conditions" in Section 13.2, the engine should be stopped and the cause of the low oil pressure determined and corrected before the engine is started again.

Water Temperature Gage
The engine coolant temperature in the water manifold is registered on the water temperature gage.

Incorrect water temperature readings will be registered if the gage assembly is incorrectly installed or the capillary tube is damaged.

To prevent damage to the gage assembly from vibration, the capillary tube must be securely fastened to the engine the full length with suitable clips at intervals of 10 inches or less. Sharp bends in the tube must be avoided, particularly at the gage or bulb connection areas. Where the tube must be bent around any object, the bend must not be less than 1 inch radius.

Any extra length can be taken up by coiling, the diameter of which should not be less than two inches. The coils must be located so that they may be securely fastened to prevent vibrating.

Ammeter
An ammeter is wired into the electrical circuit to show the current flow to and from the battery. After starting the engine, the ammeter should register a high charge rate at rated engine speed. This is the rate of charge received by the battery replenishing the current used to start the engine. As the engine continues to operate, the ammeter should show a decline in the charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery-charging generator. If lights or other electrical equipment is connected into the circuit, then the ammeter will show discharge when these items are operating and the engine speed is reduced.

Tachometer
The tachometer, driven by the engine, registers the speed of the engine in revolutions per minute (rpm).

Throttle Control

The engine throttle is connected to the governor speed control shaft through linkage. Movement of the speed control shaft changes the speed setting of the governor and thus the engine speed.

Engine Starting Switch
To start the engine, a switch is used to energize the starting motor. Starting switches may vary in design and their contacts must be rated sufficiently to carry the starter solenoid current.

Engine Stop Knob

A stop knob is used to shut the engine down. When stopping an engine, the engine speed should be reduced to idle and the engine allowed to operate at idle for a few minutes, to permit the coolant to reduce the temperature of the engine's moving parts. Then, the stop knob should be pulled and held until the engine stops. Pulling on the stop knob manually places the injector racks in the no-fuel position. The stop knob should be returned to its original position after the engine stops.

Emergency Stop Knob

In an emergency, or if the engine continues to operate after pulling the stop knob, the emergency stop knob may be used to stop the engine. When the emergency stop knob is pulled, the air shutdown valve, located between the air intake and the blower, will trip and shut off the air supply to the engine. Shutting off the supply of air to the engine will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine is stopped, and the air shut-down valve must be re-set manually. The cause of the malfunction should be determined before the engine is started again.

Tachometer Drive

A tachometer drive shaft may be installed at any one of several locations on the engine.

At the front end of the engine, the tachometer drive shaft is pressed into the end of the camshaft or balance shaft and extends through an adaptor attached to the balance weight cover.

The tachometer drive shaft may be installed in the end of either the camshaft, balance shaft or the blower drive shaft. A tachometer drive shaft adaptor is attached to the flywheel housing cover or the blower rear end plate cover. Where required, a tachometer drive cable adaptor is used to change the speed or to change direction of rotation, depending upon the location of the tachometer drive. A special key is used to connect the drive shaft to the tachometer drive cable adaptor.

Remove Tachometer Drive

If replacement is necessary, remove the tachometer drive shaft as follows:

1. Disconnect the tachometer drive cable from the tachometer drive cable adaptor.

2. If used, remove the tachometer drive cable adaptor and key (key and seal assembly if the tachometer drive shaft is driven by the-blower drive shaft).

3. Remove the tachometer drive shaft adaptor and gasket from the balance weight cover if the tachometer drive is located at the front of the engine. For a rear mounted tachometer drive, remove the flywheel housing cover and adaptor assembly and gasket. Examine the oil seal(s), if used, for wear or damage. Replace the oil seal (camshaft drive) or oil seal unit (blower drive shaft drive), if necessary.

4. If the tachometer drive shaft is driven by the blower drive shaft, remove the blower drive shaft.
5. Remove a tachometer drive shaft that is pressed into the camshaft as follows: Install Tachometer Drive

a. If threads (5/16"-24 or 3/8"-24) are provided on the outer end of the tachometer drive shaft to accommodate a removing tool, thread remover J 5901-3 on the shaft; then attach slide hammer J 2619 to the remover. A few sharp blows of the weight against the slide hammer rod will remove the tachometer drive shaft.

b. If threads are not provided on the outer end of the tachometer drive shaft, or if the end of the shaft is broken off, drill and tap the shaft. Then thread a stud into the shaft and remove the shaft with the remover and slide hammer.

   CAUTION: Use adequate protective measures to prevent the metal particles from falling into the gear train and oil pan.

1. Start the tachometer drive shaft in the end of the camshaft or blower drive shaft. Then, using a suitable sleeve, tap or press against the shoulder on the tachometer drive shaft until the shoulder contacts the camshaft or blower drive shaft.

2. Install the blower drive shaft.

3. Install the tachometer drive cover and adaptor on the flywheel housing. Use a new gasket.

4. Align the tachometer drive cover and adaptor with the tachometer drive shaft as outlined in Section 7.0.
5. Install the oil seal and key assembly (blower drive shaft driven tachometer drive).
6. If used, install the tachometer drive cable adaptor and key. Lubricate the tachometer drive cable adaptor with grease through the fitting provided.
7. Attach the tachometer drive cable.

SHUT-DOWN SYSTEM

A manually operated emergency engine shut-down device, mounted in the air inlet housing, enables the operator to stop the engine in the event an abnormal condition should arise. If the engine continues to run after the engine throttle is placed in the NO-FUEL position, or if combustible liquids or gases are accidentally introduced into the combustion chamber causing overspeeding of the engine, the shut-down device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The shut-down device consists of an air shut-down valve mounted in the air inlet housing and a suitable operating mechanism.

The air shut-down valve is retained in the open position by a latch. A Bowden wire is used to enable the operator to remotely trip the latch. Pulling the emergency shut-down knob all the way out, will stop the engine. After the engine stops, the operator must push the emergency shut-down knob all the way in and manually reset the air shut-down valve before the engine is started again.

An electrically operated emergency shut-down device is used on certain engines. This device is similar to the manual shut-down except that a solenoid, operated by a push button switch, is used to trip the shut-down latch.

Inspection

Accumulation of dirt behind the steel ball in the detent lever may prevent the lever from moving

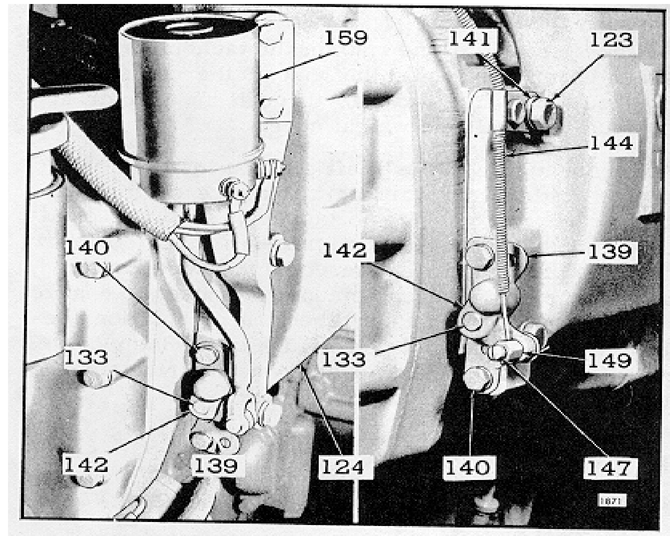


Fig. 1 - Typical Solenoid Operated and Manual Emergency Engine Shut-Down Device Mounting

123 Bolt	142 Lever--Valve
124 Housing--Air Inlet	144 Bowden Wire Assy.
133 Shaft--Valve	147 Screw--Wire Assy.
139 Lock Plate--Shut-Down	149 Nut--Valve Lever
140 Bolt--Lock Plate	159 Solenoid--ShutDown
141 Lock Washer	

when an attempt is made to close the valve. Make sure the ball detent is clean.

For disassembly and assembly of the emergency shut-down valve, refer to Section 3.3.

SHOP NOTES-SPECIFICATIONS-SERVICE TOOLS

SHOP NOTES

INSTALLING A TEMPERATURE GAGE CAPILLARY TUBE

A temperature gage may register incorrect readings if the capillary tube becomes damaged. Damage may occur if the tube has not been correctly installed and securely fastened to the engine. Factors such as sharp bends in the tube and continuous vibration can cause a faulty gage.

To install a temperature gage on an engine correctly, and prevent any subsequent damage to the capillary tube, the following precautionary steps must be taken.

1. Avoid sharp bends in the tube, particularly at each end where the tube is fastened to the gage and to the bulb. Also, whenever the tube is directed around a corner, the bend should not be less than a one inch radius.

2. The tube should be adequately supported for its full length to prevent excessive vibration. Fasten the tube securely to the engine by means of metal clips. The clips should be placed along the tube at intervals not exceeding ten inches.

3. Any extra length can be taken up by coiling; the diameter of the coils should not be less than two inches. The coils must be located so they may be securely fastened to prevent vibration.

INSTALLING A TEMPERATURE GAGE CAPILLARY SWITCH

If difficulty in starting motor engagement has been experienced in a vehicle which has been repowered by a diesel engine, check to see if the key-type starting switch on the instrument panel has been retained.

Key-type starting switches are usually not capable of carrying the current required for heavy-duty diesel engine starter solenoids. The excessive voltage drop in the solenoid circuit restricts the solenoid pull and results in failure of the starter to engage and crank. When tooth abutment occurs and the switch is turned off and on several times, breaking of the solenoid current causes burning or welding of the switch contacts.

Install a push button type starting switch which is capable of making, breaking and carrying the solenoid current without damage (refer to "Engine Starting Motor Switch" in Section 7.4). Otherwise, a heavy-duty magnetic switch should be used in the solenoid control circuit in addition to the key-type switch. The magnetic switch must be capable of making and breaking at least 90 amperes in a 12 volt system; the key switch would then carry no more than one ampere, which is sufficient to operate the magnetic switch.

CHECKING ENGINE ELECTRICAL GENERATING SYSTEM

Whenever trouble is indicated in the electrical generating system, the following quick checks can be made to assist in localizing the cause.

A fully charged battery and low charging rate indicates normal generator-regulator operation.

A low battery and high charging rate indicates normal generator-regulator operation.

A fully charged battery and high charging rate condition usually indicates the voltage regulator is set too high or is not limiting the generator output. A high charging rate to a fully charged battery will damage the battery and other electrical components.

A low battery and low or no charging rate condition could be caused by: Loose connections or damaged wiring, defective battery or generator (D.C. generator not or improperly polarized), and defective regulator or improper regulator setting.

ALINGNMENT TOOLS FOR TACHOMETER DRIVE COVER AND ADAPTORS

Whenever a tachometer drive cover assembly or a tachometer drive adaptor is installed on an engine, it is important that the cover assembly or adaptor by aligned properly with the tachometer drive shaft.

Misalignment of a tachometer drive shaft can impose a side load on a tachometer drive cable adaptor resulting in possible gear seizure and damage to other related components.

Use one of three tools in set J 23068 to establish the proper alignment. Figure 1 illustrates the use of the tools.

Because of the many different combinations of tachometer drive shafts, covers and adaptors available, it is not practical to itemize specific usages for each tool. When confronted with an alignment job, test fit each tool to determine which provides the best fit and proceed to make the alignment with that tool.

Correct alignment is established when there is no tachometer drive shaft bind on the inside diameter of the tool when one complete hand rotation of the engine is made.

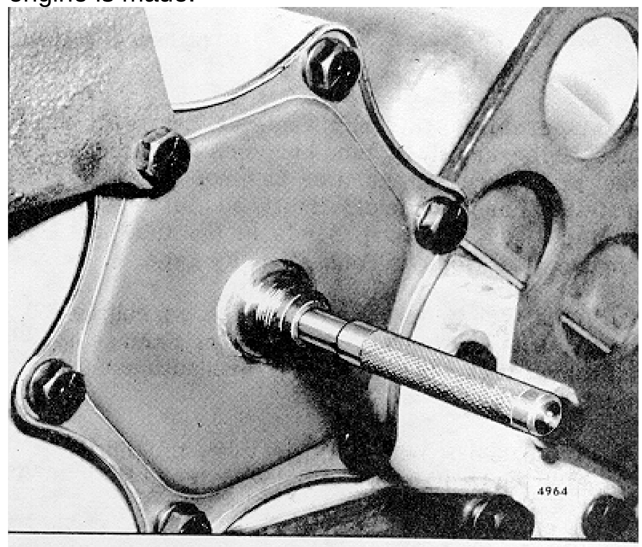


Fig. 1. -Checking Tachometer Drive Shaft Alignment

SPECIFICATIONS
STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

SIZE NUT OR BOLT	TORQUE (lb-ft)	SIZE NUT OR BOLT	TORQUE (lb-ft)	SIZE NUT OR BOLT	TORQUE (lb-ft)
1/4 - 20	7-9	7/16- 20	57-61	3/4- 10	240-250
1/4 - 28	8-10	1/2 - 13	71-75	3/4- 16	290-300
5/16 - 18	13-17	1/2 - 20	83-93	7/8 - 9	410420
5/16 - 24	15-19	9/16 - 12	90-100	7/8 -14	475-485
3/8 - 16	30-35	9/16 - 18	107-117	1 - 8	580-590
3/8 - 24	35-39	5/8 - 11	137-147	1 - 4	685-695
7/16 - 14	46-50	5/8 - 18	168-178		

SERVICE TOOLS

TOOL NO	TOOL NAME
J 2619	Slide Hammer
J 5901-3	Tachometer Drive Shaft Remover
J 23068	Tachometer Alignment Tool

SECTION 12

SPECIAL EQUIPMENT

CONTENTS

AIR COMPRESSOR

The air compressor (Fig. I) may be mounted on a bracket attached to the cylinder block of the engine and belt-driven from the crankshaft pulley, or it may be flange-mounted to the flywheel housing and gear driven by means of an accessory drive attached to the camshaft or balance shaft gear.

A six bolt design air compressor mounting base, mounting bracket and gasket are used on current engines equipped with a belt-driven air compressor. Formerly, the air compressor was attached to the base and bracket with four bolts. When installing a new air compressor, it is recommended that the new mounting parts be used to eliminate the possibility of the bracket loosening and causing oil seepage at the gasket.

The air compressor runs continuously while the engine is running. While the compressor is running, actual compression of air is controlled by the compressor governor which acts in conjunction with the unloading mechanism in the compressor cylinder block. The governor starts and stops the compression of air by loading or unloading the compressor when the air pressure in the system reaches the desired minimum or maximum pressure.

During the down stroke of each piston, a partial vacuum is created above the piston which unseats the inlet valve and then allows air drawn from the air box in the engine cylinder block or through an intake strainer to enter the cylinder above the piston. As the piston starts the upward stroke, the air pressure on top of the inlet valves, plus the inlet valve return spring force, closes the inlet valve. The air above the piston is further compressed until the pressure lifts the discharge valve and the compressed air is discharged through the discharge line into the reservoir.

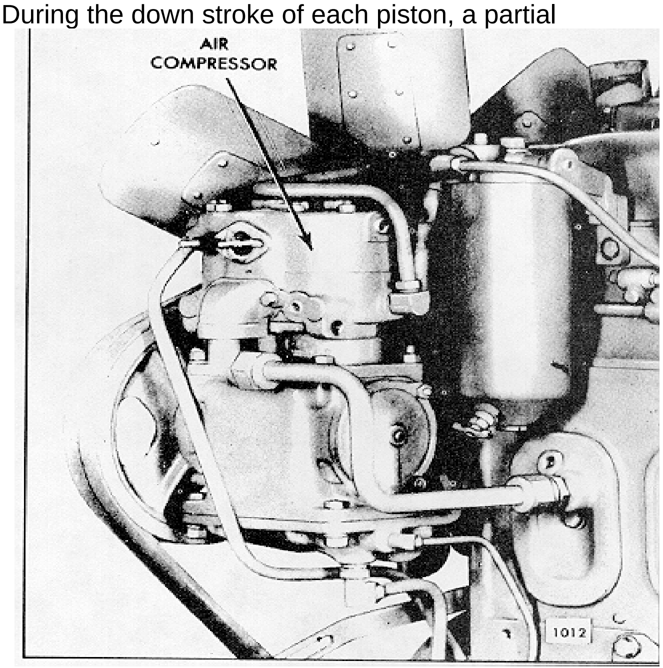


Fig. 1 - Air Compressor Mounting

As each piston starts its downstroke, the discharge valve above it returns to its seat, preventing the compressed air from returning to the cylinder and the same cycle is repeated.

When the air pressure in the reservoir reaches the maximum setting of the governor, compressed air from the reservoir passes through the governor into the cavity below the unloading pistons in the compressor cylinder block. The air pressure lifts the unloading pistons which in turn lifts the inlet valves off their seats.

With the inlet valves held off their seats, the air during each upstroke of the piston is merely passed back through the air inlet cavity and to the other cylinder where the piston is on the downstroke. When the air pressure in the reservoir drops to the minimum setting of the governor, the governor releases the air pressure beneath the unloading pistons. The unloading piston return spring then forces the piston down and the inlet valve springs return the inlet valves to their seats and compression is resumed.

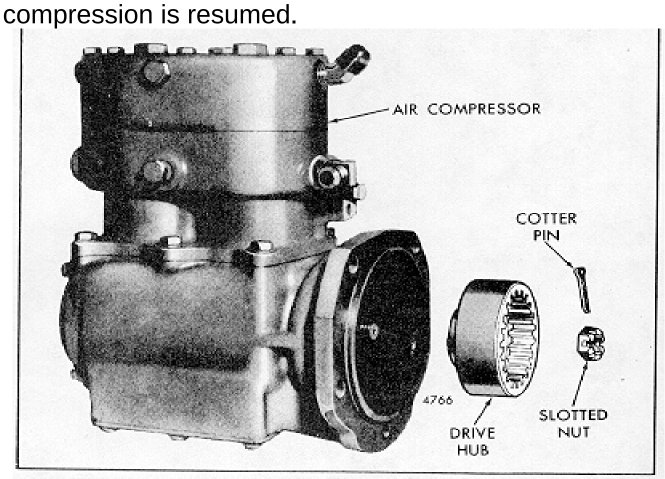


Fig. 2 - Typical Air Compressor with Drive Hub

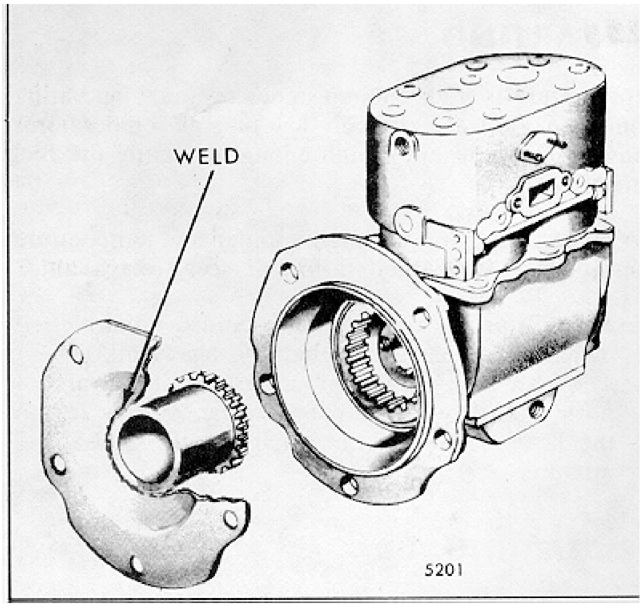


Fig. 3 - Fixture For Holding Drive While Installing or Removing Slotted Nut

Service Note

When installing a pulley or a drive hub on a flange mounted air compressor (Fig. 2), it is important the 3/4 "-10 drive shaft slotted nut be tightened to 100 lb-ft torque minimum before installing the 3/32 " x 1-1/4 " cotter pin.

The air compressor drive shaft will turn during the torquing operation unless some provision is made to hold it. One way this can be done is to weld a modified drive coupling to a support or base which in turn can be anchored to the mounting flange of the compressor. An old flywheel housing cover that matches the flange of the compressor makes an ideal base for the modified coupling. With the exterior splines of the coupling in mesh with the internal splines of the drive hub and the entire assembly secured to the compressor housing, the hub and shaft are kept from rotating when the torque is applied. That part of the base within the inner diameter of the coupling must be removed to permit placement of the wrench socket on the nut. Two bolts will secure the base to the compressor during the torquing operation (Fig. 3).

COLD WEATHER STARTING

When starting an internal combustion engine in cold weather, a large part of the energy of combustion is absorbed by the pistons, cylinder walls, coolant and in overcoming friction.

Under extremely low outside temperatures, the cold oil in the bearings and between the pistons and cylinder walls creates very high friction and the effort required to crank the engine is much greater than when the engine is warm.

In a diesel engine, the normal means of igniting the fuel sprayed into the combustion chamber is by the heat of the air compressed in the cylinder. This temperature is high enough under ordinary operating conditions, but at extremely low outside temperatures may not be sufficiently high enough to ignite the fuel injected.

To assist in starting an engine under low temperature conditions, cold weather starting devices are available.

NOTE: Starting aids are not intended to correct deficiencies such as low battery, heavy oil, etc. They are for use when other conditions are normal but the air temperature is too low for the heat of compression to ignite the fuel-air mixture.

PRESSURIZED CYLINDER STARTING AID

Operation

Start the engine during cold weather, using the "Quick Start" starting aid system (Fig. I) as follows:

1. Press the engine starter button.
2. Pull out the "Quick Start" knob for one or two seconds, then release it.
3. Repeat the procedure if the engine does not start on the first attempt.

CAUTION: Do not crank the engine more than 30 seconds at a time when using an electric starting motor. Always allow one minute intervals between cranking attempts to allow the starting motor to cool.

Service

Periodically perform the following service items to assure good performance:

1. Remove the fluid cylinder and lubricate the valve around the pusher pin under the gasket with a few drops of oil.

2. Lubricate the actuator cable.

3. Actuate the valve with the cable to distribute the oil on the cable and allow the oil to run down through the valve.

4. Remove any dirt from the orifice by removing the air inlet housing fitting, the orifice block and the screen. Then blow air through the orifice end only.

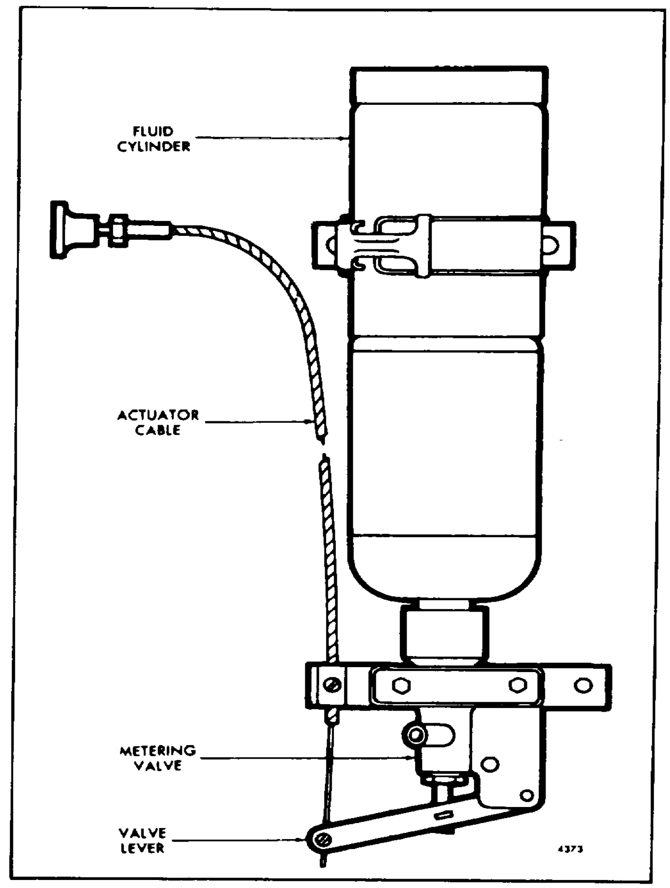


Fig. 1. - "Quick Start" Assembly

5. Assemble and tighten the air inlet housing fitting to the actuator valve and tube.

6. Check for leakage of fluid (fogging) on the outside of the engine air inlet housing by actuating the starting aid while the engine is stopped. If fogging occurs, disassemble and retighten the air inlet housing fitting to the housing.

> **CAUTION**: Do not actuate the starting aid more than once with the engine stopped. Over-loading the engine air box with this high volatile fluid could result in a minor explosion.

7. Check the fluid cylinder for hand tightness.

FLUID STARTING AID

The fluid starting aid is designed to inject a highly volatile fluid into the air intake system to assist ignition of the fuel at low ambient temperatures. It consists essentially of a pump and nozzle for injecting the fluid into the air intake and a suitable container for the fluid (Fig. 2). The fluid is contained in suitable capsules to facilitate handling.

This starting aid consists of a cylindrical capsule container fitted with a screw cap. Inside the container is a sliding plunger-like piercing shaft. From the capsule container, a tube leads from the container to a hand-operated pump and another tube leads from the pump to an atomizing nozzle threaded into a tapped hole in the air inlet housing.

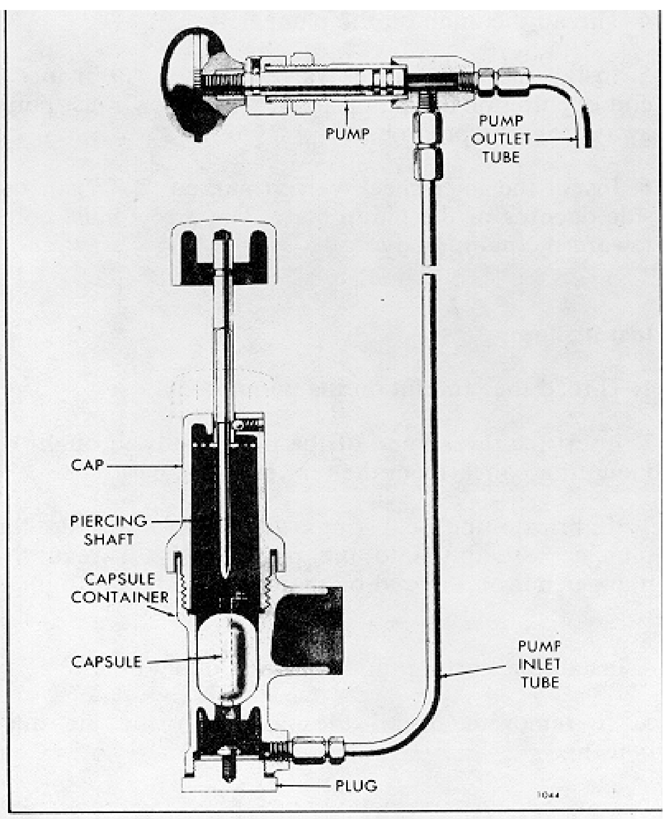


Fig. 2 · Fluid Starting Aid

Installation

The pump may be mounted on the instrument panel or in some other convenient location.' The capsule container must be mounted in a vertical position away from such high heat areas as the exhaust manifold, muffler, etc. and should not be located under a hood or in a cab. The atomizing nozzle is screwed into a tapped hole in the air inlet housing. The tank-to-pump tube should be 3/16 " O.D. copper tubing and the pump-to-nozzle tube 1/8 " O.D.

Operation

1. Refer to Fig. 2 and remove the cap from the capsule container. Insert a fluid capsule in the container.

> **CAUTION**: Mount the capsule in an upright position within the container. Use care when handling, since the starting fluid is both toxic and inflammable.

2. Pull the piercing shaft all the way out and thread the cap tight on the container.

3. Push the piercing shaft down until it bottoms. This will break the capsule and fill the container with starting fluid vapor.

4. Move the engine throttle to the full-fuel position.

5. Engage the starter and simultaneously pull the pump plunger all the way out. Then push the plunger in slowly, forcing the starting fluid through the atomizing nozzle and into the air intake. Continue to push the pump plunger in until the engine starts. If the plunger is not all the way in when the engine starts, push it in very slowly until it locks in the in position.

6. Unscrew the cap and remove the used capsule. Do not leave the empty capsule in the container.

7. Reinstall the cap tightly on the container body.
   NOTE: When not in use, the piercing shaft should be all the way down.

Starting Aid Pump

The principal parts of the starting aid pump are the body, plunger and the spring-loaded ball type inlet and outlet check valves (Fig. 2). The pump body is threaded externally at one end for mounting purposes. One end of the plunger is threaded into the operating knob. Two seal rings of oil resistant material are located in grooves at the other end of the plunger. The inlet check valve, which opens on the suction stroke of the plunger and seats under pressure, is located in the side opening of the pump body. The outlet check valve, which seats under suction and opens under pressure, is installed in the end opening of the pump body. The check valves are identified by the number “1/2” stamped on the inlet. valve and the number “30” on the outlet valve. An arrow indicating the direction of flow is also stamped on each check valve.

Remove Pump

Remove the starting aid pump from the mounting panel as follows:

1. Disconnect the starting fluid inlet and outlet tubes from the pump.

2. Unscrew the plunger nut from the pump body and withdraw the plunger assembly.

3. Loosen the pump body jam nut behind the mounting panel.

4. Remove the pump body from the rear of the panel.

5. Remove the jam nut from the pump body.

Disassemble Pump

When the pump was removed from its mounting panel, the plunger assembly was removed from the pump body. If further disassembly is required, proceed as follows:

1. Unscrew the knob from the plunger assembly.

2. Slide the plunger nut from the plunger.

3. The plunger lock ball and spring may be removed by tapping the plunger nut to dislodge them. It is not necessary to remove the plug.

4. Remove the inlet and outlet check valves.

Inspection

Clean the parts with fuel oil and dry them with compressed air. Examine the seal rings for wear or cracks. Replace the seal rings if necessary. The check valves cannot be disassembled. However, they may be cleaned by forcing fuel oil through them with any suitable pump. Inoperative valves must be replaced. If excessive resistance was encountered during operation of the pump, the nozzle in the air inlet housing may be plugged. Remove and clean the nozzle.

Assemble Pump

1. Install new seal rings on the plunger.

2. Install the lock spring in the plunger nut. Then place the steel ball on top of the spring.

3. Depress the lock ball and slide the plunger nut— hex end first—over the threaded end of the plunger.

4. Thread the knob on the plunger.

5. Install the outlet check valve (marked “30”) in the end opening of the pump body. The arrow must point away from the pump body.

6. Install the inlet check valve (marked “1/2”) in the side opening of the pump body. The arrow must point toward the pump body.

Install Pump

1. Thread the jam nut on the pump body.

2. Insert the thread end of the pump body through the mounting panel (from the rear of the panel).

3. Lubricate the seal rings and carefully slide the plunger assembly into the pump body. Thread the plunger nut on the end of the pump body and tighten it.

4. Install the starting fluid inlet and outlet tubes.

5. If removed, install the nozzle in the air inlet housing.

SECTION 13

OPERATING INSTRUCTIONS

CONTENTS

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow the instructions in Sections 13 and 14 of this manual. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

> **NOTE**: When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see Daily Operations in the Lubrication and Preventive Maintenance Chart, Section 15.1.

Cooling System

Install all of the drain cocks or plugs in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine is so equipped.

Remove the filler cap and fill the cooling system with clean, soft water or a protective solution consisting of high boiling point type antifreeze, if the engine will be exposed to freezing temperatures (refer to Engine Coolant in Section 13.3). Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

Use a quality rust inhibitor if only water is used in the cooling system.

Close the vents, if used, after filling the cooling system.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time.

It is recommended that the engine lubricating system be charged with a pressure prelubricator, set to supply a minimum of 25 psi oil pressure, to ensure an immediate flow of oil to all bearings at the initial engine start-up. The oil supply line should be attached to the engine so that oil under pressure is supplied to the main oil gallery.

With the oil pan dry, use the prelubricator to prime the engine with sufficient oil to reach all bearing surfaces. Use heavy-duty lubricating oil as specified under Lubricating Oil Specifications in Section 13.3. Then remove the dipstick, wipe it with a clean cloth, insert and remove it again to check the oil level in the oil pan. Add sufficient oil, if necessary, to bring it to the full mark on the dipstick. Do not overfill.

If a pressure prelubricator is not available, fill the crankcase to the proper level with heavy-duty lubricating oil as specified under Lubricating Oil Specifications in Section 13.3. Then pre-lubricate the upper engine parts by removing the valve rocker cover and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms.

Air Cleaner

If the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. Do not overfill.

Transmission

Check the oil level and, if necessary, add sufficient oil to bring it to the proper level.

Fuel System

Fill the fuel tank with the fuel specified under Diesel Fuel Oil Specifications in Section 13.3. If the unit is equipped with a fuel valve, it must be opened.

To ensure prompt starting, fill the fuel system between the pump and the fuel return manifold with fuel. If the engine has been out of service for a considerable length of time, prime the filter between the fuel pump and the injectors. The filter may be primed by removing the plug in the top of the filter cover and slowly filling the filter with fuel.

NOTE: The fuel system is filled with fuel before leaving the factory. If the fuel is still in the system when preparing to start the engine, priming should be unnecessary.

Lubrication Fittings

Fill all grease cups and lubricate at all fittings with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all drive belts as recommended under Lubrication and Preventive Maintenance in Section 15.1.

Storage Battery

Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

NOTE: When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

STARTING

Before starting the engine for the first time, perform the operations listed under Preparation For Starting Engine First Time.

Before a routine start, see Daily Operations in the Lubrication and Preventive Maintenance Chart, Section 15.1.

To start the engine, proceed as follows:

1. Apply the hand brake firmly. Put the transmission shift lever in the neutral position.

2. Make sure the engine stop and emergency stop knobs are pushed all the way in.

3. Hold the clutch pedal down. Energize the starter. If the engine does not start within 30 seconds, wait one minute to allow the starting motor to cool before trying again. If the engine does not start after four attempts, it is recommended that an inspection be made to determine the cause. Refer to the Trouble Shooting Charts in Section 15.2.

4. Release the starting switch immediately when the engine starts. Check the oil pressure gage; oil pressure should be indicated within a few seconds after starting.

NOTE: Do not push or tow the vehicle to start it. Excessive raw fuel will be introduced into the engine and serious damage to the cylinders and pistons will result.

Starting at air temperatures below 40 ° F. requires the use of a cold weather starting aid. See Cold Weather Starting, Section 12.6.

The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

CAUTION: Starting fluid used in capsules is highly inflammable, toxic and possesses anesthetic properties.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system. Refer to the Trouble Shooting Charts in Section 15.2.

Warm-Up

Warm-up a cold engine at about 800 rpm. Avoid all unnecessary idling during normal operation. Operate at rated speed and apply load after the engine has warmed-up.

Inspection

While the engine is running at operating temperature, check for coolant, fuel or lubricating oil leaks. Tighten the line connections where necessary to stop leaks.

Engine Temperature

Normal engine coolant temperature is 160 C F. to 185 ° F

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached, allow the oil to drain (approximately 10 minutes) back into the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the heavy duty lubricating oil specified under Lubricating Oil Specifications in Section 13.3.

Cooling System

Remove the radiator cap slowly after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or a high boiling point type antifreeze.

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

> **NOTE**: When prolonged engine idling is necessary, maintain at least 800 rpm.

STOPPING

Normal Stopping

1. Put all of the transmission shift levers in the neutral position and apply the hand brake.

2. Allow the engine to run at half speed or slower for a short time, then turn the control switch to off and pull the stop knob all the way out.

Emergency Stopping

If the engine does not stop after using the normal stopping procedure, pull the Emergency Stop knob all the way out. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected. The air shut-off valve, located on the blower air inlet housing, must be reset by hand and the Emergency Stop knob pushed in before the engine is ready to start again.

> **CAUTION**: The emergency shut-down system should never be used except in an emergency. Use of the emergency shut-down can cause oil to be sucked past the oil seals and into the blower housing.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open.

Crankcase

Check the oil level in the crankcase. Add oil, if necessary, to bring it to the proper level on the dipstick.

Transmission

Check the oil level in the transmission. Add oil, if necessary, to bring it to the proper level.

Fuel System

Fill the fuel tank; a full tank minimizes condensation.

Inspection

Make a visual check for leaks in the fuel, lubricating and cooling systems.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to the Lubrication and Preventive Maintenance Chart in Section 15.1 and perform all of the daily maintenance operations. Also perform all of the operations required for the number of miles the engine has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which may have occurred during the previous run.

ENGINE OPERATING CONDITIONS

The engine operating charts are included as ati aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represent true values, and that instruments are accurate, before attempting to make corrections to the engine.

71N ENGINES

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	30-60	38-60	40-60
Minimum for safe operation	18	27	30
*Lubricating oil temperature (degrees F.):			
Normal	200-225	200-225	200-225
Air System			
Air box pressure (inches mercury) - min. at full load:			
At zero exhaust back pressure	1.7	4.3	6.0
At max. full-load exhaust back pressure:	3.2	7.6	10.1
Air inlet restriction (inches water) - full-load speed, max.:			
Dirty air cleaner (oil bath or dry)	12.4	25.0	25.0
Clean air cleaner (with pre-cleaner) (oil bath or dry)	8.7	13.4	15.9
Clean air cleaner (less pre-cleaner) (dry)	5.2	9.1	11.5
Crankcase pressure (inches water) - max.:			
4-71N engine	1.8	2.5	2.8
6-71N engine	2.0	2.8	3.1
Exhaust back pressure (inches mercury) - max.:			
Full load	1.5	3.3	4.0
No load	1.0	2.1	2.6
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal (.080" orifice)	30-65	45-70	45-70
Fuel spill (gpm) - min. at no load:			
(.080" orifice)	0.8	0.9	0.9
Fuel pump suction at pump inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (degrees F.) - normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at seal level):			
Average - new engine at 600 rpm 565			
Minimum at 600 rpm 515			

*The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 100 lower.

ENGINE RUN-IN INSTRUCTIONS

Following a complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners or bearings, the engine should be "Run-in" on a dynamometer prior to release for service.

The dynamometer is a device for applying specific loads to an engine. It permits the serviceman to physically and visually inspect and check the engine while it is operating. It is an excellent method of detecting improper tune-up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.

The operating temperature within the engine affects the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature (160-185 ° F or 71-85 C) should be maintained throughout the Run-in.

The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10 ° higher than the water inlet temperature. Though a 10 rise across an engine is recommended, it has been found that a 15 °temperature rise maximum can be permitted.

A thermostat is used in the engine to control the coolant flow. Therefore, be sure it is in place and fully operative or the engine will overheat during the Run-in. However, if the dynamometer has a water standpipe with a temperature control regulator, such as a Taylor valve or equivalent, the engine should be tested without the thermostat.

The Basic Engine Run-In Schedule is shown in Table I. The horsepower shown is at SAE conditions: dry air density .0705 lb/cu. ft. (1.129 Kg/m 3, air temperature of 85°F (29.4°C), and 500 ft. (152 m) elevation.

DYNAMOMETER TEST AND RUN-IN PROCEDURES

The Basic Engine

The great number of engine applications make any attempt to establish comparisons for each individual model impractical. For this reason, each model has a basic engine rating for comparison purposes.

A basic engine includes only those items actually required to run the engine. The addition of any engine driven accessories will result in a brake horsepower figure less than the values shown in the Basic Engine Run-In Schedule. The following items are included on the basic engine: blower, fuel pump, water pump and governor. The fan and battery-charging alternator typify accessories not considered on the basic engine.

BASIC ENGINE RUN-IN SCHEDULE

10	21	28	4
30	67	90	13
30	82	110	16
30	85	118	18
30	92	128	19

ne of the speeds shown, whichever is at or n
ned speed and reset governor after final run,

FINAL ENGINE RUN-IN SCHEDULE
(Cross-Head Pistions)

Speed (rpm)	Time (minutes)	Horsepower	
		4-71T	6-71T
1200	10 (minimum)	28	42
2100	30	116	174
2100	30	130	195
2100	30	*	*

*Within ± 5% of rated bhp.

TABLE 1

13.2.1 Run-In Instructions

In situations where other than basic engine equipment is used during the test, proper record of this fact should be made on the Engine Test Report. The effects of this additional equipment on engine performance should then be considered when evaluating test results.

Dynamometer

The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger, and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit. The amount of power absorbed in a water brake type dynamometer, as an example, is governed by the volume of fluid within the working system. The fluid offers resistance to a rotating motion. By controlling the volume of water in the absorption unit, the load may be increased or decreased as required.

The power absorbed is generally measured in torque (lb-ft) on a suitable scale. This value for a given engine speed will show the brake horsepower developed in the engine by the following formula:

BHP = (T x RPM)/5250
Where:
BHP = brake horsepower
T - torque in lb-ft
RPM = revolutions per minute

Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.

During the actual operation, all data taken should be recorded immediately on an Engine Test Report (see sample on page 3).

Instrumentation

Certain instrumentation is necessary so that daia required to complete the Engine Test Report may be obtained. The following list contains both the minimum amount of instruments and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

a. Oil pressure gage installed in one of the engine main oil galleries.

b. Oil temperature gage installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.

c. Adaptor for connecting a pressure gage or mercury manometer to the engine air box.

d. Water temperature gage installed in the water outlet manifold.

e. Adaptor for connecting a pressure gage or water manometer to the crankcase.

f. Adaptor for connecting a pressure gage or mercury manometer to the exhaust manifold at the flange.

g. Adaptor for connecting a vacuum gage or water manometer to the blower inlet.

h. Adaptor for connecting a fuel pressure gage to the fuel manifold inlet passage.

i. Adaptor for connecting a pressure gage or mercury manometer to the turbocharger.

In some cases, gages reading in pounds per square inch are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is extremely important that the scale of such a gage be of low range and finely divided if accuracy is desired. This is especially true of a gage reading in psi, the reading of which is to be converted to inches of water. The following conversion factors may be helpful.

Inches of water = psi x 27.7"
Inches of mercury = psi x 2.04"

NOTE: Before starting the Run-In or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on Preparation for Starting Engine First Time in Section 13.1.

Run- In Procedure

The procedure outlined below will follow the order of the sample Engine Test Report.

A. PRE-STARTING

1. Fill the lubrication system as outlined under Lubrication System—Preparation for Starting Engine First Time in Section 13.1.
2. Prime the fuel system as outlined under Fuel System -- Preparation for Starting Engine First Time in Section 13.1.

ENGINE TEST REPORT

Date ____________ Unit Number ____________

Repair Order Number ____________ Model Number ____________

A — PRE-STARTING

1. PRIME LUBE OIL SYSTEM	2. PRIME FUEL SYSTEM	3. ADJUST VALVES	4. TIME INJ.	5. ADJ. GOV.	6. ADJUST INJ. RACKS

B — BASIC ENGINE RUN-IN

TIME AT SPEED	TIME START	TIME STOP	RPM	BHP	WATER TEMP.	LUBE OIL PRESS.

C — BASIC RUN-IN INSPECTION

1. Check oil at rocker arm mechanism	
2. Inspect for lube oil leaks	
3. Inspect for fuel oil leaks	
4. Inspect for water leaks	
5. Check and tighten all external bolts	
6.	

D — INSPECTION AFTER BASIC RUN-IN

1. Tighten Cylinder Head & Rocker Shaft Bolts		4. Adjust Governor Gap	
2. Adjust Valves (Hot)		5. Adjust Injector Racks	
3. Time Injectors		6.	

E — FINAL RUN-IN

TIME		TOP RPM		BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE F/L	CRANKCASE PRESSURE F/L
START	STOP	NO LOAD	FULL LOAD				

BLOWER INTAKE RES. - F/L	FUEL OIL PRESSURE RET. MAN. F/L	WATER TEMP. FULL LOAD	LUBE OIL TEMP. F/L	LUBE OIL PRESSURE		IDLE SPEED
				FULL LOAD	IDLE	

F — INSPECTION AFTER FINAL RUN

1. Inspect Air Box, Pistons, Liners, Rings	6. Tighten Oil Pump Bolts
2. Inspect Blower	7. Inspect Oil Pump Drive
3. Check Generator Charging Plate	8. Replace Lube Filter Elements
4. Wash Oil Pan, Check Gasket	9. Tighten Flywheel Bolts
5. Clean Oil Pump Screen	10. Rust Proof Cooling System

REMARKS:

Final Run OK'd ____________ Dynamometer Operator ____________ Date ____________

NOTE: Operator must initial each check and sign this report.

3. A preliminary valve clearance adjustment must be made before the engine is started. See Valve Clearance Adjustment in Section 14.1.

4. A preliminary injector timing check must be made before starting the engine. See Fuel Injector Timing in Section 14.2.

5. Preliminary governor adjustments must be made as outlined in Section 14.

6. Preliminary injector rack adjustment must be made (Section 14).

B. BASIC ENGINE RUN-IN

The operator should be observant at all times, so that any malfunction which may develop will be detected. Since the engine has just been reconditioned, this Run-in will be a test of the workmanship of the serviceman who performed the overhaul. Minor difficulties should be detected and corrected so that a major problem will not develop.

After performing the preliminary steps, be sure all water valves, fuel valves, etc. are open. Also inspect the exhaust system, being sure that it is properly connected to the engine. Always start the engine with minimum dynamometer resistance.

After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb-ft on the torque gage (or 10-15 HP on a horsepower gage). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.

Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.

Refer to the Engine Test Report sample which establishes the sequence of events for the test and run-in, and to the Basic Engine Run-In Schedule which indicates the speed (rpm), length of time and the brake horsepower required for each phase of the test. Also refer to the Operating Conditions in Section 13.2 which presents the engine operating characteristics.

These characteristics will be a guide for tracing faulty operation or lack of power.

Any four or six cylinder Series 71 engine to be run at speeds in excess of 1800 rpm must be equipped with a vibration damper.

Engine governors in most cases must be reset at the maximum full-load speed designated for the Run-in. If a governor is encountered which cannot be adjusted to this speed, a stock governor should be installed for the Run-in.

After checking the engine performance at idle speed and being certain the engine and dynamometer are operating properly, increase the engine speed to half speed and apply the load indicated on the Basic Engine Run-In Schedule.

The engine should be run at this speed and load for 10 minutes to allow sufficient time for the coolant temperature to reach the normal operating range. Record length of time, speed, brake horsepower, coolant temperature and lubricating oil pressure on the Engine Test Report.

Run the engine at each speed and rating for the length of time indicated in the Basic Engine Run-In Schedule. This is the Basic Run-In. During this time, engine performance will improve as new parts begin to “seat in”. Record all of the required data.

C. BASIC RUN-IN INSPECTION

While the engine is undergoing the Basic Run-In, check each item indicated in Section “C” of the Engine Test Report. Check for fuel oil or water leaks in the rocker arm compartment.

During the final portion of the Basic Run-In, the engine should be inspected for fuel oil, lubricating oil and water leaks.

Upon completion of the Basic Run-In and Inspection, remove the load from the dynamometer and reduce the engine speed gradually to idle and then stop the engine.

D. INSPECTION AFTER BASIC RUN-IN’

The primary purpose of this inspection is to provide a fine engine tune-up. First, tighten the cylinder head and rocker arm shaft bolts to the proper torque. Next, complete the applicable tune-up procedure. Refer to Section 14.

E. FINAL RUN-IN

After all of the tests have been made and the Engine Test Report is completed through Section “D”, the engine is ready for final test. This portion of the test and Run-in procedure will assure the engine owner that his engine has been rebuilt to deliver factory rated performance at the same maximum speed and load which will be experienced in the installation.

If the engine has been shut down for one hour or longer, it will be necessary to have a warm-up period of 10 minutes at the same speed and load used for warm-up in the Basic Run-In. If piston rings, cylinder liners or bearings have been replaced as a result of findings in the Basic Run-In, the entire Basic Run-In must be repeated as though the Run-in and test procedure were started anew.

All readings observed during the Final Run-In should fall within the range specified in the Operating Conditions in Section 13.2 and should be taken at full load unless otherwise specified. Following is a brief discussion of each condition to be observed.

The engine water temperature should be taken during the last portion of the Basic Run-In at full load. It should be recorded and should be within the specified range.

The lubricating oil temperature reading must be taken while the engine is operating at full load and after it has been operating long enough for the temperature to stabilize. This temperature should be recorded and should be within the specified range.

The lubricating oil pressure should be recorded in psi after being taken at engine speeds indicated in the Operating Conditions, Section 13.2.

The fuel oil pressure at the fuel manifold inlet passage should be recorded and should fall within the specified range. Fuel pressure should be recorded at maximum engine speed during the Final Run-In.

Check the air box pressure while the engine is operating at maximum speed and load. This check may be made by attaching a suitable gage (0-15 psi) or manometer (15-0-15) to an air box drain or to a hand hole plate prepared for this purpose. If an air box drain is used as a source for this check, it must be clean. The air box pressure should be recorded in inches of mercury.

Check the crankcase pressure while the engine is operating at maximum Run-in speed. Attach a manometer, calibrated to read in inches of water, to the oil level dipstick opening. Normally, crankcase pressure should decrease during the Run-in indicating that new rings are beginning to "seat-in".

Check the air inlet restriction with a water manometer connected to a fitting in the air inlet ducting located 2” above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to a fitting installed in the ¼”pipe tapped hole in the engine air inlet housing. If a hole is not provided, a stock housing should be drilled, tapped and kept on hand for future use.

The restriction at this point should be checked at a specific engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading. On turbocharged engines, take the reading on the inlet side of the turbocharger. The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting. Check the normal air intake vacuum at various speeds (at no-load) and compare the results with the Engine Operating Conditions in section 13.2. Record these readings on the Engine Test Report.

Check the exhaust back pressure at the exhaust manifold companion flange or within one inch of this location. This check should be made with a mercury manometer through a tube adaptor installed at the tapped hole. If the exhaust manifold does not provide a /8” pipe tapped hole, such a hole can be incorporated by reworking the exhaust manifold. Install a fitting for a pressure gage or manometer in this hole. Care should be exercised so that the fitting does not protrude into the stack. On turbocharged engines, check the exhaust back pressure in the exhaust piping 6” to 12” from the turbine outlet. The tapped hole must be in a comparatively straight area for an accurate measurement. The manometer check should produce a reading in inches that is below the Maximum Exhaust Back Pressure for the engine (refer to Section 13.2).

Refer to the Final Engine Run-In Schedule and determine the maximum rated brake horsepower and the full-load speed to be used during the Final Run-In. Apply the load thus determined to the dynamometer. The engine should be run at this speed and load for ½ hour. While making the Final Run-In, the engine should develop, within 5%, the maximum rated brake horsepower indicated for the speed at which it is operating. If this brake horsepower is not developed, the cause should be determined and corrections made.

When the above conditions have been met, adjust the maximum no-load speed to conform with that specified for the particular engine. This speed may be either higher or lower than the maximum speed used during the Basic Run-In. This will ordinarily require a governor adjustment.

All information required in Section “E”, Final Run-In, of the Engine Test Report should be determined and filled in. After the prescribed time for the Final Run-In has elapsed, remove the load from the dynamometer aud reduce the engine speed gradually to idle speed and then stop the engine. The Final Run-In is complete.

F. INSPECTION AFTER FINAL RUN-IN

After the Final Run-In and before the Engine Test Report is completed, a final inspection must be made. This inspection will provide final assurance that the engine is in proper working order. During this inspection, the engine is also made ready for any brief delay in delivery or installation which may occur. This is accomplished by rustproofing the fuel system as outlined in Section 15.3 and adding a rust inhibitor into the cooling system (refer to Section 13.3). The lubricating oil filters should also be changed.

DETROIT DIESEL FUEL OIL SPECIFICATIONS

Detroit Diesel designs, develops, and manufacturers commercial diesel engines to operate on diesel fuels classified by the A.S.T.M. as Designation D-975 (grades 1-D and 2-D). These grades are very similar to grades DF-1 and DF-2 of Federal Specification VV-F-800. Residual fuels and furnace oils. generally, are not considered satisfactory for Detroit Diesel engines. In some regions, however, fuel suppliers may distribute one fuel that is marketed as either diesel fuel (A.S.T.M. D-975) or domestic heating fuel (A.S.T.M. D-396) sometimes identified as furnace oil. In this case, the fuel should be investigated to determine whether the properties conform with those shown in the FUEL OIL SELECTION CHART, presented in this specification.

The FUEL OIL SELECTION CHART also will serve as a guide in the selection of the proper fuel for various applications. The fuels used must be clean, completely distilled, stable, and non-corrosive. DISTILLATION RANGE, CETANE NUMBER. and SULFUR CONTENT are three of the most important properties of diesel fuels that must be controlled to insure optimum combustion and minimum wear. Engine speed, load, and ambient temperature influence the selection of fuels with respect to distillation range and cetane number. The sulfur content of the fuel must be as low as possible to avoid excessive deposit formation. premature wear. and to minimize the sulfur dioxide exhausted into the atmosphere.

To assure that the fuel you use meets the required properties. enlist the aid of a reputable fuel oil supplier. The responsibility for clean fuel lies with the fuel supplier as well as the operator.

During cold weather engine operation, the cloud point (the temperature at which wax crystals begin to form in diesel fuel) should be 10° F below the lowest ex-pected fuel temperature to prevent clogging of the fuel filters by wax crystals.

At temperatures below --20° F, consult an authorized Detroit Diesel service outlet. since particular attention must be given to the cooling system. lubricating system, fuel system, electrical system. and cold weather starting aids for efficient engine starting and operation.

STATEMENT OF POLICY ON FUELS AND LUBRICANTS

In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpts have been taken from a policy statement of General Motors Corporation:

"It has been and continues to be General Motors policy to build motor vehicles that will operate satisfactorily on the commercial fuels and lubricants of good quality regularly provided by the petroleum industry through retail outlets. It is accordingly contrary to the policy of General Motors to recommend the regular and continued use of supplementary additives in such fuels and lubricants.

"This policy, should not be confused with the fact I11 that certain supplementary additives may effectively, and economically, solve specific operating problems which occasionally, arise in some vehicles. In such instances. supplementary' additives may be developed on the basis of suitable tests to remedy such problems without otherwise causing harm to %vehicles. These selected products are then given official GM part numbers and made available for use in appropriate service applications.

"While General Motors Corporation assumes responsibility for the additives selected by it to remedy specific operating problems. it cannot, of course. accept responsibility, for the many other additives which are constantly being marketed."

Although the stated Corporation policy is self-explanatory, the following is emphasized: Detroit Diesel does not recommend or support the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, reodorants, tune-up compounds. top oils, break-in oils, graphitizers and friction reducing compounds.

NOTE: The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's fuel or lubricating recommendations indicated above may not be within the coverage of the warranty.

Typical Application	General Fuel Classification	Final Boiling Point	Cetane No.	Sulfur Content
		(Max)	(Min)	(Max)
City Buses	No. 1-D	550° F	45	0.30%
All Other Applications	Winter No. 2-D Summer No. 2-D	675° F 675° F	45 40	0.50% 0.50%

NOTE: When prolonged idling periods or cold weather conditions below 320 F are encountered, the use of lighter distillate fuels may be more practical. The same consideration must be made when operating at altitudes above 5,000 ft.

13.3 Fuel, Oil and Coolant Specifications

DETROIT DIESEL LUBRICATING OIL SPECIFICATIONS

OIL QUALITY

OIL QUALITY is the responsibility of the oil supplier. (The term oil supplier is applicable to refiners, blenders, and rebranders of petroleum products, and does not include distributors of such products).

There are hundreds of commercial crankcase oils marketed today. Obviously, engine manufacturers or users cannot completely evaluate the numerous commercial oils. The selection of a suitable lubricant in consultation with a reliable oil supplier, observance of his oil drain recommendations (based on used oil sample analysis and experience) and proper filter maintenance, will provide the best assurance of satisfactory oil performance.

Detroit Diesel lubricant recommendations are based on general experience with current lubricants of various types and give consideration to the commercial lubricants presently available.

RECOMMENDATION

Detroit Diesel engines have given optimum performance and experienced the longest service life with the following oil performance levels having the ash and zinc limits shown:

Former Military and Commercial Lube Identification	New API Letter Code Service Classification	SAE Grade †
MIL-L-2104B 1964 MS Supplement 1	CC SC CB	30 or 40 30 or 40

† SAE 30 and 40 grades have both performed satisfactorily in Detroit Diesel engines. Obviously, the expected ambient temperatures and engine cranking capability must be considered by the engine owner/operator when selecting the proper grade of oil.

ASH LIMIT
The sulfated ash limit (A.S.T.M. D-874) of the above lubricants shall not exceed 1.000% by weight, except lubricants that contain only barium detergent-dispersant salts where 1.500% by weight is allowed. The majority of lubricants marketed under the performance levels shown above have a sulfated ash content between 0.55 to 0.85% by weight.

ZINC CONTENT
The zinc content, as zinc diorganodithiophosphate, shall be a minimum of 0.07% by weight.

RECOMMENDATIONS REGARDING THE USE OF CURRENT OIL PERFORMANCE LEVEL PRODUCTS MEETING PRESENT MILITARY LUBRICANT SPECIFICATIONS

The petroleum industry is currently marketing engine crankcase oils that may be identified as follows:

Military or Commercial Identification	API Letter Code Service Classification	Comment on Application and Performance
MIL-L-2104C	CD/SC	Supersedes MIL-L-45199B (Series 3) intended for diesel service.
MIL-L-46152	CC/SE	Supersedes MIL-L-2104B intended for gasoline engine passenger cars.
Universal	Numerous	Meets the performance criteria of all industry accepted tests and all current military specifications including MIL-L-2104C and MIL-L-46152.

Detroit Diesel does not have sufficient experience with any of the above described lubricants to recommend their use. Some oil suppliers have reported satisfactory performance of the above identified products marketed by them. If an owner/operator intends to use any of the above described products, it is recommended he obtain evidence from the oil supplier that the lubricant has performed satisfactorily in Detroit Diesel engines. The above products may be satisfactory for use in Detroit Diesel engines under the following conditions:

1. The sulfated ash (A.S.T.M. D-874) limit of the above lubricants shall not exceed 1.000% by weight, except lubricants that contain only barium detergent-dispersant salts where 1.500% by weight is allowed.
2. The zinc content, as zinc diorganodithiophosphate, shall be a minimum of 0.07% by weight.
3. Sufficient evidence of satisfactory performance in Detroit Diesel engines has been provided to Detroit Diesel and/or the customer.

LUBRICANTS NOT RECOMMENDED

The following lubricants are NOT recommended because of a history of poor performance in Detroit Diesel engines:

Military or Commercial Identification	API Letter Code Service Classification	Comment on Performance
MIL-L-2104B/1968 MS	CC/SD	Excessive ash deposits formed
MIL-L-45199B (Series 3)	CD	Excessive ash deposits formed
Multigrade oils	Numerous	History of poor performance in most heavy duty diesel engines

COLD WEATHER OPERATION

Cold weather starting will be facilitated when immersion type electrical coolant heaters can be used. Other practical considerations, such as the use of batteries, cables and connectors of adequate size, generators or alternators of ample capacity, proper setting of voltage regulators, ether starting aids, oil and coolant heater systems, and proper fuel selection will accomplish starting with the use of SAE 30 or SAE 40 oils. For complete cold weather starting information, consult an authorized Detroit Diesel service outlet. Ask for Engineering Bulletin No. 38 entitled: "Cold Weather Operation"

NORTH SLOPE & OTHER EXTREME SUB-ZERO OPERATIONS

Some new special arctic lubricants have recently been developed for Military use in extremely cold climates. The oils that have shown best cold temperature performance may be described as multigrades having a synthetic base stock and low volatility characteristics. At this time a new Military arctic oil specification is being developed. The good oil performers have passed the oil performance criteria defined in (tentative) Federal Test Method 354 of Federal Test Standard 791. The lubricants may be used where continuous sub-zero temperatures prevail and where engines are shut down for periods longer than eight (8) hours. These are not comparable to the performance of SAE 30 or 40 oils at operating conditions and should be considered only as a last resort when engine cranking is a severe problem and auxiliary heating aids are not available.

OIL CHANGES

The oil change period is dependent on the operating conditions (e.g. load factor, etc.) of an engine that will vary with the numerous service applications. It is recommended that new engines be started with 150 hour oil change periods. For highway vehicles this corresponds to approximately 4,500 miles, and for "city" service vehicles, approximately 2,500 miles. The drain interval may then be gradually increased, or decreased with experience on a specific lubricant while also considering the recommendations of the oil supplier (analysis of the drained oil can be helpful here) until the most practical oil drain period for the particular service has been established.

Solvents should not be used as flushing oils in running engines. Dilution of the fresh refill oil supply can occur, which may be detrimental.

Full flow oil filtration systems have been used in Detroit Diesel engines since they have been manufactured. For the best results, the oil filter element should be replaced each time the oil is changed.

NEW ENGINE OIL CLASSIFICATION SYSTEM

A relatively new engine oil classification system has been introduced to industry that describes the criteria required to meet each performance level. A simplified cross-reference of oil and current commercial and military specifications is shown below.

CROSS-REFERENCE OF LUBE OIL CLASSIFICATION SYSTEMS

API Code Letters	Comparable Military or Commercial Industry Spec.
CA	MIL-L-2104A
CB	Supplement 1
CC	MIL-L-2104B (see Note 1 below)
CD	MIL-L-45199B (Series 3)
‡	MIL-L-46152 (supersedes MIL-L-2104B for Military only)
■	MIL-L-2104C (supersedes MIL-L-45199B for Military only)
SA	none
SB	none
SC	1964 MS oils — Auto passenger car
SD	1968 MS oils — Auto passenger car
SE	1972 MS oils — Auto passenger car

NOTE 1: MIL-L-2104B Lubricants are currently marketed and readily available for Commercial use. MIL-L-2104B oils are obsolete for Military service applications only.

‡ Oil performance meets or exceeds that of CC and SE oils.
■ Oil performance meets or exceeds that of CD and SC oils.

ENGINE COOLANT

Engine coolant is considered as any solution which is circulated through the engine to provide the means for heat transfer from the various engine components. In general, water containing various materials in solution is used for this purpose.
The function of the coolant is basic in the design and the successful operation of the engine and must be carefully selected and properly maintained.

COOLANT REQUIREMENTS

A suitable coolant solution must meet the following five basic requirements:

1. Provide for adequate heat transfer.

2. Provide a corrosion resistant environment within the cooling system.

3. Prevent formation of scale or sludge deposits in the cooling system.

4. Be compatible with the cooling system hose and seal materials.

5. Provide adequate freeze protection during cold weather operation.

Normally requirements 1 through 4 are satisfied by combining a suitable water with reliable inhibitors. When operating conditions dictate the need for freeze protection, a solution of suitable water and an ethylene glycol type antifreeze containing adequate inhibitors will provide a satisfactory coolant.

WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system. Also, scale deposits may form on the internal surfaces of the cooling system due to the mineral content of the water. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered. The concentration of (1) chlorides, (2) sulfates, (3) total hardness and (4) dissolved solids. These materials are objectionable for a number of reasons: chlorides and/or sulfates will accelerate corrosion, while hardness (percentage of magnesium and calcium present) will cause deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these. Chlorides, sulfates, magnesium and calcium are among but not necessarily all the materials which make up dissolved solids. Water, within the limits specified in Tables I and 2 of Fig. 1, is satisfactory as an engine coolant when proper inhibitors are added.

CORROSION INHIBITORS

A corrosion inhibitor is a water soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. Depletion of all types of inhibitors occur through normal operation and therefore strength levels must be maintained by the addition of inhibitors at prescribed intervals. Always follow the supplier’s recommendations on inhibitor usage and handling.

> **NOTE**: Methoxy propanol base permanent antifreeze (such as Dowtherm 209, or equivalent) must be re-inhibited only with compatible corrosion inhibitor systems.

Chromates

Sodium chromate and potassium dichromate are two of the more commonly used water system corrosion inhibitors. However, the restrictive use of these materials, due to ecology considerations, has de-emphasized their use in favor of non-chromates. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors must not be used in ethylene glycol antifreeze solutions. Chromium hydroxide, commonly called “green slime”, can result from the use of chromate inhibitors with- permanent type antifreeze. This material deposits on the cooling system passages, reducing the heat transfer rate, and will result in engine overheating. Engines which have operated with a chromate inhibited water must be chemically cleaned before the addition of ethylene glycol type antifreeze. A commercial heavy duty descaler should be used in accordance with the manufacturer’s recommendation for this purpose.

13.3 Fuel, Oil and Coolant Specifications

TABLE 1

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.0
Sulfates Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

Refer to Table 2 for evaluation of Vater intended for use in a coolant solution.

TABLE 2

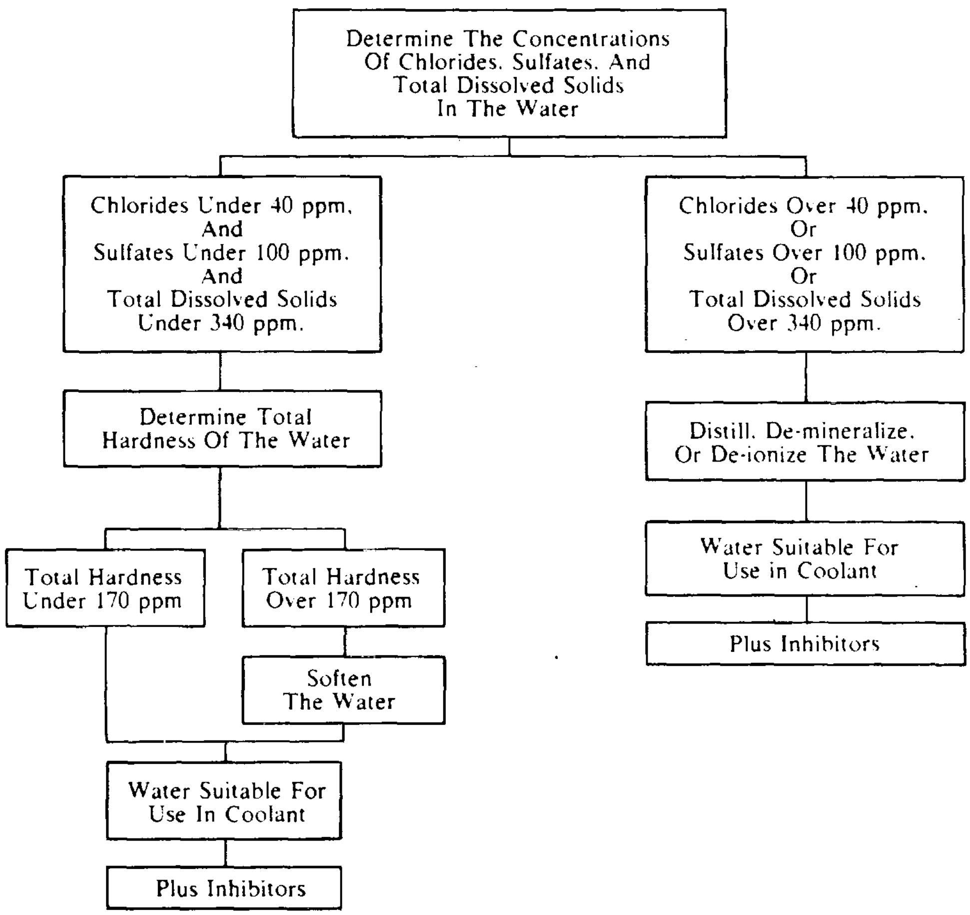


Figure 1

Soluble Oil

Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example: 1-1/4% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2-1/2% concentration raises fire deck temperature up to 15%. Soluble oil must not be used as a corrosion inhibitor.

COOLANT INHIBITOR CHART

Inhibitor Compatability

Inhibitor or Inhibitor System	Corrosion Inhibitor Type	Complete Inhibitor System	Water	Ethylene Glycol Base Antifreeze*	Methoxy Propanol Base Antifreeze
Sodium chromate	Chromate	No	Yes	No	No
Potassium dichromate	Chromate	No	Yes	No	No
Perry filter elements:					
5020 (type OS)	Chromate	Yes	Yes	No	No
S-453 (Spin-on)	Chromate	Yes	Yes	No	No
5030 (type OS)	@Non-chromate	Yes	Yes	Yes	No
S-331 (Spin-on)	@Non-chromate	Yes	Yes	Yes	No
5070 (type OS)	#Non-chromate	Yes	Yes	Yes	No
S-473 (Spin:on)	#Non-chromate	Yes	Yes	Yes	No
Lenroc filter element	Non-chromate	Yes	Yes	Yes	No
Fleetguard filter elements:					
DCA (canister)	Non-chromate	Yes	Yes	Yes	No
DCA (Spin-on)	Non-chromate	Yes	Yes	Yes	No
AC filter elements:					
DCA (canister)	Non-chromate	Yes	Yes	Yes	No
DCA (Spin-on)	Non-chromate	Yes	Yes	Yes	No
Luber-Finer filter elements:					
LW-4739 (canister)	Non-chromate	Yes	Yes	Yes	No
LFW-4744 (spin-on)	Non-chromate	Yes	Yes	Yes	No
Nalcool 2000 (liquid)	Non-chromate	Yes	Yes	Yes	No
Perry LP-20 (liquid)	Non-chromate	Yes	Yes	Yes	No
Lubercool (liquid)	Non-chromate	Yes	Yes	Yes	No
Dowtherm cooling sys - tem conditioner	Non-chromate	Yes	Yes	Yes	Yes

*Dowtherm 209, or equivalent.
@Perry "Year Around" formula.
#Perry "Universal Around" formula.

Figure 2

Non-Chromates
Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water and ethylene glycol solution.

INHIBITOR SYSTEMS

An inhibitor system is considered as a combination of chemical compounds which provide corrosion protection, pH control and water softening ability. Corrosion protection has been discussed earlier under the section on Corrosion Inhibitors. The pH control is used to maintain an acid free solution. The water softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor additives and as an integral part of permanent antifreeze.

13.3 Fuel, Oil and Coolant Specifications

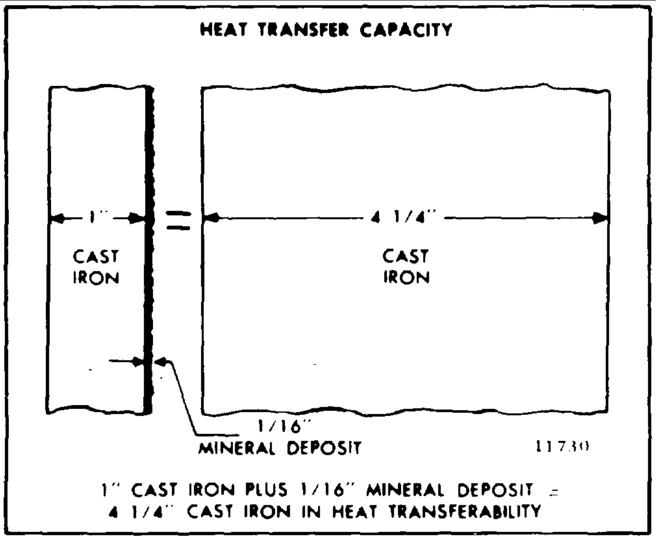


Figure 3

Coolant Filter Elements

Replaceable elements are available with various chemical inhibitor systems. Care should be used in the selection of elements relative to inhibitor compatibility with coolant solutions shown in Fig. 2.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest, zones of the engine where heat transfer is most critical (Fig. 3). The use of aluminum or zinc in preference to magnesium is recommended to eliminate this type of deposit.

A high chloride coolant will have a detrimental effect on the water softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride content solutions.

Bulk Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant or to bulk storage tanks containing coolant solution. Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatability with other coolant constituents (Fig. 2).

A non-chromate inhibitor system is recommended for

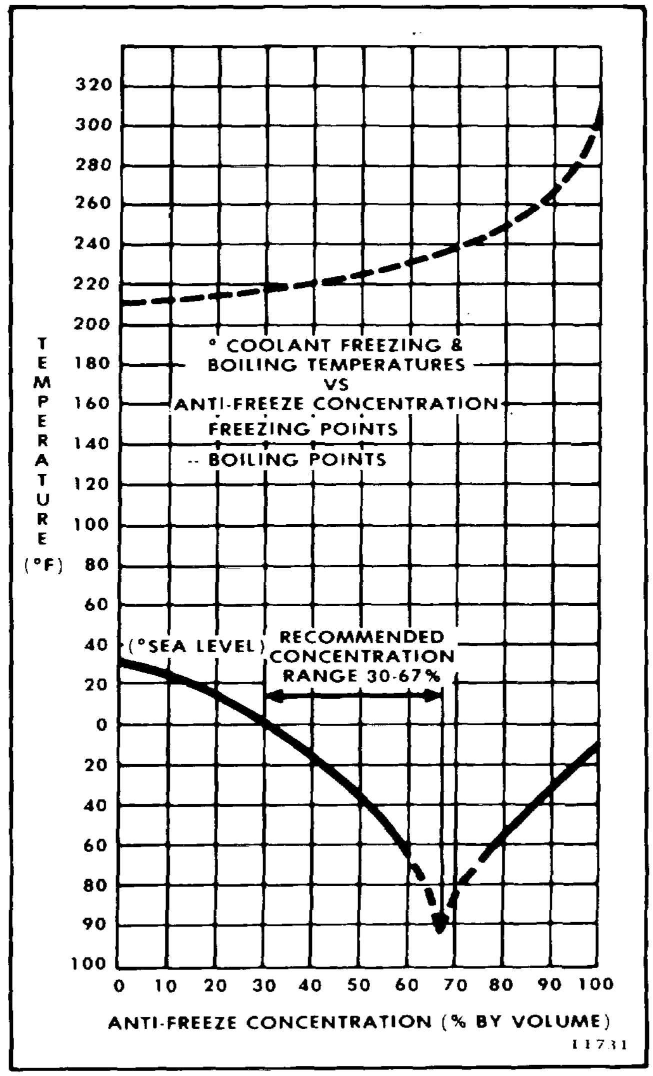


Figure 4

use in Detroit Diesel engines. The non-chromate systems can be used with either water -or ethylene glycol antifreeze solutions and provide corrosion protection, pH control and water softening. Some of the approved non-chromate inhibitor systems offer the additional advantage of a simple on site test to determine protection level and, since they are added directly to the coolant, require no additional hardware or plumbing.

ANTIFREEZE

When freeze protection is required, an ethylene glycol base permanent antifreeze should be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill if a minimum antifreeze concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection. Concentrations over 67% adversely affect freeze protection and heat transfer rates (Fig. 4).

Methoxy propanol base antifreeze may be used for freeze protection in Series 71 engines. Before installing methoxy propanol base antifreeze in an engine, the entire cooling system should be drained, flushed with clean water and examined for rust, scale, contaminants, etc. If deposits are present, the cooling system must be chemically cleaned with a commercial grade heavy-duty de-scaler.

Inhibitor depletion will occur in ethylene glycol base antifreeze through normal service. The inhibitors must be replenished at approximately 500 hour or 20,000 mile intervals with a non-chromate inhibitor system. Commercially available inhibitor systems (Fig. 2) may be used to re-inhibit antifreeze solutions.

Several brands of permanent antifreeze are available with sealer additives. The specific type of sealers vary with the manufacturer. Antifreeze with sealer. additives is not recommended for use in Detroit Diesel engines due to possible plugging problems throughout various areas of the cooling system.

COOLANT RECOMMENDATIONS

1. Always use a properly inhibited coolant.

2. If freeze protection is required, always use a permanent type antifreeze.

3. Re-inhibit antifreeze with a non-chromate inhibitor system.

4. Always follow the manufacturer’s recommendations on inhibitor usage and handling.

5. Do not use soluble oil.

6. Chromate inhibitors should never be used with permanent antifreeze.

7. Sealer type antifreeze should not be used.

8. Maintain prescribed inhibitor strength.

9. Do not mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.

SECTION 14

ENGINE TUNE-UP

CONTENTS

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanism, governor, etc. should only be required periodically to compensate for normal wear on parts.

The type of governor used depends upon the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly. The following types of governors are used:

1. Limiting speed mechanical.

3. Fuel modulating.

The governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double-weight limiting speed governor. A single-weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor or injectors have been replaced or overhauled, then certain preliminary adjustments are required before the engine is started.

The preliminary adjustments consist of the first four items in the tune-up sequence. The procedures are the same except that the valve clearance is greater for a cold engine.

> **NOTE**: If a supplementary governing device, such as the throttle delay mechanism, is used, it must be disconnected prior to the tune-up. After the governor and injector rack adjustments are completed, the supplementary governing device must be re-connected and adjusted.

To tune-up an engine completely, perform all of the adjustments, except the valve bridge adjustment on a four-valve cylinder head, in the tune-up sequence given below after the engine has reached normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

> **NOTE**: The exhaust valve bridges on a four-valve cylinder head are adjusted at the time the cylinder head is installed on the engine and, until wear occurs, no further adjustment is required. When wear is evident, perform a complete valve bridge adjustment as outlined in Section 1.2.2.

Use a new valve rocker cover gasket after the tune-up is completed.

Tune-Up Sequence

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).
9. Adjust the fuel modulator, if used.

> **NOTE**: The steps necessary to adjust an engine with a fuel modulating governor are covered in Section 14.5.

EMISSION REGULATIONS FOR ON-HIGHWAY VEHICLE ENGINES

On-highway vehicle and coach engines built by Detroit Diesel Allison are certified to be in compliance with Federal and California Emission Regulations established for each model year beginning with 1970.

Engine certification is dependent on five physical characteristics:

1. Fuel injector type.
2. Maximum full-load engine speed.
3. Camshaft timing.
4. Fuel injector timing.
5. Throttle delay (orifice size).

Tables I through 4 summarize all of the pertinent data concerning the specific engine configurations required for each model year.

When serviced, all on-highway vehicle and coach engines should comply with the specifications for the specific model year in which the engine was built.

Trucks in a fleet containing engines of various model years can be tuned to the latest model year, provided the engines have been updated to meet the specifications for that particular year.

Engines	3,4,6-71 (4 Valve)	3,4,6-71 (4 Valve)	3,4,6-71 (4 Valve)
Injectors	71N5 N55 N60	N65	N70
■ Maximum Full-load Speed	2100	2100	2300
Camshaft Timing	Std.	Adv.	Adv.
◆ Injector Timing	1.460"	1.484"	1.460"
Throttle Delay	No	No	No

◆ The adjusted height of the fuel injector follower in relation to the injector body.

■ No load engine speed will vary with injector size and governor type.

TABLE 1 (1970 AND 1971)

Engines	3-71 4-71 6-71 (4 Valve)	3-71 4-71 6-71 (4 Valve)	3-71 4-71 6-71 (4 Valve)	6-71T	*6-71T
Injectors	71N5 N55 N60	N65	N70	N65	N70 N75
**Maximum Full Load Engine Speed	2300	2300	2300	2100	2100
Camshaft Timing	Std.	Adv.	Adv.	Std.	Std.
‡ Injector Timing	1.460"	1.484"	1.460"	1.484"	1.460"
Throttle Delay	No	No	No	.016" Orifice	.016" Orifice

*6-71T Fire Truck Application exempt from certification.
‡The adjusted height of the fuel injector follower in relation to the injector body.
**No load engine speed will vary with injector size and governor type.

TABLE 2 (1972)

14 Engine Tune-Up

Engines	3-71N 4-71N 6-71N (4 Valve) ▼	3-71N 4-71N 6-71N (4 Valve) ▼	3-71N 4-71N 6-71N (4 Valve) ▼	6-71T	6-71T	*6-71T	*6-71T
Injectors	71C5	C55 C60	C65 C70	C65	N70 N75	C65	N70 N75
**Maximum Full Load Engine Speed	2300	2300	2300	2100	2100	2300	2300
Camshaft Timing	Std.	Std.	Adv.	Std.	Std.	Std.	Std.
Injector Timing	1.484"	1.460"	1.484"	1.460"	1.484"	1.460"	1.484
Throttle Delay	No	No	No	.016" Orifice	.016" Orifice	.016" Orifice	.016" Orifice

● .78" diameter fill hole.
**No Load engine speed will vary with injector size and governor type.
▼ Includes certain Parlor and Suburban Coach Engines.
*Exempt Engine Rating for Fire Truck Application only (Code No. 351).
Use Minimum idle speed of 500 rpm on all engines, except coach engines where a minimum of 400 rpm is allowed.

TABLE 3 (1973)

Engines	6-71N ■	6-71N ■	6-71N ■	6-71N ■	6-71N ■	6-71T	6-71T	6-71T
Injectors	71C5	C55	C60	C65	C70	C65	N70	N75
**Maximum Full-load Engine Speed	2300	2300	2300	2300	2300	2100	2100	2100
Camshaft Timing	Std.	Std.	Std.	Adv.	Adv.	Std.	Std.	Std.
Injector Timing	1.484"	1.460"	1.460"	1.484"	1.484"	1.460"	1.484"	1.484"
Throttle Delay	No	No	No	No	No	++ .016" Orifice	++ .016" Orifice	++ .016" Orifice
Yield Link	No	No	No	No	No	Yes	Yes	Yes

++ .78" diameter fill hole.
** No load engine speed will vary with injector size and governor type.
■ Includes Certain Parlor and Suburban Coach Engine.

TABLE 4 (1974)

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, especially in the low speed range.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must first be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

14.1 Exhaust Valve Clearance Adjustment

ENGINES WITH FOUR VALVE CYLINDER HEADS

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. Until wear occurs, no further adjustment is required on the exhaust valve bridges. When wear is evident, make the necessary adjustments as outlined in Section 1.2.2.

The exhaust valve clearance is always adjusted at the push rod. Do not disturb the exhaust valve bridge adjusting screw.

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the General Specifications at the front of the manual for the engine firing order.

Exhaust Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover and remove the cover.

2. Place the governor speed control lever in the idle speed position. If a stop lever is provided, secure it in the stop position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

> **CAUTION**: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation or the bolt may be loosened.

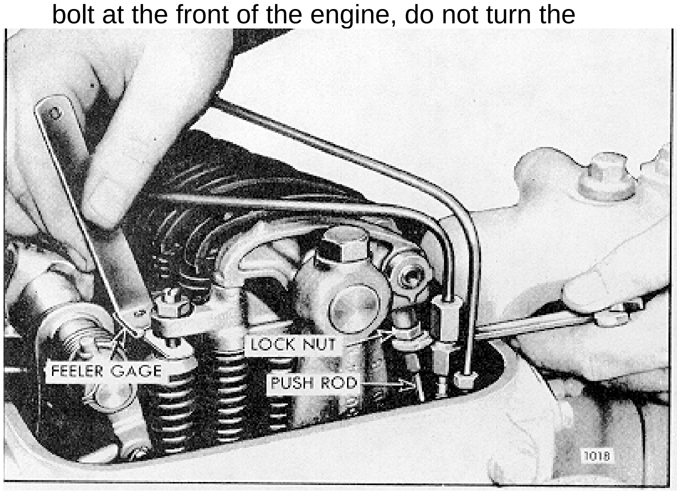


Fig. 2 - Adjusting Valve Clearance (Spring-Loaded Valve Bridge)

4. Loosen the exhaust valve rocker arm push rod lock nut.

5. Place a .017 " feeler gage, J 9708, between the end of the exhaust valve stem and the valve bridge adjustment screw (spring-loaded bridge only) or between the valve bridge and the valve rocker arm pallet (unloaded bridge only) -- refer to Figs. 2 and 3. Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16 " wrench and tighten the lock nut with a ½" wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .015 " gage will pass freely between the valve stem and the adjustment screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .017 " gage will not pass through. Readjust the push rod, if necessary.

8. Adjust and check the remaining exhaust valves in the same manner as above.

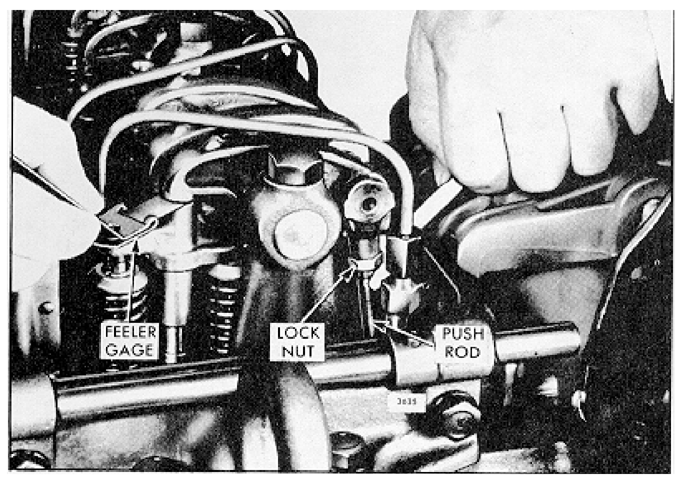


Fig. 3 - Adjusting Valve Clearance (Unloaded Valve Bridge)

Exhaust Valve Clearance Adjustment (Hot Engine)

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance, when running at full load, may become insufficient.

1. With the engine at normal operating temperature (160 C-185 ° F.), recheck the exhaust valve clearance with feeler gage J 9708. At this time, if the valve clearance is correct, the .013 " gage will pass freely between the valve stem and the valve bridge adjusting screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .015" feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

FUEL INJECTOR TIMING

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed in firing order sequence during one full revolution of the crankshaft. Refer to the General Specifications at the front of the manual for the engine firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted (Section 14.1), time the fuel injectors as follows:

1. Place the governor speed control lever in the idle speed position. If a stop lever is provided, secure it in the stop position.

2. Rotate the crankshaft, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

CAUTION: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the

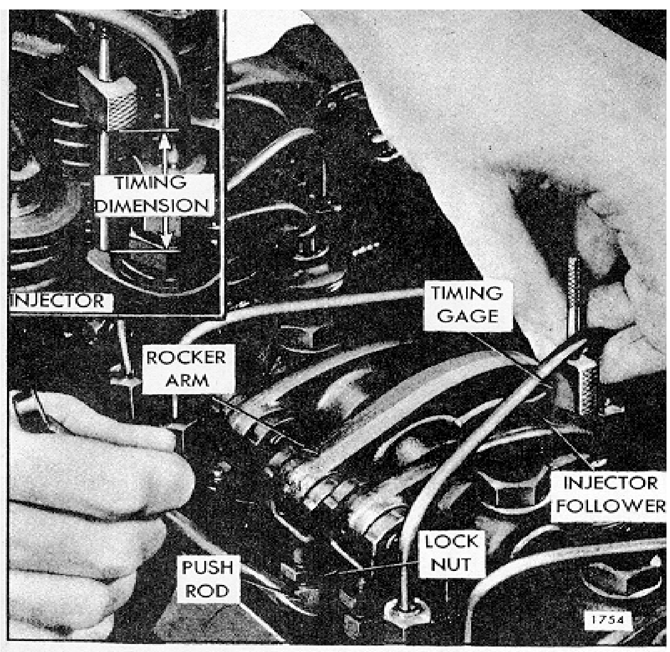


Fig. 1 - Timing Fuel Injector

crankshaft in a left-hand direction of rotation or the bolt may be loosened.

3. Place the small end of the injector timing gage (refer to the charts for the correct timing gage) in the hole provided in the top of the injector body with the flat of the gage toward the injector follower (Fig. 1).

4. Loosen the injector rocker arm push rod lock nut.

5. Turn the push rod and adjust the injector rocker

Injector	Timing Dimension	Timing Gage	Camshaft Timing
71N5	*1.460"	J 1853	*Standard
N55	*1.460"	J 1853	*Standard
N60	*1.460"	J 1853	*Standard
N65 (white tag)	*1.460"	J 1853	Standard
N65 (Turbo (brown tag)	*1.484"	J 1242	Standard
N65 Non-Turbo (brown tag)	**1.484"	J 1242	**Advance d
N70 Turbo	1 460"	J 1853	Standard
N70 Non-Turbo	1 460"	J 1853	Advanced
∅N70 Turbo	1.484"	J 1242	Standard
∅N75 Turbo	1.484"	J 1242	Standard

*Use 1 484” timing gage (J 1242) when engine has advanced camshaft timing. Correct to standard camshaft timing and 1.460” injector timing at first opportunity to be consistent with current production build.

**Use 1 460” timing gage (J 1853) when engine has standard camshaft timing Correct to advanced camshaft timing and 1 484’” injector timing at first opportunity

NOTE: Advanced camshaft timing is indicated by “ADV-CAM-TIMING” stamped on the lower right-hand side of the option plate.

∅ 1973 build engines.

INJECTOR TIMING GAGE CHART
(Needle Valve)

Injector	Timing Dimension	Timing Gage	Camshaft Timing
71C5	1.484"	J 1242	Standard
'*C55	1.460"	J 1853	Standard
*C60	1.460"	J 1853	Standard
C65	1.484"	J 1242	Advanced
∅C65	1.460"	J 1853	Standard
C70	1.484"	J 1242	Advanced

* Use 1.470" timing gage (J 24236) for city coach engines with throttle delay.
∅Turbocharged engines.

INJECTOR TIMING GAGE CHART
("C" Injectors)

arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the lock nut. Check the adjustment and, if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required, install the valve rocker cover, using a new gasket.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust the limiting speed mechanical governor and the injector rack control levers, after adjusting the exhaust valves and timing the fuel injectors.

> **NOTE:** Loosen the lever for the fuel modulator, the load limiting device or disconnect the air cylinder link, if the engine is so equipped, before proceeding with the governor adjustment.

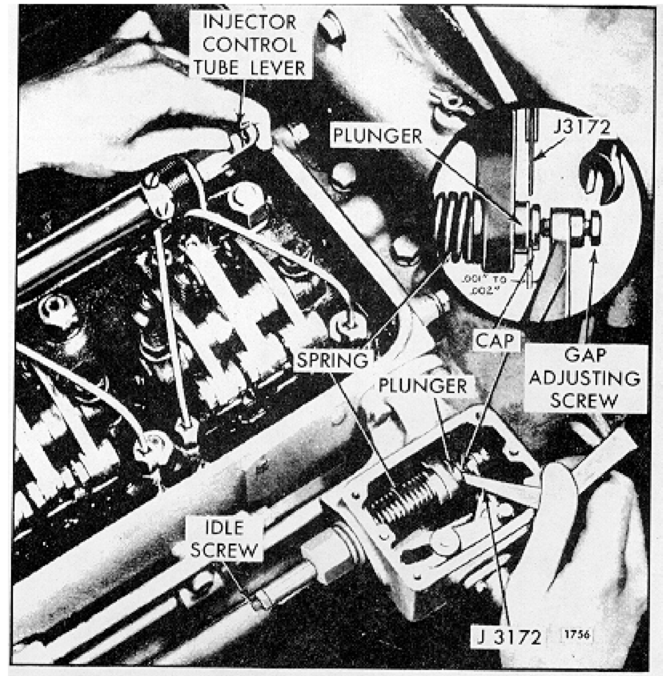


Fig. 2 Adjusting Gap

Adjust Governor Gap

With the engine at operating temperature, adjust the governor gap as follows:

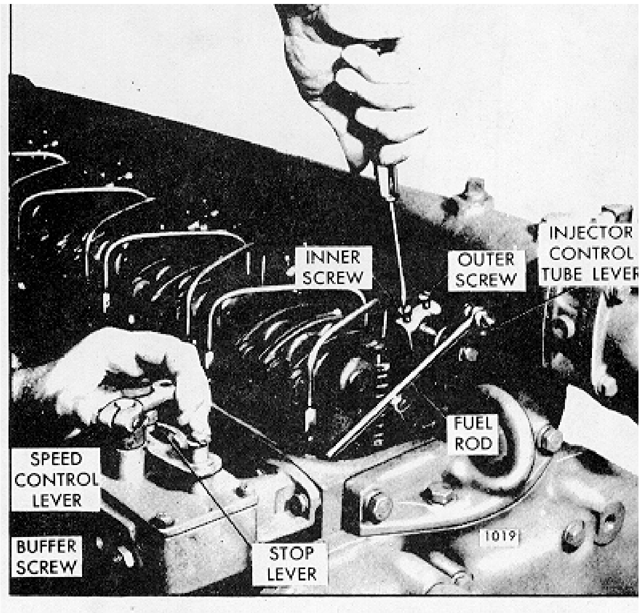


Fig. 3 - Positioning No. I Injector Rack Control Lever

1 With the engine stopped, remove the two attaching bolts and withdraw the governor high speed spring retainer cover.

2 Back out the buffer screw until it extends approximately 5/8" from the lock nut (Fig 3).

3 Start the engine and loosen the idle speed adjusting screw lock nut and adjust the idle screw -to obtain the desired idle speed (Fig 2) Hold the screw and tighten the lock nut to retain the adjustment The recommended idle speed is 450 rpm for double weight governors, but may vary with special engine applications.

4 Stop the engine and remove the governor cover and lever assembly.

5 Clean and remove the valve rocker cover.

6 Remove the fuel rod from the differential lever and the injector control tube lever (Fig 3).

7 Start and run the engine between 800 and 1000 rpm by manual operation of the control tube lever.

CAUTION: Do not overspeed the engine.

8 Check the gap between the low speed spring cap and the high speed plunger with a .0015" feeler gage as shown in Fig 2 If the gap set Pag ting is incorrect, loosen the lock nut and adjust the gap adjusting screw.

9 Hold the gap adjusting screw and tighten the lock nut.

10 Recheck the governor gap, with the engine operating between 800 and 1000 rpm, by placing a screw driver between the gap adjusting screw and the governor housing and manually forcing the gap closed If the setting is correct, the .0015" movement can be seen by placing a few drops of oil into the governor gap and pressing a screw driver against the gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

11 Stop the engine and install the fuel rod between the differential lever and the control tube lever.

12 Install the governor cover and lever assembly.

Position Injector Rack Control Levers Engines Not Using a Fuel Modulator

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers will result in the following: Speed control lever at the maximum speed position.

Governor low speed gap closed.

High speed spring plunger on the seat in the governor control housing.

Injector racks in the full-fuel position.

Adjust the No. 1 injector rack control lever, Fig 3, first to establish a guide for adjusting the remaining injector rack control levers.

1 Disconnect any linkage attached to the governor speed control lever.

2 Loosen the idle speed adjusting screw lock nut and back out the idle speed adjusting screw until 1/2" of the threads project from the lock nut when the nut is against the high speed plunger (Fig 2).

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14.3 LIMITING SPEED GOVERNOR ADJUSTMENT

3 Loosen all of the inner (270) and outer (271) injector rack control lever adjusting screws. Be sure all of the control levers are free on the injector control tube.

NOTE: On engines equipped with a yield link type fuel rod, attach a small "C" clamp at the shoulder of the rod to prevent the yield spring from compressing while adjusting the injector rack control levers.

4 Move the governor speed control lever (21)to the maximum speed position as shown in Fig.

3. Hold the lever in that position with light finger pressure. Turn the inner adjusting screw on the No. 1 injector rack control lever down until a slight movement of the control tube is observed or a step up in effort is noted. This will place the No. 1 injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 in-lbs.

NOTE: The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

5. To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screw driver or finger tip

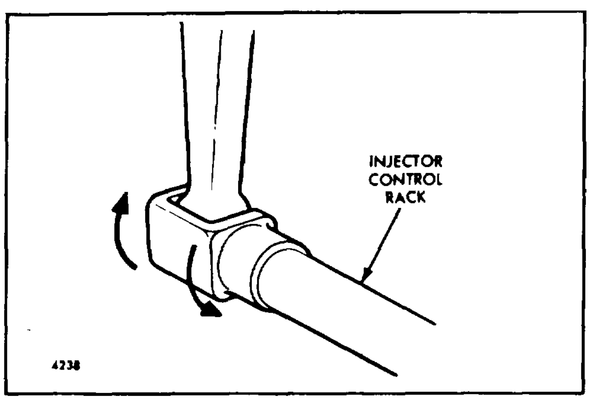


Fig. 4 - CheckingRotating Movement of Injector Control Rack

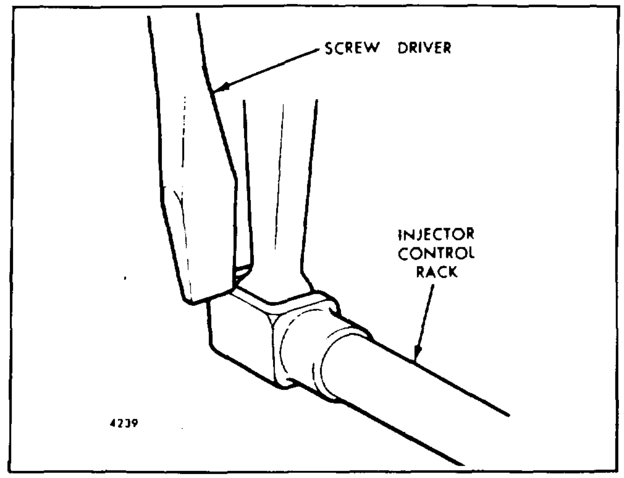


Fig. 5 - Checking Injector Control Rack "Spring"

and note "rotating" movement of the injector control rack (Fig. 4) when the speed control lever is in the maximum speed position. Hold the speed control lever in the maximum speed position and using a screw driver, press downward on the injector control rack. The rack should tilt downward (Fig. 5) and when the pressure of the screw driver is released, the control rack should "spring" back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

The setting is too tight if, when moving the speed control lever from the idle to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step up in effort required to move the speed control lever to the end of its travel. To correct this condition, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

6 Disconnect the fuel rod from the injector control tube and manually hold the No 1 injector in the full-fuel position and turn down the inner adjusting screw of the No 2 injector until the injector rack has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube Turn the outer adjusting screw down until it bottoms lightly on the injector control tube Then, alternately tighten both the inner and outer adjusting screws.

7 Recheck the No 1 injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while adjusting the

No. 2 injector. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever and tighten the outer adjusting screw.

When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

8 Position the remaining injector rack control levers as outlined in Steps 6 and 7.

9 Connect the fuel rod to the injector control tube lever.

10 Turn the idle speed adjusting screw until it projects 3/16" from the lock nut to permit starting the engine.

> **NOTE:** Remove the "C" clamp from the fuel rod on units equipped with a yield link.

Position Injector Rack Control Levers Engines Using Fuel Modulator

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load. When adjusting the fuel control racks, be sure no interference is encountered from the fuel modulator. This may be assured by loosening the fuel modulator lever "U" bolt and moving the modulator lever along the injector control tube to avoid contact with the modulator cam or adjacent cylinder head stud nut (Fig. 8).

> **NOTE:** When the modulator lever is in position, it may strike the cylinder head stud nut when the rack is moved toward the "OFF" position. However, the no-fuel position is reached before this contact takes place and should therefore cause no concern.

Adjust the No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1 Disconnect any linkage attached to the governor speed control lever.

2 Loosen the idle speed adjusting screw lock nut (56) and back out the idle speed adjusting screw (55) until 1/2" of the threads project from the lock nut when the nut is ag,inst the high speed plunger (Fig 2).

> **NOTE:** This lowers the tension on the low speed spring permitting the governor gap to close completely when performing Step 4 without overcoming the control tube fuel modulating torsion spring.

3 Loosen all of the inner (270) and outer (271) injector rack control lever adjusting screws (Fig 3) Be sure all of the control levers are free on the injector control tube.

4 Move the governor speed control lever (21)to the full-fuel position as shown in Fig 3 Turn the inner adjusting screw down until a step up of effort is noted This will place the No1 injector rack in the full-fuel position Turn the outer adjusting screw down until it bottoms lightly on the injector control tube Then, alternately tighten both the inner and outer adjusting screws.

5 To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screw driver or finger tip and note "rotating" movement of the injector control rack (Fig 4) when the speed control lever is in the maximum speed position Hold the speed control lever in the maximum speed position and, using a screw driver, press downward on the injector control rack. The rack should tilt downward (Fig 5) and when the pressure of the screw driver is released, the control rack should "spring" back upward.

6 Check the setting of the No1 injector rack by moving the governor speed control lever towards the no-fuel position while holding the governor to control tube link, with a light finger pressure, in a direction towards the governor This pressure will retain the low speed spring gap in the closed position when the speed control lever is moved from the fullspeed position toward the idle position. A proper rack setting will be indicated by an immediate corresponding movement of the No.1 injector rack from the full-fuel position when the governor speed control lever is moved away from the full-speed position.

7 If no immediate corresponding movement of the injector rack is observed in step 6, back off the inner adjusting screw approximately 1/8 of a turn and tighten the outer adjusting screw When the setting is correct, the injector rack will be snug on the pin of the rack control lever and still maintain the movement specified in Step 6.

NOTE: Performing Steps 4, 5, 6 and 7 will result in placing the governor linkage and control tube assembly in the same positions they will attain while the engine is running at full load. These positions are: a. Speed control lever in the maximum speed position.

b Governor low speed gap closed.

c High speed spring plunger on the seat in the governor control housing.

d Injector racks in the full-fuel position.

8 Remove the clevis pin between the fuel rod and the injector control tube lever.

9 Manually hold the No 1 injector in the full fuel position Do not hold the end of the control tube.

Hold the No. 1 injector lever, and turn down the inner adjusting screw of the No. 2 injector until the injector rack of the No. 2 injector has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 2436 in-lbs.

10 Recheck the No 1 injector fuel rack to be sure that it has remained snug on the pin of the rack control lever while adjusting the N 2 injector. become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever. Tighten the outer adjusting screw.

When the settings are correct, the racks o: both injectors must be snug on the pins of their respective rack control levers.

11 Position the remaining control rack levers as outlined in Steps 9 and 10.

12 Insert the clevis pin between the fuel rod and the injector control tube lever (Fig 3).

13 Reset the idle speed adjusting screw until i projects 3/8" beyond the lock nut Tighten the lock nut.

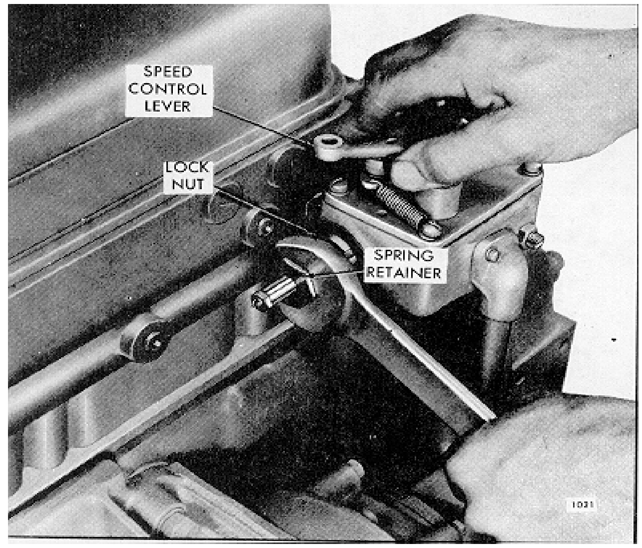


Fig. 6 Adjusting Maximum No-Load Speed

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the option plate, the maximum no-load speed may be set as follows: 1. Loosen the lock nut (Fig. 6) and back off the high speed spring retainer approximately five turns.

2 With the engine at operating temperature and no-load on the engine, place the speed control lever in the full-fuel position Turn the high speed spring retainer IN until the engine is operating at the recommended no-load speed.

3 Hold the high speed spring retainer and tighten the lock nut.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1 Remove the spring housing to uncover the idle speed adjusting screw.

2 With the engine at normal operating temperature and with the buffer screw (Fig 7) backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed.

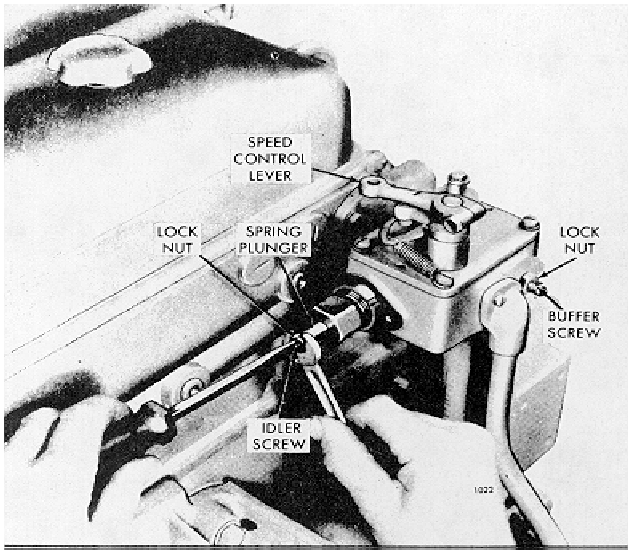


Fig. 7 - Adjusting Engine Idle Speed

1 With the engine stopped, remove the two attaching bolts and withdraw the governor high speed spring retainer cover.

The recommended idle speed is 550 rpm for single weight governors and 450 rpm for double weight governors, but may vary with engine applications.

3 Hold the idle screw and tighten the lock nut.

4 Install the high speed spring retainer and retain with the two bolts.

Adjust Buffer Screw

With the idle speed set, adjust the buffer screw as follows: 1. With the engine running at normal operating temperature, turn the buffer screw (Fig. 7) in so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

> **NOTE:** Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2 Hold the buffer screw and tighten the lock nut.

3 Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

Adjust Fuel Modulator-Engines With Fuel Modulator

After adjusting of the engine governor. adjust the Fuel modulator trig. 0), 11 the engine is so equipped, according to the following procedure.

Relocate the fuel modulator lever and roller assembly in its original position opposite the cam so the cam is centrally located on the roller. Tighten the "U" bolt nuts until the lever and roller assembly is snug on the control tube. This will not only permit the adjustment of the lever, but will retain the adjustment until the roller and lever assembly can be securely tightened.

2 Hold the fuel modulating piston and cam in the high speed position by applying not less than 20 psi air pressure to the piston or by prying the cam out with a screw driver.

3 Hold the injector rack in the full-fuel position.

4 While holding the cam and the injector rack, move the fuel modulating lever and roller assembly until the roller contacts the cam. Carefully tighten the clamping nuts on the "U" bolt alternately to avoid changing the position of the roller against the cam.

Check Fuel Modulator Setting

1 Pry the fuel modulating cam out with a screw driver.

2 Move the injector control tube to the full-fuel position.

3 Release the pressure on the screw driver slightly and allow the cam to move in slightly. If properly set, the roller of the fuel modulating lever and roller assembly will rotate as soon as the cam moves. Repeat this check several times to ensure the proper setting was not disturbed while tightening the "U" bolt clamping nuts.

Adjust Fuel Shut-Off Air Cylinder Linkage Engines

With Fuel Shut-Off Cylinder Assembly ter completing the adjustment of the engine governor, adjust the linkage between the air shut-off cylinder and the injector fuel control tube lever according to the following procedure.

1 Place the governor control lever into the full speed position. The movement of the control lever to the full-speed position will move the injector racks to the full-fuel position.

2 Loosen the lock nuts on the air cylinder fuel shut-off rod (Fig 9) and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in the end of the control tube shut-off lever. Then shorten the rod one complete turn of the turnbuckle and tighten the lock nuts.

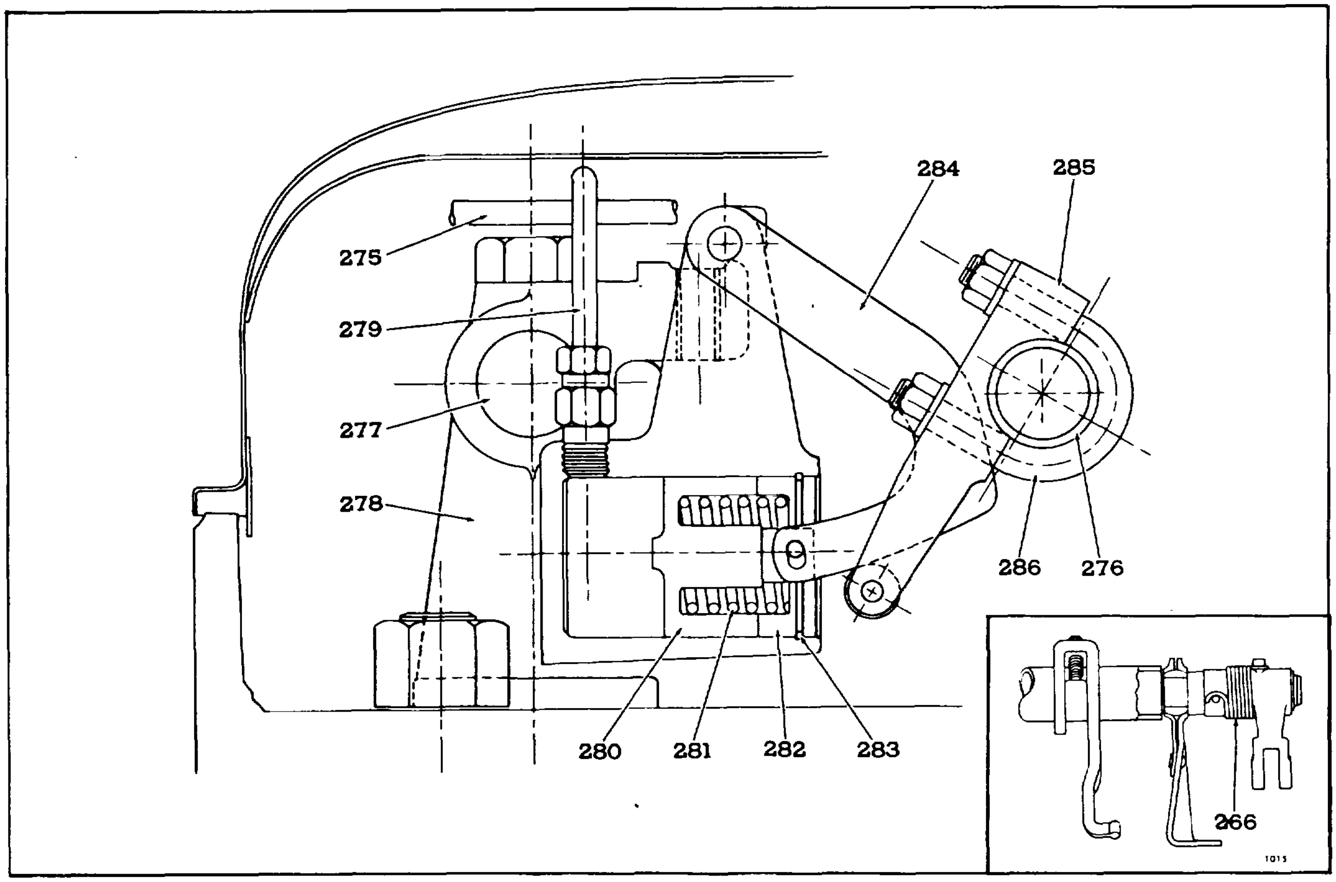


Fig. 8 - Fuel Modulator Assembly

266	Spring--Modulator Torsion	278	Bracket and Air Cylinder	281	Spring--Piston	284	Cam--Fuel Modulating
275	Pipe--Fuel Inlet			282	Retainer--Piston Spring	285	Lever and Roller Assembly
276	Tube--injector Control	279	Tube Assembly--Air Inlet	283	Retainer Ring--Piston Spring		
277	Rocker Shaft	280	Piston--Fuel Modulator			286	Bolt--1/4" - 20 "U"

Adjusting the rod in this manner will permit the engine governor to move the injector fuel control racks into the full-fuel position without coming to the end of the slot in the end of the air cylinder fuel shut-off rod.

Adjust Engine Load Limiting Device

After adjusting the engine governor, adjust the load limiting device in accordance with the following procedure.

1 Loosen the load limit screw lock nut (Fig 10).

2 Back the load limit screw out of the adjusting screw plate until approximately 1" of the screw is below the plate.

3 Adjust the load limit screw lock nut so that the bottom of the lock nut is 1 3/4" from the bottom of the load limit screw.

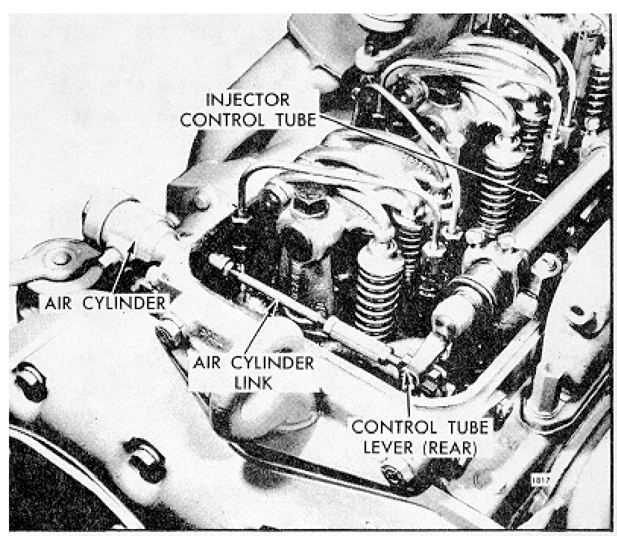


Fig. 9 Air Cylinder Used with Limiting Speed Governor

14.3 LIMITING SPEED GOVERNOR ADJUSTMENT

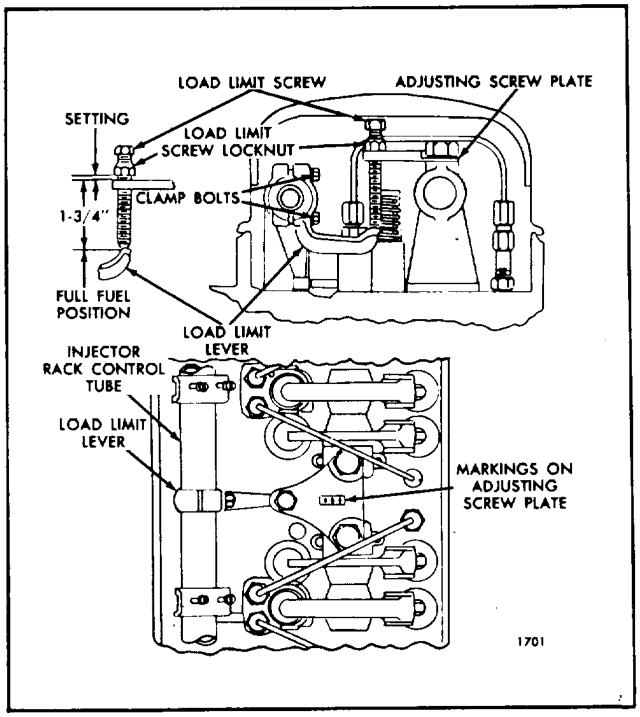


Fig. 10 - Load Limiting Device Mounted on Engine

4 Loosen the load limit lever clamp bolts so that the lever is free to turn on the injector rack control tube.

5 Thread the load limit screw into the adjusting screw plate until the lock nut "bottoms" against the top of the plate.

6 Hold the injector rack control tube in the "full fuel" position, place the load limit lever against the bottom of the load limit screw, then tighten the load limit lever clamp bolts.

7 Check to ensure that the injector racks will just go into the "full fuel" position--readjust the load limit lever, if necessary.

8 Hold the load limit screw to keep it from turning, then "set" the lock nut until the distance between the bottom of the lock nut and the top of the adjusting screw plate corresponds to the markings on the adjusting screw plate.

9 Thread the load limit screw into the plate until the lock nut "bottoms" against the top of the plate.

10 Hold the load limit screw to keep it from turning, then tighten the lock nut to secure the setting.

Occasionally, it may be necessary to vary the "setting" very slightly in accordance with the actual performance required of the engine.

LIMITING SPEED MECHANICAL GOVERNOR (DUAL RANGE) AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust the limiting speed mechanical governor (dual range) and injector rack control levers after adjusting the exhaust valves and timing the fuel injectors.

Loosen the lever and disconnect the air cylinder link (if used), before proceeding with the governor adjustment.

Adjust Governor Gap

With the engine at operating temperature, adjust the governor gap as follows:

1 With the engine stopped, remove the two attaching bolts and withdraw the governor high speed spring retainer cover.

2 Back out the buffer screw until it extends approximately 5/8" from the lock nut (Fig 2).

3 Start the engine and loosen the idle speed adjusting screw lock nut and adjust the idle screw to obtain the desired idle speed (Fig 1). Hold the screw and tighten the lock nut to retain the adjustment The recommended idle speed is 450 rpm, but may vary with special engine applications.

4 Stop the engine and remove the governor cover and lever assembly.

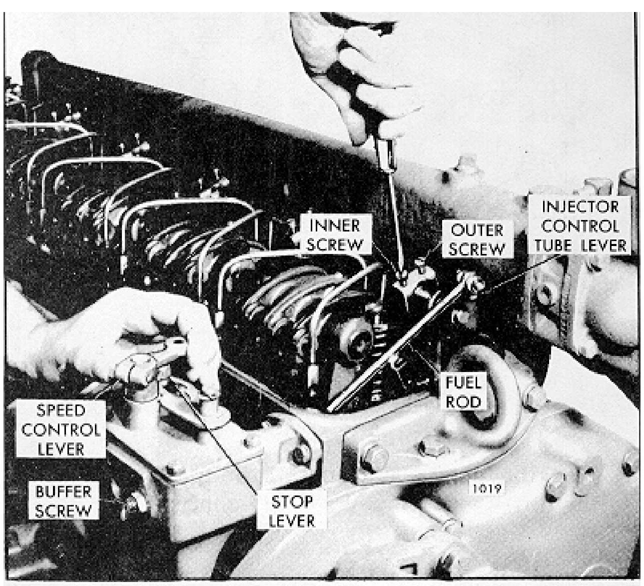


Figure 1 - Adjusting governor Cap

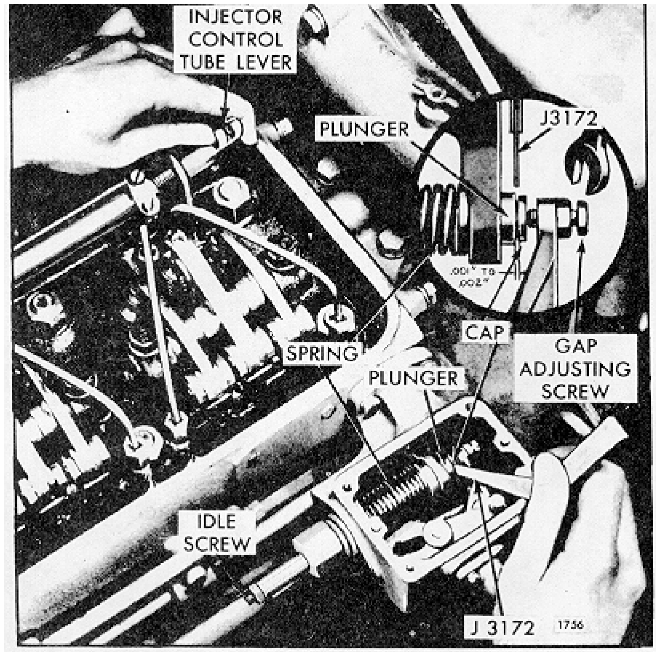


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

5 Remove the valve rocker cover.

6 Remove the fuel rod from the differential lever and the injector control tube lever.

7 Start and run the engine between 800 and 1000 rpm by manual operation of the control tube lever.

CAUTION: Do not overspeed the engine.

8 Check the gap between the low speed spring cap and the high speed plunger with a .0015" feeler gage tool J 3172 as shown in Fig 1. If the gap setting is incorrect, loosen the lock nut and adjust the gap adjusting screw.

9 Hold the gap adjusting screw and tighten the lock nut.

10 Recheck the governor gap, with the engine operating between 800 and 1000 rpm, by placing a screw driver between the gap adjusting screw and the governor housing and manually forcing the gap closed. If the setting is correct, the .0015" movement can be seen by placing a few drops of oil into the governor gap and pressing a screw driver against the gap adjusting screw. Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

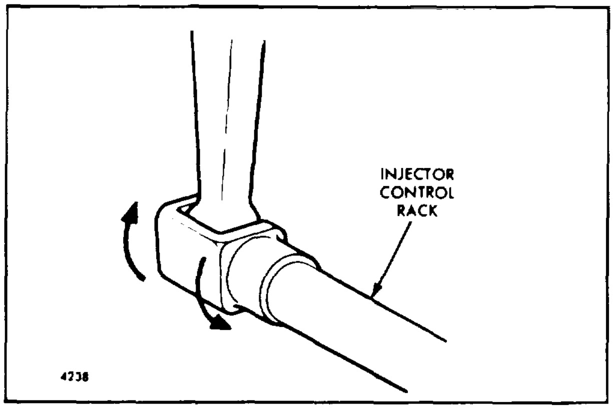


Fig 9. J - Checking Rotating Movement of Injector Control Rack

11 Stop the engine and install the fuel rod between the differential lever and the control tube lever.

12 Install the governor cover and lever assembly.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load. Properly positioned injector rack control levers will result in the following:

Speed control lever at a maximum speed position.

Governor low speed gap closed.

High speed spring plunger on the seat in the governor control housing.

Injector racks in the full-fuel position.

Adjust the No. 1 injector rack control lever (267), Fig. 2, first to establish a guide for adjusting the remaining injector rack control levers.

1 Disconnect any linkage attached to the governor speed control lever.

2 Loosen the idle speed adjusting screw lock nut and back out the idle speed adjusting screw until 1/2" of the threads project from the lock nut when the nut is against the high speed plunger.

3 Loosen all of the inner and outer injector rack control lever adjusting screws Be sure all of the control levers are free on the injector control tube.

NOTE: On engines equipped with a yield link type fuel rod, attach a small "C" clamp at the shoulder of the rod to prevent the yield spring from compressing while adjusting the injector rack control levers.

4 Move the governor speed control lever to the maximum speed position as shown in Fig 2. Hold the lever in that position withl light finger pressure. Turn the inner adjusting screw on the No. 1 injector rack control lever down until a slight movement of the control tube is observed or a step up in effort is noted. This will place the Noo 1 injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube.

> **NOTE 1:** Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 in-lbs.
>
> **NOTE 2**: The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

5 To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screw driver or finger tip and note "rotating" movement of the injector control rack (Fig 3) when the speed control lever is in the maximum speed position Hold the speed control lever in the maximum speed position and, using a screw driver, press downward on the injector control rack The rack should tilt downward (Fig 4) and when the pressure of the screw driver is released, the control rack should "spring"back upward.

If the rack does not return to its original position, it is too loose. To correct this condition, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

14.3.2 LIMITING SPEED GOVERNOR ADJUSTMENT (DUEL RANGE)

The setting is too tight if, when moving the speed control lever from the idle to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step up in effort required to move the speed control lever to the end of its travel. To correct this condition, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly.

6 Disconnect the fuel rod from the injector control tube and manually hold the No 1 injector in the full-fuel position and turn down the inner adjusting screw of the No 2 injector until the injector rack has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

7 Recheck the No 1 injector rack to be sure that. it has remained snug on the ball end of the injector rack control lever while adjusting the No 2 injector. If the rack of the No 1 injector has become loose, back off slightly on the inner adjusting screw on the No 2 injector rack control lever and tighten the outer adjusting screw.

When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

8 Position the remaining injector rack control levers as outlined in Steps 6 and 7.

9 Connect the fuel rod to the injector control tube lever.

10 Reset the idle speed adjusting screw until it projects 3/16" from the lock nut to permit starting the engine.

NOTE: Remove the "C" clamp from the fuel rod on units having a yield link

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load

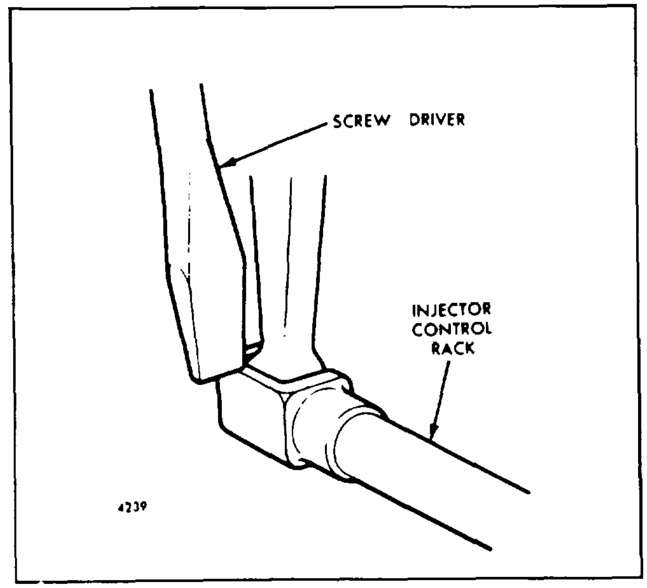


Fig. 4 - Checking Injector Control Rack "Spring"

speed as given on the unit name plate, the maximum no-load speed may be set as follows: Engines with Early Dual Range Limiting Speed Mechanical Governor After positioning the injector rack control levers and setting the idle speed, set the maximum engine speeds.

NOTE1: Be sure the buffer screw projects 5/8" from the lock nut to prevent its interference while adjusting the maximum no-load speeds.

NOTE2: To prevent air leakage between the piston and sleeve assembly, coat the mating threads with sealant.

With the spring housing assembly mounted on the governor, the piston and sleeve assembly assembled as illustrated in Fig. 5, and the low maximum speed adjusting screw extended from the spring housing approximately 3/4" beyond the lock nut, proceed as follows:

CAUTION: Do not apply air pressure to the governor until performing Step1h.

1 Set the high maximum no-load speed.

a Start the engine and place the speed control lever in the maximum speed position.

14.3.2 LIMITING SPEED GOVERNOR ADJUSTMENT (DUEL RANGE)

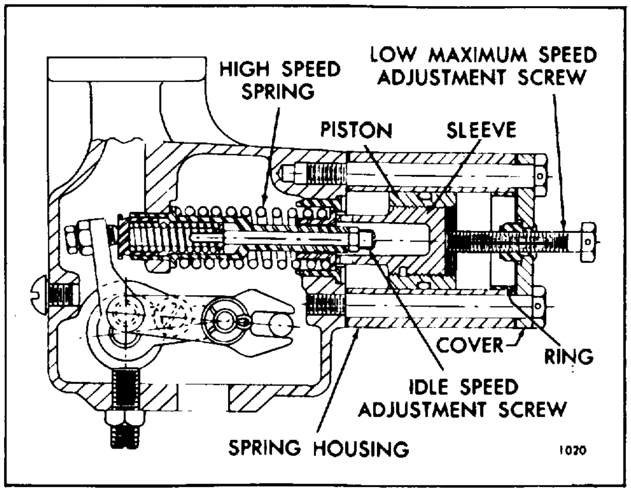


Figure 5 - Former Dual Range Governor

b. Loosen the lock nut and turn the low maximum speed adjusting screw in until the desired no-load high maximum speed is obtained.

c. Stop the engine and remove the spring housing. Note the distance the sleeve extends beyond the spring housing.

CAUTION: Do not permit the seal ring on the piston to slide past the air inlet port, since the seal ring will be damaged.

d. Remove the piston and sleeve from the bottom of the spring housing.

e. Turn the piston until the sleeve extends from the bottom of the piston the same distance the sleeve extends beyond the spring housing, Step c.

f. Check the adjustment by installing the piston and sleeve in the spring housing. The piston should be flush to 1/64" below the bottom of the spring housing when it is tight against the adjustment screw.

NOTE: The cover, cover gasket and spring housing must be held as an assembly when checking the piston position g. Replace the piston and sleeve in the governor spring housing and assemble to the governor.

h Start the engine and place the speed control Pag lever in the maximum speed position and apply air pressure to the governor.

NOTE: To overcome the tension of the governor high speed spring, 50 psi air pressure will be required in the governor spring housing.

i. Back out the low maximum speed adjustment screw 1/4". If the piston is adjusted correctly, the engine will operate at the recommended high maximum no-load speed.

j. Remove the air pressure from the governor.

k. Make minor adjustment on the piston and sleeve if necessary to establish the exact speed desired.

1 Disconnect any linkage attached to the governor speed control lever.

2 Set the low maximum no-load engine speed,

a Adjust the low maximum speed adjusting screw, with the engine speed control lever in the maximum speed position, until the desired low maximum speed is obtained. Turn the screw in to increase or out to decrease engine speed.

b. Tighten the lock nut and recheck the engine speed.

maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 and 2.

Engines with Current Dual Range Limiting Speed Mechanical Governor After positioning the injector rack control levers, set the maximum engine speeds.

NOTE: Be sure the buffer screw projects 5/8" from the lock nut to prevent interference while adjusting the maximum no-load speeds.

With the spring housing assembly mounted on the governor, the piston and sleeve assembled with four .100" shims and ten .010" shims as illustrated in Fig. 6, and the low maximum speed screw extending from the spring housing approximately 1-1/4", proceed as follows:
CAUTION
: Do not apply air pressure to governor until performing Step if.

1 Set the high maximum no-load speed.

a. Start the engine and position the speed control lever in the maximum speed position.

b. Turn the low maximum speed adjustment screw in until the high maximum speed desired is obtained.

c. Stop the engine and remove the spring housing assembly.

CAUTION: Do not permit the seal ring on the piston to slide past the air inlet port, since the seal ring will be damaged.

d. Note the distance the piston is within the spring housing when it is against the low maximum speed screw, and then remove the sleeve from the piston.

NOTE: When checking this distance, the piston should be held tight against the adjustment screw of the cover that is held in position, with its gasket, against the end of the spring housing.

e. Remove a quantity of shims, from the shims within the piston, equal to the distance noted in Step d.

f. Start the engine and position the engine speed control lever in the maximum speed position and apply air pressure to the governor and note the engine speed.

g. Remove the air pressure from the governor and stop the engine, then install or remove shims as required to obtain the correct high maximum no-load speed. Removing shims will decrease the engine speed and adding shims will increase the engine speed.

NOTE: Each .010" shim removed or added will decrease or increase the engine speed approximately 10 rpm.

2 Set the low maximum no-load engine speed.

a. Adjust the low maximum speed adjusting screw, with the speed control lever held in the maximum speed position, until the desired low maximum is obtained. Turn the screw in to increase or out to decrease the engine speed.

b. Recheck the engine speed and readjust if necessary.

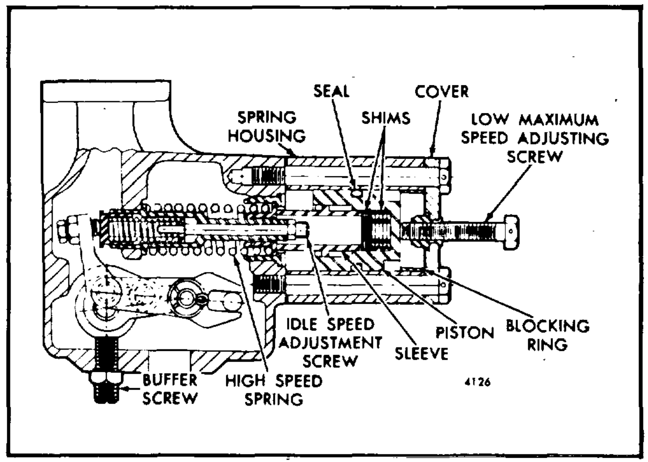


Fig. 6 Current Dual Range Governor

3 Check both the high maximum and low maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 and 2.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1 Refer to Figs 5 and 6 and remove the spring housing to uncover the idle speed adjusting screw.

2 With the engine at normal operating temperature and with the buffer screw, Fig 6, backed out to avoid contact with the differential lever, engine is operating at approximately 15 rpm below the recommended idle speed.
The recommended idle speed is 450 rpm but may vary with engine applications.

3 Hold the idle screw and tighten the lock nut.

4 Install the high speed spring retainer and retain with the two bolts.

Adjust Buffer Screw

With the idle speed set, the buffer screw may be adjusted as follows:

1 With the engine running at normal operating temperature, turn the buffer screw in so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

14.3.2 LIMITING SPEED GOVERNOR ADJUSTMENT (DUEL RANGE)

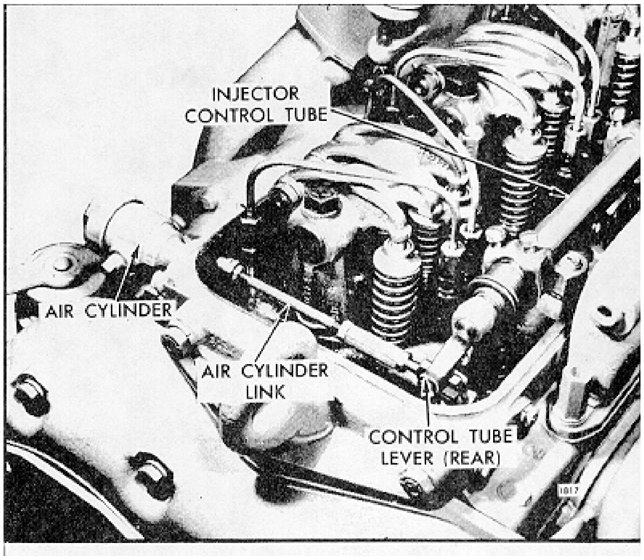


Fig. 7 - Air Cylinder Used with Limiting Speed Governor

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2 Hold the buffer screw and tighten the lock nut.

3 Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

Adjust Fuel Shut-Off Air Cylinder Linkage Engines With Fuel Shut-Off Cylinder Assembly

After completing the adjustment of the engine governor, adjust the linkage between the air shut-off cylinder and the injector fuel control tube lever according to the following procedure.

1 Place the speed control lever into the fullspeed position. The movement of the control lever to the full-speed position will move the injector racks to the full-fuel position.

2 Loosen the lock nuts on the air cylinder fuel shut-off rod (Fig 7) and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in the end of the control tube shut-off lever. Then shorten the rod one complete turn of the turnbuckle and tighten the lock nuts.

Adjusting the rod in this manner will permit the engine governor to move the injector fuel control racks into the full-fuel position without coming to the end of the slot in the end of the air cylinder fuel shut-off rod.

LIMITING SPEED MECHANICAL GOVERNOR ADJUSTMENT

(Variable Low-Speed)

The variable low-speed limiting speed mechanical governor is used on 6-71 highway vehicle engines where the same engine powers both the vehicle and the auxiliary equipment for unloading bulk products (such as cement, 'grain or liquids) and a high idle speed range is desired during auxiliary operation.

During highway operation, the governor functions as a limiting speed governor, controlling the engine idling speed and limiting the maximum operating speed. At the unloading area, the throttle is left in the idle speed position and the speed adjusting handle (Fig. I) is turned to obtain the speed required to operate the auxiliary equipment. The governor then functions as a variable speed governor, maintaining a constant speed even when the load is constantly changing, during the' unloading operation.

Before resuming highway operation, turn the speed adjusting handle back against the stop, then turn it back in about one-quarter of a turn.

Governor identification is provided by a name plate attached to the governor housing. The letters V.L.S.L.S. stamped on the name plate denote a variable low speed limiting speed governor.

After adjusting the exhaust valves and timing the injectors, adjust the governor and position the injector rack control levers.

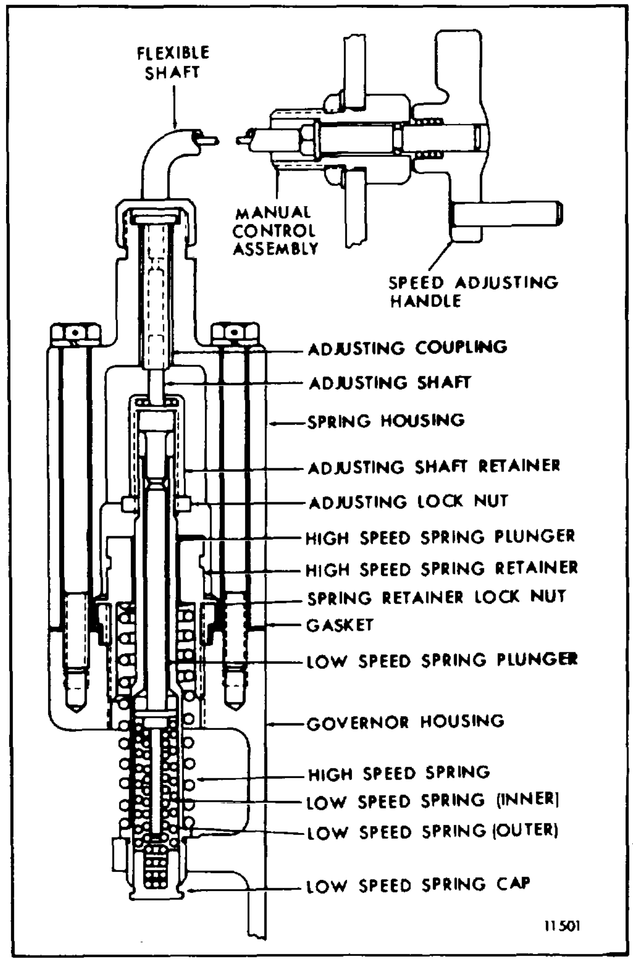


Fig. 1 - Governor Spring Housing and Components

14.3.3 Variable Low-Speed Governor

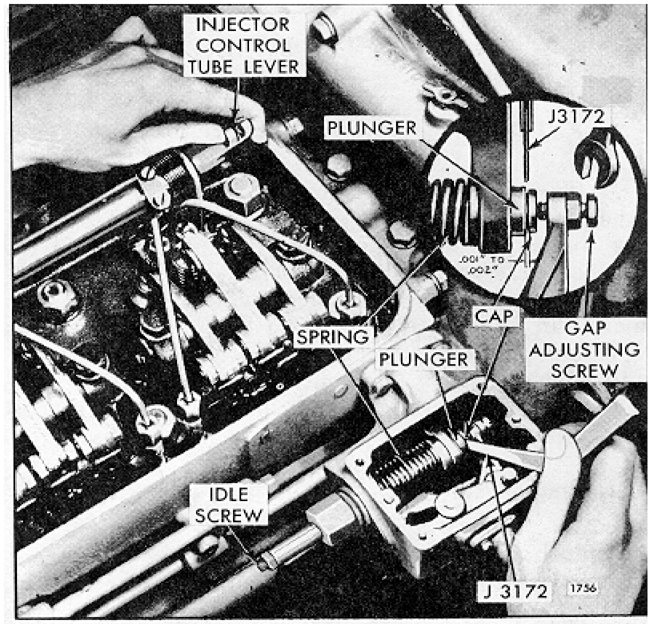


Fig. 3 - Adjusting Governor Gap

1 Stop the engine, remove the two bolts and withdraw the governor spring retainer cover.

2 Back out the buffer screw until it extends approximately 5/8" from the lock nut.

3 Make a preliminary idle speed (normal highway idle speed) adjustment as follows:

a Back out the variable low-speed adjusting shaft until the shoulder on the shaft contacts the shaft retainer (Fig 1).

b. Start the engine. Then hold the lock nut and loosen the low-speed adjusting shaft retainer.

c. Adjust the retainer and shaft assembly to obtain the desired idle speed (450 rpm minimum).

NOTE: It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8"). Then hold the retainer and tighten the lock nut to retain the adjustment.

Adjust Governor Gap

With the engine at operating temperature, adjust the governor gap as follows:

4 Stop the engine and remove the governor cover and lever assembly.

5 Start and run the engine between 900 and 1050 rpm by manual operation of the differential lever as shown

in Fig. 3. This gap setting range is required because of the lighter low-speed weights and heavier highspeed weights.

> **CAUTION:** Do not overspeed the engine.

6 With the engine operating between 900 and 1050 rpm, set the gap between the low-speed spring cap and the high-speed spring plunger (Fig 3) at .0015" by adjusting the gap adjusting screw in the operating shaft lever If the setting is correct, the .0015" movement can be seen by placing a drop of oil into the governor gap and pressing a screw driver against the gap adjusting screw Movement of the cap toward the plunger will force the oil from the gap in the form of a small bead.

7 Hold the gap adjusting screw and tighten the lock nut.

8 Re-install the governor cover and lever assembly.

Position Injector Rack Control Levers

Position the injector rack control levers as outlined in Section 14.3.

Adjust Maximum No-Load Engine Speed

Adjust the maximum no-load engine speed as outlined for the limiting speed mechanical governor in Section 14.3.

Adjust Idle Speed

Adjust the normal highway idle speed as follows:

1 With the engine running at normal operating temperature and with the buffer screw backed Qut to avoid contact with the differential lever, hold the lock nut and loosen the variable low-speed adjusting shaft retainer Adjust the retainer and shaft assembly to obtain a minimum of 550 rpm idle speed (current single-weight governor) or 450 rpm (former doubleweight governor).

> **NOTE:** It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8").

Adjust Buffer Screw

Adjust the buffer screw as outlined in Section 14.3.

LIMITING SPEED MEC
(Fast Idle Cylinder)

The limiting speed governor equipped with a fast idle air cylinder is used on vehicle engines where the engine powers both the vehicle and auxiliary equipment.

The fast idle system consists of a fast idle air cylinder installed in place of the buffer screw and a throttle locking air cylinder mounted on a bracket fastened to the governor cover (Fig. 1). An engine shutdown air cylinder, if used, is also mounted on the governor cover.

The fast idle air cylinder and the throttle locking air cylinder are actuated at the same time by air from a common air line. The engine shutdown air cylinder is connected to a separate air line.

The air supply for the fast idle air cylinder is usually controlled by an air valve actuated by an electric solenoid. The fast idle system should be installed so that it will function only when the parking brake system is in operation to make it tamper-proof.

The vehicle accelerator-to-governor throttle linkage is connected to a yield link so the operator cannot overcome the force of the air cylinder holding the speed control lever in the idle position while the engine is operating at the single fixed high idle speed.

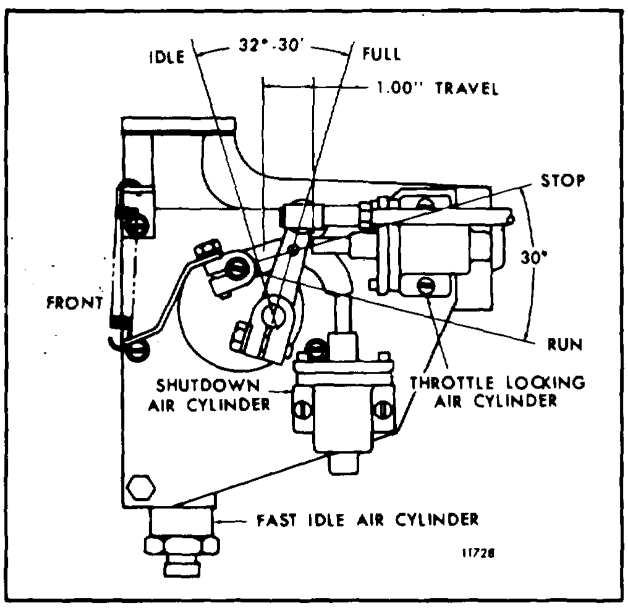


Fig. 1 - Governor with Fast Idle Cylinder

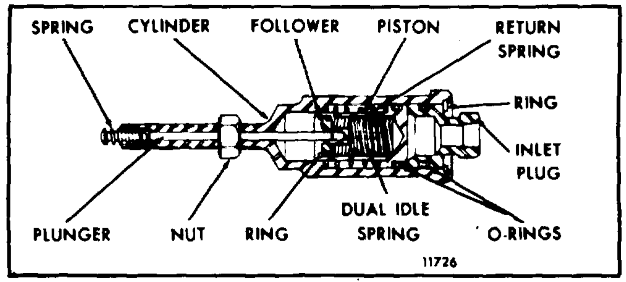


Fig. 2 - Fast Idle Air Cylinder

Operation

During highway operation, the governor functions as a limiting speed governor.

For operation of auxiliary equipment, the vehicle is stopped and the parking brake set. Then, with the engine running, the low-speed switch is placed in the ON position. When the fast idle air cylinder is actuated, the force of the dual idle spring (Fig. 2) is added to the force of the governor low-speed spring, thus increasing the engine idle speed.

The governor now functions as a constant speed governor at the high idle speed setting, maintaining a near constant engine speed regardless of the load within the capacity of the engine. The fast idle system provides a single fixed high idle speed that is not

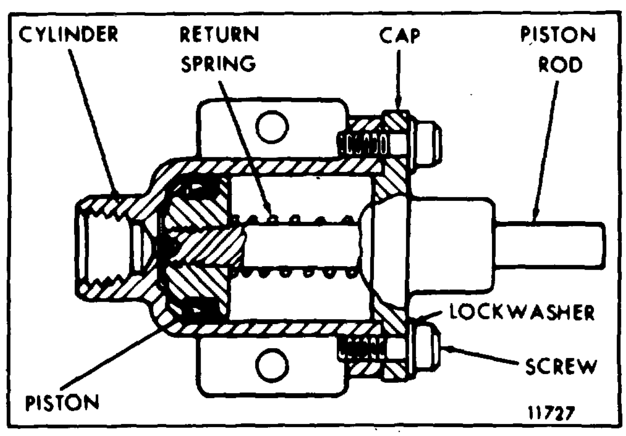


Fig. 3 - Throttle Locking Air Cylinder

14.3.4 Limiting Speed Governor (Fast idle)

adjustable, except by disassembling the fast idle air cylinder and changing the dual idle spring. As with all mechanical governors, when load is applied, the engine speed will be determined by the governor droop.

Adjust Governor

Adjust the governor as outlined in Section 14.3.

However, before adjusting the governor gap, back out the de-energized fast idle air cylinder until it will not interfere with the governor adjustments. After the normal idle speed setting is made, adjust the deenergized fast idle air cylinder as follows:

1 Disconnect any linkage attached to the governor speed control lever.

1 Turn the fast idle cylinder assembly in until an increase of idle speed is noted. The increase in idle speed should not exceed 15 rpm Tighten the fast idle jam nut.

2 Lock the governor throttle in the idle position and apply full shop air pressure to the fast idle air cylinder. The engine idle speed must increase 250-550 rpm, depending upon the dual idle spring used.

The throttle locking air cylinder is adjusted on its mounting bracket so it will lock the throttle in the idle position when it is activated, but will not limit the throttle movement when not activated.

FUEL MODULATING GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust the exhaust valve clearance and time the fuel injectors before adjusting the governor and injector rack control levers.

Governor Adjustment Sequence

The following seven basic steps in setting a fuel modulating type governor must be performed in the order listed. Any deviation from this order may result in an improperly adjusted governor.

1 Set the fuel modulating spring tension.
2 Set the low speed spring gap.
3 Check the fuel modulating gap closing space.
4 Set the fuel modulating cam.
5 Set the injector racks.
6 Set the no-load high speed.
7 Set the idle speed.

Only Settings 1, 3 and 4 are new and peculiar to the fuel modulating governor. Steps 2, 5, 6 and 7 are the same or similar to those of the limiting speed governors. However, the following adjustment procedures should be thoroughly studied and carefully followed.

The seven basic settings are set forth in bold face type in the following pages. The adjustments required before each of these seven settings can be made are set forth prior to each setting and are listed as "Preliminary Adjustment".

No. 1-Fuel Modulating Spring Tension Setting

Preliminary Adjustment

A Remove the governor adjustment cover (44), Fig 1, control housing cover, housing plug (9) and copper gasket Disconnect the governor external control linkage and remove the valve rocker cover.

B Loosen the idle speed screw lock nut (42) and back out idle screw (43) until the low speed spring (59) exerts no pressure on the low speed spring cap (61) This may be determined by moving the low speed cap in and out Use care

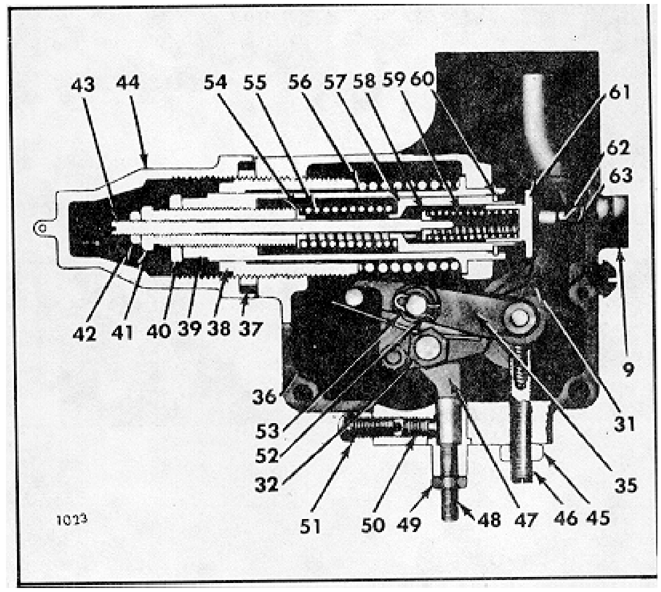


Fig. 1 - Fuel Modulating Governor Spring

9	Housing Plug	46	Buffer Screw
31	Operating Lever	47	Modulating Cam
32	Torsion Spring Screw	48	Cam Adjusting Screw
35	Differential Lever	49	Lock Nut
36	Torsion Spring	50	Cam Lock Screw
37	High Speed Lock Nut	51	Plugging Screw
38	High Speed Adjusting Screw	52	Retaining Spring Pin
		53	Washer
39	High Speed Spring Plunger	54	Modulating Spring Seat
		55	Modulating Spring
40	Modulating Screw Lock Nut	56	High Speed Spring
		57	Modulating Spring Plunger
41	Modulating Speed Adjusting Screw	58	Low Speed Spring Seat
42	Idle Speed Screw Lock Nut	59	Low Speed Spring
		60	Retainer Ring
43	Idle Speed Adjusting Screw	61	Low Speed Spring Cap
		62	Lock Nut
44	Adjustment Cover	63	Low Speed Gap Adjusting Screw
45	Buffer Screw Lock Nut		

not to back the screw out too far as it is possible to turn it completely out of the low speed spring seat (58).

> **NOTE:** If the type of fuel modulating spring (55) is not known (70, 95, 150, 175 or 225 lbs. per inch), consult the Chart on Fuel Modulating Governors, RPM, and Springs in Section 2.7.1. The type of spring is identified by color code (and must be known) before proceeding with preliminary adjustment "C" below.

C. Loosen the high speed lock nut (37) and turn the high speed adjusting screw (38) into the body

14.5 FUEL MODULATING GOVERNOR ADJUSTMENT

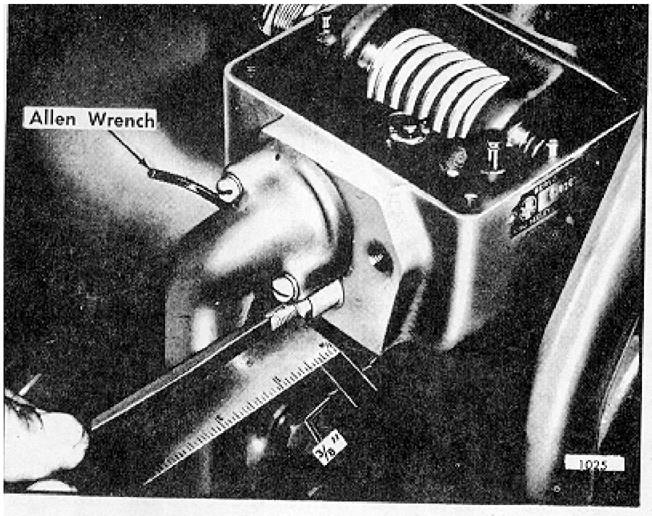


Fig. 2 - Preliminary Adjustment of Low and High Speed Springs

until the flats on the end of the high speed spring plunger (39) are fully exposed.

D Loosen the modulating screw lock nut (40) and turn the screw (41) out by hand until the modulating plunger (57) may be moved back toward the high speed plunger 1/16" before touching the spring.

Adjustment No. 1
Turn the screw (41) in by hand until resistance indicates the spring has forced the plunger forward to contact the retainer ring (30). Repeat as necessary until sure that the plunger is just contacting the ring with no tension on the spring. Then, turn the modulating adjusting screw (41) in 1/3 of a turn (two flats). Lock the adjusting screw in position with the lock nut (40).

> **CAUTION:** The high speed plunger (39) and the fuel modulating spring adjusting screw (41) should both be held securely in position with two wrenches when tightening the fuel modulating adjusting screw lock nut (40) to prevent the screw and plunger relationship from being disturbed.

No. 2-Low Speed Spring Gap Setting Preliminary Adjustment

A Reset the idle adjusting screw (43) to 2" projection ("A" in Fig 2) and replace the control housing cover. Secure it with the two screws.

> **CAUTION:** Be sure that the throttle shaft pin is positioned between the torsion spring (36) and the end of the differential lever.

B Start the engine and make a preliminary idle speed setting by setting the speed at 385 rpm with the low speed screw (43) and advancing the speed to 400 rpm by turning in the buffer screw (46) Tighten the low speed lock nut (42).

C Stop the engine.

D Remove the governor control housing cover and lever assembly. Remove the cover gasket.. Disconnect the link rod between the differential lever and injector control tube lever. Then, remove the link through the governor.

E Thread the buffer screw (46) outward 4 or 5 turns.

F Loosen the cam adjusting screw lock nut (49). Remove the plugging screw (51) and use an Allen wrench to loosen the cam lock screw (50) approximately 1/8 turn to permit the cam to be moved in and out without allowing it to turn in housing.

G Thread the cam adjusting screw (48) into the housing until the screw extends 3/8" beyond the lock nut when the nut is against the sleeve, Fig. 3. Tighten the cam lock screw with the Allen wrench to hold the cam in position until adjusted later.

H Start the engine and operate it between 600 and 700 rpm, checking with a tachometer.

NOTE: Governor to control tube link is removed and engine speed must be

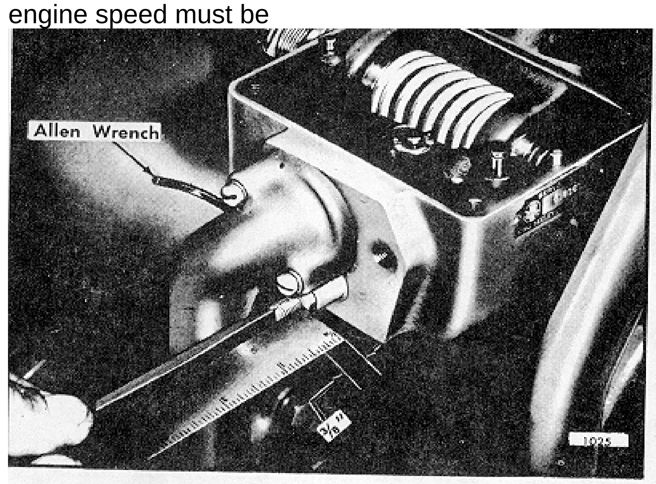


Fig. 3 Preliminary Adjustment of Modulating Cam

controlled by hand or temporary adjustable link and spring at control lever tube, Fig. 4.

Adjustment No. 2

Check the gap between the low speed spring cap (61) and modulating spring plunger (57) with a .0015" feeler gage, Fig. 5.

If the gap is not within .001"-.002" at 600-700 rpm, loosen the lock nut (62) and turn the low speed gap adjusting screw (63) as necessary to obtain the proper gap. Tighten the lock nut (62) and recheck the gap.

No. 3-Checking Fuel Modulating Gap Closing

Preliminary Adjustment

A If an adjustable link has been used, it should be removed, Fig 4.

B Install the control link between the differential lever and injector control tube lever The link is secured at the governor end with a flat washer and retaining spring pin A straight pin and cotter pins are used at the control tube. The link must be free with no bind.

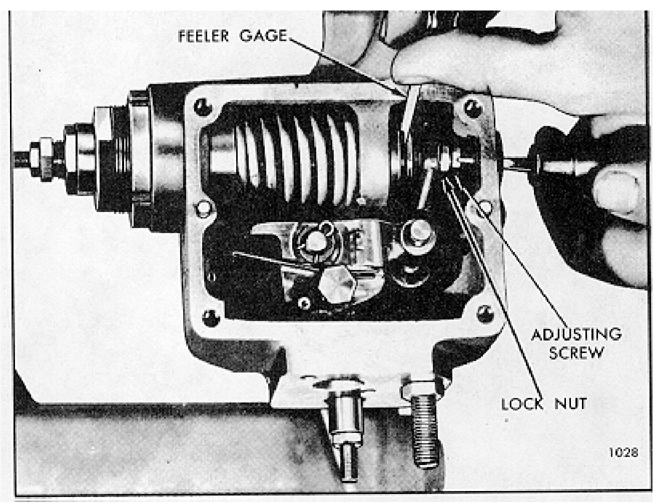


Fig. 4 Injector Rack with Adjustable Link and Spring Installed

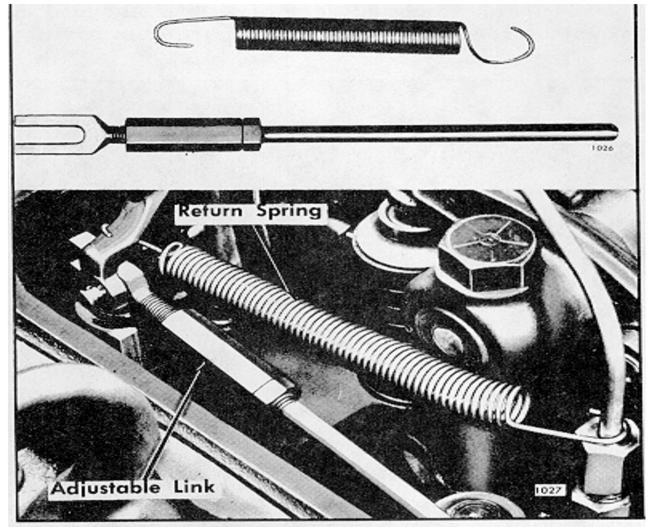


Fig. 5 Low Speed Spring Gap Adjustment

C Start the engine and control the speed manually by exerting force against the torsion spring (36) with a finger.

> **CAUTION:** Care must be exercised to avoid overspeeding the engine.

Adjustment No. 3
Advance the engine speed gradually until the low speed spring cap (61) contacts the high speed plunger (39). Do not exceed 2100 rpm. The gap closing speed should be checked with a .0015" feeler gage between the mating surface of (61) and (39), and will vary according to the following table:

Fuel Modulator Spring Chart

F. M Spring	Closing Speed Range
225#/inch-WH ITE	1950-2040
175#/inch-GREEN	1850-1940
150#/inch-BROWN	1750-1840
70#/inch-YELLOW	1525-1625

If the closing speed does not fall within the correct range, then recheck setting No. 1 or preliminary "B" to setting No. 2 or check for the correct fuel modulating spring.

If, after rechecking the adjustments as indicated above, the closing speed still does not fall within the specified range, the modulating spring should be replaced.

No. 4-Fuel Modulating Cam Setting
Preliminary Adjustment
A Stop the engine.

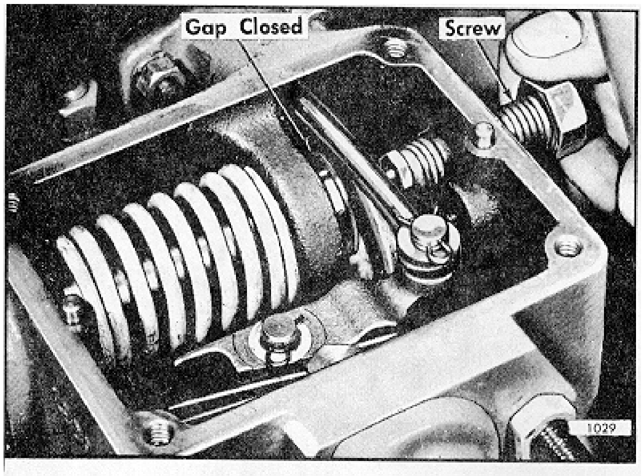


Fig. 6 - Closing Modulator Gap with Special Screw

B Set the high speed adjusting screw (38) to extend 3/4" beyond the high speed screw lock nut (37) when the nut is tight against the housing, Fig 2.

C Temporarily install the cap screw (1/2"-13 x 2") into the front of the control housing and thread the screw inward until the gap between the low speed cap (61) and high speed spring plunger (39) just closes, Fig 6. Be careful that the high speed spring plunger is not moved.

D Loosen the inner and outer adjusting screws at each injector rack control lever until each lever is free on the control tube.

E Install the cover to governor control housing gasket Install the control housing cover assembly, being sure that the throttle shaft pin is between the differential lever (35) and the torsion spring (36). Secure the cover with the four screws and lock washers.

Adjustment No. 4

Use an Allen wrench and loosen the cam lock screw (50) only enough (1/8 turn) to permit turning the cam adjusting screw (48) with the fingers. If the lock screw is backed out further, the cam may be released and turned by its own weight out of the operating position.
With the control lever in the full throttle position, Fig. 7, thread the cam adjusting screw (48) outward with the finger tips until the cam (47) can be felt bottoming against the roller on the bottom of the differential lever (35). Thread the cam adjusting screw outward an additional 1,/8 turn to provide positive engagement between the differential lever roller and the cam. After making contact, it may be necessary to turn the screw very slightly IN or p: OUT to produce the final 1/64" clearance illustrated in Fig. 7, which is required after the Allen screw has been tightened. Tighten the lock nut (49); also install the plugging screw (51).

> **CAUTION:** The adjustment of the modulating cam is extremely important and must be carefully and accurately performed.

No. 5-Injector Rack Setting
Preliminary Adjustment

A Manually hold the control lever in the full throttle position, Fig 8.

B Loosen all of the inner and outer injector rack control lever adjusting screws.

Adjustment No. 5

A Turn down the inner adjusting screw of the No 1 injector rack control lever.. Adjust the No. 1 injector rack control lever, Fig 8, so that a very light finger tip pressure at the coupling will produce a tendency to roll, but the coupling should not be loose.

B Turn down the outer adjusting screw until it bottoms on the control tube. After the outer adjusting screw has bottomed, tighten the inner and outer adjusting screws alternately until the injector control lever is held firmly in position.

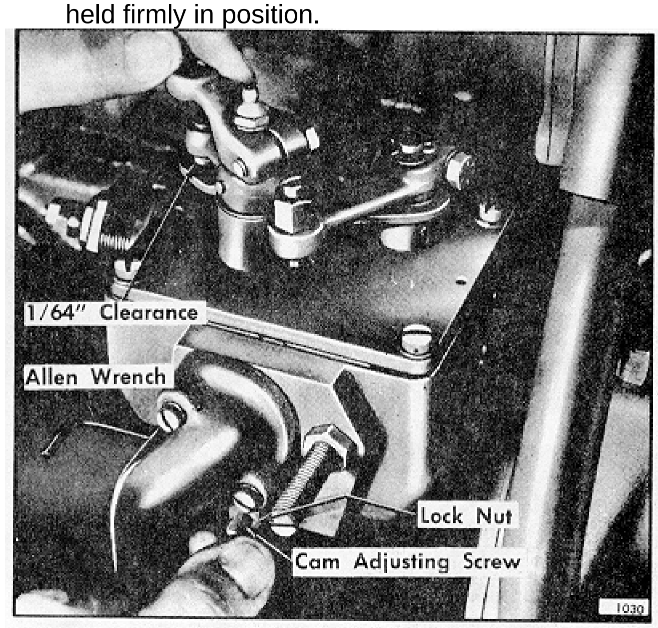


Fig. 7 - Modulating Cam Adjustment

CAUTION: Do not set No. 1 or any other rack too tight as this will produce clearance between the cam and the differential roller and will result in delay and reduction of the fuel modulating action.

Holding the injector control tube lever for "feel", adjust the remaining rack control couplings, Fig. 9. Adjust the No. 2 rack control lever so that it has the same "feel" as the No. 1 coupling. Repeat this procedure on all of the remaining racks. That is, compare the No. 3 rack with No. 1, etc., making certain no other injector is tighter than No. 1.

No. 6-No-Load High Speed Setting
Preliminary Adjustment

A Remove the temporarily installed cap screw, then install the control housing plug (9), with a gasket.

B Loosen the high speed adjusting screw lock nut, if tight.

C Install the valve rocker cover.

Adjustment No. 6

Start the engine and move the throttle lever toward the FULL-FUEL position while observing the tachometer. Avoid overspeeding the engine more than 100 rpm above the desired speed.

Turn the high speed adjusting screw (38) until the desired no-load maximum speed is obtained with the throttle lever in a wide open position, Fig. 10.

Lock the nut (37).

No. 7-Idle Speed and Buffer Screw Setting

Adjustment No. 7

With the engine running at idle speed, observe the

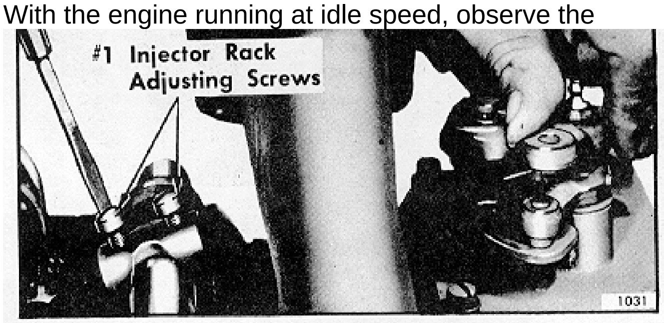


Figure 8 - Adjusting No. 1 rack to Governor

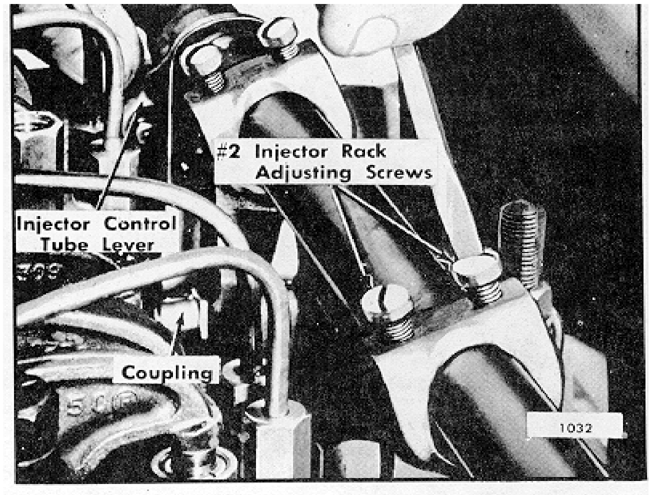


Fig. 9 Adjusting No. 2 Rack to No. 1 Rack

engine rpm at the tachometer; then, loosen the lock nut (42) and thread the idle adjusting screw (43) IN to increase or OUT to decrease until 385 engine rpm is obtained, Fig. 11. Tighten the lock nut.

With the engine running at idle speed, thread the buffer screw (46) in until the "surge" or "roll" of the engine just disappears, but not higher than 400 rpm. Any variation from this speed will affect fuel modulating action.

Do not raise the engine speed more than 20 rpm with the buffer screw, otherwise it may not be possible to stop the engine. Hold the screw (46) and tighten the lock nut, Fig. 12. Stop and start the engine several times to be sure of its stopping.

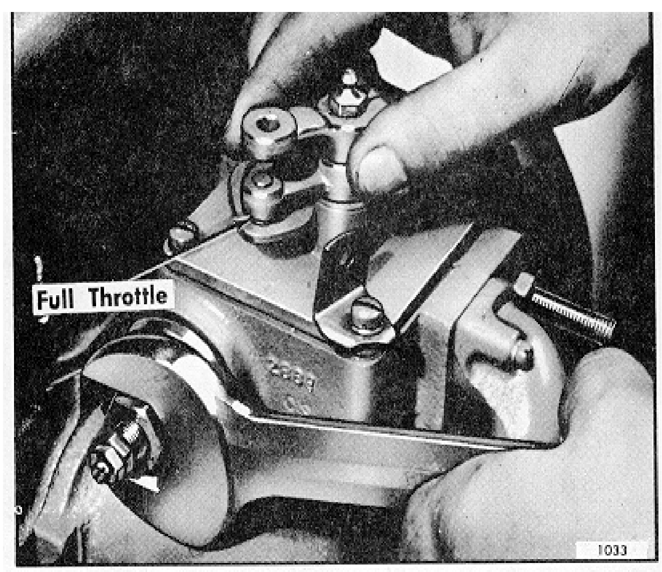


Figure 10 - Adjusting High Speed

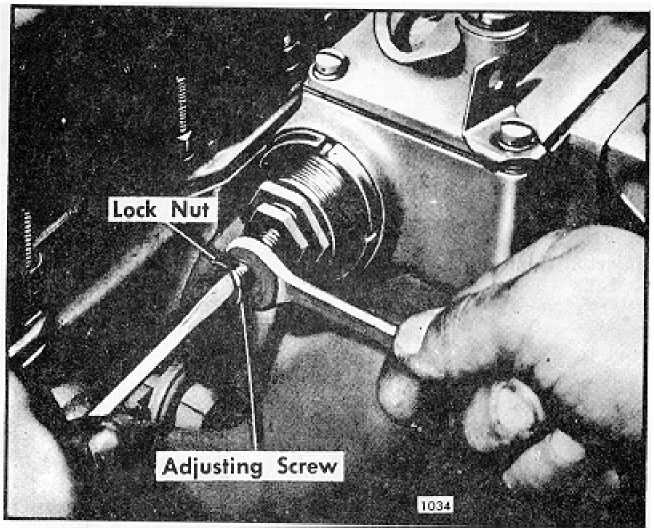


Fig. 11 - Adjusting Idle Speed

Install Removed Parts

1 Install and tighten the governor adjustment cover (44).

2 Connect the throttle control rod to the throttle control lever at the governor cover.

3 Connect the linkage to the engine stop lever at

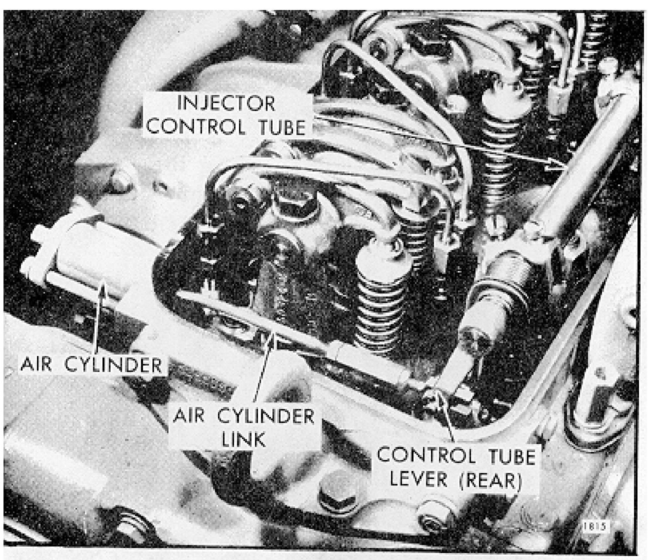


Fig 13 Air Cylinder Linkage

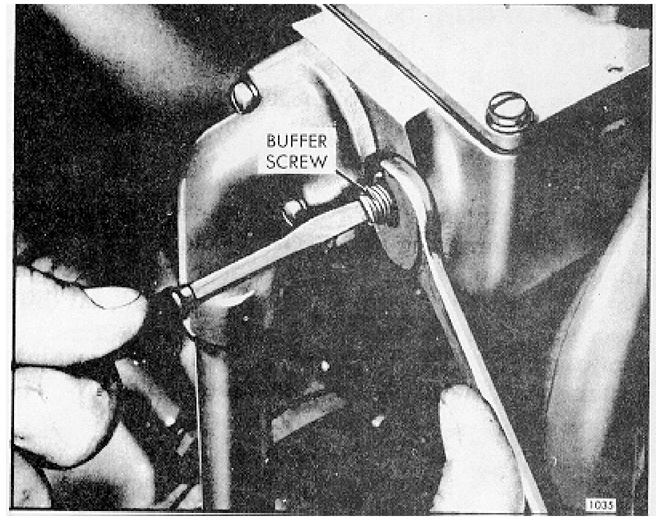


Fig 12 - Adjusting Buffer Screw

the governor cover.

Adjust Fuel Shut-Off Air Cylinder Linkage Engines Having Fuel Shut-Off Air Cylinder Assembly

After completing the adjustment of the engine governor, adjust the linkage between the air shut-off cylinder (Fig. 13) and the injector fuel control tube WV lever according to the following procedure.

1 Place the governor control lever into the full speed position The movement of the control lever to the full speed position will move the injector racks to the FULL-FUEL position.

2 Loosen the lock nuts on the air cylinder fuel shut-off rod and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in end of the control tube shut-off lever. Then shorten the rod one complete turn of the turnbuckle and tighten the lock nuts.

Adjusting the rod in this manner will permit the governor to move the injector fuel control racks into the FULL-FUEL position without coming to the end of the slot in the end of the air cylinder fuel shut-off rod.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT
ENDINE LOAD LIMIT DEVI E

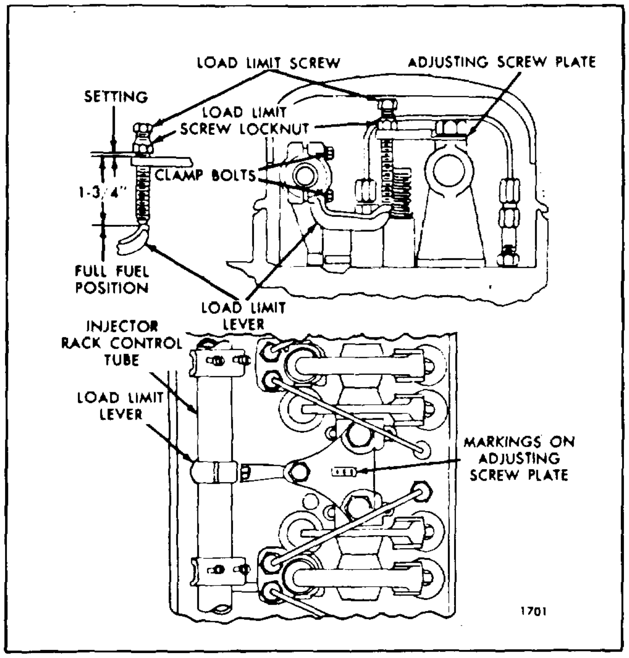


Fig. 1 - Engine Load Limit Device

Engines with mechanical governors may be equipped with a load limit device (Fig. 1) to reduce the maximum horsepower.

This device consists of a load limit screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a load limit lever clamped to the injector control tube.

The load limit device is located between the No. I and No. 2 cylinders of a three cylinder engine, between the No. 2 and No. 3 cylinders of a four cylinder engine or between the No. 3 and No. 4 cylinders of a six cylinder engine.

When properly adjusted for the maximum horsepower desired, this device limits the travel of the injector control racks and thereby the fuel output of the injectors.

Adjustment

After the engine tune-up is completed, make sure the load limit device is properly installed as shown in Fig. 1. Make sure the counterbores in the adjusting screw plate are up. The rocker arm shaft bracket bolts which fasten the adjusting screw plate to the brackets are tightened to 75-85 lb-ft torque (all other rocker arm shaft bracket bolts are tightened to 90-100 lb-ft torque). Then adjust the load limit device as follows:

1 Loosen the load limit screw lock nut and remove the screw.

2 Loosen the-load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

3 With the screw out of the plate, adjust the load limit screw lock nut so the bottom of the lock nut is 1 3/4" from the bottom of the load limit screw (Fig I) for the initial setting.

4 Thread the load limit screw into the adjusting screw plate until the lock nut bottoms against the top of the plate.

5 Hold the injector rack control tube in the full-fuel position and place the load limit lever against the bottom of the load limit screw Then tighten the load limit lever clamp bolts.

6 Check to ensure that the injector racks will just go into the full-fuel position -readjust the load limit lever if necessary.

7 Hold the load limit screw to keep it from turning, then set the lock nut until the distance between the bottom of the lock nut and the top of the adjusting screw plate corresponds to the dimension (or number of turns) stamped on the plate. Each full turn of the screw equals .042", or .007" for each flat on the hexagon head.

> **NOTE:** If the plate is not stamped, adjust the load limit screw while operating the engine on a dynamometer test stand and note the number of turns required to obtain the desired horsepower. Then stamp the plate accordingly.

8 Thread the load limit screw into the plate until the lock nut bottoms against the top of the plate. Be sure the nut turns with the screw.

9 Hold the load limit screw to keep it from turning, then tighten the lock nut to secure the setting.

14.14 GOVERNING DEVICE ADJUSTMENT

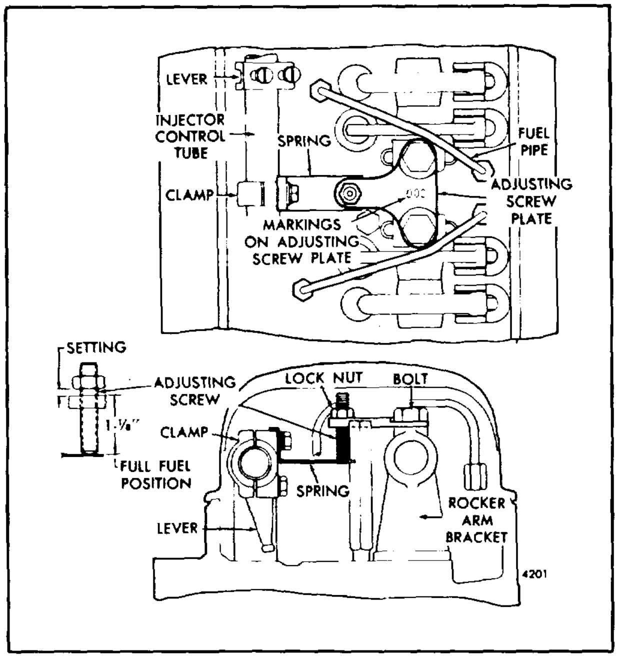


Fig. 2 - Power Control Device

The power control (torque limiting) device (Fig. 2) is used, on some vehicle engines, to limit the maximum horsepower output at the wheels without diminishing the performance at lower speeds where full power may be required. It limits the horsepower at, or just below, the normal full-load governed speed. These limiting characteristics are proportionately lessened as the engine speed is reduced and the horsepower required is reduced.

This device consists of an adjusting screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a spring attached to a clamp on the injector control tube.

> **NOTE:** The rocker arm shaft bracket bolts that retain the adjusting screw plate are tightened to 75-85 lb-ft torque. All other rocker arm shaft bracket bolts are tightened to 90-100 lb-ft torque.

The power control device is located between the No. I and No. 2 cylinders on a 3-cylinder engine, between the No. 2 and No. 3 cylinders on a 4-cylinder engine and between the No. 3 and No. 4 cylinders on a 6-cylind'er engine.

Adjustment

After the engine tune-up is completed, adjust the power control device as follows:

1 Place the vehicle on a chassis dynamometer and check the maximum wheel horsepower.

2 Loosen the power control spring attaching bolts. Then adjust the spring until it projects parallel to the cylinder head when the injector control racks are held in the full-fuel position. Tighten the spring attaching bolts to 7-9 Ib-ft torque to retain the adjustment.

3 Set the power control device, while holding the injector control racks in the full-fuel position, by turning the adjusting screw down (clockwise) until it just touches the spring and the lock nut is tight against the plate Then release the injector control racks.

> **NOTE:** Wipe the oil from the spring and the bottom of the adjusting screw so the point of contact can be seen readily.

4 Start the engine. Then, with the engine running at full governed speed, check the horsepower. If necessary, re-adjust the screw to obtain the specified horsepower Turn the screw down to decrease the horsepower; turn the screw up to increase the horsepower. When the desired wheel horsepower is obtained, hold the screw from turning and tighten the lock nut.

> **NOTE**: If a dynamometer is not available, back up the lock nut the distance stamped on the plate. Then turn the screw and lock nut down together until the lock nut bottoms on the plate.

14.14 GOVERNING DEVICE ADJUSTMENT

The throttle delay mechanism is used to retard full fuel injection when the engine is accelerated. This reduces exhaust smoke and also helps to improve fuel economy.

The throttle delay mechanism (Fig. 3) is installed between the No. I and No. 2 cylinders on the cylinder head. It consists of a special rocker arm shaft bracket (which incorporates the throttle delay cylinder), a piston, throttle delay lever, connecting link, orifice plug, ball check valve and U-bolt.

A yield lever and spring assembly replaces the standard lever and pin assembly on the front end of the injector control tube.

Operation

Oil is supplied to a reservoir above the throttle delay cylinder through an orifice plug in the drilled oil passage in the rocker arm shaft bracket (Fig. 3). As the injector racks are moved toward the no-fuel position, free movement of the throttle delay piston is assured by air drawn into the cylinder through the ball check valve. Further movement of the piston uncovers an opening which permits oil from the reservoir to enter the cylinder and displace the air. When the Pnoine is accelerated movement of the iniector racks while the piston expels the oil from the cylinder through an orifice. To permit full accelerator travel, regardless of the retarded injector rack position, a spring loaded yield lever and spring assembly replaces the standard lever on the front end of the injector control tube.

Adjustment

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be re-adjusted. With the engine stopped, proceed as follows:

1 Refer to Fig 4 and insert gage J 23190 (.454" setting) between the injector body and the shoulder on the injector rack. Then exert a light pressure on the injector control tube in the direction of full fuel.

2 Align the throttle delay piston so it is flush with the edge of the throttle delay cylinder.

3 Tighten the U-bolt on the injector control tube and

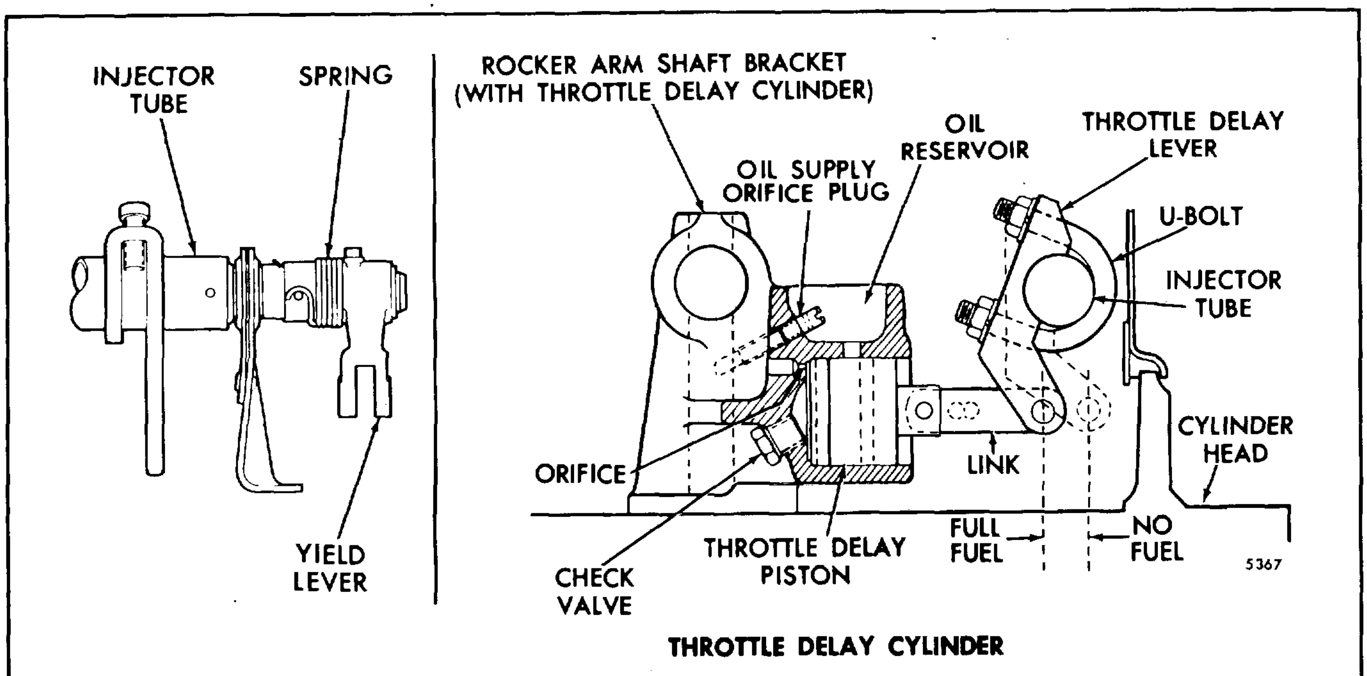


Fig. 3. Throttle Delay Cylinder and Yield Link.

14.14 GOVERNING DEVICE ADJUSTMENT

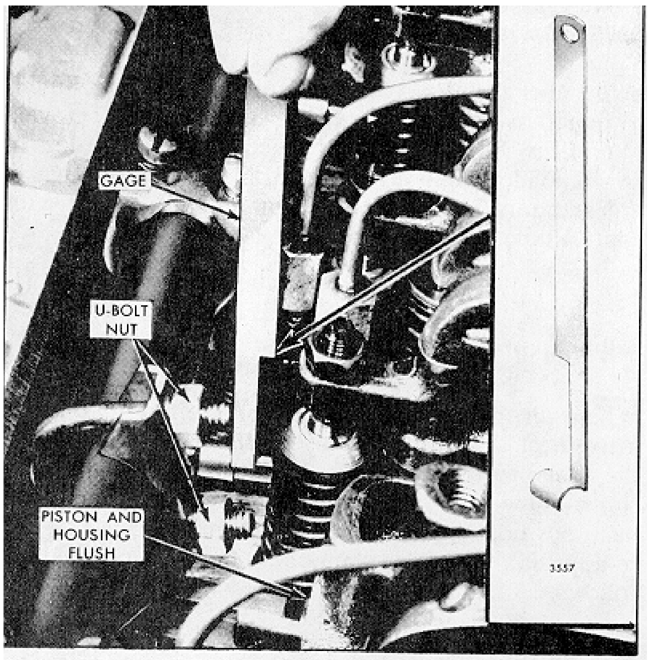


Fig. 4 - Adjusting Throttle Delay Cylinder

4 Move the injector rack from the no-fuel to the full fuel position to make sure it does not bind.

14.14 GOVERNING DEVICE ADJUSTMENT

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor, the governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel.

The solenoid plunger can be properly aligned to the governor stop lever as follows:

1 Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs 5 and 6). Align and clamp the lever to the shutdown shaft in such a way that, at its mid-travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible The solenoid plunger has available 1/2 " travel which is from the full-fuel to the complete no-fuel position and shutdown will occur prior to attaining complete travel.

2 With the stop lever in the run position, adjust the rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap, with a resultant build-up of pull-in force prior to initiating stop lever movement.

3 The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32"

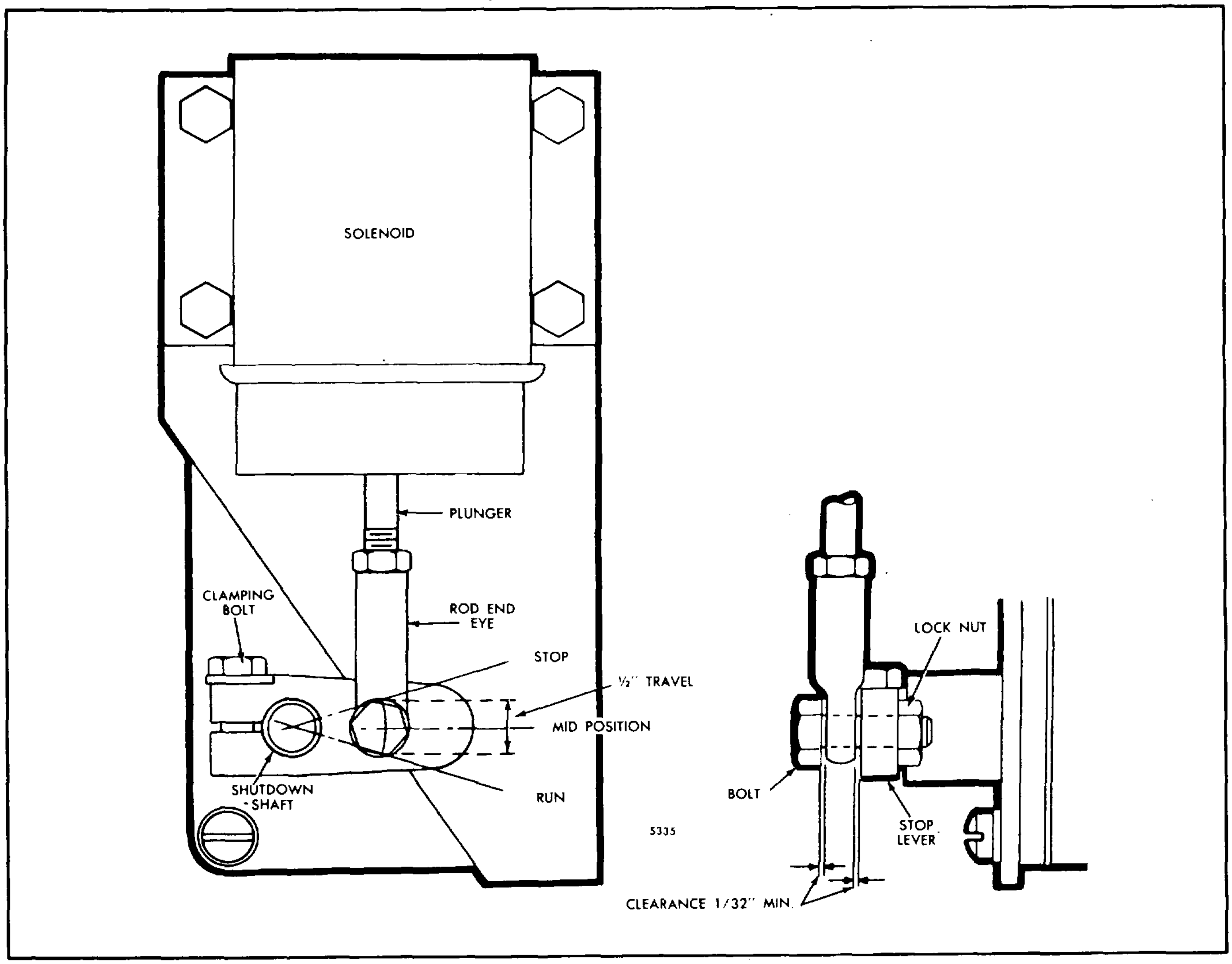


Fig. 5 - Typical Variable Speed Governor Lever Position

14.14 GOVERNING DEVICE ADJUSTMENT

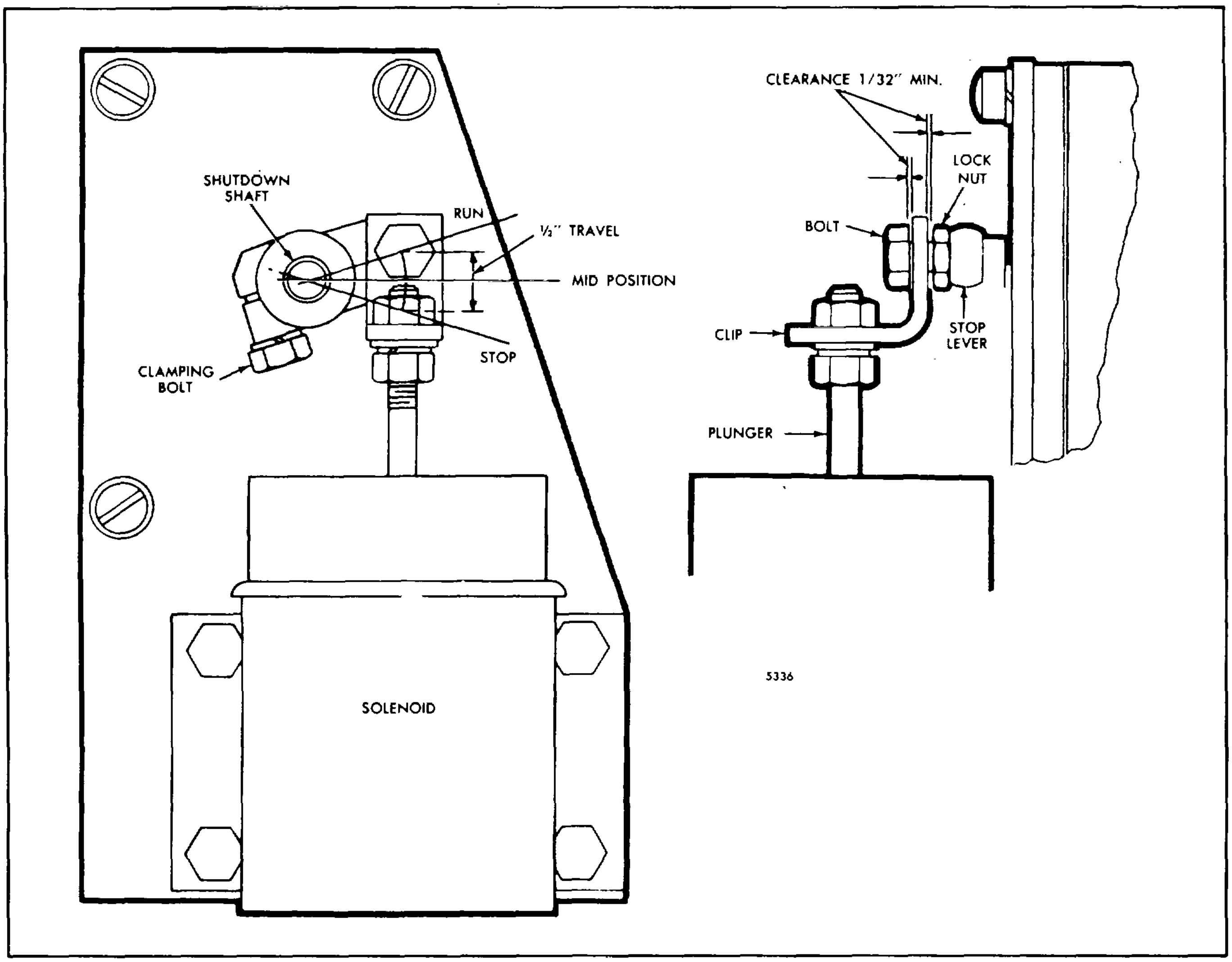


Fig. 6 - Typical Limiting Speed Governor lever Position

NOTE: The lock nut can be either on top of or below the stop lever.

4 Move the lever to the stop position and observe the plunger for any possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger motion.

SECTION 15

PREVENTIVE MAINTENANCE - TROUBLE SHOOTING -

STORAGE

CONTENTS

LUBRICATION AND PREVENTIVE MAINTENANCE

The Lubrication and Preventive Maintenance Schedule is intended as a guide for the vehicle owner in establishing his own preventive maintenance schedule. The suggestions and recommendations for preventive maintenance should be followed as closely as possible to obtain long life and best performance from a Detroit Diesel engine. The intervals indicated on the chart are time or miles (in thousands) of actual operation.

MAINTENANCE SCHEDULE EXPLANATION

The time or mileage increments shown apply only to the maintenance function described. These functions should be coordinated with other regularly scheduled vehicle maintenance such as chassis lubrication.

Maintenance functions I through 5 should be performed daily. Items 6 through 10 should be performed at 4,000 to 6,000 mile intervals. Items II through 32 should be performed at the intervals (whichever comes first, the time or mileage increments) as shown in the chart. Items 33 through 37 should be performed annually and item 38 should be performed as required.

Instructions on the pages following the chart describe the maintenance function involved.

EXAMPLE

6. Air Cleaner (Oil Bath)

This maintenance function should be performed at 4,000 to 6,000 miles and each 4,000 to 6,000 mile interval thereafter.

LUBRICATION AND PREVENTIVE MAINTENANCE CHART

DAILY	
1. Lubricating oil	(I)
2. Fuel tanks	(I)
3. Fuel lines	(I)
4. Cooling system	(I)

4,000 TO 6,000 MILE INTERVALS	
6. Air cleaner (oil bath)	(I)
7. Lubricating oil	(R) *
8. Lubricating oil filters	(R) *
9. Drive belts	(I)
10. Air compressor	(I)

6 MONTHS OR 10,000 MILE INTERVALS										
Months	6	12	18	24	30	36	42	48	50	60
Miles in Thousands	10	20	30	40	50	60	70	80	90	100
11. Fuel filters	(R)	(R)	(R)	(R)	(R)	(R)	(R)	(R)	(R)	(R)
12. Air cleaner (dry)		(I)		(I)		(I)		(I)		(I)
13. Coolant filter	(R)	(R)	(R)	(R)	(R)	(R)	(R)	(R)	(R)	(R)
14. Starting motor	(I)	(I)	(I)	(I)	(I)	(I)	(I)	(I)	(I)	(I)
15. Fuel tanks		(I)		(I)		(I)		(I)		(I)
16. Cooling system		(I)		(I)		(I)		(I)		(I)
17. Air system		(I)		(I)		(I)		(I)		(I)
18. Exhaust system		(I)		(I)		(I)		(I)		(I)
19. Air compressor		(I)		(I)		(I)		(I)		(I)
20. Air box drain tubes		(I)		(I)		(I)		(I)		(I)
21. Emergency shutdown		(I)		(I)		(I)		(I)		(I)
22. Engine (steam clean)		(I)		(I)		(I)		(I)		(I)
23. Radiator		(I)		(I)		(I)		(I)		(I)
24. Shutter operation		(I)		(I)		(I)		(I)		(I)
25. Oil pressure		(I)		(I)		(I)		(I)		(I)
26. Governor					(I)					(I)
27. Fuel injectors and valve clearance					(I)					(I)
28. Generator (battery-charging)							(I)			
29. Engine and transmission mounts							(I)			
30. Crankcase pressure							(I)			
31. Fan hub							(I)			
32. Throttle delay					(I)					(I)

ANNUALLY	
33. Cooling system	(I)
34. Thermostats and seals	(I)
35. Blower and screen	(I)
36. Fan (thermo-modulated)	(I)
37. Crankcase breather	(I)
38. Engine Tune-Up	+

(I) = Inspect, Correct or Replace if Necessary
(R) = Replace
* = Check Level Daily and Replace Initial Oil and Filter at 3,000 Miles
+ = As Required

15.1 Preventive Maintenance

1. Lubricating Oil

a. Check the lubricating oil level with the engine stopped. If the engine has just been stopped, wait approximately twenty minutes to allow the oil to drain back to the oil pan. Add the proper grade oil as required to maintain the correct level on the dipstick.

CAUTION: Oil may be blown out through the crankcase breather if the crankcase is overfilled.

b. Make a visual check for oil leaks around the filters and the external oil lines.

2. Fuel Tanks

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the Diesel Fuel Oil Specifications in Section 13.3. Open the drain at the bottom of the fuel tank every 15,000 miles to drain off any water or sediment.

3. Fuel Lines

Make a visual check for fuel leaks at the cross-over lines and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tanks.

4. Cooling System

a. Before starting the engine, always check the coolant level. Make sure the coolant covers the radiator tubes. Add coolant as necessary. Do not overfill.

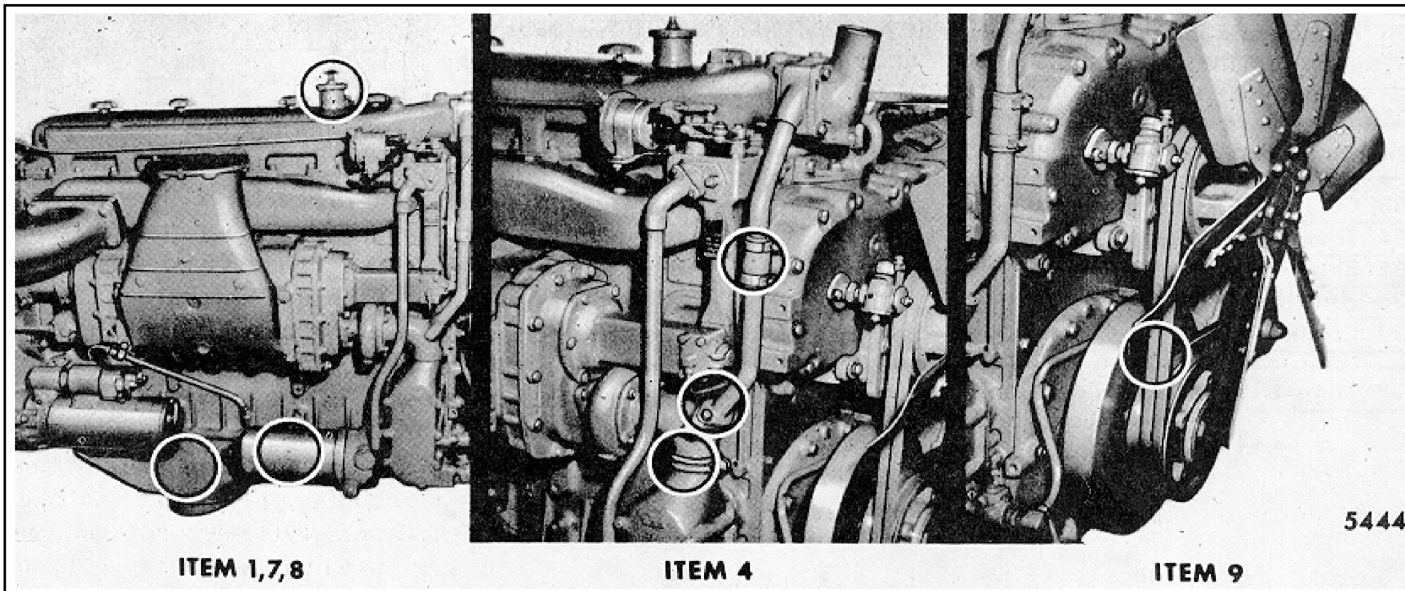
b. Make a visual check for cooling system leaks. Check for an accumulation of coolant beneath the vehicle during periods when the engine is running and when the engine is stopped.

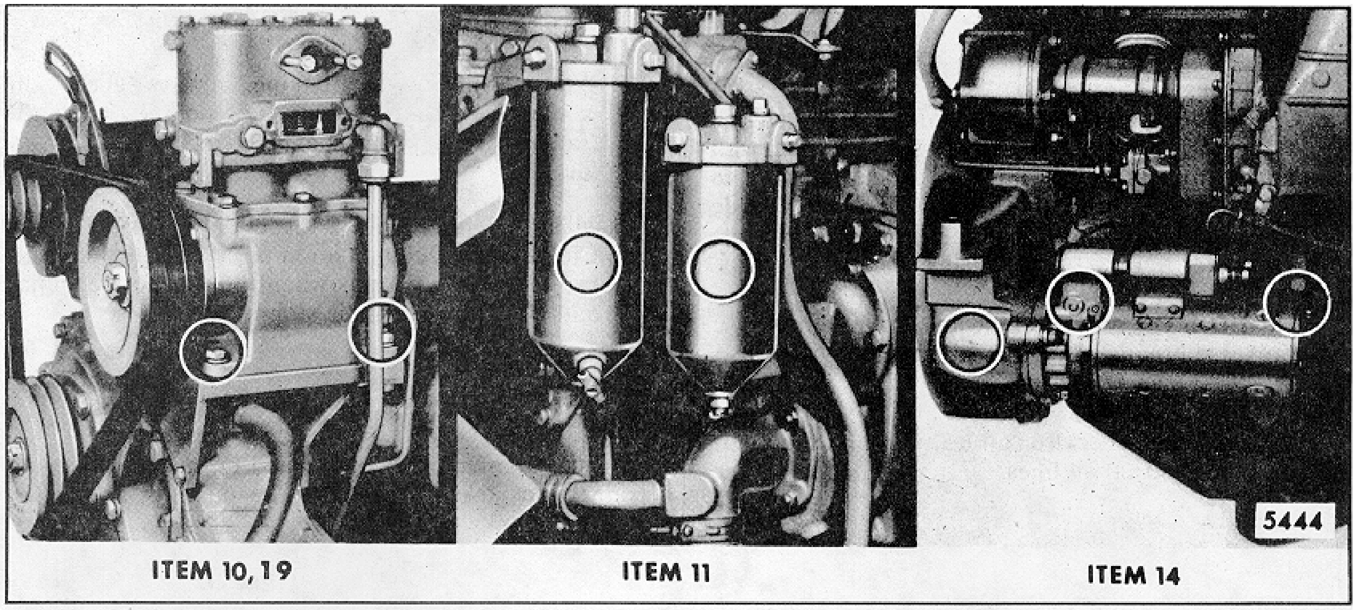
6. Air Cleaner Oil Bath)

Drain the oil and clean the sludge from the air cleaner oil cup. Wash the oil cup with clean fuel oil and refill it to the proper level with the same grade of oil as used in the engine. If heavy rain or snow has been encountered, check the air cleaner for an accumulation of water.

Remove and steam clean the air cleaner element and baffle annually.

Service the air cleaner more often if the engine is operated under severe dust conditions.





Under no engine operating conditions should the air inlet restriction exceed 25 inches of water for non-turbocharged engines.

A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

7. Lubricating Oil

Change the initial lubricating oil at approximately 3,000 miles and at 4,000 to 6,000 mile intervals thereafter. The drain interval may be established on the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the oil sample analysis) until the most practical oil change period has been determined. Select the proper grade of oil in accordance with the instructions given in the Lubricating Oil Specifications in Section 13.3.

8. Lubricating Oil Filters

a. Change the lubricating oil filters when the engine oil is changed. Any deviation, such as changing filters every other oil change, should be based on a laboratory analysis of the drained oil and the used filter elements to determine if such practice is practical for proper protection of the engine.

b. Make a visual check of all lubricating oil lines for wear and chafing. If any indication of wear is evident, replace the oil lines and correct the cause.

Engine	Fan Drive		Generator Drive		
	2 or 3 belts	Single belt	Two 3/8" or 1/2" belts	One 1/2" belt	One wide belt
6-71	60-80	80-100	40-50	50-70	40-50
All	For 3 point or triangular drives use a tension of 90-120.				

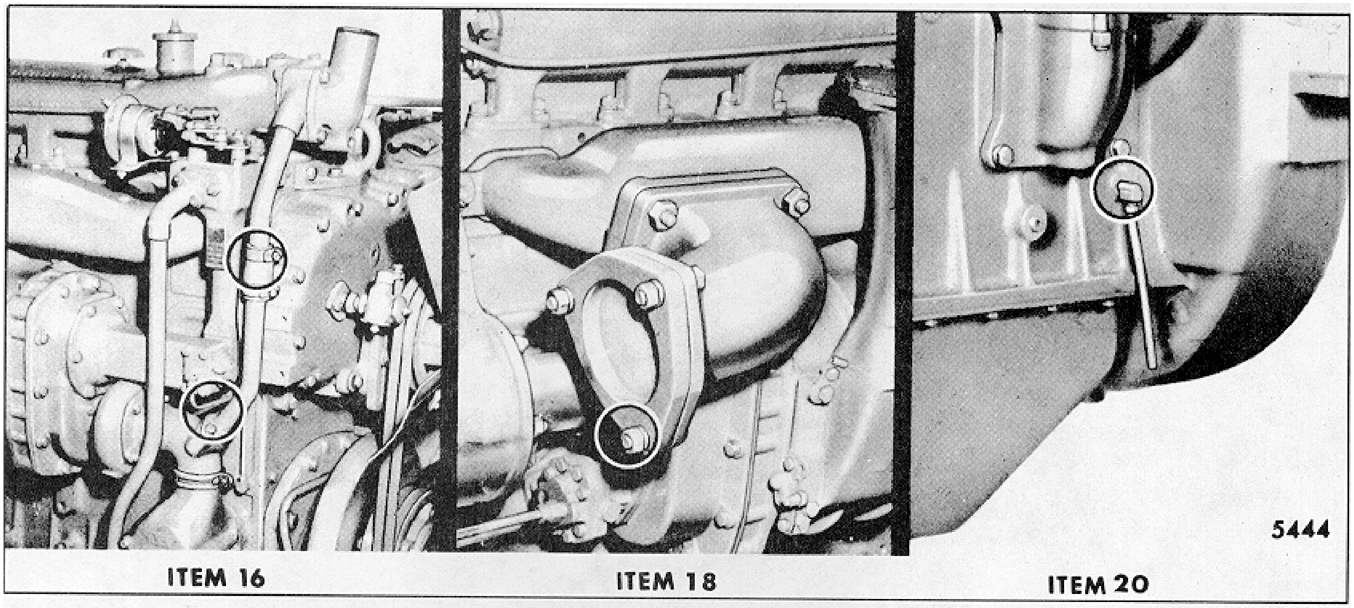
Belt tension is 50-70 for a single premium high capacity belt (.785" wide) used to drive a 12 cfm air compressor.

BELT TENSION CHART (lbs/belt)

9. Drive Belts

New drive belts stretch during the first few hours of operation. Run the engine 15 seconds, to seat the belts, and readjust the tension. Then check the belts and retighten fan drive, pump drive and battery-charging generator drive belts after 30 miles and again after 240 miles of operation. Thereafter check the tension of the drive belts at the intervals shown in the chart. Too tight a belt is destructive to the bearings of the driven part, a loose belt will slip.

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set; premature belt wear can result because of belt length variation. All belts in a matched belt set are within .032"of their specified center distances.



> **NOTE**: When installing or adjusting an accessory drive belt(s), be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.

Adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will depress the belt 1/2" to 3/4" . If belt tension gage BT-33-73FA, or equivalent, is available, adjust the belt tension as outlined in the chart.

10. Air Compressor

Remove and clean all air compressor air intake parts. To clean either the hair or polyurethane type element, saturate and squeeze it in fuel oil, or any other cleaning agent that would not be detrimental to the element, until dirt free. Then dip in lubricating oil and squeeze dry before placing the element back in the air strainer.

For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available.

11. Fuel Filters

Install new elements in the strainer and the filter at the intervals shown in the chart, or when plugging is indicated.

A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury. At normal operating speeds, the fuel pressure is 45 to 70 psi. Change the fuel filter elements whenever the inlet restriction (suction) at the fuel pump reaches 12 inches of mercury at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to 45 psi.

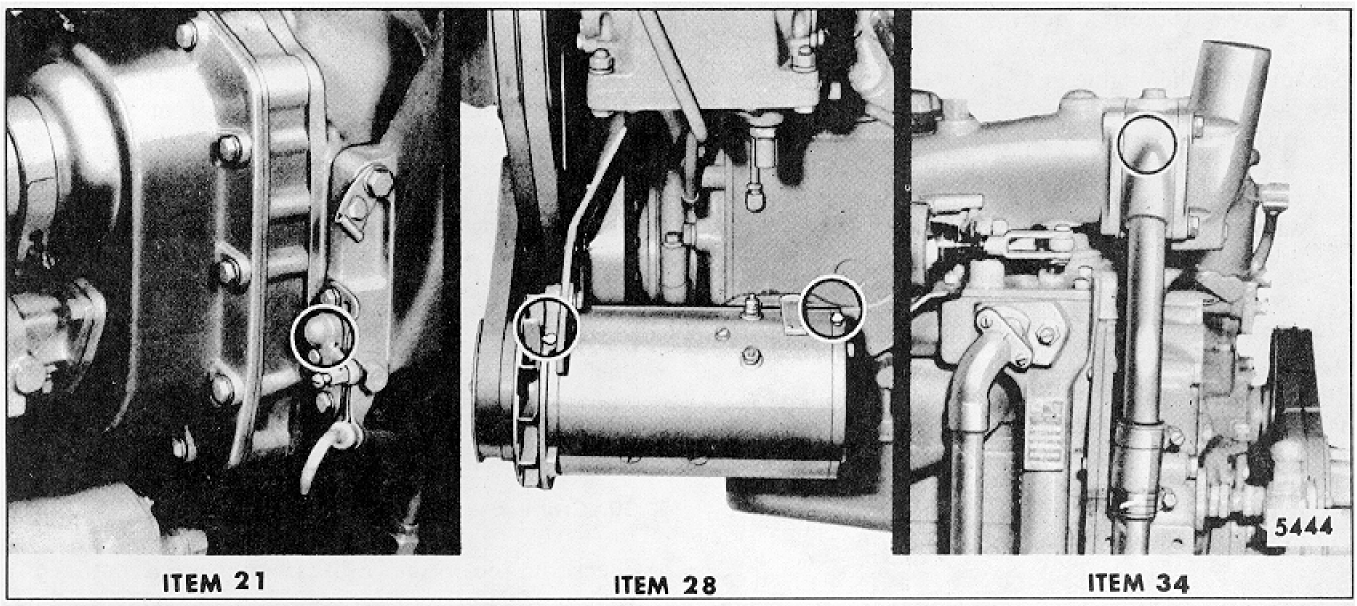
12. Air Cleaner (Dry)

Inspect and service the air cleaner element every 20,000 miles, or more often if the engine is operated under severe dust conditions. Check the gaskets for deterioration and replace, if necessary. If the dry type air cleaner is equipped with an aspirator, check for aspirator damage or clogging. Clean and repair as necessary.

Under no engine operating conditions should the air inlet restriction exceed 25 inches of water for non-turbocharged engines or 20 inches of water for turbocharged engines. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

13. Coolant Filter

Replace the coolant filter element. Select the proper coolant filter element in accordance with the instructions given under Engine Coolant in Section 13.3. Use a new filter cover gasket when



installing the filter element. After replacing the filter element and cover gasket, start the engine and check for leaks.

14. Starting Motor

Starting motors which are provided with lubrication fittings (grease cups, hinge cap oilers, or oil tubes sealed with pipe plugs) should be lubricated at the intervals shown on the chart. Add 8 to 10 drops of oil, of the same grade as used in the engine, to hinge cap oilers; if sealed tubes are provided, remove the pipe plugs, add oil and re-seal the tubes. Grease cups should be turned down one turn. Refill the grease cups, if necessary. However, some starting motors do not require lubrication except during overhaul.

15. Fuel Tanks

Tighten all fuel tank mountings and brackets. At the same time, check the seal in the fuel tank cap, the breather hole in the cap, and the condition of the cross-over fuel line. Repair or replace the parts as necessary.

16. Cooling System

Check the cooling system hoses for deterioration or damage and replace, if necessary. Check all of the hose clamps to make sure they are tight and properly seated on the hoses.

17. Air System

Check all of the connections in the air system to be sure they are tight. Check all hoses for punctures or other damage and replace, if necessary.

18. Exhaust System

Check the exhaust manifold retaining nuts, exhaust flange clamp, and other connections for tightness. Check for proper operation of the exhaust pipe rain cap, if one is used.

19. Air Compressor

Tighten the air compressor mounting bolts. If the air compressor is belt driven, check the belts for proper tension.

20. Air Box Drain Tubes

With the engine running, check for flow of air from the air box drain tubes. If the tubes are clogged, remove, clean and reinstall the tubes.

21. Emergency Shutdown

With the engine running at idle speed, check the operation of the emergency shutdown. Reset the air shutdown valve in the open position after the check has been made.

22. Engine (Steam Clean)

Steam clean the engine and engine compartment.

> **CAUTION:** Do not apply steam or solvent directly on the battery-charging generator, starting motor or electrical components as damage to electrical equipment may result.

23. Radiator

Inspect the exterior of the radiator core and steam clean it, if necessary.

> **NOTE:** Never use fuel oil, kerosene or petroleum base solvents for cleaning since they may leave an oil film on the radiator fins.

24. Shutter Operation

Check the operation of the shutters and clean the linkage and controls.

25. Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started. In the event the engine is equipped with warning lights rather than pressure indicators, the pressure should be checked and recorded at the interval indicated.

26. Governor

Check and record the engine idle speed and no-load speed. Adjust as necessary.

An idle speed lower than recommended will cause the engine to be accelerated from a speed lower than the speed at which the engine was certified.

A no-load speed higher than recommended will result in a full-load speed higher than rated and higher than the speed at which the engine was certified.

27. Fuel Injectors

Check the injector timing and exhaust valve clearance as outlined in Section 14.2 and 14.1 every 50,000 miles. The proper height adjustment between the injector follower and injector body is of primary importance to emission control.

28. Generator (Battery-Charging)

If the battery-charging generator is equipped with hinge cap oilers, add a few drops of medium grade SAE 20 engine oil to each oiler during the vehicle lubrication period. Generators having a built-in supply of grease or sealed bearings require no additional lubrication except during engine or unit overhaul.

29. Engine and Transmission Mounts

Check the engine and transmission mounting bolts and the condition of the mounting pads. Tighten and repair as necessary.

30. Crankcase Pressure

Check and record the crankcase pressure as outlined in Section 15.2.

31. Fan Hub

At major overhaul, the bearing in the fan hub assembly should be discarded. Install a new bearing and pack the hub assembly and bearing with Texaco Premium RB grease or an equivalent performance grease.

32. Throttle Delay

Inspect and adjust, if necessary.

The throttle delay system limits the amount of fuel injected during acceleration by limiting the rate of injector rack movement with a hydraulic cylinder. The initial location of this cylinder must be set with the proper gage to achieve the appropriate time delay (Section 14.14).

Inspect the check valve by filling the throttle delay cylinder with diesel fuel and watching for valve leakage while moving the throttle from the idle to the full-fuel position.

33. Cooling System

Drain and flush the cooling system. If necessary, use a cooling system cleaner and reverse flush. Refill the cooling system (refer to Engine Coolant in Section 13.3). Start the engine and check for leaks.

34. Thermostats and Seals

Check the thermostats and seals (preferably at the time the cooling system is prepared for winter operation). Replace the seals if necessary.

35. Blower Screen

Inspect the blower screen and, if necessary, clean the screen in fuel oil and dry it with compressed air. Install the screen and gasket assembly with the screen side of the assembly towards the blower. Inspect for evidence of blower seal leakage.

36. Fan (Thermo-Modulated)

A. DRIVE FLUID LEVEL:

Check the fan drive fluid level to avoid improper operation and damage to the drive components.

Current modulated fan drive housings have an inspection plug for checking the fluid level. Formerly partial disassembly of the drive was necessary to make the fluid level check. Former units can be updated by installing a current drive housing which includes the fluid inspection plug and a grease fitting for lubricating the bearing.

1. Check the fan drive fluid level after the unit has been idle for at least 1/2 hour.

2. Turn the fan drive so that the inspection plug is 3/4" below the horizontal center line, then allow the silicone fluid to drain down an additional five minutes.

3. Remove the inspection plug. If fluid begins to flow from the inspection hole, the drive has sufficient fluid. Replace the inspection plug.

4. If the fluid does not flow from the hole, proceed as follows:

   a. Rotate the fan drive downward and observe when the fluid begins to flow from the hole. If it is necessary to lower the drain hole more than 2" below the horizontal center line, the fan drive should be removed from the engine, disassembled and inspected for possible damage to the components.

   b. Turn the fan drive back so the inspection hole is 3/4" below the horizontal center line and add fluid until the overflow point is reached. Replace the inspection plug.

   NOTE: Use only the manufacturer’s Special 20 Cenistroke fluid.

B. DRIVE BEARING LUBRICATION:

The fan drive bearing should be lubricated as outlined in the chart with a Medium Consistency Silicone Grease (Dow Corning No. 44, or equivalent).

The bearing on current fan assemblies is lubricated through a grease fitting in the drive housing hub. Lubrication of the bearing in former assemblies requires the removal of the fan assembly and partial disassembly. The former assemblies can be updated to include a grease fitting by installing the current housing.

37. Crankcase Breather

The crankcase breather assembly is mounted on the flywheel housing or the valve rocker cover. Clean the breather pads annually. Remove the steel mesh breather pads from the engine; wash them in fuel oil and dry with compressed air. The cleaning period may be reduced or lengthened depending upon severity of operating conditions.

38. Engine Tune-Up

Minor adjustments such as injector timing, exhaust valve clearance, governor and throttle delay (Items 26, 27 and 32) should be made every 50,000 miles to compensate for normal wear on parts. There is no scheduled interval for performing a complete engine. tune-up. As long as the engine performance is satisfactory, a complete tune-up should not be required.

TROUBLESHOOTING

Certain abnormal conditions which sometimes interfere with satisfactory engine operation, together with methods of determining the cause of such conditions, are covered on the following pages.

Satisfactory engine operation depends primarily on:

1. An adequate supply of air compressed to a sufficiently high compression pressure.

2. The injection of the proper amount of fuel at the right time.

Lack of power, uneven running, excessive vibration, stalling at idle speed and hard starting may be caused by either low compression, faulty injection in one or more cylinders, or lack of sufficient air.

Since proper compression, fuel injection and the proper amount of air are important to good engine performance, detailed procedures for their investigation are given as follows: Locating a Misfiring Cylinder

1. Start the engine and run it at part load until it reaches normal operating temperature.

2. Stop the engine and remove the valve rocker cover.

3. Check the valve clearance.

4. Start the engine. Then hold an injector follower down with a screw driver (Fig I) to prevent operation of the injector If the cylinder has been misfiring, there will be no noticeable difference in the sound and operation of the engine If the cylinder has been firing properly, there will be a noticeable difference in the sound and operation when the injector follower is held down. This is similar to short-circuiting a spark plug in a gasoline engine.

5. If the cylinder is firing properly, repeat the procedure on the other cylinders until the faulty one has been located.

6. If the cylinder is misfiring. check the following:

   a. Check the injector timing (refer to Section 14.).

   b. Check the compression pressure.

   c. Install a new injector.

   d. If the cylinder still misfires, remove the cam follower (refer to Section 1.2.1) and check for a scorn cam roller, camshaft lobe, bent push rod or worn rocker arm bushings.

7. If installation of a new injector does not eliminate the misfiring, check the compression pressure of the cylinder in question.

Checking Compression Pressure

Compression pressure is affected by altitude as shown in Table 1.

Check the compression pressure as follows

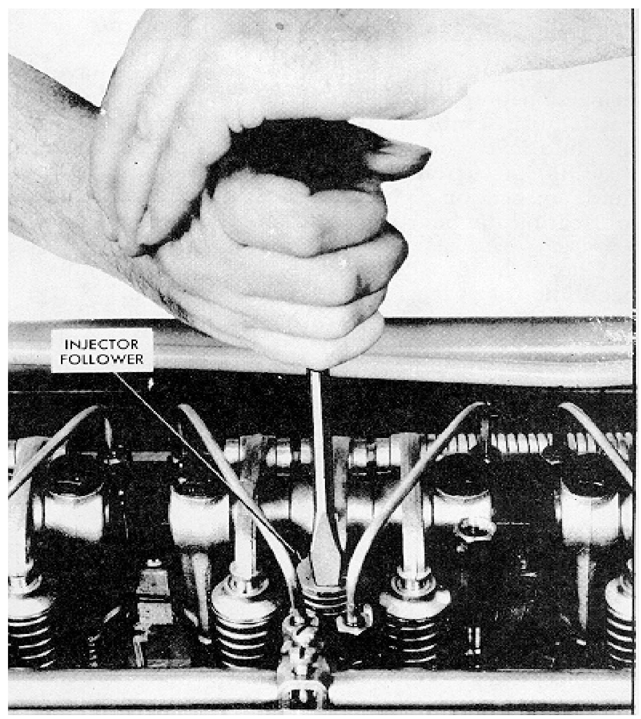


Fig. 1 - Locating a Misfiring Cylinder

Minimum Compression Pressure (psi) at 600 rpm				Altitude, Feet Above Sea Level
Engine				
—	—	71N		
		515		0
		480		2,500
		440		5,000
		410		7,500
		380		10,000

Table 1

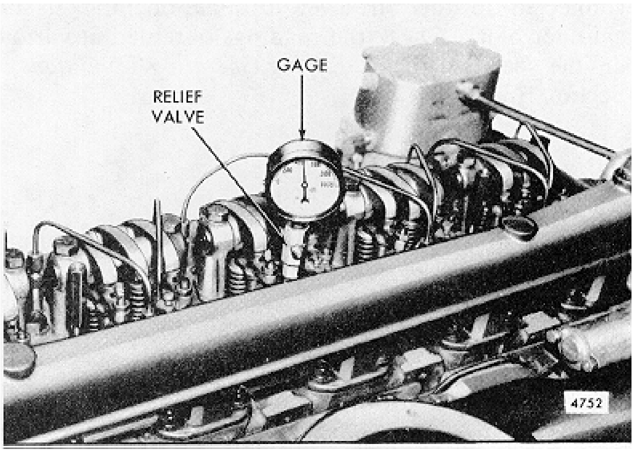


Fig. 2 - Checking Compression Pressure

Cylinder	Gage Reading
1	445 psi
2	440 psi
3	405 psi
4	435 psi
5	450 psi
6	445 psi

TABLE 2

1. Start the engine and run it at approximately one half rated load until normal operating temperature is reached.

2. Stop the engine and remove the fuel pipes from the injector and fuel connectors of the No. 1 cylinder.

3. Remove the injector and install an adaptor and pressure gage (Fig. 2) from Diagnosis Kit J 9531-01.

4. Use one of the fuel pipes as a jumper connection between the fuel inlet and return manifold connectors. This will permit fuel from the inlet manifold to flow directly to the return manifold.

5. Start the engine and run it at a 600 rpm. Observe and record the compression pressure indicated on the gage. Do not crank the engine with the starting motor to obtain the compression pressure.

6. Perform Steps 2 through 5 on each cylinder. The compression pressure in any one cylinder at a given altitude above sea level should not be less than the minimum shown in Table 1. In addition, the variation in compression pressures between cylinders must not exceed 25 psi at 600 rpm.

EXAMPLE: If the compression pressure readings were as shown in Table 2, it would be evident that No. 3 cylinder should be examined and the cause of the low compression pressure be determined and corrected.

The pressures in Table 2 are for a 71E engine operating at an altitude near sea level. Note that all of the cylinder pressures are above the low limit for satisfactory engine operation. Nevertheless, the No. 3 cylinder compression pressure indicates that something unusual has occurred and that a localized pressure leak has developed.

Low compression pressure may result from any one of several causes:

A. Piston rings may be stuck or broken. To determine the condition of the rings, remove the air box cover and inspect them by pressing on the rings with a blunt tool (Fig. 3). A broken or stuck ring will not have a "spring-like" action.

B. Compression pressure may be leaking past the cylinder head gasket, the valve seats, the injector tube or a hole in the piston.

Engine Out of Fuel The problem in restarting an engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is then pumped from the primary fuel strainer and sometimes partially removed from the secondary fuel filter before the fuel supply becomes insufficient to sustain engine firing.

Consequently, these components must be refilled with

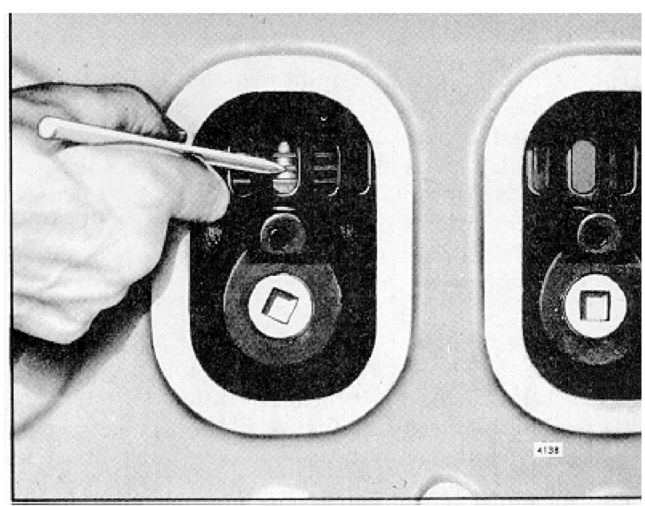


Fig. 3 Inspecting Piston Rings

fuel and the fuel pipes rid of air in order for the system to provide adequate fuel for the injectors.

When an engine has run out of fuel, there is a definite procedure to follow for restarting it:

1 Fill the fuel tank with the recommended grade of fuel oil. If only partial filling of the tank is possible, add a minimum of ten gallons of fuel.

2 Remove the fuel strainer shell and element from the strainer cover and fill the shell with fuel oil. Install the shell and element.

3 Remove and fill the fuel filter shell and element with fuel oil as in Step 2.

4 Start the engine. Check the filter and strainer for leaks.

> **NOTE:** In some instances, it may be necessary to remove the valve rocker cover and loosen a fuel pipe nut to bleed trapped air from the fuel system. Be sure the fuel pipe is retightened securely before replacing the rocker cover.

Primer J 5956 may be used to prime the entire fuel system. Remove the filler plug in the fuel filter cover and install the primer. Prime the system. Remove the primer and install the filler plug.

Fuel Flow Test

The proper flow of fuel is required for satisfactory engine operation. Check the condition of the fuel pump, fuel strainer and fuel filter as outlined in Section 2.0 under Trouble Shooting.

Crankcase Pressure

The crankcase pressure indicates the amount of air passing between the oil control rings and the cylinder liners into the crankcase, most of which is clean air from the air box. A slight pressure in the crankcase is desirable to prevent the entrance of dust. A loss of engine lubricating oil through the breather tube, crankcase ventilator or dipstick hole in the cylinder block is indicative of excessive crankcase pressure.

The causes of high crankcase pressure may be traced to excessive blow-by due to worn piston rings, a hole or crack in a piston crown, loose piston pin retainers, worn blower oil seals, defective blower, cylinder head or end plate gaskets, or excessive exhaust back pressure. Also, the breather tube or crankcase ventilator should be checked for obstructions.

Check the crankcase pressure with a manometer connected to the oil level dipstick opening in the cylinder block. Check the readings obtained at various engine speeds with the Engine Operating Conditions in Section 13.2.

Exhaust Back Pressure

A slight pressure in the exhaust system is normal. However,. excessive exhaust back pressure seriously affects engine operation. It may cause an increase in the air box pressure with a resultant loss of efficiency of the blower. This means less air for scavenging which results in poor combustion and higher temperatures.

Causes of high exhaust back ’pressure are usually a result of an inadequate or improper type of muffler, an exhaust pipe which is too long or too small in diameter, an excessive number of sharp bends in the exhaust system, or obstructions such as excessive carbon formation or foreign matter in the exhaust system.

Check the exhaust back pressure, measured in inches of mercury, with a manometer. Connect the manometer to the exhaust manifold (except on turbocharged engines) by removing the 1/8 " pipe plug which is provided for that purpose. If no opening is provided, drill an 11/32 " hole in the exhaust manifold companion flange and tap the hole to accommodate a 1/8 " pipe plug. Check the readings obtained at various speeds (at noload) with the Engine Operating Conditions in Section 13.2.

Air Box Pressure

roper air box pressure is required to maintain sufficient air for combustion and scavenging of the burned gases. Low air box pressure is caused by a high air inlet restriction, damaged blower rotors, an air leak from the air box (such as leaking end plate gaskets) or a clogged blower air inlet screen. Lack of power or black or gray exhaust smoke are indications of low air box pressure.

High air box pressure can be caused by partially plugged cylinder liner ports.

Check the air box pressure with a manometer connected to an air box drain tube.

Check the readings obtained at various speeds with the Engine Operating Conditions in Section 13.2.

Air Inlet Restriction

Excessive restriction of the air inlet will affect the flow of air to the cylinders and result in poor combustion and lack of power. Consequently the restriction must be kept as low as possible considering the size and capacity of the air cleaner. An obstruction in the air inlet system or dirty or damaged air cleaners will result in a high blower inlet restriction.

Check the air inlet restriction with a water manometer connected to a fitting in the air inlet ducting located 2 " above the air inlet housing. When practicability prevents the insertion of a fitting at this point, the manometer may be connected to the engine air inlet housing. The restriction at this point should be checked at a specific engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading.

The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

Check the normal air inlet vacuum at various speeds (at no-load) and compare the results with the Engine Operating Conditions in Section 13.2.

PROPER USE OF MANOMETER

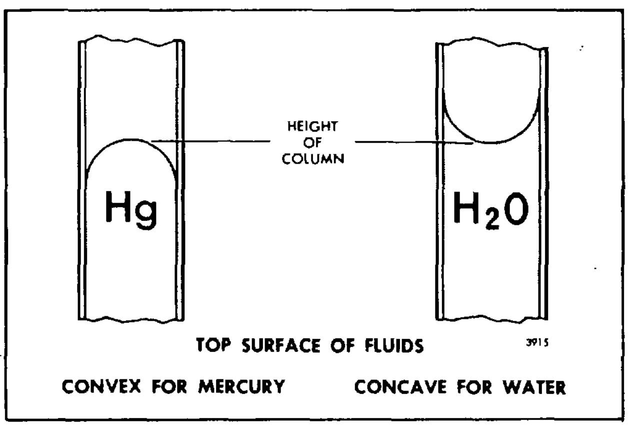


Fig. 4 - Comparison of Column Height for Mercury and Water Manometers

The U-tube manometer is a primary measuring device indicating pressure or vacuum by the difference in the height of two columns of fluid.

Connect the manometer to the source of pressure, vacuum or differential pressure. When the pressure is imposed, add the number of inches one column of fluid travels up to the amount the other column travels down to obtain the pressure (or vacuum) reading.

PRESSURE CONVERSION CHART		
1" water	=	.0735" mercury
1" water	=	.0361 psi
1" mercury	=	.4919 psi
1" mercury	=	13.6000" water
1 psi	=	27.7000" water
1 psi	=	2.0360" mercury

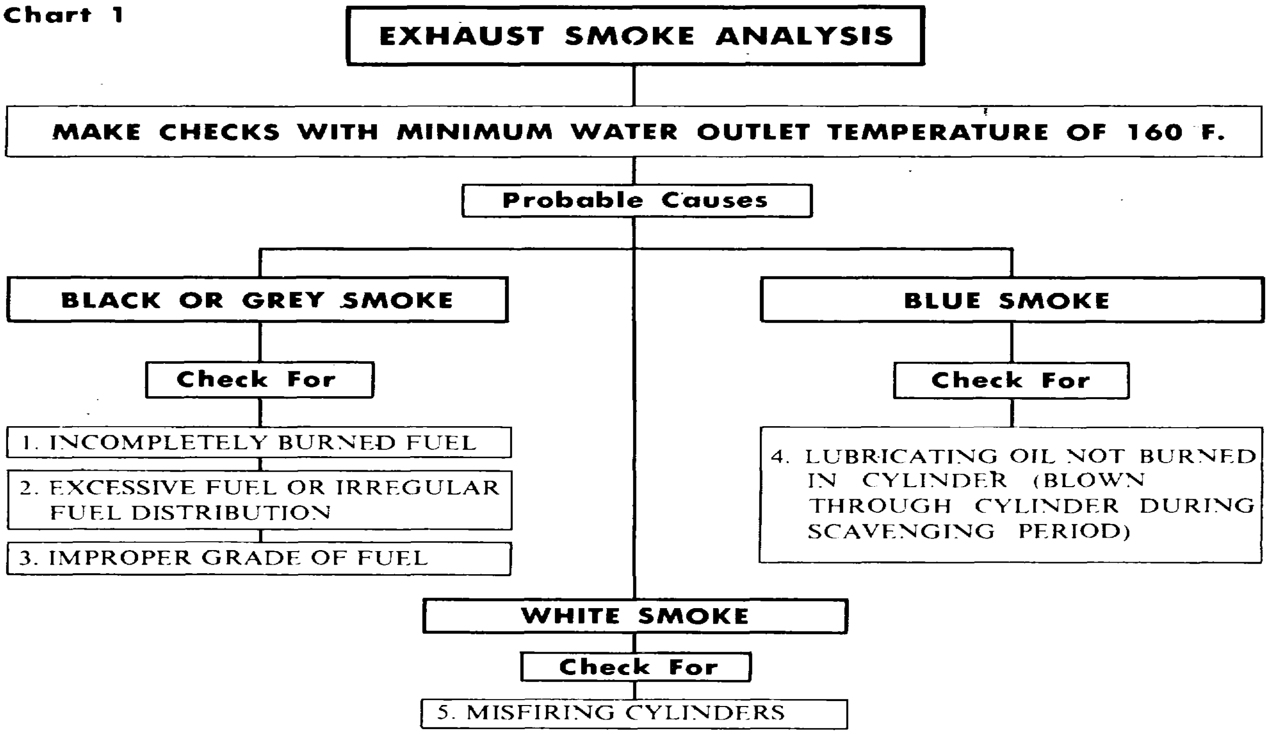
TABLE 3

The height of a column of mercury is read differently than that of a column of water. Mercury does not wet the inside surface; therefore, the top of the column has a convex meniscus (shape). Water wets the surface and therefore has a concave meniscus. A mercury column is read by sighting horizontally between the top of the convex mercury surface (Fig. 4) and the scale. A water manometer is read by sighting horizontally between the bottom of the concave water surface and the scale.

Should one column of fluid travel further than the other column, due to minor variations in the inside diameter of the tube or to the pressure imposed, the accuracy of the reading obtained is not impaired.

Refer to Table 3 to convert the manometer reading into other units of measurement.

Chart 1



SUGGESTED REMEDY

1 High exhaust back pressure or a restricted air inlet causes insufficient air for combustion and will result in incompletely burned fuel.

High exhaust back pressure is caused by faulty exhaust piping or muffler obstruction and is measured at the exhaust manifold outlet with a manometer. Replace faulty parts.

Restricted air inlet to the engine cylinders is caused by clogged cylinder liner ports, air cleaner or blower air inlet screen. Clean these items. Check the emergency stop to make sure that it is completely open and readjust it if necessary.

2 Check for improperly timed injectors and improperly positioned injector rack control levers. Time the fuel injectors and perform the appropriate governor tune-up.

Replace faulty injectors if this condition still persists afte timing the injectors and performing the engine tune-up.

Avoid lugging the engine as this will cause incomplete combustion. Operate the engine as outlined in the Drivers Handbook.

3 Check for use of an improper grade of fuel. Refe to Fuel Oil Specifications in Section 13.3.

4 Check for internal lubricating oil leaks and refer t the High Lubricating Oil Consumption chart.

5 Check for faulty injectors and replace as necessary.

Check for low compression and consult the Hard Starting chart.

The use of low cetane fuel will cause this condition. Refer to Fuel Oil Specifications in Section 13.3.

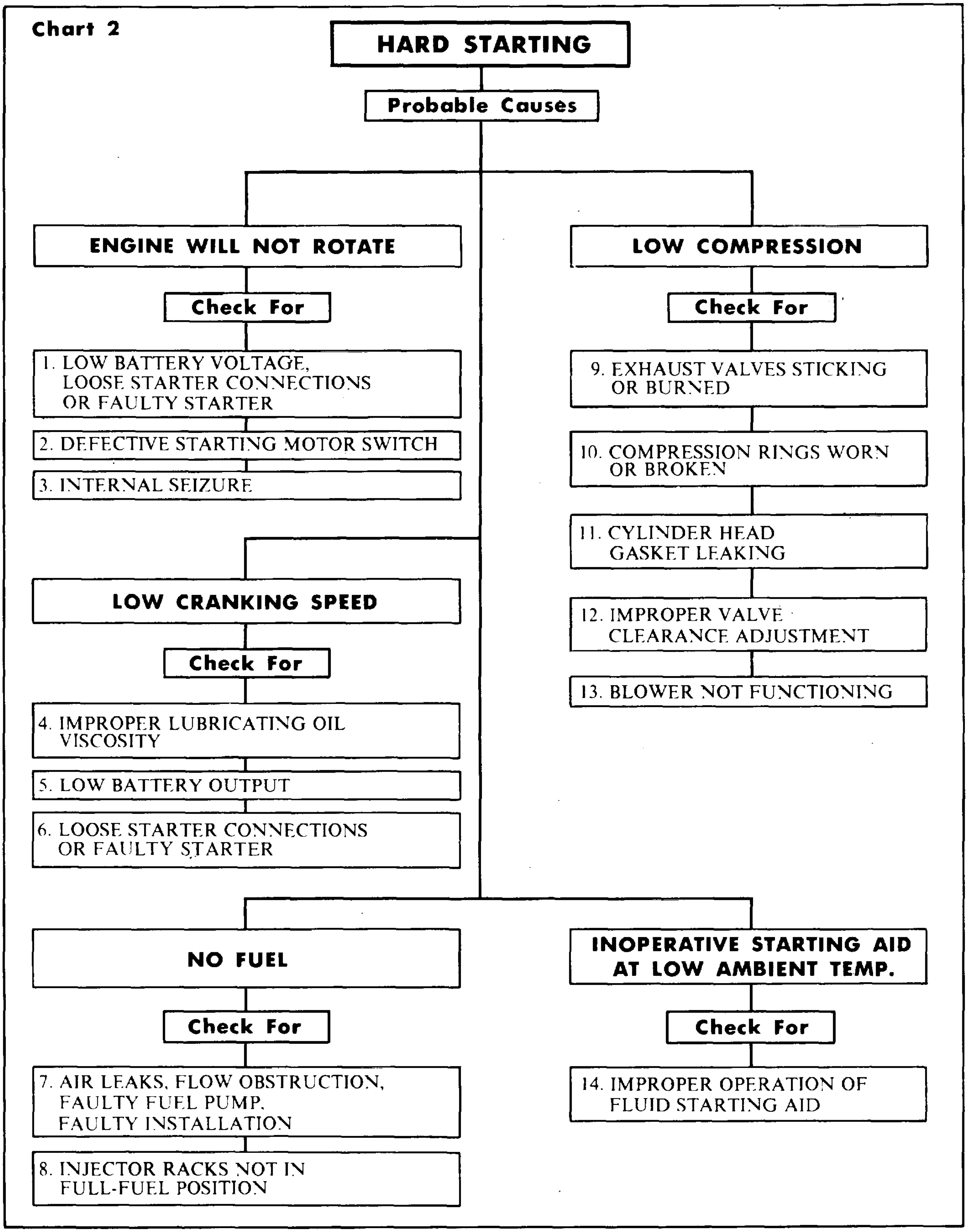


Chart 2
HARD STARTING
Probable Causes
ENGINE WILL NOT ROTATE
Check For
1. LOW BATTERY VOLTAGE, LOOSE STARTER CONNECTIONS OR FAULTY STARTER
2. DEFECTIVE STARTING MOTOR SWITCH
3. INTERNAL SEIZURE
LOW CRANKING SPEED
Check For
4. IMPROPER LUBRICATING OIL VISCOSITY
5. LOW BATTERY OUTPUT
6. LOOSE STARTER CONNECTIONS OR FAULTY STARTER
NO FUEL
Check For
7. AIR LEAKS, FLOW OBSTRUCTION, FAULTY FUEL PUMP, FAULTY INSTALLATION
8. INJECTOR RACKS NOT IN FULL-FUEL POSITION
LOW COMPRESSION
Check For
9. EXHAUST VALVES STICKING OR BURNED
10. COMPRESSION RINGS WORN OR BROKEN
11. CYLINDER HEAD GASKET LEAKING
12. IMPROPER VALVE CLEARANCE ADJUSTMENT
13. BLOWER NOT FUNCTIONING
INOPERATIVE STARTING AID AT LOW AMBIENT TEMP.
Check For
14. IMPROPER OPERATION OF FLUID STARTING AID

Chart 2

HARD STARTING

SUGGESTED REMEDY

1 Refer to Items 2, 3 and 5 and perform the operations listed.

2 Replace the starting motor switch.

3 Hand crank the engine at least one complete revolution. If the engine cannot be rotated a complete revolution, internal damage is indicated and the engine must be disassembled to ascertain the extent of damage and the cause.

4 Refer to Lubricating Oil Specifications in Section 13.3 for the recommended grade of oil.

5 Recharge the battery if a light load test indicates low or no voltage. Replace the battery if it is damaged or will not hold a charge.

Replace terminals that are damaged or corroded.

At low ambient temperatures, use of a starting aid will keep the battery fully charged by reducing the cranking time.

6 Tighten the starter connections. Inspect the starter commutator and brushes for wear. Replace the brushes if badly worn and overhaul the starting motor if the commutator is damaged.

7 To check for air leaks, flow obstruction, faulty fuel pump or faulty installation, consult the No Fuel or Insufficient Fuel chart.

8 Check for bind in the governor-to-injector linkage.

Readjust the governor and injector controls if necessary.

9 Remove the cylinder head and recondition the exhaust valves.

10 Remove the air box covers and inspect the compression rings through the ports in the cylinder liners.. Overhaul the cylinder assemblies if the rings are badly worn or broken.

11 To check for compression gasket leakage, remove the coolant filler cap and operate the engine. A steady flow of gases from the coolant filler indicates either a cylinder head gasket is damaged or the cylinder head is crackedRemove the cylinder head and replace the gaskets or cylinder head.

12 Adjust the exhaust valve clearance.

13 Inspect the blower drive shaft and drive coupling. Replace damaged parts.

14 Operate the starting aid according to the instructions under Cold Weather Starting Aids.

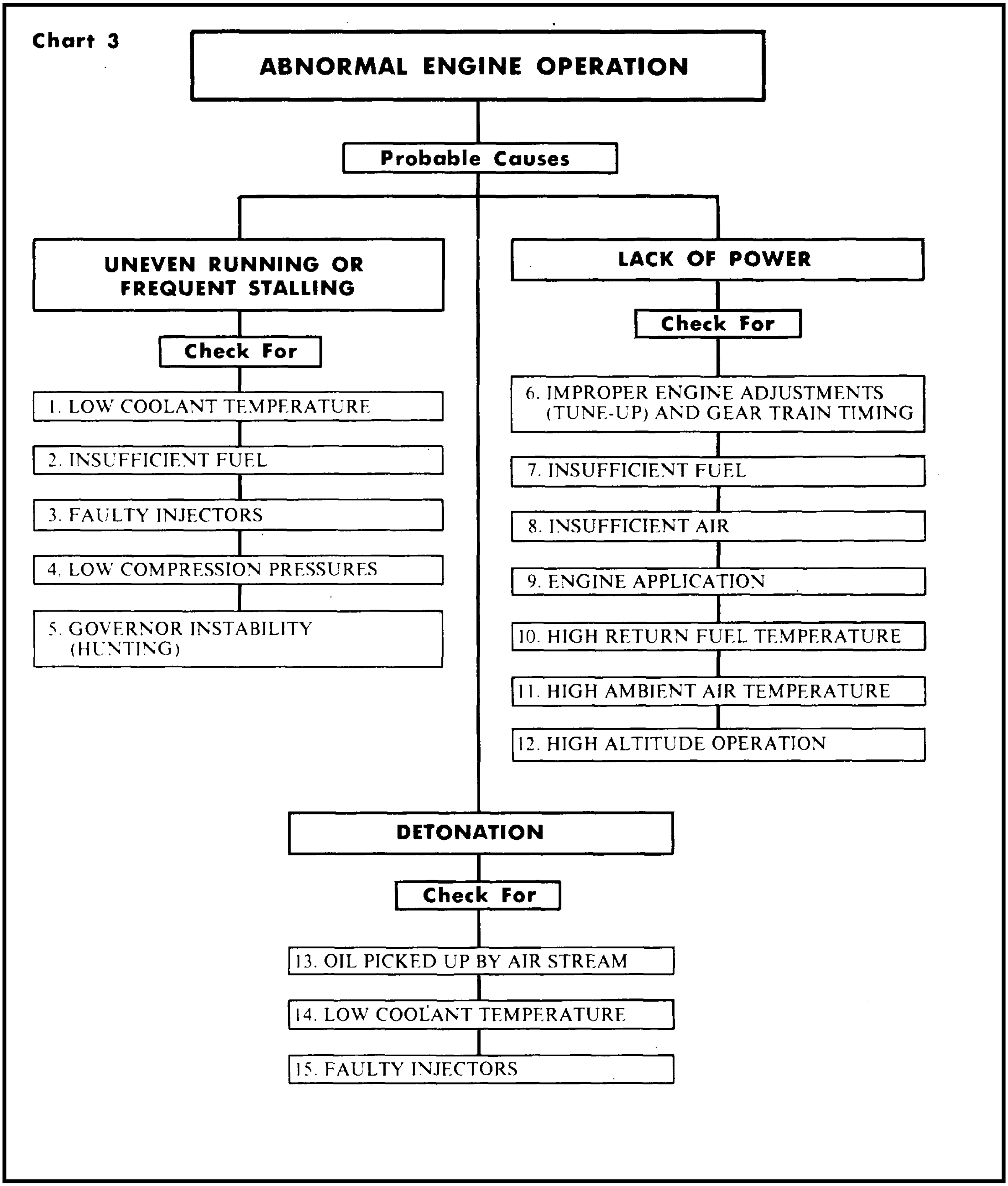


Chart 3
ABNORMAL ENGINE OPERATION
Probable Causes
UNEVEN RUNNING OR FREQUENT STALLING
Check For
1. LOW COOLANT TEMPERATURE
2. INSUFFICIENT FUEL
3. FAULTY INJECTORS
4. LOW COMPRESSION PRESSURES
5. GOVERNOR INSTABILITY (HUNTING)
LACK OF POWER
Check For
6. IMPROPER ENGINE ADJUSTMENTS (TUNE-UP) AND GEAR TRAIN TIMING
7. INSUFFICIENT FUEL
8. INSUFFICIENT AIR
9. ENGINE APPLICATION
10. HIGH RETURN FUEL TEMPERATURE
11. HIGH AMBIENT AIR TEMPERATURE
12. HIGH ALTITUDE OPERATION
DETONATION
Check For
13. OIL PICKED UP BY AIR STREAM
14. LOW COOLANT TEMPERATURE
15. FAULTY INJECTORS

Chart 3

ABNORMAL ENGINE OPERATION

SUGGESTED REMEDY

1 Check the engine coolant temperature gage and, if the temperature does not reach 160° to 185 °F while the engine is operating, consult the Abnormal Engine Coolant Temperature chart.

2 Check engine fuel spill back and if the return is less than specified, consult the No Fuel or Insufficient Fuel chart.

3 Check the injector timing and the position of the injector racks. If the engine was not tuned correctly, perform an engine tune-up. Erratic engine operation may also be caused by leaking injector spray tips. Replace the faulty injectors.

4 Check the compression pressures within the cylinders and consult the Hard Starting chart if compression pressures are low.

5 Erratic engine operation may be caused by governor-to-injector operating linkage bind or by faulty engine tune-up Perform the appropriate engine tune-up procedure as outlined for the particular governor used.

6 Perform an engine tune-up if performance is not satisfactory.

Check the engine gear train timing. An improperly timed gear train will result in a loss of power due to the valves and injectors being actuated at the wrong time in the engine's operating cycle.

7 Perform a Fuel Flow Test and, if less than the specified fuel is returning to the fuel tank, consult the No Fuel or Insufficient Fuel chart.

8 Check for damaged or dirty air cleaners and clean, repair or replace damaged parts.

Remove the air box covers and inspect the cylinder liner ports. Clean the ports if they are over 50% plugged.

Check for blower air intake obstruction or high exhaust back pressure. Clean, repair or replace faulty parts.

Check the compression pressures (consult the Hard Starting chart).

9 Incorrect operation of the engine may result in excessive loads on the engine. Operate the engine according to the approved procedures outlined in the Drivers Handbook.

10 Refer to Item 13 on Chart 4.

11 Check the ambient air temperature. A power decrease of .15 to .50 horsepower per cylinder, depending upon injector size, for each 10 °F.

temperature rise above 90 °F will occur. Relocate the engine air intake to provide a cooler source of air.

12 Engines lose horsepower with increase in altitude. The percentage of power loss is governed by the altitude at which the engine is operating.

13 Fill oil bath air cleaners to the proper level with the same grade and viscosity lubricating oil that is used in the engine.

Clean the air box and drain tubes to prevent accumulations that may be picked up by the air stream and enter the engine's cylinders.

Inspect the blower oil seals by removing the air inlet housing and watching through the blower inlet for oil radiating away from the blower rotor shaft oil seals while the engine is running. If oil is passing through the seals, overhaul the blower.

Check for a defective blower-to-block gasket. Replace the gasket, if necessary.

14 Refer to Item I of this chart.

15 Check injector timing and the position of each injector rack. Perform an engine tune-up, if necessary. If the engine is correctly tuned, the erratic operation may be caused by an injector check valve leaking, spray tip holes enlarged or a broken spray tip. Replace faulty injectors.

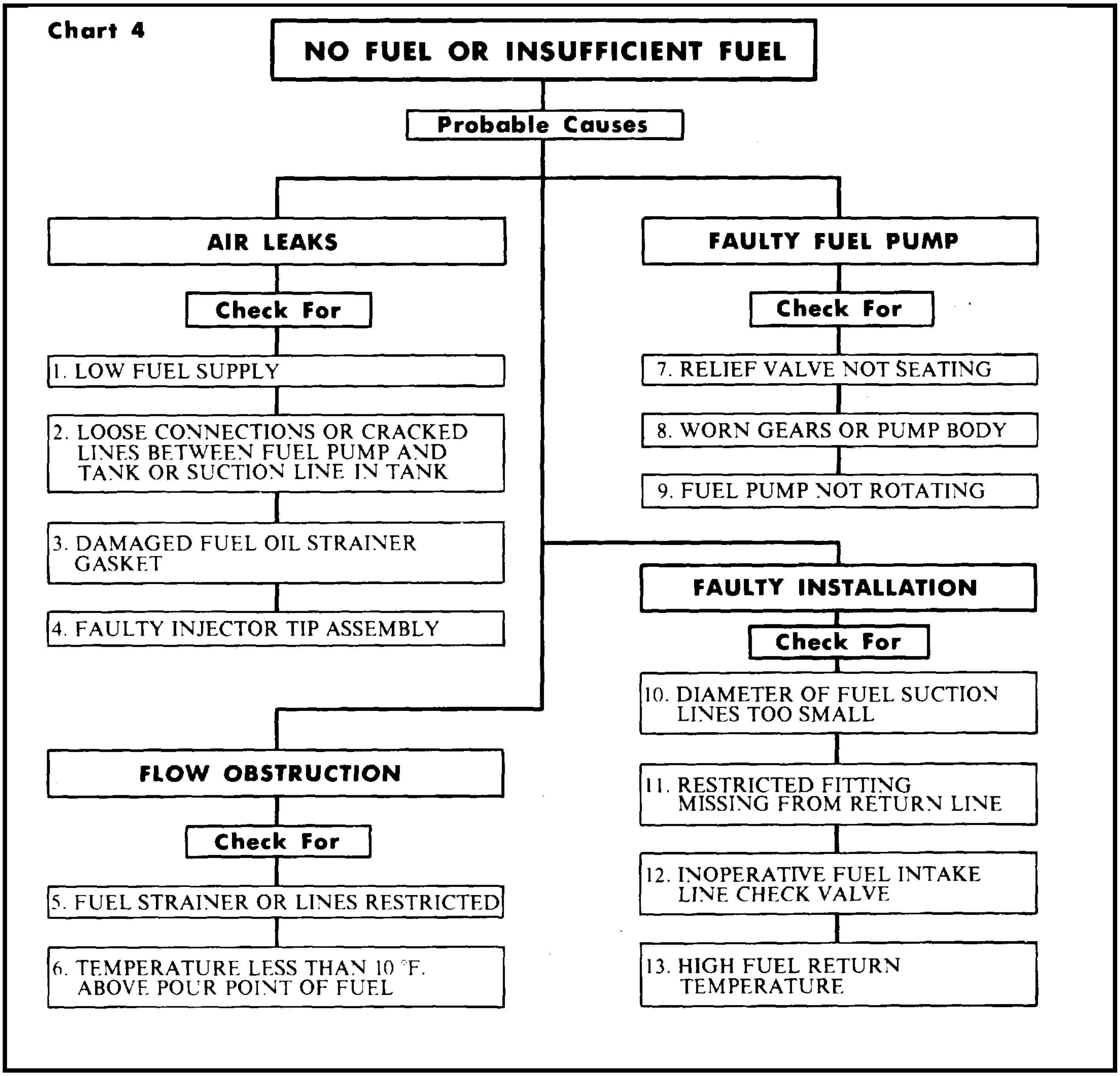


Chart 4
NO FUEL OR INSUFFICIENT FUEL
Probable Causes
AIR LEAKS
Check For
1. LOW FUEL SUPPLY
2. LOOSE CONNECTIONS OR CRACKED LINES BETWEEN FUEL PUMP AND TANK OR SUCTION LINE IN TANK
3. DAMAGED FUEL OIL STRAINER GASKET
4. FAULTY INJECTOR TIP ASSEMBLY
FLOW OBSTRUCTION
Check For
5. FUEL STRAINER OR LINES RESTRICTED
6. TEMPERATURE LESS THAN 10 °F. ABOVE POUR POINT OF FUEL
FAULTY FUEL PUMP
Check For
7. RELIEF VALVE NOT SEATING
8. WORN GEARS OR PUMP BODY
9. FUEL PUMP NOT ROTATING
FAULTY INSTALLATION
Check For
10. DIAMETER OF FUEL SUCTION LINES TOO SMALL
11. RESTRICTED FITTING MISSING FROM RETURN LINE
12. INOPERATIVE FUEL INTAKE LINE CHECK VALVE
13. HIGH FUEL RETURN TEMPERATURE

Chart 4

NO FUEL OR INSUFFICIENT FUEL

SUGGESTED REMEDY

1 The fuel tank should be filled above the level of the fuel suction tube.

2 Perform a Fuel Flow Test and, if air is present, tighten loose connections and replace cracked lines.

3 Perform a Fuel Flow Test and, if air is present, replace the fuel strainer gasket when changing the strainer element.

4 Perform a Fuel Flow Test and, if air is present with all fuel lines and connections assembled correctly, check for and replace faulty injectors.

5 Perform a Fuel Flow Test and replace the fuel strainer and filter elements and the fuel lines, if necessary, 6. Consult the Fuel Oil Specifications for the recommended grade of fuel.

7 Perform a Fuel Flow Test and, if inadequate, clean and inspect the valve seat assembly.

8 Replace the gear and shaft assembly or the pump body.

9 Check the condition of the fuel pump drive and blower drive and replace defective parts.

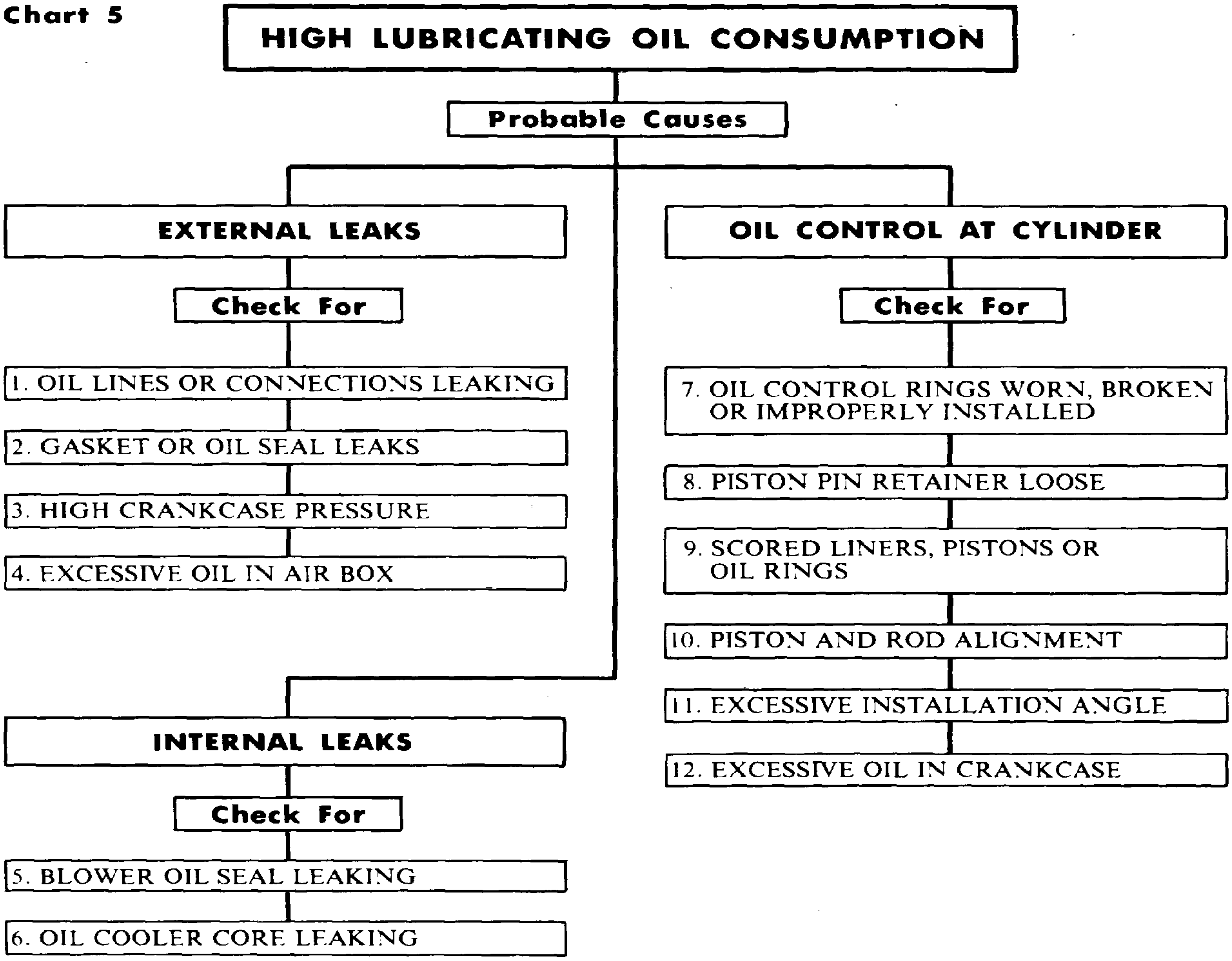
10 Replace with larger tank-to-engine fuel lines.

11 Install a restricted fitting in the return line.

12 Make sure that the check valve is installed in the line correctly; the arrow should be on top of the valve assembly or pointing upward Reposition the valve if necessary. If the valve is inoperative, replace it with a new valve assembly.

13 Check the engine fuel spill-back temperature. The return fuel temperature must be less than 150 °F or a loss in horsepower will occur. This condition may be corrected by installing larger fuel lines or relocating the fuel tank to a cooler position.

Chart 5



SUGGESTED REMEDY

1 Tighten connections or replace defective parts.

2 Replace defective gaskets or oil seals.

3 Refer to the Excessive Crankcase Pressure chart.

4 Refer to the Abnormal Engine Operation chart.

5 Remove the air inlet housing and inspect the blower end plates while the engine is operating If oil is seen on the end plate radiating away from the oil seal, overhaul the blower.

6 Inspect the engine coolant for lubricating oil contamination; if contaminated, replace the oil cooler core. Then use a good grade of cooling system cleaner to remove the oil from the cooling system.

7 Replace the oil control rings.

8 Replace the piston pin retainer and defective parts.

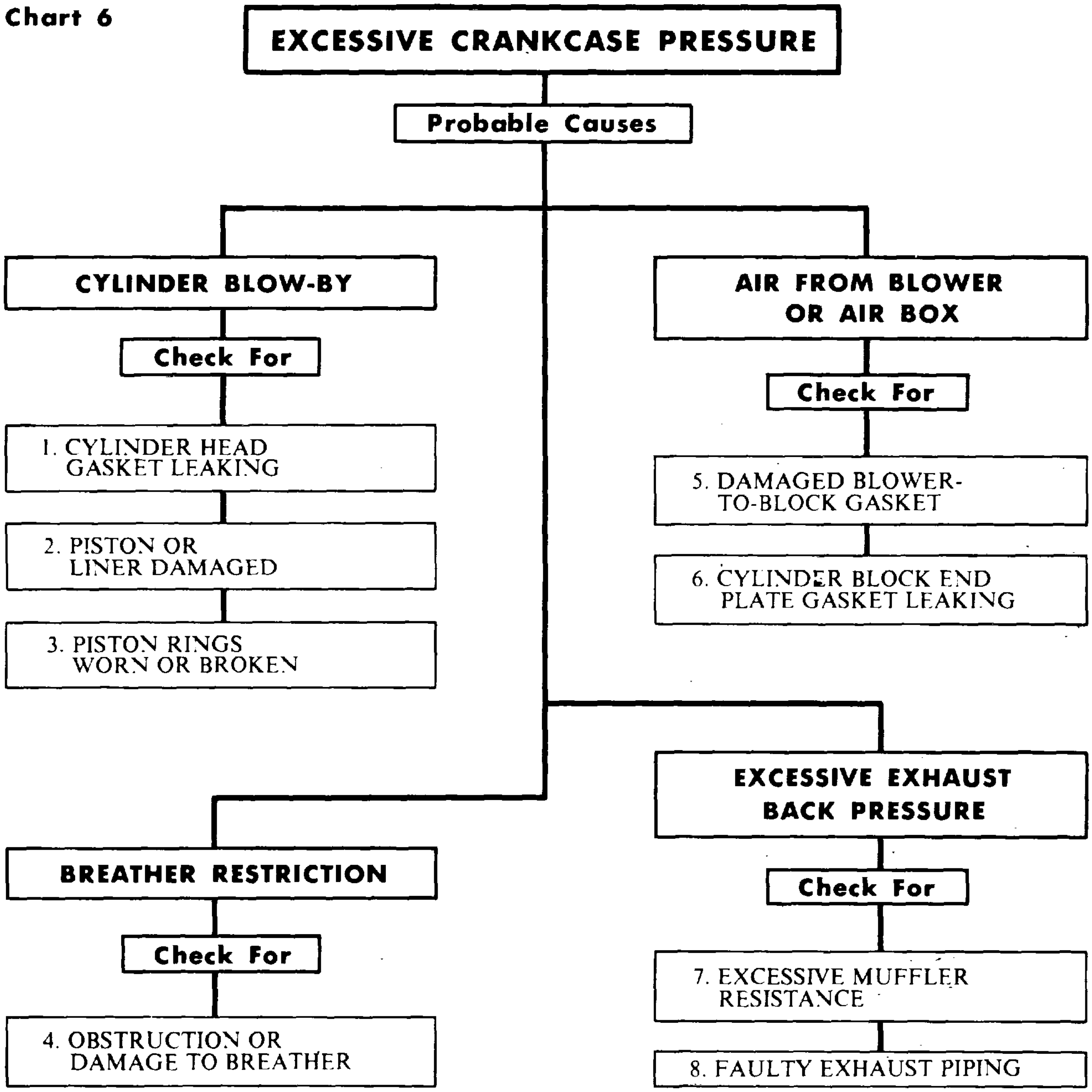
9 Remove and replace the defective parts.

10 Check the crankshaft thrust washers for wear. Replace worn and defective parts.

11 Decrease the installation angle.

12 Fill the crankcase to the proper level only.

Chart 6



SUGGESTED REMEDY

1 Check the compression pressure and, if only one cylinder has low compression, remove the cylinder head and replace the head gaskets.

2 Inspect the piston and liner and replace damaged parts.

3 Install new piston rings.

4 Clean and repair or replace the breather assembly.

5 Replace the blower-to-block gasket.

6 Replace the end plate gasket.

7 Check the exhaust back pressure and repair or replace the muffler if an obstruction is found.

8 Check the exhaust back pressure and install larger piping if it is determined that the piping is too small, too long or has too many bends

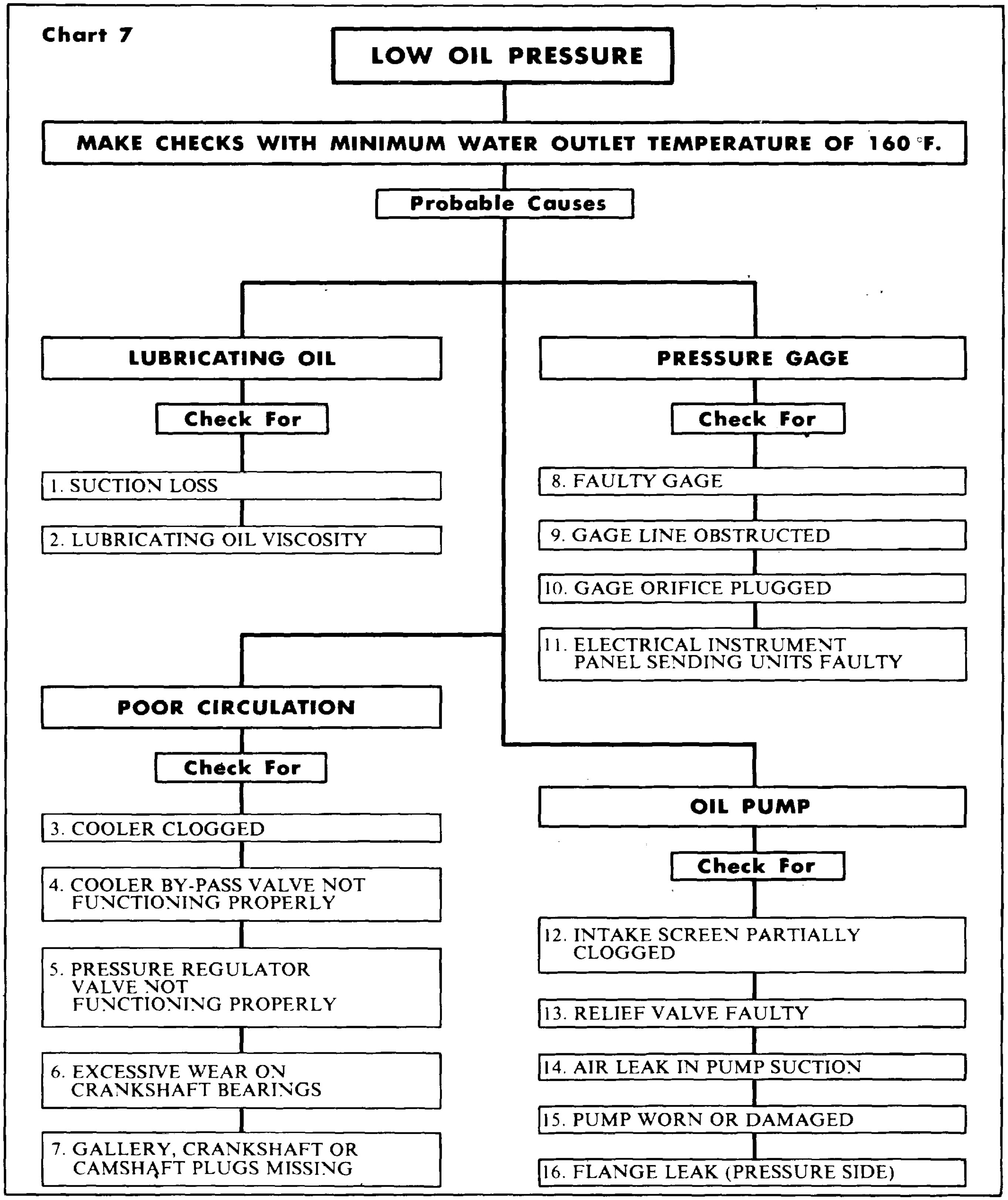


Chart 7
LOW OIL PRESSURE
MAKE CHECKS WITH MINIMUM WATER OUTLET TEMPERATURE OF 160 °F.
Probable Causes
LUBRICATING OIL
Check For
1. SUCTION LOSS
2. LUBRICATING OIL VISCOSITY
PRESSURE GAGE
Check For
8. FAULTY GAGE
9. GAGE LINE OBSTRUCTED
10. GAGE ORIFICE PLUGGED
11. ELECTRICAL INSTRUMENT PANEL SENDING UNITS FAULTY
POOR CIRCULATION
Check For
3. COOLER CLOGGED
4. COOLER BY-PASS VALVE NOT FUNCTIONING PROPERLY
5. PRESSURE REGULATOR VALVE NOT FUNCTIONING PROPERLY
6. EXCESSIVE WEAR ON CRANKSHAFT BEARINGS
7. GALLERY, CRANKSHAFT OR CAMSHAFT PLUGS MISSING
OIL PUMP
Check For
12. INTAKE SCREEN PARTIALLY CLOGGED
13. RELIEF VALVE FAULTY
14. AIR LEAK IN PUMP SUCTION
15. PUMP WORN OR DAMAGED
16. FLANGE LEAK (PRESSURE SIDE)

Chart 7

LOW OIL PRESSURE

SUGGESTED REMEDY

1 Check the oil and bring it to the proper level on the dipstick or correct the installation angle.

2 Consult the Lubricating Oil Specifications in Section 13.3 for the recommended grade and viscosity of oil.

Check for fuel leaks at the injector nut seal ring and fuel pipe connections Leaks at these points will cause lubricating oil dilution.

3 A plugged oil cooler is indicated by excessively high lubricating oil temperature. Remove and clean the oil cooler core.

4 Remove the by-pass valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.

5 Remove the pressure regulator valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.

6 Change the bearings. Consult the Lubricating Oil Specifications in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.

7 Replace missing plugs.

8 Check the oil pressure with a reliable gage and replace the gage if found faulty.

9 Remove and clean the gage line; replace it, if necessary.

10 Remove and clean the gage orifice.

11 Repair or replace defective electrical equipment.

12 Remove and clean the oil pan and oil intake screen. Consult the Lubricating Oil Specifications in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.

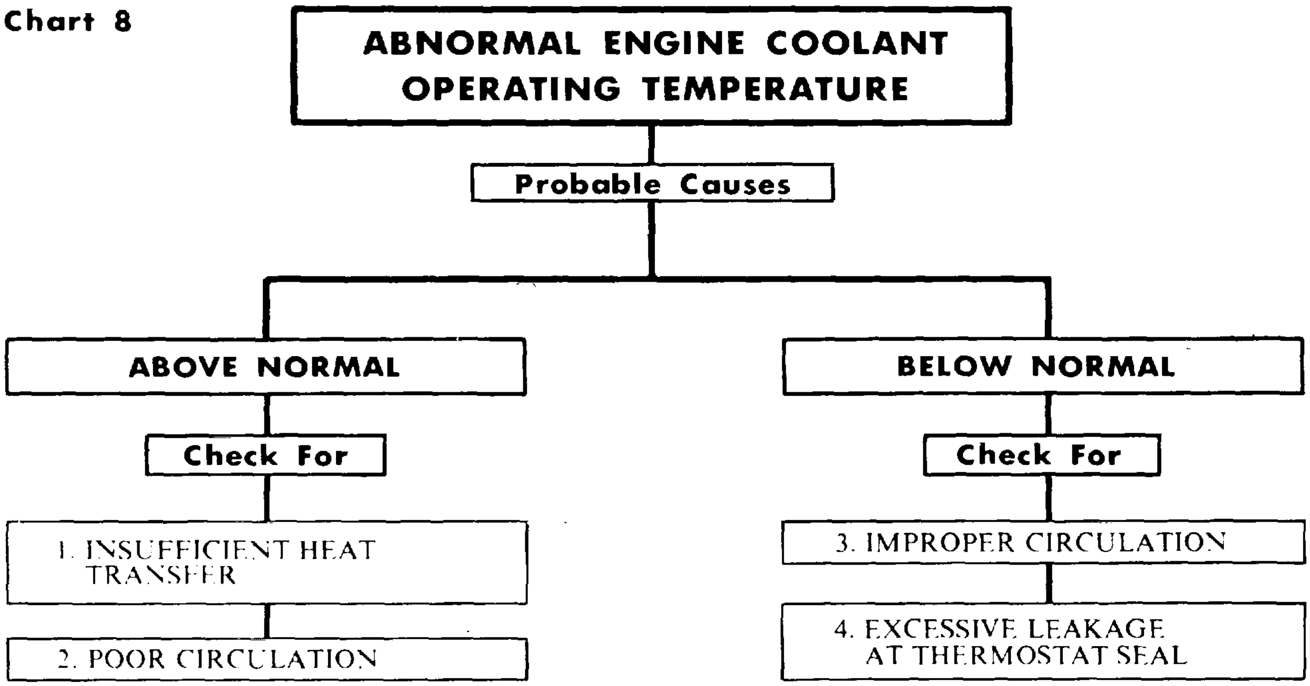
13 Remove and inspect the valve, valve bore and spring. Replace faulty parts.

14 Disassemble the piping and install new gaskets.

15 Remove the pump. Clean and replace defective parts.

16 Remove the flange and replace the gasket.

Chart 8



SUGGESGTED REMEDY

1 Clean the cooling system with a good cooling system cleaner and thoroughly flush to remove scale deposits.

Clean the exterior of the radiator core to open plugged passages and permit normal air flow.

Adjust fan belts to the proper tension to prevent slippage.

Check for an improper size radiator or inadequate shrouding.

Repair or replace inoperative temperature-controlled fan or inoperative shutters.

2 Check the coolant level and fill to the filler neck if the coolant level is low.

Inspect for collapsed or disintegrated hoses. Replace faulty hoses.

Thermostat may be inoperative. Remove. inspect and test the thermostat; replace if found faulty Check the water pump for a loose or damaged impeller.

Check the flow of coolant through the . A clogged radiator will cause an inadequate supply of coolant on the suction side of the pump. Clean the radiator core.

Remove the coolant filler cap and operate the engine, checking for combustion gases in the cooling system.

The cylinder head must be removed and inspected for cracks and the head gaskets replaced if combustion gases are entering the cooling system.

Check for an air leak on the suction side of the water pump. Replace defective parts.

3 The thermostat may not be closing Remove, inspect and test the thermostat Install a new thermostat, if necessary.

Check for an improperly installed heater.

4 Excessive leakage of coolant past the thermostat seal is a cause of continued low coolant operating temperature When this occurs, replace the thermostat seal.

STORAGE
PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 days or less)

To protect an engine for a temporary period of time, proceed as follows:

1 Drain the engine crankcase.
2 Fill the crankcase to the proper level with the recommended viscosity and grade of oil.
3 Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

> **NOTE:** Do not drain the fuel system or the crankcase after this run.

4 Check the air cleaner and service it, if necessary, as outlined in Section 3.1.
5 If freezing weather is expected during the storage period, add a high boiling point type antifreeze solution in accordance with the manufacturer's recommendations.
6 Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with compressed air.
7 Seal all of the engine openings. The material used for this purpose must be waterproof, vapor proof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil and the transmission.

EXTENDED STORAGE (30 days or more)

When an engine is to be removed from operation for an extended period of time, prepare it as follows:

1 Drain and thoroughly flush the cooling system with clean, soft water.

2 Refill the cooling system with clean, soft water.

3 Add a rust inhibitor to the cooling system (refer to Corrosion Inhibitors in Section 13.3).

4 Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.

5 Reinstall the injectors in the engine, time them, and adjust the exhaust valve clearance.

6 Circulate the coolant through the entire system by Page operating the engine until normal operating temperature is reached (160 -F to 185 -F.).

7 Stop the engine.

8 Remove the drain plug and completely drain the engine crankcase. Reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.

9 Fill the crankcase to the proper level with a 30weight preservative lubricating oil MIL-L-21260, Grade 2 (PI0), or equivalent

10 Drain the engine fuel tank.

11 Refill the fuel tank with enough rust preventive fuel oil such as American Oil Diesel Run - In Fuel (LF- 4089), Mobil 4Y17, or equivalent, to enable the engine to operate 10 minutes.

12 Drain the fuel filter and strainer. Remove the retaining bolts, shells and elements. Discard the used elements and gaskets. Wash the shells in clean fuel oil and insert new elements. Fill the cavity between the element and shell about two-thirds full of the same rust preventive compound as used in the fuel tank and reinstall the shell.
13 Operate the engine for 5 minutes to circulate the rust preventive throughout the engine.
14 Refer to Section 3.1 and service the air cleaner.
16 Apply a non-friction rust preventive compound to all exposed parts. If it is convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

CAUTION: Do not apply oil, grease or any wax base compound to the flywheel The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip.

17 Drain the engine cooling system.
18 The oil may be drained from the engine crankcase if so desired. If the oil is drained, reinstall and tighten the drain plug.
19 Remove and clean the battery and battery cables with a baking soda solution and rinse them with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32 'F.) dry place. Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.
20 Insert heavy paper strips between the pulleys and belts to prevent sticking.
21 Seal all of the openings in the engine, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.
22 Clean and dry the exterior painted surfaces of the engine. Spray the surfaces with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.
23 Cover the engine with a good weather-resistant tarpaulin or other cover if it must be stored outdoors.
A clear plastic cover is recommended for indoor storage.
The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

PROCEDURE FRO RESTORING AN ENGINE TO S ERVICE WHIC HAS BEEN IN EXTENDE STORAGE

1 Remove the value rocker cover and pour dl one-half gallon of oil, of the same grade as used in the crankcase, over the rocker arms and push rods.
2 Reinstall the valve rocker cover.
3 Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. Do not overlook the exhaust outlet.
4 Wash the exterior of the engine with fuel oil to remove the rust preventive.
5 Remove the rust preventive from the flywheel.
6 Remove the paper strips from between the pulleys and the belts.

7 Check the cran casoil level Fill the crankcase to the proper level with the heavy-duty lubricating oil recommended under Lubricating Oil Specifications (Section 13.3).
8 Fill the fuel tank with the fuel specified under Diesel Fuel Oil Specifications (Section 13.3).

9 Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, fill the cooling system with a high boiling point type antifreeze solution (refer to Section 13.3).

10 Install and connect the battery.
11 Service the air cleaner as outlined in Section 3.1.
13 After all of the preparations have been completed, start the engine. The small amount of rust preventive compound which remains in the fuel system will cause a smoky exhaust for a few minutes.

NOTE: Before a subjecting the engine to a load or high speed, it is advisable to check the engine tune-up

ALPHABETICAL INDEX

*General Information Section

*General Information Section

*General Information Section

*General Information Section

*General Information Section

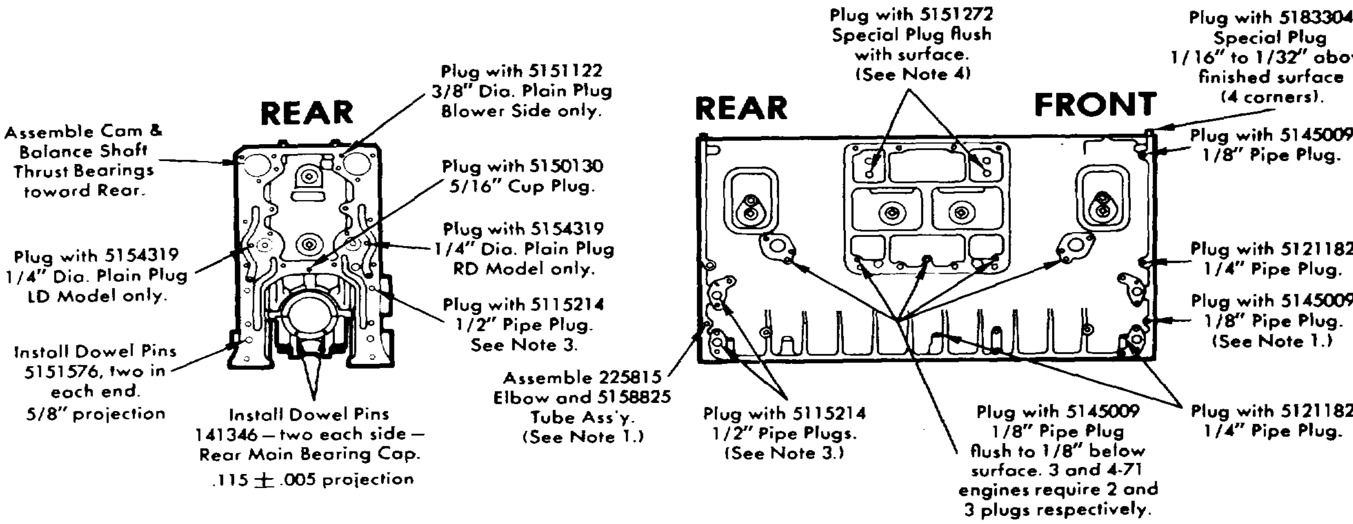
SECTION 16

CYLINDER BLOCK PLUGGING INSTRUCTIONS FOR

-71 ENGINES

CONTENTS

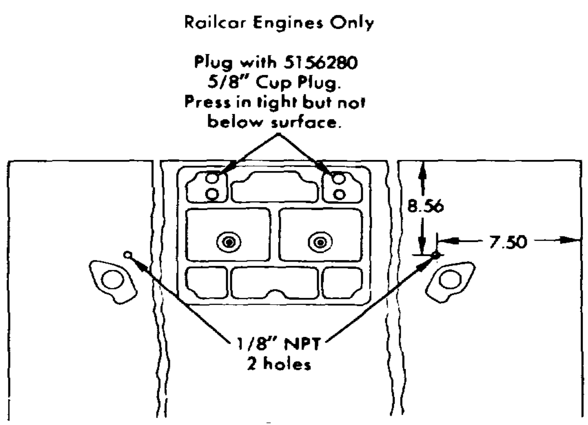
LD and RD ENGINES



STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

*CAUTION — Do Not Over Torque Teflon Wrapped Pipe Plugs.
(See Note 2.)

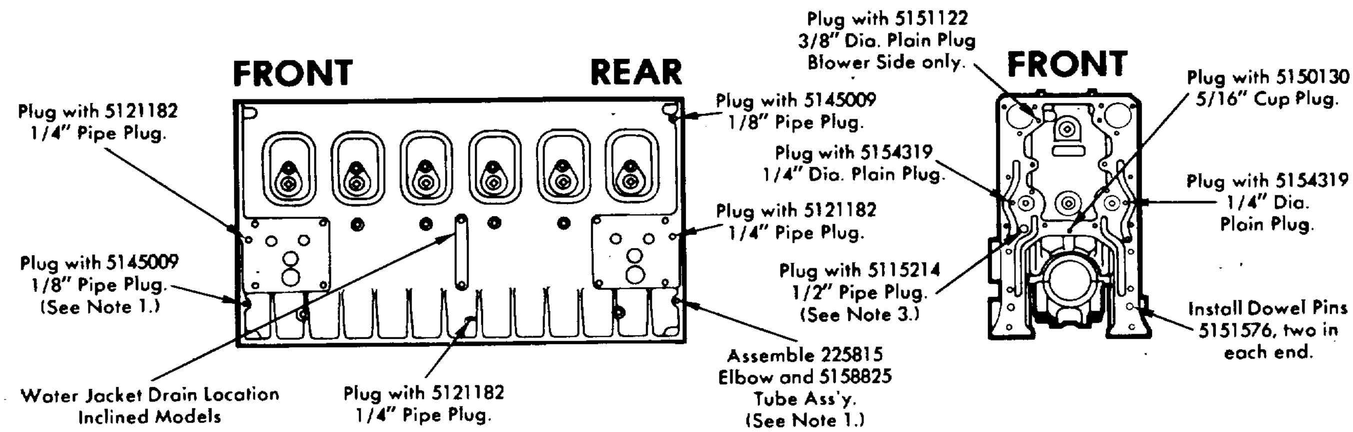


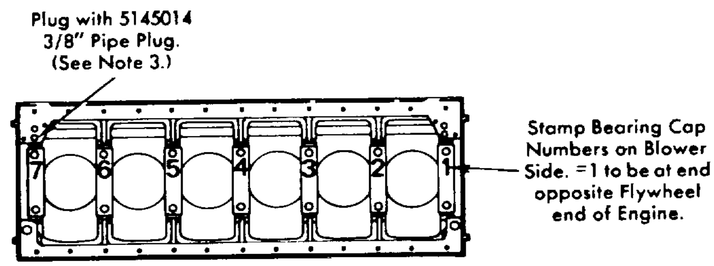
NOTES

(1) Assemble 225815 Elbow and 5158825 Tube Ass'y to the front of the block for-LD engine of Model 24001B and RD engine of Model 240028 Assembly 5145014 Plugs to rear of block on aforementioned engines On Truck engines, assemble 225815 Elbow and 5158825 Tube Ass'y to the front and to the rear on the Blower Side. Assemble 5145009 Plugs on the opposite side of the block Page.

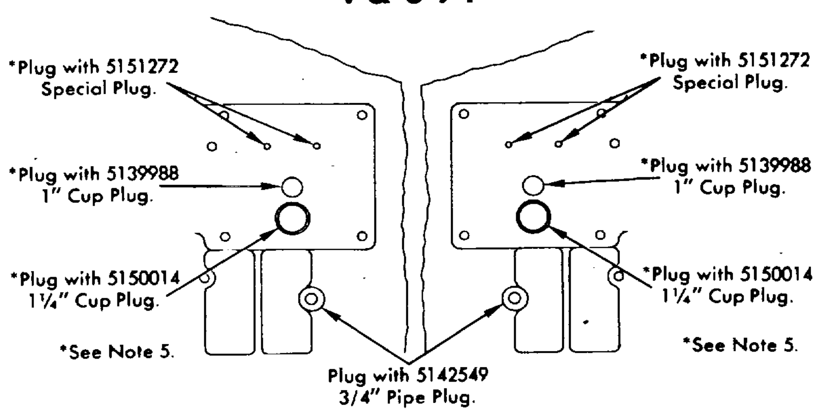
(2) Use "Aviation Permoatex", Minnesota Mining EC-712 Sealant or equivalent when assembling oil plugs except Teflon wrapped plugs Apply Sealant to Plug only.

LD and RD ENGINES (Cont'd)





Accessory Pads
4 & 6-71



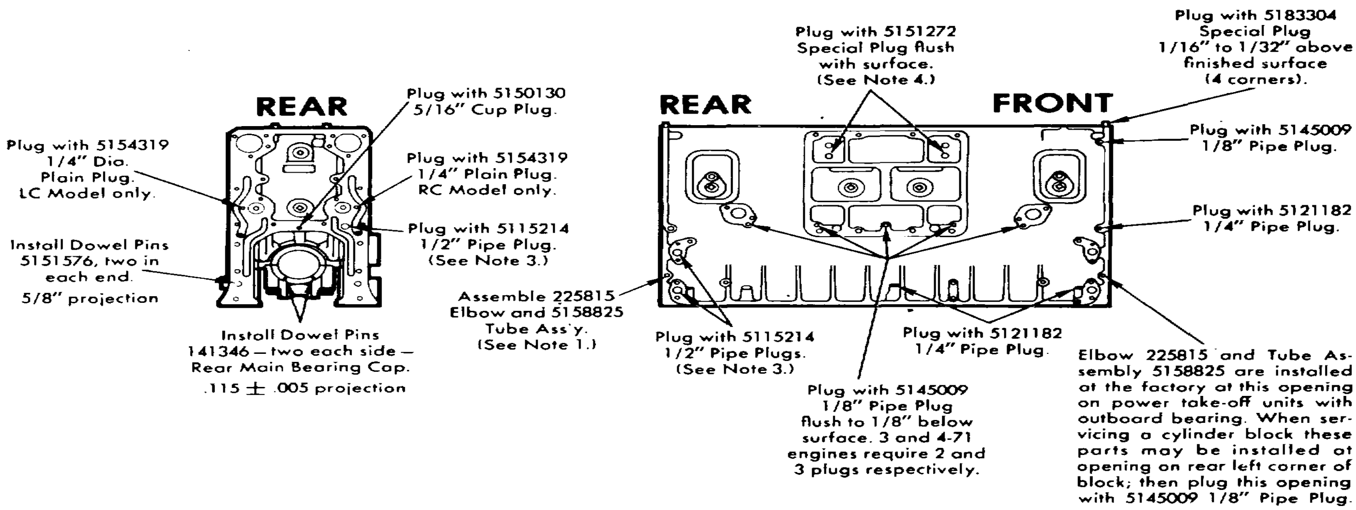
NOTES

(3) Replace Oil Cooler Pad and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling an aluminum cylinder block.

(4) Omit one 5151272 plug when using supercharged air compressor connection.

(5) Do not install plugs when crankcase breather is to be installed on accessory pad.

LC and RC ENGINES

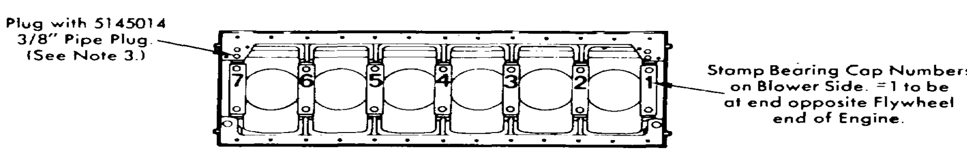


STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

*CAUTION – Do Not Over Torque Teflon Wrapped Pipe Plugs.

(See Note 2.)



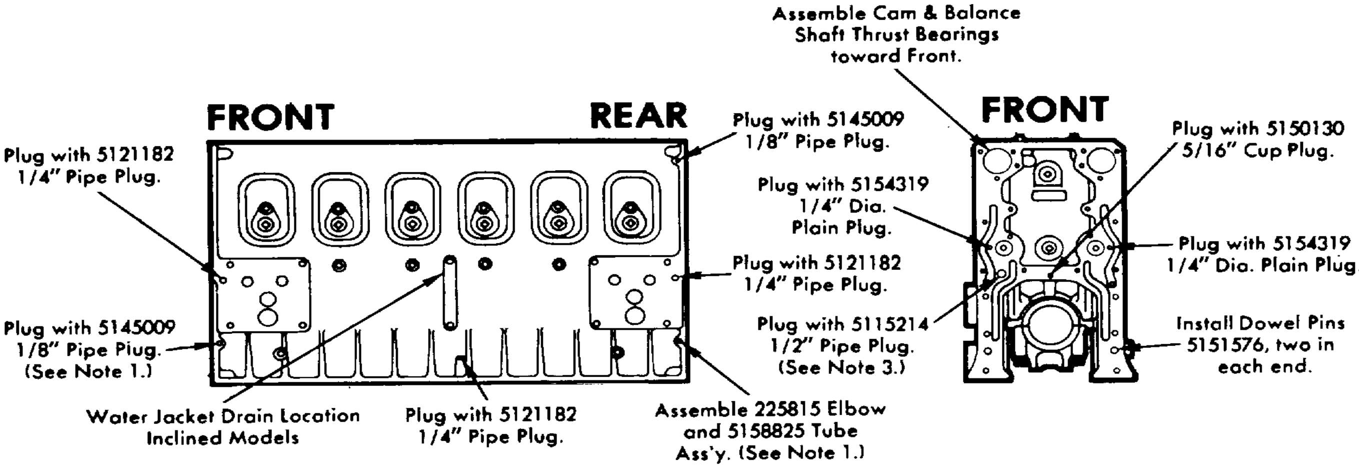
NOTES

(1) Assemble 225815 Elbow and 5158825 Tube Ass'y in each of the two air box drain holes on the blower side of the block for G M C Truck Models Assemble 5145009 Plugs in the two corresponding holes on the opposite side of the block For single engine generator units assemble 225815 Elbow and 5171500 Tube Ass y to the front of the block on the handhole cover side Assemble 225815 Elbow and Tube Ass'y 5171500 (for 3-Cyl 1, 5171501 (for 4-Cyl I or 5171502 (for 6-Cyl) to the rear on the some side of the block The front and rear tubes should then be connected to the common drain tank Assemble 5145009 Plugs in the two corresponding holes on the opposite side of the block.

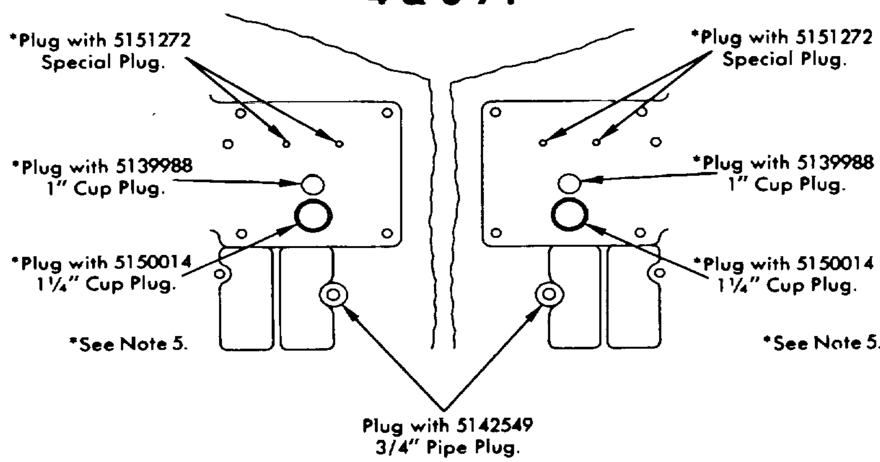
*Not included with service block

Each engine of Model 12201 and 12202 units requires 2 Elbows 225815 and Tube Assemblies 5171500 (Front) and 5171502 (Rear) on the blower side of the block For these Twin Generator Units, 2 Plugs 5145009 are, therefore, used on the handhole cover side of the block.

LC and RC ENGINES (Cont'd)



Accessory Pads
4 & 6-71



____NOTES ____

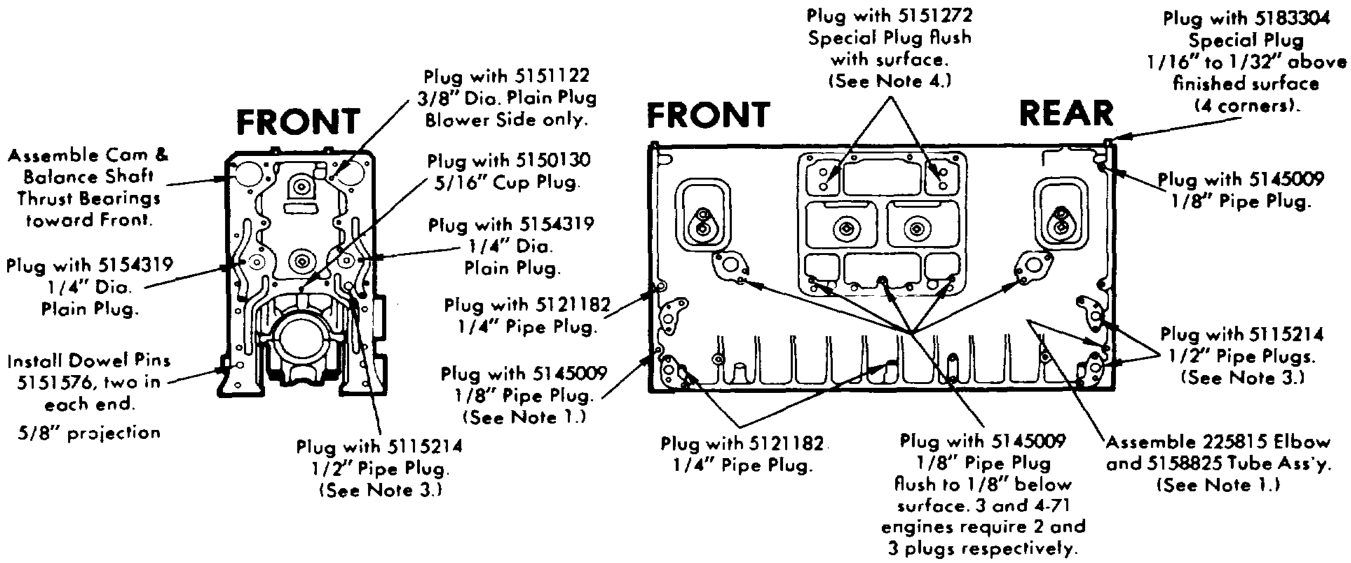
(2) Use "Aviation Permatex," Minnesota Mining EC-712 Sealant or equivalent when assembling all plugs except Teflon wrapped plugs. Apply Sealant to plug only

(3) Replace Oil Cooler Pod and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling on aluminum cylinder block.

(4) Omit one 5151272 plug when using supercharged air compressor connection.

(5) Do not install plugs when crankcase breather is to be installed on accessory pod.

LB and RB ENGINES

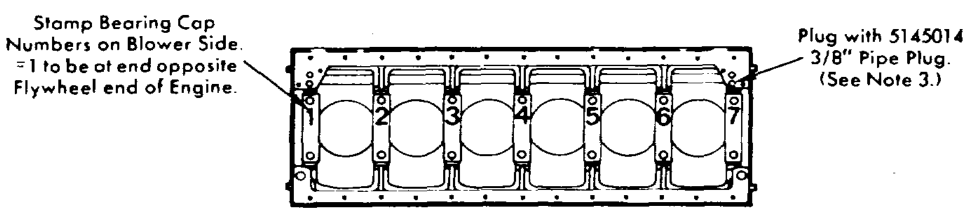


STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

*CAUTION – Do Not Over Torque Teflon Wrapped Pipe Plugs.

(See Note 2.)



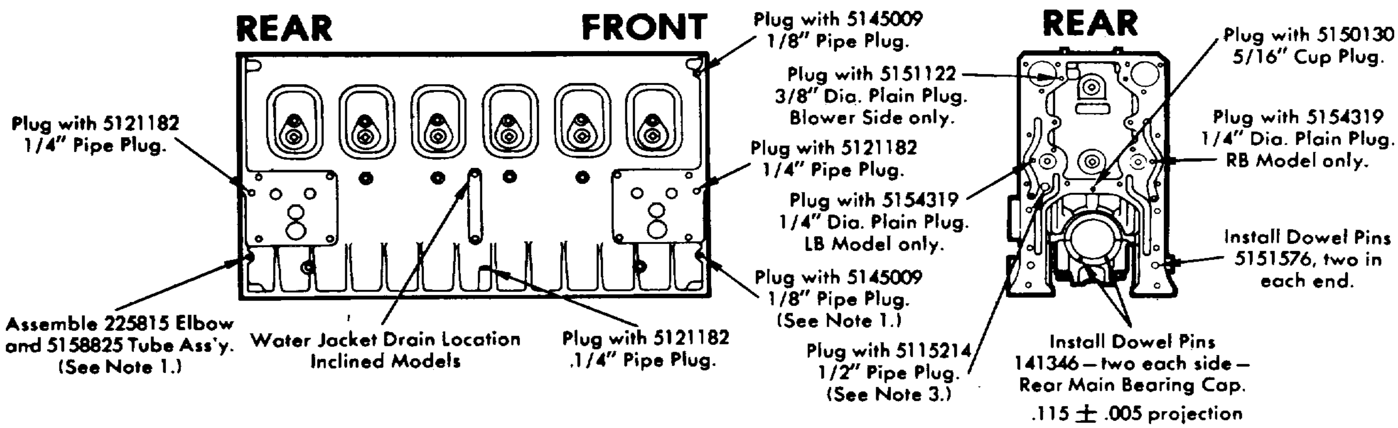
NOTES

(1) Assemble 225815 Elbow and a 58825 Tube Ass'y on each side and to the front of the block for LB engine of Model 24001B and RB engine of Model 24002B Assemble 5145009 Plugs to rear of block on aforementioned engines.

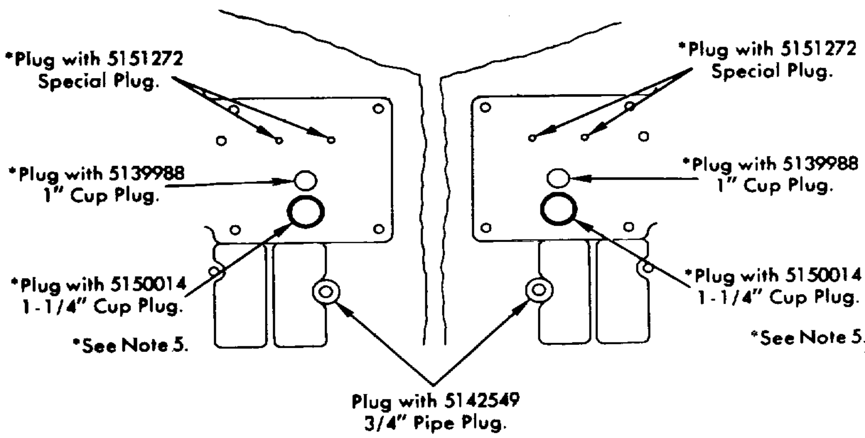
(2) Use "Aviation Permatex," Minnesota Mining EC-712 Sealant or equivalent when assembling all plugs except Teflon wrapped plugs Apply Sealant to Plug only.

16.3

LB and RB ENGINES (Cont'd)



Accessory Pads
4 & 6-71



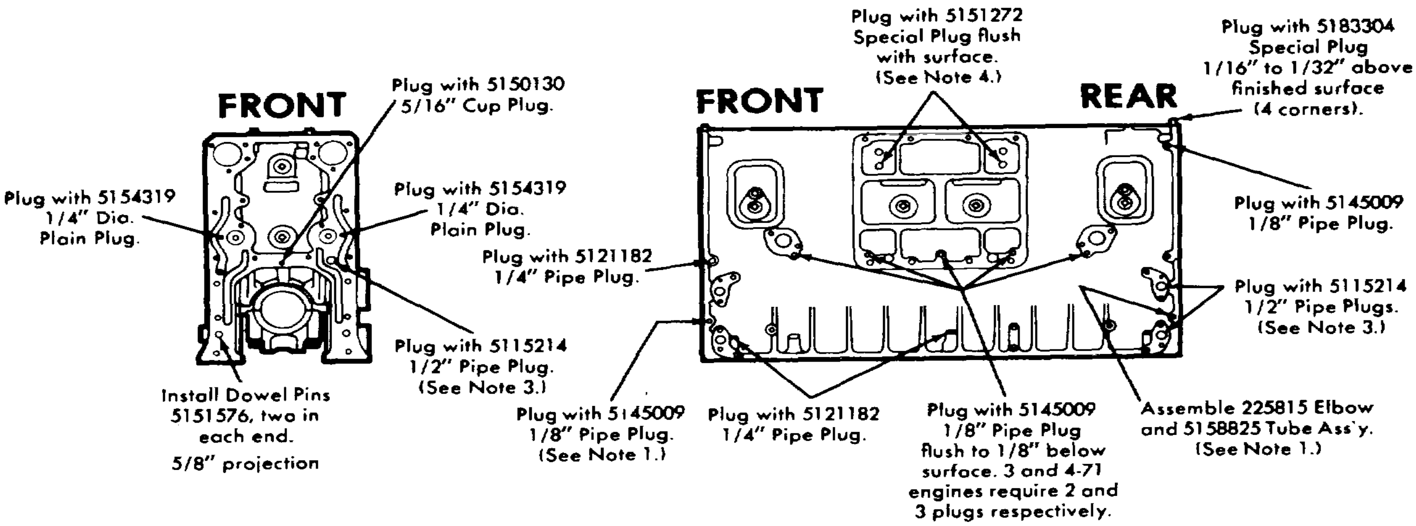
NOTES

(3) Replace Oil Cooler Pod and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling on aluminum cylinder block.

(4) Omit one 5151272 plug when using supercharged air compressor connection.

(5) Do not install plugs when crankcase breather is to be installed on accessory pad.

LA and RA ENGINES



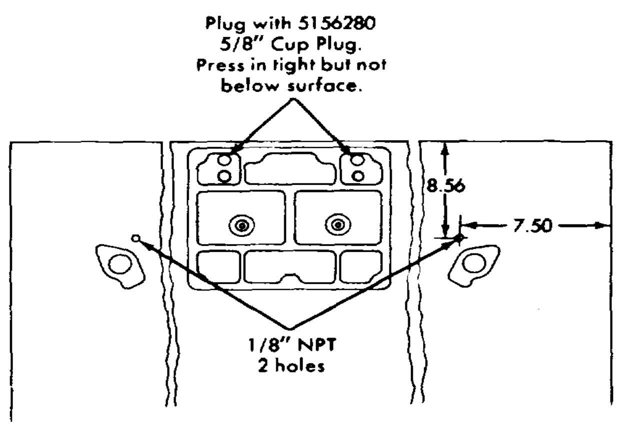
STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

*CAUTION – Do Not Over Torque Teflon Wrapped Pipe Plugs.

(See Note 2.)

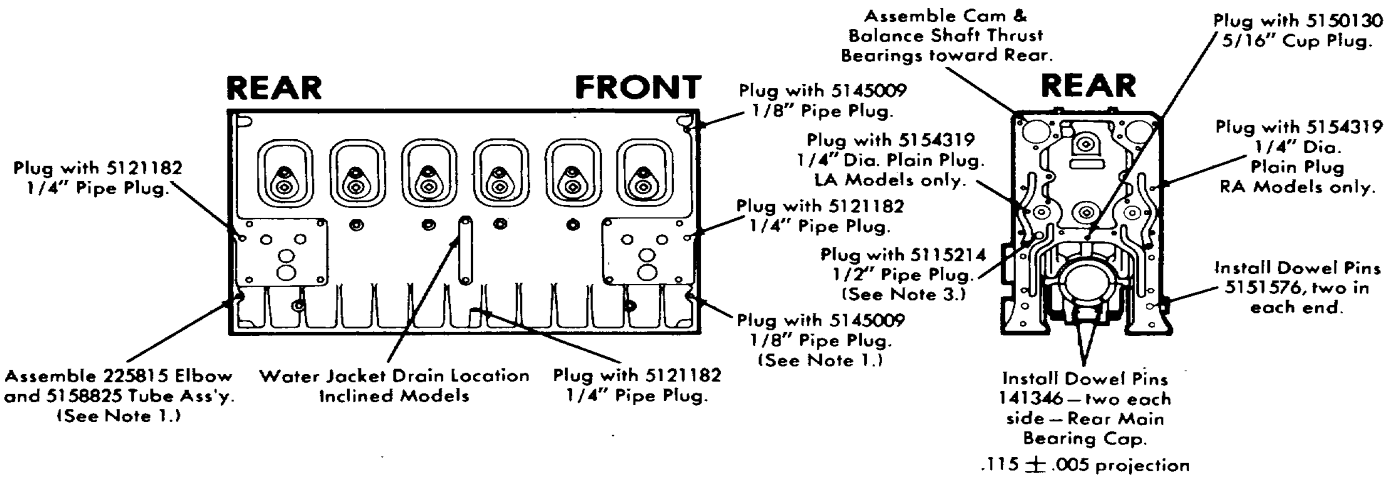
Railcar Engines Only

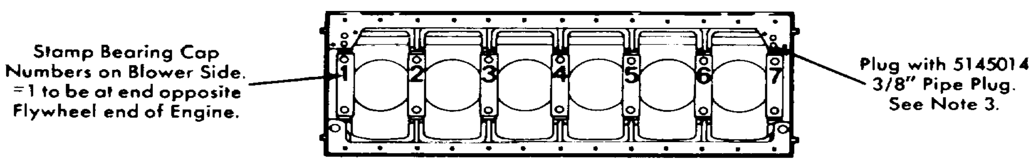


NOTES

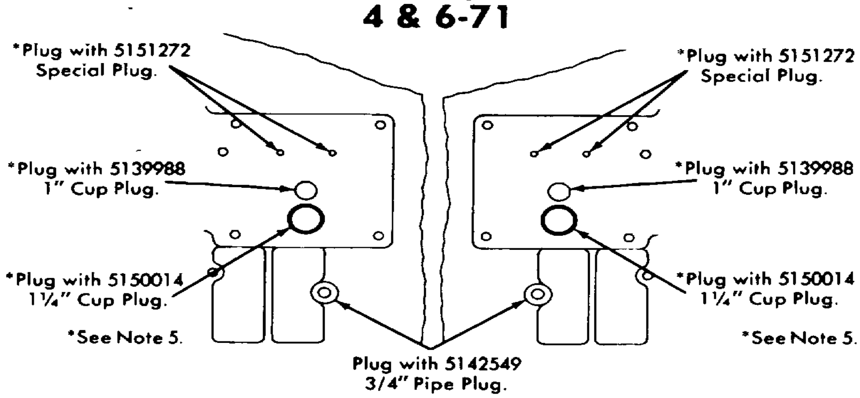
(1) On Coach engines, assemble 225815 Elbow and 5158825 Tube Ass'y to the front, and to the rear of the block - both on the blower side On RA engine of Model 120048, assemble 225815 Elbow and 5158825 Tube Ass'y on each side and to the front of the block. For the LA engine of Model 12201, assemble 225815 Elbow and 5171502 Tube Ass'y to the front and to the rear of the block - both on the blower side. On the aforementioned engines, assemble a 5145009 Plug in each of the two remaining corresponding holes.

LA and RA ENGINES





Accessory Pads
4 & 6-71



NOTES

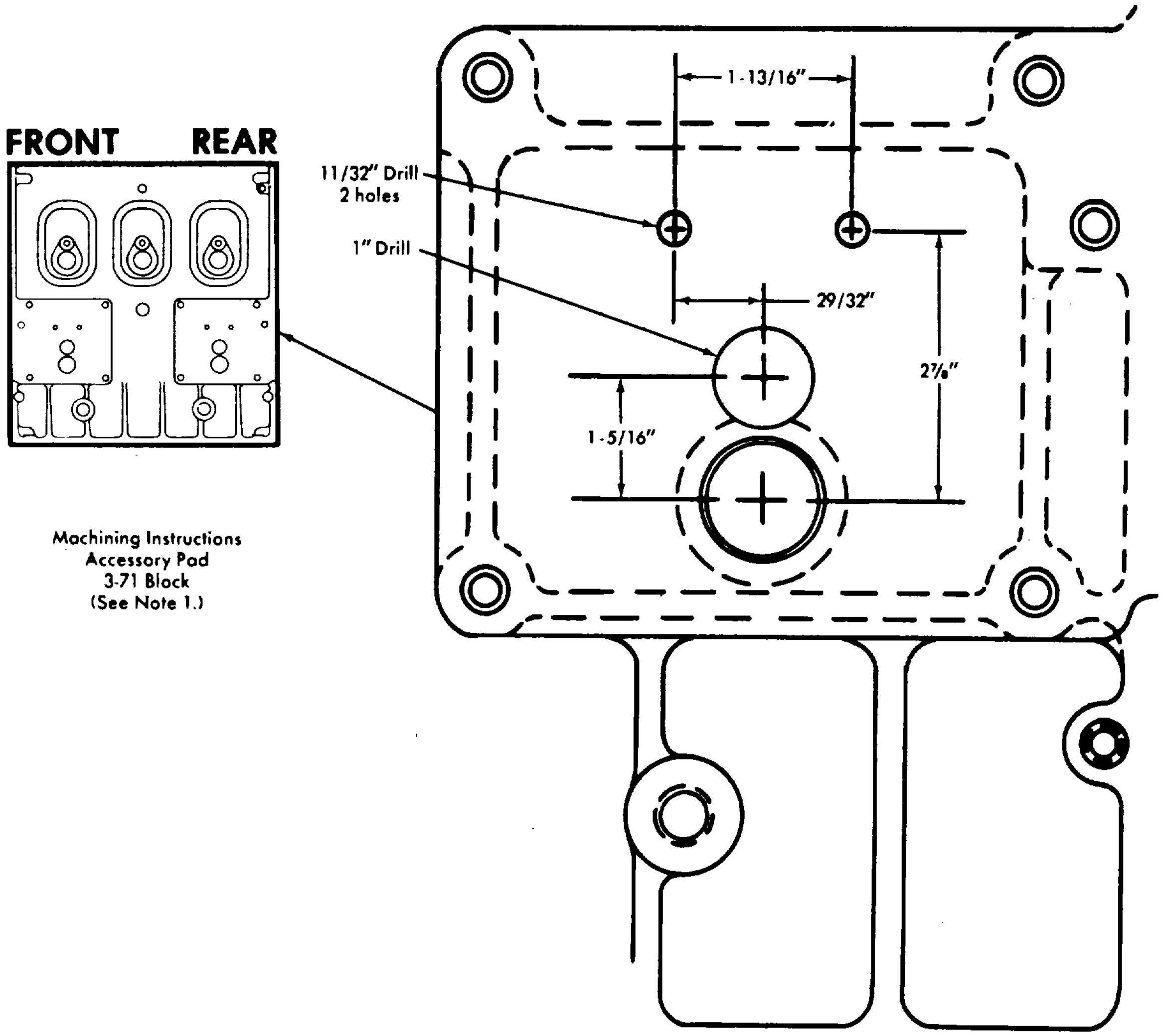
(2) Use "Aviation Permatex," Minnesota Mining EC-712 Sealant or equivalent when assembling all plugs except Teflon wrapped plugs. Apply Sealant to Plug only.

(3) Replace Oil Cooler Pod and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling an aluminum cylinder block.

(4) Omit one 5151272 plug when using supercharged air compressor connection.

(5) Do not install plugs when crankcase breather is to be installed on accessory pad.

16.5 Accessory Pad Machining Instructions



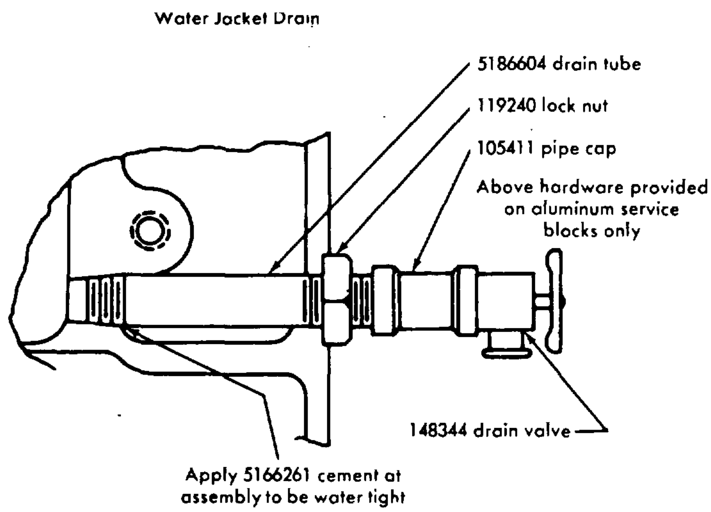
Machining Instructions
Accessory Pad
3-71 Block
(See Note 1.)

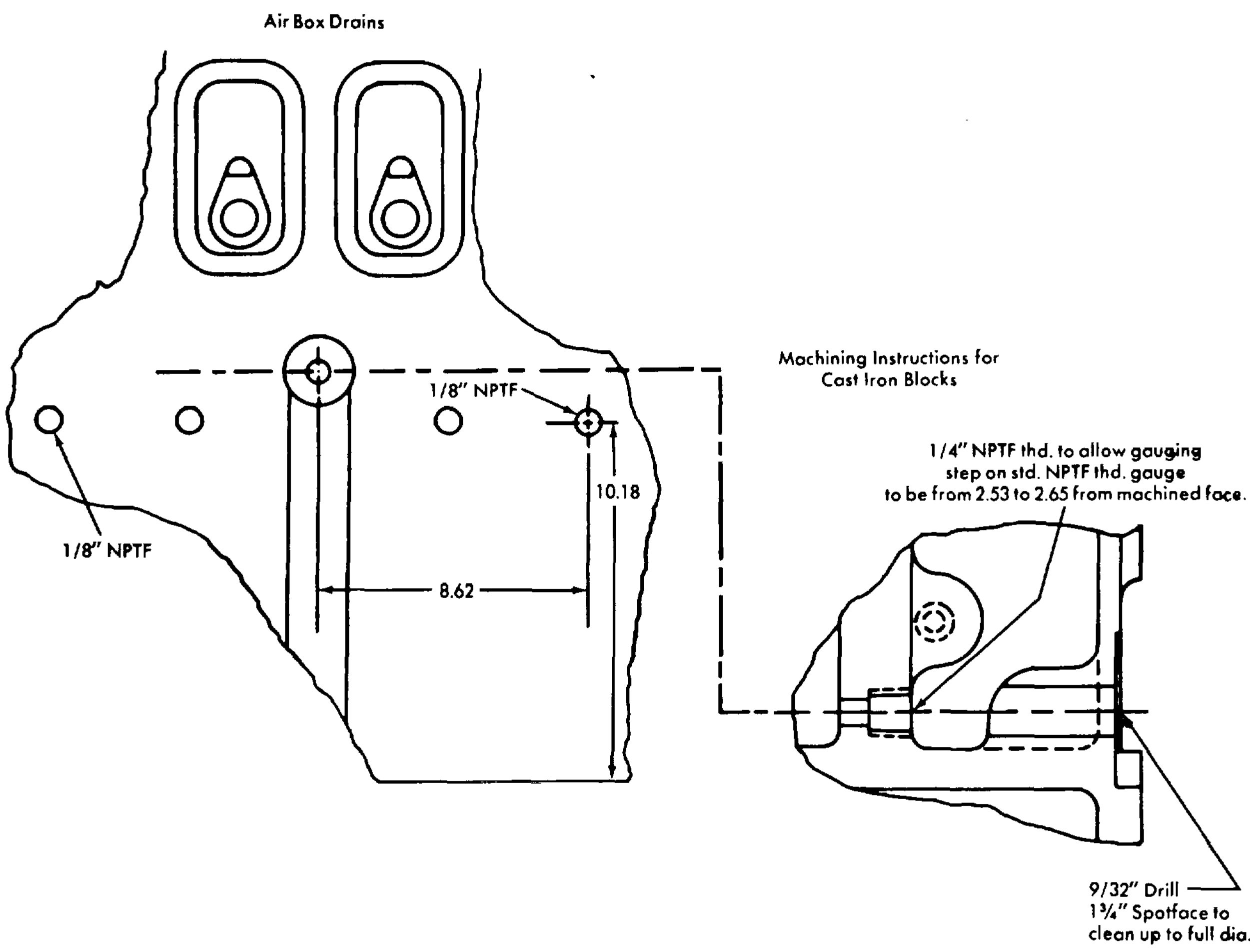
____NOTES ____

(1) For the 3-71 Engines with dry type air cleaners the crankcase breather must be mounted on the accessory pod front or rear. Add 3 holes as shown; two for mounting the internal baffle plate and one for the drain.

16.6 Inclined Block

INCLINED BLOCK





CHAPTER III

PARTS CATALOG

DETROIT DIESEL ENGINES

INDEX

ASSEMBLY BREAKDOWN

The Assembly Breakdown section is designed to eliminate repeating components of assemblies and sub-assemblies. When the Assembly Breakdown is used it is always found at the end-of the group it pertains to. The pages are easily identified. They are numbered with an alphabetical prefix. Assemblies which make use of the Assembly Breakdown will have a note to that effect under the sub-group heading. The note will refer to the page on which the assembly is shown. The part number will appear in the first group of the Assembly Breakdown showing the quantity used in one of the alphabetically designated columns. All other items appearing in that column are components of the assembly.

ALPHABETICAL INDEX

The Alphabetical Index on page 5 is particularly helpful when only a part name is known and the group cannot readily be determined. Parts are listed alphabetically by noun name, followed by a description of the application of the part and the final group location. Component parts of assemblies are not listed since they will appear in the body of the book immediately following the assembly to which they belong.

PARTS RELEASE

A Parts Release, on microfiche, is issued monthly to keep this catalog up-to-date. It consists of revised fiche for insertion in tile set. All new fiche carry a date of issue. These should be inserted into the deck immediately upon receipt. Old fiche may then be destroyed.

A checklist is included with each monthly Microfiche update. The checklist will indicate, by date, those Fiche revised and reissued.

MISCELLANEOUS

At the beginning of each of the sections of this catalog there are several pages of illustrations. In each section of the parts list figure numbers refer to illustrations within that section only, unless otherwise noted. In the majority of cases illustrations are typical, that is, they may represent more than one part number. For example, in the case of the flywheel housing, figure 7A of section 1.0000, a single housing is shown to represent all housings. Key numbers on illustrations are final group numbers.

In many instances a part has more than one application. Wherever a part appears in its second or third application the basic group is shown in parenthesis following the description.

Unless otherwise specified, standard bolts in the parts list are hexagon head. Other standard parts are described in detail.

The information and illustrations in this publication are based on the information in effect at the time of approval for printing. The right is reserved to make changes at any time without notice.

YOUR PARTS ORDER WILL BE HANDLED MORE EFFICIENTLY IF YOU-

1. Provide the following information for material ordered:
   A. Group in parts book in which it is specified.
   B. Quantity desired.
   C. Part Number.
   D. Complete Nomenclature.
   E. The Type number for the model concerned.
   F. Complete Unit Model identification and Serial number
   G. "TYPE" rather than "WRITE" the above information.
2. Furnish complete shipping instruction. This is particularly important in case the order is not to be handled in the regular manner. Indicate whether shipment should be made via parcel post, express, freight, air freight, air express, etc.
3. Confirm all telegraph and telephone orders immediately, clearly marking any such orders "CONFIRMING" to avoid duplication of shipment or such orders.

MODEL DESCRIPTION CHART

1 0 6 7 - 7 0 0 1

SERIES 71 IN-LINE ENGINE	NUMBER OF CYLINDERS	APPLICATION DESIGNATION (see below)	BASIC ENGINE ARRANGEMENT AND DRIVE SHAFT ROTATION (see below)	DESIGN VARIATION (see below)	SPECIFIC MODEL NUMBER

APPLICATION DESIGNATION

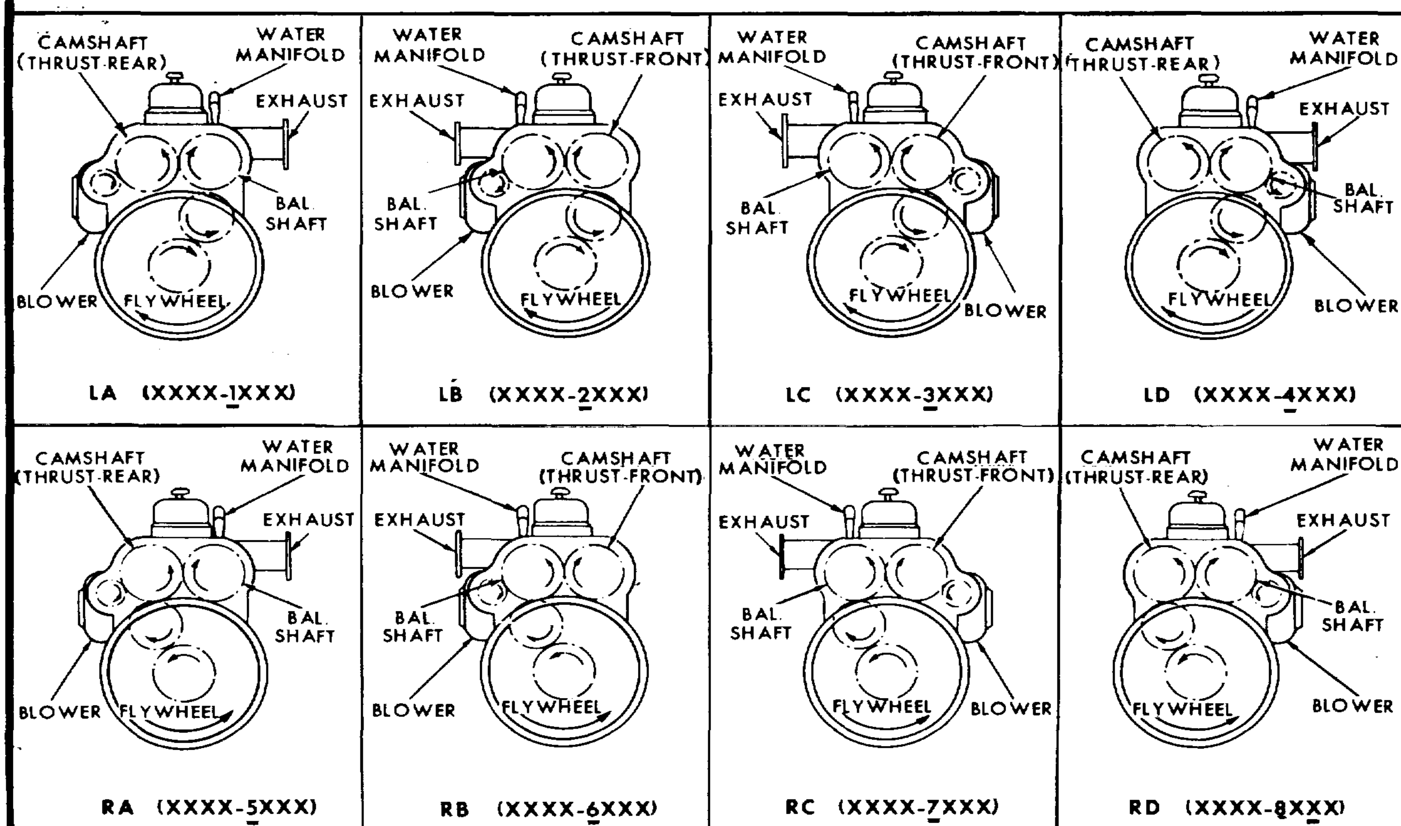
1067–7001 VEHICLE F-F

BASIC ENGINE ARRANGEMENTS:

Rotation: L (left) and R (right) designates rotation viewed from the front of the engine. Type A-B-C-D designates the accessory arrangements.

DESIGN VARIATIONS

1067–7001	4 VALVE HEAD ("N" ENGINE)
1067–7101	2 VALVE HEAD ENGINE
1067–7201	4 VALVE HEAD ("E" ENGINE)
1067–7301	TURBOCHARGED ENGINE
1067–7501	CUSTOMER SPEC. ENGINE

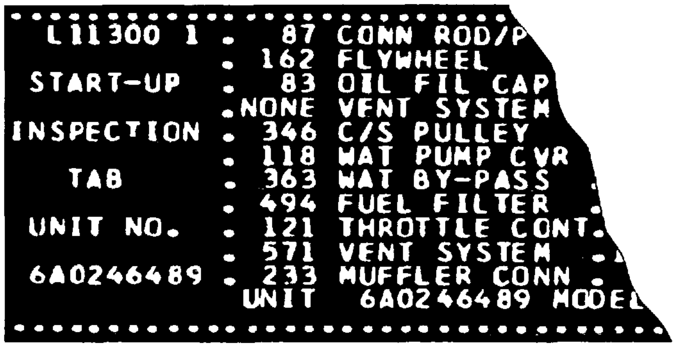


ALL VIEWS FROM FLYWHEEL REAR END OF ENGINE P 1133

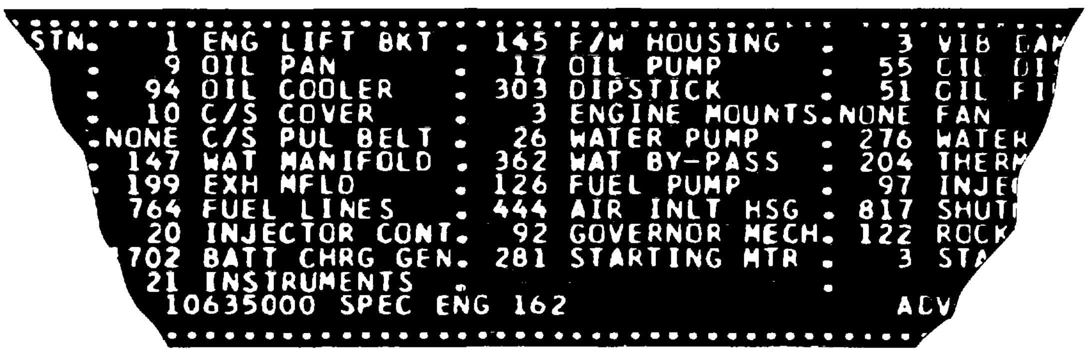
ENGINE ROTATION DETERMINED BY VIEWING ENGINE FROM BALANCE WEIGHT COVER (FRONT) END

Built-In Parts Book

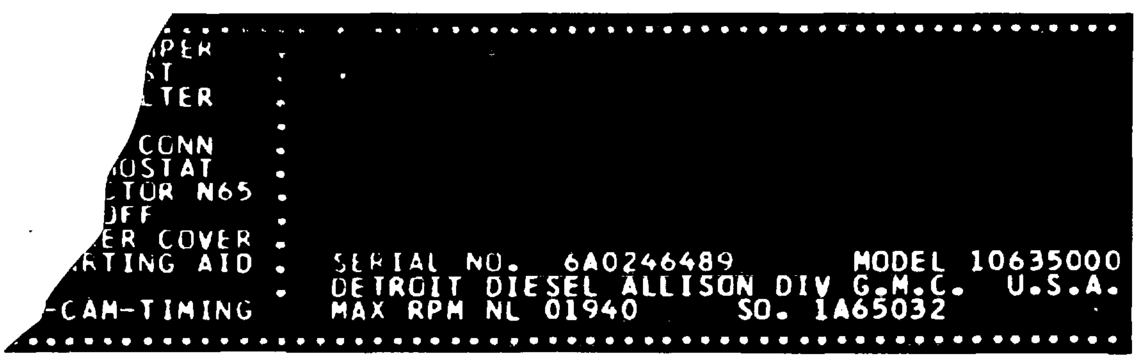
What is this "built-in" book? It is an anodized aluminum plate that fits into a holding channel on the engine rocker cover.



ON THE LEFT SIDE of the plate is the Start-up Inspection Tab which is removed by the dealer when he has completed the inspection.



NEXT is the type number and the equipment description. On the left is the type number. The type number designates all service parts applicable to the equipment. On the right is a brief description of the equipment.

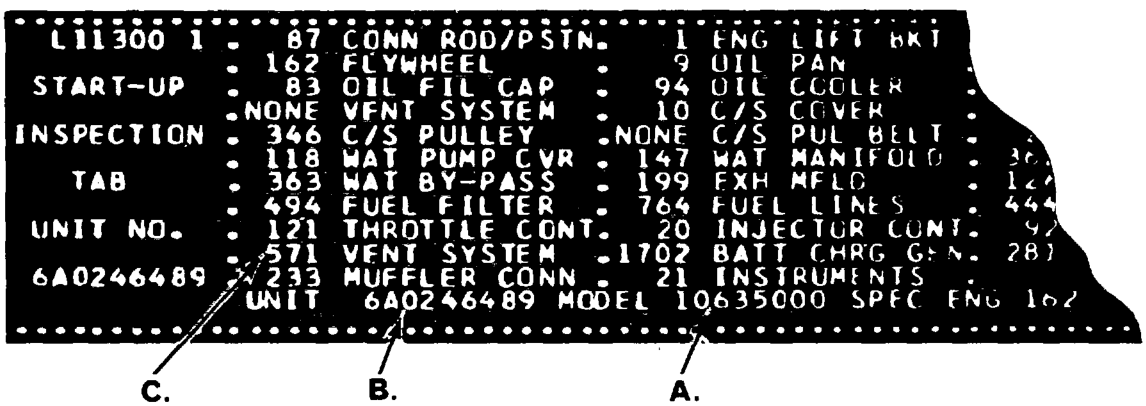


ON THE RIGHT SIDE of the plate is pertinent data on the model number, serial number and the related governor setting.

Built-In Parts Book

Progress in industry comes at a rapid pace. In order for the engine manufacturer to keep pace with progress he needs a versatile product for the many models and arrangements of accessories and mounting parts needed to suit a variety of equipment. In addition, engine refinements and improvements are constantly being introduced. All of this dynamic action must be documented so that the equipment can be serviced if and when it's needed. It is fully documented in the manufacturer's plant and in dealer Parts Departments with Master Files and adequate supporting records. But, what about YOU the user of this equipment? You have neither the time nor the inclination to ferret out specific part number' data. What is the answer?-It is Detroit Diesel's exclusive BUILT-IN PARTS BOOK which is furnished with each engine. It takes the form of an "Option Plate" mounted on the rocker cover of the engine. With it, ordering parts becomes as simple as A, B, C. You have merely to provide the Dealer with.

A. The "Model" number B. The "UNIT" number C. The "TYPE" number



From that much information, the dealer with his complete records on all engine models, can completely interpret your parts requirements.

Within each of these sub-groups, various designs of similar equipment are categorized as "Types" and identified by a Type Number.

The Distributor, Dealer has a Model Index for each engine model. The Model Index lists all of the "Standard" and "Standard Option" equipment for that model.

DETROIT DIESEL 71 **1063-5100 (RA)**

STANDARD AND STANDARD OPTION EQUIPMENT

GROUP NAME	GROUP NO.	TYPE
Cylinder Block	1.1000	4
Air Box Drains	1.1000A	1
Cylinder Head	1.2000	4
Engine Lifter Bracket	1.2000A	1
Crankshaft	1.3000	4
Crankshaft Front Cover	1.3000A	10
Crankshaft Pulley	1.3000C	172
Crankshaft Pulley Belt	1.3000D	240
Flywheel	1.4000A	170
Flywheel Housing (SAE #1)	1.5000A	22
Connecting Rod and Piston	1.6000	101
Camshaft and Gear Train	1.7000	18
Balance Weight Cover	1.7000A	25
Valve Operating Mechanism	1.8000	4
Rocker Cover	1.8000A	22
Fuel Injector NV60	2.1000A	78
Fuel Pump	2.2000	126
Fuel Pump Drain	2.2000A	2
Fuel Filter	2.3000A	381
Fuel Manifold Connections	2.4000	56

NOTE The option plate reflects which choice of options has been built into the engine. The Distributor/Dealer uses his model index to interpret the standard equipment. The plate, therefore, lists only the non-standard or choice items.

So, give the dealer the

A-Model No. ___________
B-Unit No. ___________
***C-Type No.** ___________

*(If not shown, indicate "NONE". The dealer knows the "standard" for the model).

GROUP NOMENCLATURE

1.0000	ENGINE (less major assemblies)
1.1000	Cylinder Block
1.1000A	Air Box Drains
1.2000	Cylinder Head
1.2000A	Engine Lifter Bracket
1.3000	Crankshaft, Oil Seals and stabilizers
1.3000B	Water Connections
1.3000A	Crankshaft Front Cover
1.3000B	Vibration Damper
1.3000C	Crankshaft Pulley
1.3000D	Crankshaft Pulley Belt
1.4000A	Flywheel
1.5000A	Flywheel Housing
1.5000B	Flywheel Housing Adaptor
1.6000	Connecting Rod and Piston
1.7000	Camshaft and Gear Train
1.7000A	Balance Weight Cover
1.7000B	Accessory Drive
1.8000	Valve and Injector Operating Mechanism
1.8000A	Rocker Cover
2.0000	FUEL SYSTEM
2.1000A	Fuel Injector
2.2000	Fuel Pump
2.2000A	Fuel Pump Drain
2.3000A	Fuel Filter
2.4000	Fuel Manifold and/or Connections
2.4000A	Dual Fuel System
2.5000A	Fuel Lines and Fuel Cooler
2.6000A	Fuel Tank
2.7000A	Mechanical Governor
2.8000A	Hydraulic Governor
2.9000	Injector Controls
2.9000	Injector Controls
2.9000A	Throttle Controls
3.0000	AIR SYSTEM
3.1000A	Air Cleaner and/or Adaptor
3.2000A	Air Silencer
3.3000A	Air Inlet Housing
3.4000	Blower
3.4000A	Blower Drive Shaft
3.4000B	Blower End Plate Cover
3.5000A	Turbocharger and Intercooler
4.0000	LUBRICATING SYSTEM
4.1000A	Oil Pump
4.1000B	Oil Distribution System
4.1000C	Oil Pressure Regulator
4.2000A	Oil Filter
4.3000A	Oil Filter Lines
4.4000A	Oil Cooler and Marine Gear Lines
4.5000A	Oil Filler
4.6000A	Dipstick
4.7000A	Oil Pan
4.8000A	Ventilating System
5.0000	COOLING SYSTEM
5.1000	Fresh Water Pump
5.1000A	Fresh Water Pump Cover
5.2000A	Water Outlet Manifold and/or Elbow
5.2000C	Thermostat
5.3000A	Radiator
5.3000B	Water Connections
5.4000A	Fan
5.4000B	Fan Shroud
5.5000A	Heat Exchanger or Keel Cooling
5.6000A	Raw Water Pump
5.7000A	Water Filter
6.0000	EXHAUST SYSTEM
6.1000A	Exhaust Manifold
6.2000A	Exhaust Muffler and/or Connections
7.0000	ELECTRICAL-INSTRUMENTS
7.1000A	Battery Charging Generator
7.2000A	Battery Cables
7.20008	Automatic Starting
7.3000A	Starting Motor
7.4000A	Instruments
7.4000B	Tachometer Drive
7.4000A	Instruments
7.4000C	Shut-off, Alarm and O.S. Governor
7.5000A	Power Generator
7.6000A	Control Cabinet
7.7000A	Wiring Harness
7.8000A	Air Heater
7.10000A	Hydraulic Governor Solenoid
8.0000	POWER TAKE-OFF
8.1000A	Power Take-off and/or Clutch
8.3000A	Torque Converter
8.3000B	Transmission Lines
9.0000	TRANSMISSION AND PROPULSION
9.1000A	Hydraulic Marine Gear
9.2000A	Reverse and Reduction Gear (mechanical)
9.3000A	Power Transfer Gear
9.4000	Transmission-Highway
9.7000	Transmission-Off-highway
9.9000	Transmission-Rail Car
10.0000	SHEET METAL
10.1000A	Engine Hood
11.0000	ENGINE MOUNTING
11.1000A	Engine Mounting and Base
12.0000	MISCELLANEOUS
12.2000A	Bilge Pump
12.3000A	Vacuum Pump
12.4000A	Air Compressor
12.5000A	Hydraulic Pump
12.6000A	Gasoline Starter
12.6000C	Air Starter
12.6000D	Hydraulic Starter
12.6000E	Hydraulic Starter Accessories
12.8000A	Supplies
12.8000B	Fabrication Material
12.8000C	Service Kits

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

ALPHABETICAL INDEX

A L P H A B E T I C A L I N D E X

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ENGINE
CONTRACT DSA700-77-C-8511
GROVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

1067-7040(RC)

GROUP NAME	GROUP NO.	TYPE
Cylinder Block, Cast Iron Type	1.1000	4
Air Box Drains	1.1000A	1
Cylinder Head, 4 Valve Type	1.2000	17
Engine Lifter Bracket	1.2000A	1
Crankshaft	1.3000	4
Crankshaft Front Cover	1.3000A	10
Vibration Damper	1.3000B	63
Crankshaft Pulley	1.3000C	334
Crankshaft Pulley Belt	1.3000D	237
Flywheel	1.4000A	682
Flywheel Housing (SAE #2)	1.5000A	486
Connecting Rod and Piston, Cross Head Type	1.6000	139
Camshaft and Gear Train	1.7000	18
Balance Weight Cover	1.7000A	9
Valve Operating Mechanism	1.8000	21
Rocker Cover	1.8000A	324
Fuel Injector C65, Needle Valve Type	2.1000A	115
Fuel Pump, RH Rotation	2.2000	125
Fuel Pump Drain	2.2000A	2
Fuel Filter	2.3000A	351
Fuel Manifold Connections	2.4000	52
Fuel Lines	2.5000A	1131
Governor, Mechanical (Limited Speed (Double Weight)	2.7000A	1409
Injector Controls	2.9000	22
Throttle Controls	2.9000A	789
Air Inlet Housing	3.3000A	131
Blower	3.4000	144
Blower Drive Shaft	3.4000A	3
Oil Pump	4.1000A	104
Oil Distribution System	4.1000B	8
Oil Pressure Regulator	4.1000C	23
Oil Filter	4.2000A	83
Oil Cooler	4.4000A	52
Oil Filler	4.5000A	125
Dipstick	4.6000A	731
Oil Pan	4.7000A	19
Ventilating System	4.8000A	631
Fresh Water Pump, Centrifugal Type	5.1000	7
Fresh Water Pump Cover	5.1000A	16
Water Outlet Manifold	5.2000A	162
Thermostat	5.2000B	174
Water By-Pass Tube	5.2000C	15
Water Connections	5.3000B	12
Fan	5.4000A	1080
Exhaust Manifold	6.100A	306
Exhaust Muffler	6.2000A	233
Battery Charging Generator	7.1000A	1983
Starting Motor	7.3000A	252
Tachometer Drive	7.4000B	269
Engine Mounting	11.1000A	3
Air Compressor	12.4000A	937
Hydraulic Pump	12.5000A	228

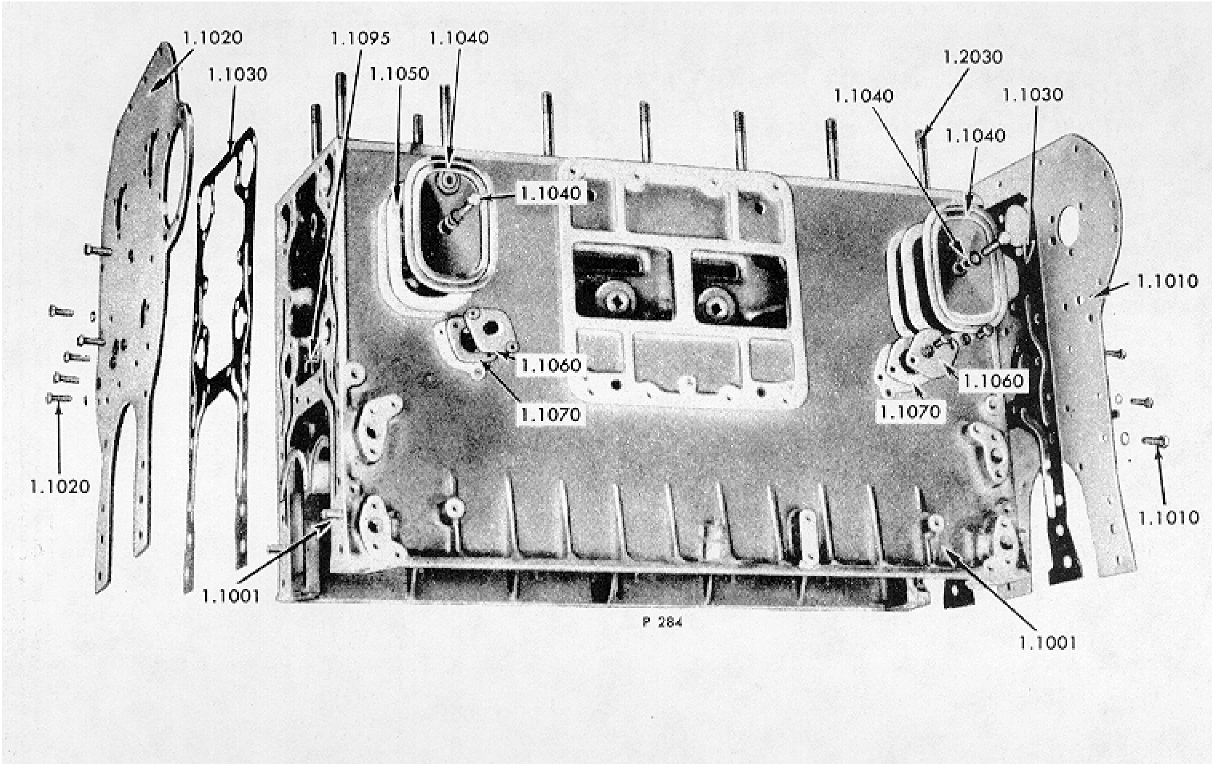


FIG. 1A. CYLINDER BLOCK

Fig. 1A of 1.0000

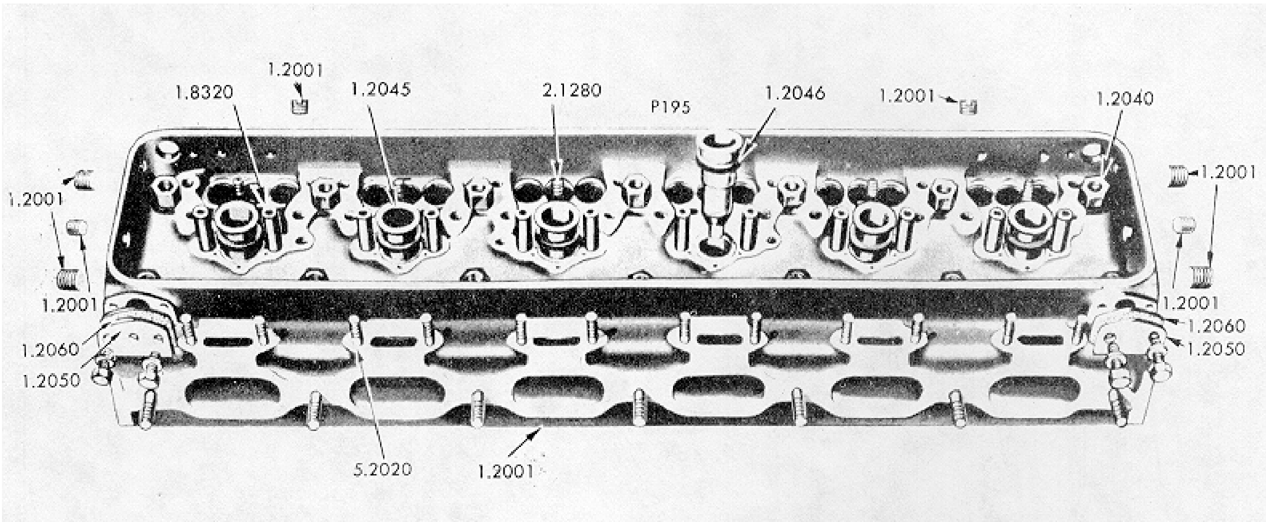


FIG. 3A. CYLINDER HEAD (2 VALVE)

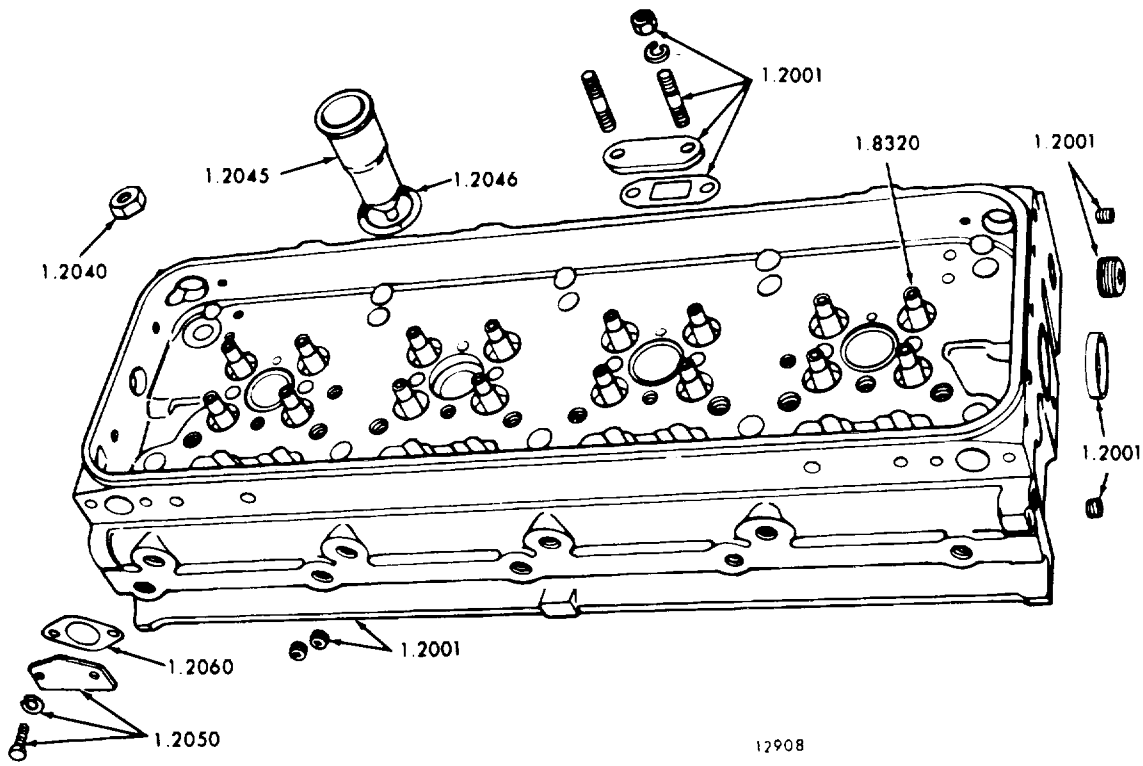


FIG. 3B. CYLINDER HEAD (4 VALVE)

Figs. 3A & 3B of 1.0000

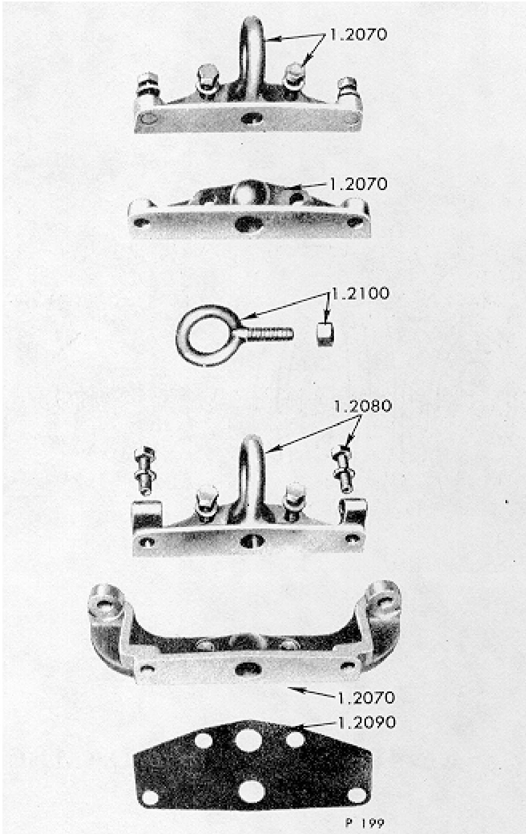


FIG. 3D. (Engine Lifter Bracket)

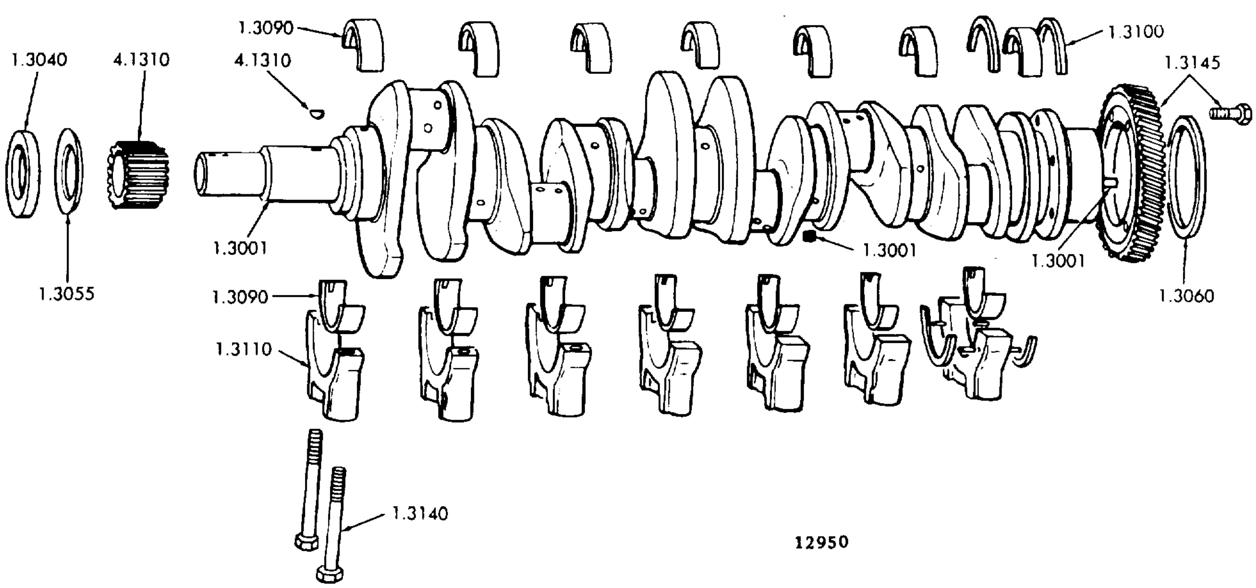


FIG. 4A. CRANKSHAFT

Figs. 3D & 4A of 1.0000

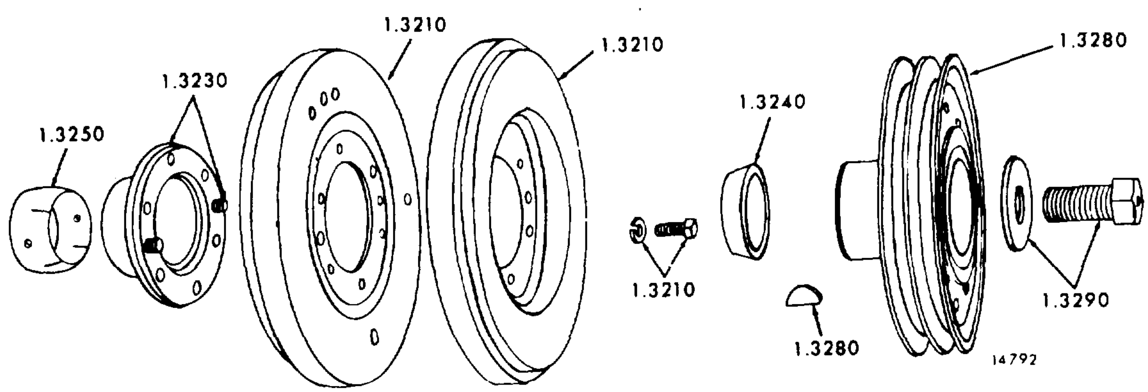


FIG. 4D. VIBRATION DAMPER

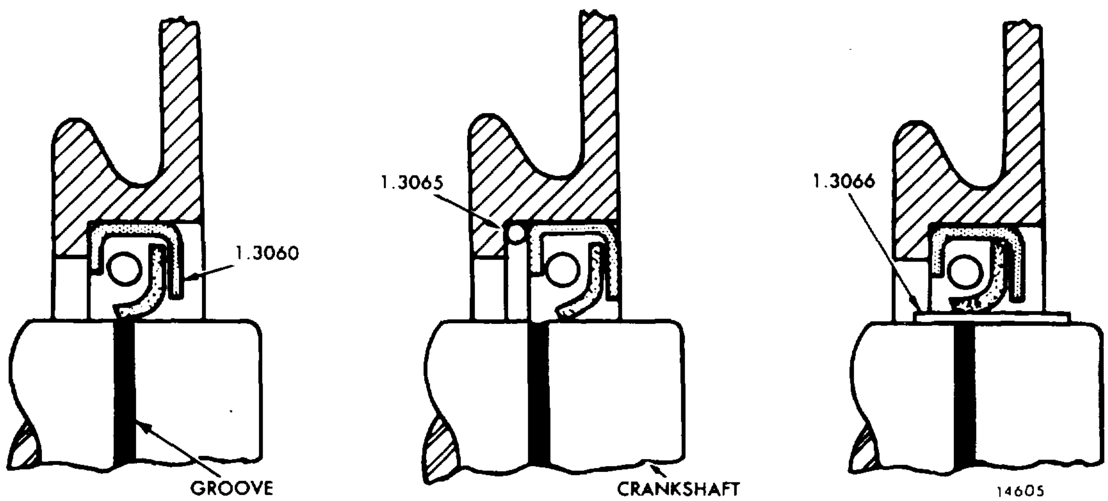


FIG. 4E. CRANKSHAFT REAR OIL SEAL

Figs. 4D & 4E of 1.0000

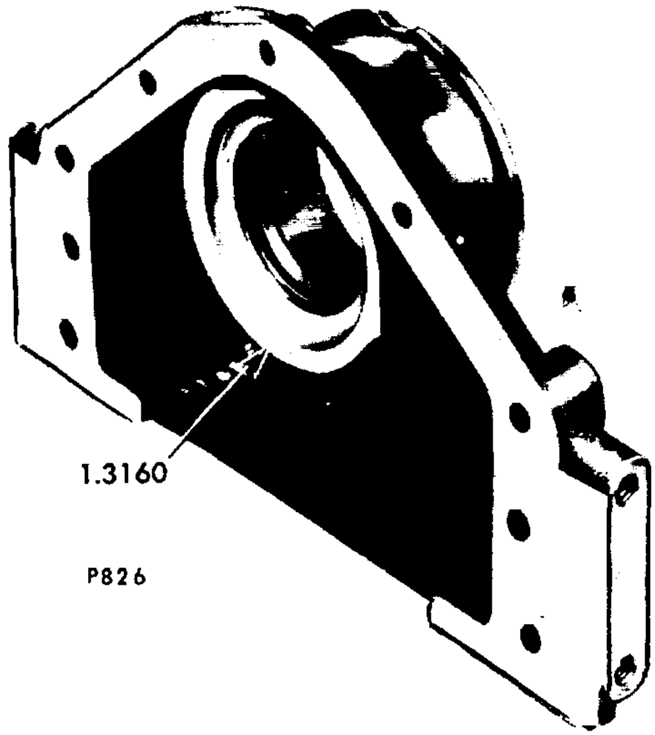


FIG. 5B. CRANKSHAFT FRONT COVER

Fig. 5B of 1.0000

FIG. 6A. CRANKSHAFT PULLEYS

Fig. 6A of 1.0000

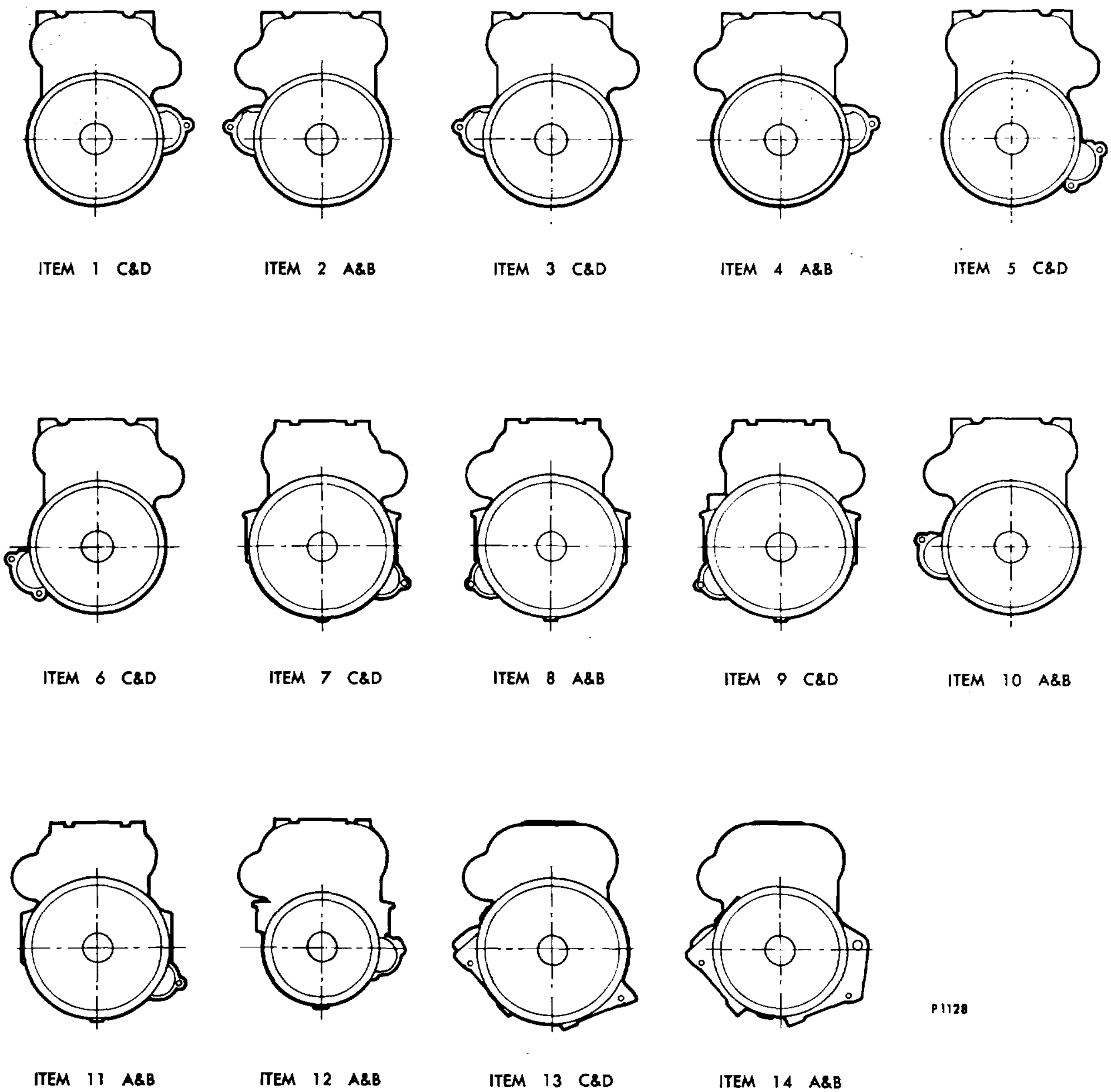


FIG. 6B. FLYWHEEL HOUSING CHART

Fig. 6B of 1.0000

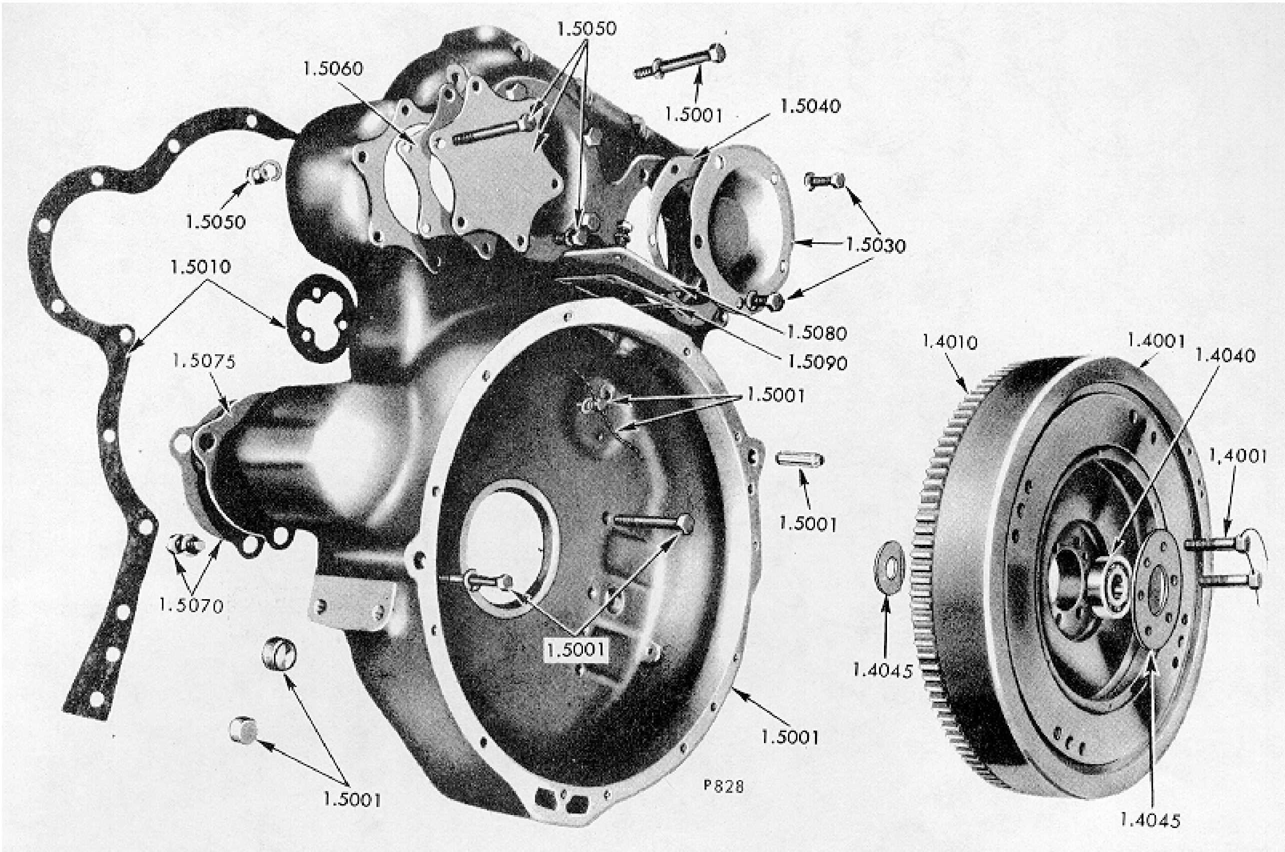


FIG. 7A. FLYWHEEL AND FLYWHEEL HOUSING

Fig. 7A of 1.0000

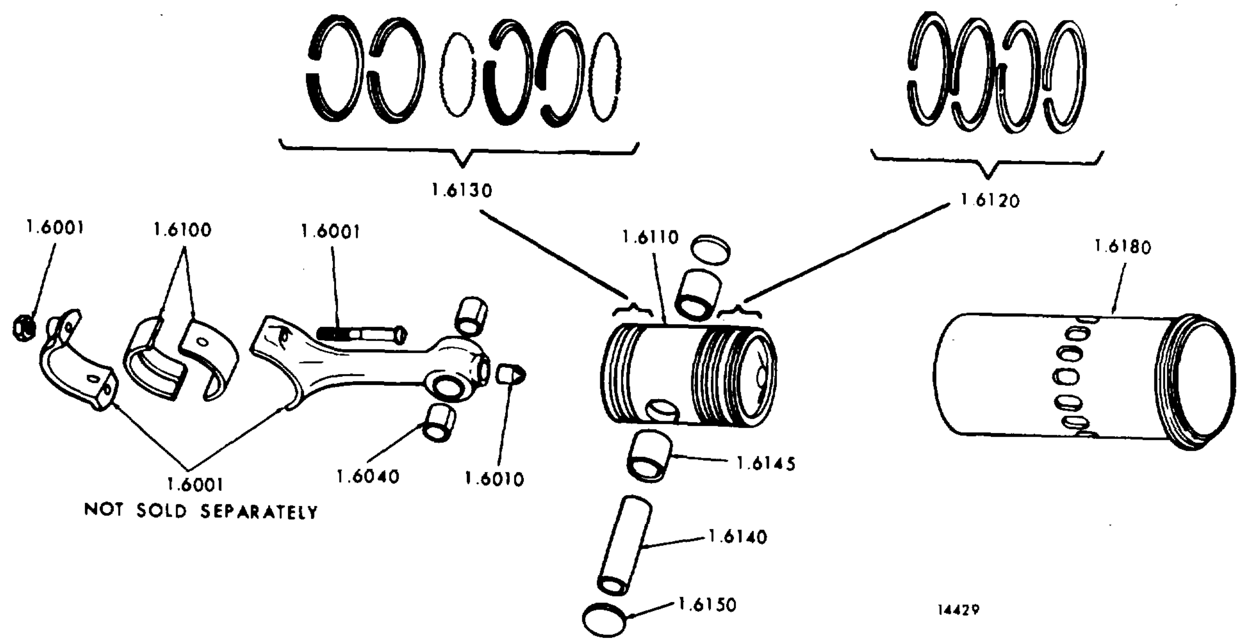


FIG. 7B. CONNECTING ROD AND PISTON

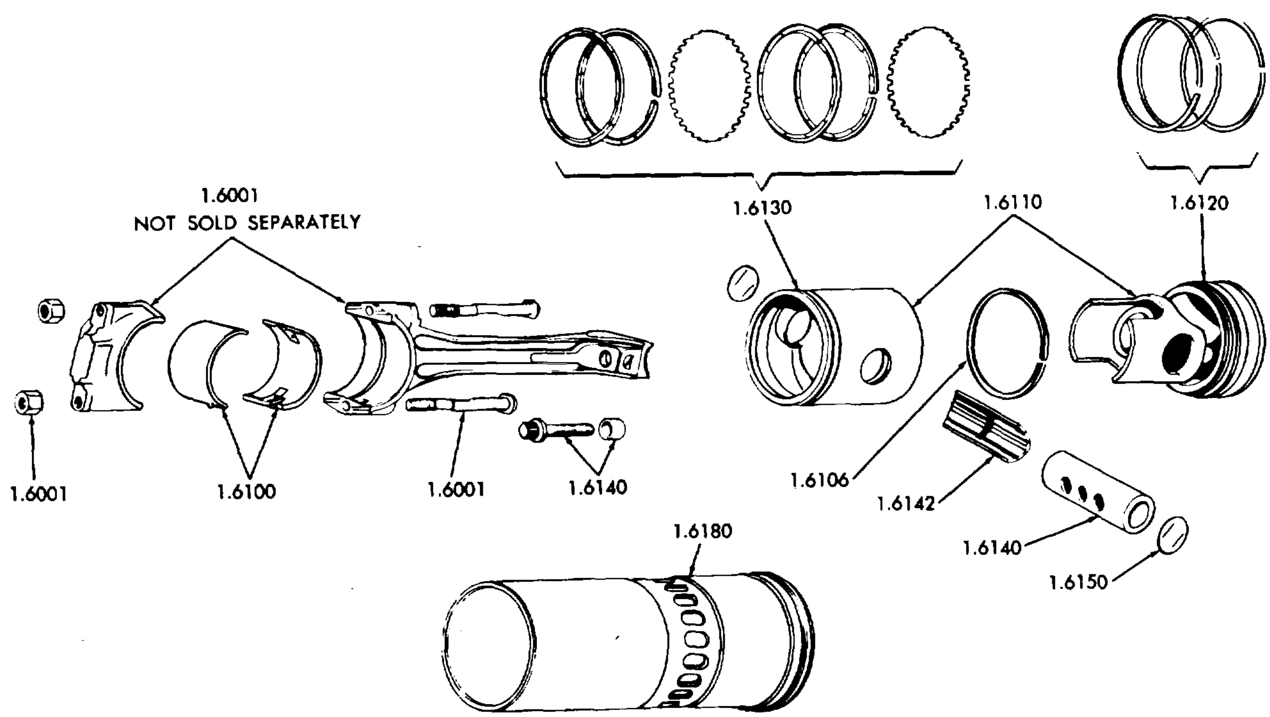


FIG. 7C. CONNECTING ROD AND PISTON (CROSSHEAD)

Figs. 7B & 7C of 1.0000

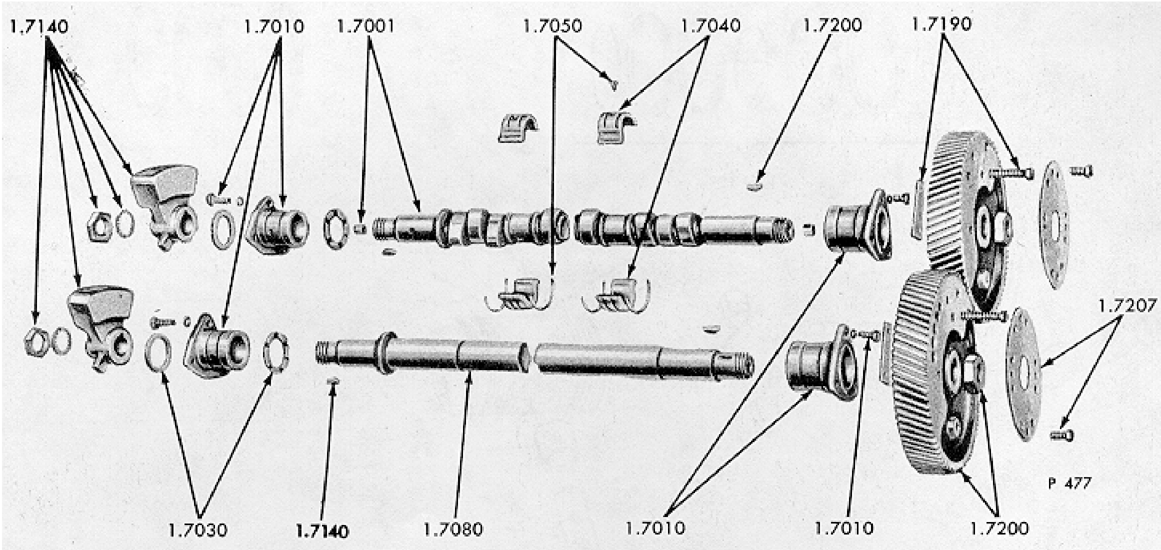


FIG. 8A. CAMSHAFT AND GEAR TRAIN

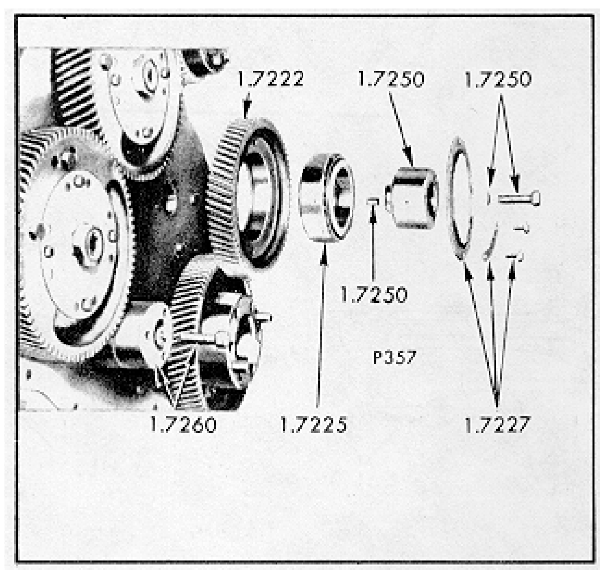


FIG. 8C. IDLER GEAR

Figs. 8A & 8C of 1.0000

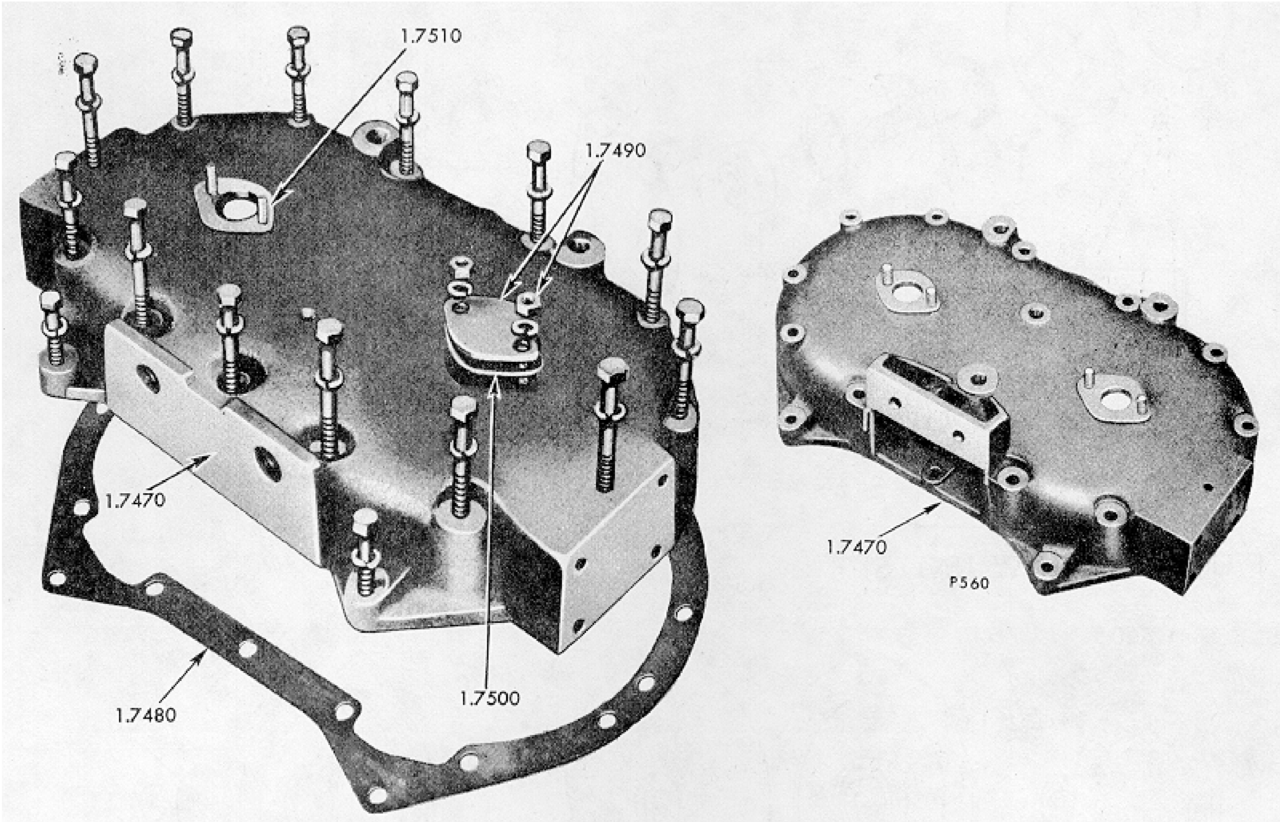


FIG. 9A. BALANCE WEIGHT COVER

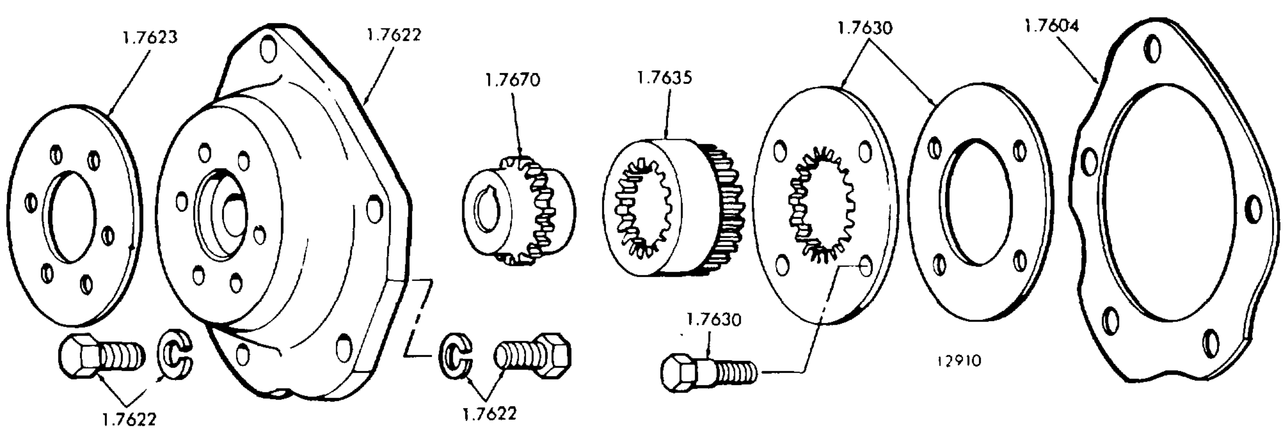


FIG. 9D. ACCESSORY DRIVE

Figs. 9A & 9D of 1.0000

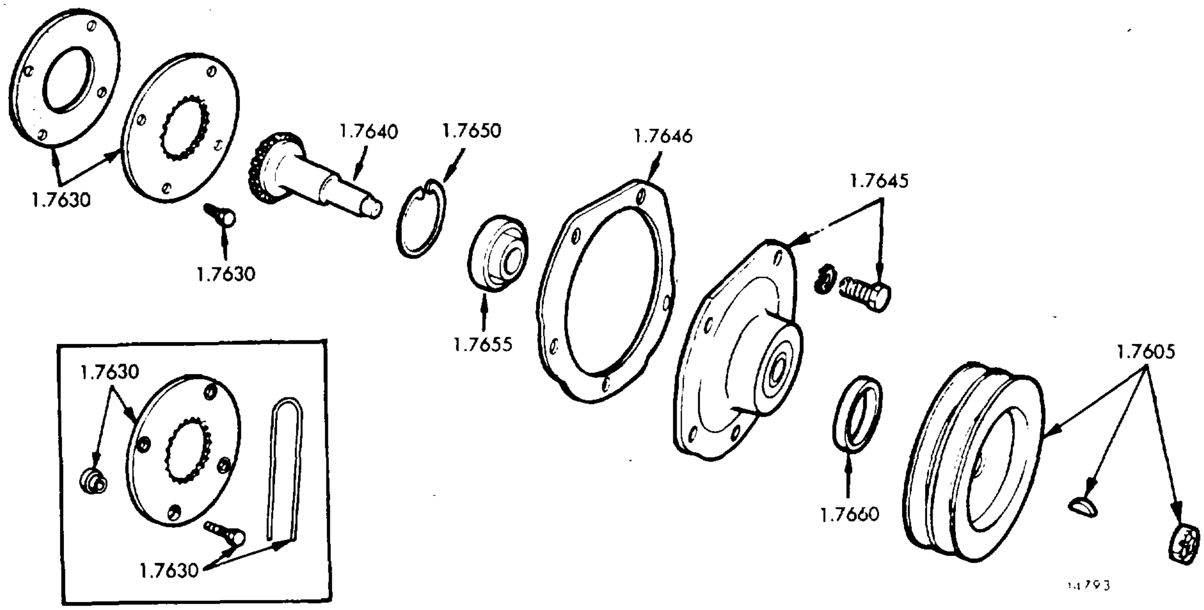


FIG. 9F (EARLY UNITS)

FIG. 9E

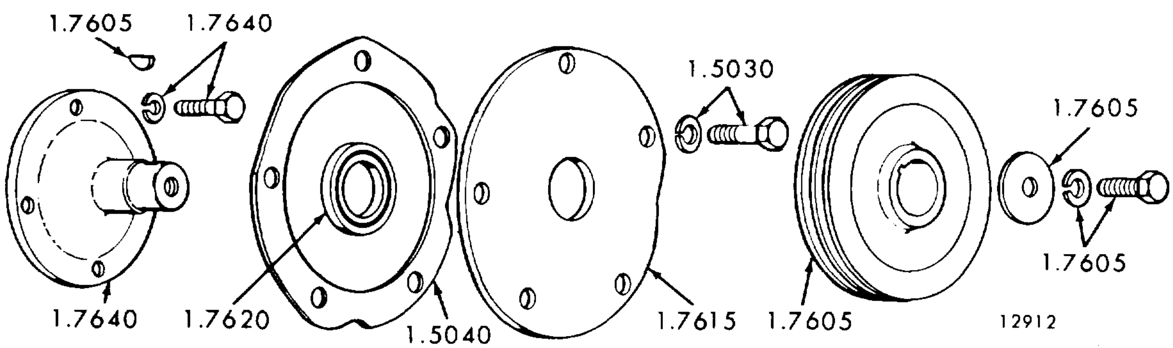


FIG. 9G

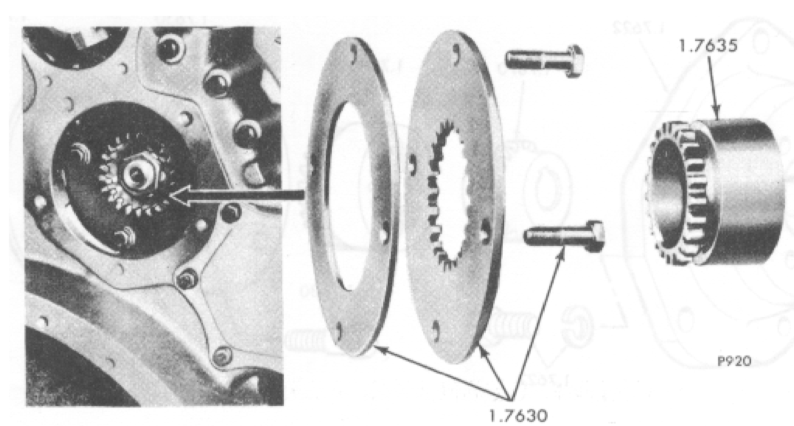


FIG. 9H
ACCESSORY DRIVE

Figs. 9E, 9F, 9G & 9H of 1.0000

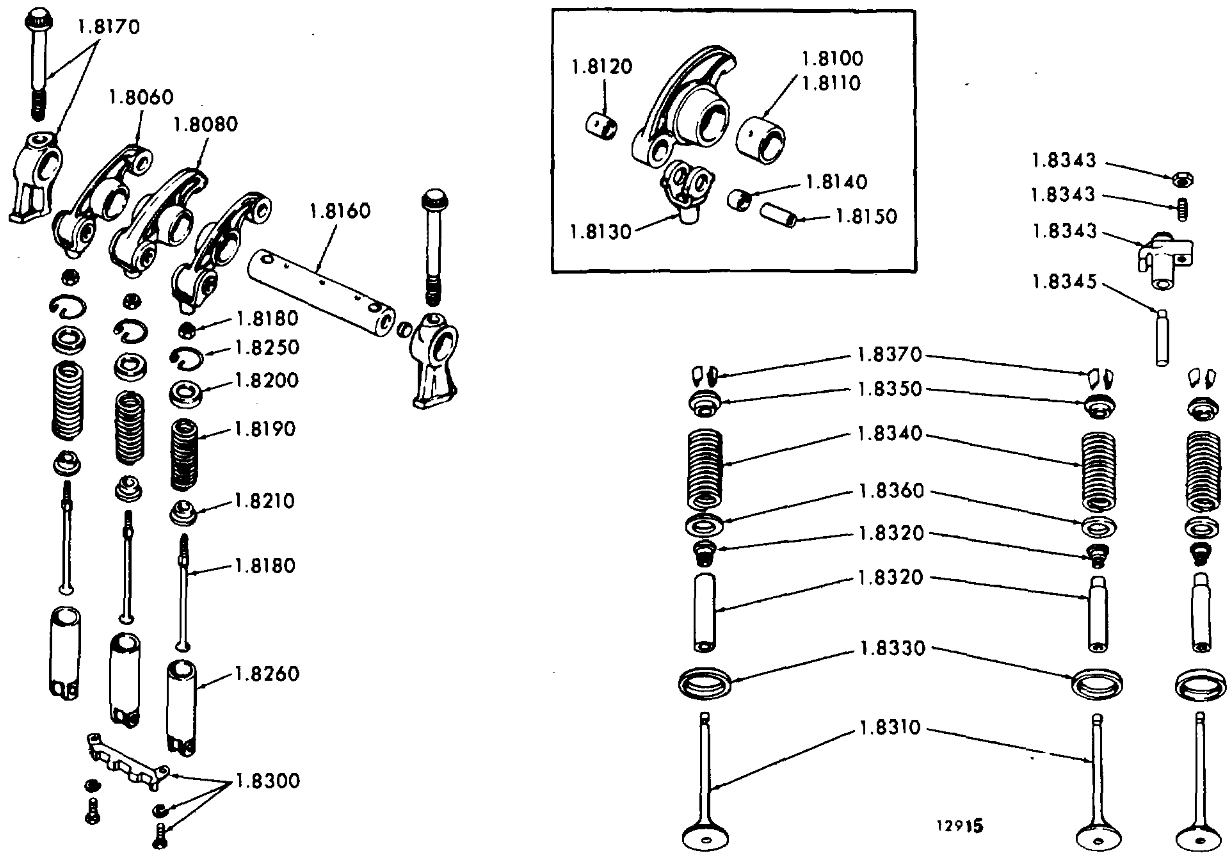


FIG. 10A

FIG. 10B
(2 VALVE)

FIG. FIG. 10C
(4 VALVE)

VALVE OPERATING MECHANISM

Figs. 10A,10B & 10C of 1.0000

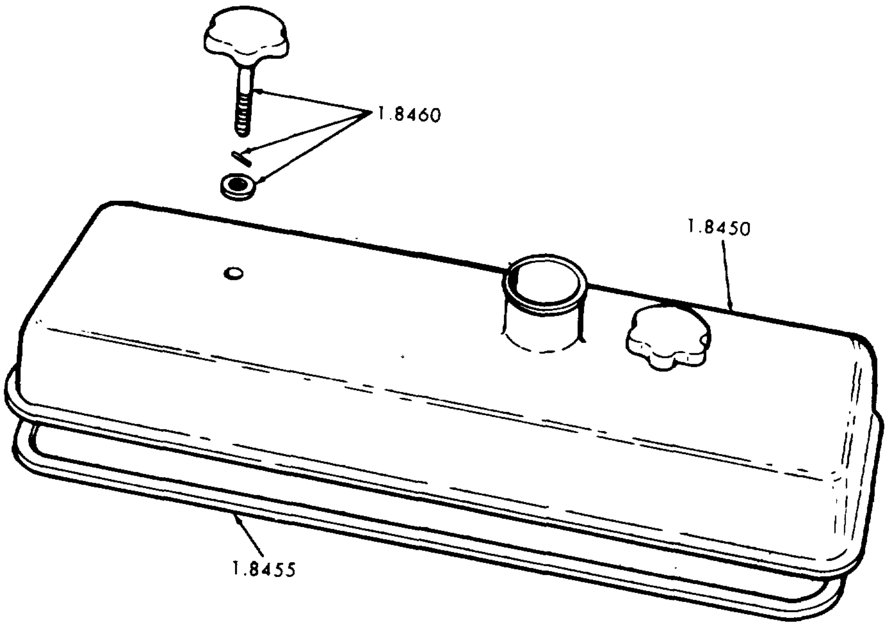


FIG. 10D. ROCKER COVER (Stamped)

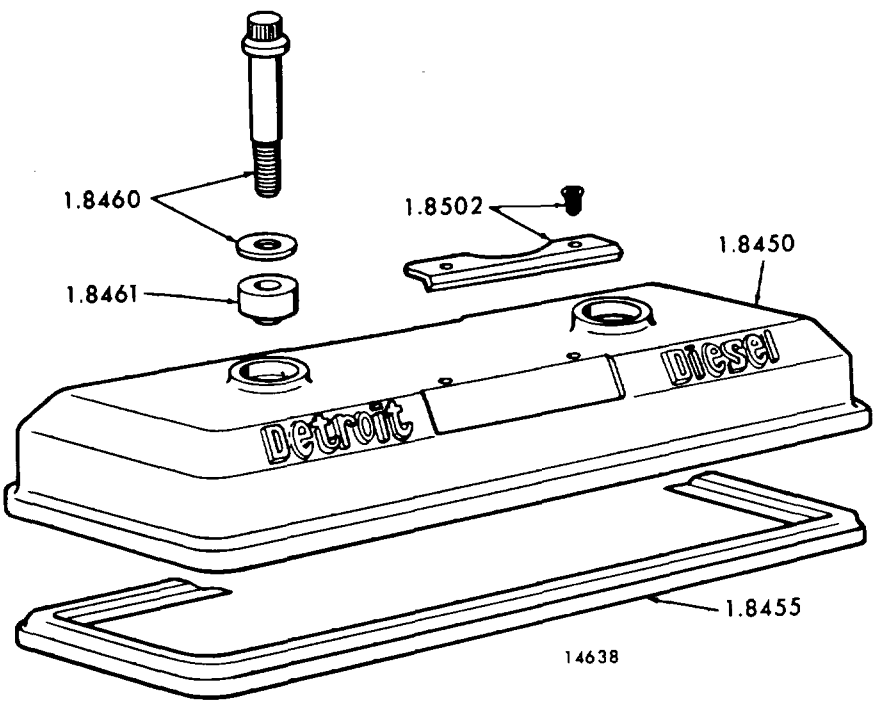
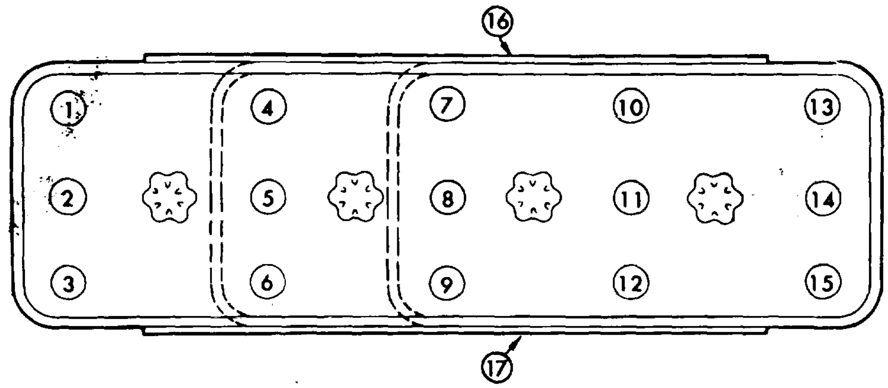


FIG. 10E. ROCKER COVER (Cast)

Figs. 10D & 10E of 1.0000



6, 12-V71 4, 8-V71 3, 6-V71

ROCKER COVER OIL FILLER AND BREATHER LOCATION

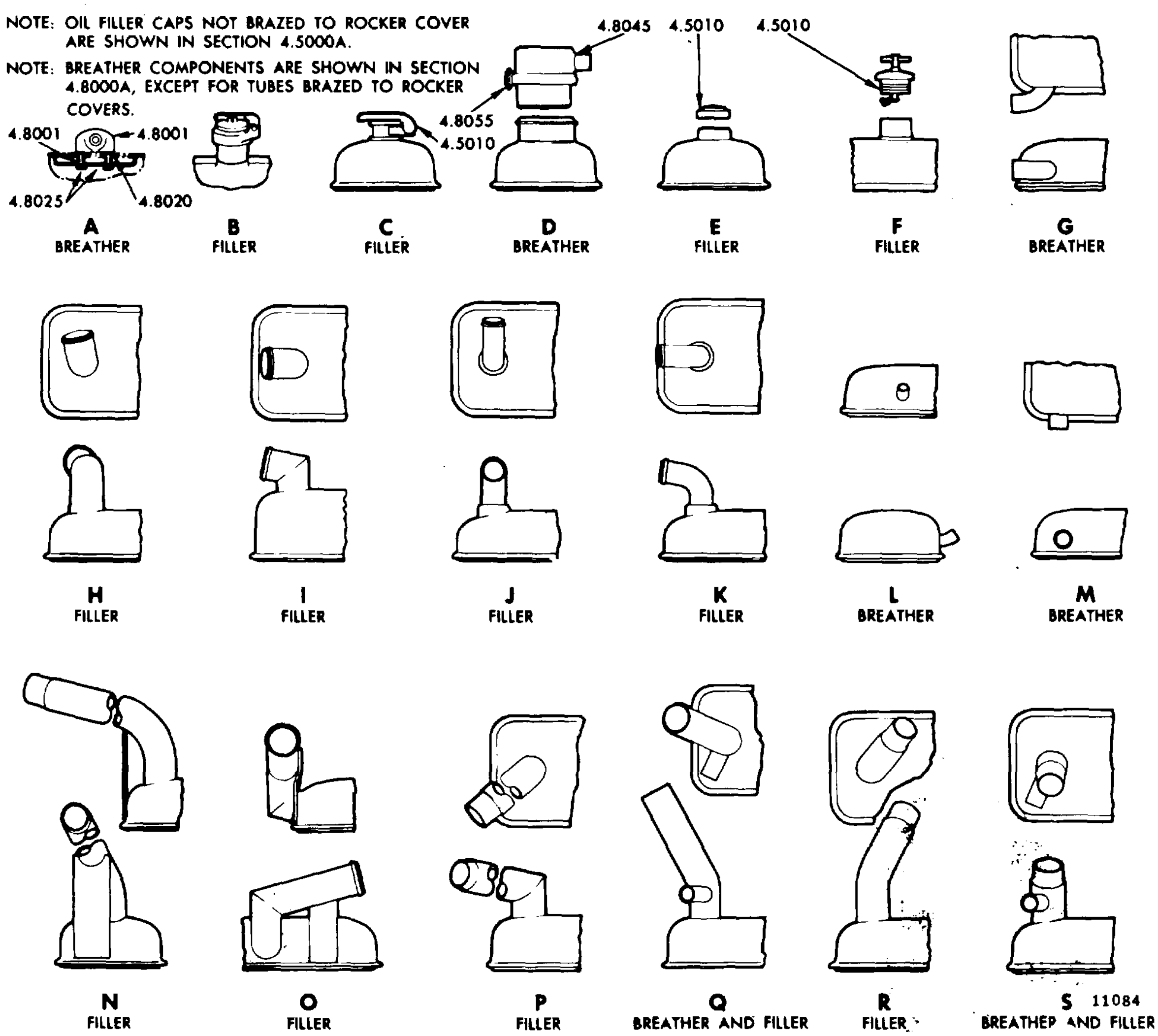


Fig. 10F of 1.0000

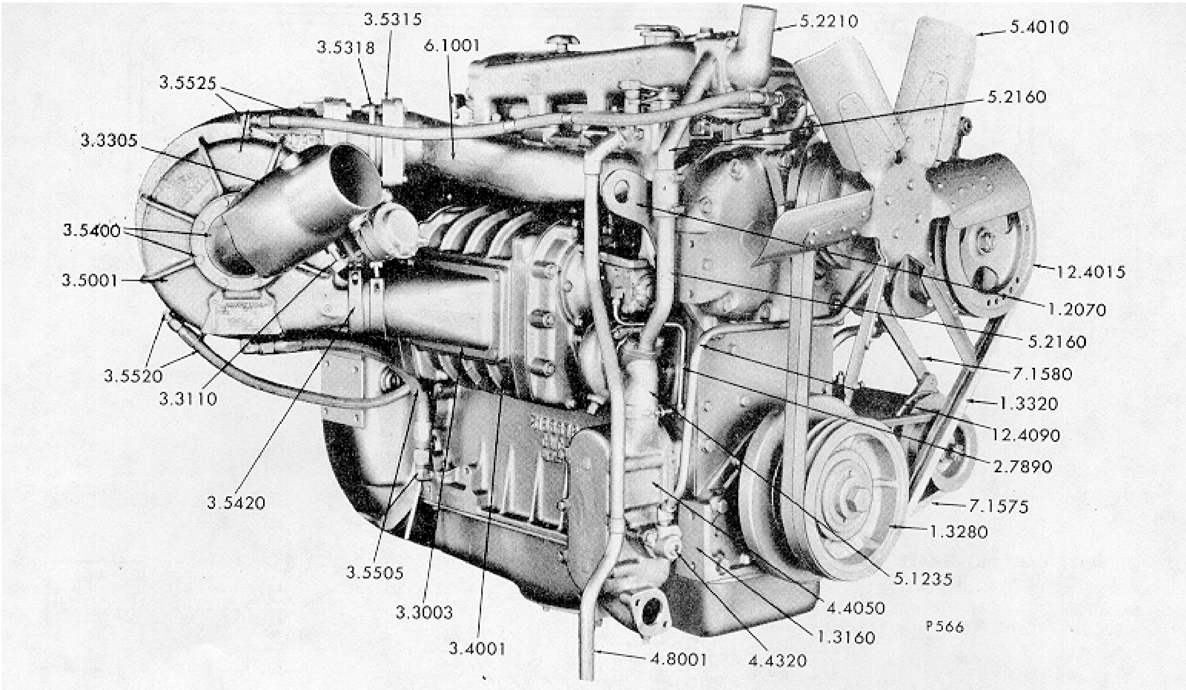


FIG. 11E

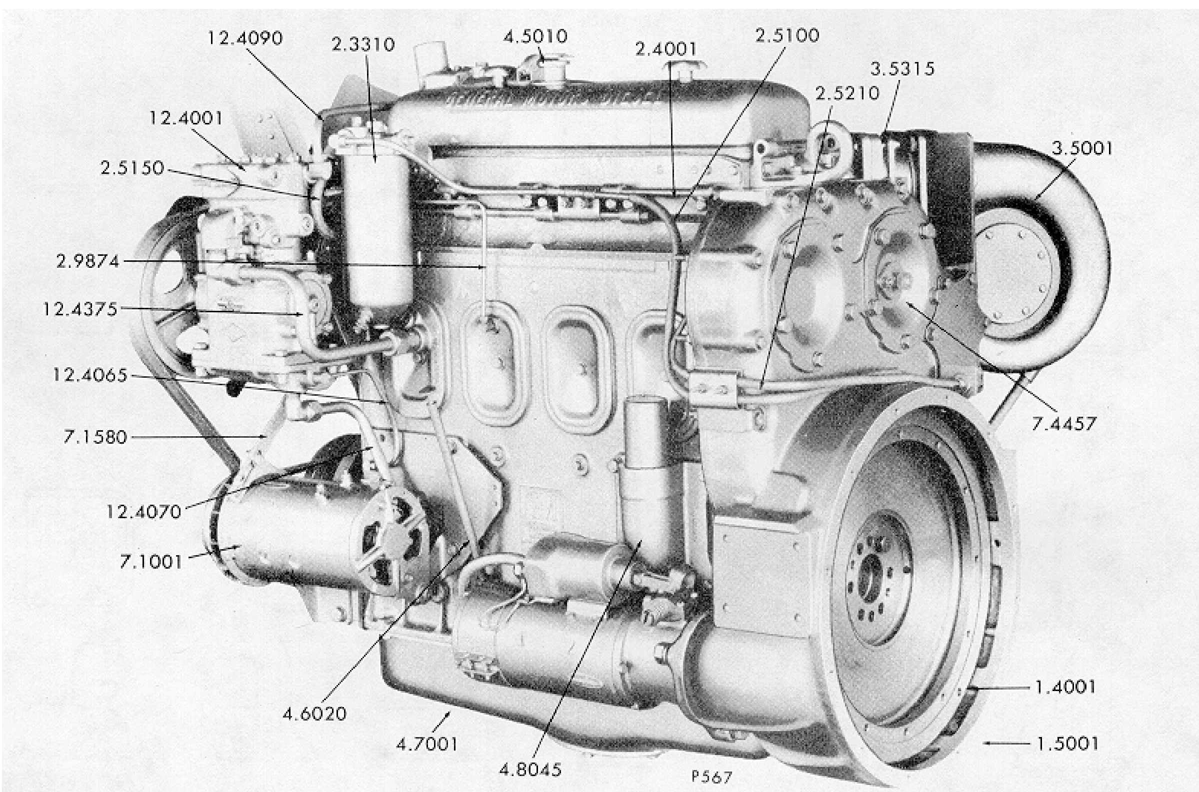


FIG. 11F

Figs. 11E & 11F of 1.0000

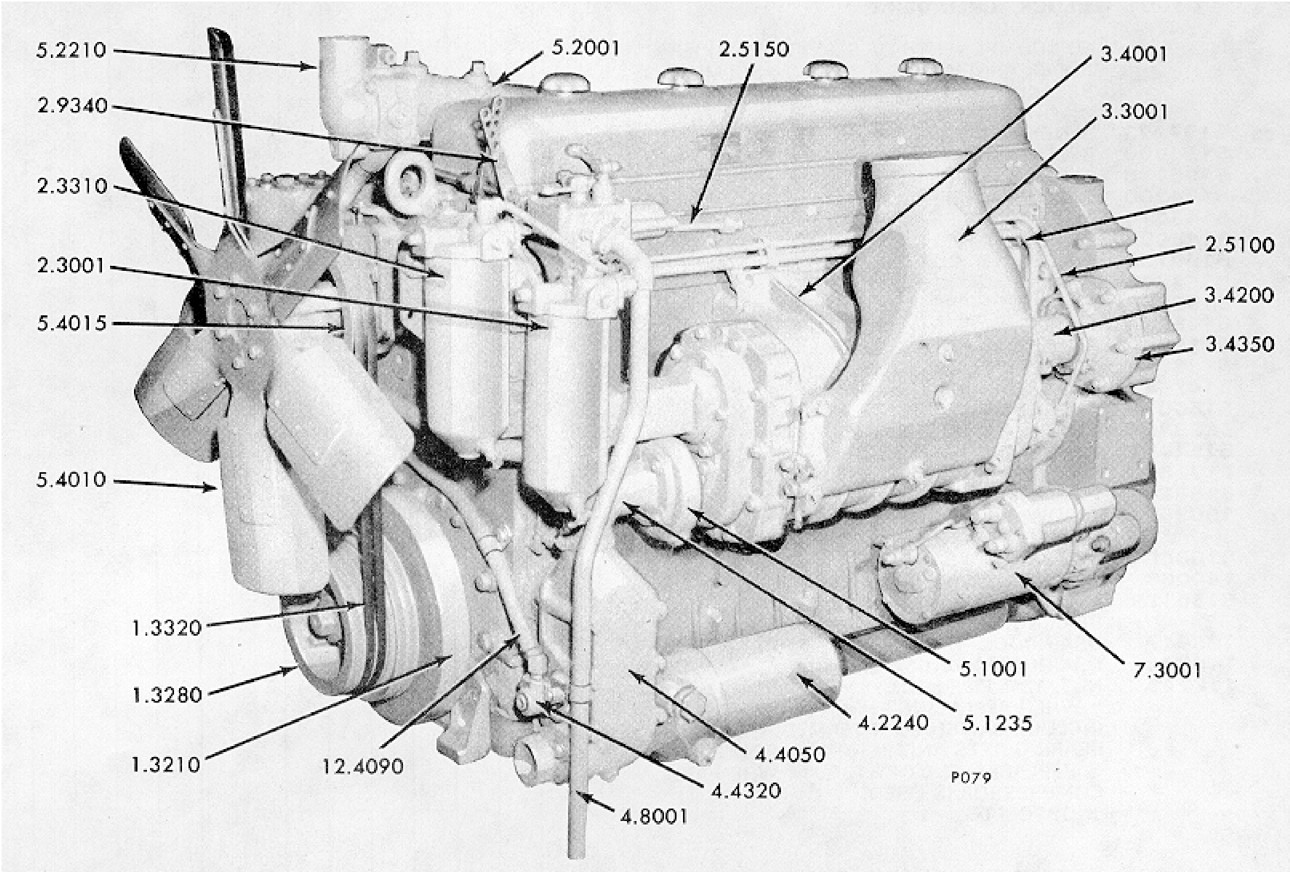


FIG. 11H. TYPICAL 6-CYLINDER ENGINE

Fig. 11H of 1.0000

1.1000 CYLINDER BLOCK

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 4
		1.1001 - BLOCK, CYLINDER	
		FOR COMPONENTS OF SERVICE CYLINDER BLOCK ASSEMBLIES REFER TO ASSEMBLY BREAKDOWN, PAGE A1.	
1B	**5197273**	BLOCK ASM., 371 C. I	
1C	**6194900**	BLOCK ASM., 471 C. I	
1A	**5196146**	BLOCK ASM., 671 C. I	1
1A	**5194200** *	# BLOCK ASM., ALUM	
	5145010	PLUG, 1/8" PIPE (12.9550)	
	5145009	PLUG, 1/8" PIPE(12.9550)	
	5150130	PLUG, 5/16" CUP (SPL.)	
	5154319	PLUG, 1/4"X5/16" SPL	
	6183256	PLUG, 3/8" PIPE	
	5145014	PLUG, 3/8" PIPE (12.9550)	
	5115214	PLUG, 1/2" PIPE (12.9550)	
	5156280	PLUG, 5/8" CUP (3.3003)	
	5142549	PLUG, 3/4" PIPE (12.9550)	
	5150014	PLUG, 1 1/4" CORE HOLE	
	6183266 @	PLUG (1 1/4" O.D.-3/8" PIPE TAP)	1
	5154082	PLUG (AIR COMPRESSOR RETURN LINE)	1
	5177650	PLUG (CORE HOLE)	1
	5183304	PLUG, SPL	
	190367	ELBOW, 90 DEG (1/4" STREET) (12.9590)	
	5186604	NIPPLE, 1/4"X3.86" PIPE	
	144068	COUPLING, 1/4" PIPE (12.9580)	
	5150129	STUD, 3/ 8"X1 1/2" (PUMP TO MAIN BEARING CAP) (4.1010)	2
	103647	DRAINCOCK, 1/4" PIPE (12.9510)	
	148344	DRAINCOCK, 5/16" (12.9510)	
	119240	NUT, 1/4" PIPE LOCK	
		* WHEN REPLACING THRU 6A-76744, INCLUDE CAMSHAFT INTERMEDIATE BEARING SETS AND RETAINING BOLTS. @ REPLACES ONE OF 5150014 WHEN AIR COMPRESSOR IS USED. # OBSOLETE.	
		1.1002 - GASKET KIT, ENGINE OVERHAUL	
		A GASKET KIT CONSISTS OF THE NECESSARY GASKETS FOR (1) COMPLETE ENGINE OVERHAUL. GASKET KITS DO NOT INCLUDE THE ADDITIONAL GASKET REQUIRED FOR TURBOCHARGED ENGS.	
	5193113	GASKET KIT, 371	
	5198622 $	GASKET KIT, 471	

1.1000 CYLINDER BLOCK

FIG	PART NUMBER		NAME AND DESCRIPTION	TYPES 4
	1.1002 -		**GASKET KIT, ENGINE OVERHAUL (CONT'D)**	
	5198945		$ GASKET KIT, 671	AR
	5198287		GASKET KIT, 671 GMT&C	
			$ DOES NOT INCLUDE END PLATE GASKET 5186643 FOR ALUMINUM ENGINES.	
	1.1010 -		**PLATE, CYLINDER BLOCK END - FRONT**	
1A	**5152878**		PLATE (CAST-IRON)	1
1A	**5111686**	@	PLATE (CAST-IRON)	
1A	**179839**		BOLT, 3/8"-16X1" (12.9001)	6
1A	**179882**		BOLT, 1/2"-13X1 1/8" (12.9001)	2
	103321		LOCKWASHER, 3/8" (12.9200)	6
	103323		LOCKWASHER, 1/2" (12.9200)	2
			@ CAN BE USED IN TYPES 2, 3 OR 23 OR 85 WHEN AN ENGINE LIFTER BRACKET IS SUPPORTED BY BALANCE WEIGHT COVER BOLTS.	
	1.1020 -		**PLATE, CYLINDER BLOCK END - REAR**	
	5138428	+	PLATE (CAST-IRON)	
1A	**5150060**		PLATE (CAST-IRON)	1
	5140241		PLATE (CAST-IRON)	
1A	**179839**		BOLT, 3/8"-16X1 " (12.9001)	
	103321		LOCKWASHER, 3/8" (12.9200)....6	
			+ OPTIONAL TO 5150060, PROVIDES RELIEF ON SIDE OPPOSITE BLOWER.	
	1.1030 -		**GASKET, CYLINDER BLOCK END PLATE**	
1A	**6177798**		GASKET....2	
1A	**6186643**	#	GASKET (ALUMINUM END PLATES)	
			# NOT INCLUDED IN GASKET KIT 5193115.	
	1.1040 -		**COVER, AIR BOX**	
	5115578		COVER (ONE 1/2" TAPPED HOLE)	
	5132116		COVER (TURBO UNITS)	
1A	**5153117**	*****	COVER (PLAIN)	8
1A	**5184459**	@	COVER (TWO 1/2" TAPPED HOLES, CAST IRON)	1
1A	**5184726**	#	COVER (ONE 1/2", ONE 3/4" TAPPED HOLES)	1

1.1000 CYLINDER BLOCK

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 4
		1.1002 - COVER, AIR BOX (CONT'D)	
	5180189	COVER (TWO 3/4" TAPPED HOLES)	1
	5188901 &	COVER (INCLUDES NOZZLE) (A & B ENGINE)	1
	5188902 &	COVER (INCLUDES NOZZLE)..........1 (C & D ENGINE)	
1A	**105451**	GASKET, 3/8" COPPER (12.9360)	8
	5115214	PLUG, 1/2" PIPE (12.9550)	AR
	5142549	PLUG, 3/4" PIPE (12.9550)	2
1A	**108608**	BOLT, 3/8"-16X2 1/8" (12.9001)	8
	103341	WASHER, 3/8" FLAT (12.9190)	8
		* DELETE ONE 5153117 FOR EACH WHEN 5115578, 5180189, 5184459, 5176409, 5184726 OR 5132116 IS USED.	
		@ NOT SERVICED, SUPERCEDED BY 5180189 COVER AND INCLUDES 2-144034 BUSHING.	
		# NOT SERVICED, FOR SERVICE USE 5180189 AND INCLUDE (1) 144034 BUSHING.	
		& USED IN CONJUNCTION WITH STARTING AID, GROUP 12.6000C.	
		1.1050 - GASKET, AIR BOX COVER	
1A	**5150020**	GASKET	8
	5132117	GASKET (TURBO UNITS) (1.1070)	
		1.1080 - COVER, CYLINDER BLOCK WATER HOLE	
1A	**5150023** %	COVER (PLAIN)	1
1A	**5164190**	COVER (1/4" TAPPED HOLE)	1
1A	**5115097**	COVER (3/8" TAPPED HOLE)	1
	5114712	ADAPTER	
	148344	DRAINCOCK, 1/4" (12.9510)	1
	118536	DRAINCOCK, 3/8" (12.9510)	1
	112578	PLUG, 1/4" BRASS PIPE (12.9550)	1
	5148436	BOLT, 5/16"-18X3/4" (W/LW)(12.9001)	2
	186625	BOLT, 5/16"-18X7/8" (12.9001)	2
	189697	BOLT, 5/16"-18X1" (W/LW) (12.9001)	
	103320	LOCKWASHER, 5/16" (12.9200)	2
	5110211	LOCKNUT, 1/4" PIPE (1.1001)	
		% NOT REQUIRED WHEN 5164190 OR 5115097 IS USED.	
		1.1070 - GASKET, CYLINDER BLOCK WATER HOLE COVER	
1A	**5116357**	GASKET	1

1.1000 CYLINDER BLOCK

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		1.1001 - BLOCK, CYLINDER														
	5197273	BLOCK ASSY. (3-71 CAST-IRON)														
	5194900	BLOCK ASSY. (4-71 CAST-IRON)														
	5194200	BLOCK ASSY. (6-71 ALUMINUM)														
	5196146	BLOCK ASSY. (6-71 CAST-IRON)			1											
		THE FOLLOWING ITEMS ASSEMBLED TO CYLINDER BLOCK:														
	5196794 #	INSERT, WATER HOLE SMALL (STAINLESS) (1.1001)														
	5196795 #	INSERT, WATER HOLE LARGE (STAINLESS) (1.1001)														
	5126599 #	INSERT, WATER PUMP INLET (STAINLESS)														
	105411	CAP, 1/4" PIPE (12.9610)														
	5158674	CAP, MAIN BEARING (FINISHED)			7											
	5194614	CAP, MAIN BEARING (FINISHED)														
	5145009	PLUG 1/8" PIPE (12.9550)			5											
	5145010	PLUG, 1/4" ALLEN HD. PIPE (12.9550)			4											
	5150130	PLUG, 5/16" CUP (1.1001)			2											
	5173334	PLUG, 1/2" PIPE (ALUMINUM) (12.9550)														
	5115214	PLUG, 1/2" HEX. SKT. HD. PIPE			2											
	5142649	PLUG, 3/4" PIPE (12.9550)			2											
	5173336	PLUG, 3/4" PIPE (ALUMINUM) (12.9550)														
	5150042	PLUG, 1" CUP (1.2001)			2											
	5111798	PLUG, 1" PIPE (12.9550)			10											
	5173336	PLUG, 1" PIPE (12.9550)														
	5150014	PLUG, 1 1/4" CUP (12.9550)			2											
	5178998	PLUG, 1 3/4"-16 (1.1001)			4											
	5151272	PLUG, .346" DIA.X7/32" L. (1.8160)			6											
	5178997	GASKET, (W/5178998 PLUG) (1.1001)			4											
	225815	ELBOW, 5/16" INV. FL. TUBE 90 DEG (12.9480)			2											
	5175305	STUD, MAIN BEARING CAP (1.3140)														
	5152149	BOLT, MAIN BEARING CAP (1.3140)			14											
	103334	LOCKWASHER, MAIN BEARING CAP BOLT (12.9200)			14											
	5110211	NUT, 1/4" LOCK (1.1001)														
	5150572	NUT, MAIN BEARING STUD (1.3130)														
	5118453	STUD, CYLINDER HEAD														
	452668	INSERT, HELI-COIL (5/16"-18X15/32")														
	452692	INSERT, HELI-COIL (3/8"-1 6X9/16")														
	462716	INSERT, HELI-COIL (7/16"-14X21/32")														
	452740	INSERT, HELI-COIL (7/16"-14X21/32")														
		# EFFECTIVE WITH 6A-88979.														
		THE FOLLOWING ITEMS ARE "SHIPPED LOOSE" WITH THE CYLINDER BLOCK.														

1.1000 CYLINDER BLOCK

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	1.1001 -	**BLOCK, CYLINDER (CONT'D)**														
		REFER TO PLUGGING CHART 18SP74.														
	5145009	PLUG, 1/8" PIPE (12.9550)				4										
	5154319	PLUG, 1/4"X5/16" SPECIAL (1.1001)				3										
	5145010	PLUG, 1/4" ALLEN HD. PIPE (12.9550)				5										
	5115214	PLUG, 1/2" HEX. SKT. HD. PIPE (12.9550)				2										
	5173333	PLUG, 3/8" PIPE (ALUMINUM)(12.9550)														
	5145014	PLUG, 3/8" PIPE HDLS. (12.9550)........................1														
	5151122	PLUG, 3/8" PIPE (12.9550)				2										
	5183304	PLUG, .370" DIA.X.50"L(TOP OF BLOCK)............4														
	5151272	PLUG (1.8160)														
	5150130	PLUG, 5/16" CUP (1.1001)														
	5139988	PLUG, 1" CUP (1.1001)														
	5150014	PLG, 1 1/4" CUP (1.1001)														
	5151576	DOWEL PIN (1.1001)														
	141346	DOWEL PIN (12.9290)														
	103385	PIN, 1/8"X1" COTTER (12.9250)														
	5189353	INSERT, CYLINDER LINER (1.6187)														
	225815	ELBOW, 90 DEG. (5/16" TUBE) (12.9480)														
	105411	CAP, 1/4" PIPE (12.9650)														
	5188604	NIPPLE, 1/4"X3.86" (12.9001)														
	5173334	PLUG, 1/2" PIPE (ALUMINUM)(12.9550)														
	5156280	PLUG, 5/8" CUP (3.3003)				2										
	5145013	PLUG, 3/4" HEX. SKT. HD. PIPE (12.9550)				2										
	141346	DOWEL PIN, CRANKSHAFT THRUST WASHER (12.9290)				4										
1A,D	**5151576**	DOWEL PIN (F/W HSG. AND FRT. COVER) (1.1001)				4										
	103385	PIN, 1/8"X1" COTTER (MAIN BEARING														
	5184484	INSERT, CYLINDER LINER (1.6187)				6										
	5189363	INSERT, CYLINDER LINER (1.6187)														
	5123383	BOLT, CAM. INTER. BRG. LOCK (1.7050)				5										
	5117649	BOLT, CAM. INTER. BRG. LOCK (1.7050)														

1.1000A AIR BOX DRAINS

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 1														
1.1100 -		**TUBE, AIR BOX DRAIN**															
	5140146	TUBE (DEV. L 3”)	2														
	5158825	TUBE (DEV. L 4 ¼”) (2.2300)															
	5188977	TUBE (DEV. L 6 ¼”)															
	225815	ELBOW, 5/16” INV. FL. TUBE 90 DEG (12.9480)	2														
	442322	CONNECTOR, 5/16” INV. FL TUBE, 1/8” P.T. (12.9460)															
	5145009	PLUG, 1/8” HEX. SOC. HD. PIPE (12.9550)															
	137398	NUT, 5/16” INV. FL. TUBE(12.9500)															

1.2000 CYLINDER HEAD

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	1.2000 -	**HEAD ASSY., CYLINDER**														
	5198216	HEAD ASSY (2 VALVE) (4-71)														
	5198217	HEAD ASSY (2 VALVE) (6-71)														
	5198218	HEAD ASSY (2 VALVE) (3-71)														
	5102771	HEAD ASSY (4 VALVE) (4-71)														
	5102770	HEAD ASSY (4 VALVE) (6-71)				1										
		THE FOLLOWING ITEMS ARE ASSEMBLED TO THE CYLINDER HEAD.														
	5193541	PLUG.FUSE					1									
	5142549	PLUG, 3/4’ PIPE (12.9550)					4									
	5113773	SLEEVE, PILOT .70’L					2									
	5172875	NOZZLE, WATER (DOUBLE OUTLET)														
	5111332	NOZZLE, WATER (DOUBLE OUTLET) (1.2005)					10									
	5172874	NOZZLE, WATER (SINGLE OUTLET) (1.2005)					4									
	6199627	TUBE KIT(INCLUDES RING 5160037) (1.2005)					6									
	6104701	RING (2 2048)					6									
	6129919	GUIDE, EXHAUST VALVE (1.8320)					24									
	5120930	GUIDE, EXHAUST VALVE (1.8320)														
	5172757	INSERT, EXHAUST VALVE (1.8330)					24									
	5131096	INSERT, EXHAUST VALVE (1.8330)														
		THE FOLLOWING ITEMS ARE ’SHIPPED LOOSE” WITH THE CYLINDER HEAD.														
	5121182	PLUG, 1/4' PIPE (2.4015)					13									
	5125237	PLUG, 1/4' HEX SKT HD					5									
	5145014	PLUG, 3/8' PIPE (12.9550)					2									
	5154453	PLUG, 3/8'-16 SPECIAL					4									
	5178978	PLUG, 7/16-14 SPECIAL (1.3160)					4									
	5150132	PLUG, 3/4' DIA CUP (1.1001)					2									
	5117186	PLUG, 2' DIA CUP														
	5117344	PLATE, COVER														
	5117564	GUIDE, EXHAUSTVALVE BRIDGE(1.8345)					12									
	5117562	SEAT (1.8360)					24									
	5117369	CONNECTOR (2.4030)					12									
	5129845	CONNECTOR (2.5210)					1									
	5150362	STUD, 3/8'-16X1 11/16' (5.2020)					12									
	5112899	STUD, 7/16'-14X2 3/32 (6.1020)					7									
	5125108	WASHER (2.4030)					12									
	103321	LOCKWASHER, 3/8' (12.9200)														
	117049	NUT, 3/8 '-24 HEX (12.9120)														
	18SP-80	CYLINDER HEAD ASSY INSTRUCTION DRAWING FOR 2 VALVE.														
	18SP-85	CYLINDER HEAD ASSY INSTRUCTION DRAWING FOR 4 VALVE.					1									

1.2000 CYLINDER HEAD

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 17
	1.2001 -	**HEAD ASSY., CYLINDER**	
		FOR COMPONENTS OF SERVICE CYLINDER HEAD ASSEMBLIES, REFER TO ASSEMBLY BREAKDOWN PAGES AI AND A2	
3A	**5198218**	HEAD ASSY. (2 VALVE) (3-71)	
3A	**5198218**	HEAD ASSY. (2 VALVE) (4-71)	
3A	**5198217**	HEAD ASSY. (2 VALVE) (-71)	
3B	**5102771**	HEAD ASSY. (4 VALVE) (4-71)	
3B	**5102770**	HEAD ASSY. (4 VALVE) (6-71)	1
	116453	ELBOW, ¼" FL. TUBE 90 DEG (12.9390)	
	137894	ELBOW, 1/2' STREET 45 DEG (12.9590)	
	118757	ELBOW, 1/2' FL. TUBE 90 DEG (12.9390)	
	116524	BUSHING, 1/2'XI/4- RED (12.9570)	
	142269	BUSHING, 1/2'X3/8' PLAIN (12.9570)5	
3A,B	**5121182**	PLUG, 1/4' PIPE (2.4015)	13
3A,B	**5125237**	PLUG (1/4'X.320'L., HEX SOCKET HD.)	5
3A,B	**5145014**	PLUG, 3/8' PIPE (12.9550)	3
3A,B	**5154453**	PLUG (3/8'-16 SL HDLS.)	4
	5178978	PLUG, 7/16'-14 (1.3160)	4
	5150132	PLUG, 3/4' CUP (1.1001)	2
3A,B	**5142549**	PLUG, 3/4' PIPE (12.9550)	AR
3B	**5117186**	PLUG (2' CUP)	
	5144945	PLUG.FUSE	1
	5129867$	HOSE, FLEX. (#4X24' L.)	
	5113689$	HOSE (#6X20' L.)	1
	5127819	HOSE, 13/32'X28 7/8' L. 6 CYL WTR MANIFOLD VENT (4.4330)	
	5137685	HOSE, 13/32'X33' L. 4 CYL WTR MANIFOLD VENT (4.4335)	
	5111277	FITTING, 1/4' HOSE	
	5189292	FITTING, 1/4' HOSE	
	5129845	CONNECTOR, .080' (RESTRICTED)	1
	118752	CONNECTOR, 1/2' FL... TUBE (12.9380)	
	5153473	CLIP, 1/2	
	5100929	SLEEVE, PILOT	2
		$ NOT SERVICED, STANDARD LENGTH HOSE IN PARENTHESES WILL BE PROVIDED.	
	1.2002 -	**GASKET KIT, CYLINDER HEAD OVERHAUL**	
		A GASKET KIT INCLUDES ITEMS IN 1.2010, 1.2020, 1.2022, 1.2090, 1.8455, 2.7020, 2.7051, 2.7530, 2.8045, 2.8260, 4.8020, 5.2010, 5.2170 AND PLAIN STEEL ASBESTOS GASKETS IN 6.1010.	

1.2000 CYLINDER HEAD

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES													
							1 7									
	1.2002 -	**GASKET KIT, CYLINDER HEAD OVERHAUL (CONT'D)**														
		METAL-CLAD GASKETS IN 6.1010 ARE INCLUDED IN OPTIONAL KITS														
	5193116	GASKET KIT, 371														
	6198676	GASKET KIT, 471														
	5193118	GASKET KIT,671					AR									
	5195742	GASKET KIT, 671 METAL CLAD (OPT.).					AR									
	1.2005 -	**NOZZLE, CYLINDER HEAD WATER**														
3A	**5172874**	NOZZLE (SINGLE OUTLET) (COPPER).					4									
3A	**5172875**	NOZZLE (DOUBLE OUTLET) (COPPER)														
	5111332	NOZZLE (DOUBLE OUTLET) (COPPER)					10									
	1.2010 -	**GASKET, CYLINDER HEAD COMPRESSION**														
1C	**5183330**	GASKET					6									
	1.2020 -	**GASKET SET, CYLINDER HEAD OIL**														
1C	**5119972**	RING, SEAL														
1C	**5119973**	RING, SEAL														
1C	**5119974**	RING, SEAL					1									
1C	**518579**	RING, SEAL (WATER HOLE)					10									
1C	**5186577**	RING, SEAL (END WATER HOLE)					2									
	1.2022 -	**GASKET, CYLINDER HEAD WATER AND OIL**														
1C	**5183305**	GASKET					2									
	1.2030 -	**STUD, CYLINDER HEAD**														
1A	**5112658**#	STUD(6 5/8' L.) (ALUMINUM BLOCK)					14									
1A	**5118453** +	STUD (7 1/4' L.) (ALUMINUM BLOCK)					14									
	5117003	BOLT (5 42W L.) # THRU 4A-79661, 6A-76744. + EFFECTIVE WITH 4A-79962, 6A-76745.					14									
	1.2040 -	**NUT, CYLINDER HEAD STUD**														
3A	**5150013**	NUT					4									

1.2000 CYLINDER HEAD

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 17
	1.2045 -	**TUBE, INJECTOR HOLE**	
3A,B	**5199527**	TUBE KIT (INCLUDES SEAL RING IN 1.2046) (2.1290)	6
	1.2046 -	**RING, INJECTOR HOLE TUBE SEAL**	
3A,B	**5104701**	RING	6
	1.2050 -	**COVER, CYLINDER HEAD GOVERNOR HOLE**	
	5180112*	COVER (TAPPED)	AR
3A	**5150268**	COVER (PLAIN)	AR
	5164062 %	COVER (TAPPED)	
	180016	BOLT, 1/4'-20X1/2' (12.9001)	6
	186630 %	BOLT, 1/4'-20X5/8' (12.9001)	
	120380	LOCKWASHER, 1/4' (12.9200)	6
		* USE WITH FUEL MODULATOR CONTROLS IN 2.9000A.	
		% USE IN CONJUNCTION WITH VENTILATING SYSTEM IN 4.8000A.	
	1.2060 -	**GASKET, CYLINDER HEAD GOVERNOR HOLE COVER**	
3A	**5123812**	GASKET	4

1.2000A ENGINE LIFTER BRACKET

FIG	PART NUMBER	NAME AND DESCRIPTION	1		212	13	121	166	154	133	197	3				
		1.2070 - BRACKET,ENGINE LIFTER FRONT														
3D	**5150050**	BRACKET(ITEM 1)	1													
	5186630	BRACKET (AT BALANCE WEIGHT COVER)														
3D	**5181674**	BRACKET (ITEM 2)														
	5140218	BRACKET														
3D	**5160051**	BRACKET(ITEM 3)														
3D	**2136458**	BRACKET ASSY(INCLUDES BEARINGS)														
	189404	BEARING, NEEDLE														
	179862	BOLT , 7/16'-14X1 1/2 (12.9001)	4													
	100173	BOLT, 9/16'-12X1 3/4 (12.9001)														
	103322	LOCKWASHER, 7/16' (12.9200)	4													
	120898	LOCKWASHER, 9/16' (12.9200)														
		1.2080 - BRACKET, ENGINE LIFTER - REAR														
3D	**5150051**	BRACKET (ITEM 3)	1													
3D	**5181674**	BRACKET (ITEM 2)														
3D	**5150050**	BRACKET (ITEM 1) (1 2070)														
	5118806	BRACKET														
3D	**2136459**	BRACKET (ITEM 3)														
	5139709	BRACKET (ANGLE)														
	148403	BEARING, NEEDLE (2.7270)														
	179862	BOLT, 7/16'-14X1 1/2 (12.9001)	4													
	442733	BOLT, 1/2'-13X1 1/4' (12.9001)														
	223449	BOLT, 3/4'-10X1 3/4- (12.9001)														
	103322	LOCKWASHER, 7/16 (12.9200)	4													
	103323	LOCKWASHER, 1/2' (12.9200)														
	103328	LOCKWASHER, 3/4- (12.9200)														
		1.2090 - GASKET, ENGINE LIFTER BRACKET														
3D	**5150052**	GASKET	2													
		1.2100 - BOLT, ENGINE LIFTER EYE														
3D	**5176601**	BOLT, EYE														
3D	**102640**	NUT, ¾"-10 HEX. (12.9120)														

1.3000 CRANKSHAFT

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	13	14	31
	1.3001 -	**CRANKSHAFT ASSY.**						
		A CRANKSHAFT ASSY INCLUDES 1/8' PIPE PLUG AND DOWEL IN 1.3001 PLUS PUMP DRIVE GEAR KEY IN 4.1310.						
4A	**6184215**	CRANKSHAFT ASSY., 371						
4A	**6182941**	CRANKSHAFT ASSY., 471						
4A	**5179068**	CRANKSHAFT ASSY., 671			1			
4A,C	**444687**	PLUG, 1/8' PIPE (12.9550)			6			
4C	**444692 +**	* PLUG, 1/4' PIPE (12.9550)			1			
4A	**5173048** *	PLUG (1/4') (USED WITH BAFFLE 5155661)			1			
4A,C	**5177528**	DOWEL			2			
		+ USED WITH SEALED ROLLER TYPE CLUTCH PILOT BEARING OR WHEN BAFFLE OR OIL WICK IS NOT REQUIRES. * THRU 3A-51238, 4A-101720, 6A-109237. NO PROVISION IN CRANKSHAFT FOR PILOT BEARING OILING AFTER THESE SERIAL NUMBERS.						
	1.3010 -	**BAFFLE, CRANKSHAFT OIL**						
4B	**5159331** *	BAFFLE(OIL, HOLE FOR WICK ASSY.)			1			
4A	**5155661***	BAFFLE (GREASE, NO HOLE)			1			
		* THRU 3A-51238, 4A-101720, 6A-109237. NO PROVISION IN CRANKSHAFT FOR PILOT BEARING OILING AFTER THESE SERIAL NUMBERS.						
	1.3020 -	**WICK ASSY., CLUTCH PILOT BEARING**						
		A WICK ASSY IS USED TO LUBRICATE UNSEALED BALL TYPE CLUTCH PILOT BEARING AND CONSISTS OF A HOLDER WHICH IS NOT SOLD SEPARATELY AND WICK IN 1.3030 THE LENGTHS SHOWN ARE FOR WICK HOLDER ONLY.						
4B	**5176721** *	WICK ASSY. (LENGTH 1 1/2')			1			
	5155491 *	WICK ASSY. (LENGTH 2 7/8')			1			
		* THRU 3A-51238, 4A-101720, 6A-109237. NO PROVISION IN CRANKSHAFT FOR PILOT BEARING OILING AFTER THESE SERIAL NUMBERS.						
	1.3030 -	**WICK, CRANKSHAFT OIL**						
	51655492*	WICK			1			
4B	**5175777***	WASHER (FELT) (WITH WICK ASSY 5176721)			6			

1.3000 CRANKSHAFT

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	13	14	31
	1.3030 -	**WICK, CRANKSHAFT OIL (CONT'D)**						
		* THRU 3A-51238, 4A-101720, 6A-109237. NO PROVISION IN CRANKSHAFT FOR PILOT BEARING OILING AFTER THESE SERIAL NUMBERS.						
	1.3040 -	**SEAL, CRANKSHAFT OIL - FRONT**						
		USED WITH CRANKSHAFT FRONT COVER IN 1.3160.						
4A,5C	**5115454**	SEAL			1			
4A,5C	**5153373**	SEAL (RUBBER AND FELT LIP)			AR			
	1.3050 -	**SLINGER, CRANKSHAFT OIL-FRONT**						
4A	**5150175**	SLINGER						
4A	**6150174**	SLINGER			1			
	1.3055 -	**SPACER, CRANKSHAFT FRONT OIL SEAL**						
		USE ONE OF THE BELOW SPACER AS REQUIRED.						
4A	**5151475**	SPACER, 7/8' L						
4A	**5153713**	SPACER, 7' L						
4A	**513713**	SPACER, 1' L						
4A	**5132181**	SPACER, 1.34' L						
4A	**5183023**	SPACER,2 3/16' L						
4A	**5132430**	SPACER, 2.88' L			1			
4A	**5151420**	SPACER, 2 13/16' L			1			
4A	**5168462**	SPACER,3 5/16' L						
	5130480	SPACER, 3.32' L			1			
	1.3057 -	**WASHER, CRANKSHAFT CAP RETAINER FRONT**						
	5160380#	RETAINER (WASHER) (1/8' THICK)			1			
	5157930#	RETAINER (WASHER) (1/2' THICK) (1.3290)			1			
	117982#	KEY, 3/8'X1 1/4' WOODRUFF (12.9350).			1			
	5153623#	BOLT (1 3290)			1			
		# USED ONLY WHEN PULLEY IS NOT USED.						

1.3000 CRANKSHAFT

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 2	3	4	13	14	31
	1.3001 -	**CRANKSHAFT ASSY.**						
	1.3058 -	**CAP CRANKSHAFT · FRONT**						
	5137103#	CAP (SPACER) (2 27/32" L.) (1.3290)			1			
	5112608$	CAP (3 11/32" L.)			1			
	5160302#	CAP (3 15/16" L.)			1			
		# USED ONLY WHEN PULLEY IS NOT USED. $ NOT SERVICED, REFERENCE ONLY FOR REPLACEMENT USE 5137103 AND (1) 5157930 WASHER.						
	1.3060 -	**SEAL, CRANKSHAFT OIL - REAR**						
4A	**5114335** *	SEAL (SINGLE LIP, STANDARD)			1			
4A	**5127821** +	SEAL (DOUBLE LIP, STANDARD)..........			1			
4A	**5197860** *	SEAL (SINGLE LIP, O.S.) (USE WITH .... 5197159 SLEEVE)			AR			
4A	**56196927** +	SEAL (DOUBLE LIP, O.S) (USE WITH ... 5197159 SLEEVE)			AR			
		USED ON ALL UNITS EXCEPT THOSE WITH OIL IN THE FLYWHEEL HOUSING. + USED ONLY ON UNITS WITH OIL IN THE FLYWHEEL HOUSING.						
	1.3065 -	**SPACER, CRANKSHAFT REAR OIL SEAL**						
4E	**5192496** %	SPACER			AR			
		% CAN BE USED ONLY WITH SINGLE LIP OIL SEAL.						
	1.3066 -	**SLEEVE, CRANKSHAFT REAR OIL SEAL**						
4E	**5197159**	SLEEVE (USE WITH O.S. SEAL)............			AR			
	1.3090 -	**SHELL, CRANKSHAFT MAIN BEARING**						
		A SHELL SET CONSISTS OF ONE UPPER AND ONE LOWER BEARING SHELL.						
	5192874	SHELL SET (STANDARD)......................			AR			
	5192875	SHELL SET (.002" U.S.)			AR			
	5192876	SHELL SET (.010" U.S.)			AR			
	5192877	SHELL SET (.020" U.S.)			AR			
	5192878	SHELL SET (.030" U.S.)			AR			
	5193738	SHELL SET (.040" U.S.)			AR			
	5193739	SHELL SET (.050" U.S.)			AR			
	5193740	SHELL SET (.060" U.S.)			AR			

1.3000 CRANKSHAFT

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 2	3	4	13	14	31
	1.3001 -	**CRANKSHAFT ASSY.**						
4A	**5159353**	WASHER (STANDARD)			4			
4A	**5160542**	WASHER (.005' O.S.)			AR			
4A	**5192111**	WASHER (.010' O.S.)			AR			
4A	**141346**	PIN, 3/16'X1/2' DOWEL (12 9290)...........			4			
	1.3110 -	**CAP, CRANKSHAFT MAIN BEARING**						
		A CAP SET CONSISTS OF 1-5158674 CAP, 2-5152149 BOLT, 2-103334 LOCKWASHER AND 4-141346 PIN.						
	5191503*	CAP SET...			7			
4A	**5161697**	CAP (UNFINISHED)			7			
4A	**5158674**	CAP(CASTIRON BLOCK)........................			7			
	5194614@	CAP (ALUMINUM BLOCK)						
		* NOT SERVICED USE COMPONENTS.						
		@ OBSOLETE.						
	1.3130 -	**NUT, CRANKSHAFT MAIN BEARING CAP STUD**						
	5150572	NUT..						
	103385	PIN, 1/8'X1' COTTER(12.9250)						
	1.3140 -	**BOLT, CRANKSHAFT MAIN BEARING CAP**						
4A	**5152149**	BOLT(4 3/4' L.)..			14			
	5175305	STUD						
4A	**103334**	LOCKWASHER, 5/8' (12.9200)			14			
	1.3145 -	**GEAR, CRANKSHAFT TIMING**						
4A	**5113815**	GEAR (L.H. HELIX) (LA-LB-LC-LD ENG.)			1			
4A	**5113814**	GEAR (R.HHELIX) (RA-RB-RC-RD ENG.)			1			
	5150271	BOLT...			6			
	103321	LOCKWASHER, 3/8' (12.9200)			6			

1.3000A CRANKSHAFT FRONT COVER

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	10	21	27	42	47	94	98	107	111			
	1.3180 -	**COVER, CRANKSHAFT FRONT**														
5B	**5143281**	COVER														
5B	**5175939**	COVER														
5B	**5184482**	COVER														
5B	**5175941**	COVER			1											
5B	**5112640**	COVER														
5B	**5184071**	COVER														
5B	**5179133**	COVER														
5B	**5120289**	COVER														
5B	**5138176**	COVER														
5B	**5139313**	COVER														
	179846	BOLT, 3/8'-16X1 7/8' (12.9001)			2											
	181360	BOLT, 3/8'-24X3/4' (12.9001)														
	181361	BOLT, 3/8'-24X7/8' (12.9001)														
	186627	BOLT, 3/8'-24X1' (12.9001)														
	186689	BOLT, 1/2'-13X2' (12.9001)														
	186631	BOLT, 1/2'-13X2 1/4' (12.9001)			4											
	454992	BOLT, 1/2'-13X2 1/2' (12.9001)														
	186659	BOLT, 1/2'-13X3 3/4' (12.9001)														
	103341	WASHER, 3/8' FLAT (12.9190)														
	103343	WASHER, 1/2' FLAT (12.9190)														
	103321	LOCKWASHER .... 3/8' (12.9001)			AR											
	103323	LOCKWASHER, 1/2' (12.9200)			AR											
	1.3170 -	**GASKET, CRANKSHAFT FRONT COVER**														
	5150181	GASKET			1											
	5112641	GASKET														

1.3000B VIBRATION DAMPER

FIG	PART NUMBER	NAME AND DESCRIPTION	43	45	50	52	59	62	63	68	70	76	77
	1.3210 -	**DAMPERVIBRATION**											
4D	**5177763**	DAMPER, (LIGHT, VISCOUS)											
4D,6B	**5140653**	DAMPER (HEAVY, VISCOUS)							1				
	181394	BOLT, 7/16'-20X7/8' (12.9001)							6				
	179858	BOLT, 7/16'-14X1 ' (12.9001)											
	181396	BOLT, 7/16'-20X1 1/8' (12.9001)											
	181397	BOLT, 7/16'-2OXl 1/4' (12.9001)											
	103322	LOCKWASHER, 7/16- (12.9200)							6				
	1.3230 -	**HUB ASSY., VIBRATION DAMPER**											
		A HUB ASSY INCLUDES DOWEL IN 1.3230.											
4D	**5179243**	HUB ASSY											
4D	**5186050**	HUB ASSY											
4D	**5179011**	HUB ASSY											
4D	**5182310**	HUB ASSY							1				
4D	**5100421**	DOWEL (1' L.)							2				
4D	**5175641**	DOWEL(1 3/8 L.)											
	1.3240 -	**CONE, VIBRATION DAMPER-FRONT**											
4D	**5134917**	CONE (.531' L.)							1				
4D	**5151344**	CONE (.687' L.)											
	1.3250 -	**CONE VIBRATION DAMPER - REAR**											
4D	**5153144**	CONE (1.40' L.)											
4D	**5158640**	CONE (2.12' L.)							1				
4D	**5122481**	CONE(3.09' L.)											
	1.3275 -	**SPACER, VIBRATION DAMPER**											
	5179588	SPACER											

1.3000C CRANKSHAFT PULLEY

FIG	PART NUMBER	NAME AND DESCRIPTION	330	331	333	334	338	347
	1.3280 -	**PULLEY, CRANKSHAFT**						
	A PULLEY ASSY INCLUDES ITEMS IN 1.3311.							
	NPN	PULLEY (CUSTOMER...... FURNISHED).						
	5141158	PULLEY, 7 1/2' DIA., 3 GROOVES..........						
	5145390	PULLEY, 9' DIA., 2 GROOVE; 3/8'W.......						
	5139346	PULLEY ASM., 7 1/2' DIA., 3 GROOVES				1		
	5162919	PULLEY, 7 1/2' DIA., 4 GROOVES..........						
	5147168	PULLEY ASM., 7 1/2' DIA.,...................... GROOVES)						
	5139735	PLATE, LOCKING (7.1505)						
4D	**117982**	KEY, 3/8'X1 1/4' WOODRUFF (12.9350).				2		
	180120	BOLT, 3/8'-16X3/4' (12.9001)						
	186627	BOLT, 3/8'-24X 1' (12.9001)						
	180121	BOLT, 3/8'-16 X7/8' (12.9001)						
	103321	LOCKWASHER, 3/8' (12.9200)						
	1.3290 -	**RETAINER, CRANKSHAFT PULLEY**						
4A	**5157930**	RETAINER (2 3/8' O.D.)				1		
4A,D	**5153623**	BOLT, 1'-14X2 1/4' L. (12.9001)						
4A,D	**5160266**	BOLT, 1'-14X2 3/4' L................................				1		
	1.3310 -	**HUB, CRANKSHAFT PULLEY**						
	5178036	HUB						
	1.3311 -	**INSULATOR ASSY., CRANKSHAFT PULLEY HUB**						
	5145047	INSULATOR ASSY				1		
	147489	BALL, 3/8' DIA., STEEL (12.9670)...........				3		

1.3000D CRANKSHAFT PULLEY BELT

FIG	PART NUMBER	NAME AND DESCRIPTION	195	197	202	220	226	232	234	236	237	238	240	257
	1.3320 -	**BELT, CRANKSHAFT PULLEY DRIVE**												
		ALL BELTS UNLESS INDICATED (M.S.) “MILITARY STANDARD” OR “POLY-VEE” ARE 'PREMIUM' POLYESTER BELTS. SIZES SHOWN ARE EFFECTIVE LENGTH AT WIDTH SHOWN.												
	5130528	BELT SET (2 BELTS) (45.14'L................. .500'W.)												
	5136265	BELT SET (2 BELTS) (69.00'L................. .500'W.)												
	5136266	BELT SET (2 BELTS) (68.00’L .... .500’W.)												
	5135883	BELT SET (2 BELTS) (63.00’L .... .500'W.)												
	5136000	BELT SET (2 BELTS) (72.00'L................. .500’W)												
	5137849	BELT SET (2 BELTS) (81.00’L .... .500'W.)												
	5179076	BELT SET (2 BELTS) (69.00’L .... .500'W.)												
	5135904	BELT SET (2 BELTS) (77.00’L .... .660'W.)												
	5135882	BELT SET (2BELTS) (57.00’L .... .500’W.)									1			
	5138850	BELT SET (2 BELTS) (67.00’L .... .500’W)												
	5135942	BELT SET (2 BELTS) (55.00'L................. .500'W.)												
	5141155	BELT SET (2 BELTS) (71.00'L................. .500'W.)												

1.4000A FLYWHEEL

FIG	PART NUMBER	NAME AND DESCRIPTION	661	662	663	664	666	671	672	674	682	683	698	712
	1.4001 -	**FLYWHEEL ASSY.**												
		FOR TYPE 678 USE TYPE 671. INCLUDES GEAR IN 1.4010. “C” INDICATES A CHAMFERED ASSY. 'NC' NON-CHAMFERED.												
7A	5138586	FLYWHEEL ASSY (SAE #2) (C)												
7A	5129650	FLYWHEEL ASSY (SAE #1) (C)												
7A	5138863	FLYWHEEL ASSY (SAE #1) (C)												
7A	5138864	FLYWHEEL ASSY (SAE #1) (C)												
7A	5138343	FLYWHEEL ASSY (SAE #2) (C)												
7A	5138227	FLYWHEEL ASSY (SAE #2) (NC)												
7A	5140740	FLYWHEEL ASSY (SAE #2) (C)									1			
7A	5142122	FLYWHEEL ASSY (SAE #2) (NC)												
7A	5128919	FLYWHEEL ASSY (SAE #1) (C)												
7A	5120753	PLATE, SCUFF (BEARING RETAINER) (1.4045)									1			
7A	9409532	BOLT 9/16'-18X2' HEX LOCK (12.9001)												
7A	9410925	BOLT, 9/16'-18X2 1/4' HEX LOCK (12.9001)												
7A	9412015	BOLT, 9/16'-18X2 1/2' HEX LOCK (12.9001)									6			
7A	9411631	BOLT, 9/16'-18X2 3/4' HEX LOCK (12.9001)												
7A	9409606	BOLT 9/16'-18X2 7/8' HEX LOCK (12 9001)												
	1.4010 -	**GEAR, FLYWHEEL RING**												
7A	5166664	GEAR (SAE #1 - 118 TEETH W/CHAMFER)												
7A	5110894	GEAR (SAE #2 - 102 TEETH, W/CHAMFER)									1			
7A	5188030	GEAR (SAE #2 - 102 TEETH W/O CHAMFER)												
7A	5181776	GEAR (SAE #2 - 103 TEETH, W/O CHAMFER)												
	1.4040 -	**BEARING, CLUTCH PILOT**												
7A	907594	BEARING (N.D. Z99606X1C)									1			
	1.4045 -	**RETAINER, CLUTCH PILOT BEARING**												
7A	5120753	RETAINER												

71 VEH. ENGINES

1.5000A FLYWHEEL HOUSING

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPE 4 6 8
	1.50001 -	HOUSING ASSY FLYWHEEL	
6B	5147078	HOUSING (SAE #2)(Item 1)	1
	5114335	SEAL OIL LIP TYPE	1
6B	5111798	PLUG PIPE 1 IN	1
7A	190770	BOLT 2 - 13X3/	6
7A	179839	BOLT 3/8 - 16X1	2
7A	186314	BOLT 3/8 - 24X4Y4	4
7A	117049	NUT 3/8 - 24 HEX	4
7A	186312	BOLT 3/8 - 24X4	4
7A	9409028	BOLT 3/8 - 16X1 AA LK	6
7A	5106559	BOLT FLC HEXHD 3/8X16X1 w/seal patch	6
7A	5138619	WASHER PLN 25/64X3/4X.083	6
7A	103321	LOCK WASHER 3/8	10
7A	103323	LOCK WASHER 1/2	6
6B	5164294	SPACER 7/8 - 13/22X1/8 THK	2
7A	5173935	PLUG 1/2 - 13	4
	1.5010 -	GASKET LARGE	
7A	5150054	GASKET FLYWHEEL HSG	1

1.5000B FLYWHEEL HOUSING ADAPTOR

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 1	2	3	4	7	26	41	42						
	1.5130 -	**ADAPTOR, FLYWHEEL HOUSING**														
	3224296	ADAPTOR (SAE #1 TO SAE #2)	1													
	5174313	ADAPTOR (SAE #1 TO SAE #3)		1				1								
	6882885	ADAPTOR, #2 TO #2 (SPACER)							1							
	3229281 *	ADAPTOR (SAE #1 TO SAE #2, 1/4			1											
	6881378	ADAPTOR, #1 TO #2 OFFSET)								1						
	5173389	ADAPTOR (SAE #1 TO SAE #3, 5/16				1										
	5174287	ADAPTOR (SAE #2 TO SAE #3, 1/2 OFFSET)					1									
	9409028@	BOLT, 3/8'-16X1'(12.9001)	12	12	12	12	12	12								
	138243	BOLT, 3/8'-16X 1 1/4' SKT-HD							2							
	5130293#	BOLT, 7/16'-14X1 1/4' (12.9001)	12	12	12	12	12	12								
	427564	BOLT, 7/16'-14X1 3/8' (12.9001)								12						
	103321 @	LOCKWASHER, 3/8' (12.9200)	12	12	12	12	12	12								
	103322 @	LOCKWASHER, 7/16' (12.9200)	12	12	12	12	12	12		12						

$ NOT SERVICED, NO LONGER AVAILABLE FROM VENDOR.
@OPTIONAL USAGE - DEPENDENT ON SIZE OF HOLES IN FLYWHEEL HOUSING., TYPES 1 THRU 26 ONLY.
NYLON INSERT.

1.6000 CONNECTING ROD AND PISTON

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 109	125	126	139	140	175
	1.6001 -	**CONNECTING ROD ASSY.**						
		A ROD ASSY INCLUDES CAP WHICH IS NOT SOLD SEPARATELY, PLUS ITEMS IN 1 6001, 1 6010, 1 6020 AND 1.6040. THE CROSSHEAD ROD INCLUDES ONLY ITEMS IN 1.6001.						
7B	5135515	ROD ASSY (NON-TURBO.)....................						
78	5135528	ROD ASSY (TURBO)..............................						
7C	6144847	ROD ASSY (CROSSHEAD)....................				1		
7B	6132383	BOLT (CROSSHEAD)............................				2		
7B,C	5132383 $	BOLT, 7/16 -2OX3.32'............................						
7B,C	6117829 $	NUT...				2		
		* EFFECTIVE WITH 3A-48539, 4A-96993, 6A-103126						
	1.6010 -	**NOZZLE CONNECTING ROD SPRAY**						
7B	6150140	NOZZLE..						
	1.6020 -	**ORIFICE, CONNECTING ROD**						
	5154360#	ORIFICE						
		# EFFECTIVE WITH 3A-57339, 4A-112372, 6A-121773.						
	1.6040 -	**BUSHING, CONNECTING ROD PISTON PIN**						
7B	5157274	RUSHING (UNFINISHED)						
	1.6100 -	SHELL, CONNECTING ROD BEARING						
		A SHELL SET CONSISTS OF ONE UPPER AND ONE LOWER BEARING SHELL						
7B,C	5192895	SHELL SET (STANDARD).......................				AR		
7B,C	5192896	SHELL SET (002' US).............................				AR		
7B,C	5192897	SHELL SET (010' US).............................				AR		
7B,C	5192898	SHELL SET (020' U S)............................				AR		
7B,C	5192899	SHELL SET (030' US).............................				AR		
7B,C	5193741	SHELL SET (040'US)..............................				AR		
7B,C	5193742	SHELL SET (050' US).............................				AR		
7B,C	5193743	SHELL SET (060' US).............................				AR		

1.6000 CONNECTING ROD AND PISTON

FIG	PART NUMBER	NAME AND DESCRIPTION	109	125	126	139	140	175
	1.6108 6	**- RING, SEAL CROSSHEAD PISTON**						
7C	**6144837**	RING, SEAL				1		
	1.6110	**- PISTON ASSY.**						
		A PISTON ASSY INCLUDES BUSHING AND RETAINER IN 1.6145 AND 1.6150 HG INDICATES HARD FIRE RING GROOVE NG NON-HARDENED. A CROSSHEAD PISTON ASSY INCLUDES CROWN AND SKIRT IN 1.6110 PLUS ITEMS IN 1 6106, 1 6142 AND 1 6150.						
7B	**6198467***	PISTON ASM, 18.7 TO 1 (N)						
7B	**5149235**	PISTON ASM, 18 7 TO 1 (N) (NG)						
7B	**5198839***	PISTON ASM, 18 7 TO 1						
7B	**6149234**	PISTON ASM, 18 7 TO 1 (NG)						
7C	**6199350**	PISTON ASM, 18 7 TO 1 (CROSSHEAD KEYSTONE)				1		
7C	**5199573**	PISTON ASSY., 17 1 (CROSSHEAD KEYSTONE TURBO)						
7C	**5147650**	CROWN, PISTON (NON-TURBO.)				1		
7C	**5147651**	CROWN, PISTON (TURBO).						
7C	**5144836**	SKIRT PISTON (CROSSHEAD)				1		
		* NOT SERVICED, USE SECOND ASM. IN TYPE WITH NC FIRE RING IN 1 6120.						
	1.6115	**- RING SET, PISTON**						
		A PISTON RING SET CONSISTS OF SUFFICIENT RINGS FOR ONE (1) CYLINDER HG INDICATES SET CONTAINS CHROME FIRE RING FOR HG PISTON AND NG FOR NON-HARDENED PISTON.						
	5199807	RING SET(HG)						
	6149232	RING SET (NG)						
	5199329	RING SET (187)(HG)						
	5149230	RING SET (NG)						
	5199825	RING SET (18.7:1) (CROSSHEAD) (KEYSTONE) ABOVE 75MM INJECTORS.				1		
	5199824	RING SET (17 1)(CROSSHEAD) (KEYSTONE, TURBO)						
	5149248	RING SET, 17.1 CROSSHEAD TURBO, BELOW 80MM INJECTORS.						

1.6000 CONNECTING ROD AND PISTON

FIG	PART NUMBER	NAME AND DESCRIPTION	109	125	126	139	140	175
	1.6120 -	**RING, PISTON COMPRESSION**						
		CF INDICATES CHROMED; NC NON-CHROMED						
7B,C	**5100797**	RING, (FIRE) (KEYSTONE)(NC)				1		
7A	**518N325**	RING						
7B	**651326068**	RING, FIRE (CF).....................................						
7B	**61026486**	RING, FIRE (NC)						
	6122321	RING (RG 6						
7C	**6122321**	RING (LOWER GROOVE).......................				1		
7B	**6148036**	RING (UPPER GROOVE)........................				1		
	1.6130 -	**RING, PISTON OIL CONTROL**						
		AN OIL CONTROL RING CONSISTS OF SCRAPERS AND EXPANDER FOR ONE AN OIL CONTROL RING SET CONSISTS OF GROOVE SCRAPERS AND EXPANDERS FOR ONE PISTON.						
7B	**5197576**	RING SET (TRANSIT COACH ONLY).....				1		
7B	**5198089**	RING SET						
7B	**5199827**	RINGSET				1		
7B	**5199826**	RING SET (TURBOXABOVE 75 MM....... INJECTORS)						
7B	**5149247**	RING SET(TURBOX75MM. INJECTORS AND BELOW)						
	1.8140 -	**PIN PISTON**						
7B	**5188406**	PIN (STD.) (NON-DRILLED) .						
	5146383	PIN (DRILLED)						
7B	**5194543**	PIN (.010' O.S.) (NON-DRILLED)						
7B	**5144495'**	PIN (TURBO)						
7C	**5144744**	PIN (CROSSHEAD)................................				1		
7C	**5144846@**	SPACER				2		
7C	**6148373@**	BOLT, 7/16'-20X2' (12 PT.)......................				2		
		* NOT PART OF CYLINDER KITS USE WHERE DESIRED IN PLACE OF 5188406 FOR NON-TURBO ENGINES						
		@ NOT PART OF CYLINDER KITS						
	1.6142 -	**BEARING, PISTON PIN**						
7C	**5144843**	BEARING (SLIPPER TYPE)				1		

1.6000 CONNECTING ROD AND PISTON

FIG	PART NUMBER	NAME AND DESCRIPTION	109	125	126	139	140	175
	1.8145 -	**BUSHING, PISTON PIN**						
7B	**6155839**	BUSHING						
	1.6150 -	**RETAINER, PISTON PIN**						
7B	6188405	RETAINER						
7C	5180250	RETAINER				2		
	1.6180 -	**LINER, CYLINDER**						
7B.C	**5113953**	LINER (STANDARD)				1		
7B,C	**6197565**	LINER (001' O.S., O.D.)				AR		
7B,C	**5193732**	LINER (.005' O S., O.D.)				AR		
7B,C	**5193733**	LINER (.010' O S, O.D.)				AR		
7B,C	**5193734**	LINER(020' O S, O.D)				AR		
7B,C	**5193735**	LINER (030' O S., O.D).)				AR		
	1.6182 -	**CYLINDER KIT**						
		CYLINDER KIT NOT AVAILABLE FOR TYPE 109, USE COMPONENTS. A KIT INCLUDES STANDARD SIZE ITEMS UNLESS OTHERWISE NOTED, IN 1.6110, 1.6115, 1.6140, 1.6150 AND 1.6180 FOR (1) CYLINDER.						
	5199518#	CYLINDER KIT ('N', PUMPER ENGINE)						
	5199822	CYLINDER KIT (NON-TURBO) (CROSSHEAD)				AR		
	5199821	CYLINDER KIT (CROSSHEAD) (KEYSTONE TURBO)(ABOVE 75MM INJECTORS)						
	5149302	CYLINDER KIT (CROSSHEAD) (KEYSTONE TURBO) (.001' 0 S.,O D LINER. ABOVE 75MM INJECTORS)						
	5149303	CYLINDER KIT (CROSSHEAD KEYSTONE TURBO) (010' O.S., OD LINER- ABOVE 75MM INJECTORS)						
	5149304	CYLINDER KIT (CROSSHEAD KEYSTONE TURBO) (020' 0 S.0 D LINER- ABOVE 75MM INJECTORS)						
	5149249	CYLINDER KIT (CROSSHEAD)(KEYSTONE, TURBO)(75MM AND BELOW INJECTORS)						
	5199956	CYLINDER KIT (NON-TURBO) (CROSSHEAD) (001' 0 S,OD LINER)				AR		
	5149300	CYLINDER KIT (NON-TURBO) (CROSSHEAD) (.010 0 S O.D LINER)				AR		
	6149301	CYLINDER KIT (NON-TURBO) (CROSSHEAD)				AR		

1.6000 CONNECTING ROD AND PISTON

FIG	PART NUMBER	NAME AND DESCRIPTION	109	125	126	139	140	175
	1.6182 - (CONT'D)	**CYLINDER KIT**						
		(020' O S.O D LINER) NOT SERVICED, USE COMPONENTS.						
	1.6185 -	**SHIM CYLINDER**						
	5199569	SHIM,.002				AR		
	1.6187 -	**INSERT, CYLINDER LINER**						
1C	**5199871**	INSERT(0015' OS) AR						
1C	**5184484**	INSERT (STD) (CAST IRON BLOCK) .. 1						
1C	**5194073** +	INSERT (004' U S) AR						
1C	**5194074** +	INSERT (008' U S.) AR						
1C	**5193316** *	INSERT(STD) AR						
1C	**5194163** *	INSERT 004' US) AR						
1C	**5194164** *	INSERT(B008' US) AR						
1C	**6148399**	INSERT (STD)(STD AND 005' OS..... AR LINER)(1810'- 1815' THK)(RED)						
1C	**5148440**	INSERT (STD)(STD AND 005' OS..... AR LINER) (1780'- 1785' THK) (BLACK)						
1C	**5199872**	INSERT(0015'US) AR						

+ FOR USE WITH STANDARD AND 005'
* FOR USE WITH 010' TO 030' O S
OS LINER
LINER.

1.7000 CAMSHAFT AND GEAR TRAIN

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	15	16	18	26	28	36	45	46	47	48		
	1.7001 -	**CAMSHAFT ASSY.**														
		A CAMSHAFT ASSY INCLUDES PLUG IN 1. A CAMSHAFT KIT INCLUDES CAMSHAFT ASS 2-5153914, 2-5102668 KEYS AND 1BSP1 B														
8A	5185745	CAMSHAFT ASM., 371 LA-LD-RB-RC ENG. (STAMPED 51B5746)														
8A	5183954	CAMSHAFT ASM, 371 LB-LC-RA-RD ENG (STAMPED 5183936)														
BA	5149392	CAMSHAFT KIT., 471 LA-LB-LC-LD ENG (STAMPED 5102066-ADV TIMING)														
8A	5179961	CAMSHAFT ASM 471 LA-LB-LC-LD ENG (STAMPED 5125337-STD TIMING)														
8A	5149391	CAMSHAFT KIT, 471 RA-RB-RC-RD ENG (STAMPED 5102663-ADV TIMING)														
8A	5122487 *	CAMSHAFT ASM 471 RA-RB-RC-RD ENG (STAMPED 5122203-STD TIMING)														
8A	5103163	CAMSHAFT ASM 671 RA-RB-RC-RD ENG (5149391) (STAMPED 5102665-ADV TIMING)					1									
8A	5122486	CAMSHAFT ASM 671 RA-RB-RC-RD ENG (STAMPED 5122202-STD TIMING)					1									
8A	5151277	PLUG					2									
	1.7010 -	**BEARING CAM AND BALANCER SHAFT END**														
8A	5111422	BEARING (STD.) (INCLUDES BUSHINGS)					4									
8A	5194858	BEARING (010'U.S.) (INCLUDES..........D					AR									
8A	5194859	BEARING (.020-U S.) (INCLUDES .... BUSHING)					AR									
	5197238@	BEARING (.01O' D WITH STD ..........I.D.)					AR									
	5197237@	BEARING (.O 100 D WITH .010 I.D.)					AR									
	5197238@	BEARING (010'0D WITH .020-I.D.)					AR									
8A	186622	BOLT, 3/8'-16X1 1/4- (12.9001)...............					12									
	103321	LOCKWASHER, 3/8B (12.9200)............. @ INCLUDES BUSHING.					12									
	1.7015 -	**BUSHING, CAM AND BALANCER SHAFT END**														
	6194825	BUSHING (.020 U S., UNFINISHED)					8									
	5111423	BUSHING (GROOVED)...........................					8									
	1.7030 -	**WASHER, CAM AND BALANCER SHAFT END BEARING THRUST**														
8A	5111424	WASHER(STANDARD)					4									
8A	5194828	WASHER (005-O.S.)					AR									
8A	5194827	WASHER (.010-O.S)					AR									

1.7000 CAMSHAFT AND GEAR TRAIN

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	15	16	18	26	28	36	45	46	47	48		
	1.7040 -	**BEARING, CAMSHAFT INTERMEDIATE**														
		A BEARING SET CONSISTS OF ONE UPPER AND ONE LOWER BEARING.														
8A	5196022#	BEARING SET(STD.)					5									
8A	6196025#	BEARING SET (.010'O.S. ON O.D.)					AR									
8A	5196023 #	BEARING SET (.010'U.S. ON I.D.)					AR									
8A	5196024#	BEARING SET (.020'U.S. ON I.D.)					AR									
8A	51960268	BEARING SET (STD)					5									
BA	5196029 *	BEARING SET (.010'O.S. ON O.D.)					AR									
8A	5196027 $	BEARING SET (.010'0.S. ON I.D.)...........					AR									
8A	5196028 $	BEARING SET (.020'U.S. ON I.D.)					AR									
		# ALL CAST IRON CYLINDER BLOCKS; NOT USED IN ALUMINUM CYLINDER BLOCK EFFECTIVE WITH 4A-79662, 6A-76745. $ USE ONLY IN ALUMINUM CYLINDER BLOCK EFFECTIVE WITH 4A-79662, 6A-76745.														
	1.7050 -	**RING, CAMSHAFT INTERMEDIATE BEARING**														
8A	5115572	RING					10									
8A	6123383@	BOLT(1/4'-28X45/64'L)					5									
8A	5117849 $	SCREW (3/B'.24X.62'L.)					5									
		@ THRU 4A-79661, 6A-76744 FOR ALUMINUM CYLINDER BLOCKS. $ USE ONLY IN ALUMINUM CYLINDER BLOCK EFFECTIVE WITH 4A-79662, 6A-76745.														
	1.7080 -	**SHAFT, BALANCER**														
8A	51 58871	SHAFT, 371														
8A	5158872	SHAFT, 471														
8A	5158873	SHAFT, 671					1									
	1.7140 -	**WEIGHT, FRONT BALANCE**														
	5153000	WEIGHT, 371														
	5153001	WEIGHT, 471														
8A	5114031 $	WEIGHT, 71					2									
BA	51 50074 +	WEIGHT ASSY					2									
8A	5153914	KEY,1/4'X1'WOODRUFF.........................					2									
8A	5102668 *	KEY, 1/4'X1' WOODRUFF(.056' OFFSET)					AR									
8A	5177769	LOCKWASHER, 1 1/8' (INT. TOOTH)					2									
8A	5150087	NUT, 1 1/8'-18...					2									

1.7000 CAMSHAFT AND GEAR TRAIN

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	15	16	18	26	28	36	45	46	47	48
	1.7140 -	**WEIGHT, FRONT BALANCE**												
		(CONT'D)												
		$ EFFECTIVE WITH 6A-75447.												
		+ ASSEMBLY AND COMPONENTS NOT SERVICED: FOR COMPLETE REPLACEMENT THRU 6A-75446 USE 5114031.												
		* USE WITH ADV TIMED CAMSHAFTS IN 1.7001 FOR STD TIMING OR WITH STD TIMED CAMSHAFTS FOR ADVANCED TIMING.												
	1.7190 -	**WEIGHT, REAR BALANCE**												
8A	**5121968** #	WEIGHT, 371												
8A	**5121989** *	WEIGHT, 471												
8A	**5172346** @	WEIGHT,471												
8A	**5172347** %	WEIGHT,671					2							
8A	**5121970** &	WEIGHT, 671					2							
8A	**1813570**	BOLT, 3/8'-24X1 1/4' (12.9001)												
8A	**181365**	BOLT, 3/8'-24X1l 1/4' (12.9001)					4							
8A	**181371**	* BOLT, 3/8'-24X1 3/8' (12.9001)												
8A	**181374**	BOLT, 3/8'-24X1 1/2' (12.9001)					4							
		# EFFECTIVE WITH 3A-48440.												
		* EFFECTIVE WITH 4A-96718.												
		@ THRU 4A-86717.												
		% THRU 6A-101508.												
		& EFFECTIVE WITH BA-101509.												
	1.7200 -	**GEAR, CAMSHAFT AND/OR BALANCER SHAF-**												
8A	**5121815**	GEAR (R.H. HELIX) (CAMSHAFT LA-LD-RA-RD, BALANCER LB-LC-RB-RC					1							
8A	**5121816**	GEAR (L.H. HELIX) (CAMSHAFT ENG.)					1							
8A	**5108872**	GEAR (L.H. HELIX, BALANCER) LB-LC-RB-RC, BALANCER LA-LD-RA-RD												
8A	**5153914**	KEY, ¼"X1"WOODRUFF (1.7140)					2							
8A	**510268 ***	KEY, 1/4'X11 WOODRUFF(.056- OFFSET)					AR							
8A	**5150087**	NUT, 1/8'-18 (1.7140)					2							
		* USE WITH ADV... TIMED CAMSHAFTS IN 1.7001 FOR STD TIMING OR WITH STD TIMING CAMSHAFTS FOR ADV TIMING.												
	1.7207 -	**RETAINER, CAM AND BALANCER SHAFT GEAR NUT**												
8A	5172734	RETAINER					2							
8A	5185792	RETAINER												
8A	217946	BOLT, 5/16'-24X1/2' HEX SOCKET HD...												

1.7000 CAMSHAFT AND GEAR TRAIN

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	15	16	18	26	28	36	45	48	47	48		
	1.7207 -	**CAMSHAFT AND GEAR TRAIN**														
	1.7207 -	**RETAINER, CAM AND BALANCER SHAFT GEAR NUT (CONT'D)**														
8A	186627	@ BOLT, 3/8'-24X1' (12.9001).................					8									
	103320	LOCKWASHER, 5/16' (12.9200)														
8A	103321	LOCKWASHER, 3/8' (12 9200)					AR									
		@ THRU 4A-96717.														
	1.7220 -	**GEAR ASSY., IDLER**														
		A GEAR ASSY INCLUDES ITEMS IN 1.7222, 1.7225, 1.7250 AND FLYWHEEL HOUSING ATTACHING PARTS.														
8E	5199384 $	GEAR ASSY (L.H. HELIX).......................					1									
		(RA-RB-RC-RD ENG., ALUMINUM FLYWHEEL														
8E	5199327 $	GEAR ASSY (R.H. HELIX) .														
		(LA-LB-LC-LD ENG., ALUMINUM FLYWHEEL														
		$ REQUIRES ONE 454992 BOLT IN 1.7250.														
	1.7222 -	**GEAR, IDLER**														
8C	5113817	GEAR (L.HHELIX) (RA-RB-RC-RD ENG.)					1									
8C	5113818	GEAR (R.H HELIX) (LA-LB-LC-LD ENG.)														
1.7225	BEARING, IDLER GEAR															
8C	7451948	BEARING ASSY					1									
	1.7227 -	**RETAINER, IDLER GEAR BEARING**														
8C	5178998	RETAINER...					1									
8C	5178999 *	LOCK, BOLT...					3									
8C	446072	* BOLT, 5/16'-24X1/2' (12.9001)..............					6									
		* NOT SERVICED, USE 6-5103534 BOLTS ONLY.														
	1.7250 -	**HUB ASSY., IDLER GEAR**														
8C	5130135	HUB ASSY (INCLUDES DOWEL)					1									
8B,C	5151444	DOWEL..					1									
8B,C	18668889	$ BOLT, 1/2'-13X2' (12.9001)					1									

1.7000 CAMSHAFT AND GEAR TRAIN

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	15	16	18	26	28	36	45	46	47	48
	1.7250 -	**HUB ASSY., IDLER GEAR (CONT'D)**												
1.7250	-	HUB ASSY, IDLER GEAR												
8B,C	454992	+ BOLT, 1/2'-13X2 1/2' (12.9001)					1							
8B.C	5167714	WASHER (.0937' THICIK					1							
		* THRU 3A-4B439 4A-96717.												
		+ EFFECTIVE WITH 3A-48440, 4A-96718, 6A-101509.												
1.7280	-	SPACER ASSY., IDLER GEAR HOLE												
		A SPACER ASSY INCLUDES DOWEL IN												
8C	5131719*	SPACER ASSY					1							
8C	5117141 @	SPACER ASSY					1							
	6151444	DOWEL(1.7250)					1							
8C	5167714	WASHER (.0937' THICK)(1.7250)					1							
BC	186689	#BOLT 1/2'-13X2' (12.9001)					1							
BC	454992	* BOLT 1/2'-13X2 1/2' (12.9001)					1							
		* EFFECTIVE WITH 3A-51064, 4A-101902, 6A-1OBB013.												
		@ NOT SERVICED, THRU 3A-51063, 4A-101902, 6A-108812; USE 5131719 SPACER ASSY AND INCLUDE 1-454992 THRU 3A-51063, 4A-101902, 6A-108812.												

1.7000A BALANCE WEIGHT COVER

FIG	PART NUMBER	NAME AND DESCRIPTION	1	6	9	10	13	14	17	21	22	25	32	35		
	1.7470 -	**COVER, BALANCE WEIGHT**														
1.7470	COVER, BALANCE WEIGHT															
9A	6138237	COVER														
9A	5118653*	COVER			1											
9A	5188310	COVER (ALUM.)														
	6120231	COVER.														
	5177077	COVER														
9A	5182790+	COVER														
	6143644	PLUG, 5/16'-18 SPL.														
	5172472	STUD, 1/2'-13-20X2 1/4 SPL														
	179848	BOLT, 3/8'-16X1 7/8' (12.9001)			1											
	179848	BOLT, 3/8'-16X2 1/4' (12.9001)			1											
	188283	BOLT, 3/8'-16X3 1/2' (12.9001)			1											
	191249	BOLT 3/8'-16X3 3/4' (12.9001)			2											
	114926	BOLT, 3/8'-16X4 1/4 (12.9001)			1											
	450517	BOLT, 3/8'-16X4 3/4' (12.9001)														
	181t385	BOLT, 3/8'-24X3' (12.9001)			9											
	188309	BOLT, 3/8'-24X3 1/4' (12.9001)			2											
	186314	BOLT, 3/8'-24X4 1/2' (12.9001)														
	103341	WASHER, 3/8' FLAT (12.9190)			AR											
		* NOT SERVICED, USE 5162790 AND (2) 191249 BOLTS.			15											
		+ NOT SERVICED, USE 5138237, 2-5150014, 4-5143644.														
	1.7480 -	**GASKET, BALANCE WEIGHT COVER**														
	6121763	GASKET														
	1.7490 -	**COVER, BALANCE WEIGHT COVER**														
	515581	COVERC														
	103320	LOCKWASHER, 5/ 16' (12.9200)														
	103321	LOCKWASHER, 3/8' (12.9200)														
	121917	NUT, 5/16'-24 HEX (12.9120)														
	1.7500 -	**GASKET, BALANCE WEIGHT COVER HOLE COVER**														
	5135935	GASKET (7.4455)														
	1.7510 -	**STUD, BALANCE WEIGHT COVER HOLE COVER**														
	5155831	STUD														
	2192336	STUD														
	2076265	STUD (6.1050)														

1.7000B ACCESSORY DRIVE

FIG	PART NUMBER	NAME AND DESCRIPTION	1	9	28	29	33	50	51	54	56	62	63	64
	1.7605 -	**PULLEY, ACCESSORY DRIVE**												
9G	**5133559**	PULLEY (3.24” DIA., SINGLE GROOVE)									1			
9G	**5184291**	PULLEY (5 ½” DIA., SINGLE GROOVE).	1											
9G	**5168696**	PULLEY (5 ½” DIA., SINGLE GROOVE).		1										1
9E	**5108500**	PULLEY (6 ¼” DIA., DOUBLE GROOVE)1						1					1	
9E	**5113853**	PULLEY (6 3/8” DIA., 2 GROOVES)........			1									
9E	**5131726**	PULLEY (6 ¼” DIA, 2 GROVOES)...........										1		
9G	**5188124**	PULLEY (7.390” DIA., SINGLE GROOVE) (7.1505)							1					
9G	**6109507**	PULLEY (7.50” DIA., SINGLE GROOVE) (7.1505)									1			
9E	**124548**	KEY, 5/32'X3/4” WOODRUFF (12.9350) .	1						1		1			
9E	**124549**	KEY, 3/16'X3/4’ WOODRUFF (12.9350) .		1	1			1				1	1	1
9G	**179858**	BOLT, 7/16'-14X1” (12.9001)..................	1						1					
9G	**180147**	BOLT, 7/16'-14X1 ¼” (12.9001)...............									1			
9G	**5132987**	WASHER(29/64'X1 ½”X.320')	1						1		1			
	103322	LOCKWASHER, 7/16” (12.9200).............	1						1		1			
9E	**272906**	NUT, ¾” - 16 HEX. LOCK (12.9140)........		1								1	1	1
	1.7810 -	**HUB, DRIVE PULLEY**												
9G	**6164286**	HUB	1						1		1			
9G	**5194670**	RING, SPACER (OIL SEAL) (7.1515)......	AR						4		4			
9G	**5176474**	BOLT (3/8'-24X1 1/8")(1.7630)	4						4		4			
	103321	LOCKWASHER 3/8* (12.9200)................	4						4		4			
	1.7615 -	**RETAINER, DRIVE PULLEY HUB OIL SEAL**												
		A RETAINER ASSY. INCLUDES OIL SEAL IN 1.7620.												
9G	**5123115**	RETAINER ASSY	1						1		1			
9G	**179858**	BOLT 7/16'-14X1' (12.9001)	1						1		1			
9G	**179882**	BOLT, 1/2'-13X1 1/8 (12.9001)................	4						4		4			
	5150568	WASHER, FLAT COPPER (2.4050)........	1											
9G	**103322**	LOCKWASHER, 7/16' (12.9200)	1						1		1			
	103323	LOCKWASHER, 1/2' (12.9200)	4						4		4			
	1.7620 -	**SEAL, DRIVE PULLEY HUB OIL**												
9G	**5102458**	SEAL...	1						1		1			
	1.7630 -	**PLATE ASSY., ACCESSORY DRIVE**												
9E,H	**5133449**	PLATE..		1	1	1		1		1				
9E	**5131627**	PLATE..											1	1
9F	**5170450**	PLATE..					1					1		

1.7000A BALANCE WEIGHT COVER

FIG	PART NUMBER	NAME AND DESCRIPTION	1	9	28	29	33	50	51	54	56	62	63	64		
	1.7470 -	**COVER, BALANCE WEIGHT**														
9E,H	5177026	SPACER		1	1	1		1		1				1	1	
9H	5176474	BOLT(1 1/8'L.)		4	4	4		4		4				4	4	
9F	5145092	BOLT (1.20'L.) (SELF LOCKING) (12.5015)											4			
9F	6119920	BOLT (SELF LOCKING)					4									
	103321	LOCKWASHER, 3/8' (12.9200) $ NOT SERVICED, USE 5131627 AND 5143616.				AR										
	1.7835 -	**COUPLING, ACCESSORY DRIVE**														
9H	3292492 @	COUPLING @ NOT SERVICED, USE 5143616 AND 5131627.				1										
	1.7840 -	**SHAFT, ACCESSORY DRIVE**														
9E	6188897 #	SHAFT			1			1								
9E	6131130	SHAFT										1	1	1		
	461082	NUT, 3/4'-16 HEX LOCK (12.9140) # NOT SERVICED, USE 1-5122876 AND 1-5131627 PLATE.			1			1								
	1.7645 -	**RETAINER ASSY., ACCESSORY DRIVE**														
		A RETAINER ASSY INCLUDES ITEMS IN 1.7650, 1.7655 ND 1.7660														
9E	5123116	RETAINER ASSY		1	1			1								
9E	179858	BOLT, 7/16'-14X1' (12.9001)		1	1			1				1	1	1		
9E	179882	BOLT, 1/2'-13X1 1/8' (12.9001)		4	4			4				4	4	4		
9E	103322	LOCKWASHER, 7/16' (12.9200)											1	1		
9E	103323	LOCKWASHER, 1/2' (12.9200)											4	4		
	1.7860 -	**LOCKRING, ACCESSORY DRIVE BEARING**														
9E	5155783	LOCKRING		1	1			1								
9E	9415285	LOCKRING (2.7470)										1	1	1		
	1.7655 -	**BEARING, ACCESSORY DRIVE**														
9E	94407191	BEARING (N.D ......4605L1A)		1	1			1								
9E	944607191	BEARING (N.D ......5206W0)										1	1	1		

1.7000BACCESSORY DRIVE

FIG	PART NUMBER		NAME AND DESCRIPTION	1	9	28	29	33	50	51	54	56	62	63	64		
	1.7880	-	SEAL, ACCESSORY DRIVE OIL														
9E	5131329		SEAL		1	1			1				1	1	1		
	1.7665	-	SPACER, ACCESSORY DRIVE OIL SEAL														
	5131131	-	SPACER														
	1.7750	-	GEAR, GENERATOR STEP-UP														
	5185791		GEAR (INTERNAL)					1									
	5185793		BOLT, 7/16'-20X1 1/4' SOC. HD (1.7200)					6									
	6186794		LOCKWASHER, 7/16' (1.7200)					6									
	1.77655	-	RING, GENERATOR DRIVE SPACER														
	5185790		RING (7.1598)					1									
	5185810		GASKET (1.5040)					1									
	5185795		SCREW, 3/8'-24X5/8' SET (1.5130)					3									
	138221		SCREW, 5/16'-18X3/4' SOC. HD (12.9027)					3									

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1.7000BACCESSORY DRIVE

FIG	PART NUMBER	NAME AND DESCRIPTION	72	87	93	103	104	106	110	119	123	129	138	139		
	1.7600 -	DRIVE ASSY., ACCESSORY A DRIVE ASSY. INCLUDES ITEMS IN 1.7610, 1.7640, 1.7642, 1.7645, 1.7650, 1.7655 AND 1 7660.														
	5133747	DRIVE ASSY									1					
	179839	BOLT, 3/8'-16X1' (12.9001)									2					
	186318	BOLT, 3/8'-24X5 1/4' (12.9001)									4					
	103321	LOCKWASHER, 3/8' (12.9200)									6					
	117049	NUT, 3/8'-24 HEX. (12.9120)								4						
	1.7605 -	PULLEY, ACCESSORY DRIVE														
9E	5108600	PULLEY (6 1/4' DIA., DOUBLE GROOVE)		1												
9E	6113863	PULLEY (6 3/8' DIA., 2 GROOVES)	1													
9G	6129172	PULLEY (6.25' DIA., SINGLE GROOVE) (7.1505)							1							
9E	6133377	PULLEY (6.25' DIA., 2 GROOVES) (7.1505)									1					
9E	6144554	PULLEY (7.50' DIA., 2 GROOVES) (7.1505)										1				
9G	5142131	PULLEY (9' DIA., SINGLE GROOVE) (1.3280)					1	1								
	51397365	PLATE, SUPPORT (7.1505)					1	1								
9E	124543	KEY, 1/8'X1/2' WOODRUFF (12.9350)									1					
9E	124649	KEY. 3/16'X3/4' WOODRUFF (12.9350)	1	1			1									
	5167104	SPACER, 9/32'X1 1/2' O.D. (6.2022)							1			1				
	180120	BOLT, 3/8'-16X3/4' (12.9001)					3									
	181429	BOLT, 1/2'-20X1 1/4' (12.9001)							1			1				
	103321	LOCKWASHER, 3/8' (12.9200)					3	3								
	103323	LOCKWASHER, 1/2' (12.9200)							1			1				
9E	272906	NUT, 3/4'-16 HEX. LOCK (12.9140)	1	1			1									
	1.7810 -	HUB, DRIVE PULLEY														
	5142516	HUB					1									
9G	5164286	HUB								1						
	5143234	HUB									1					
	124643	KEY, 1/8'X1/2' WOODRUFF (12.9350)									2					
	124649	KEY, 3/16'X3/4' WOODRUFF (12.9350)					1									
	5125491	BOLT (SELF LOCKING) (1.7630)								4						
	1.7815 -	RETAINER. DRIVE PULLEY HUB OIL SEAL A RETAINER ASSY. INCLUDES OIL SEAL IN 1.7620.														
9G	5102S86	RETAINER ASSY								1						

1.8000 VALVE OPERATING MECHANISM

1.8070-BRAKE, Engine

Valve Operating Mechanism types shown on this chart include Detroit Diesel components as listed in type 60. The types also contain the following braking system parts which are not serviced by Detroit Diesel but are available thru the Jacobs Manufacturing Company, West Hartford, Connecticut. Furnish the Jacobs part numbers shown.

Jacob's Number	D.D.E.D. Number	Types Name and Description	60	69	82	83
1300	5136114	Harness, Dash Control Switch	1	1	1	
1510	5136116	Harness, Cluster Switch to Buffer Switch	1	1	1	1
1785	5136293	Harness, Cylinder Brake Wiring		1	1	1
1777	5136294	Harness, Buffer Switch to Leadout	1	1	1	1
3489	5101738	Cylinder Assy., Master Oil Supply	2	2	2	2
1301	5136113	Harness, Cylinder Brake Wiring	1			
3490	5101737	Cylinder Assy., Drone	2	4	4	4
1287	5136106	Connector, Master Supply	2	4	4	4
1332	5136107	Seal Ring, Brake Oil Supply	2	4	4	4
1341	5136128	Plug, 1/4"-28x1/2"	2	4	4	4
1322	5136104	Bridge, Exhaust Valve	4	6	6	6
1318	5136105	Bolt, Rocker Shaft and Cylinder Brake	8	12	12	12
2303	5145408	Switch Assy., Governor Buffer	1	1	1	
1495	5136109	Switch Assy., Cluster	1	1		1
1304	5136110	Switch Assy., Dash Control (on/off)	1	1		1
2733	5145667	Switch Assy., Governor Buffer	1			1
1305	5136111	Plate, Dash Control	1	1		1
2131	5139209	Bracket Assy., Electric Terminal	2	2	2	2
2335	5142169	Terminal Assy., Brake Leadout	1	1	1	1

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1.8000BVALVE OPERATING MECHANISM

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 2	3	4	17	18	21	38	58	60	64	85	91		
	1.8060 -	ARM ASSY., EXHAUST VALVE ROCKER AN ARM ASSY. INCLUDES ITEMS IN 1.8100, 1.8120, 1.8130, 1.8140 AND 1.8150.														
10A	5150304	ARM ASSY. (LEFT)														
10A	5150305	ARM ASSY. (RIGHT)														
10A	5148472	ARM ASSY. (LEFT)						6								
10A	5148475	ARM ASSY. (RIGHT)						6								
	1.8070 -	ENGINE BRAKE														
		FOR VALVE OPERATING MECHANISM TYPES INVOLVING JACOBS ENGINE BRAKE EQUIPMENT CONSULT THE CHART ON LAST PAGE OF SECTION 1.8000.														
	NPN	BRAKE ASSY. (SEE PAGE 6)														
	5101738 +	CYLINDER ASSY., MASTER OIL SUPPLY (JACOBS BRAKE #3489)														
	6101737 +	CYLINDER ASSY., DRONE (JACOBS BRAKE ...														
	6138106 +	CONNECTOR, MASTER SUPPLY (JACOBS BRAKE #1287)														
	5138107 +	SEAL RING, OIL SUPPLY (JACOBS BRAKE														
	5142169 +	TERMINAL ASSY., LEAD-OUT (JACOBS . BRAKE #2335)														
	5139209 +	BRACKET ASSY., ELECTRIC TERMINAL (JACOBS BRAKE #2131)														
	5136128 +	PLUG, 1/4’-28X 1/2’ (NYLON LOCK) (JACOBS BRAKE #1341)														
	120613	NUT, 1/4 -28 JAM. (12.9120)														
	5174286	NUT, 3/8’-24 LOCK (12.9140)														
		+ NOT SERVICED, PROCURE FROM JACOBS MANUFACTURING CO., WEST HARTFORD, CONNECTICUT. FURNISH THEIR PART NUMBER SHOWN IN PARENTHESES.														
	1.8080 -	ARM ASSY., INJECTOR ROCKER AN ARM ASSY. 5179954 INCLUDES ITEMS IN 1.8110 THRU 1.8150. ARM ASSY. 5146871 INCLUDES ITEMS IN 1.8110, 1.8130, 1.8140 AND 1.8150.														
10A	5179954	ARM ASSY						6								

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1.8000BVALVE OPERATING MECHANISM

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	17	18	21	38	58	60	64	85	91
	1.8100 -	BUSHING, EXHAUST VALVE ROCKER ARM-LARGE												
10A	5122445	BUSHING						12						
	1.8110 -	BUSHING. INJECTOR ROCKER ARM-LARGE												
10A	6160318	BUSHING						6						
	1.8120 -	BUSHING, INJECTOR AND EXHAUST VALVE ROCKER ARM-SMALL												
10A	5160311	BUSHING						18						
	1.8130 -	CLEVIS. INJECTOR AND EXHAUST VALVE ROCKER ARM												
10A	5150312	CLEVIS (PUSH ROD END)						18						
	1.8140 -	BUSHING, INJECTOR AND EXHAUST VALVE ROCKER ARM CLEVIS												
10A	5123700	BUSHING						18						
	1.8160 -	PIN, INJECTOR AND EXHAUST VALVE ROCKER ARM CLEVIS												
10A	5150314	PIN (CLEVIS END)						18						
	1.8160 -	SHAFT ASSY ROCKER ARM												
10A	6160322	SHAFT ASSY. (INCLUDES PLUG)						6						
10A	5140456	SHAFT ASSY. (INCLUDES NOZZLE)												
10A	5140454	NOZZLE												
	5151272	PLUG						6						
	1.8170 -	BRACKET. ROCKER ARM SHAFT												
10A	6150324	BRACKET						12						
10A	5150325	BOLT (SEE PAGE 6)						12						
	5136105 +	BOLT (JACOBS BRAKE #13)18												
		+ NOT SERVICED, PROCURE FROM JACOBS MANUFACTURING CO., WEST HARTFORD, CONNECTICUT. FURNISH THEIR PART												

1.8000BVALVE OPERATING MECHANISM

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 2	3	4	17	18	21	38	58	60	64	85	91		
	1.8170 -	BRACKET, ROCKER ARM SHAFT (CONT'D)														
		NUMBER WHICH IS SHOWN IN PARENTHESES.														
	1.8180 -	ROD, PUSH														
10A	5128840	ROD						18								
10A	5151601	LOCKNUT						18								
	1.8190 -	SPRING, PUSH ROD														
10A	5186858	SPRING						18								
	1.8200 -	SEAT, PUSH ROD SPRING -UPPER														
11A	5150302	SEAT						18								
	1.8210 -	SEAT. PUSH ROD SPRING - LOWER														
10A	5123250	SEAT						18								
	1.8250 -	RETAINER, PUSH ROD														
10A	6160303	RETAINER (SNAP RING)						18								
	1.8280 -	FOLLOWER ASSY CAM														
10A	5115087	FOLLOWER ASSY						18								
	1.8265 -	ROLLER SET. CAM FOLLOWER														
		A SET INCLUDES ROLLER WITH BUSHING AND PIN.														
	5195220	ROLLER SET						18								
	1.8300 -	GUIDE, CAM FOLLOWER														
10A	5150298	GUIDE						6								
10A	443603	BOLT. 1/4'-20X3/4' (12.9001)						12								
10A	120380	LOCKWASHER. 1/4' (12.9200)						12								

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1.8000BVALVE OPERATING MECHANISM

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 2	3	4	17	18	21	38	58	60	64	85	91		
	1.8310 -	VALVE, EXHAUST														
106	5193686	VALVE (INCLUDES LOCKS) (JET BLADE)														
10C	5194968	VALVE (INCLUDES LOCKS) (TURBO)														
10C	5195167	VALVE(INCLUDES LOCKS)						24								
	1.8320 -	GUIDE, EXHAUST VALVE INSTALLER (PKG.) CONSISTS OF 100 PIECES.														
10B	5120930	GUIDE(2VALVE HEAD)														
10C	5129919	GUIDE (4 VALVE HEAD)						24								
	5192717	GUIDE (.016'O.S. ON O.D.)														
	5100699*	SEAL (2 VALVE HEAD)														
	5129920*	SEAL (4 VALVE HEAD)						24								
	5199913	INSTALLER. EXHAUST VALVE SEAL (4 VALVE)						AR								
	5199914	INSTALLER, EXHAUST VALVE SEAL (2 VALVE) *NOT PART OF CYL. HEAD ASSY.														
	1.8330 -	INSERT, EXHAUST														
10B	5131096	INSERT (2 VALVE HEAD)														
10C	5101101	INSERT (4 VALVE HEAD)						24								
10B	5198230	INSERT (.010-O.S.)														
10C	5197167	INSERT (.O0'O.S.)						AR								
	1.8340 -	SPRING, EXHAUST VALVE														
10B	5150289	SPRING														
10C	5111339+	SPRING (BRIDGE AND VALVE)						36								
10C	5117561@=	SPRING (VALVE ONLY)						24								
10C	5147347	SPRING (SINGLE OR DOUBLE YELLOW STRIPE) THRU 4A-85186, 6A-94750. @ EFFECTIVE WITH 4A-85187, 6A-94751. = NOT SERVICED, FOR SERVICE USE 5147347 AND CHANGE OUT ALL CYLINDERS						24								
	1.8343 -	BRIDGE, EXHAUST VALVE														
10C	51175S85	BRIDGE (SEE PAGE 6)						12								
10C	5129101	SCREW (ADJUSTING)						12								
10C	5151601	NUT						12								

1.8000BVALVE OPERATING MECHANISM

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	17	18	21	38	58	60	64	85	91
	1.8345 -	GUIDE, EXHAUST VALVE BRIDGE												
10C	5117684 $	GUIDE (PRESSED IN TYPE)						12						
10C	5196843 +	GUIDE ITHREADED TYPE)							12					
		* EFFECTIVE WITH 4A-85187, 6A-94751.												
		+ THRU 4A-85186, 6A-94750.												
	1.8350 -	CAP, EXHAUST VALVE SPRING												
10B	5150291	CAP												
10C	5111338 +	CAP						24						
10C	5117563 $	CAP						24						
		+ THRU 4A-85186, 6A-94750.												
		$ EFFECTIVE WITH 4A-85187, 6A-94751.												
	1.8360 -	SEAT, EXHAUST VALVE SPRING												
106	5150292	SEAT												
10C	5198148 +	SEAT						24						
10C	5117562 $	SEAT						24						
	5111467 @	WASHER						24						
		+ THRU 4A-85186, 6A-94750.												
		* EFFECTIVE WITH 4A-85187, 6A-94751.												
		@ THRU 4A-78270, 6A-82175.												
	1.8370 -	LOCK, EXHAUST VALVE SPRING												
10B	838029	LOCK (HALVES)												
10C	5111337	LOCK (HALVES)						48						

1.8000BVALVE OPERATING MECHANISM

FIG.	PART NUMBER	NAME AND DESCRIPTION	322	323	324	325	326	327	328	329	390
1.8450 -		COVER ASSY., ROCKER									
	5103744	COVER, 671 CAST ALUM.-PLAIN									
	5103739 *	COVER, 671 CAST ALUM.-W/FILLER.									
	5103738 *	COVER, 671 CAST ALUM.-W/FILLER				1					
	5103737 *	COVER, 671 CAST ALUM.-W/FILLER									
	5103800 *	COVER, 671 CAST ALUM.-W/FILLER									
	5103798 @	COVER, 671 CAST ALUM.-W/BTHR									
	5103799 #	COVER, 671 CAST ALUM.-W/FILLER									
	5103801 %	COVER, 671 CAST ALUM.-W/FILLER-BTHR.									
	5103986 +	COVER, 671 CAST ALUM.-W/FILLER									
		* USE WITH ITEMS IN 4.5000A, TYPE 125.USE WITH ITEMS IN 4.8000A, TYPE 727.USE WITH ITEMS IN 4.5000A, TYPE 126.USE WITH ITEMS IN 4.5000A, TYPE 125 AND 4.BOOO8A, TYPE 727.									
		+ USE WITH ITEMS IN 4.5000A, TYPE 131 AND JACOBS BRAKE.									
1.8455 -		GASKET. ROCKER COVER									
	5104019	GASKET, 671-CAST COVER			1						
1.8460 -		BOLT, ROCKER COVER									
	5104015	BOLT, 6.57" L.-CAST COVER			4						
	5104020	BOLT, 8.53 L.-CAST COVER									
	5104514	WASHER, SPEC.-CAST COVER BOLT			4						
1.8461 -		ISOLATOR, ROCKER COVER BOLT									
	5104515	ISOLATOR, CAST COVER BOLT			4						
1.8500 -		PLATE, OPTION NAME									
	5104282 *	PLATE			AR						
		* NOT SERVICED. FOR REPLACEMENT PLATE CONTACT YOUR LOCAL DISTRIBUTOR AND PROVIDE ENGINE SERIAL NUMBER.									
1.8502 -		RETAINER, ROCKER COVER NAMEPLATE									
	5104202	RETAINER			2						
	5104109	RETAINER									
	9416857	SCREW, #8-32X 3/B' (12 9065)			4						

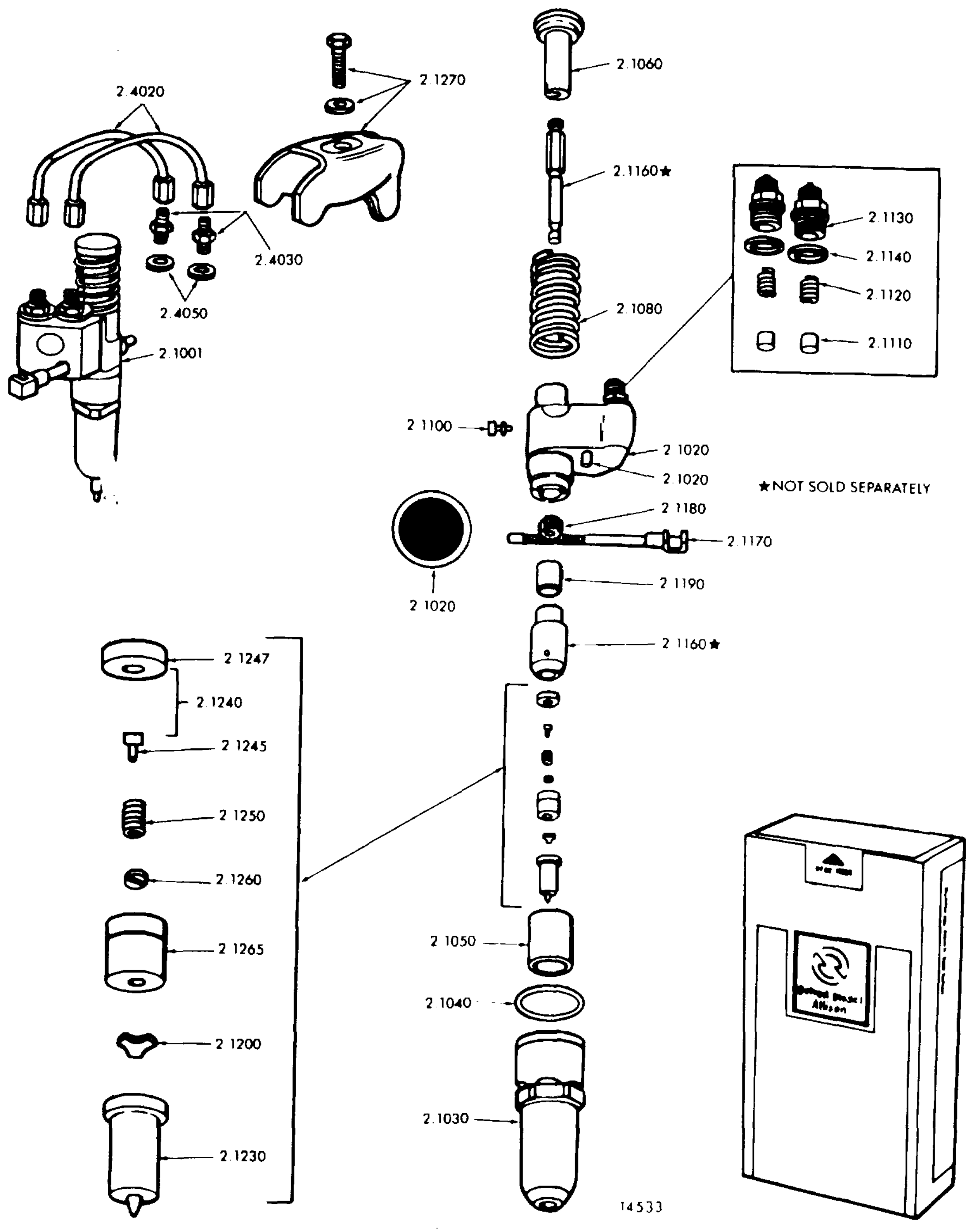

Fig. 1B FUEL INJECTOR

Fig. 1B of 2.0000

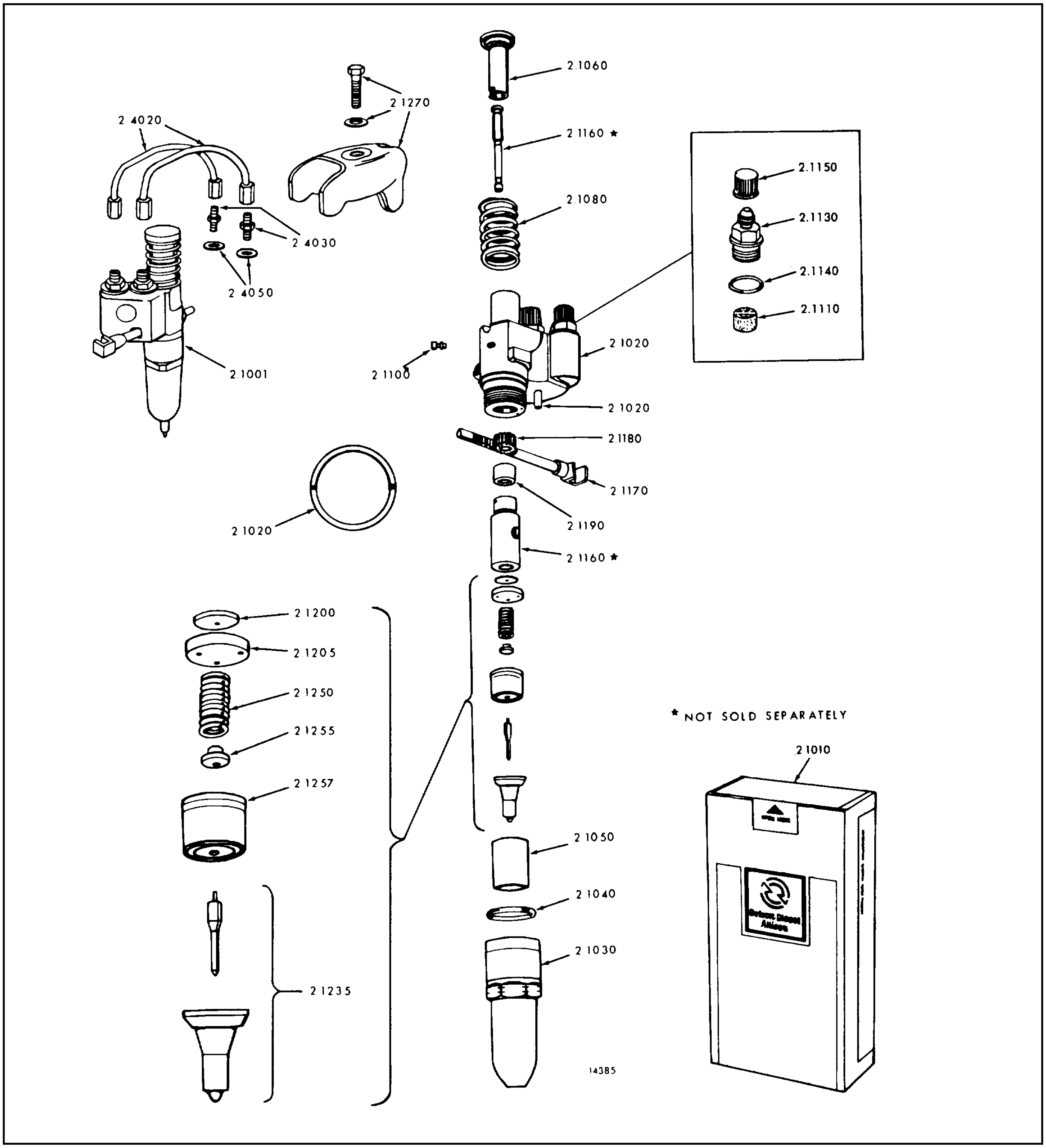

FIG. 1C FUEL INJECTOR

Fig. 1C of 2.0000

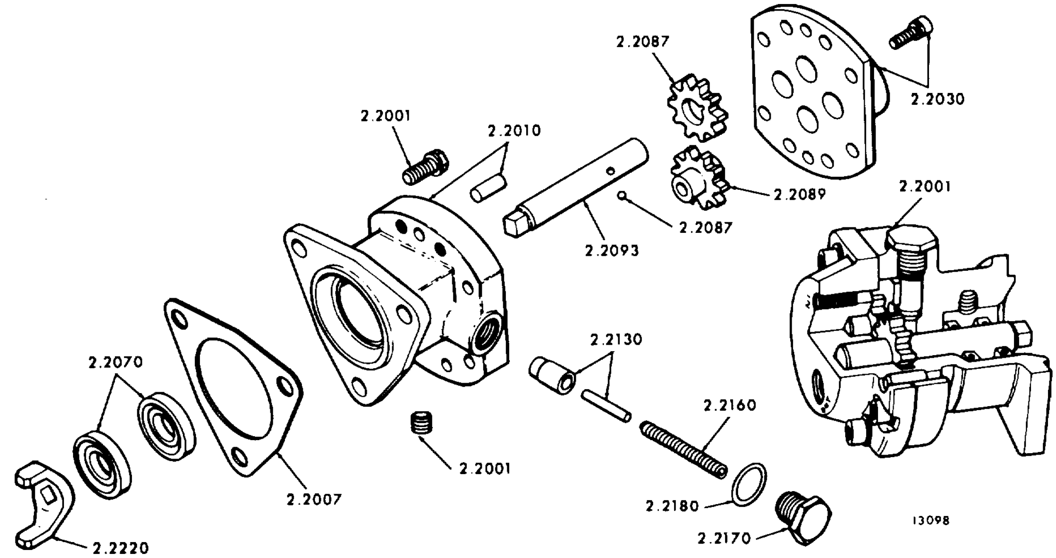

FIG. 2B. FUEL PUMP

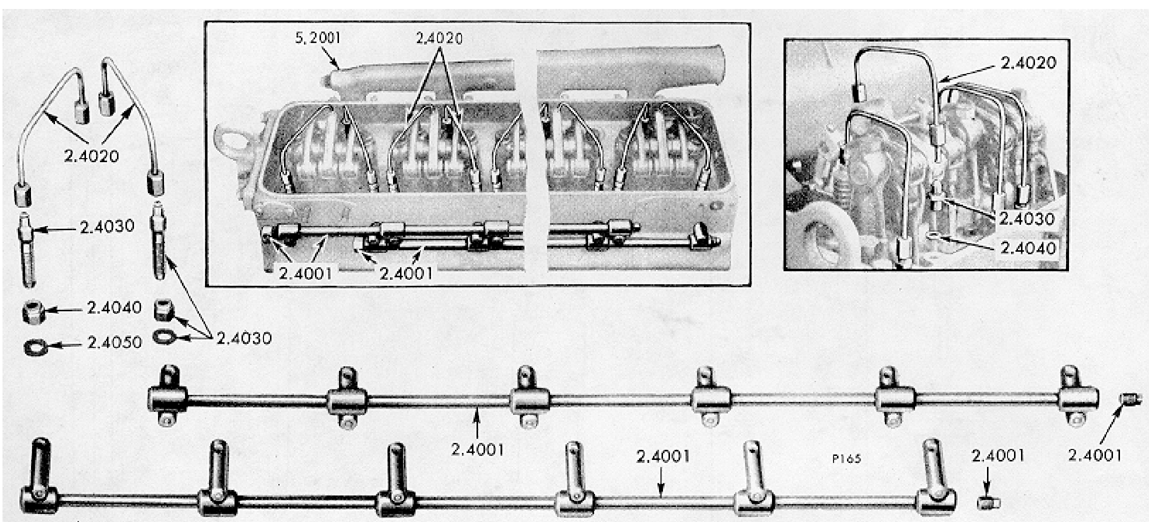

FIG. 3P FUEL MANIFOLD

Figs. 2B & 3P of 2.0000

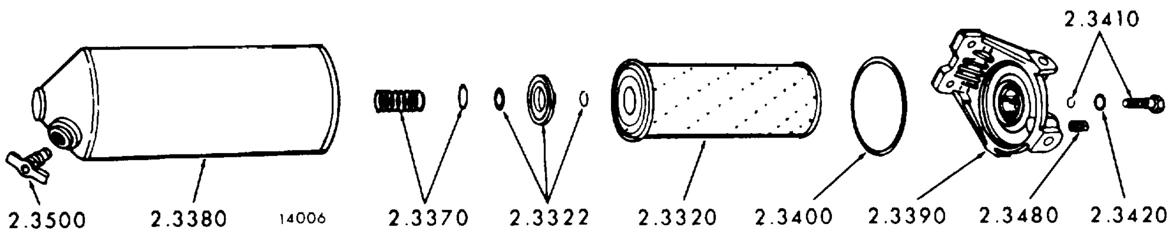

FIG. 4A FUEL FILTER

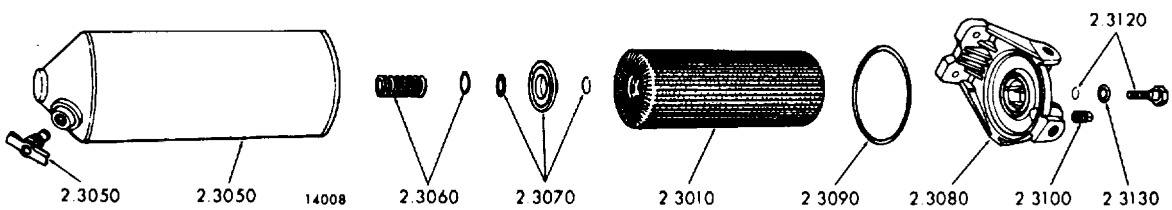

FIG. 4B FUEL STRAINER

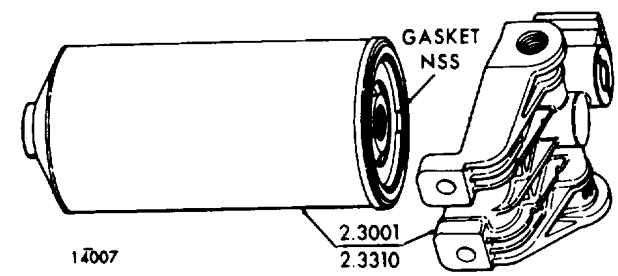

FIG. 4C FUEL STRAINER, FUEL FILTER (Spin-on)

Figs. 4A, 4B & 4C of 2.0000

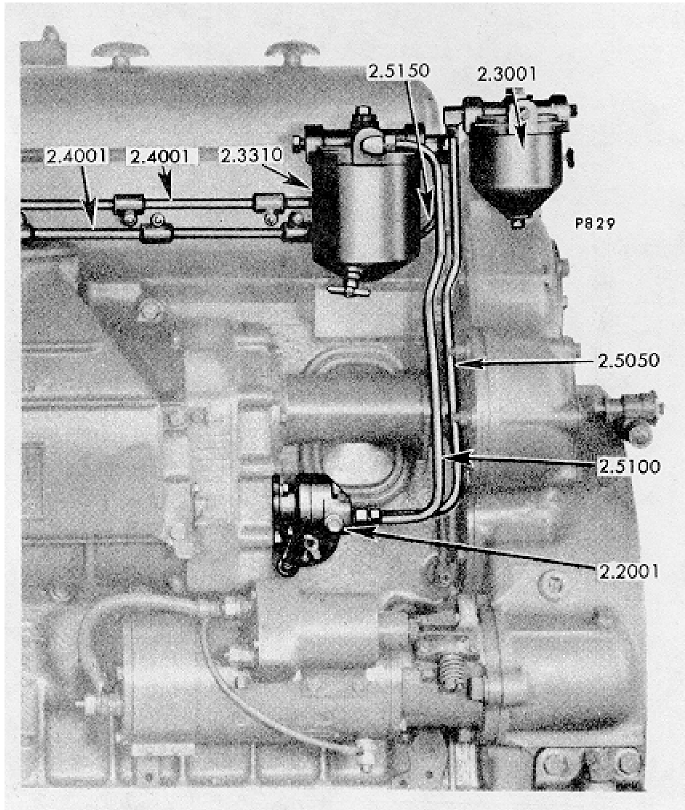

FIG. 5C TYPICAL FUEL LINES

Fig. 5C of 2.0000

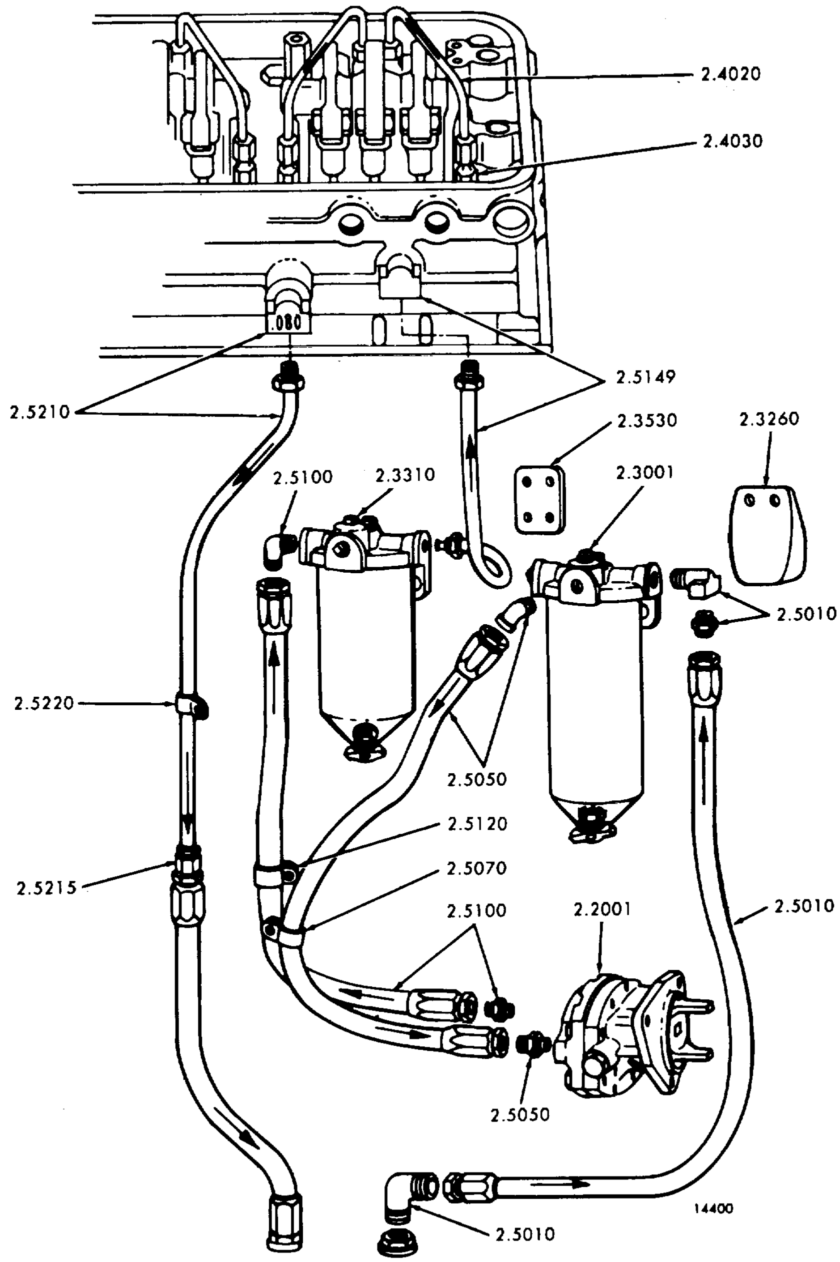

FIG. 5D TYPICAL FUEL SYSTEM

Fig. 5D of 2.0000

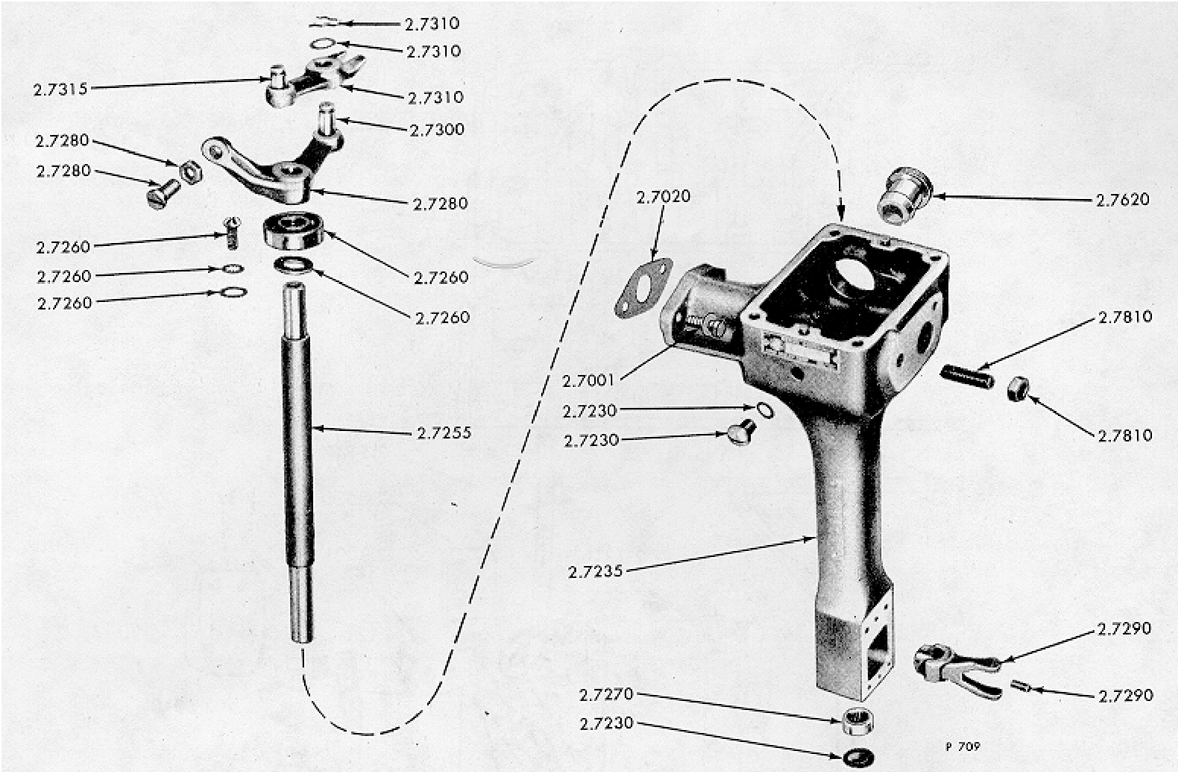

FIG. 6B GOVERNOR CONTROL HOUSING

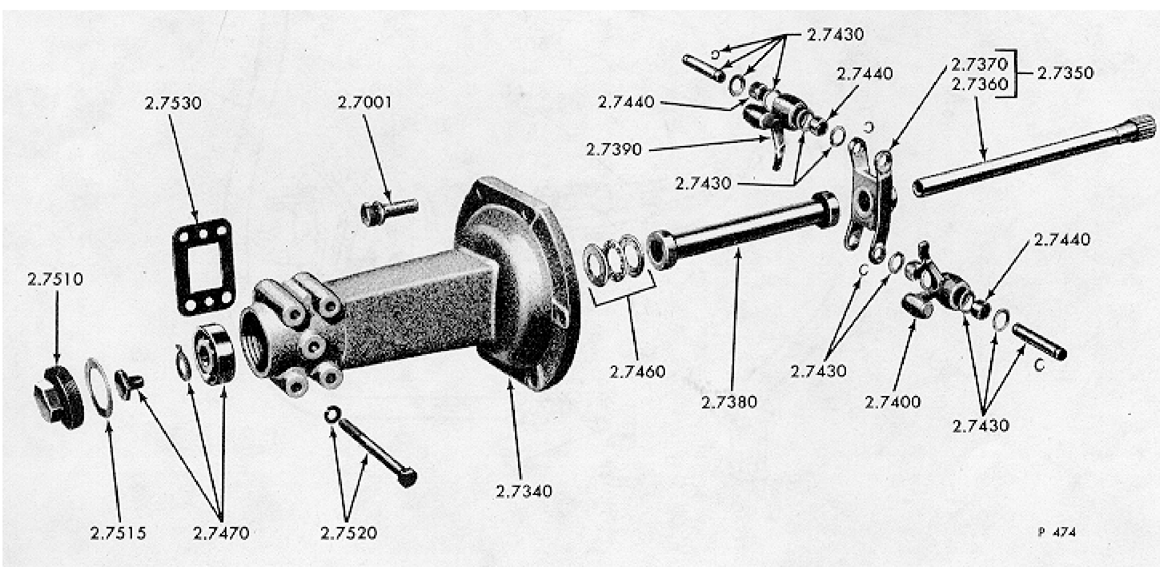

FIG. 6C GOVERNOR WEIGHT SHAFT AND HOUSING

Figs. 6B & 6C of 2.0000

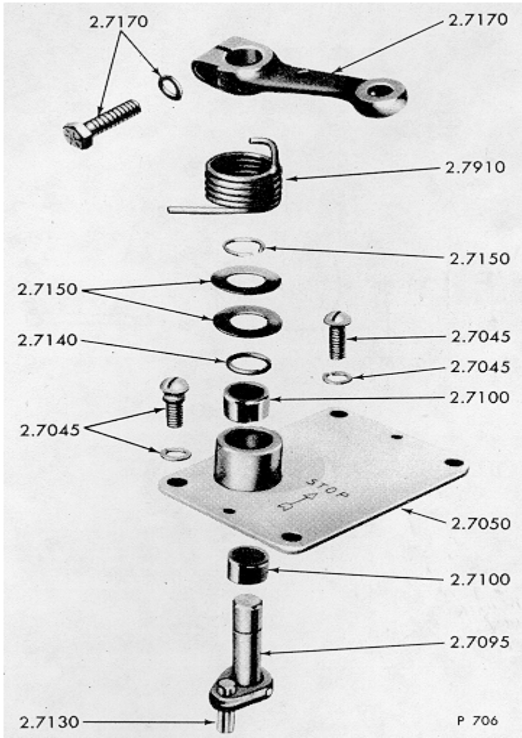

FIG. 6D GOVERNOR COVER
(Variable Speed)

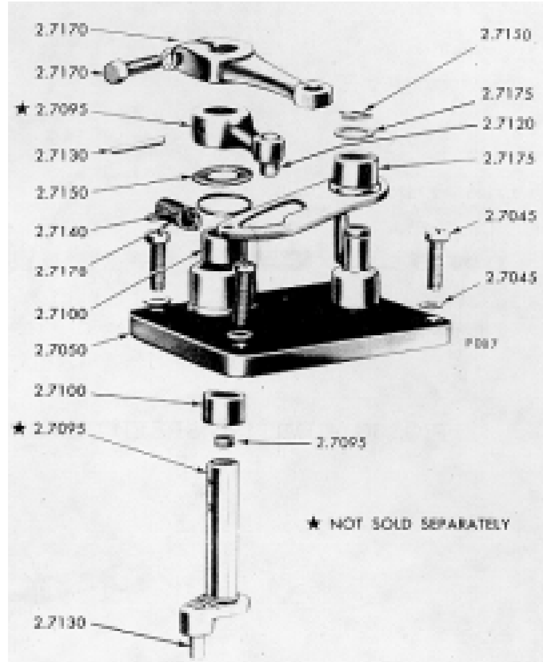

FIG. 6E GOVERNOR COVER
(Limiting Speed)

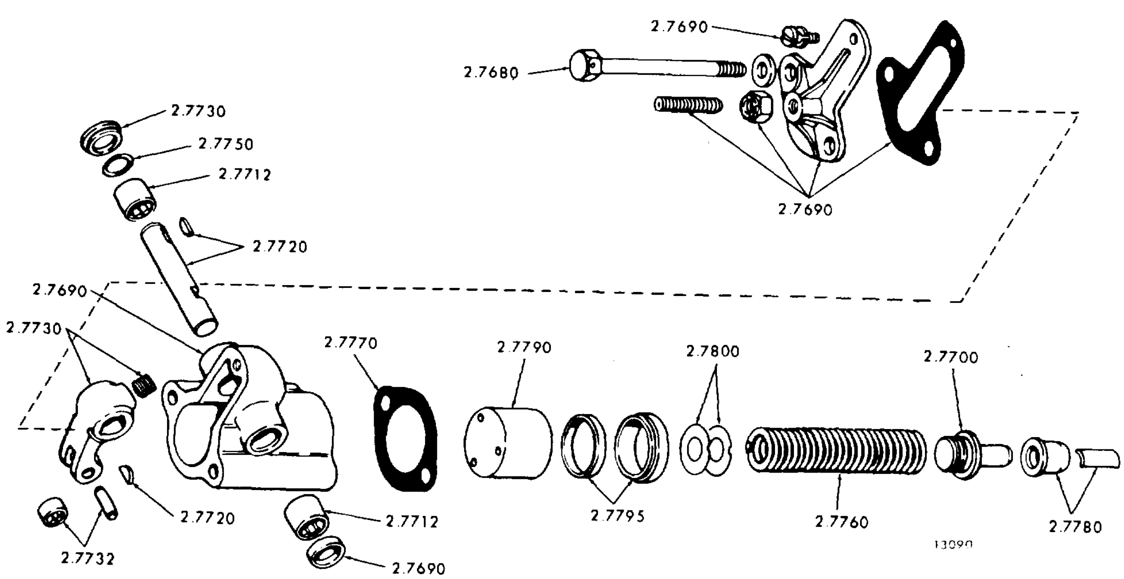

FIG. 6F GOVERNOR SPEED SPRING HOUSING (Variable Speed)

Figs. 6D, 6E & 6F of 2.0000

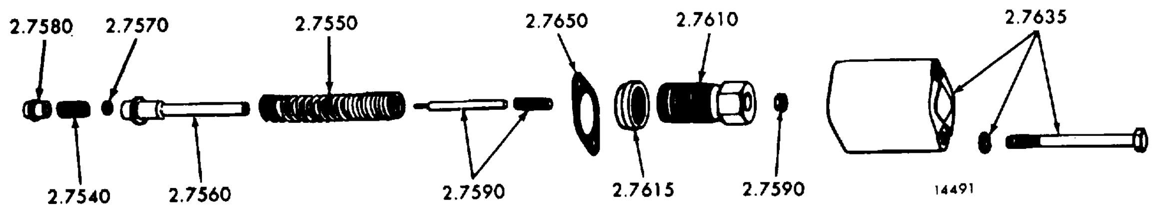

FIG. 6G LIMITING SPEED GOVERNOR SPRING AND HOUSING

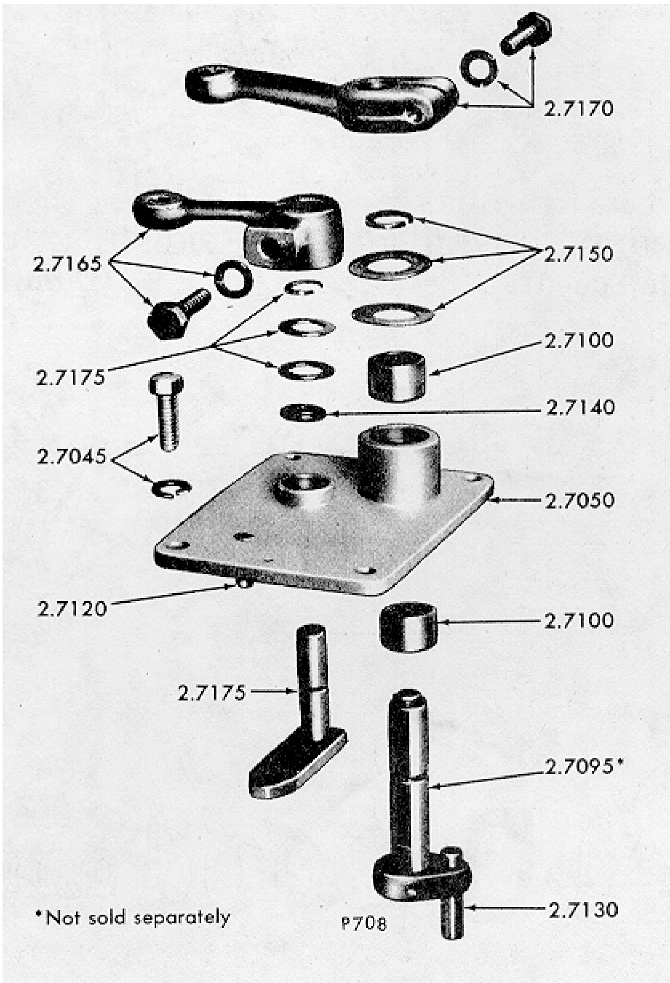

FIG. 6H GOVERNOR COVER (Limiting Speed) (Dual Controls)

Figs. 6G & 6H of 2.0000

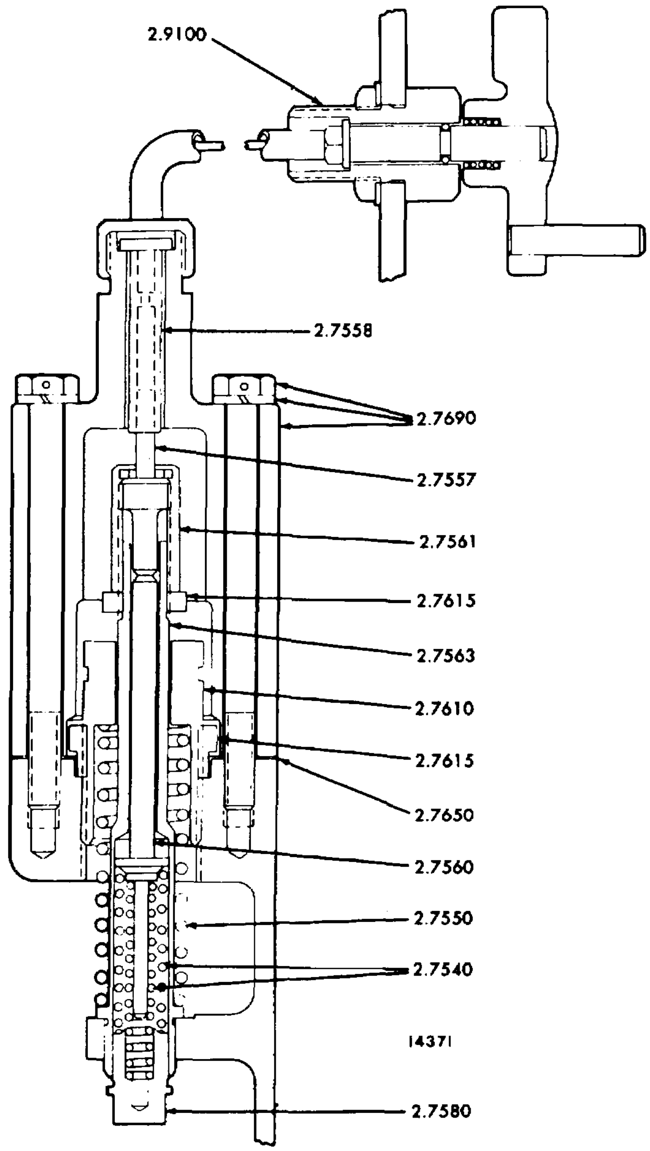

FIG. 6J VARIABLE - LIMITING SPEED GOVERNOR SPRING AND HOUSING (Pumper)

Fig. 6J of 2.0000

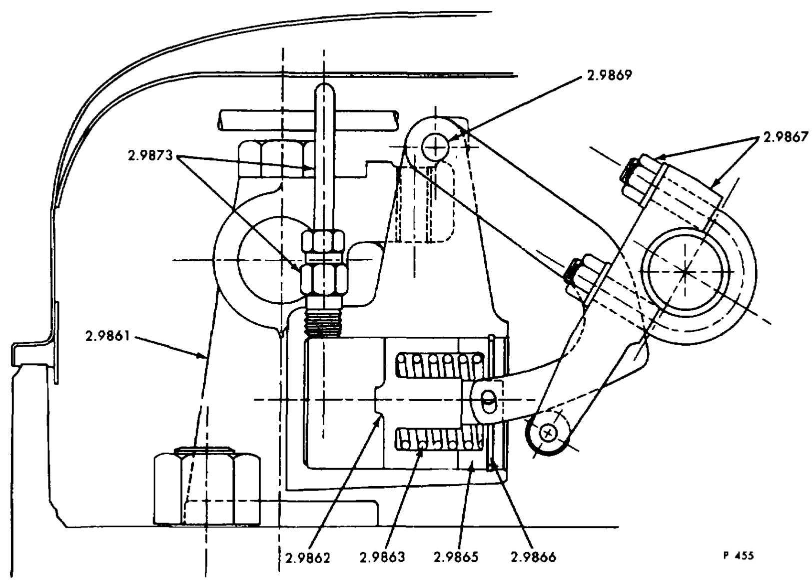

FIG. 7A FUEL MODULATOR ASSEMBLY

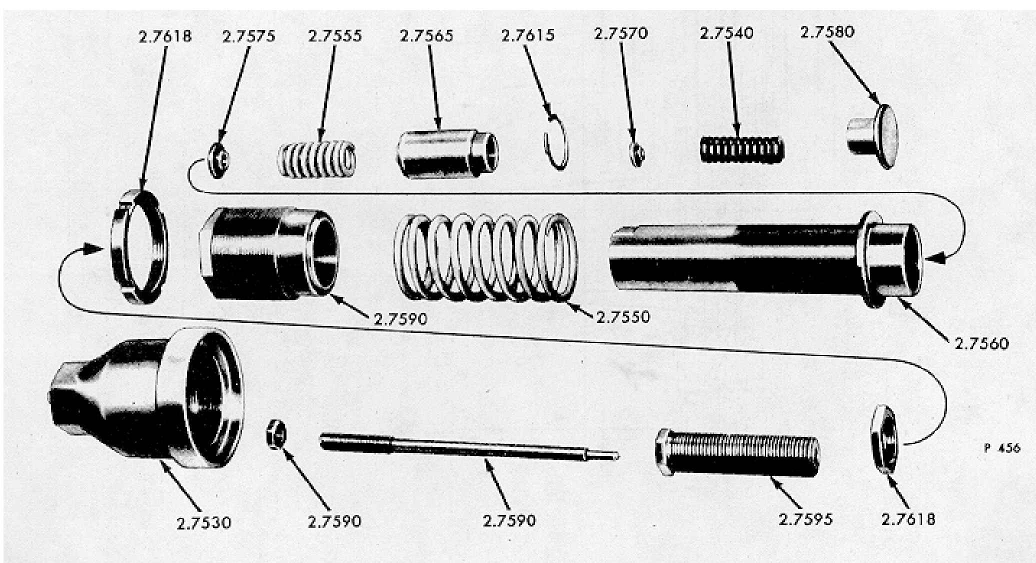

FIG. 7B FUEL MODULATING GOVERNOR SPEED SPRINGS AND CAP

Fig. 7A & 7B of 2.0000

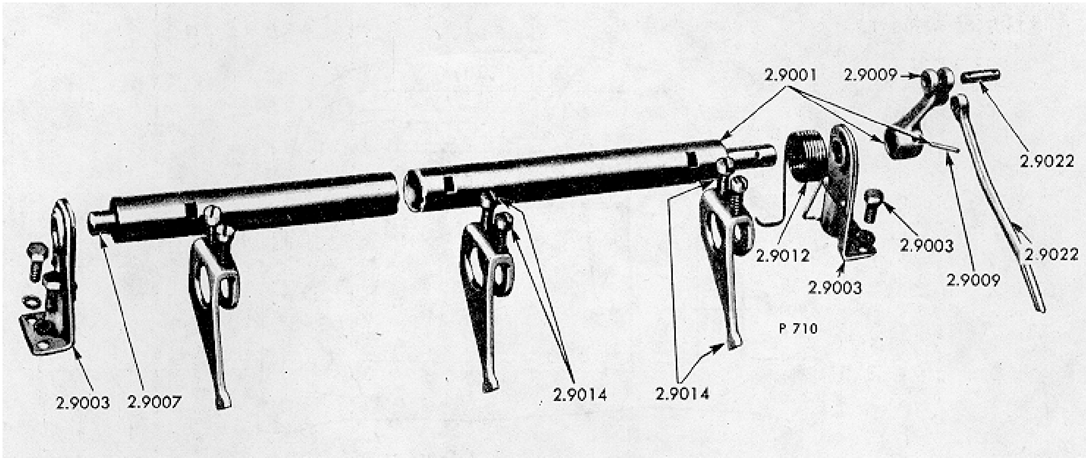

FIG. 8A INJECTOR CONTROL

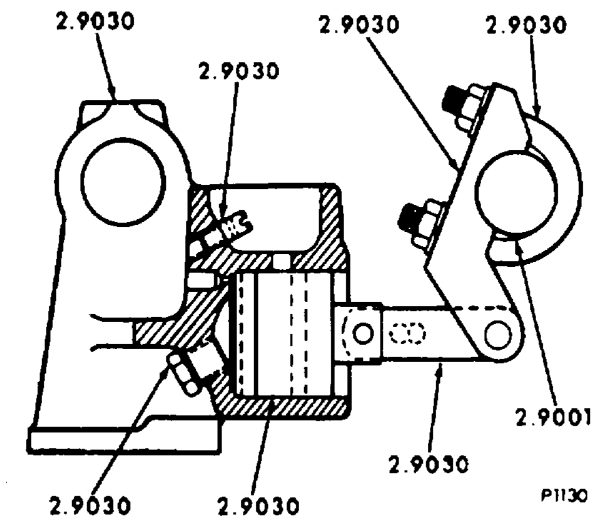

FIG. 8B THROTTLE DELAY CYLINDER

Figs. 8A & 8B of 2.0000

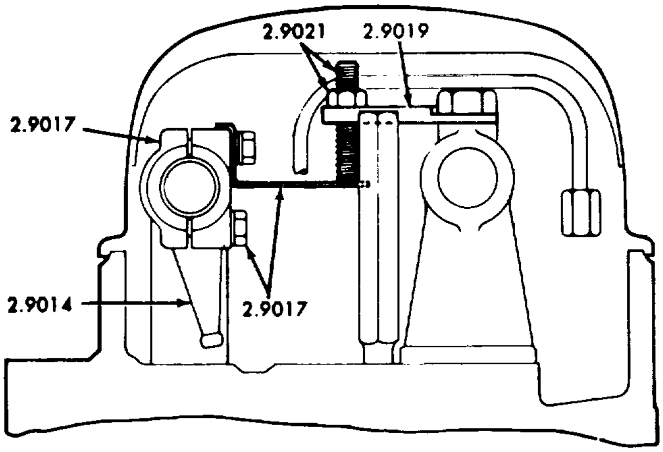

FIG. 8F POWER CONTROL

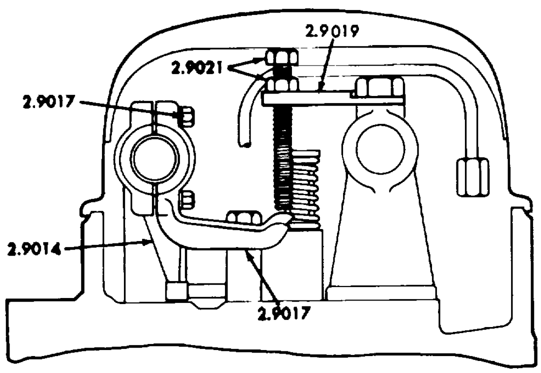

FIG. 8G TORQUE LIMIT CONTROL

Figs. 8F & 8G of 2.0000

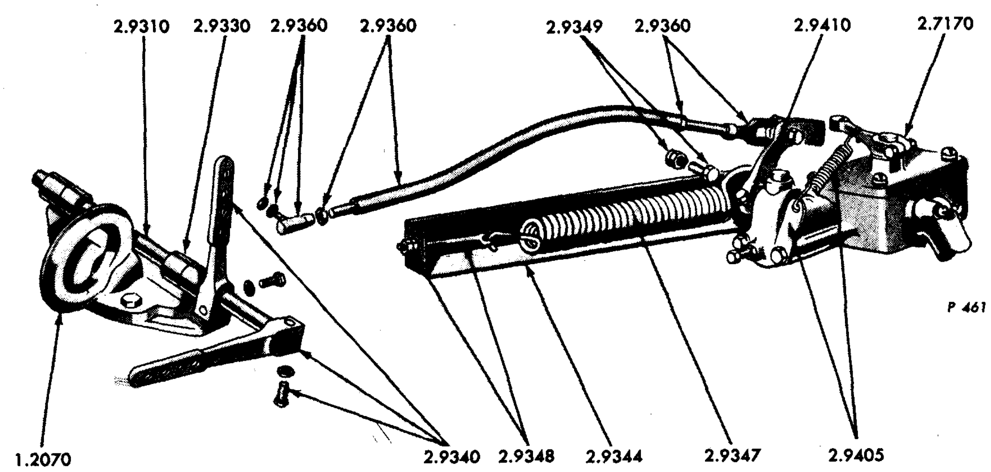

FIG. 9A THROTTLE CONTROLS (Variable Speed)

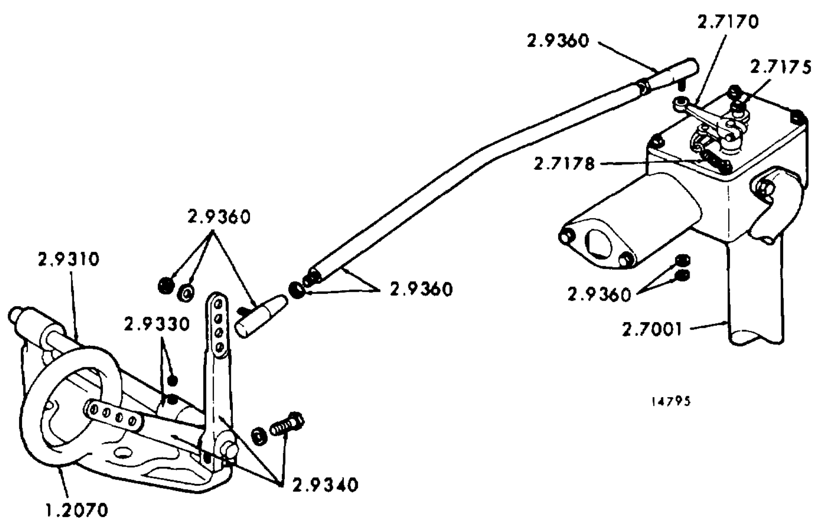

FIG. 9D THROTTLE CONTROLS (Limiting Speed)

Figs. 9A & 9D of 2.0000

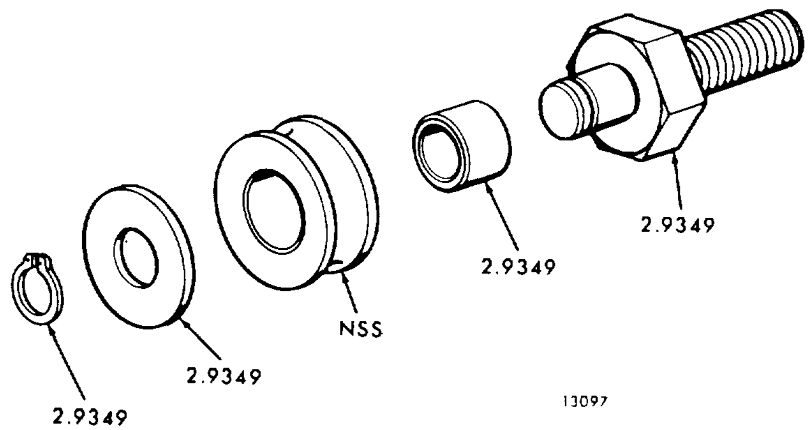

FIG. 9E HANGER ASSY., THROTTLE BOOSTER SPRING

Fig. 9E of 2.0000

71 VEH. ENGINES

2.1000AFUEL INJECTOR

FIG.	PART NUMBER	NAME AND DESCRIPTION	TYPES 114	115	128	129	130
	2.1001 -	INJECTOR ASSY.					
		QUANTITIES SHOWN ARE PER CYLINDER. AN INJECTOR ASSY. INCLUDES ITEMS IN 2.1020 THRU 2.1265.					
1C	5229370	INJECTOR ASSY. (C70)					
1C	5229365	INJECTOR ASSY. (C65)		1			
1C	5229555	INJECTOR ASSY. (B55)					
1C	5229560	INJECTOR ASSY. (B60)					
1C	5229565	INJECTOR ASSY. (B65)					
	2.1002 -	SERVICE KIT, INJECTOR					
		A KIT CONSISTS OF ONE (1) SEAL RING, TWO (2) FILTER CAP GASKETS, TWO (2) FILTER ELEMENTS AND TWO (2) SHIPPING CAPS.					
	5228701	SERVICE KIT		AR			
	2.1010 -	CONTAINER, INJECTOR SHIPPING					
1C	5293171	CONTAINER (12.8050)		AR			
	2.1020 -	BODY ASSY., INJECTOR					
		A BODY ASSY. INCLUDES DOWEL AND PLUG IN 2 1020.					
1C	5228583	BODY ASSY			1		
1C	5226416	DOWEL		1			
1C	5226912	PLUG, BODY		2			
1C	5229383	TAG, NUMBER (C70)					
1C	5229369	TAG, NUMBER (C65)		1			
1C	5229533	TAG, NUMBER (B55)					
1C	5229537	TAG, NUMBER (B60B)					
1C	5229539	TAG, NUMBER (B65)					
	2.1030 -	NUT, INJECTOR VALVE					
1C	5228601	NUT		1			
	2.1040	- RING, INJECTOR SEAL					
1C	5229167	RING -		1			

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2.1000AFUEL INJECTOR

FIG.	PART NUMBER	NAME AND DESCRIPTION	TYPES 114	115	128	129	130
	2.1050 -	DEFLECTOR, INJECTOR SPILL					
1C	5228109	DEFLECTOR		1			
	2.1060 -	FOLLOWER, INJECTOR					
1C	5228104	FOLLOWER		1			
	2.1080 -	SPRING, INJECTOR PLUNGER					
1C	5228739	SPRING (LOW CRAB BODY)		1			
	2.1100 -	PIN, INJECTOR STOP					
1C	5228608	PIN		2			
	2.1110 -	ELEMENT, INJECTOR FILTER					
1C	5228587	ELEMENT (INLET SIDE)		1			
	2.1130 -	CAP INJECTOR FILTER					
1C	5228588	CAP		2			
	2.1132 -	FILTER KIT. CONVERSION					
		KIT INCLUDES (1) EACH 5228587 ELEMENT IN 2.1110, 5228588 CAP IN 2.1130 AND 5226186 GASKET IN 2.1140.					
	5228882	FILTER KIT		AR			
	2.1140	GASKET. INJECTOR FILTER CAP					
1C	226186	GASKET		2			
	2.1150 -	CAP, INJECTOR SHIPPING					
	5226414	CAP	AR				
	2.1160 -	PLUNGER & BUSHING ASSY., INJECTOR					
		PLUNGERS AND BUSHINGS ARE NOT SOLD SEPARATELY. AN ASSY. INCLUDES PIN IN 2.1165.					

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2.1000AFUEL INJECTOR

FIG.	PART NUMBER	NAME AND DESCRIPTION	TYPES 114	115	128	129	130
	2.1160 -	PLUNGER & BUSHING ASSY INJECTOR (CONT'D)					
1C	5229372	PLUNGER AND BUSHING ASSY. (C70)					
1C	5229366	PLUNGER AND BUSHING ASSY. (C65)	1				
1C	5229346	PLUNGER AND BUSHING ASSY. (B55)					
1C	5229542	PLUNGER AND BUSHING ASSY. (B65)					
1C	5229354	PLUNGER AND BUSHING ASSY. (B60)					
	2.1165 -	PIN, BUSHING GUIDE					
	5226393	PIN		1			
	2.1170 -	RACK ASSY INJECTOR					
1C	5226719	RACK ASSY		1			
	2.1180-	GEAR. INJECTOR					
1C	5226400	GEAR		1			
1C	5228802	GEAR					
	2.1190 -	RETAINER,INNJECTOR GEAR					
1C	5228586	RETAINER		1			
	2.1200 -	VALVE. INJECTOR CHECK					
1C	5228694	VALVE		1			
	2.1205 -	CAGE. INJECTOR CHECK VALVE					
1C	5228696	CAGE		1			
	2.1235 -	TIP ASSY., INJECTOR SPRAY					
1C	229192	TIP ASSY.(C5)		1			
1C	S229532	TIP ASSY. (B55) (B60)					
1C	5229030	TIP ASSY. (B65)					
	2.1238 -	VALVE KIT, INJECTOR					
	5228769	VALVE KIT (INCLUDES ITEMS IN 2.1250 AND 2.1255)	AR				

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2.1000A FUEL INJECTOR

FIG	PART NUMBER	NAME AND DESCRIPTION	114	115	128	129	130
	2.1250 -	SPRING. INJECTOR VALVE					
1C	5228596	SPRING					
	2.12655 -	SEAT, INJECTOR VALVE SPRING					
1C	5228766	SEAT		1			
	2.1257 -	CAGE, INJECTOR VALVE SPRING					
1C	6228694	CAGE		1			
	2.1270 -	CLAMP, INJECTOR					
1C	5121259	CLAMP(LOWCRAB)		1			
1C	6150250	WASHER		1			
	2.1280 -	STUD, INJECTOR CLAMP					
1C	179847	BOLT, 3/8’-16X2’ (WITH LOW CRAB CLAMP)		1			

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2.2000 FUEL PUMP

FIG.	PART NUMBER	NAME AND DESCRIPTION	7	8	71	76	84	99	115	125	126	133	141
	2.2001 -	PUMP ASSY., FUEL											
		FOR TYPE 111 USE TYPE 84. SEE ASSEMBLY BREAKDOWN PAGE AS INDICATED BELOW. A FUEL PUMP KIT INCLUDES A 3/8' INLET PUMP, GASKET IN 2 2007 AND REDUCING BUSHING IN 2.2030.											
2B	5184532 *	PUMP ASM., C OR D ENG.-1/4' INLET (PAGE A1)											
2B	5134706 *	PUMP ASM., C OR D ENG. 1/4'											
	5199561	PUMP KIT, C OR D ENG (PAGE B1)								1			
2B	5184531 *	PUMP ASM., A OR B ENG-1/4' INLET (PAGE A1)											
2B	5134705 *	PUMP ASM., A OR B ENG.-3/8'. INLET (PAGE A1)											
	5199560	PUMP KIT, A OR B ENG. (PAGE B1)											
2B	5111366 #	PUMP ASM., A OR B ENG.-1/4' INLET (PAGE A1)											
	5199562	PUMP KIT, A OR B ENG. (PAGE B1)											
2B	5111367 #	PUMP ASM., C OR D ENG.-1/4' INLET (PAGE A1)											
	5198875	PUMP KIT, CORD ENG. (PAGE B1)											
2B	5134703 @	PUMP ASM, R.H.-3/8' INLET HIGH CAP (PAGE A1)											
2B	5134704 @	PUMP ASSY. (D ENG) (L H.) 3/8' INLET HI CAP (PAGE A1)											
2B	5146340 @	PUMP ASSY (R H.) (3/8' INLET) (PAGE A1)								1			
2B	51463410 @	PUMP ASSY. (L.H.) (3/8' INLET) (PAGE A1)											
2B	5146700	PUMP ASSY. (L.H) (3/8' INLET) (PAGE B1)											
2B	5199734	PUMP KIT. R.H.-3/8' INLET HIGH CAP. (PAGE 61)											
	5152716	COVER, FUEL HOLE (3 4223)											
	5150193	GASKET (5.1010)											
	5136240	PLUG (.420' DIA.) (OUTLET)								1			
	S136241	PLUG (5(0' DIA.) (INLET) .							1				
	5145009	PLUG, 1/8' PIPE (129550)								3			
2A	5131685	BOLT(WITH SEAL-WASHER)								3			
	179816	BOLT, 5/16'-18X3/4' (12 9001)											
	186625	BOLT, 5/16'-18X7/8' (12 9001)											
	103320	LOCKWASHER, 5/16' (12.9200)											
	446202	WASHER, 5/16' (12.9190)											
		* NOT SERVICED COMPONENTS ARE AVAILABLE, FOR COMPLETE REPLACEMENT USE 5199560 PUMP KIT FOR A OR, B ENG. AND 5199561 PUMP KIT FOR C OR D ENG											

71 VEH. ENGINES

2.2000 FUEL PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 7	8	71	76	84	99	115	125	126	133	141			
	2.2001 -	PUMP ASSY., FUEL														
		# USE WHEN FUEL TANK IS MTD. HIGHER THAN FUEL PUMP, NOT SERVICED-COMPONENTS ARE AVAILABLE, FOR COMPLETE REPLACEMENT USE 5199562 PUMP KIT FOR A OR B ENG. AND 5198875 PUMP KIT FOR C OR D ENG. @ NOT SERVICED. COMPONENTS ARE AVAILABLE, FOR COMPLETE REPLACEMENT USE PUMP KIT OR ASSEMBLY SHOWN IN SAME TYPE.														
	2.2004 -	OVERHAUL KIT, FUEL PUMP														
	6195078 &	OVERHAUL KIT														
	6196938	OVERHAUL KIT														
	2.2007 -	GASKET, FUEL PUMP TO ENGINE														
2A,B	5150193	GASKET(5.1010)								1						
	2.2220 -	FORK, FUEL PUMP COUPLING														
2A6B	5102257	FORK								1						
	2.22365 -	PLATE, FUEL PUMP MOUNTING														
	5139332	PLATE														
	2.2237 -	GASKET, FUEL PUMP MOUNTING PLATE														
	5117061	GASKET														
	2.2260 -	ADAPTER ASSY., FUEL PUMP DRIVE														
	5139309	ADAPTER														
	9409035	BOLT, 3/8'-24X1' (LOCK)(12.9001)														

2.2000A FUEL PUMP DRAIN

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 2													
		2.2300 - TUBE, FUEL PUMP DRAIN														
2B	**5158825**	TUBE ASSY. (DEV. L. 4 1/4")	1													
	444687	PLUG, 1/8" PIPE (12.9550)	1													
	137406	CONNECTOR, 5/16" INV. FL. TUBE (12.9460)	1													

2.2000 FUEL PUMP ASSEMBLIES

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.2001 - PUMP ASSY., FUEL														
2B	**5184532** *	PUMP ASM., C OR D ENG	1													
2B	**5134706** *	PUMP ASM., C OR D ENG		1												
2B	**5184531** *	PUMP ASM., A OR B ENG			1											
2B	**5134705** *	PUMP ASM., A OR B ENG				1										
2B	**5111366** *	PUMP ASM., A OR B ENG					1									
28	**5111367** *	PUMP ASM., C OR D ENG						1								
2B	**5134703** *	PUMP ASM., R.H.-HIGH CAP							1							
2B	**5134704** *	PUMP ASM., L.H.-HIGH CAP								1						
2B	**5146340** *	PUMP ASM., R.H.-3/8" INLET									1					
2B	**5146341** *	PUMP ASM., L.H.-3/8" INLET										1				
		* NOT SERVICED, REFERENCE ONLY.														
		2.2010 - BODY, FUEL PUMP														
2B	**5100311** @	BODY (5146339)								1						
2B	**5177292** @	BODY (5113776)	1	1				1								
2B	**5100310** @	BODY (5146338)							1							
2B	**5177293** @	BODY (5146337)			1	1	1									
2B	**5113776**	BODY									1					
2B	**5146337**	BODY										1				
2B	**141195**	PIN, 1/4"X5/8" DOWEL (12.9220)	2	2	2	2	2	2	2	2	2	2				
		@ NOT SERVICED, FOR REPLACEMENT USE PART NUMBER IN PARENTHESES AND INCLUDE 2-5145009 PLUG.														
		2.2030 - COVER, FUEL PUMP														
2B	**5134560**	COVER				1				1		1				
2B	**5134628**	COVER		1					1		1					
2B	**5174962** $	COVER	1		1		1	1								
	5198558 #	BUSHING, 3/8"X1/4" RED. (FACE)	1		1		1	1								
2B	**3719219**	BOLT (W/LOCKWASHER)	8	8	8	8	8	8	8	8	8	8				
		$ NOT SERVICED, USE 5134560 FOR L.H ROTATION PUMPS OR 5134628 FOR R.H ROTATING PUMPS AND INCLUDE (1) 5198558 REDUCING BUSHING IN 2 2030.														
		BUSHING USED TO REDUCE 3/8" INLET PUMPS TO 1/4" INLET.														
		2.2070 - SEAL, FUEL PUMP OIL														
2B	**5230007**	SEAL	2	2	2	2	2	2	2	2	2	2				

2.2000 FUEL PUMP ASSEMBLIES

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.2087 - GEAR, FUEL PUMP DRIVE														
2B	**5174975**	GEAR, 1/4" WIDE	1	1	1	1	1	1			1	1				
2B	**5128217**	GEAR, 3/8" WIDE							1	1						
	147481	BALL, 1/8" DIA STEEL (12.9670)	1	1	1	1	1	1	1	1	1	1				
		2.2089 - SHAFT, FUEL PUMP DRIVEN														
		A SHAFT ASSY. INCLUDES GEAR, NOT SOLD SEPARATELY.														
2B	**5181747**	SHAFT ASSY	1	1	1	1	1	1			1	1				
2B	**5100313**	SHAFT ASSY							1	1						
		2.2093 - SHAFT, FUEL PUMP DRIVE														
		A SHAFT ASSY. INCLUDES SHAFT IN 2.2093 AND ITEMS IN 2.2087.														
2B	**5181746**	SHAFT ASM	1	1	1	1	1	1			1	1				
2B	**5100314**	SHAFT ASM							1	1						
	5178700	SHAFT	1	1	1	1	1	1			1	1				
2B	**5108444**	SHAFT							1	1						
		2.2094 - SLEEVE, FUEL PUMP OIL SEAL														
	5192649 #	SLEEVE	1		1		1	1								
		2.2130 - VALVE, FUEL PUMP														
2B	**5174973**	VALVE	1	1	1	1	1	1	1	1	1	1				
2B	**103709**	PIN, 5/32"X1" STRAIGHT (12.9300)	1	1	1	1	1	1	1	1	1	1				
		2.2160 - SPRING, FUEL PUMP VALVE RETAINING														
2B	**5184530**	SPRING	1	1	1	1	1	1	1	1	1	1				
		2.2170 - PLUG, FUEL PUMP VALVE														
2B	**5174971**	PLUG	1	1	1	1	1	1	1	1	1	1				
		2.2180 - GASKET, FUEL PUMP VALVE PLUG														
2B	**5161003**	GASKET	1	1	1	1	1	1	1	1	1	1				

2.2000 FUEL PUMP ASSEMBLIES

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.2001 - PUMP ASSY., FUEL														
2B	**5146700**	PUMP ASSY (L.H.) (3/8" INLET)	1													
2B	**5199734**	PUMP ASSY (R.H.) (3/8" INLET)		1												
	5199562	PUMP KIT, FUEL			1											
	5198875	PUMP KIT, FUEL				1										
	5199568	PUMP KIT, FUEL					1									
	5199561	PUMP KIT, FUEL						1								
	5145009	PLUG, 1/8" PIPE (12.9550)		2	2		2	2								
		2.2010 - BODY, FUEL PUMP														
2B	**5146339**	BODY	1													
2B	**5146338**	BODY		1												
2B	**5146337**	BODY			1		1									
2B	**5177292** @	BODY (5146337)				1										
2B	**5113776**	BODY						1								
2B	**141196**	PIN, 1/4"X5/8" DOWEL (12 9290)	2	2	2	2	2	2								
	5136240	PLUG (.420" DIA.) (OUTLET)		1	1	1	1	1								
	5136241	PLUG (.580" DIA.) (INLET)		1	1	1	1	1								
	5150193	GASKET (5.1010)		1	1	1	1	1								
		@ NOT SERVICED, FOR REPLACEMENT USE P/N IN PARENTHESES AND INCLUDE 2-5145009 PLUG.														
		2.2030 - COVER, FUEL PUMP														
2B	**5134680**	COVER	1		1		1									
2B	**5134828**	COVER		1		1		1								
	5198558	BUSHING, 3/8"X1/4"		1	1	1	1	1								
2B	**3719219**	BOLT (W/LOCKWASHER)	8	8	8	8	8	8								
		2.2070 - SEAL, FUEL PUMP														
2B	**5230007**	SEAL	2	2	2	2	2	2								
		2.2087 - GEAR, FUEL PUMP DRIVE														
2B	**5128217**	GEAR	1	1												
2B	**5174975**	GEAR			1	1	1	1								
2B	**147481**	BALL, 1/8" DIA STEEL(12.970)	1	1	1	1	1	1								
		2.2089 - SHAFT, FUEL PUMP DRIVEN														
		A SHAFT ASSY. INCLUDES GEAR, NOT SOLD SEPARATELY.														
2B	**5100313**	SHAFT ASSY	1	1												

2.2000 FUEL PUMP ASSEMBLIES

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	2.2089 -	**SHAFT, FUEL PUMP DRIVEN (CONT'D)**														
2B	**5181747**	SHAFT ASSY			1	1	1	1								
	2.2093 -	**SHAFT, FUEL PUMP DRIVE**														
		A SHAFT ASSY. INCLUDES SHAFT IN 2.2093 AND ITEMS IN 2.2087.														
2B	**5178700**	SHAFT (DRIVE)	1	1												
2B	**5148706**	SHAFT ASSY	1	1												
2B	**5176740**	SHAFT ASSY. (DRIVE)			1	1	1	1								
2B	**5178700**	SHAFT (DRIVE)			1	1	1	1								
	2.2130 -	**VALVE, FUEL PUMP**														
2B	**5174973**	VALVE	1	1	1	1	1	1								
2B	**103709**	PIN, 5/32X1" STRAIGHT (12.9300)	1	1	1	1	1	1								
	2.2160 -	**SPRING, FUEL PUMP VALVE RETAINING**														
2B	**5184530**	SPRING	1	1	1	1	1	1								
	2.2170 -	**PLUG, FUEL PUMP VALVE**														
2B	**5174971**	PLUG	1	1	1	1	1	1								
	2.2180 -	**GASKET, FUEL PUMP VALVE PLUG**														
2B	**5161003**	GASKET	1	1	1	1	1	1								

2.3000A FUEL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	351	381	391	399	422	443	467	473	474	477	480	489		
	2.3001	**STRAINER ASSY., FUEL**														
		SEE ASSEMBLY BREAKDOWN PAGE A1.														
	6436075	STRAINER ASSY	1													
	5577342	STRAINER ASSY														
	5575568	STRAINER ASSY. (6") (TYPE T-60)														
4C	**6438839** *	CARTRIDGE, FUEL STRAINER (8") (SPIN-ON)	1													
4C	**5148023** *	COVER, FUEL STRAINER (SPIN-ON)	1													
	6439603 *	DECAL, FUEL STRAINER (SPIN-ON)	1													
	6436060	DECAL	1													
	5577249	DECAL														
	5575197	DECAL														
	5121182	PLUG, 1/4" PIPE (2.4015)														
	5145014	PLUG, 3/8" PIPE (12.9550)	2													
	181370	BOLT, 3/8"-24X1 1/4" (12.9001)	2													
	181377	BOLT, 3/8"-24X1 3/4" (12.9001)														
	103341	WASHER, 3/8" FLAT (12.9190)	1													
	103321	LOCKWASHER, 3/8" (12 9200)	2													
	117049	NUT, 3/8"-24 HEX. (12.9120)	2													
		* EFF. WITH 3A-80327, 4A-181084, 6A-267158.														
	2.3260-	**BRACKET, FUEL STRAINER MOUNTING**														
	5113207	BRACKET														
	5141232	BRACKET														
	5157412	SPACER (7/8"O.D X13/32"O.D.X1/4" THK.) (7.4013)														
	5184294	SPACER (7.1581)														
	5164789	SPACER (13/32"X7/8") (5.4025)														
	180121	BOLT, 3/8"-16X7/8" (12.9001)														
	179839	BOLT, 3/8"-16X1 1/8" (12.9001)														
	186619	BOLT, 3/8"-16X1/8-(129001)														
	179862	BOLT, 7/16"-14X1 1/2" (12.9001)														
	103321	LOCKWASHER, 3/8" (12.9200)														
	103322	LOCKWASHER, 7/16" (12.9200)														
	117049	NUT, 3/8"-24 HEX. (12.9120)														
	2.3310 -	**FILTER ASSY., FUEL**														
		SEE ASSEMBLY BREAKDOWN PAGE B1.														
	5573949	FILTER ASSY. (4") (AC TYPE, T-58)														
	5574533	FILTER ASSY. (B") (AC TYPE, T-65)	1													
4C	**6438840** *	CARTRIDGE, FUEL FILTER (8 1/2") (SPIN-ON)														
4C	**5148171** *	COVER, FUEL FILTER (SPIN-ON)														

2.3000A FUEL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	351	381	391	399	422	443	467	473	474	477	480	489
		2.3310 - FILTER ASSY., FUEL (CONT'D)												
	6439604 *	DECAL, FUEL FILTER (SPIN-ON)												
	5574516	DECAL (WITH 5574533 FILTER)	1											
	5574083	DECAL (WITH 5573949 FILTER)												
	5121182	PLUG, 1/4" PIPE (2.4015)	2											
	5145014	PLUG, 3/8" PIPE (12.9550)												
	179839	BOLT, 3/8"-16X1" (12.9001)												
	186619	BOLT, 3/8"-16X1 1/8" (12.9001)												
	181370	BOLT, 3/8"-24X1 1/4" (12.9001)	2											
	454906	BOLT, 3/8"-16X1 1/2" (12.9001)												
	179846	BOLT, 3/8"-16X1 7/8" (12.9001)												
	103321	LOCKWASHER, 3/8" (12.9200)	AR											
	117049	NUT, 3/8"-24 (12.9120)												
		* EFF. WITH 3A-80327, 4A-181084, 6A-267158.												
		2.3530 - BRACKET, FUEL FILTER MTG.												
	5123415	BRACKET (FILTER AND STRAINER)	1											
	5133083	BRACKET												
	5137971	BRACKET												
	5139528	BRACKET												
	5108349	BRACKET												
	5140683	BRACKET												
	5159347	SPACER, 3/4"X1/2" (7.1581)	1											
	5118896	SPACER, 3 3/16"X1 1/4"X3/8"												
	180120	BOLT, 3/8"-16X3/4" (12.9001)												
	180121	BOLT, 3/8"-16X7/8" (12.9001)	2											
	179839	BOLT, 3/8"-16X1" (12.9001)												
	186678	BOLT, 3/8"-16X1" (12.9001)												
	189330	BOLT, 3/8"-24X3 3/4" (12.9001)	1											
	179862	BOLT, 7/16"-14X1 1/2" (12.9001)												
	103341	WASHER, 3/8" FLAT (12.9190)												
	106283	WASHER, 3/8" FLAT (12.9190)												
	103321	LOCKWASHER, 3/8" (12.9200)	AR											
	103322	LOCKWASHER, 7/16" (12.9200)												

2.3000A FUEL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.3001 - STRAINER ASSY., FUEL														
	5182041	STRAINER ASSY	1													
	5184154	STRAINERASSY		1												
	5575568	STRAINER ASSY. (AC TYPE T-60)			1											
	5577342	STRAINER ASSY. (AC TYPE TL-70)				1										
	6436075	STRAINER ASSY. (AC TYPE T-74) (2.3310)					1									
		2.3010 - ELEMENT, FUEL STRAINER (PRIMARY)														
		INCLUDES GASKETS IN 2.3090 AND 2.3130.														
	5574981	ELEMENT (AC TYPE T-553) (6" SOCK TYPE)	1	1	1											
	1595655	ELEMENT (PRIMARY FILTER)				1										
4B	**5575032**	ELEMENT (AC TYPE T-552) (8" FELT SOCK TYPE)					1									
		2.3020 - GASKET, FUEL STRAINER ELEMENT TOP														
	1503542	GASKET				1										
		2.3040 - SPACER, FUEL STRAINER ELEMENT														
4B	**5574126**	SEAL (2.3322)			1		1									
4B	**5574123**	SEAL, ELEMENT (2.3322)			1											
4B	**5574120**	RING, RETAINING			1		1									
4B	**5575060**	RETAINER, STRAINER ELEMENT					1									
		2.3050 - SHELL, FUEL STRAINER (PRIMARY)														
3B	**5192916**	SHELL	1	1												
3B,4B	**5577588** @	SHELL (2.3380)			1											
3B	**5577342**	SHELL				1										
4B	**5575056**	SHELL ASSY. (COMPONENTS NOT SERVICED SEPARATELY) (2.3380)					1									
3B,4B	**103647**	DRAINCOCK, 1/4" (12.9510)	1	1	1	1	1									
		2.3080 - SPRING, FUEL STRAINER														
4B	**5574124**	SPRING (2.3370)			1		1									
4B	**6435048**	SPRING				1										
4B	**5574122**	SEAT, SPRING (2.3370)			1		1									

2.3000A FUEL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.3080 - COVER, FUEL STRAINER														
	6436746	COVER (IDENTIFIED WITH CAST "P")					1									
4B	**6435045** #	COVER				1										
4B	**6436253** +	COVER ASSY. (IDENTIFIED WITH CAST "P") (2.3390)			1											
		2.3090 - GASKET, FUEL STRAINER COVER														
3B	**5192801**	GASKET (2.3400)	1	1												
4B	**5574161**	GASKET (2.3400)			1		1									
4B	**1503541**	GASKET				1										
		2.3100 - PLUG, FUEL STRAINER COVER														
	5121182	PLUG, 1/4" PIPE (12.9550)	1		2											
	143980	PLUG, 3/8" PIPE (12.9550)					1									
	8435047	PLUG				1										
		2.3110 - GASKET, FUEL STRAINER COVER PLUG														
	1503538	GASKET				1										
		2.3120 - SCREW, FUEL STRAINER COVER														
	5194083	NUT ASSY. (INCLUDES SCREW AND WASHER)		1												
3B	**5192913**	NUT	1													
	131375	SCREW, 1/4"-20X3/8" (12.9075)		1												
	6435046	SCREW				1										
4B	**5575790**	BOLT (USE WITH EARLY COVERS) (2.3410)			1											
	6435793	BOLT (USE WITH COVER MARKED "P")			1		1									
		2.3130 - GASKET, FUEL STRAINER COVER SCREW														
3B	**2243485**	GASKET	1	1												
4B	**1503536**	GASKET (USE WITH EARLY COVER)			1	1										
	8435794	GASKET (USE WITH COVER MARKED "P)			1		1									

2.3000A FUEL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.3310 - FILTER ASSY., FUEL														
#	**5179839**	FILTER ASSY. (8")	1													
	5573949	FILTER ASSY. (4")		1												
	5573950	FILTER ASSY. (8")			1											
	5184153	FILTERASSY.(8)					1									
	5575824	FILTER ASSY. (8")						1								
	5574533	FILTER ASSY. (8")				1										
		2.3320 - ELEMENT, FUEL FILTER (SECONDARY)														
	5573264 @	ELEMENT (8" PAPER, AC TYPE TP-512) (HORIZONTAL PLEATED)	1		1		1									
	5192855 @	ELEMENT (8" COTTON)	1				1									
	5573261 #	ELEMENT (4" PAPER, AC TYPE TP-509)		1												
4A	**5574508** #	ELEMENT (8" PAPER, AC TYPE TP-540X) (VERTICAL PLEATED)				1										
4A	**5576032**	ELEMENT (8" SOCK TYPE) (AC TYPE T-552)						1								
		@ OPTIONAL.														
		INCLUDES GASKETS IN 2.3400 AND 2.3420.														
		2.3322 - SEAT, FUEL FILTER ELEMENT														
4A	**5574123**	SEAT		1	1	1										
4A	**5574126**	SEAL		1	1	1										
4A	**5574120**	RETAINER		1	1	1										
		2.3370 - SPRING, FUEL FILTER ELEMENT														
4A	**5574124**	SPRING		1	1	1										
4A	**5574122**	SEAT		1	1	1										
		2.3380 - SHELL, FUEL FILTER (SECONDARY)														
	5192915	SHELL	1				1									
	5574125 *	SHELL ASSY		1												
	5574119 *	SHELL ASSY			1											
4A	**5575169** *	SHELL ASSY				1										
4A	**5575893**	SHELL ASSY. (ASSY. COMPONENTS N.S.S.)						1								
		* INCLUDES ITEMS IN 2.3322 AND 2.3370.														

2.3000A FUEL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.3390 - COVER, FUEL FILTER (SECONDARY)														
4A	**6436254** +	COVER ASSY. (IDENTIFIED WITH CAST "S")		1	1	1										
4A	**5575789** +	COVER ASSY + INCLUDES ITEMS IN 2.3400, 2.3410 AND 2.3420.						1								
		2.3400 - GASKET, FUEL FILTER COVER SHELL														
	5192801	GASKET	1				1									
4A	**5574161**	GASKET		1	1	1		1								
		2.3410 - SCREW, FUEL FILTER COVER														
4A	**5574118**	NUT {SCREW)		1	1	1										
	131375	SCREW, 1/4"-20X3/8" (12.9025)					1									
	5194063	NUT ASSY. (INCLUDES SCREW AND WASHER)					1									
4A	**5575790**	BOLT						1								
		2.3420 - GASKET, FUEL FILTER COVER SCREW														
	2243465	GASKET	1				1									
	5193710	GASKET (VENT SCREW)					1									
4A	**1503536**	GASKET (2.3130)		1	1	1		1								
		2.3480 - PLUG, FUEL FILTER														
4A	**5145010**	PLUG, 1/4" PIPE (IN COVER) (12.9550)	1	2	2	2		2								
		2.3500 DRAINCOCK, FUEL FILTER														
	103647	DRAINCOCK, 1/4" (12.9510)	1	1	1	1	1	1								

2.4000 FUEL MANIFOLD

2.4001 - MANIFOLD, FUEL

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	30	32	34	35	38	39	46	52	56
3P	**5150558** #	MANIFOLD, 371 UPPER												
3P	**5150657** #	MANIFOLD, 371 LOWER												
3P	**5150560** #	MANIFOLD, 471 UPPER												
3P	**5150559** #	MANIFOLD, 471 LOWER												
3P	**5150562** #	MANIFOLD, 671 UPPER												
3P	**5150561** #	MANIFOLD, 671 LOWER												
	5155524 #	ELBOW, 1/4" PIPE (STAMPED R)												
3P	**5128927** #	ELBOW, 5/16" INV. FL. TUBE (STAMPED R)												
	5179969 #	ELBOW, 3/8" TUBE 90 DEG SEALASTIC (12.9425)												
	137423 #	ELBOW, 3/8" INV. FL. TUBE 90 DEG (12.9480												
	118755	ELBOW, 3/8" FL. TUBE 90 DEG (12.9390)												
	5129848 #	ELBOW (SEALASTIC) (STAMPED R) (.080")												
	110200 #	CONNECTOR, 5/16"X1/4" INV. FL (12.9380)												
3P	**137407** #	CONNECTOR, 3/8" INV. FL. TUBE (12.9460)												
3P	**103878** #	PLUG, 1/4" PIPE (12.9550)												
3P	**5145010** #	PLUG, PIPE 1/4" SQ. HD. (12.9550)												
		# USE THRU 3A-37643, 4A-77064, 6A-84032, ON 2 VALVE CYLINDER HEADS AND THRU 4A-78270, 5A-81275, ON 4 VALVE CYLINDER HEADS.												

2.4020 - PIPE, FUEL

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	30	32	34	35	38	39	46	52	56
3P	**5151121**	PIPE ASSY. (INLET AND OUTLET)												
3P	**5111526**	PIPE ASSY., SHORT											6	
3P	**5111527**	PIPE ASSY., LONG											6	
3P	**5127276** *	PIPE ASSY., SHORT											AR	
3P	**5127275** *	PIPE ASSY., LONG											AR	
	5136103 +	PIPE ASSY., SHORT (JACOBS #1294)											6	
	5136102 +	PIPE ASSY., LONG (JACOBS #1295)											6	
		* MUST BE USED ADJACENT TO LOAD LIMIT SCREW, MAY BE USED THROUGHOUT. + NOT SERVICED, COMPONENT OF ENGINE BRAKE, SOLD BY JACOBS MANUFACTURING CO., WEST HARTFORD, CONNECTICUT. FURNISH THEIR PART NUMBER SHOWN IN PARENTHESIS.												

2.4030 CONNECTOR, FUEL PIPE

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	30	32	34	35	38	39	46	52	56
	6117369 @	CONNECTOR												
3P	**5188227** #	CONNECTOR (NYLON INSERT)											12	
		# USE THRU 3A-37643, 4A-77064,												

2.4000 FUEL MANIFOLD

FIG	PART NUMBER	NAME AND DESCRIPTION	2	3	4	30	32	34	35	38	39	46	52	56		
	2.4030 -	**CONNECTOR, -FUEL PIPE (CONT'D)**														
		6A-84032, ON 2 VALVE CYLINDER HEADS AND THRU 4A-78270, 5A-81275, ON 4 VALVE CYLINDER HEADS. @ EFFECTIVE WITH 3A-37644, 4A-77065, 6A-84033, ON 2 VALVE CYLINDER HEADS AND EFFECTIVE WITH 4A-78271, 6A-81276, ON 4 VALVE CYLINDER HEADS.														
	2.4040 -	**NUT, FUEL PIPE CONNECTOR**														
3P	**5117972** &	NUT .... & NOT REQUIRED WITH CONNECTOR HAVING NYLON INSERT.														
	2.4050 -	**WASHER, FUEL PIPE CONNECTOR**														
3P	**5125108** @	WASHER .... @ EFFECTIVE WITH 3A-37644, 4A-77065, 6A-84033, ON 2 VALVE CYLINDER HEADS AND EFFECTIVE WITH 4A-78271, 6A-81276, ON 4 VALVE CYLINDER HEADS.											AR			

2.5000A FUEL LINES

FIG	PART NUMBER	NAME AND DESCRIPTION	980	982	991	1011	1043	1047	1063	1067	1131	1135	1140	1141
		2.5001 - TUBE, FUEL SUPPLY TO STRAINER												
	5125900	HOSE, FLEX (5/16"I.D.X23.75"L.) (2.5150)									1			
	118755	ELBOW, 3/8" 90 DEG INV. FL. TUBE (12.9390)									1			
		2.6010 - TUBE,FUEL SUPPLY TO STRAINER (FLEXIBLE)												
	5130696	HOSE ASSY., FLEX (#6X23"L.) (2.5210)												
	143338	ELBOW, 3/8" TUBE, 1/4" PT. 45 DEG (12.9480)												
	137423	ELBOW, 3/8" INV. FL. TUBE 90 DEG (12.9480)												
		2.6050 - TUBE, STRAINER TO FUEL PUMP												
5C	**5109819**	TUBE (DEV. L. 25 9/16")												
5C	**5134961**	TUBE (DEV. L. 28 3/4")									1			
5C	**5184043**	TUBE (DEV. L. 27 23/32")												
5D	**5138217**	HOSE ASSY., FLEX. (#8-42"L.)												
5D	**5136987**	HOSE ASSY, FLEX. (#8-45"L.)												
5D	**5142889**	HOSE ASSY., FLEX. (#8-45"L.)												
5D	**5138298** *	ELBOW ASM. 3/8"-90 DEG. SEALASTIC (12.9425)												
5D	**143340**	ELBOW, 1/2"-45 DEG. INV FL. TUBE (12.9480)												
5D	**137425**	ELBOW, 1/2"-90 DEG INV. FL. TUBE (12.9480)									2			
	5138305 *	CONNECTOR ASM. 3/8" SEALASTIC (12.9415)												
5D	**137409**	CONNECTOR, 1/2" TUBE, 3/8" PT (12.9460)												
	5179938	SEAL RING, 3/8" TUBE SEALASTIC (12.9435)												
		* INCLUDES SEAL IN 2.5050 PLUS NUT, NOT SOLD SEPARATELY.												
		2.6070 - CLIP, STRAINER TO FUEL PUMP TUBE												
5D	**5110070**	CLIP, 3/8" TUBE, 1/2" BOLT (2.5120)												
5D	**3291251**	CLIP, 5/8" TUBE, 1/2" BOLT (1.1060)												
5D	**5151189**	CLIP, 3/4" (4.8040)												
5D	**2362448**	CLIP, #8 HOSE (12.8554)												

2.5000A FUEL LINES

FIG	PART NUMBER	NAME AND DESCRIPTION	980	982	991	1011	1043	1047	1063	1067	1131	1135	1140	1141		
		2.5070 - CLIP, STRAINER TO FUEL PUMP TUBE (CONT'D)														
	5173022	SUPPORT, CLIP (5.5379)														
	179839	BOLT, 5/16"-16X1" (12.9001)														
	181361	BOLT, 3/8"-24X7/8" (12.9001)														
	188146	BOLT, 3/8"-24X4 5/8" (12.9001)														
	186318	BOLT, 3/8"-24X5 1/4" (12.9001)														
	103341	WASHER, 3/8" (12.9190)														
	103342	WASHER, 7/16" FLAT (12.9190)														
	103321	LOCKWASHER, 3/8" (12.9200).														
	117062	NUT, 3/8"-16 HEX. (12 9120)														
	121932	NUT, 3/8"-24 HEX. (12.9120)														
		2.5100 - TUBE, FUEL PUMP TO FILTER														
5C	**5119976** *	TUBE (DEV. L. 23 15/16") (2.5001)														
5C	**5184021**	TUBE (DEV. L. 25 1/8)														
5C	**5125144**	TUBE ASSY. (DEV. L. 54.34")									1					
5C	**5144670**	TUBE ASSY. (DEV. L. 67.39")														
5C	**5114176**	TUBE ASSY. (DEV. L. 77 50")														
5D	**5141599**	HOSE ASSY. (#6-60"L.)														
5D	**5133829**	HOSE ASSY. (#6-50"L.) (2.5110)														
5D	**5142891**	HOSE ASSY. (#6-51.50"L.)														
6D	**5132540**	HOSE ASSY. (#6-54.75"L.) (2.5050)														
5D	**5139201**	HOSE ASSY. (#6-63"L.)														
5D	**5138298** @	ELBOW ASM. 3/8"-90 DEG. SEALASTIC (12.9425)														
	137423	ELBOW, 3/8" INV. FL. TUBE 90 DEG (12.9480)									2					
5D	**137407**	CONNECTOR, 3/8" INV FL. TUBE (12.9460)														
5D	**5179936**	CONNECTOR, 3/8" TUBE SEALASTIC (12.9415)														
	5179938	SEAL RING, 3/8" TUBE SEALASTIC (12.9435)														
	5126530	PLUG, ANCHOR (7.7010)														
		* NOT SERVICED, CUSTOMER TO FABRICATE. REFER TO SECTION 12.8000B. @ INCLUDES SEAL IN 2.5100 PLUS NUT, NOT SOLD SEPARATELY.														
		2.5120 - CLIP, FUEL PUMP TO FILTER TUBE														
5D	**2488022**	CLIP, 1/2" TUBE, 3/8" BOLT (12.8554)														
5D	**5153473**	CLIP, 1/2" TUBE, 3/8" BOLT 2 (4.6040)														

[CONTINUED ON P. 119]

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 1401	1404	1409	1489	1490	1514	1520	1523
		2.7030 - SPACER, GOVERNOR TO CYLINDER HEAD								
	5150512	SPACER			1					
	5103925	SPACER								
	120687	SCREW, #10-24X 1/2"(12.9010)								
		2.7045 - COVER ASSY., GOVERNOR-COMPLETE								
		SEE ASSY. BREAKDOWN PAGE AS INDICATED								
	5110653	COVER ASSY. (PAGE A1)								
	5110654	COVER ASSY. (PAGE A1)			1					
	5104733	COVER ASSY								
	5104734	BOLT, 1/4"-20X .69" BREAK-OFF HD								
	9417926	BOLT W/LW., 1/4"-20X 3/4" (12.9010)			4					
		2.7051 - GASKET, GOVERNOR COVER								
	5150889	GASKET			1					
		2.7165 - LEVER, GOVERNOR COVER SHUTDOWN SHAFT								
	5183042	LEVER (2.9410)			1					
	443603	BOLT, 1/4"-20X 3/4" (12.9001)								
	213546	BOLT, 1/4"-20X1" (12.9001)			1					
	103319	LOCKWASHER, 1/4" (12.9200)			1					
		2.7170 - LEVER, GOVERNOR COVER THROTTLE SHAFT								
	5100845	LEVER (2.9410)			1					
	5100846	LEVER								
	5158432	LEVER								
	5146369	SPACER			1					
	213546	BOLT, 1/4"-20X1" (12.9001)			1					
	103319	LOCKWASHER, 1/4" (12.9200)			1					
		2.7230 - HOUSING ASSY, GOVERNOR CONTROL								
		SEE ASSY. BREAKDOWN PAGE B1.								
	5101002	HOUSING ASSY			1					
	5101074	HOUSING ASSY								
		2.7320 - HOUSING & WEIGHT ASSY., GOVERNOR								
		SEE ASSEMBLY BREAKDOWN PAGE C1.								
	5183612	HOUSING & WEIGHT ASSY., 671			1					
	5174445	HOUSING & WEIGHT ASSY., 671								

2.5000A FUEL LINES

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 980	982	991	1011	1043	1047	1063	1067	1131	1135	1140	1141
	2.5120 -	**CLIP, FUEL PUMP TO FILTER TUBE (CONT'D)**												
5D	**5153473**	CLIP, 1/2" TUBE, 3/8" BOLT												
5D	**5171509**	CLIP, 5/8" TUBE, 3/8" BOLT												
5D	**5100364**	CLIP, 5/8" TUBE, 3/8" BOLT												
5D	**5110070**	CLIP, 3/8" TUBE, 1/2" BOLT												
5D	**5160388**	CLIP, 3/8" TUBE, 3/8" BOLT												
5D	**5177623**	CLIP, 3/8" TUBE, 3/8" BOLT												
5D	**5151883**	CLIP, 3/8" SPECIAL (2.5070)												
5D	**5151189**	CLIP, 3/4" TUBE, 3/8" BOLT (4.8040)												
	5114210	SUPPORT, CLIP (4.8042)												
	5130913	BRACKET, CLIP (7.4597)												
	5163906	SPACER (15/32"X1/4"X13/16") (7.1598)									2			
	5134552	BRACKET (7.187)												
	5182647	ADAPTOR, 7/8" W. CLIP (5.2190)									2			
	446072	BOLT, 5/16"-24X1/2" (12.9001)												
	181595	BOLT, 5/16"-24X3/4" (12.9001)									2			
	181333	BOLT, 5/16"-24X5/8" (12.9001)												
	443603	BOLT, 1/4"-20X3/4" (12.9001)												
	179835	BOLT, 3/8"-16X5/8" (12.9001)												
	180120	BOLT, 3/8"-16X3/4" (12.9001)												
	180121	BOLT, 3/8"-16X7/8" (12 9001)												
	179839	BOLT, 3/8--16X1" (12.9001)												
	179846	BOLT, 3/8"-16X1 7/8" (12.9001)												
	179867	BOLT, 7/16"-14X2 1/4" (12.9001)									2			
	5152148	WASHER, 3/8"X9/16" SEAL (COPPER) (2.4050)												
	103341	WASHER, 3/8" FLAT (12.9190)												
	120392	WASHER, 1/4" FLAT (12.9190)												
	103340	WASHER, 5/16" (12.9190)												
	103320	LOCKWASHER, 5/16" (12.9200)												
	103319	LOCKWASHER, 5/16" (12.9200)									2			
	103321	LOCKWASHER, 3/8" (12.9200)												
	121917	NUT, 5/16"-24 HEX. (12.9120)									2			
	117062	NUT, 3/8 "-16 HEX. (12.9120)												
	2.5130 -	**BRACKET, FUEL PUMP TO FILTER TUBE CLIP**												
	5114210	SUPPORT, CLIP (4.8042)												
	180120	BOLT, 3/8"-16X3/4" (12.9001)												
	103321	LOCKWASHER, 3/8" (12.9200)												

2.5000A FUEL LINES

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 980	982	991	1011	1043	1047	1063	1067	1131	1135	1140	1141		
		2.5210 - TUBE, FUEL DRAIN (CONT'D)														
	187343	CONNECTOR, 5/16" INV. FL. TUBE (12.9460)														
	5129845	CONNECTOR, 5/16".INV. FL. TUBE (.080") (RESTRICTED)														
		2.5215 - TUBE, FUEL DRAIN FLEXIBLE														
	5122246	HOSE ASSY. (1/4"1 D.X1 6 1/2") (2.5210)									1					
	5129844	ADAPTOR 1/4" PIPE (.080") (RESTRICTED) (2.5210)														
	143338	ELBOW, 3/8" TUBE 1/4" PT. 45 DEG. (12.9480)														
	5145010	PLUG, 1/4" PIPE (12.9550)														
		2.5220 - CLIP, FUEL DRAIN TUBE														
	5178450	CLIP, 5/16" TUBE, 7/16" BOLT														
	5110070	CLIP, 3/8" TUBE X 1/2" BOLT (2.5120)														
	5138090	CLAMP									2					
	5138091	CLAMP									2					
	436574	SCREW, # 10-24X1" SL. HD. (12.9025)									2					
	120391	WASHER, 7/32"X1/2" (12.9190) 2														
	120217	LOCKWASHER, #10(12.9200) 2														
	110633	NUT, #10-24 HEX. (12.9120) 2														
		2.5230 - BRACKET, FUEL DRAIN TUBE CLIP														
	5124631	BRACKET														
	109091	SCREW, 1/4"-20X1 1/4" RD. HD. SL (12.9025)														
		2.5255 - SHIELDING, FLEXIBLE HOSE														
	5101020	STRAP, HOSE (NYLON)									AR					

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	1401	1404	1409	1489	1490	1514	1520	1523
		2.7001 - GOVERNOR ASSEMBLY								
		A GOVERNOR INCLUDES ITEMS IN 2.7045 THRU 2.7817 EXCEPT ITEMS IN 2.7165 AND 2.7170.								
	5104279	GOVERNOR, 671 LIM. SPD								
	5122153 *	GOVERNOR, 671 LIM. SPD								
	5100974	GOVERNOR, 671 LIM. SPD			1					
	5101076 *	GOVERNOR, LIM. VAR. HIGH								
	5101075	GOVERNOR, 671 LIM. SPD								
	5103924	GOVERNOR, 671 LIM. SPD								
	5118219	BOLT, 5/16"-18X7/8" (2.2001)			6					
	5104604	BOLT, 1/4"-20X1 1/4" (12.9001)			2					
	443603	BOLT, 1/4"-20X 3/4" (12.9001)								
	103319	LOCKWASHER, 1/4" (12.9200)			2					
		* FOR ASSY. REPLACEMENT INCLUDE FOR TYPES 1404-1409-1489-1490., 1-5103911, 1-5103044, 1-5194495, 1-5103208, 1-5152944, 1-187593.								
		2.7002 - NAME PLATE, GOVERNOR								
	5113056	NAME PLATE			1					
	5103926	NAME PLATE, INSTRUCTION								
	109371	SCREW, #0x3/16" DRIVE (12.9067)								
		2.7005 - COVER, GOVERNOR BREATHER HOLE								
	3223193	COVER			1					
	120687	SCREW, #10-24X 1/2" (12.9010)			2					
	120217	LOCKWASHER, #10 (12.9200)			2					
		2.7006 - GASKET, GOVERNOR BREATHER HOLE COVER								
	5150900	GASKET (4.8020)			1					
		2.7010 - GASKET, GOVERNOR TO BLOWER								
	5150246	GASKET			1					
		2.7020 - GASKET, GOVERNOR TO CYLINDER HEAD								
	5123812	GASKET (1.2060)			2					

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	1401	1404	1409	1489	1490	1514	1520	1523
		2.7030 - SPACER, GOVERNOR TO CYLINDER HEAD								
	5150512	SPACER			1					
	5103926	SPACER								
	120887	SCREW, #10-24X 1/2" (12.9010)								
		2.7046 - COVER ASSY., GOVERNOR-COMPLETE								
		SEE ASSY. BREAKDOWN PAGE AS INDICATED								
	5110853	COVER ASSY. (PAGE A1)								
	5110654	COVER ASSY. (PAGE A1)			1					
	5104733	COVER ASSY								
	5104734	BOLT, 1/4"-20X.69" BREAK-OFF HD								
	9417928	BOLT W/LW., 1/4"-20X 3/4" (12.9010)			4					
		2.7051 - GASKET, GOVERNOR COVER								
	5150889	GASKET			1					
		2.7185 LEVER, GOVERNOR COVER SHUTDOWN SHAFT								
	5183042	LEVER (2.9410)			1					
	443603	BOLT, 1/4"-20X 3/4 " (12.9001)								
	213546	BOLT, 1/4"-20X1" (12.9001)			1					
	103319	LOCKWASHER, 1/4" (12.9200)			1					
		2.7170 - LEVER, GOVERNOR COVER THROTTLE SHAFT								
	5100845	LEVER			1					
	5100846	LEVER								
	5158432	LEVER								
	5146369	SPACER			1					
	213546	BOLT, 1/4-20X1" (12.9001)			1					
	103319	LOCKWASHER, 1/4" (12.9200)			1					
		2.7230 - HOUSING ASSY., GOVERNOR CONTROL								
		SEE ASSY. BREAKDOWN PAGE B1.								
	5101002	HOUSING ASSY			1					
	5101074	HOUSING ASSY								
		2.7320 - HOUSING & WEIGHT ASSY., GOVERNOR								
		SEE ASSEMBLY BREAKDOWN PAGE C1.								
	5183612	HOUSING & WEIGHT ASSY., 671								
	5174445	HOUSING & WEIGHT ASSY., 671 1								

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	1401	1404	1409	1489	1490	1514	1520	1523
		2.7590 - SCREW, GOVERNOR LOW SPEED SPRING ADJUSTING (CONT'D)								
	5101432	FIN, ADJUSTING			1					
		* PART OF GOV. ASSY., USE P/N IN PARENTESES FOR TYPES 1404-1409-1489-1490.								
		2.7610 - RETAINER, GOVERNOR HIGH SPEED SPRING								
	5102896	RETAINER								
	5182557	RETAINER			1					
	5102903	BUSHING								
	5102970	WASHER, BELLEVILLE								
	5102141	WASHER, BELLEVILLE								
		2.7615 - LOCKNUT, GOVERNOR HIGH SPEED SPRING RETAINER								
	5182558	LOCKNUT								
	5186115	LOCKNUT			1					
		2.7635- HOUSING, GOVERNOR HIGH SPEED ADJUSTING SCREW								
	5182559 *	HOUSING (5103911)			1					
	5103208	HOUSING								
	5100606	HOUSING								
	5100603	PLUG .875" DIA.-SPEC. (2.7001)								
	5100604	PIN, 1" L. TAPER (2.7001)								
	426444	BOLT, 5/16"-18X3 1/4" (12.9001)								
	445520 *	BOLT, 5/16"-18X3 1/2" (12.9001) (187953)			2					
	187953	BOLT, 5/16"-18X4 1/2" (12.9001)								
	5155596	WASHER, 21/64" FLAT-COPPER								
	103320	LOCKWASHER, 5/16" (12.9200)			2					
		* PART OF GOV. ASSY., USE P/N IN PARENTHESES FOR TYPES 1404-1409-1489-1490 PLUS 1-5103208 AND 1-5152944. FOR TYPE 1520 SEE 5104870 IN 2.7690.								
		2.7650 - GASKET, GOVERNOR HIGH SPEED SPRING COVER								
	5152944	GASKET			1					

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 1401	1404	1409	1489	1490	1514	1520	1523
		2.7030 - HOUSING, VARIABLE SPEED SPRING								
	5104870	HOUSING ASSY., VAR. HI-SPD								
	5103911	HOUSING ASSY., VAR. HI-SPD								
	5104884 @	COVER								
	5103044	SCREW, 1/4"-28X1 1/2" SET								
	272545 @	BOLT, 5/16"-18X5 1/4" (12.9001)								
	103320 @	LOCKWASHER, 5/16" (12.9200)								
	5194495	NUT, 1/4"-28 ELASTIC STOP								
	5103067 *	PISTON (2.7736)								
	5178857 @	PISTON (2.7612)								
	5152944 @	GASKET (2.7650)								
	5103046 *	SEAL RING (2.7737)								
	5103550 *	SEAL RING (2.7737)								
		* PART OF 5103911 AND 5104870 ASSEMBLIES.								
		@ PART OF 5104870 ASSY.								
		2.7810 - SCREW ASSY., GOVERNOR BUFFER								
	5152987	SCREW ASSY., W/SPRING			1					
	5177083	SCREW ASSY., W/SPRING								
	124925	NUT, 3/8"-24 CAD. (12.9120)			1					
		2.7840 - CLIP, GOVERNOR MANUAL STOP CONTROL								
	142583	RETAINER, 13/64" SPRING (12.9460)			1					
	5184200	SUPPORT, CLIP (2.9428)								
	5150941	WASHER (2.7310)			1					
	5161464	PIN (2.9426)								
	132106	SCREW, #10-32X 7/8" (12.9010)								
		2.7890 - TUBE, GOVERNOR BEARING LUBRICATION								
	5176834	TUBE ASSY			1					
	5166265	ELBOW, 1/4"X90 DEG. RESTR (7.4074)			1					
	9432337	ELBOW, 1/4" INV. FL.-90 DEG			1					
	444134	TEE, 1/4" PIPE (12.9616)								
		2.7945 - SEAL, GOVERNOR								
	5101140	SEAL								

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7045 - COVER ASSY., GOVERNOR (COMPLETE)														
	5110653	COVER ASSY. (A & B ENGINE)	1													
	5110654	COVER ASSY. (C & D ENGINE)		1												
	5174403	COVER ASSY. (A & B ENGINE)			1											
	5174404	COVER ASSY. (C & D ENGINE)				1										
	5174405	COVER ASSY. (A & B ENGINE)					1									
	5174406	COVER ASSY. (C & D ENGINE)						1								
	5118336 +	COVER ASSY. (A & B ENGINE)							1							
	5189138 +	COVER ASSY. (C & D ENGINE)								1						
	5127575	COVER ASSY. (A & B ENGINE)									1					
	5127576	COVER ASSY. (C & D ENGINE)										1				
	5183619	COVER ASSY. (A & B ENGINE)											1			
	5183620	COVER ASSY. (C & D ENGINE)												1		
	5183614	COVER ASSY. (A & B ENGINE)													1	
		+ NOT SERVICED AS AN ASSY.														
		2.7060 - COVER ASSY., GOVERNOR (LESS SHAFT AND LEVERS)														
		INCLUDES ITEMS IN 2.7100 AND 2.7120.														
6H	**5110651**	COVER ASSY	1													
6H	**5110652**	COVER ASSY		1												
	5174415	COVER ASSY			1		1			1						
	5174416	COVER ASSY				1		1	1							
	5127573	COVER ASSY									1					
	5127674	COVER ASSY										1				
	5183662	COVER ASSY											1	1	1	
		2.7095 - SHAFT ASSY., GOVERNOR THROTTLE														
		INCLUDES ITEMS IN 2.7095, 2.7120 AND 2.7130.														
6E	**5110661**	SHAFT ASSY. (LESS SPACER)	1	1												
6E	**5174431**	SHAFT ASSY. (A & B ENGINE)			1		1			1						
6E	**5174432**	SHAFT ASSY. (C & D ENGINE)				1		1	1							
6E	**5174425**	SHAFT ASSY									1	1				
	5183657	SHAFT ASSY											1		1	
	5183658	SHAFT ASSY												1		
	5164320 #	SPACER (2.9330)...	1	1												
6E	**113500**	PIN, #1X7/8" TAPER (12.9280)	1	1	1	1	1	1	1	1			1	1		
	5145009	PLUG, 1/8" PIPE (12.9550)	1	1									1	1		
		# REQUIRED WITH EARLY DESIGN SHAFT ASSY.														
		2.7100 - BEARING, GOVERNOR THROTTLE SHAFT														
6D,E	**148402**	BEARING	2	2	2	2	2	2	2	2			2	2	2	
	5144065	BUSHING									1	1				
	5110665	BUSHING	1	1												

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7120 - PIN, GOVERNOR THROTTLE ACCELERATOR LEVER STOP														
6H	**141195**	PIN, 1/4"X5/8" DOWEL (12.9290)	1	1												
6E	**5150959**	PIN			1		1			1						
6E	**5186224**	PIN				1		1	1				1	1	1	
		2.7130 - PIN, GOVERNOR FULCRUM LEVER														
6D,H	**5174428**	PIN	1	1							1	1	1	1	1	
6E	**5174435**	PIN			1	1	1	1	1	1						
		2.7140 - WASHER, GOVERNOR THROTTLE SHAFT														
6D,E	**5182977**	SEAL RING (3.3055)	1	1												
6D,E	**5176557**	SEAL RING			1	1	1	1	1	1	1	1	1	1	1	
6H	**5197151**	WASHER (33/64"I.D.) (SEAL RING SPACER)	AR	AR	AR	AR	AR	AR	AR	AR	AR	AR				
		2.7150 - RETAINER, GOVERNOR THROTTLE SHAFT PACKING														
6D,E	**5144177**	RETAINER	2	2	1	1	1	1	1	1	2	2	1	1	1	
6D,E	**5174429** +	RING, RETAINING	1	1												
6D,E	**5174429**	RING, RETAINING + EFFECTIVE WITH LATEST DESIGN 5110661 SHAFT ASSY.									1	1				
		2.7180 - LEVER, GOVERNOR COVER STUB SHAFT														
	5154448	LEVER (2.7170)					1	1	1	1						
	186647	BOLT, 1/4"-20X1" (12.9001)					1	1	1	1						
	103319	LOCKWASHER, 1/4" (12.9200)					1	1	1	1						
		2.7175 - CAM, GOVERNOR COVER														
6E	**5110659**	CAM	1	1												
6E	**5119003**	CAM			1											
6E	**5159004**	CAM				1										
6E	**5151517**	CAM					1			1						
6E	**5151518**	CAM						1								
6E	**5161797**	CAM							1							
6A,E	**5183667**	CAM											1			
6A,E	**5183668**	CAM												1		
6A,E	**5184332**	CAM													1	
6E	**5151487**	WASHER (2.7430)	2	2												

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7175 - CAM, GOVERNOR COVER (CONT'D)														
6E	**5150946**	WASHER			1	1	1	1	1	1			1	1	1	
	5150941 =	WASHER (2.7310)		1												
6H	**5178581**	RING, RETAINER (2.7430)	1	1												
	142583 =	RETAINER 13/64" SPRING		1	1	1	1	1	1				1	1	1	
		= NOT PART OF GOVERNOR ASSY.														

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7230 - HOUSING ASSY., GOVERNOR CONTROL														
	5110753 *	HOUSING ASSY., A & B ENGINE	1													
	5101002	HOUSING ASSY., C & D ENGINE		1												
	5101074	HOUSING ASSY., A & B ENGINE			1											
	5158904	HOUSING ASSY., C & D ENGINE				1										
	5183621	HOUSING ASSY., A & B ENGINE					1									
	5183622	HOUSING ASSY., C & D ENGINE						1								
	5101002	HOUSING ASSY., C & D ENGINE							1							
	5150942	PIN, 3/16"X7/16" (DOWEL)	2	2	2	2	2	2	2							
6B	**142656**	PLUG, 3/4" EXPANSION (12.9330)	1	1	1	1	1	1	1							
		* NOT SERVICED. USE 5101074.														
		2.7235 - HOUSING, GOVERNOR CONTROL														
6B	**5183313** *	HOUSING, A & B ENG. (5101072)	1		1											
6B	**5183314** *	HOUSING, C & D ENG. (5100991)		1		1										
	5183639	HOUSING, A & B ENGINE, FUEL MODULATING					1									
	5183640	HOUSING, C & D ENGINE, FUEL MODULATING						1								
	5101540	HOUSING, C & D ENGINE							1							
	5101197	SCREW, ADJUSTING							1							
	124926	NUT, 3/8"-24 JAM (12.9120)							1							
		* NOT SERVICED. USE P/N IN PARENTHESES WHICH INCLUDES 5101197 SCREW, 124925 NUT AND 2-5150942 PIN														
		2.7240 - SHAFT ASSY., GOVERNOR OPERATING (INCL. FORK & LEVER)														
		INCLUDES ITEMS IN 2.7250 AND 2.7290.														
	5158819	SHAFT ASSY. (A & B ENGINE)	1		1											
	5168820	SHAFT ASSY. (C & D ENGINE)		1		1			1							
	5183641	SHAFT ASSY. (A & B ENGINE)					1									
	5183642	SHAFT ASSY. (C & D ENGINE)						1								
		2.7250 - SHAFT ASSY., GOVERNOR OPERATING														
		INCLUDES ITEMS IN 2.7255, 2.7280, 2.7300 PLUS BEARING AND WASHER IN 2.7260.														
	5154437	SHAFT ASSY. (A & B ENGINE)	1		1											
	5154438	SHAFT ASSY. (C & D ENGINE)		1		1			1							
	5183643	SHAFT ASSY. (A & B ENGINE, FUEL MODULATING)					1									

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	2.7230 -	**SHAFT ASSY., GOVERNOR OPERATING (CONT'D)**														
	5183644	SHAFT ASSY. (C & D ENGINE, FUEL MODULATING						1								
	2.7255 -	**SHAFT, GOVERNOR OPERATING**														
6B	**5154435**	SHAFT	1	1	1	1			1							
6B	**5183645**	SHAFT					1	1								
	2.7260 -	**BEARING, GOVERNOR OPERATING SHAFT (UPPER)**														
6B	**9431894**	BEARING	1	1	1	1	1	1	1							
6B	**5159080**	WASHER (3/4"O.D.X.078")	1	1	1	1	1	1	1							
6B	**9421917**	SCREW AND LOCKWASHER, #10-24X7/16" RD. HD. SL. (12.9025)	1	1	1	1	1	1	1							
6B	**120391**	WASHER, 3/16" PLAIN (12.9190)	1	1	1	1	1	1	1							
	2.7270 -	**BEARING, GOVERNOR OPERATING SHAFT (LOWER)**														
6B	**148403**	BEARING (3/4" WIDE)			1	1	1	1								
6B	**5188611** +	BUSHING (OILITE) + MAY REPLACE 148403 PROVIDING BUSHING HOLE HAS CHAMFER.	1	1	1	1	1	1	1							
	2.7280-	**LEVER, GOVERNOR OPERATING SHAFT**														
6B	**5154403**	LEVER (A & B ENGINE)	1		1		1									
6B	**5154422**	LEVER (C & D ENGINE)		1		1		1	1							
6B	**5150898**	SCREW (GAP ADJUSTING)	1	1	1	1	1	1	1							
6B	**122161**	NUT, 1/4"-28 HEX. (12.9120)	1	1	1	1	1	1	1							
	2.7290 -	**FORK, GOVERNOR OPERATING SHAFT**														
6B	**5185605**	FORK	1	1	1	1	1	1	1							
6B	**139013** =	SCREW, 1/4"-28X1/2" SET(12.9076) = EARLY UNITS.	1	1	1	1	1	1								
	2.7300 -	**PIN, GOVERNOR OPERATING SHAFT LEVER**														
6B	**5150943**	PIN (5/16" DIA.X29/32")	1	1	1	1	1	1	1							

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7310 - LEVER ASSY., GOVERNOR DIFFERENTIAL														
6B	**5110666**	LEVER ASSY. (INCLUDES PIN IN 2.7315)	1	1					1							
6B	**5150394**	LEVER ASSY. (INCLUDES PIN IN 2.7315)			1	1										
	5183647 #	LEVER AND SPRING ASSY. (A & B ENGINE, FUEL MODULATING)					1									
	5183648 #	LEVER AND SPRING ASSY. (C & D ENGINE, FUEL MODULATING)						1								
	5183649 *	LEVER ASSY. (A & B ENGINE, FUEL MODULATING)					1									
	5183650 *	LEVER ASSY. (C & D ENGINE, FUEL MODULATING)						1								
	5183654	ROLLER, CAM					1	1								
6B	**5150941**	WASHER, 21/64"	1	1	1	1	1	1	1							
68	**142583**	RETAINER, 13/64" (SPRING) (12.9640) # INCLUDES LEVER IN 2.7310 AND ITEMS IN 2.7313. * INCLUDES LEVER IN 2.7310 AND ITEMS IN 2.7310, 2.7313 AND 2.7315.	1	1	1	1	1	1	1							
		2.7313 - SPRING, GOVERNOR DIFFERENTIAL TORSION														
	5183653	SPRING					1	1								
	5183646	BOLT					1	1								
		2.73165 - PIN, GOVERNOR DIFFERENTIAL LEVER														
6B	**5110648**	PIN (1/4" DIA.X1 1/32"L.)	1	1					1							
6B	**5150894**	PIN (1/4" DIA.X25X32"L.)			1	1	1	1								
	5183655	PIN (5/16" DIA.X1 1/16"L.)					1	1								

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7320 - HOUSING & WEIGHT ASSY., GOVERNOR														
	5174443	HOUSING & WEIGHT ASSY	1													
	5183608	HOUSING & WEIGHT ASSY		1												
	5111975	HOUSING & WEIGHT ASSY			1											
	5174444	HOUSING & WEIGHT ASSY				1										
	5183610	HOUSING & WEIGHT ASSY					1									
	5188607	HOUSING & WEIGHT ASSY						1								
	5111976	HOUSING & WEIGHT ASSY							1							
	5174445	HOUSING & WEIGHT ASSY								1						
	5183612	HOUSING & WEIGHT ASSY									1					
	5142459	HOUSING & WEIGHT ASSY										1				
	5150942	PIN, DOWEL (2.7230)		2												
		2.7330- CARRIER & WEIGHT ASSY., GOVERNOR														
		INCLUDES ITEMS IN 2.7350 THRU 2.7440 EXCEPT 2.7380.														
	5174447	CARRIER & WEIGHTASSY	1													
	5183628	CARRIER & WEIGHTASSY		1												
	5111977	CARRIER & WEIGHT ASSY			1											
	5174448	CARRIER & WEIGHT ASSY				1										
	5183629	CARRIER & WEIGHT ASSY					1									
	5188608	CARRIER & WEIGHT ASSY						1								
	5111978	CARRIER & WEIGHTASSY							1							
	5174449	CARRIER & WEIGHT ASSY								1						
	5183630	CARRIER & WEIGHT ASSY									1					
	5142440	CARRIER & WEIGHT ASSY										1				
		2.7340- HOUSING, GOVERNOR WEIGHT														
6C	**5144759**	HOUSING	1	1												
6C	**5183285** &	HOUSING (5143209)			1	1	1	1								
6C	**5183286** &	HOUSING (5143023)							1	1	1	1				
		& NOT SERVICED. FOR COMPLETE REPLACEMENT USE P/N IN PARENTHESES.														
		2.7350 - SHAFT & CARRIER ASSY., GOVERNOR WEIGHT														
		INCLUDES ITEMS IN 2.7360 THRU 2.7370.														
6C	**5183624**	SHAFT & CARRIER ASSY		1												
6C	**5174451**	SHAFT & CARRIER ASSY	1													
6C	**5183625**	SHAFT & CARRIER ASSY					1	1								

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7350 - SHAFT & CARRIER ASSY., GOVERNOR WEIGHT (CONT'D)														
6C	**5174452**	SHAFT & CARRIER ASSY			1	1										
6C	**5183626**	SHAFT & CARRIER ASSY									1					
6C	**5174453**	SHAFT & CARRIER ASSY							1	1						
6C	**5142441**	SHAFT & CARRIER ASSY										1				
		2.7360 - SHAFT, GOVERNOR WEIGHT CARRIER														
6C	**5150923**	SHAFT	1	1												
6C	**5150924**	SHAFT			1	1	1	1								
6C	**5150925**	SHAFT							1	1	1	1				
		2.7370- CARRIER, GOVERNOR WEIGHT														
6C	**5184336**	CARRIER		1			1	1			1					
6C	**5185606**	CARRIER	1		1	1			1	1						
6C	**5142474**	CARRIER										1				
		2.7380 - RISER, GOVERNOR														
6C	**5154501**	RISER	1	1												
6C	**5154502**	RISER			1	1	1	1								
6C	**5164503**	RISER							1	1	1	1				
		2.7390 - WEIGHT, GOVERNOR														
		WEIGHT ASSY. INCLUDES BEARING IN 2.7440.														
6H	**5117737** =	WEIGHT ASSY., HIGH SPEED (USE 5110665 BUSHING)		2			2	2			2					
6H	**5117738**	WEIGHT HIGH SPEED (USE 5147886 BUSHING)		2			2	2			2					
	5188606 @	WEIGHT, LOW SPEED (REQUIRES SET SCREW)						2								
	5147103	WEIGHT, LOW SPEED (PRESS-ON)						2								
6H	**5183631** $	WEIGHT, LOW SPEED (REQUIRES SET SCREW)		2			2				2					
	5147869	WEIGHT, LOW SPEED (PRESS-ON)		2			2				2					
	5174455	WEIGHT ASSY. (INCLUDES WEIGHT IN 2.7390)	2			2				2						
	5174456	WEIGHT(LESS BEARING)	2			2				2						
6C	**5111979** #	WEIGHT ASSY. (NARROW CAM)			2				2							
6C	**5147913**	WEIGHT ASSY. (WIDE CAM)			2				2							
	5183723	WEIGHT ASSY., HIGH SPEED										3				

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7390- WEIGHT, GOVERNOR (CONT'D)														
	-5183779 *	WEIGHT, LOW SPEED (REQUIRES SET. SCREW)											3			
	5144028 %	SCREW , SET (2.7400)		2			2	2			2	3				
		= NOT SERVICED; USE 5117738 PLUS 5147866 BUSHING.														
		NOT SERVICED; USE (2) EACH OF 5147103,5117738, 5147866 .... 5185153; (4) 5178581 AND 5151487.														
		$ NOT SERVICED; USE (2) EACH OF 5147869,5185153,5151487,5117738. 5147866 AND (4) 5178581.														
		# NOT SERVICED; USE 5147913.														
		* NOT SERVICED; USE (3) EACH 5147870, 5185153, 5151487 AND (6) 5178581.														
		% NOT USED WITH PRESS-ON WEIGHTS.														
6C	5185153	PIN (USE WITH NEW PRESS-ON WEIGHTS)		2				2	2			2	3			
6C	5183632	PIN (REOUIRES SET SCREW IN 2.7390)		2				2	2			2	3			
		2.7430 - PIN, GOVERNOR WEIGHT														
6C	5185154	PIN (RING GROOVE)	2		2	2				2	2					
6C	5183632	PIN											2			
6C	5151487	WASHER	8	4	8	8	4	2	8	8	2					
6C	5178581	RING, RETAINER	4	4	4	4	4	4	4	4	4	6				
6C	451995	BEARING (FOR FORMER DESIGN WEIGHT		2				2	2			2				
2.7440 - BEARING, GOVERNOR WEIGHT																
BC	447196	BEARING 4	4			4	4			4						
6C	5110665	BUSHING (PRESS FIT IN FORMER		2	2			2	2							
6C	5147866 WEIGHTS)	BUSHING (SLIP-FIT IN NEW WEIGHTS) 2			2			2	2							
2.7460 - BEARING, GOVERNOR WEIGHT RISER																
6C	451905	BEARING 1 THRUST	1	1	1	1	1	1	1	1	1					
2.7470- BEARING		GOVERNOR WEIGHT SHAFT END														
6C	907674	BEARING (ND 3301LR1A)	1	1	1	1	1	1	1	1	1					
6C	5150884	SCREW 1	1	1	1	1	1	1	1	1	1					
6C	5150941	WASHER (2.7310)	1	1	1	1					1					

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	2.7470 (CONT'D)	BEARING, GOVERNOR WEIGHT SHAFT END														
6C	5150897	LOCKWASHER (2.7310)	1	1	1	1	1	1	1	1	1	1				
6C	5183288	CAP 1	1	1	1	1	1	1	1	1	1					
	2.7510 - CAP, GOVERNOR WEIGHT HOUSING															
6C	5165221	GASKET 1	1	1	1	1	1	1	1	1	1	1				
	2.7515	GASKET, GOVERNOR WEIGHT HOUSING CAP														

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7320 - HOUSING & WEIGHT ASSY ....GOVERNOR														
5113907		HOUSING & WEIGHT ASSY......................................	1													
5142464		HOUSING & WEIGHT ASSY......................................	1													
		2.7330 - CARRIER & WEIGHT ASSY., GOVERNOR INCLUDES ITEMS IN 2.7350 THRU 2.7440 EXCEPT 2.7380.														
5113906		CARRIER & WEIGHT ASSY	1													
5142463		CARRIER & WEIGHT ASSY		1												
		2.7340 - HOUSING, GOVERNOR WEIGHT														
6C	5144759	HOUSING	1													
6C	5143023	HOUSING		1												
		2.7350 - SHAFT & CARRIER ASSY., GOVERNOR WEIGHT														
		INCLUDES ITEMS IN 2.7360 THRU 2.7370.														
6C	5183624	SHAFT & CARRIER ASSY	1													
6C	5183626	SHAFT & CARRIER ASSY		1												
		2.7360 - SHAFTGOVERNOR WEIGHT CARRIER														
6C	5150923	SHAFT	1													
6C	5150925	SHAFT		1												
		2.7370 - CARRIER, GOVERNOR WEIGHT														
6C	5184336	CARRIER..	1	1												
		2.7380 - RISER, GOVERNOR														
6C	5154501	RISER..	1													
6C	5154503	RISER..		1												
		2.7390- WEIGHT, GOVERNOR														
6H	5117737 @	WEIGHT ASSY(HIGH SPEED) (5117738) (INCLUDES BUSHING IN 2.7440)	2													
	5183723	WEIGHTASSY.(HIGH SPEED)(INCLUDES		2												

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	2.7390 - WEIGHT, GOVERNOR															
		(CONT'D)														
		BEARING IN 2.7440)														
	5188606 =	WEIGHT (LOW SPEED) (5147103)	2													
		(REQUIRES SET SCREW)														
6H	5117738	WEIGHT, (HIGH SPEED) (USE 5147866	2													
		BUSHING IN 2.7440)														
	5147103	WEIGHT (LOW SPEED) (PRESS-ON)	2													
	5147870	WEIGHT (LOW SPEED) (PRESS-ON)		2												
	5183779 *	WEIGHT (LOW SPEED) (REQUIRES SET		2												
	5144028%	SCREW,SET(2.7400)	2	2												
		SCREW)														
		@ NOT SERVICED, USE P/N IN PARENTHESES PLUS 5147866.														
		= NOT SERVICED, USE P/N IN PARENTHESES PLUS (2) EACH 5117738, 5147866,5185153 AND (4) 5178581, 5151487.														
		NOT SERVICED; USE 5147870 AND INCLUDE (2) EACH 5185153, 5151487 AND (4) 5178581.														
		NOT USED WITH PRESS-ON WEIGHTS.														
	2.7430 - SHAFT, GOVERNOR WEIGHT															
6C	6151487	WASHER 2 2														
6C	5185153	PIN (FOR PRESS FIT RETAINED WEIGHTS)	2	2												
6C	5183632	PIN (FOR SET SCREW RETAINED WEIGHTS)	2	2												
6C	5178581	RING, RETAINER (WITH PRESS-ON WEIGHT PIN)	4	4												
	451995	BEARING, NEEDLE		2												
6C	5110665	BUSHING (PRESS FIT IN FORMER WEIGHT)	2													
6C	5147866	BUSHING (CLIP-FIT IN NEW WEIGHT)	2													
	2.7460 - BEARING, GOVERNOR WEIGHT RISER															
		THRUST														
6C	451905	BEARING	1	1												
		2.7470 - BEARING, GOVERNOR WEIGHT SHAFT END														
6C	907674	BEARING (ND 3301LR1A)	1	1												
6C	5150884	SCREW	1	1												
6C	5150941	WASHERS	1	1												

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
2.7470 - BEARING, GOVERNOR WEIGHT SHAFT END (CONT'D)																
6C	5150897	LOCKWASHER (2.7310)	1	1												
2.7510- CAP, GOVERNOR WEIGHT HOUSING																
6C	5183268	CAP	1	1												
2.7515 - GASKET, GOVERNOR WEIGHT HOUSING CAP																
6C	5165221	GASKET	1	1												

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
		2.7680 - HOUSING ASSY GOVERNOR VARIABLE														
	5144096	HOUSING ASSY (A & B ENGINE, ROLLER							1							
		SPEED SPRING														
	512841 =	HOUSING ASSY (C & D ENGINE, ROLLER				1										
	5126842=	HOUSING ASSY (A & B ENGINE, ROLLER			1											
		CONTACT) (5139262)														
	5127654=	HOUSING ASSY (C & D ENGINE.................. ROLLER						1								
		CONTACT) (5139662)														
	5127657 =	HOUSING ASSY (A & B ENGINE .... ROLLER					1									
		CONTACT) (5139262)														
	5179124=	HOUSING ASSY (C & D ENGINE, ROLLER	1													
		CONTACT) (5144096)														
	5139262	HOUSING ASSY (C & D ENGINE, ROLLER...............							1							
		CONTACT (5139262)														
	5183479	HOUSING ASSY (A & B ENGINE, ROLLER		1												
		CONTACT)														
	5139662	HOUSING ASSY (A & B ENGINE ROLLER									1					
		CONTACT)														
		= NOT SERVICED USE P/N IN														
		CONTACT)														
		PARENTESES.														
		2.7690 - HOUSING, GOVERNOR VARIABLE SPEED														
6F	5172557 $	HOUSING	1	1												
6F	5126060*	HOUSING			1	1	1	1	1							
6F	5145444	HOUSING			1	1	1	1	1	1						
6F	271468	SCREW ASSY., 1/4'-20X3/4' FIL HD			1	1	1	1	1	1	1					
		SPRING														
6F	5143564	SCREW, 1/4'-20X1 1/2' (12.9076)..............................	1		1	1	1	1	1	1	1					
6F	5145446	COVER			1	1	1	1	1	1	1					
6F	5145445	GASKET 1...			1	1	1	1	1	1	1					
		(12.9010)														
6F	5145009#	PLUG, 1/8 PIPE (HEX SOCKE....................................	1	1												
6F	5145010 +	PLUG, 1/4' PIPE (12.9550)			1	1	1	1	1	1	1	1				
6F	5167552	PLUG, 1/4' PIPE (12.9550)...					1		1							
6F	5126789	PLUG, 5/8' EXPANSION (12.9330)............................			1				1	1	1					
		(12.9550)														
6F	142656	PLUG, 3/4' EXPANSION (12.9330)........................... 1	1													
6F	5179613	BOLT (IDLE SPEED ADJUSTING SCREW)						1								
6F	274856	NUT, 1/4'-20 HEX (12.9120)..	1	1	1	1	1									
6F	123390	NUT, 1/4-20 HEX (12.9120)						1	1	1	1					
		S NOT SERVICED, USE 5126060 HOUSING														
		AND INCLUDE 1-5176557 SEAL AND														
		* NOT SERVICED, FOR SERVICE														
		REQUIREMENTS USE 5145444 HOUSING														
		1-5126789 PLUG.														
		AND INCLUDE (1) 5145446 COVER, (1)														

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	2.7690 - HOUSING, GOVERNOR VARIABLE SPEED															
	5145445 GASKET AND (1) 271468 SCREW	SPRING (CONT'D) ASSY., TO INSURE INTERCHANGEABILITY. # EARLY UNITS. + LATE UNITS.														
	2.7712	BEARING, GOVERNOR VARIABLE SPEED														
6F	148402	BEARING (2.7100)	2	2	2	2	2	2	2	2	2					
		SPRING LEVER SHAFT														
	2.7720 - SHAFT, GOVERNOR VARIABLE SPEED															
6F	5173964	SHAFT	1	1	1		1	1		1	1					
	5112090	SHAFT				1			1							
6F	103904	KEY 332'X1/2" WOODRUFF(12.9350)	1	1	2	2	3	1	2	3	2					
		SPRING LEVER														
	2.7730 - LEVER, GOVERNOR VARIABLE SPEED	A LEVER ASSY ... INCLUDES LEVER, NOT SOLD SEPARATELY, PLUS ITEMS IN														
	5139469	LEVER ASSY							1	1	1	1				
6F	5179102	LEVER ASSY (ROLLER CONTACT)	1	1	1	1	1									
SF	5152932	WASHER							1	1						
6F	5143665	WASHER(PACKING RETAINER)								1	1	2	1			
		2.7732.														
6F	5152239	#SCREW, ALLEN HEAD SET							1	1						
6F	223065	+ SCREW, 5/16'-24X1/4' SET (12.9076) (5/16'-24X15/32') # EARLY UNITS. + LATE UNITS.	1	1	1	1	1	1	1	1	1					
	2.7732 - BEARING, GOVERNOR VARIABLE SPEED															
	5179105	BEARING (ROLLER)	1	1	1	1	1									
	5139468	BEARING (ROLLER)							1	1	1					
	9425166	BEARING BAIG							1	1	1					
	SPRING LEVER															
	9425165	PIN	1	1	1	1	1									
	5179104	PIN								1	1	1				
	5185305	WASHER	1		1	1	1									

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	2.7750 - PACKING	GOVERNOR VARIABLE SPEED SPRING LEVER SHAFT														
6F	5153007	PACKING	1	1												
6F	5176557	RING, SEAL (2.7140)			1	1	2	1	1	2	1	V				

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	COLUMN 656													
2.8910 - TUBE, GOVERNOR OPERATING PRESSURE (CONT'D)																
	5170063	TUBE ASSY (SOLENOID VALVE TUBE)	1													
	137422	ELBOW 5/16' INV FL TUBE 90 DEG	1													
	143337	ELBOW, 5/16' INV FL TUBE 45 DEG	1													
	143343	ELBOW, 5/16' INV FL TUBE 90 DEG	2													
	3290573	CLIP, TUBE (12.4080)	1													
2.8915 - VALVE, GOVERNOR OPERATING SOLENOID																
	5134104	VALVE ASSY., SOLENOID (12V.) (7.4652)	1													
2.8920		BRACKET, GOVERNOR A BRACKET ASSY INCLUDES BUSHING IN 2.8925.														
	5155879	BRACKET ASSY (C ENG.) (MANUAL STARTING)	1													
2.8925 - BUSHING, GOVERNOR BRACKET																
	3222765	BUSHING	1													

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	16	18	19	20	22	23	27	51	60	61		
2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL																
		PLUS ITEMS LISTED WITH EACH NUMBER.														
8A	5195521	+ TUBE ASM 371 A ENG (INCLUDES 1- BRACKET IN 2.9003 PLUS LEVER AND PIN IN 2.9009)														
8A	5195533	+ TUBE ASM 371 C ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)														
8A	5195522	+ TUBE ASM 471 A ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)														
8A	51 95534	+ TUBE ASM471 C ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)														
8A	5195526	+ TUBE ASM 471 D ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)														
8A	5195809	+ TUBE ASM 671 A ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND														
8A	5195810	+ TUBE ASM 671 C ENG (INCLUDES 1- PIN IN 2.9009) BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)							1							
8A	5195527	+ TUBE ASM 671 C ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009 PLUS SPACER IN 2.9010)														
	5195519	+ TUBE ASM 471 A ENG (INCLUDES 1- BRACKET IN 2.9003 PLUS LEVER AND PIN AT EACH END IN 2.9009)														
8A	5195520	+ TUBE ASM 671 A ENG (INCLUDES 1- BRACKET IN 2.9003 PLUS LEVER AND PIN AT EACH END IN 2.9009)														
		+ WHEN REPLACEMENT IS REQUIRED THRU 8A-73930 OR 6A-77150, INCLUDE 5115922, 5115923 OR 5115924 SPRING IN THE RESPECTIVE TYPE IN 2.9012 PLUS REQUIRED QUANTITY OF 5115322 LEVER AND 2-5176228 SCREWS IN 2.9014.														
2.9003- BRACKET, INJECTOR CONTROL TUBE																
8A	5130509	BRACKET 2							2							
8A	186676	BOLT, 1/4'-20X5/8' (12.9001)							4							
	103319	LOCKWASHER, 1/4' (12.9200)							4							

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	16	18	19	20	22	23	27	51	60	61		
		2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL														
		2.9007- SHAFT, INJECTOR CONTROL TUBE END														
8A	6150259	SHAFT (1 1/16 L.) 1							1							
	5150258	SHAFT (1.88' L.)							1							
		2.9009 - LEVER, INJECTOR CONTROL TUBE														
8A,D	5150263	LEVER							1							
	142486	PIN, 1/8'X3/4' GROOVE (12.9270)							1							
		2.9010 - SPACER, INJECTOR CONTROL TUBE LEVER														
8D	5150843	SPACER (ITEM 6)														
		2.9012- SPRING, INJECTOR CONTROL TUBE														
	5115922 +	SPRING (PLAIN) 1							1							
8A	5150994 =	SPRING (UPRIGHT ENGINE) (REAR)							1							
	5115923 +	SPRING (BLUE)														
8A	5188744 =	SPRING														
8A	5188086=	SPRING							1							
	5115924+	SPRING (YELLOW)							1							
		+ EFFECTIVE WITH 3A-35688, 4A-73931 AND 6A-77151.														
		THRU 3A-35687, 4A-73930, 6A-77150.														
		2.9014 - LEVER, INJECTOR CONTROL TUBE RACK														
8A	5115322+	LEVER							6							
	5111333 @	LEVER							6							
BA	5176228 +	SCREW							12							
	5 1 1334 @	SCREW W														
	5150033 #	PIN							6							
		+ EFFECTIVE WITH 3A-35688, 4A-73931 AND 6A-77151.														
		THRU 3A-35687, 4A-73930, 6A-77150.														
		# PIN REQUIRED WITH EARLY COST DESIGN LEVER ONLY.														
		2.9017 - LEVER, INJ CNTRL TUBE (TORQUE LIMITOR POWER CONTR)														
		ITEMS IN 2.9017, 2.9019 AND 2.9021 ARE USED TOGETHER TO PROVIDE LOAD LIMIT ADJUSTMENT USED WITH MECHANICAL GOVERNOR.														

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	2	4	16	18	19	20	22	23	27	51	60	61		
2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL																
	2.9017 -LEVER, INJ	CNTRL ....TUBE (TORQUE LIMI														
8F	5126314	ARM (POWER LIMIT CONTROL)														
8G	2090519	ARM TORQUE LIMIT CONTROL)..............................							1							
	213548	BOLT, 1/4'-20X1' (12.9001)...							2							
8F	6126313	SPRING (POWER CONTROL)														
		BOLT, 1/4'-20X1' (12.9001)														
8F	186601	& BOLT, 1/4'-20X1 1/4' (12.9001)...............................														
	120392	& WASHER, 1/4' FLAT(12 9180)														
	103319	LOCKWASHER, 1/4' (12.9200) 2							2							
		& POWER CONTROL ONLY.														
	2.9019 - PLATE, INJECTOR CONTROL TUBE LEVER (LOAD LIMIT ADJ.)															
8F,G	5136159	PLATE...							1							
	2.9021	SCREW, INJECTOR CONTROL TUBE LEVER														
8F,G	5178817	SCREW (TOROUE LIMIT CONTROL)							1							
8F	5140625	SCREW (POWER LIMIT CONTROL).........................														
8E,G	121917	NUT, 5/16'-24 HEX ....(12.9120)							1							
	2.9022 - LINK, INJECTOR CONTROL TUBE TO															
8A	5150990	LINK (A, C ENGINE, MECHANICAL GOV							1							
8A	5150990	LINK (A, C ENGINE, MECHANICAL GOV)							1							
	5183703	LINK (D ENGINE, FUEL MODULATING .... GOV.)														
	5183702	LINK (C ENGINE, FUEL MODULATING .... GOV.)							1							
	5188681	LINK, YIELD (A AND C ENGINES)														
8A	5147345	PIN, (1/4'X15/16')							1							
	103361	PIN, 1/16'X1/2' COTTER (12.9250)............................							2							
	142583	RETAINER, 13/64' SPRING (12.9640).......................							1							
	5150941	WASHER (2.7310)1							1							
	2.9060 - SOLENOID, SHUT-OFF															
	1119875	SOLENOID ASSY (32V.)..														
	2.9061 - SEAL, SHUT-OFF SOLENOID OIL															
	2090539	SEAL (2.9355)														

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	COLUMN 2	4	16	18	19	20	22	23	27	51	60	61			
2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL																	
2.9062 - ADAPTOR, SHUT-OFF SOLENOID																	
	2104231	* ADAPTOR ASSY .... (INCLUDES DOWEL PINS)															
	141161	*PIN, 3/16'X1 1/4' DOWEL (12.9290)															
	180021	BOLT, 1/4'-20X7/8' (12.9001)															
		* NO LONGER AVAILABLE FOR SERVICE.															
2.9063 - GASKET		SHUT-OFF SOLENOID ADAPTOR															
	5123812	GASKET (1.2060)															
	2104233	* ROD ASSY (INCLUDES DISC) (7.4530)						NOT APPLICABLE									
2.9064 - ROD		SHUT-OFF SOLENOID															
	2104235	* DISC, ROD END (7.4530)															
	2090270	COUPLING (2.9430)															
	121912	NUT, 1/4'-28 HEX (12.9120)															
		* NO LONGER AVAILABLE FOR SERVICE.															
2.9065 - SPRING, SHUT-OFF SOLENOID ROD RETURN																	
	2104236	SPRING															
2.9066 - ROD		SHUT-OFF SOLENOID PUSH															
	2090271	ROD (2.9095)															
	5150265	PIN (1/4'X15/16') (2.9022)															
	103361	PIN, 1/16'X1/2' COTTER(12.9250)															
	121902	NUT, 1/4 '-28 HEX .... (12.9120)															

2.7000A MECHANICAL GOVERNOR

COLUMN: 2, 4, 16, 18, 19, 20, 22, 23, 27, 51, 60, 61

PART
FIG NUMBER NAME AND DESCRIPTION

2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL

2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL

A TUBE ASSY INCLUDES PIN IN 2.9007
PLUS ITEMS LISTED WITH EACH NUMBER.
8A 5195534 + TUBE ASM 471 C ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)
8A 5195809 + TUBE ASM 671 A ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)
8A 5195520 + TUBE ASM 671 A ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN AT EACH END IN 2.9009)
5195527 + TUBE ASM 671 D ENG (INCLUDES1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009 PLUS SPACER IN 2.9010)
5195548@TUBEASM 471 DENG (INCLUDES 1- BRACKET IN 2.9003, RETAINING RING IN 2.9009 PLUS (2) SPACERS AND PIN — NOT APPLICABLE
5195549 @ TUBE ASM 671 D ENG (INCLUDES BRACKET IN 2.9003, RETAINING RING IN 2 9009 PLUS (2) SPACERS AND PIN — 1-.
5195546 + TUBE ASM 671 B ENG (INCLUDES 1- BRACKET IN 2.9002, RETAINING RING IN 2.9009 PLUS (2) SPACERS AND PIN IN
5116744 + TUBE ASM 471 COMPLETE (INCLUDES ITEMS IN 2.9003 THROUGH 2.9014)
8A 5195534 + TUBE ASM 471 C ENG (INCLUDES 1- BRACKET IN 2.9003, PLUS LEVER AND PIN IN 2.9009)
8A 5195526 + TUBE ASM 471 D ENG (INCLUDES 1- BRACKET IN 2.9003 LEVER AND PIN IN 2.9009 PLUS SPACER IN 2.9010)

+ WHEN REPLACEMENT IS REQUIRED THRU 8A-73930 OR 6A-77150, INCLUDE 5115922, 5115923 OR 5115924 SPRING IN THE RESPECTIVE TYPE IN 2.9012 PLUS REQUIRED QUANTITY OF 5115322 LEVER AND 2-5176228 SCREWS IN NO LONGER AVAILABLE FOR SERVICE.

2.9003 - BRACKET, INJECTOR CONTROL TUBE
8A 5130509 BRACKET
8A 186676 BOLT, 1/4'-20X5/8' (12.9001)
103319 LOCKWASHER, 1/4' (12 9200)

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	763	778	788	789	793	801	804	809	810	812	816	817		
2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL																
2.9100 - KNOB		THROTTLE CONTROL														
		A KNOB ASSY INCLUDES ITEMS IN 2.9100 AND ITEMS IN 2.9105, 2.9106, 2.9108 AND 2.9132.														
	5140054	KNOB ASSY														
	5141066	KNOB (WITH PIN)														
	138561	LOCKWASHER, 3/4' (12.9220														
	107827	NUT, 3/4'-16 HEX (12.9130)														
2.9105 - WASHER		THROTTLE CONTROL TUBE BRAKE														
	5140255	WASHER														
2.9106 - SHAFT, THROTTLE CONTROL KNOB																
	5140057	SHAFT														
	5179178	RING, SEAL (1/16'X1/4'I.D.) (2.7066)														
	9426547	PIN, 5/16' DOWEL (12.9290)														
2.9108- SPRING, THROTTLE CONTROL SHAFT TENSION																
	5140058	SPRING														
2.9132	ADAPTOR	THROTTLE CONTROL KNOB														
2.9280 * ROD AND CLEVIS ASSY., THROTTLE CONTROL																
	5108721	ROD														
	5141396	ROD (2.9262)														
	5118951	JOINT, 5/16'-24 BALL (12.9680)														
	121917	NUT, 5/16'-24 HEX (12.9120)														
2.9310 - SHAFT, THROTTLE CONTROL CROSS																
9D	3290823	SHAFT (8.62'L.) 1														
9D	5168212	SHAFT (11.75'L.)														
9D	5141386	SHAFT (15'L.)														
9D	5139393	SHAFT (18'L.) (3.3050)														
	5139038	SHAFT (22.14'L.)														

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	763	778	788	789	793	801	804	809	810	812	816	817		
2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL																
2.9320 - SPACER, THROTTLE CONTROL CROSS SHAFT																
	3290822	SPACER (1/2'I.D.X1/4'L)														
2.9330 - COLLAR, THROTTLE CONTROL CROSS SHAFT																
9A,D	5184320	COLLAR ... 1				1										
9D	139009	SCREW, 1/4'-28X1/4' SET (12.9076)				1										
2.9340 - LEVER, THROTTLE CONTROL CROSS SHAFT																
9D	5154448	LEVER (1 HOLE) (2.7170) ... :.														
9D	5164318	LEVER (4 HOLE) 2				2										
9D	179796	BOLT, 1/4'-20X7/8' (12.9001)				2										
9D	213546	BOLT, 1/4'-20X1' (12.9001)														
	103319	LOCKWASHER, 1/4' (12.9200)				2										
	114604	LOCKWASHER, 1/4' EXT TOOTH (12.9210)														
2.9355 - SOLENOID, THROTTLE CONTROL																
	1118128	SOLENOID ASSY (12V.)				1										
	123460	BOLT, 1/4'-2 8X3/4' (12.9001)				4										
	120392	WASHER, 9/32- (12.9190)				4										
	103319	LOCKWASHER, 1/4' (12.9200)				4										
	121902	NUT, 1/4'-28 HEX (12.9120)				4										
	120613	NUT, 1/4'-28 JAM (12.9120)														
2.9357 BRACKET, THROTTLE CONTROL SOLENOID																
	5137196	BRACKET (2 8917)														
	5136809	BRACKET				1										
	132288	SCREW, 1/4'-20X7/8' FIL HD				3										
	103319	LOCKWASHER, 1/4' (12.9200)				AR										
(12.9010)																
2.9360 - SHAFT		THROTTLE CONTROL (REAR OF ENGINE TO GOVERNOR)														
9D	5141396	SHAFT (2.62') (2.962)														
9D	5119653	SHAFT (21 5/16'L.)														
9D	3290828	SHAFT (33 3/8'L.)				1										
9D	5119654	SHAFT (33 7/16'L.)														
	5118951	JOINT, 5/16'-24 BALL(12.9680)				2										
	103320	LOCKWASHER, 5/16' (12.9200)				2										
	121917	NUT, 5/16' HEX (12.9120)				4										

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	763	778	788	789	793	801	804	809	810	812	816	817		
2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL																
2.9400 - LINK, GOVERNOR CONTROL SHAFT LEVER						1										
	5138687	LINK 1														
	5112299	BRACKET (2.9360)														
	103361	PIN, 1/16'X1/2' COTTER (12.9250)														
	5147345	PIN, 1/4' CLEVIS (12.9260)														
	123435	BOLT, 1/4'-2 8 X 5/8' CAD (12.9001)				1										
	120392	WASHER 9/32' (12.9190)				AR										
	103319	LOCKWASHER, 1/4' (12.9200) 1				1										
	120613	NUT, 1/4'-28 HEX CAD(12.9120)				3										
	122161	NUT, 1/4'-28 HEX CAD(12.9120)														
2.9410		LEVER, GOVERNOR CONTROL														
	6154448	LEVER (2.7170)														
	5138525	LEVER				1										
	5131189	LEVER														
	180021	BOLT, 1/4'-20X7/8' (12.9001)				1										
	213546	BOLT, 1/4'20X1' (12.9001)														
	114604	LOCKWASHER, 1/4' EXT TEETH														
	103319	LOCKWASHER, 1/4' (12.9200) (12.9210)				AR										
2.9422 - WIRE, GOVERNOR CONTROL																
	5146238	WIRE ASSY (57')														
	110730	LOCKWASHER, 3/8' (12.9200)														
2.9426		PIN, GOVERNOR CONTROL WIRE SWIVELIT}														
	5161464	PIN I														
	142583	RETAINER, 13/64' SPRING (12.9640)														
	132105	BOLT, #10-32X3/8' (12.9010)														
	5150941	WASHER (2.7310)														
2.9428- CLIP, GOVERNOR CONTROL WIRE TUBE																
	5155782	CLIP, 3/16' TUBE, 1/4' BOLT (7.8320)														
	5184200	BRACKET, CLIP														
	5170010	SPACER (7.8297)														
	132286	SCREW, 1/4'-20X1 3/4' FIL HD														
	132105	SCREW, #10-32X3/8' FIL HD														
	123298	BOLT, 1/4'-28X3/8' (12.9001)														
	103319	LOCKWASHER, 1/4' (12.9200)														

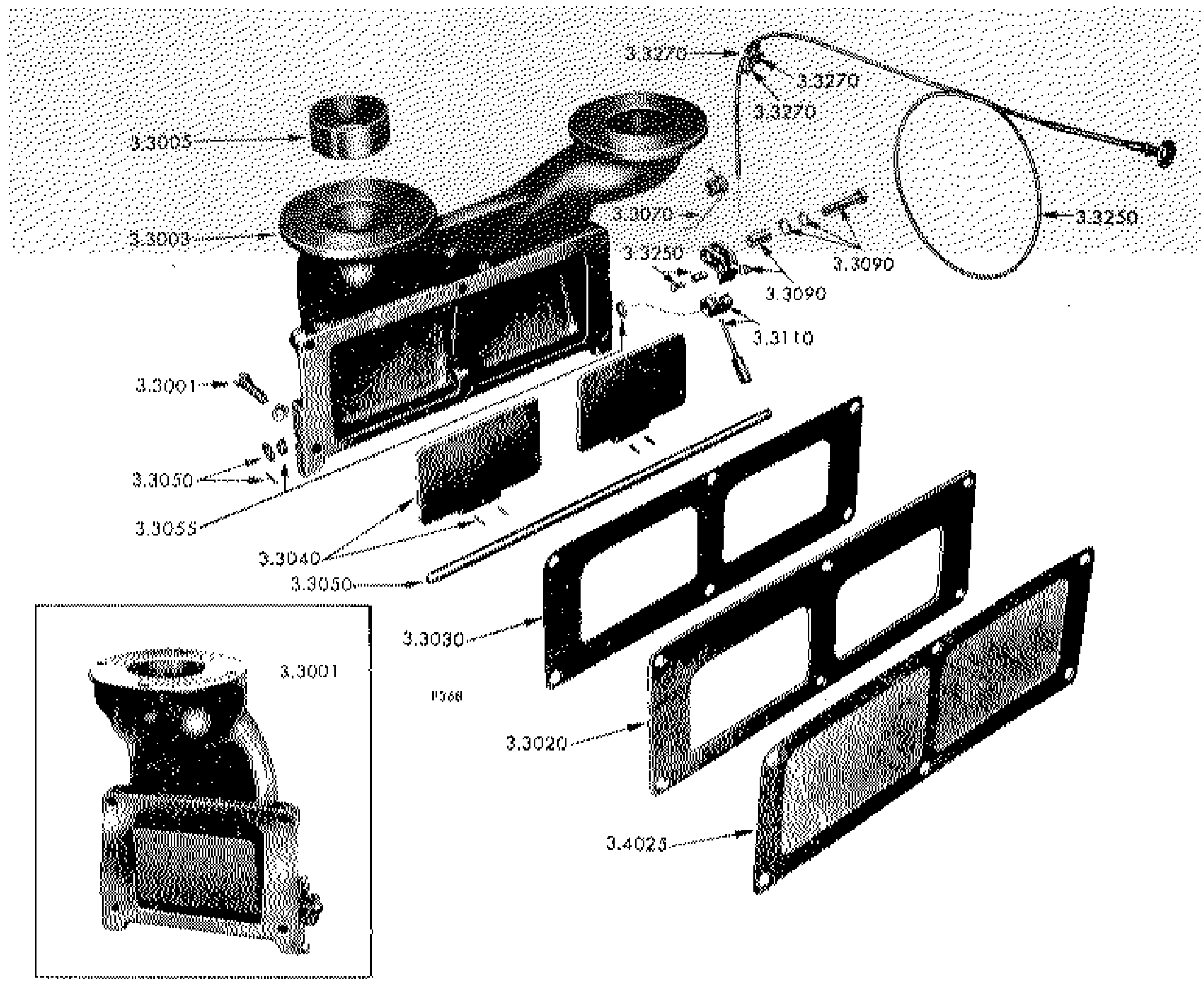

FIG. 2B AIR INLET HOUSING

Fig. 2B of 3.0000

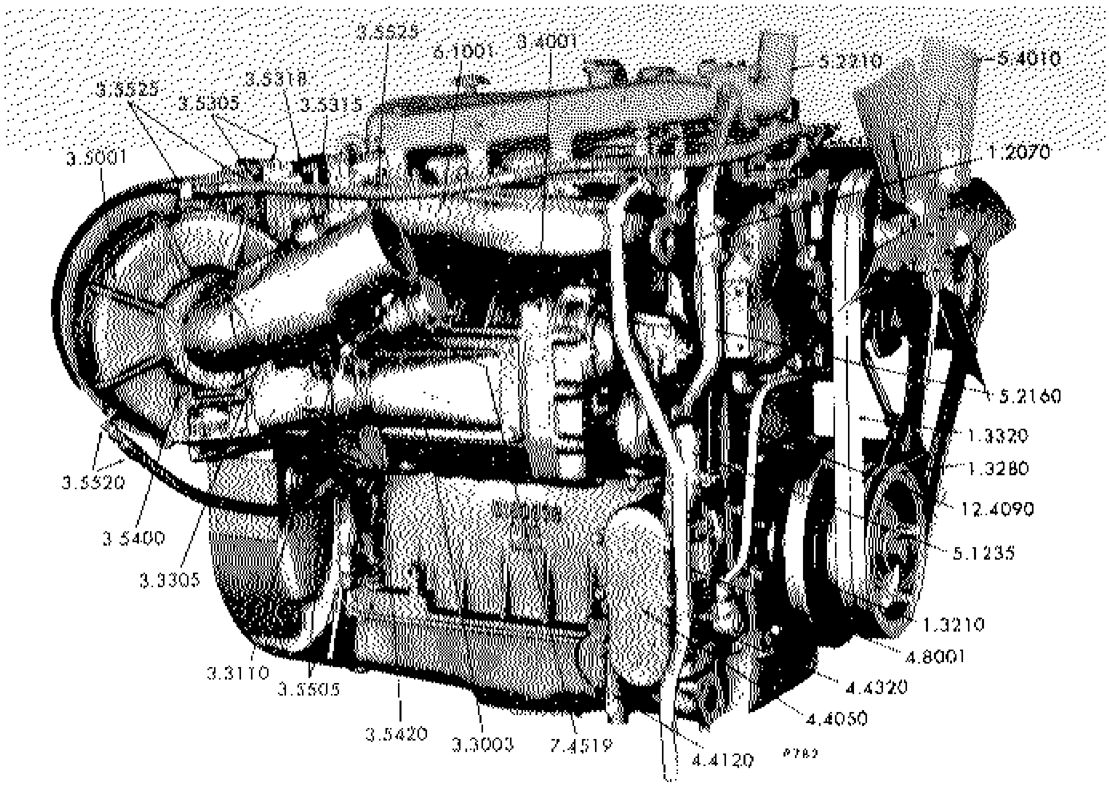

FIG. 2C AIR INLET HOUSING &
AIR CLEANER ADAPTOR

Fig. 2C of 3.0000

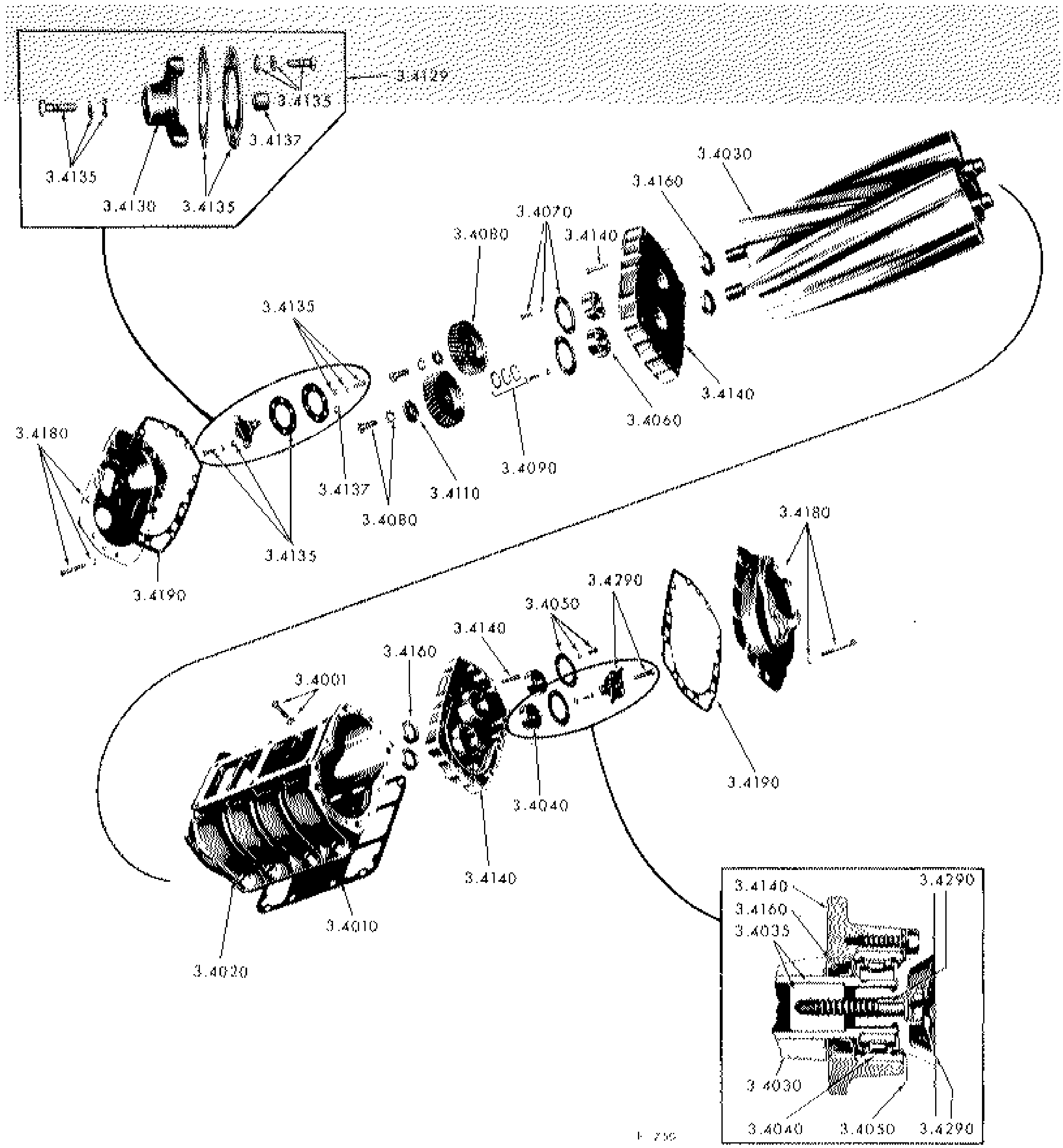

FIG. 3A BLOWER

Fig. 3A of 3.0000

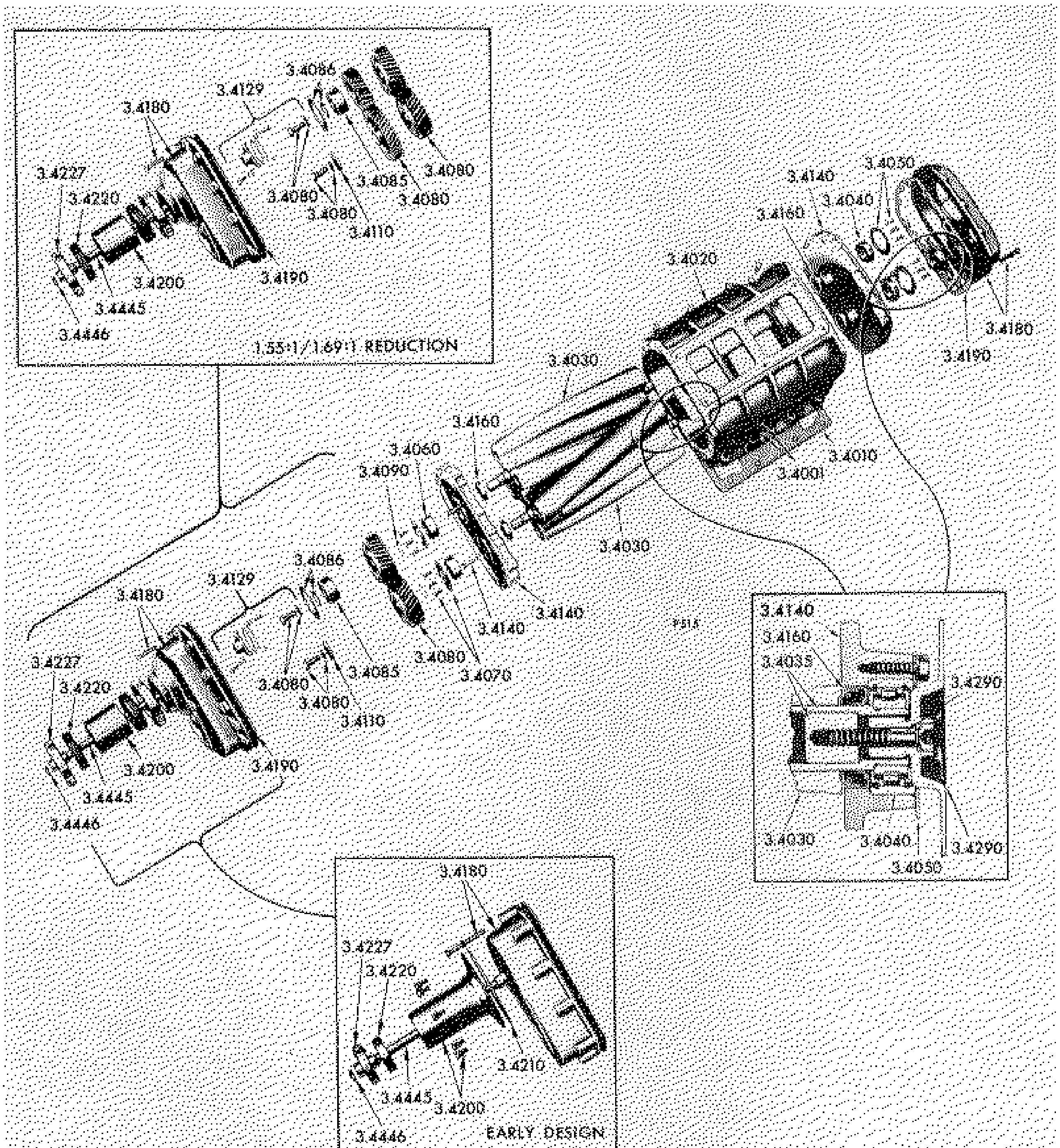

FIG. 3B BLOWER

Fig. 3B of 3.0000.

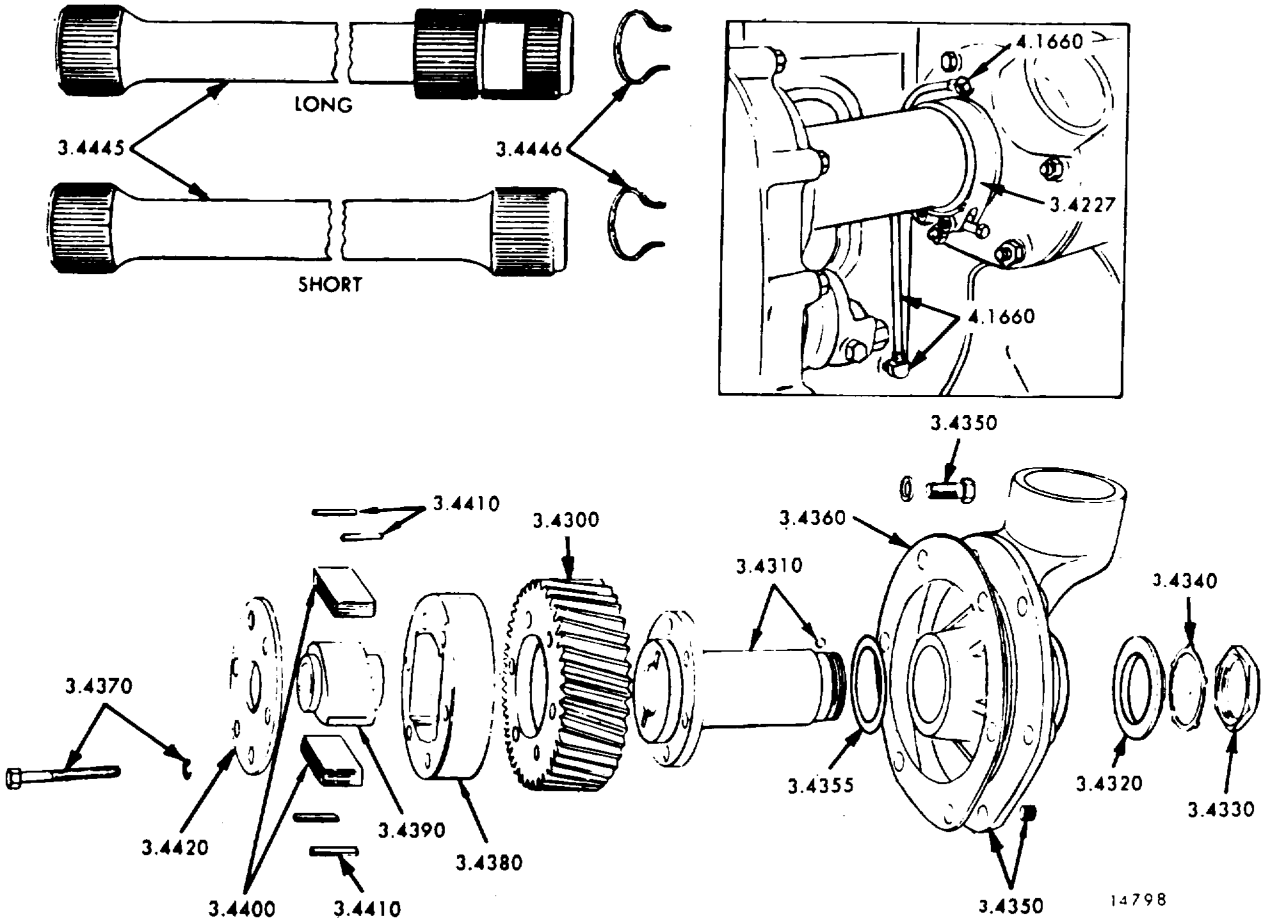

FIG. 3C BLOWER DRIVE

Fig. 3C of 3.0000

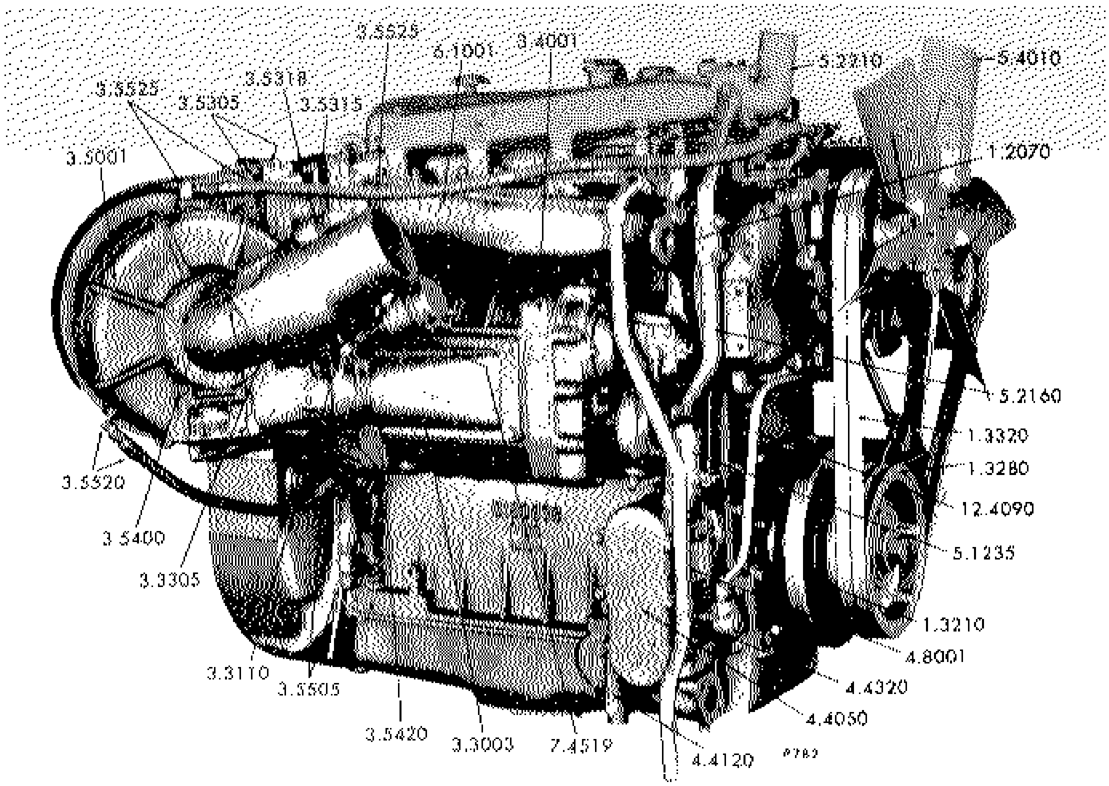

FIG. 5A

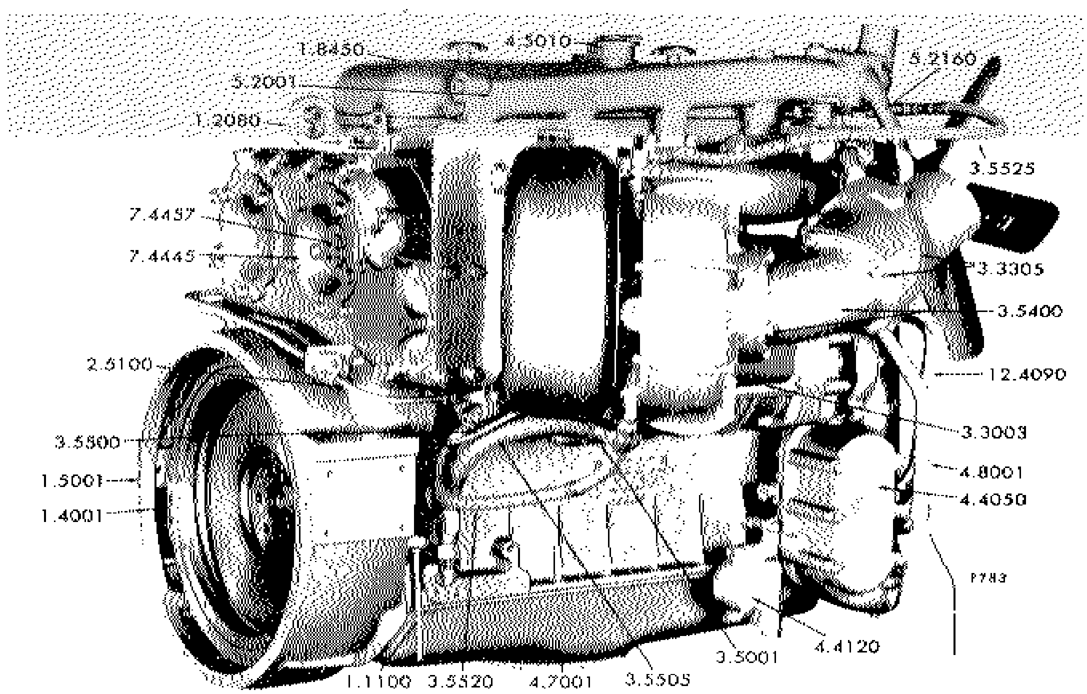

FIG 5B

Figs. 5A & 5B of 3.0000

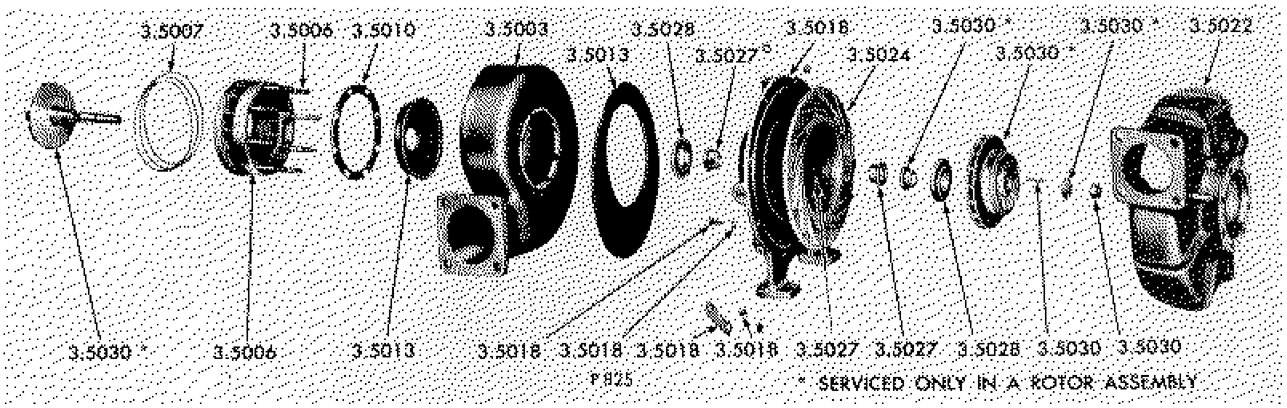

FIG. 5E TURBOCHARGER M5 (ELLIOTT)

Fig. 5E of 3.0000

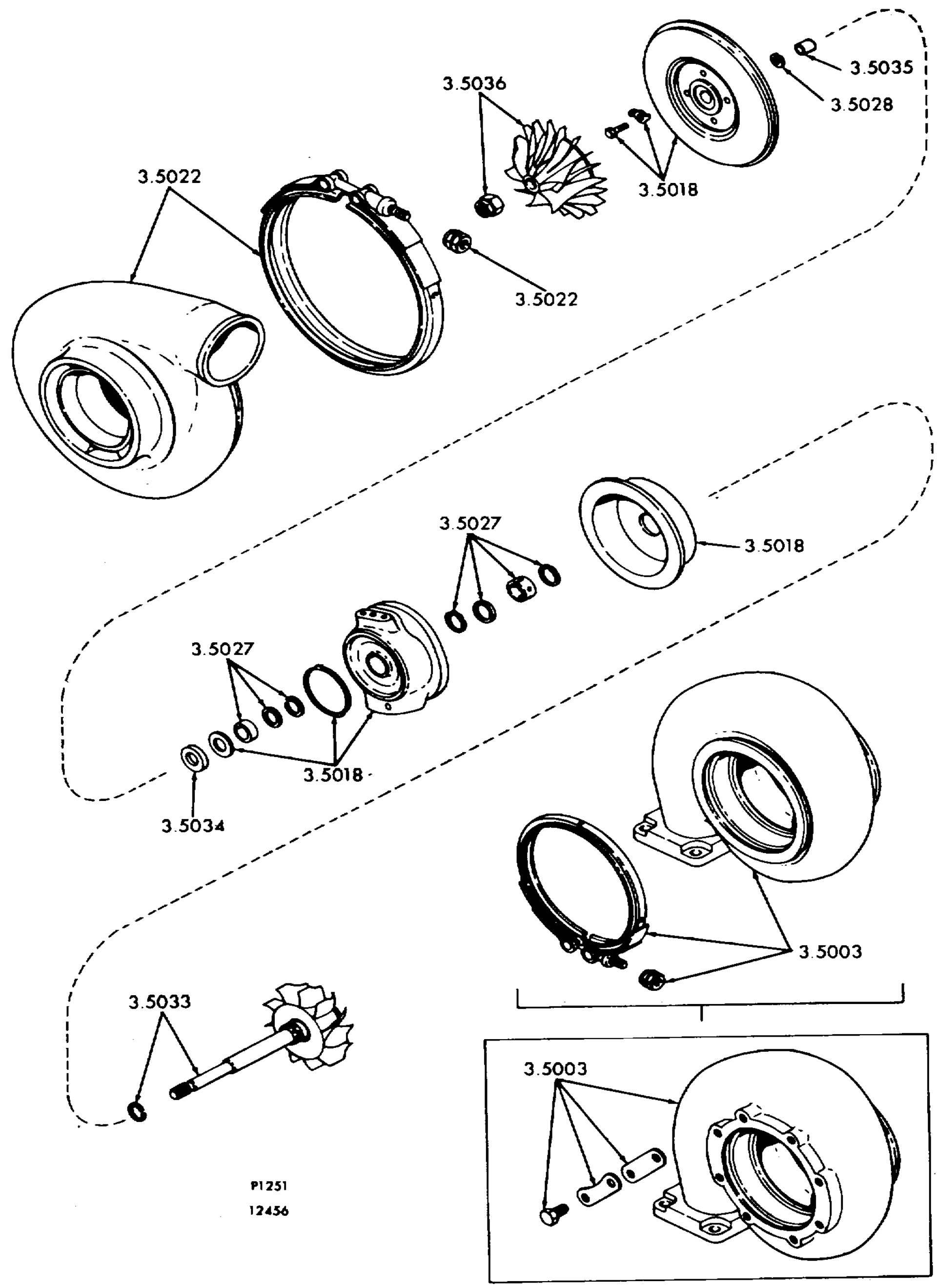

FIG. 5F TURBOCHARGER ASSY. T18A40

Fig. 5F of 3.0000

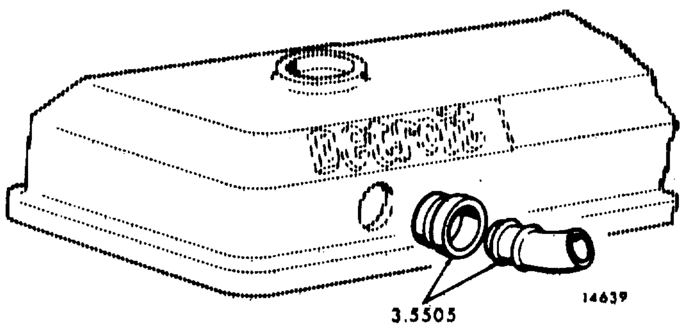

FIG. 5G TURBOCHARGER DRAIN (Cast Cover)

Fig. 5G of 3.0000

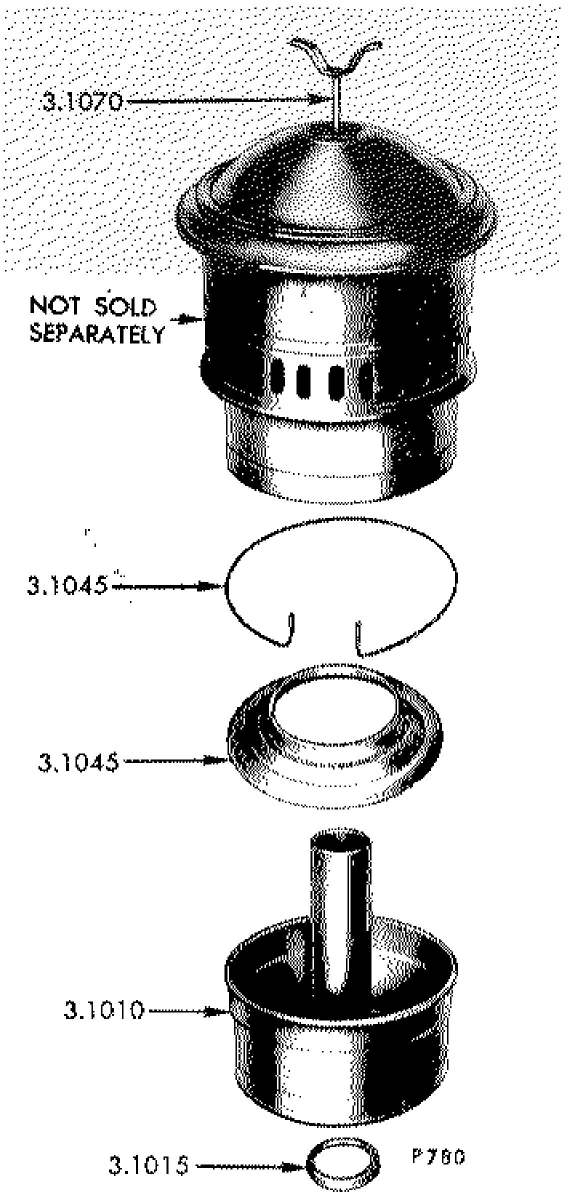

FIG. 1A

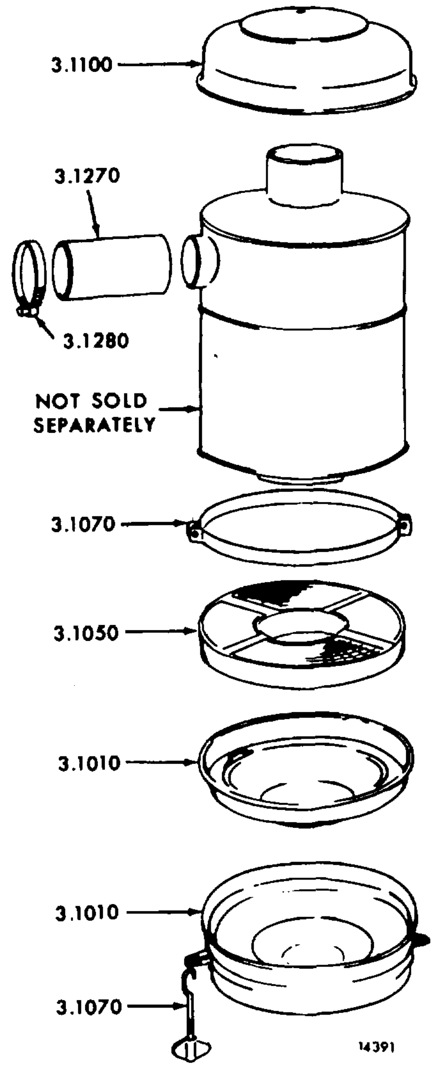

FIG. 1B

AIR CLEANERS

Figs. 1A & 1B of 3.0000

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	COLUMN 124	126	128	129	131	132	154	169	202	210	225	242		
		2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL														
		3.3001 - HOUSING ASSY., AIR INLET														
		A HOUSING ASSY....................INCLUDES ITEMS IN 3.3003, 3.3005 AND 3.3040 THROUGH 3.3110.														
	5181935	HOUSING ASSY 6-71														
	5113797	HOUSING ASSY 6-71														
	5116818	HOUSING ASSY 6-71														
2B	5113802	HOUSING ASSY 6-71														
2B	5147602	HOUSING ASSY 6-71					1									
	5123206	* HOUSING ASSY 4- 7 1 (5147603)														
2B	51266853	* HOUSING ASSY 3-71 (5147606)														
2B	5139624	HOUSING ASSY 6-71														
2B	5108271	* HOUSING ASSY 6-71 (5147621)														
	5129021	* HOUSING ASSY 4-71														
	2363347#	VALVE HOUSING ASSY														
		* NOT SERVICED USE P/N IN PARENTHESES AND 2-5145013														
		# OBSOLETE														
		3.3003 - HOUSING, AIR INLET														
2C	5187806	HOUSING, 6-71					1									
	5113493	HOUSING , 6-71														
	5113616	HOUSING, 6-71														
2B	2286231	@ HOUSING, 6-7 1														
	5122194#	HOUSING, 4-71 (5146458)														
2B	5139730	HOUSING, 6-71														
2B	5 1 08225#	HOUSING, 6-71 (5147422)														
2B	5111710	HOUSING, 6-71														
	2258144	BUSHING														
2D	5145010	PLUG, 1/4’ PIPE (12.9550)					AR									
	5145012	PLUG, 1/2’ PIPE(12.9550)					2									
	5142549	PLUG, 3/4’ PIPE (12.9550)														
2B	179844	BOLT, 3/8’-16X1 5/8’ (12.9001)					4									
2B	180130	BOLT, 3/8’-16X2’ (12.9001)					1									
	108608	BOLT, 3/8’-16X2 1/8’ (12.9001)														
	179851	BOLT, 3/8’-16X3’ (12.9001)					1									
2B	179848	BOLT, 3/8’-16X2 1/4’ (12.9001)														
2B	186282	BOLT, 3/8’-16X3 1/4’ (12.9001)					AR									
	191249	BOLT, 3/8’-16X3 3/4’ (12.9001)														
	103341	WASHER, 3/8’ FLAT (12.9190)														
		@ OBSOLETE. NOT SERVICED, USE P/N IN PARENTHESES PLUS 2-5145013.														
		3.3007 - GASKET, AIR INLET HOUSING FLANGE														
	5124405	GASKET														
	5126862	GASKET														

2.7000A MECHANICAL GOVERNOR

FIG	PART NUMBER	NAME AND DESCRIPTION	124	126	128	129	131	132	154	169	202	210	225	242		
		2.9001 - TUBE AND LEVER ASSY., INJECTOR CONTROL														
		3.3070 - SPRING, AIR INLET HOUSING SHUTDOWN VALVE TENSION (CONT'D)														
2C	5112787	SPRING (EXTERNAL)		1	1											
2C	5114124	SPRING (EXTERNAL)					1									
2B	104919	BALL, 5/16' DIA STEEL (12.9760)														
		3.3080 - LOCKPLATE, AIR INLET HOUSING SHUTDOWN														
2B	5188276	LOCKPLATE														
2B	180016	BOLT, 1/4'-20X1/2' (12.9001).														
2B	103319	LOCKWASHER, 1/4' (12.9200)														
		3.3090 - LEVER, AIR INLET HOUSING SHUTDOWN VALVE														
2B	3290624	LEVER														
2C	5112785	LATCH 1														
2C	5114727	LATCH														
2C	5113633	SPACER														
2B	103381	PIN, 1/16'X1/2' COTTER (12 9250)														
	121926	BOLT, 1/4'-20X1 1/2' (12.9001)					1									
2B	273436	PIN, 1/8'X11/16' ROLL(12.9300)														
	120392	WASHER, 1/4' PLAIN (12.9190)					1									
	120380	LOCKWASHER, 1/4' (12.9200)					1									
	103319	LOCKWASHER, 1/4' (12.9200)														
2B	5168374	NUT														
		3.3110 - LEVER ASSY., AIR INLET HOUSING														
2C	5114974	HANDLE ASSY					1									
2C	5122623	CAM 1														
	455921	PIN, RESET (3.3060)														
		3.3250 - WIRE ASSY., AIR INLET HOUSING SHUTDOWN CONTROL CUSTOMER MUST DETERMINE PROPER WIRE AND ATTACHING PARTS REOUIRED FOR AN INSTALLATION.														
2B	5146238	WIRE ASSY (57'L.) (2.9422)					1									
2B	5146239	WIRE ASSY (90'L.) (2.9422)					1									
2B	5185300	WIRE ASSY (58'L.) (7.4525)					1									
2C	3796374	STOP SHUTDOWN WIRE (2.9426)					1									

3.3000A AIR INLET HOUSING

FIG	PART NUMBER	NAME AND DESCRIPTION	124	126	128	129	131	132	154	169	202	21	22S	242
	3.3250 -	**WIRE ASSY., AIR INLET HOUSING SHUTDOWN CONTROL (CONT'D)**												
2C	**140855**	SCREW, #8-32X5/16' HEX. SKT. SET					1							
2B	**100659**	SCREW, #10-32X3/8' FIL. HD (12.9076)					1							
	110730	LOCKWASHER, 3/8' (12.9200)					1							
2B	**121902**	NUT, 1/4'-20 HEX. (12.9120)					1							
2B	**124925**	NUT, 3/8'-24 JAM (12.9120)					1							
	3.3270-	**CLIP, AIR INLET HOUSING SHUTDOWN**												
2B	**3290560**	**CLIP (1 3/16'L.-3/8' BOLT) (7.8320) .. AR CONTROL WIRE**												
2B	**3290569**	CLIP (3/16' TUBE, 3/8' BOLT)					AR							
2B	**123298**	BOLT, 1/4'-28X3/8' (12.9001)					1							
2B	**179835**	BOLT, 3/8'-16X5/8' (12.9001)					AR							
	120393	WASHER, 5/16' FLAT (12.9190)					AR							
	103319	LOCKWASHER. 1/4' (12.9200)					AR							
	103321	LOCKWASHER. 3/8' (12.9200)					AR							
2B	**121902**	NUT, 1/4'-28 HEX. (12.9120)					AR							

7 1 VEH. E N G I N E S

3.4000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	51	58	118	128	142	144	162	168	189	170	184	187		
	3.4001	BLOWER ASSY. A BLOWER ASSY. INCLUDES ITEMS IN 3.4020 AND 3.4030 THRU 3.4190, PLUS ITEMS IN 3.4290.														
3B	**5114474**	BLOWER ASSY. 4-71 C&D ENG. 'E&N'..														
3B	**5114477**	BLOWER ASSY. 4-71 A&B ENG. 'E&N'..														
	5140109	* BLOWER ASSY. 6-71 A&B ENG														
	5140212	@ BLOWER ASSY. 6-71 C&D ENG.														
3B	**6138554**	BLOWER ASSY. 6-71 A&B ENG 'E&N'...														
3A	**5138553**	BLOWER ASSY. 6-71 C&D ENG 'E&N'...						1								
3A	**5142017**	BLOWER ASSY. 6-71 C&D ENG														
3A	**5141897**	#BLOWER ASSY. 6-71 C&D ENG														
3A	**5142189**	# BLOWER ASSY. 6-71 AI&B ENG.........														
3B	**5138555**	BLOWER ASSY. 6-71 C&D .... ENG 'T'														
3B	**5138727**	BLOWER ASSY. 6-71 C&D ENG 'E&N'...														
3A.B	**427570**	BOLT, 7/16'-14X2' (12.9001)						8								
3B	**5150238**	WASHER (7/16'X13/16').........................						8								
		* ASSY. NOT SERVICED; COMPONENT PARTS ARE AVAILABLE FOR SERVICE. FOR COMPLETE REPLACEMENT USE														
		@ NOT SERVICED. USE 5114475 PLUS 5142189.														
		SD-41 AND SD-43.														
		NOT SERVICED. USE COMPONENTS.														
	3.4003 -	**BLOWER KIT, INSTALLATION** KIT INCLUDES ITEMS IN 2.2007, 2.7010, 2.7020, 2.7051, 2.7530, 3.3030. 3.4010, 3.4025, 3.4210, 3.4220, 3.4225, 5.1010, 5.1220. 5.1240 AND 5.1250.														
	5192753	**BLOWER KIT, 4-71**														
	5192754	**BLOWER KIT, 671**						AR								
	3.4005 -	**BLOWER KIT, REPAIR** A NON-TURBO BLOWER KIT INCLUDES ITEMS IN 3.4040, 3.4060, 3.4090, 3.4160, 3.4163 AND 3.4190 PLUS LOCKWASHERS IN 3.4080. A TURBO BLOWER KIT INCLUDES ITEMS IN 3.4040, 3.4060, 3.4070, 3.4085, 3.4090, 3.4150, 3.4160, 3.4190 AND LOCKWASHERS IN 3.4080.														
	5197638	**BLOWER KIT (TURBO)**														

3.3000A AIR INLET HOUSING

FIG	PART NUMBER	NAME AND DESCRIPTION	51	58	118	128	142	144	162	168	169	170	184	187
	3.4005 -	**BLOWER KIT, REPAIR (CONT'D)**												
	5192796	**BLOWER KIT (NON-TURBO**) .... :						AR						
	3.4010 -	GASKET. BLOWER												
3A,5	**5115657**	GASKET, 471												
3A,B	**5115656**	GASKET, 471						1						
3A,B	**5118877**	GASKET, 671												
	3.4020 -	HOUSING, BLOWER												
3A,B	**5114200**	HOUSING, 471												
3A,B	**5111715**	HOUSING, 671												
3A,B	**5138705**	* HOUSING, 671....................................						1						
3A,B	**5140105**	HOUSING, 671												
3B	**5138516**	HOUSING, 471												
		* OBSOLETE.												
	3.4025 -	**SCREEN, BLOWER**												
	5150780	SCREEN, 471..						1						
	511881	SCREEN, 671.......................................												
	34030 -	**ROTOR, BLOWER**												
		ROTOR SET INCLUDES ONE (1) UPPER AND ONE (1) LOWER ROTOR ASSY. A ROTOR ASSY. INCLUDES SHAFT AND PIN IN 3.4035. ASSEMBLIES INDICATED (#) ALSO INCLUDE ITEMS IN 3.4158 AND 3.4160.												
3B	**5114749**	ROTOR ASM., 671 LWR. L.H. HELIX												
3B	**5114746**	ROTOR ASM., 671 UPR. R.H. HELIX												
3B	**5114748**	ROTOR ASM., 471 LWR. L.H. HELIX												
3A	**5138558**	ROTOR ASM., 671 UPR. R.H. HELIX						1						
3B	**5114745**	ROTOR ASM., 471 UPR. R.H. HELIX												
3A	**5138560**	ROTOR ASM., 671 LWR. L.H. HELIX						1						
3A	**5142229** @	ROTOR ASM., 671 LWR. L.H. HELIX												
3A	**5142230**@	ROTOR ASM., 671 UPR. R.H. HELIX												
3B	**5138729**	ROTOR ASM., 671 LWR. L.H. HELIX												
3B	**5138562**	ROTOR ASM., 671 UPR. R.H. HELIX - ...												
3A,B	**5138559**	ROTOR ASM., 471 LWR. L.H. HELIX												
	9428477	PLUG, 15/16' DIA. CUP (2.7340)............						AR						
3A,B	**5138557**	ROTOR ASM., 471 UPR. R.H. HELIX												

71 VEH ENGINES

34000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 51	58	118	128	1~42	144	162	168	119	670	184	187		
	3.4030 -	**ROTOR, BLOWER (CONT'D)**														
		@ OBSOLETE.														
	3.4030	*** SHAFT, BLOWER ROTOR**														
	6150218	SHAFT														
	S114751	SHAFT														
	5150216	SHAFT,						2								
	5114750	SHAFT														
	5142412	SHAFT														
	5142411	@ SHAFT														
	6114741	SHAFT														
	6150869	SHAFT ASSY. (INCLUDES PLUG)						1								
3A,B	5179046	SHAFT ASSY. (INCLUDES PLUG)						1								
	142622	PIN, 1/4'X1 3/4' GROOVE (12.9270)						4								
		@ OBSOLETE.														
	3.4037	**PLUG, BLOWER ROTOR SHAFT**														
	5179045	PLUG						1								
	5150829	PLUG, 7/8' CUP (4.8001)						1								
	3.4040 -	**BEARING. BLOWER ROTOR FRONT**														
3A,B	7451054	BEARING						2								
3A,B	7455623	BEARING														
	3.4050 -	**RETAINER. BLOWER ROTOR FRONT BEARING**														
'3A,B	5179017	RETAINER						2								
3A,B	443603	BOLT, 1/4'-20X3/4 (12.9001)						6								
3A,B	5142233*	RETAINER.														
3A,B	186625	BOLT, 5/16'-18X7/8' (12.9001)														
	103320	LOCKWASHER, 5/18' (12.9200)														
	120380	LOCKWASHER, 1/4' (12.9002)						6								
		* OBSOLETE.														
	3.4060 -	**BEARING, BLOWER ROTOR REAR**														
3A,B	954418	BEARING						2								
3A,B	907933	BEARING														

71 VEH ENGINES

34000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	51	58	118	128	1~42	144	162	168	119	670	184	187		
	34070 -	**RETAINER, BLOWER ROTOR REAR BEARING**														
3A,B	**5179017**	RETAINER (3.4050)						2								
3A.B	**443803**	BOLT, 1/4'-20X3/4' (12.9001)						6								
3A.B	**5142308***	RETAINER (3.4050)														
	103319	LOCKWASHER, 1/4' (12.9200)						6								
3A,B	**186625**	BOLT, 5/16'-1X7/8' (12.9001)														
	103320	LOCKWASHER, 5/16' (12.9200) * OBSOLETE.														
	3.4080 -	**GEAR SET, BLOWER ROTOR**														
3A,B	**5192234**	GEAR SET (ROTOR TIMING)						1								
3B	**5194805**	GEAR SET (REDUCTION, 1.69:1 RATIO).														
3A,B	**5194937**	GEAR SET														
3B	**186645**	BOLT, 7/16'-20X1 1/4' (12.9001)														
3A,B	**182776**	BOLT, 1/2'-20X1 1/4' (12.9001)						2								
3A	**182776**	BOLT, 1/2'-20X1 1/4' (12.9001)														
3B	**5189973**	LOCKWASHER (7/16')														
3A,B	**5154398**	LOCKWASHER (1/2')						2								
3B	**5154398**	LOCKWASHER (1/2')														
	3.4085-	**BEARING, BLOWER ROTOR GEAR**														
3B	**905304**	BEARING														
	3.4086 -	RETAINER, BLOWER ROTOR GEAR BEARING														
3B	**5189966**	RETAINER (OUTER RACE)														
3B	**5189967**	RETAINER (INNER RACE)														
	3.4090-	**SHIM, BLOWER ROTOR GEAR**														
3A,B	**5150372**	SHIM (.002')						AR								
3A.B	**5163938**	SHIM (.003')						AR								
3A,B	**5150855**	SHIM (.005')						AR								
3A,B	**5150856**	SHIM (.010')						AR								
	3.4110-	**DISC. BLOWER ROTOR FUEL PUMP**														
3A,B	**5154401**	DISC COUPLING						1								
	3.4120	**WASHER, BLOWER ROTOR GEAR RETAINING**														
3A	**5154400**	WASHER						1								

34000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	51	58	118	128	1~42	144	162	168	119	670	184	187		
	3.4129 -	**HUB KIT, BLOWER ROTOR GEAR**														
		A KIT INCLUDES ITEMS IN 3.4130, 3.4135 AND 3.4137.														
3A,B	**5192751**	HUB KIT						1								
	3.4130 -	**HUB, BLOWER ROTOR GEAR**														
3A,B	**5173366**	HUB						1								
3A	**103340**	WASHER, 5/16' FLAT (12.9190)						6								
3A	**103320**	LOCKWASHER, 5/16' (12.9200)						6								
	3.4135 -	**PLATE, BLOWER ROTOR GEAR HUB**														
3A	**5173365**	PLATE						2								
3A	**5173362**	BOLT (PLATE TO HUB)						3								
3A	**5173363**	BOLT (PLATE TO GEAR)						3								
3A	**5117729**	* BOLT(PLATE TO GEAR) * OBSOLETE.														
	3.4137	**SPACER. BLOWER ROTOR GEAR HUB**														
3A	**5173364**	SPACER						3								
3A	**5142305**	SPACER														
	3.4140 -	**PLATE, BLOWER HOUSING END**														
3A	**5193719**	PLATE ASSY. (INCLUDES DOWEL PINS)						2								
3B	**5142234**	* PLATE ASSY. (INCLUDES DOWEL PINS)														
3B	**5114528**	PIN (DOWEL)						4								
3B	**5142309**	- PLATE ASSY. (INCLUDES DOWEL PINS)														
3B	**5142304**	PIN (DOWEL)														
3A,B	**1117296**	SCREW, 5/16'-18X1 1/2' FL. H D (12.9010) * OBSOLETE.						4								
	3.4158	**CARRIER, BLOWER HOUSING END PLATE SEAL RING**														
	5110329	CARRIER														
	3.4159 -	COLLAR, BLOWER HOUSING END PLATE SEAL RING														
	5110330	COLLAR														

3.4000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 51	58	118	128	1~42	144	162	168	119	670	184	187		
	3.4129	**HUB KIT, BLOWER ROTOR GEAR**														
		A KIT INCLUDES ITEMS IN 3.4130, 3.4135 AND 3.4137.														
3A,B	**5192751**	HUB KIT.. 1														
	3.4130 - HUB, BLOWER ROTOR GEAR															
3A,B	**5173366**	HUB 1														
3A	**103340**	WASHER, 5/16' FLAT (12.9190) 6														
3A	**103320**	LOCKWASHER, 5/16' (12.9200) 6														
	3.4135 - PLATE, BLOWER ROTOR GEAR HUB															
3A	**5173365**	PLATE.. 2														
3A	**5173362**	BOLT (PLATE TO HUB) 3														
3A	**5173363**	BOLT (PLATE TO GEAR) 3................... 3														
3A	**5117729**	* BOLT (PLATE TO GEAR)..................... * OBSOLETE.														
	3.4137 - SPACER, BLOWER ROTOR GEAR HUB															
3A	**5173364**	SPACER 3														
3A	**5142305**	SPACER														
	3.4140 - PLATE, BLOWER HOUSING END															
3A	**5193719**	PLATE ASSY. (INCLUDES DOWEL PINS)	2													
3B	**5142234**	* PLATE ASSY. (INCLUDES DOWEL .PINS)														
3B	**5114528**	PIN (DOWEL) 4														
3B	**5142309**	* PLATE ASSY. (INCLUDES DOWEL .PINS)														
3A,B	**117296**	SCREW, 5/16'-1BX1 1/2' FIL. HD.......... 4														
3B	**5142304**	* PIN (DOWEL) .... (12.9010) * OBSOLETE.														
	3.4158	**CARRIER, BLOWER HOUSING END PLATE SEAL RING**														
	5110329	CARRIER..														
	3.41S9 - COLLAR, BLOWER HOUSING END PLATE SEAL RING															
	5110330	COLLAR..														

34000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES: 51	58	118	128	1~42	144	162	168	119	670	184	187		
	3.4192 -	**TUBE, BLOWER OIL SUPPLY**														
		INV. FLARED TUBE (12.9460)														
	5167220	TEE, 1/4' INV. FL. TUBE (7.8300)														
	3.4200 -	**COVER. BLOWER DRIVE**														
	5143425	COVER, 471 (.44'L.)														
	5118354	COVER, 671 (1 1/2'L.)														
	6112904	COVER, 671 (3 1/2'L.)														
	5118353	COVER, 671 (4 3/4'L.)						1								
	3.4220 - SEAL BLOWER DRIVE COVER															
	5115375	SEAL (HOSE 1 1/2'L.).............................														
	5172865	SEAL (HOSE 7/8'L.)................................						2								
	3.4227 - CLAMP. BLOWER DRIVE COVER PACKING															
3A,B,C	**5138336**	CLAMP..						2								
	3.4290 - COUPLING, BLOWER TO WATER PUMP DRIV'															
3A,B	**5122089**	COUPLING						1								
3A,B	**6142287**	* COUPLING .														
3A,B	**138234**	BOLT, 5/1 6'-24X1 1/2' HEX. SOCKET.... * NO LONGER AVAILABLE FOR SERVICE. HD. (12.9027)						1								
	3.4300 - GEAR. BLOWER DRIVE															
3C	**5122910**	GEAR (R.H. HELIX) 40 TEETH .... (LC-LD-RC-RD ENG.)						1								
3C	**5122911**	GEAR (L.H. HELIX) 40 TEETH................ (LA-LB-RA-RB ENG.)														
3C	**6116898**	GEAR (R.H. HELIX) 39 TEETH .... (LC-LD-RC-RD ENG.)														
3C	**5115897**	GEAR (L.H. HELIX) 39 TEETH................ (LA-LB-RA-RB ENG.)														
	3.4310- HUB, BLOWER DRIVE GEAR															
3C	**5160279**	HUB						1								
3C	**189067**	BALL, 7/32 DIA. STEEL (12.9670)						1								

7 1 VEH E N G I N E S

3.4000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 51	58	118	128	1~42	144	162	168	119	670	184	187		
	3.4320 -	WASHER, BLOWER DRIVE GEAR HUB THRUST														
3C	**5168901**	WASHER						1								
	3.4330 -	**NUT, BLOWER DRIVE GEAR HUB**														
3C	**5152804**	NUT						1								
	3.4340	**LOCKWASHER. BLOWER DRIVE GEAR**														
3C	**6150281**	LOCKWASHER						1								
	3.4350-	**SUPPORT, BLOWER DRIVE GEAR HUB A SUPPORT ASSY. INCLUDES BEARING IN**														
3C	**5129884** +	SUPPORT ASSY. (NO PROVISION FOR OIL IN 3.4355.						1								
3C	**51 2228 +**	SUPPORT ASSY. (WITH PROVISION FOR FILLER TUBE) (CAST IRON) OIL FILLER TUBE) (CAST IRON)						1								
3C	**5172871**=	SUPPORT ASSY. (WITH PROVISION FOR OIL FILLER TUBE) (CAST IRON)														
3C	**5172870** =	SUPPORT ASSY. (NO PROVISION FOR OIL														
3C	**5145009**	PLUG, 1/8' PIPE (12.9550) FILLER TUBE) (CAST IRON) 20903186 * PLUG (2 1/4' DIA.) P(1 D.AR						1								
3C	**181361**	BOLT, 3/8'-24X7/8' (12.9001)						2								
3C	**103321**	LOCKWASHER, 3/8' (12.9200)						2								
		+ EFFECTIVE WITH 3A-44434, 4A-89065, = THRU 3A-44433, 4A-89064, 6A-97323; 6A-97324. NOT SERVICED, REPLACE WITH 5122528 OR 5129884 SUPPORT ASSY., INCLUDE 1-5122529 WASHER. USED TO PLUG FILLER HOLE WHEN REQUIRED.														
	3.4355 - BEARING, BLOWER DRIVE GEAR HUB															
	5122530	BEARING						2								
	5150285	* BEARING (FLANGED)														
	5122529	WASHER, THRUST (3.4320)						1								
		* NOT SERVICED, USE 1-5122530 BEARING AND 1-5122529. THRUSTWASHER														

3.4000 BLOWER

FIG	PART NUMBER	NAME AND DESCRIPTION	51	58	118	128	1~42	144	162	168	119	670	184	187		
	3.4360	**GASKET. BLOWER DRIVE GEAR HUB**														
3C	**5148810**	GASKET						1								
	3.4370-	COUPLING. BLOWER DRIVE A COUPLING ASSY. INCLUDES SUPPORT. CAM, SPRING AND SEAT IN 3.4380 THRU 3.4410.														
	5150344	**COUPLING ASSY**						**11**								
3C	**5150340**	BOLT														
	103320	LOCKWASHER, 5/16' (12.9200)														
	3.4380 -	SUPPORT. BLOWER DRIVE COUPLING														
3C	**5150345**	SUPPORT						1								
	3.4390 -	CAM, BLOWER DRIVE COUPLING														
3C	**5150348**	CAM						1								
	3.4400 -	SPRING. BLOWER DRIVE COUPLING														
3C	**5196314**	SPRING PACK						1								
	3.4410 -	SEAT. BLOWER DRIVE COUPLING SPRING														
3C	**5150346**	SEAT						4								
	3.4420 -	RETAINER, BLOWER DRIVE COUPLING														
3C	**5150349**	RETAINER ... 1														

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3.4000 BLOWER

TYPES

FIG	PART NUMBER	NAME AND DESCRIPTION	51	58	118	128	1~42	144	162	168	119	670	184	187		
3.4360 -	**GASKET, BLOWER DRIVE GEAR HUB SUPPORT**															
3C	**5148810**	GASKET 1														
	3.4370	COUPLING, BLOWER DRIVE														
		A COUPLING ASSY. INCLUDES SUPPORT. CAM, SPRING AND SEAT IN 3.4380 THRU 3.4410.														
	5160344	COUPLING ASSY................................. 1														
3C	**5160350**	BOLT... 6														
	103320	LOCKWASHER, 5/16’ (12.9200) 8														
	3.4380 -	SUPPORT, BLOWER DRIVE COUPLING														
3C	**5160346**	CAM 1														
	3.4390 -	CAM, BLOWER DRIVE COUPLING														
3C	**5150348**	SUPPORT... 1														
	3.4400	SPRING, BLOWER DRIVE COUPLING														
3C	**5196314**	SPRING PACK 1														
	3.4410	SEAT, BLOWER DRIVE COUPLING SPRING														
3C	**5150346**	SEAT... 4														
	3.4420 -	RETAINER, BLOWER DRIVE COUPLING														
3C	**5150349**	RETAINER.. 1														
	3.4000A	BLOWER DRIVE SHAFT														
FIG	PART NUMBER	NAME AND DESCRIPTION	**1**	**2**	**3**	**6**	**13**	**14**	**39**	**44**						
	3.4445 -	**SHAFT. BLOWER DRIVE**														
3C	**5154638**	SHAFT, 3-71 SHORT (6 3/16’ L.)..............														
3C	**5164639**	SHAFT, 4-71 SHORT (7 13/16’ L.).............														
3C	**5154640**	SHAFT, 6-71 SHORT(11 1/16 L.).............	1													
3C	**5193476**	SHAFT. 6-71 LONG (11 15/16’ L.).............														
3C	**5189977**	SHAFT, 4-71 SHORT (6 15/16’ L.).............														
3C	**5189970**	SHAFT, 6-71 SHORT (10 3/16’ L.).............														
3C	**5113346**	SHAFT, 6-71 LONG (11’ L.)...............														
3C	**5189454**	SHAFT, 6-71 LONG (12 1/8’ L.)...............														
	3.4446-	**RING, BLOWER DRIVE SHAFT**														
3C	**5167727**	RING... 1														

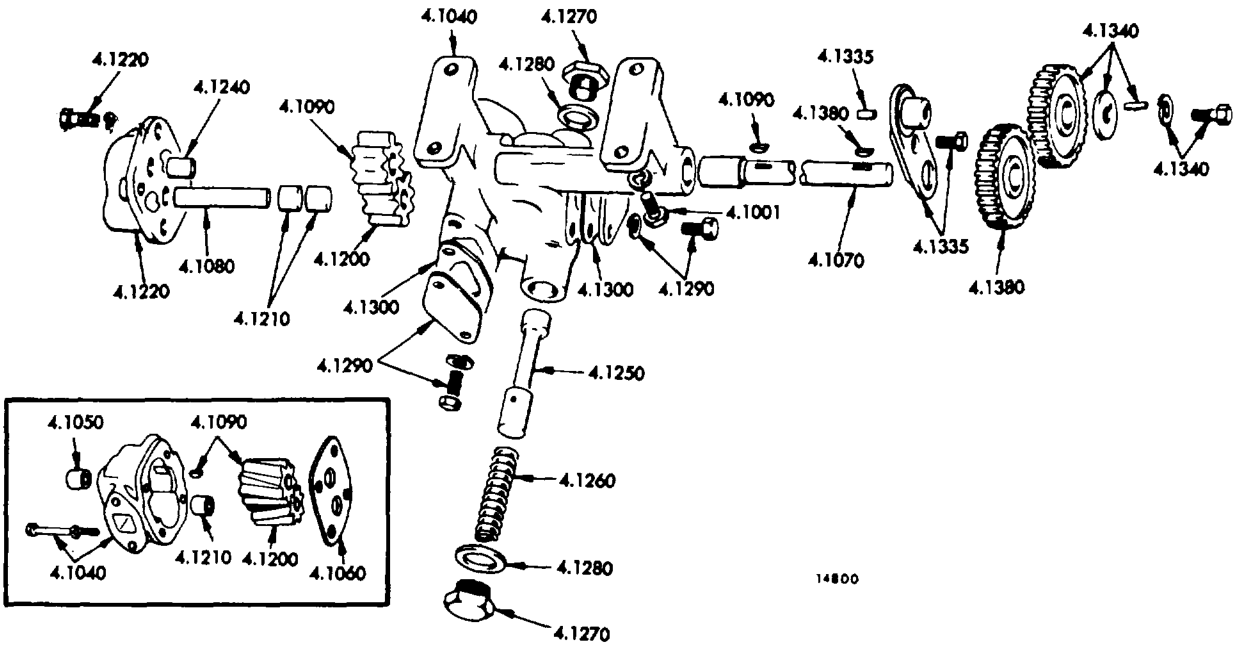


FIG. 1B OIL PUMP

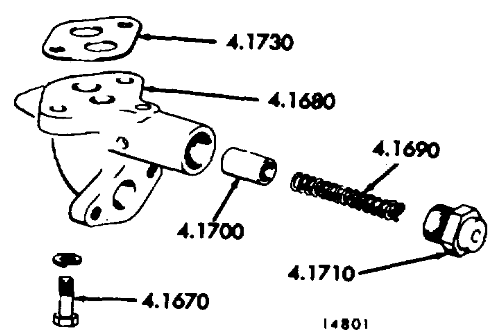


FIG. 1C OIL PRESSURE REGULATOR

Figs. 1B & 1C of 4.0000

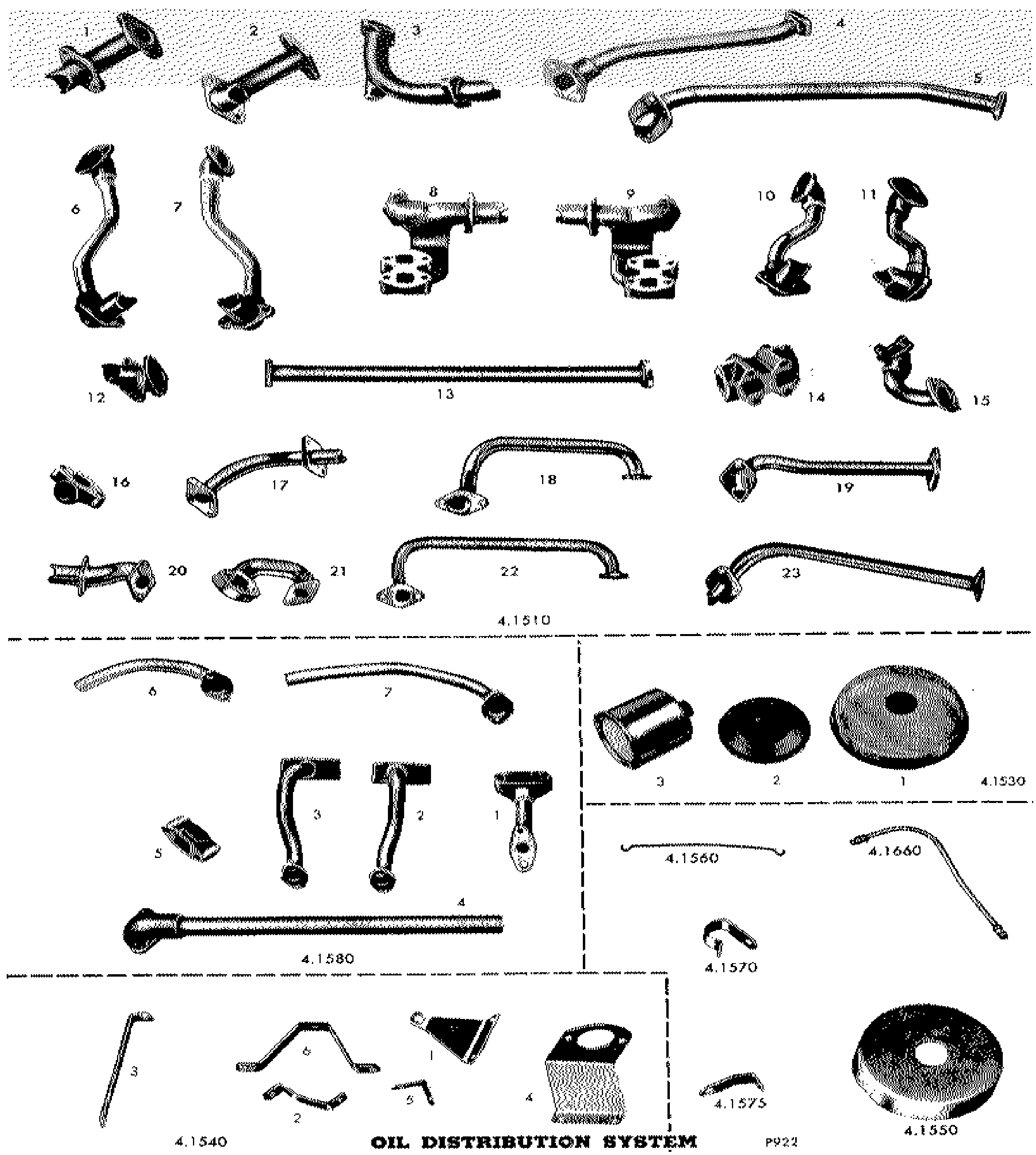


Fig. 2A of 4.0000

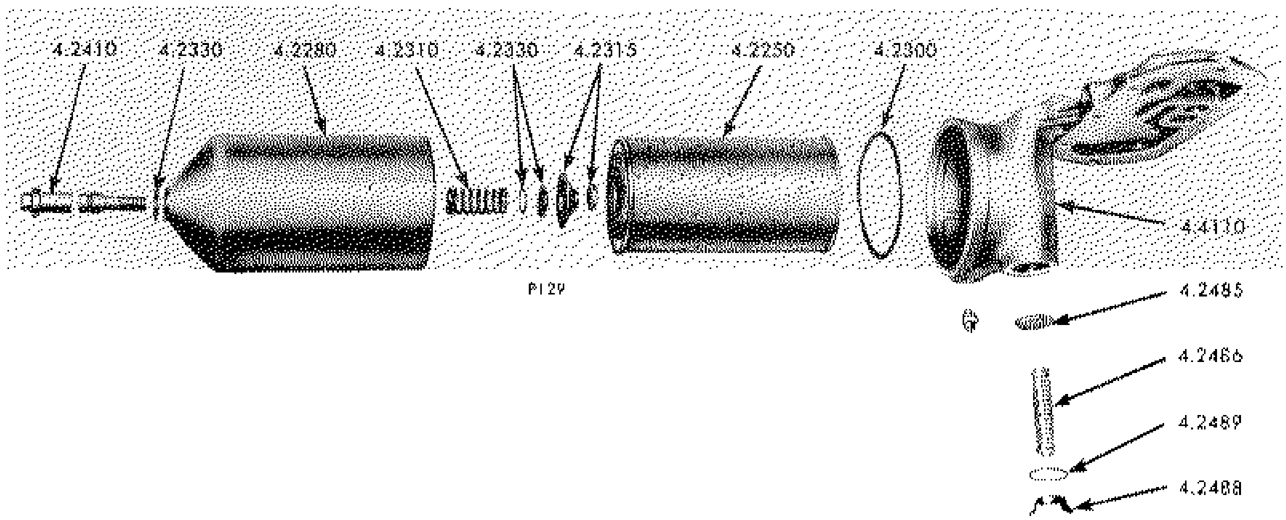


FIG. 3B OIL FILTER (By-Pass)

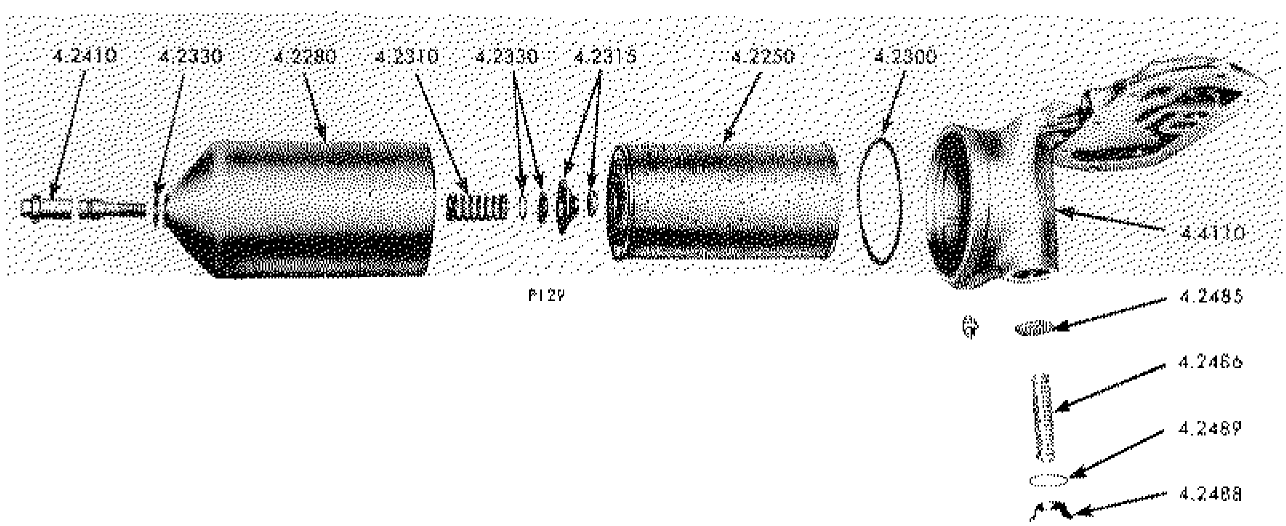


FIG. 3L OIL FILTER (Full Flow)

Figs. 3B & 3 L of 4.0000

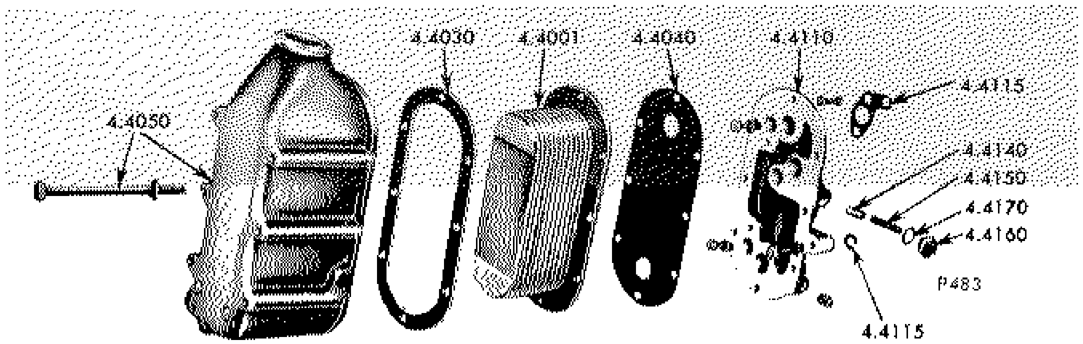


FIG. 4D OIL COOLER (Single Element)

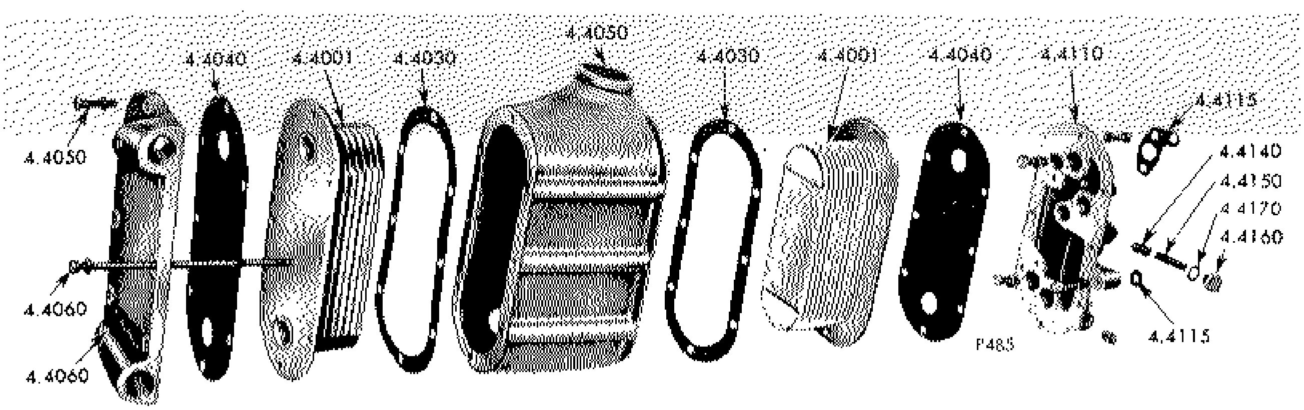


FIG. 4E OIL COOLER (Double Element)

Figs. 4D & 4E of 4.0000

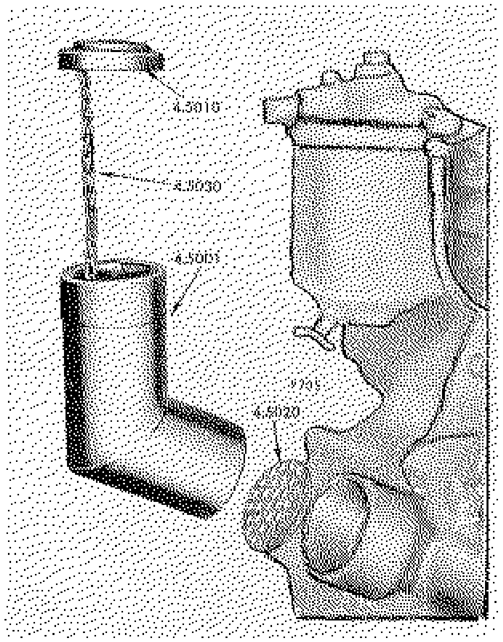


FIG. 5A OIL FILLER (Spring Type Cap)

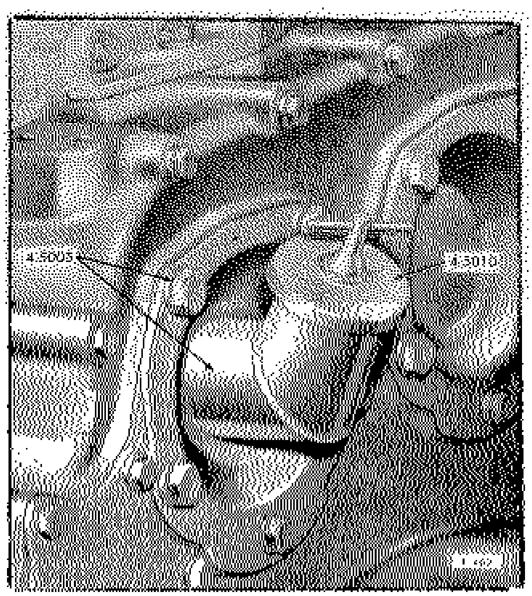


FIG. 5B OIL FILLER (Squeeze Type Cap)

Figs. 5A & 5B of 4.0000

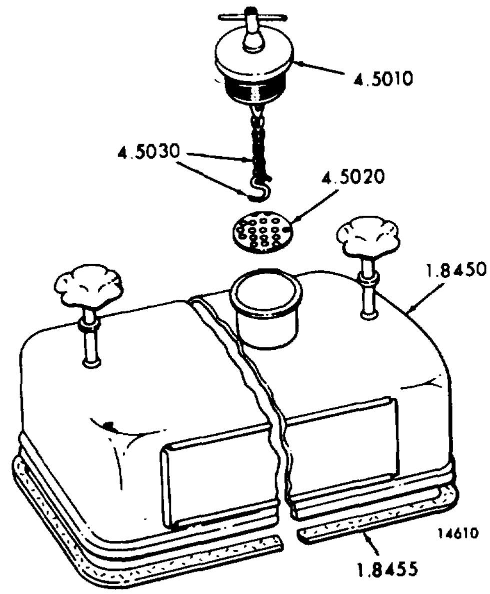


FIG. 5C OIL FILLER CAP (Expansion Type) (Stamped Cover)

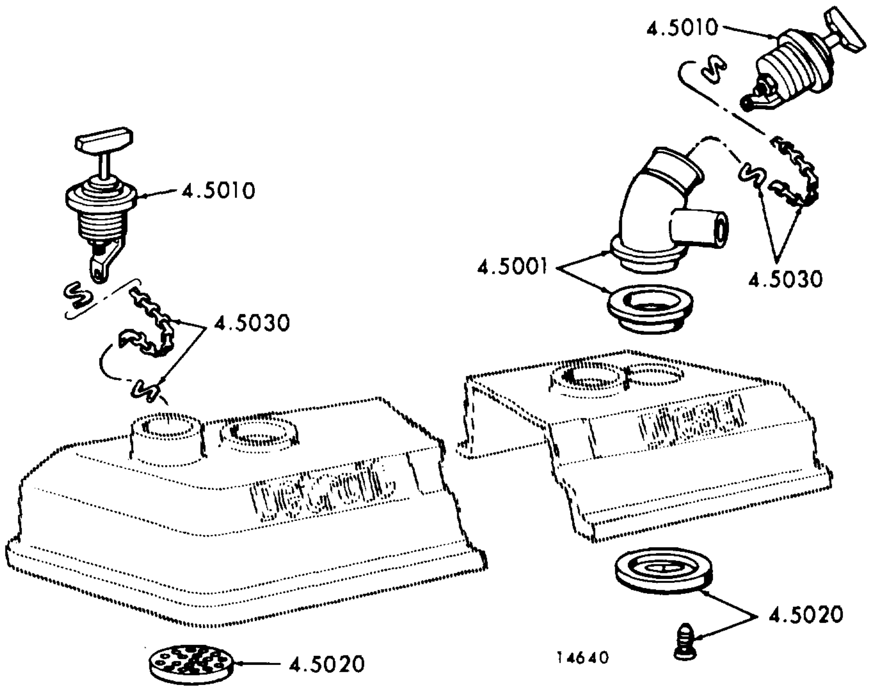
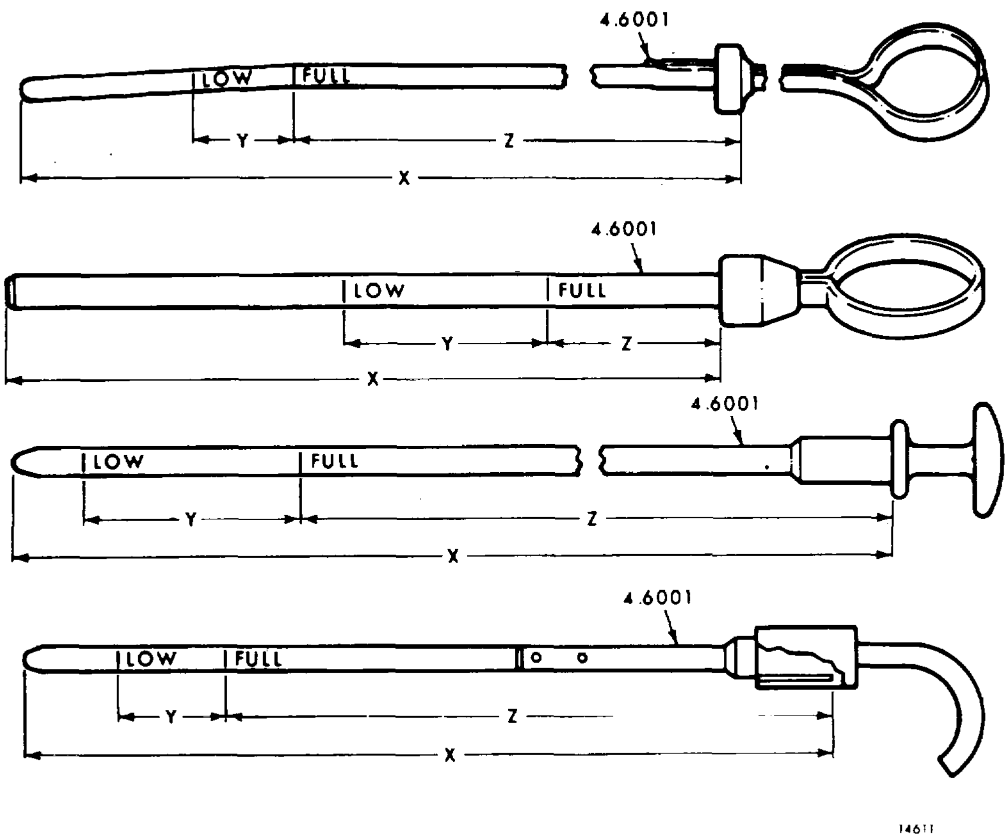


FIG. 5D OIL FILLER CAP (Expansion Type) (Cast Cover)

Figs. 5C & 5D of 4.0000



DIPSTICK

Figs. 6A, 6B, 6C & 6D of 4.0000

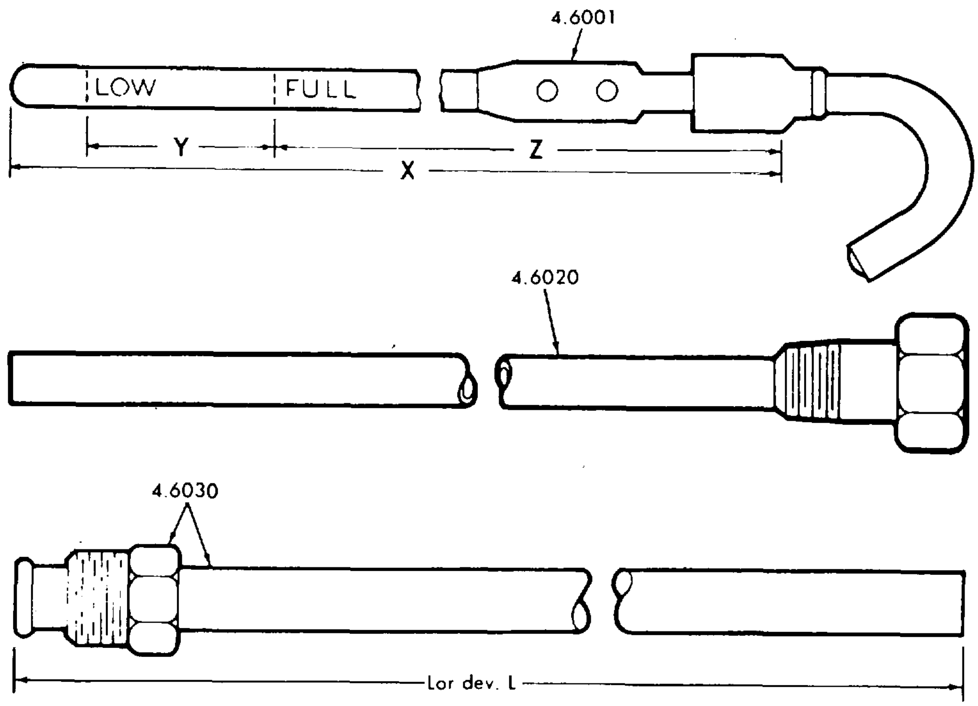


FIG. 6E DIPSTICK (Cane Type)

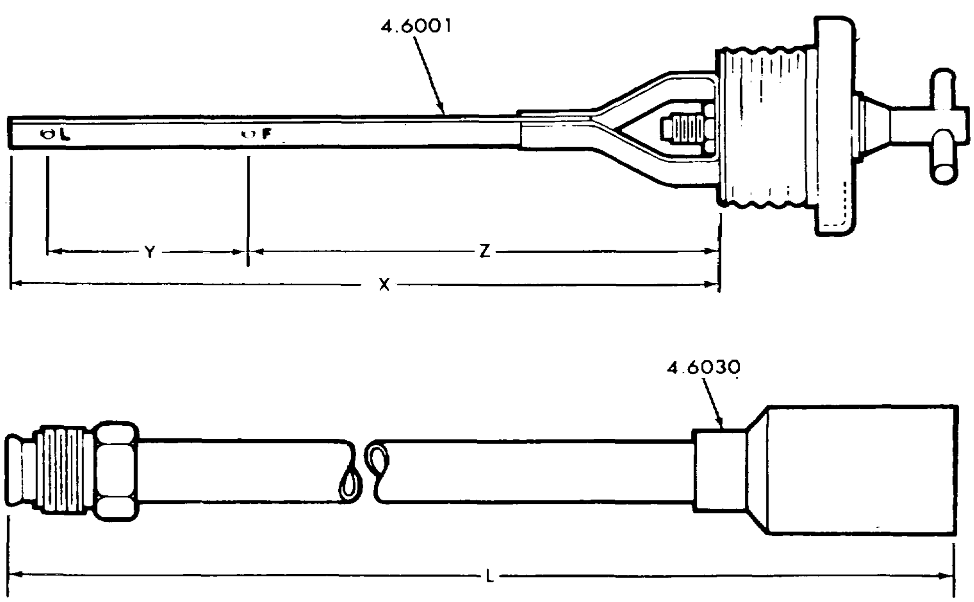


FIG. 6F DIPSTICK (Expansion Type)

Figs. 6E & 6F of 4.0000

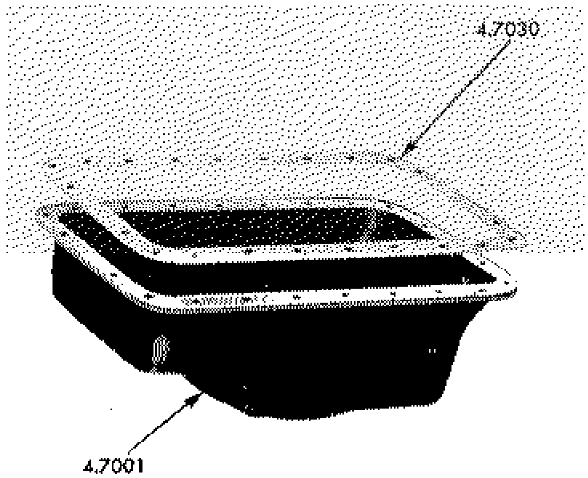


FIG. 7A

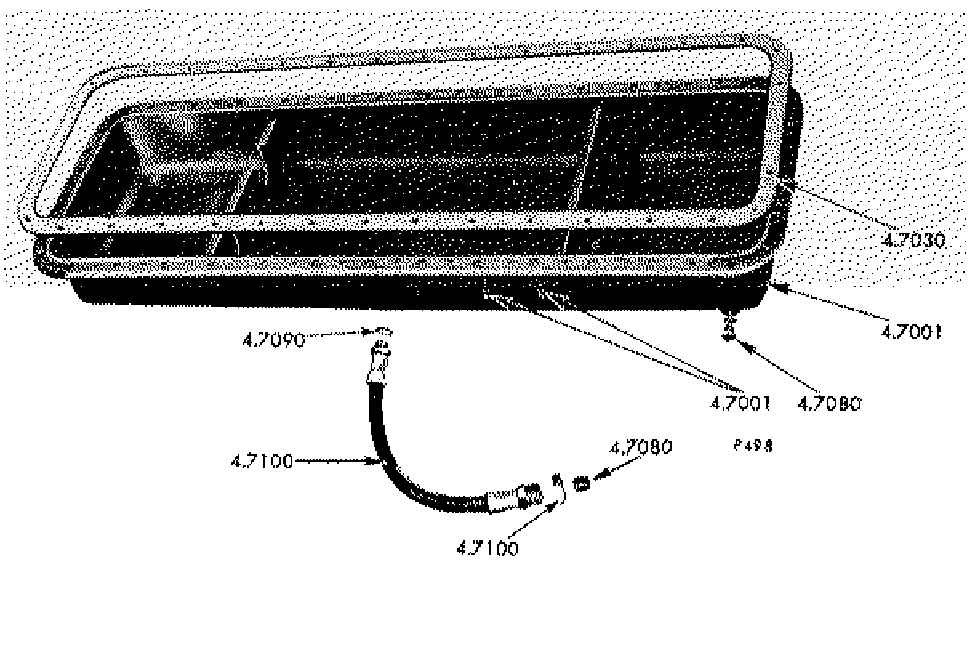


FIG. 7C
OIL PAN

Figs. 7A & 7C of 4.0000

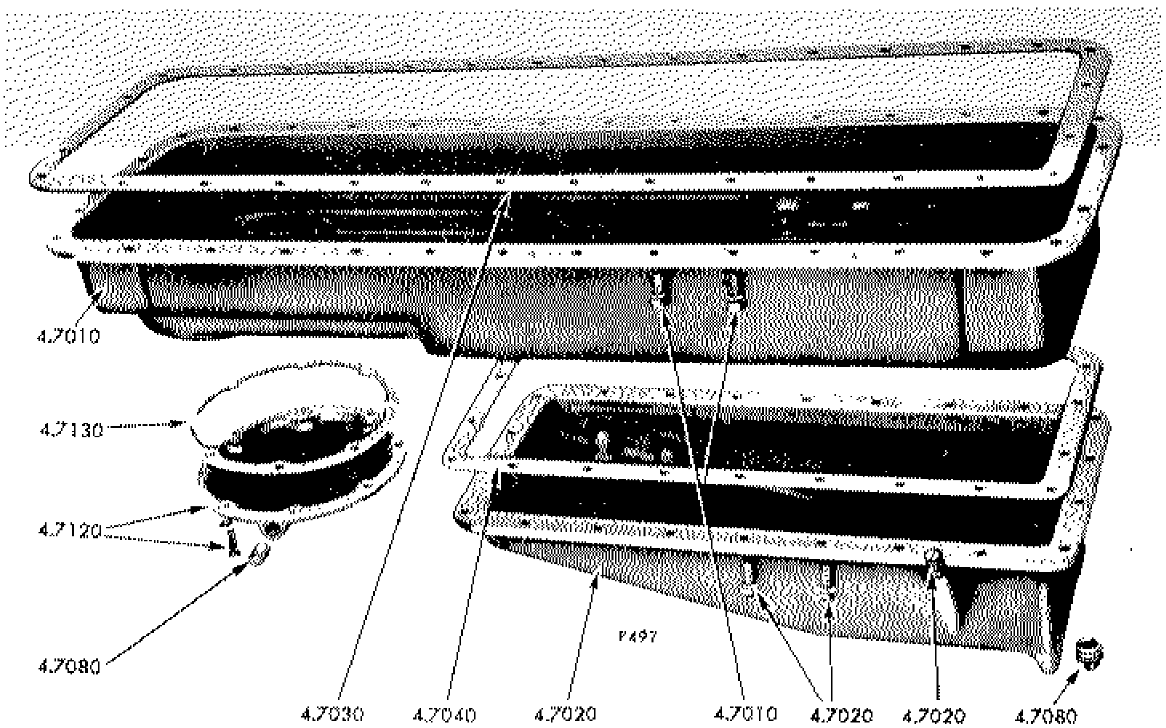
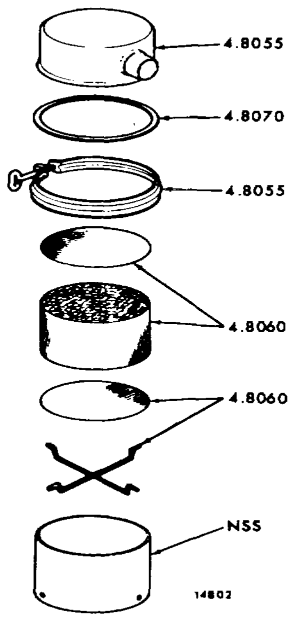


FIG. 7D OIL PAN

Fig. 7D of 4.0000



IG. 8A BREATHER ASSEMBLY (Stamped Cover)

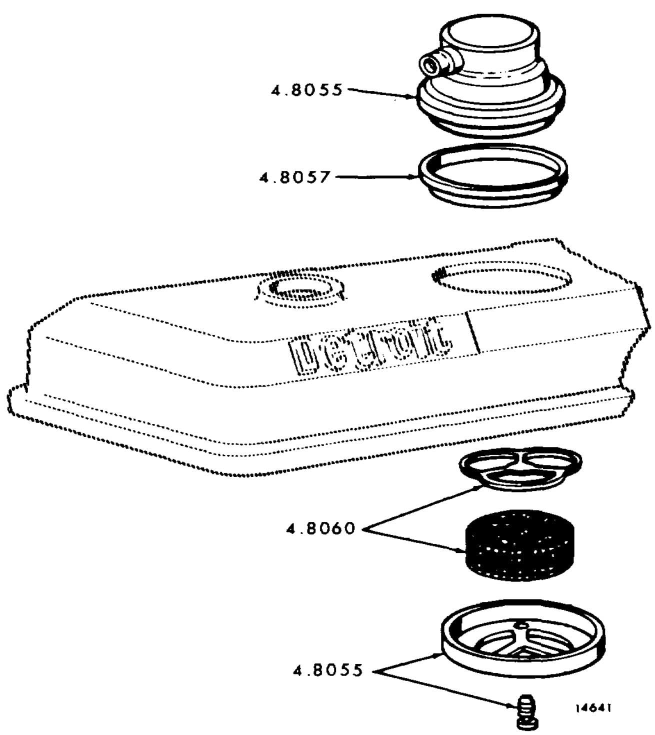


FIG. 8B BREATHER ASSEMBLY (Cast Cover)

Figs. 8A & 8B of 4.0000

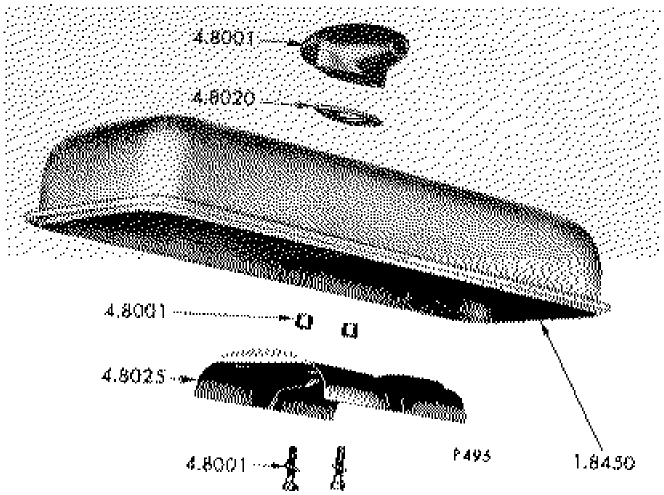


FIG. *8C ROCKER COVER BREATHER*

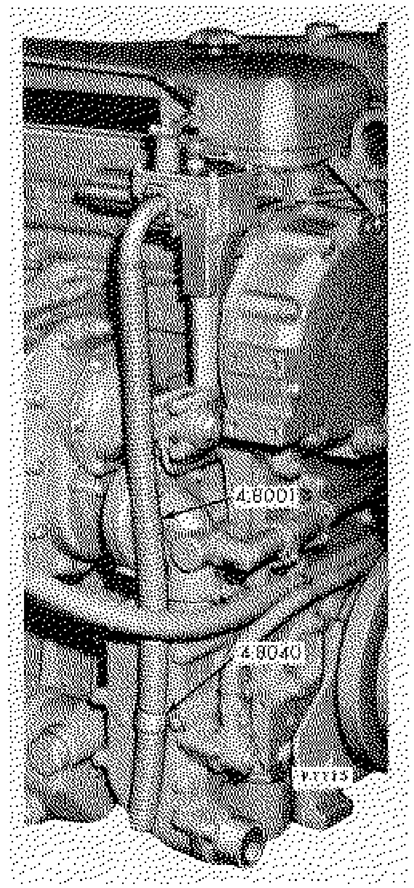


FIG. 8F GOVERNOR BREATHER

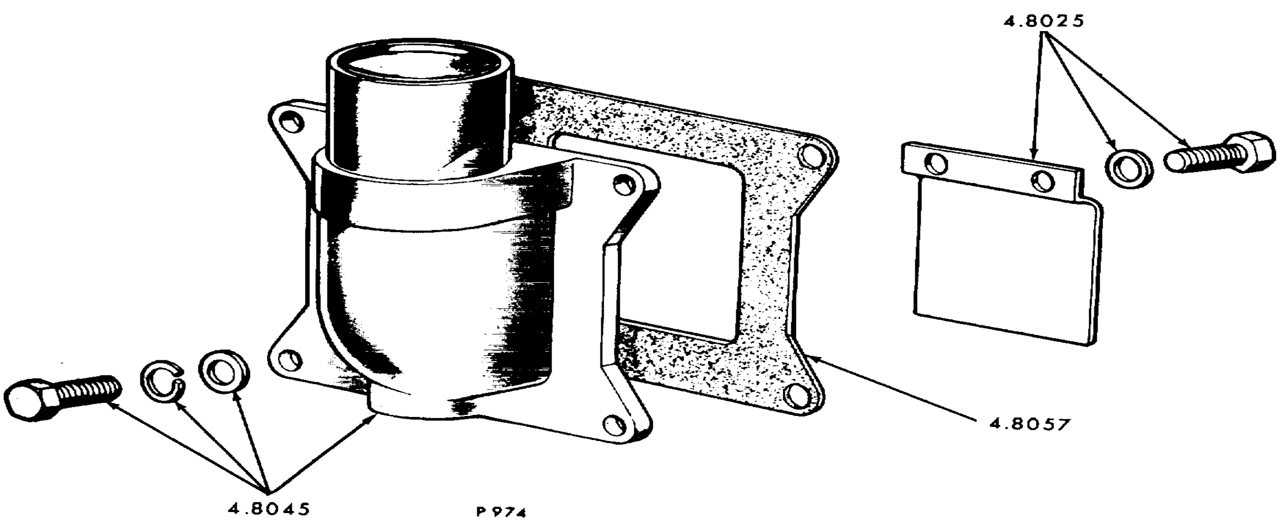


FIG. 8D CRANKCASE BREATHER
VENTILATING SYSTEM

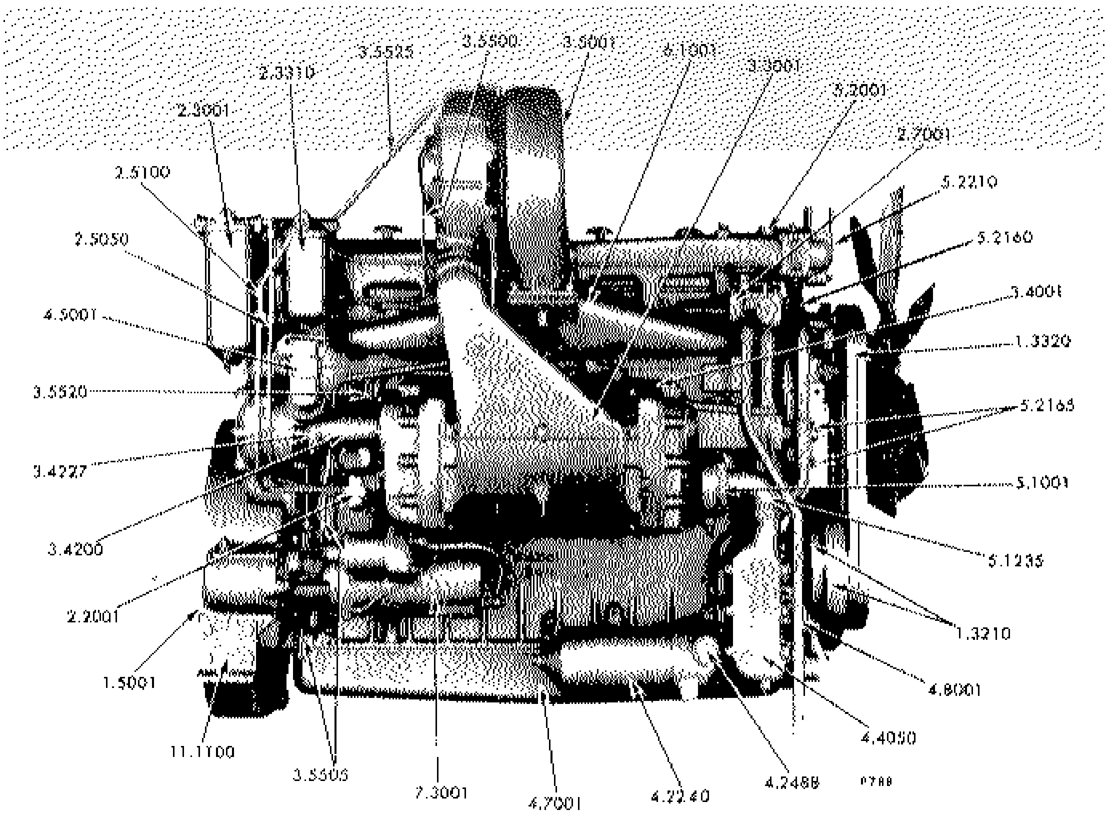


FIG. 10A TYPICAL 6-71 TURBOCHARGED ENGINE

4.1000A OIL PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	16	17	20	22	23	24	26	27	28	96	97	104
	4.1001 -	PUMP ASSY., OIL A L. H. PUMP IS USED ON LA, LB, LC, LD ENGINES AND R. H. PUMP IS USED ON RA, RB, RC, RD ENGINES. A PUMP ASSY. INCLUDES ITEMS IN 4.1040 THRU 4.1300, PLUS ITEMS IN 4.1335 THRU 4.1380.												
	6175988	PUMP ASSY. (R.H.)................................												1
	6175980	PUMP ASSY. (R.H.)................................												
	6175984	PUMP ASSY. (R.H.)................................												
	5175986	PUMP ASSY. (L.H.)												
	6176986	PUMP ASSY. (R.H.)................................												
	6175982	PUMP ASSY. (R.H.)................................												
	5177349	PUMP ASSY. (R.H.)................................												
1B	186627	BOLT, 3/8'-24X1' (1I.9001)												4
	103321	LOCKWASHER, 3/8' (12.9200)												4
	4.1002 -	GASKET KIT, OIL PUMP OVERHAUL A GASKET KIT CONSISTS OF OIL PAN GASKET IN 4.7030 AND GASKETS IN 4.1280, 4.1520, 4.1590, 4.1730 AND 4.7090.												
	5192106	GASKET KIT (3-71)												
	5192108	GASKET KIT (6-71)											AR	
	5192107	GASKET KIT (4-71)											AR	
	4.1003 -	OVERHAUL KIT, OIL PUMP NOT APPLICABLE TO SCAVENGING. PUMPS AN OVERHAUL KIT INCLUDES. SHAFTS GEARS, BUSHINGS, VALVE SPRING AND GASKETS REOUIRED TO OVERHAUL A PUMP.-												
	5194800	OVERHAUL KIT......................................												
	6194801	OVERHAUL KIT......................................												
	4.1030 -	SHIM, OIL PUMP												
	5176119	SHIM (.005-)											AR	
	4.1040	BODY, OIL PUMP												
		BODY ASSY. INCLUDES BUSHINGS IN 4.1050.												
1B	5153122	BODY ASSY, (SCAVENGING)											1	

4.1000A OIL PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	16	17	20	22	23	24	26	27	28	96	97	104
	4.1040 -	**BODY. OIL PUMP**												
1B	**5178121**	BODY ASSY. (WITH SHAFT)												1
1B	**5169193**	BODY ASSY. (WITH SHAFT)												
1B	**5175680**	BODY ASSY. (WITH SHAFT)												
1B	**179830**	BOLT, 5/16'-18X3' (12.9001)												4
	103320	LOCKWASHER, 5/16- (12.9200)												4
1B	**6179019**	BODY ASSY. (WITH SHAFT)												
	4.1050 -	BUSHING, OIL PUMP BODY												
	5153147	BUSHING..												2
1B	**5153154**	BUSHING (4.1210)												
	4.1080 -	**SPACER, OIL PUMP BODY**												
1B	**5153257**	SPACER												1
	4.1070 -	SHAFT, OIL PUMP DRIVE												
1B	**5153309**	SHAFT												1
1B	**5153146**	SHAFT												
	4.1080 - SH	AFT, OIL PUMP DRIVEN GEAR												
1B	**5153146**	SHAFT												1
18	**6163310**	SHAFT												
	4.1090	GEAR. OIL PUMP DRIVE												
1B	**6163260**	GEAR..												1
1B	**518G65**	GEAR (PRESSURE)...............................												
1B	**103906**	KEY, 1/8'X5/8' WOODRUFF (12.9350)....												3
	4.1200	**GEAR, OIL PUMP DRIVEN**												
		A GEAR ASSY. INCLUDES BUSHING IN 4.1210.												
1B	**6163617**	GEAR ASSY. (SCAVENGING)												2
1B	**51666849**	GEAR ASSY. (PRESSURE)												
1B	**6153617**	GEAR ASSY												

4.1000A OIL PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	16	17	20	22	23	24	26	27	28	96	97	104		
	4.1210 -	**BUSHING. OIL PUMP DRIVEN GEAR**														
1B	**5166840**	BUSHING (IN 5 1 66649 GEAR ASSY.) ..														
1B	**5163154**	BUSHING (IN 5153517 GEAR ASSY.)												4		
1B	**5163164**	BUSHING (IN 5153517 GEAR ASSY.)														
	4.1220 -	**COVER, OIL PUMP**														
		A COVER ASSY. INCLUDES BUSHING 4.1240.														
1B	**5154262**	COVER ASSY. (R.H.)														
1B	**5153299**	COVER ASSY..														
1i	**5154251**	COVER ASSY. (L.H.)..............................														
18	**1886624**	BOLT. 5/16'-17X .... 1/4' (12.9001)														
	103320	LOCKWASHER. 5/16- (12.9200)														
	4.1240	**BUSHING, OIL PUMP COVER**														
I B	**5153164**	BUSHING (2 3/32-O.D.X11/16-L.)												1		
	4.1260 -	**VALVE. OIL PUMP RELIEF**														
1B	**5153247**	VALVE												1		
	4.1260	**SPRING. OIL PUMP RELIEF VALVE**														
1B	**5156786**	SPRING												1		
	4.1270	**PLUG, OIL PUMP RELIEF VALVE**														
1B	**5152513**	PLUG (7/8'-18 SPL.)												2		
	4.1280 -	**GASKET, OIL PUMP RELIEF VALVE**														
1B	**106466**	GASKET, 7/8' COPPER (12.9360)												2		
	4.1290 -	**COVER, OIL PUMP PAD**														
1B	**5156955**	COVER (1 7/8' BOLT CENTER)												1		
1B	**5153311**	COVER (2 1/8' BOLT CENTER)														
1B	**179816**	BOLT, 5/16'-18X3/4' (12.9001)												2		
1B	**179816**	BOLT, 5/16'-1BX3/4' (12.9001)................														
	103320	LOCKWASHER, 5/16' (12.9200)												AR		

71 VEH ENGINES

4.1000A OIL PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 16	17	20	22	23	24	26	27	28	96	97	104		
	4.1300 -	**GASKET, OIL PUMP PAD COVER**														
1B	**5151370**	GASKET(1 7/8' BOLT CENTER)												1		
1B	**5153313**	GASKET (2 1/8' BOLT CENTER)														
	4.1310 -	**GEAR, OIL PUMP DRIVE (ON CRANKSHAFT)**														
1B	**5156532**	GEAR..												1		
1B	**5156821**	GEAR..														
	124649	KEY, 3/16'X3/4' WOODRUFF (12.9350)..														
	4.1336 -	**SUPPORT, OIL PUMP IDLER GEAR**														
1B	**5159195**	SUPPORT...												1		
1B	**5176035**	DOWEL (5/16'X3/4')................................												1		
1B	**9409079**	BOLT, 3/8'-16X7/8' (12.9001)												1		
	4.1340 -	**GEAR. OIL PUMP IDLER**														
	A GEAR AS	SY. INCLUDES BUSHING IN **4.1350.**														
1B	**5156683**	GEAR ASSY												1		
1B	**5169197**	WASHER (LARGE).................................												1		
1B	**5175944**	WASHER (SMALL)												1		
1B	**186625**	BOLT, 5/16'-1BX7/8 (12.9001)................												1		
1B	**443230**	PIN, 1/8'X3/8' GROOVE (12.9270)												1		
	4.1360	**BUSHING, OIL PUMP IDLER GEAR**														
	5156521	BUSHING														
	4.1380	**GEAR, OIL PUMP DRIVE (ON PUMP)**														
1B	**5156528**	GEAR..												1		
	103905	KEY, 1/8'X5/8" WOODRUFF (12.9350) ...												1		

4.1000 OIL DISTRIBUTION SYSTEM

FIG	PART NUMBER	NAME AND DESCRIPTION	3	6	8	10	19	39	42	43	44	48	49	51			
	4.1510 -	**PIPE, OIL PUMP INLET**															
2	**5156848**	PIPE (ITEM 2)...															
2	**5174988**	PIPE (ITEM 7)...															
2	**5176602**	PIPE (ITEM 20).......................................															
2	**5159408**	PIPE (ITEM 5)...															
2	**5159415**	PIPE (SCAVENGING) (ITEM 15)............															
2	**5159413**	PIPE (SUPPORT) (ITEM 14)															
2	**5156871**	PIPE (ITEM 1)...															
2	**5159481**	PIPE (ITEM 23).......................................															
2	**5153815**	PIPE (SCAVENGING) (ITEM 13)............			1												
2	**5153828**	PIPE (SUPPORT) (ITEM 12)			1												
2	**5153943**	PIPE (ITEM 8)...			1												
2	**5158847**	PIPE (ITEM 3)...															
	179816	BOLT, 5/16a- 1 8X3/4' (12.9001)............															
	186625	BOLT, 5/16'- 1 8X7/8' (12.9001...............			4												
	186629	BOLT, 5/16'-18X1' (12.9001)															
	179824	BOLT, 5/16'-18Xl 3/4' (12.9001)..............			4												
	186648	BOLT, 5/16'-18Xl 7/8 (12.9001)															
	179829	BOLT, 5/16'-S18X2 3/4' (12.9001)..........															
	120393	WASHER, 5/16' FLAT (12.9190			AR												
	103320	LOCKWASHER, 5/16' (12.9200)			AR												
	4.1520 -	GASKET, OIL PUMP INLET PIPE															
	5153627	GASKET (2 9/16' BOLT CENTERS.........															
		1 3/16'X15/32' DIA. CENTER HOLE)															
	5153313	GASKET (2 1/8' BOLT CENTERS..........)															
	5153313	GASKET (2 1/8' BOLT CENTERS)..........															
		(4.1300)															
	5153313	GASKET (2 1/8' BOLT CENTERS)..........			2												
	5157380	GASKET (2 9/16' BOLT CENTERS.........															
		1 11/16' DIA. CENTER HOLE) (AT															
	5157380	GASKET (2 9/16' BOLT CENTERS, ...			2												
		1 11/16' DIA. CENTER HOLE) (AT															
	5153902	GASKET (2 1/4' BOLT CENTERSS)........			2												
	4.1530 -	**SCREEN, OIL PUMP INLET**															
2	**5155830**	SCREEN (4 1/2' DIA.) (ITEM 25).............															
2	**5153286**	SCREEN (6 7/16' DIA.) (ITEM 24)...........															
2	**5153286**	SCREEN (6 7/16' DIA.) (ITEM 24j............			2												
	114351	BOLT, 1/4'-20X3/8' FIL. HD															
		(12.9010)															

4.1000 OIL DISTRIBUTION SYSTEM

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 3	6	8	10	19	39	42	43	44	48	49	51		
	4.1530 * SCREEN, OIL PUMP INLET (CONT'D)															
	103319	LOCKWASHER, 1/4' (12.9200)														
	4.1540 -	**BRACKET, OIL PUMP SCREEN SUPPORT**														
2	**5156868**	BRACKET (ITEM 28)														
2	**5153317**	BRACKET (ITEM 32)														
2	**5159398**	BRACKET (ITEM 311)														
2	**5130005**	BRACKET (ITEM 33)														
	5173135	BRACKET														
2	**5153829**	BRACKET (ITEM 30)			1											
2	**5156935**	BRACKET(ITEM 27)														
	120228	BOLT, 5/1 6'- 1 8X5/8 - (1 2. 9001 1														
	179816	BOLT, 5/16'-18X3/ 4- (12 .... 9001)														
	113862	BOLT, 5/16'-18X7/8' RD. HD. SL														
	181360	BOLT, 3/8'-2 4X3/4' (12 9001) .... (12.9025)			2											
	186627	BOLT, 3/8 -24X .... (12.900)														
	120393	WASHER, 5/16- FLAT (12.9190)														
	103341	WASHER, 3/8- FLAT (I12.9190)														
	103320	LOCKWASHER, 5/16' (12.9200)														
	103321	LOCKWASHER, 3/8- (12.9200)			AR											
	4.1550 -	**COVER, OIL PUMP INLET SCREEN**														
	192481	NUT, 3/8 -24 HEX. LOCK (12.9140)														
2	**5118302**	COVER			2											
	179816	BOLT, 5/16'-18X3/42(12.9001)			4											
	9417889	BOLT, 5/16'-24X1 1/8' (WASHER HEAD)														
	120393	WASHER, 5/16- FLAT (12.9190)			4											
	103320	LOCKWASHER, 5/16' (12 9200)			AR											
	121917	NUT, 5/16'-24 HEX. (12.9120)														
	4.1560	*** RETAINER, OIL PUMP INLET PIPE SCREEN**														
2	**5153284**	RETAINER (7 5/16- LONG)			2											
	4.1670 - CLIP, OIL PUMP OUTLET PIPE															
2	**55155664**	CLIP, l' SPECIAL														
	181360	BOLT, 3/8'-24X3/4' (12. 9001)														
	103321	LOCKWASHER, 3/8' (12.9200)														
	117049	NUT, 3/8'-24 HEX. (12.9120)														

4.1000B OIL DISTRUBUTION SYSTEM

FIG	PART NUMBER	NAME AND DESCRIPTION	3	6	8	10	19	39	42	43	44	48	49	51		
	4.1575	BRACKET, OIL PUMP OUTLET PIPE														
2	5159393	BRACKET (DEVL 3 5/')														
	181360	BOLT, 3/8'-24X3/4' (12.9001)														
	103321	LOCKWASHER, 3/8' (12.9200)														
	4.1580	PIPE, OIL PUMP OUTLET														
2	5159388	PIPE (ITEM 35)			1											
2	5110126	PIPE (ITEM 34)														
2	5159399	PIPE (SCAVENGINS) (ITEM 37)														
2	5156994	PIPE (SCAVENGING) (ITEM 38)			1											
	179816	BOLT, 5/16'-18X3/4' (12.9001'			2											
	186625	BOLT, 5/16'-,8X7/8' (TO BLOCK)			2											
	186629	BOLT, 5/1 6'-18X l ' (12.9001)														
	179819	BOLT, 5/16'-18X1 1/8' (12.9001)														
	179824	BOLT, 5/16'-18X1 3/4' (TO PUMP) (12.9001)														
	179824	BOLT, 5/16'-18X1 3/4- (12.9001)			4											
	120393	WASHER, 5/16' FLAT (12.9190)			2											
	103320	LOCKWASHER, 5/16' (12.9200)			AR											
	4.1590 - GASKET, OIL PUMP OUTLET PIPE															
	5151370	GASKET (1 7/8' BOLT CENTERS) (AT BLOCKI (4.1300)			1											
	5153313	GASKET (2 1/8' BOLT CENTERS) (4.1300)														
	5153313	GASKET (2 1/8' BOLT CENTERS) (AT PUMP) (4.1300)			2											
	4.1595 - TUBE, OIL RETAINER (BALANCER SHAFT)															
	5169995	TUBE														
	5150027	BOLT (1.7050)														
	4.1660	PIPE, BLOWER DRIVE BEARING OIL														
2.#	5150431t	PIPE (DEV L 8 5/8')														
2,#	5150433=	PIPE (DEV L 11 7/8')			1											
	137421	ELBOW, 1/4' INV FL TUBE 90 DEG (TO SUPPORT) (12.9480)			1											
#	143342	ELBOW, 1/4' INV FL TUBE 90 DEG 1/4' P.T (TO BLOCK) (12.9480)			1											
	120401	ELBOW, 1/8' STREET 90 DEG (12.9590)														
	5151617	TEE, 1/4' INV FL TUBE (AT BLOCK)														
	4.1660 - PIPE, BLOWER DRIVE BEARING OIL (CONT'D)															
	5167220	TEE, 1/4' INV FL TUBE (7 8300)														
	5145009	PLUG, 1/8' PIPE (12 95501														
		#FIG 3C OF 3 0000.														
		WITH VERTICAL OIL FILLER.														
		= WITH 60 DEG OIL FILLER.														

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	46	47	51	54	60	83	190	66	276	80	293
	4.2240 - FILTER, OIL -	REFER TO ASSEMBLY BREAKDOWN PAGE AS IF OIL COOLER ADAPTORS OTHER THAN 5123635 OR 5123636 IN 4.2290 ARE REQUIRED, ORDER FILTER REPLACEMENT BY COMPONENTS; DO NOT ORDER FILTER ASSY FILTER ASSYS DO NOT INCLUDE DECALS IN 4.2240.											
	5194287	FILTER ASSY (FULL FLOW) (A OR B ENGINES) (PAGE Al)											
	5194288	FILTER ASSY (FULL FLOW) (C OR D ENGINES) (PAGE Al)											
	5572942#&	FILTER ASSY ....(BY-PASS) (PAGE Al) --						1					
	5181797 @	FILTER ASSY (FULL FLOW) (5147683)											
	2325391	FILTER ASSY (BY-PASS) (LUBER-FINER) (PAGE Al)											
3L	5137659 @	FILTER ASSY (FULL FLOW) (5147683)											
	5573199	DECAL (BY-PASS FILTER)											
	5573162	DECAL (FULL FLOW FILTER)						AR					
	5146010	PLUG, 1/4' PIPE (12.9550)						AR					
	5133279	BUSHING, 1/2'X1/4' (.062' RESTRICTION) (4.3001)											
	180121	BOLT, 3/8'-16X7/8' (12.9001)											
	186ee679	BOLT, 3/8'-16X1 1/4' (12.9001)											
	103321	LOCKWASHER, 3/8' (12.9200)											
		# INCLUDES ITEMS IN 4.2440.											
		& NOT SERVICED, REPLACED BY 1-5570141 FILTER, 2-5573419											
		@ NOT SERVICED, COMPONENTS ARE AVAILABLE FOR A COMPLETE REPLACEMENT USE ASSY NUMBER SHOWN IN PARENTHESES PLUS 5111798 AND 12800.3 @ TWO EACH.											
	4.2250 - ELEMENT, OIL FILTER												
3L	5573014+	ELEMENT (PAPER) (DOMESTIC USE) (FULL-FLOW) (AC TYPE PF-132)						1					
		+ INCLUDES GASKET IN 4.2300.											
	4.2270 - SPACER, OIL FILTER												
	5570487=	SPACER											
		= NO LONGER AVAILABLE FOR SERVICE.											

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	46	47	51	54	60	83	190	66	276	80	293			
4.2280-		SHELL, OIL FILTER														
3B,L	5574008	SHELL (INCLUDES PLUG)						1								
	4.2290	COVER, OIL FILTER														
	5114500	ADAPTOR ASSY (4.4110)														
	5123928	ADAPTOR														
	5571540	TUBE (IN ADAPTOR)														
3B	112578	PLUG, 1/4' PIPE (12.9550)														
	5145010	PLUG, 1/4' PIPE (12.9550).														
	179819	BOLT, 5/16'-18X1 1/' (12.9001)														
	179823	BOLT, 5/16'-1BX1 5/' (12.9001)														
	179844	BOLT, 3/8'-16X1 5/8 ' (12.9001)														
	108608	BOLT, 3/8'-16X2 1/8' (12.9001)														
	179851	BOLT, 3/8'-16X3' (12.9001)														
	103320	LOCKWASHER, 5/16^ (12.9200)														
	103321	LOCKWASHER, 3/8' (12.9200)														
	4.2293 -	GASKET, OIL FILTER ADAPTOR TO OIL COOLER ADAPTOR														
	5188028	GASKET														
	5114459	GASKET (4.4117)						1								
	4.2300-	GASKET, OIL FILTER COVER														
38	6571024	GASKET (BY-PASS FILTER)														
3L	5571024	GASKET (FULL FLOW FILTER)						1								
	4.2310-	SPRING, OIL FILTER														
3B	1503518	SPRING (BY-PASS FILTER)														
3L	5187308	SPRING (FULL FLOW FILTER)														
	5574129 &	SPRING (BY-PASS FILTER)														
3B	5187308	SPRING (BY-PASS FILTER)														
		& NO LONGER AVAILABLE FOR SERVICE.														
	4.2315 -	RETAINER, OIL FILTER SPRING														
3L	5187309	RETAINER						1								
3L	5179197 %	RING, RETAINER SNAP (2.4227)						1								
3L	5120602 +	RING, RETAINER SNAP						1								
	1 22366	7 NUT, 5/8'-1 B HEX (12.9120)						1								
		% THRU 3A-35686, 4A-73887, 6A-77569.														
		+ EFFECTIVE WITH 3A-35687, 4A-73888,														

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	46	47	51	54	60	83	190	66	276	80	293
	4.2315 - RETAINER	OIL FILTER SPRING											
		6A-77570 AND THRU 3A-49382, 4A-98323, 6A-104617.											
		? EFFECTIVE WITH 3A-49383, 4A-98324, 6A-104618.											
	4.2320 - NUT, OIL FILTER COVER												
	5574127	& BOLT, LOCK											
		& NO LONGER AVAILABLE FOR SERVICE.											
	4.2330 - GASKET	OIL FILTER COVER NUT											
3B	6437298	GASKET (BY-PASS FILTER)											
3L	6437298	GASKET (FULL FLOW FILTER)						1					
3L	5187310	GASKET RETAINER (FULL FLOW FILTER)						1					
3L	5154538	WASHER (1.8182)						1					
	4.2410 - STUD, OIL FILTER CENTER												
3B	1595893	STUD (BY-PASS FILTER)											
3L	5120740	STUD (FULL FLOW FILTER)						1					
36	5120740	STUD (BY-PASS FILTER)											
	4.2440 - BRACKET, OIL FILTER MOUNTING												
3B	5186068	BRACKET (BY-PASS FILTER)											
	5127156	BRACKET (BY-PASS FILTER) (2.3165)											
	5112134	BRACKET (FULL FLOW FILTER)											
	132430	BOLT, 3/8'-16X2 1/2' (12.9010)											
	454933	BOLT, 7/16'-14X1 1/8' (12.9001)											
	110730	LOCKWASHER, 3/8' (12.9200)											
	103322	LOCKWASHER, 7/16' (12.9200)											
	117062	NUT, 3/8'-16 HEX (12.9120)											
	4.2485 - VALVE, OIL FILTER BY-PASS												
3L	5187315 +	VALVE											
3L	5133431 =	VALVE											
		+ THRU 3A-40364, 4A-80703, 6A-86658.											
		= EFFECTIVE WITH 3A-40365, 4A-80704, 6A-86659.											

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	46	47	51	54	60	83	190	66	276	80	293				
	4.2486	* SPRING, OIL FILTER BY-PASS VALVE															
3L	5187314+	SPRING															
3L	5 1 33594=	SPRING															
		+ THRU 3A-40364, 4A-80703, 6A-86658. = EFFECTIVE WITH 3A-40365, 4A-80704, 6A-86659.															
	4.2488	- PLUG, OIL FILTER BY-PASS															
3L	5187313 +	PLUG															
3L	6126686=	PLUG															
		+ THRU 3A-403864, 4A-80703, 6A-86658. = EFFECTIVE WITH 3A-40365, 4A-80704, 6A-86659.															
	4.2489	GASKET, OIL FILTER BY-PASS PLUG						NOT APPLICABLE									
3L	5187316+	GASKET															
3L	5575086 =	GASKET															
		+ THRU 3A-40384, 4A-80703, 6A-86658. = EFFECTIVE WITH 3A-40365, 4A-80704, 6A-86659.															
	4.2495	- BRACKET, LOW OIL PRESSURE SWITCH															
	5188572	BRACKET ASSY-															
	425250	CONNECTOR, 5/16' TUBE, 1/4' N.P.T.															
	5121466	BOLT, 3/8'-24X3 7/8' (12.9001)															
	103341	WASHER, 3/8' (12.9190)															
	4.2497	- TUBE, LOW OIL PRESSURE SWITCH															
	5143443	TUBE ASSY															
	5188570	TUBE ASSY															
	137422	ELBOW, 90 DEG.-5/1 6' TUBE (12.9480)															
	5145010	PLUG, 1/4' PIPE (12.9550)															
	112877	BUSHING, 1/4'X1/8' RED (12.9570)															

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	5194287	FILTER ASSY (A OR B ENGINES)	1													
	5194288	FILTER ASSY (C OR D ENGINES)		1												
	5572942	@ FILTER ASSY			1											
	5181797	= FILTER ASSY				1										
	2325391	FILTER ASSY					1									
3L	5137659	= FILTER ASSY						1								
		@ NOT SERVICED, USE 1-5570141														
		FILTER, 2-5127156 BRACKETS,														
		= SHOWN FOR COMPONENT REFERENCE														
		2-5571568 BOLTS.														
		ONLY.														
	4.2250	* ELEMENT, OIL FILTER														
		INCLUDES GASKET IN 4.2300.														
3L	5573014	ELEMENT (AC TYPE PF- 132) (PAPER)	1	1		1	1									
	5187830	ELEMENT (METAL) (EXPORT USE)	1	1												
3B	6572425	ELEMENT (AC TYPE P-1 17)			1	1										
	5573898	ELEMENT (AC TYPE C-267)														
	5570487	* SPACER 1			1											
	4.2270	- SPACER OIL FILTER														
		* NO LONGER AVAILABLE FOR SERVICE.														
3B	6674008	SHELL ASSY(INCLUDES PLUG)	1	1				1								
	4.2280	- SHELL, OIL FILTER														
39	657409 08	SHELL ASSY (INCLUDES PLUG)			1											
	5570480	PLUG, DRAIN (2.3050)	1	1	1	1										
	112578	PLUG, 1/4' PIPE (12.9550)	1	1	1	1										
		* OBSOLETE														
	4.2290	- COVER, OIL FILTER														
		A COVER INCLUDES PLUGS.														
3B	5571505	COVER (SINGLE BY-PASS FILTER)			1											
	5574128	* COVER ASSY(INCLUDES ITEMS IN			1											
		4.2310,4.2320, 4.2330)														
3L	6123635	ADAPTOR (A OR B ENGINE) (4.4110)	1													
3L	5123638	ADAPTOR (C OR D ENGINE) (4.4110)		1												
	5188923#	ADAPTOR (5147684)				1										
	5137651 #	ADAPTOR (5147684)						1								

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	4.2489 -	GASKET, OIL FILTER BY-PASS PLUG														
3L	5187316@	GASKET	1	1		1										
3L	5575086 &	GASKET	1	1		1										
		@ EFFECTIVE WITH 3A-40365, 4A-80704, 6A-B6659														
		& THRU 3A-40364, 4A-80703, 6A-86658.														

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	4.2290	COVER, OIL FILTER														
	5177777	VALVE, BY-PASS (OIL COOLER) (4.4140)	1	1												
	5177778	SPRING, BY-PASS (OIL COOLER)	1	1												
	5177773	GASKET, VALVE PLUG (OIL COOLER)	1	1												
	6177772	PLUG, BY-PASS VALVE PLUG (OIL (4 4170)	1	1												
	5146010	PLUG, 1/4' PIPE (12.9550)	1	1	2											
	5571540	TUBE,ADAPTOR COOLER) (4.4160)			2											
		* NO LONGER AVAILABLE FOR SERVICE. # NOT SERVICED, USE PART NUMBER IN PARENTHESES PLUS 5111798 AND 128003 @ TWO EACH.														
3L	5571024	GASKET A	1	1	1	1	1	1								
4.2300 - GASKET, OIL FILTER COVER																
3L	5187308	S P R I N G --	1	1		1		1								
	4.2310 - SPRING, OIL FILTER															
3B	1503518	SPRING			1		1									
	4.2315	RETAINER, OIL FILTER SPRING														
3L	5179197	* RING, RETAINER SNAP	1	1		1		1								
	122386	? NUT, 5/8'-18 HEX (12.9120)	1	1		1		1								
		* THRU 3A-35686, 4A-73887, 6A-77569. = EFFECTIVE WITH 3A-35687, 4A-73888, 6A-77570 ? EFFECTIVE WITH 3A-49383, 4A-98324, 6A-104618.														
	4.2488 - PLUG, OIL FILTER BY-PASS															
3L	5187313@	PLUG	1	1		1										
3L	5126686 &	PLUG	1	1		1										
	@ EFFECTIVE WITH 3A-40365, 4A-80704, 6A-86659 & THRU 3A-40364, 4A-80703, 6A-86658.															

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	49	50	51	52	53	84	85	89	90	91	92	93		
		4.4001 - CORE, OIL COOLER														
4D	853993	CORE ASSY (PLATE)														
4D,E	8514600	CORE ASSY (12 PLATE)				1										
4D,E	8539953	CORE ASSY (8 PLATE)														
4D	8501328	CORE ASSY (6 PLATE)														
		4.4030 - GASKET, OIL COOLER CORE INNER														
4D	5150155	GASKET				1										
		4.4040 - GASKET, OIL COOLER CORE OUTER														
4D	5154215	GASKET				1										
		4.4050- HOUSING, OIL COOLER														
4D	5159451	HOUSING														
4D	6159645	HOUSING														
4D	6159446	HOUSING														
4D	6169481	HOUSING														
4D	5159481	HOUSING														
	103647	DRAINCOCK, 1/4" (COOLER HOUSING)				1										
	5112672	DRAINCOCK, 3/8' (WATER PUMP COVER). (12.9510)														
	6132634	DECAL, DRAIN (1.1001)														
	190367	ELBOW, 1/4' (12.9590)				1										
4D	186624	BOLT, 5/16'-18X1 1/4' (12.9001)				AR										
	179829	BOLT, 5/16'-18X2 3/4' (12.9001)														
4D	186270	BOLT, 5/16'-18X3 1/2' (12.9001)														
4D	186650	BOLT, 5/1S'-18X4 3/4* (12.9001)				AR										
	103320	LOCKWASHER, 5/16' (12.9200)				AR										
		4.4060 - COVER, OIL COOLER HOUSING														
4E	5188862	COVER														
	274682	BOLT, 5/16'-18X7 3/4' (12.9001)														
	216857	BOLT, 5/16'-18XB' (12.9001)														
	103320	LOCKWASHER, 5/16' (12.9200)														
	4.4110	ADAPTOR ASSY., OIL COOLER														
		AN ADAPTOR ASSY INCLUDES PLUG IN 4.4160 AND ITEMS IN 4.4140 THRU 4.4170.														

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	49	50	51	52	53	84	85	89	90	91	92	93		
	4.4110	- ADAPTOR ASSY., OIL COOLER (CONT'D)														
4D,E	5183211	+ ADAPTOR ASSY														
4D,E	5183212	+ ADAPTOR ASSY				1										
3L	5123636	* ADAPTOR .- 6X														
	186619	BOLT, 3/8'-16X1 1/8' (12.9001)				AR										
	186612	BOLT, 3/8'-16X1 3/8' (12.9001)				3										
	179846	BOLT, 3/8'-16X1 7/8' (12.9001)				1										
	180130	BOLT, 3/8'-16X2' (12.9001)														
	5152148	WASHER, 3/8'X9/16' SEAL (COPPER)				1										
	103321	LOCKWASHER, 3/8' (12.9200) (2.4050)				AR										
		+ INCLUDES ITEMS IN 4.4116, 4.4117.														
		- REQUIRES 5575088 VALVE, 5575087 SPRING, 5126686 PLUG AND 5575086 GASKET IN 4.2485 THRU 4.2489 EFF. WITH 3A-40365, 4A-80705, 6A-88958.														
	4.4115	GASKET, OIL COOLER ADAPTOR TO BLOCK														
4D,E	5150154	GASKET A				2										
4D,E	5152904	GASKET -				1										
	4.4116	- COVER, OIL COOLER ADAPTOR														
	5177923	COVER				1										
	186824	BOLT, 5/16'-18X1 1/4' (12.9001)				2										
	103320	LOCKWASHER, 5/16' (12.9200)-				AR										
	4.4117	- GASKET, OIL COOLER ADAPTOR														
	5177923	GASKET AK				1										
	4.4140	VALVE, OIL COOLER BY-PASS														
4D	5177777	VALVE				2										
4D,E	5177777	VALVE														
	4.4150	- SPRING, OIL COOLER BY-PASS VALVE														
4D	5177778	SPRING (4.1260)				2										
4D,E	5177778	SPRING (4.1260)														

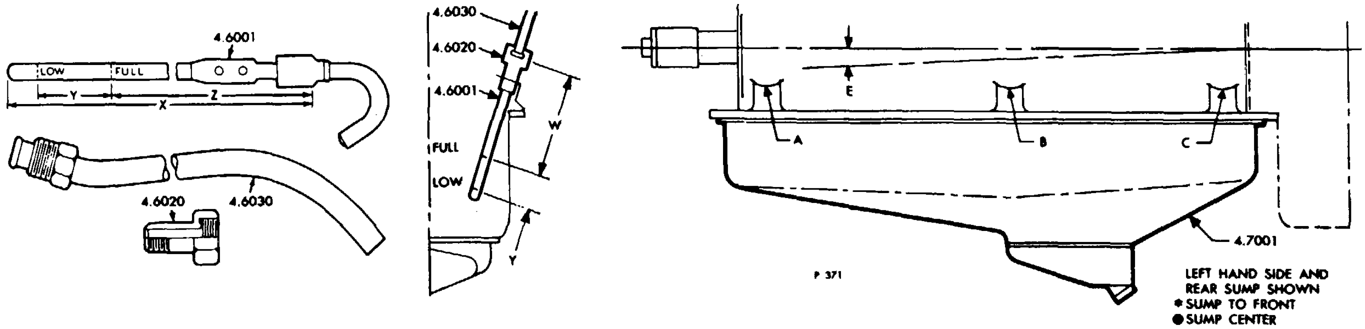
4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	49	50	51	52	53	84	85	89	90	91	92	93
	4.4160 - PLUG	OIL COOLER BY-PASS VALVE												
4D	5177772	PLUG				2								
4D	5177772	PLUG												
	4.4170- GASKET	OIL COOLER BY-PASS VALVE PLUG												
4D	5177773	GASKET				2								
4D	5177773	GASKET												
	4.4320 - FLANGE, OIL COOLER WATER HOLE													
*	5177241	FLANGE				1								
	5146010	PLUG, 1/4' PIPE (12.9550)												
	5145014	PLUG, 3/8' PIPE (12.9550)				AR								
	5115214	PLUG, 1/2' PIPE (12.9550)				1								
	186624	BOLT, 5/16'-18X1 1/4' (12.9001)				2								
	103320	LOCKWASHER, 5/16' (12.9200)				2								
	* FIG	3E OF 5.0000.												
	4.4325 - GASKET, OIL COOLER WATER HOLE FLANGE													
	5153902	GASKET (4.1520)				1								

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	COLUMN 104	125	126	127	128	129
	4.5001 - TUBE, OIL FILLER							
	5145087	TUBE						
	5104108	TUBE						
	5104180	TUBE						
	5104181	TUBE						
	6104182	TUBE						
	6104105	SEAL, TUBE						
5B	6145233*	TUBE ASSY						
	6120302	TUBE ASSY (INCLUDES LUGS)						
5A	6124141	@TUBEASSY						
		* TUBE ASSY INCLUDES TUBE IN 4.5001, CAP IN 45010, STRAINER IN 4.5020 AND CHAIN IN 4.5030.						
		@ NOT SERVICED; USE 1-5120302 AND 1-5145233.						
	4.6010 - CAP, OIL FILLER TUBE							
5B	5117362	CAP (SQUEEZE TYPE) (2' DIA.)		1				
	4.5020 - STRAINER	OIL FILLER TUBE						
5A,B	6150147	STRAINER						
	5103943	STRAINER		1				
	5104110	STRAINER						
	5103842	SCREW, #10-24X .375						
	4.5030 - CHAIN, OIL FILLER TUBE		1					
	5146248	HOOK- -	2					

DIPSTICK CHART



This chart 3rovides dipstick, adaptor and guide arrangements for 6-71 Vehicle applications, other than those specifically designated by type number.

TRUCK MANU	TRUCK MODEL	DIPSTICK 4.6001	W	X	Y	Z	ADAPTER 4.6030	ADAPTER DEV. L	GUIDE 4.6020	GUIDE LENGTH	OIL PAN	OIL PAN TYPE	DIPSTICK LOCATION	INSTALLATION ANGLE E
InternationalHarvester	DCO-405	5131893	6.66	39.00	60	37.14	5131892	30.48	5168497	7.25	5169460	105	B RH	0°-6°
InternationalHarvester	D-DB-405	5162944	6.66	29.00	60	27.32	5131891	20.72	5168497	7.25	5169460	105	B RH	0°-6°
InternationalHarvester	CO-4000D (50" cab)	5135197	5.36	30.Q0	60	28.98	5135096	23.74	5176827	5.62	5169460	105	C RH	3°-5°
InternationalHarvester	C0-40QOD(73 &83"cab	5135198	5.36	41.00	60	39.75	5135097	34.50	5176827	5.62	5169460	105	C RH	
InternationalHarvester	2000-D	5132575	5.76	32.00	58	30.20	5108417	24.50	5176827	5.62	5176689	23	B RH	0°-6°
International Harvester	M-623-CBE	5138571	4.84	31.00	58	29.28	5108417	24.50	5176827	5.62	5141753t	364	B RH	0°-6°
InternationalHarvester	-	5162937	-	25.00	1.06	23.25	5143309	17.00	5139079	6.75	5169460	284	-	
International Harvester	-	5135197	5.36	30.00	60	28.98	5135096	23.74	5168497	7.25	5169460	284	-	
Kenworth	C.O.E.	5132025	3.94	58.00	.60	56.75	5131941	52.82	5131786	3.62	5174986	22		0°-6°
Freightliner	C.O.E (Frt Access)	5131772	6.66	56.00	60	54.62	5130183	48.02	5168497	7.25	5169460	105	B RH	1 1/2°-4 1/4°
Freightliner	C.O.E (Frt Access)	5138593	6.66	62.50	60	61.44	5138769	54.90	5173274	6.50	5169460	105	B RH	1 1/2°--4 1/4°
White	7400TD-DB	5142001	4.84	71.00	60	69.62	5142000	64.90	5131786	3.62	5141753t	364	B RH	3°-30°
White	7400TD-D	5131772	4.84	56.00	60	54.62	5141073	49.90	5131786	3.62	5141753t	364	B RH	3°-30°
White	9400 "OLIYD"	5141159	3.96	32.00	62	30.30	5137936	26.90	5131786	3.62	5141753t	364	B RH	3°-15° Tilt
White	9500 TDD	5131893	4.78	39.00	60	37.14	5141759	32.40	5131786	3.62	5141753t	364	B LH	2°-30°
Ford	C.O.E W-1000	5138571	-	31.00	58	29.28	5141462	26.06	5151430	1.50	5141753t	364	C RH	-
Ford (6-71)	C.O.E W-1000 (Sleeper)	5146305	-	41.25	62	39.50	5146081	35.47	5151430	1.50	5144777	364	A RH	4°-40°
Ford (6-71)	W-9000 (Sleeper)	5146632	-	45.25	62	43.38	5146259	39.62	5151430	1.50	5144777	559	C RH	-
Ford (6-71 Conv.)	W & WT-9000 (Std Cab	5146649	-	31.25	62	29.38	5146258	25.62	5151430	1.50	5144777	559	C RH	-

t Not Serviced, superseded by 5144777 and include (2) 5145C12 plug.

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	660	662	667	672	674	679	689	704	725	726	731	735		
	4.6001 - DIPSTICK															
	NPN	DIPSTICK (CUSTOMER FURNISHED)														
6D	5131503	DIPSTICK (X-35', Y-1.06', Z-33.20')														
6E	5132194	DIPSTICK (X-21 , Y-.62, Z-18.62)														
6E	5144992	DIPSTICK (X-40.00', Y-.60',Z-39.00-)														
6D	5138571	DIPSTICK (X-31 , Y-.58' ,-29.2')														
6D	5132575	DIPSTICK (X-32 Y-.58', Z-30.20')														
6E	5122393	DIPSTICK (X-33 YY1.06', Z-31.18')														
6E	5147132	DIPSTICK (X-26.00' Y-.88',														
6E	5131896	DIPSTICK (X-31.00', Y-1.00,											1			
6F	5140126	DIPSTICK (X-14.50' Y-.94' Z-12.81')														
	4.6020 - GUIDE DIPSTICK															
6E	5151430	GUIDE											1			
	5139079	GUIDE														
6A	5176827	GUIDE														
6E	5131786	GUIDE														
6E	5184079	GUIDE (4.6030)														
	4.6030 - ADAPTOR, DIPSTICK															
6E	5131502	ADAPTOR (24.60' DEV L.)														
6E	5141462	ADAPTOR (26.06' DEV L.)														
6E	6109760	ADAPTOR(11.12' DEV L.)														
	5142571	ADAPTOR (34.25' DEV L.)														
6E	5126893	ADAPTOR (24.56' DEV L.)														
6E	5108417	ADAPTOR (24.50' DEV L.)														
6E	51538332	ADAPTOR (23 423/' DEV L.)											1			
6E	513189332	ADAPTOR (2 3/842' DEV L.)														
6F	5145515	ADAPTOR (5.90- DEV L.)														
	4.6040 - CLIP, DIPSTICK															
	5168001	CLIP, 1/2' TUBE, 7/16' BOLT (12.4095)											1			
	5151189	CLIP, 3/4' TUBE, 3/8' BOLT (4.8040)														
	140571	CLIP, 21/32' TUBE, 5/16' BOLT														
	6169476	CLIP, 1' TUBE, 7/16 BOLT (5.2190)														
	6165464	BRACKET, TUBE														
	6188248	BRACKET (7.1606)														
	6166565	BRACKET, CLIP(9.1591)														
	5130179	SPACER, 3/4'X.40'X.18' (12.5023)														

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	660	662	667	672	674	679	689	704	725	726	731	735		
4.8040- CLIP, DIPSTICK																
	5177844	SUPPORT, CLIP (4.1575)														
	123435	BOLT, 1/4'-28X5/8' (12.9001)														
	179829	BOLT, /16'-18X2 3/4' (12.9001)											1			
	186618	BOLT, 6/16'-18X5/8' (12.9001)														
	181360	BOLT, 3/8'-24X3/4' (12.9001)														
	108281	WASHER (5/16'X3/4') (12 9200)											1			
	181361	BOLT, 3/8'-24X7/8' (12.9001)														
	103320	LOCKWASHER, 5/16' (12.9200)											1			
	103319	LOCKWASHER, 1/4' (12.9200)														
	103321	LOCKWASHER, 3/8' (12.9200)														
	121902	NUT, 1/4-28 HEX (12.9120)														
	120376	NUT, 5/1 6-18 HEX (12.9120)														
	117049	NUT, 3/8'-24 HEX (12.9120)														

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	1	2	4	5	8	9	19	20	21	22	23	24		
4.7001 - PAN		**OIL**														
		FOR TYPE 26 USE TYPE 105.														
7A	5167809	PAN, 371 CAST														
7A	5145786	PAN, 371 STAMPED														
7D	6167810	PAN, 471 CAST														
7C	167808	PAN, 471 STAMPED														
7C	6174986	PAN, 671 STAMPED														
7C	17689	PAN, 671STAMPED														
7D	5174150	PAN 471 CAST														
7C	5148436	BOLT, 5/16'-1B8X3/4' (WLW)(12.9001)														
7C	5148437	BOLT, 5/16'-18X1 (W/LW) (12.9001)														
		4.7010- PAN, OIL - UPPER														
7C	5153942	PAN,671 CAST							1							
	5148437	BOLT, 5/16'-18X1' (W/LW)(12 9001)							34							
	4.7020 - PAN, OIL - LOWER															
7D	6163153*	PAN,671 CAST 1								1						
7D	6146013	PLUG, 3/4- PIPE (12.9550)							1							
7D	6148437	BOLT, 5/16'-18X1' (W/LW)(12.9001)							22							
		* NOT SERVICED, SUPERSEDED BY														
	5163616 AND (1)5145012.															
	4.7030 - GASKET, OIL PAN TO BLOCK															
7A	6160116	GASKET, 371 (STAMPE D PAN)														
7A,C	5150116	GASKET.471 (STAMPED PAN)														
	5195625	GASKET SET, 671 (FOR CAST PANS)							1							
7D	5150117	GASKET, 671 (STAMPED PAN)														
	4.7040 - GASKET, LOWER OIL PAN															
7D	6153256	GASKET, 671							1							
	4.7080 - PLUG, OIL PAN DRAIN															
		PLUGS ARE OPTIONAL WHEN MULTIPLE QUANTITIES ARE SHOWN IN SAME TYPE.														
7C	5177772	PLUG (18MM.) (4.4160)														
7C	53688	* PLUG (MAGNETIC) (18MM.)														
7C	5145011	PLUG, 3/8' SQ HD PIPE (12.9550)							1							

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 1	2	4	5	8	9	19	20	21	22	23	24		
		4.7080 - PLUG, OIL PAN DRAIN (CONT'D)														
7C	444524	PLUG, 3/8' HEX HD PIPE (12.9550)							1							
	5145012	PLUG, 1/2' PIPE (12.9550)														
	5115214	PLUG, 1/2' PIPE (12.9550)														
7C	144014	PLUG, 1/2' PIPE SQ RECESS HD														
	5146891	PLUG, 1/2' PIPE SQ HD (MAGNETIC)														
7C	5145013	PLUG, 3/4' PIPE (12.9550)							1							
7C	444636	PLUG, 3/4' HEX HD PIPE (12.9550)							1							
		* NOT SERVICED; USE 1-5139140 AND 1-5138620.														
		4.7090 - GASKET, OIL PAN DRAIN PLUG														
7C	840277	GASKET (18MM.)														
		4.7100 - TUBE, OIL PAN DRAIN														
7C	5175082	TUBEASSY.(13 3/4' L.)														
7C	122432	NUT, 7/8'-14 HEX (12.9120)														
	4.7120	**COVER, OIL PAN**														
7D	5171165	COVER (SIDE DRAIN)							1							
7D	5188498	COVER (FILLER HLE)														
7D	5148437	BOLT, 5/16'-18X1' (W/LW) (12.9001)							8							
7D	5148438	BOLT, 5/16'-18X1 1/4' (W/LW) (12.9001)														
7D	186679	BOLT, 3/8'-16X1 1/4' (12.9001)														
	120393	WASHER, 5/16' FLAT (12.9190)														
	103321	LOCKWASHER, 3/8' (12.9200)														
	103320	LOCKWASHER, 5/16' (12.9200)														
		4.7130 - GASKET, OIL PAN COVER														
7D	5153788	GASKET							1							
7D	5154607	GASKET														
7D	6168176	GASKET (4.5007)														

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	578	581	582	591	600	631	633	638	641	642	645
	4.8001 - PIPE ASSY., BREATHER												
8F	5141358	* PIPE ASSY											
	5131380	PIPE ASSY (CRANKCASE)											
	5173726	* PIPE ASSY											
8F	5147019	@ PIPE ASSY (50L.)						1					
8F	5146553	@ PIPE ASSY (26'L.)											
	6138563	HOSE (1 1/4'I.D.X90 DEG.)											
	5154529	ELBOW (L.H.)											
	5154530	ELBOW (R.H.)											
	272869	CLAMP, HOSE (1 5/8'1.D.) (12.9660)											
8B	120687	SCREW, #10-24X1/2' FIL HD						2					
	110492	SCREW, #10-24X1 1/8' FIL HD											
	179862	BOLT, 7/16'-14X1 1/2' (12.9001)											
	103342	WASHER, 7/16' FLAT (12.9120)											
	120217	LOCKWASHER, #10 (12.9200)						2					
	103322	LOCKWASHER, 7/16' (12.9200)											
		* NOT SERVICED, SUPERSEDED BY 5147019, 2-2419766 CLIPS, 2-120687 SCREWS.											
		@ STANDARD LENGTH HOSE; CUT TO LENGTH SHOWN.											
	4.8020 - GASKET, BREATHER TUBE												
		5150900 GASKET											
	4.8025 - BAFFLE BREATHER												
	5176066	BAFFLE (IN CRANKCASE)						1					
	5140846	BAFFLE (IN CRANKCASE)											
8B	100014	BOLT, 5/16'-24X1'(12.9001)						2					
8B	103320	LOCKWASHER, 5/16' (12.9200)						2					
	4.8040 - CLIP, BREATHER TUBE												
	5141134	CLIP (7/8' TUBE, 5/16' BOLT)											
	5165244	CLIP (7/8' TUBE, 5/16' BOLT)											
	5158779	CLIP(1 1/2' TUBE, 5/16' BOLT) (5.5376)											
8F	2419766	CLIP (1' TUBE, 3/8' BOLT)						1					
	186271	BOLT, 5/16'-18X3 3/4' (12.9001)											
	186274	BOLT, 5/16'-1BX5' (12.9001)						1					
	103340	WASHER, 5/16' FLAT (12.9120)						1					

4.2000A OIL FILTER

FIG	PART NUMBER	NAME AND DESCRIPTION	578	581	582	591	600	631	633	638	641	642	645
	4.8045 - BREATHER ASSY.												
		SEE ASSEMBLY BREAKDOWN AS INDICATED BELOW											
8C	5176694	BREATHER ASSY (CRANKCASE)						1					
8C	5140734 +	BREATHER ASSY (CRANKCASE)											
8A	5110384	BREATHER ASSY (PAGE A)											
8C	5171230	BREATHER ASSY (CRANKCASE)											
	5173482	GASKET (4.5007)						1					
8C	5139492	BREATHER ASSY (CRANKCASE)											
	5110393	GASKET (WITH WING STUD)											
	5110392	STUD, 5/16'-18 WING											
	5139988	PLUG, 1' CUP (1.2001)											
	186274	BOLT, 5/16'-18X5' (12.9001)											
	179862	BOLT, 7/16'-14X1 1/2' (12.9001)						4					
	5171344	WASHER, 5/16' FLAT (2.8830)											
	103340	WASHER, 5/16' PLAIN (12.9120)											
	103342	WASHER, 7/16' FLAT (12.9120)						4					
	103322	LOCKWASHER, 7/16' (12.9200)						4					
		+ INCLUDES ADAPTOR AND CUP PLUG IN 4.8045.											
	4.8050 - BODY, BREATHER OR SEPARATOR												
	5110397	BODY											
	5173729	ADAPTOR (4.5005)											
	5112067	ADAPTOR (CRANKCASE)											
	186628	BOLT, 3/8'-16X1 1/2' (12.9001)											
	427588	BOLT, 3/8'-16X2 1/2' (12.9001)											
	103341	WASHER, 3/8' FLAT (12.9190)											
	103321	LOCKWASHER, 3/8' (12.9200)											
	4.8057 - GASKET, BREATHER SHELL COVER												
6179282		GASKET											
	4.8059	**SEAL BREATHER SHELL**											
5180214		SEAL RING (1/8'X1/4')											
	4.8070 - GASKET	**BREATHER BODY OR SEPARATOR**											
5130349		GASKET (1.1085)											
	4.8170 - PIPE, BREATHER EXTENSION												
5141728		PIPE (4.8010)											

4.2000A VENTILATING SYSTEM

FIG	PART NUMBER	NAME AND DESCRIPTION	A	B	C	D	E	F	G	H	I	J	K	L	M	N
	4.8046 - BREATHER ASSY.															
	5110384	BREATHER ASSY.	1													
	4.8055 - SHELL BREATHER															
8A	2443795	COVER ASSY (4')	1													
8A	2443793	CLAMP ASSY	1													
	4.8070- GASKET	**BREATHER SEPARATOR**														
8A	5144038	GASKET	1													

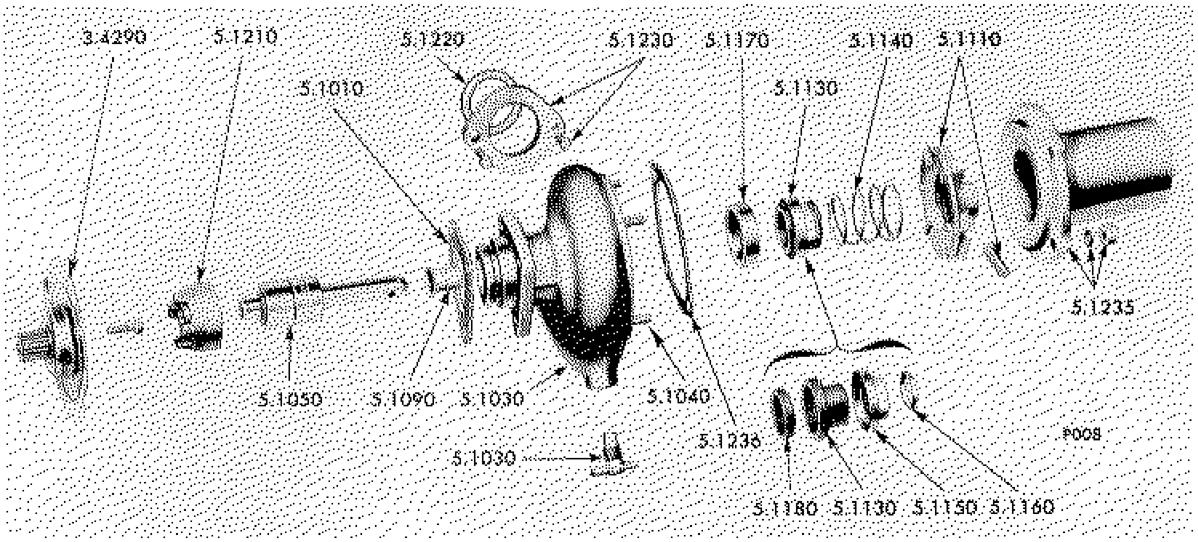


FIG. 1C FRESH WATER PUMP

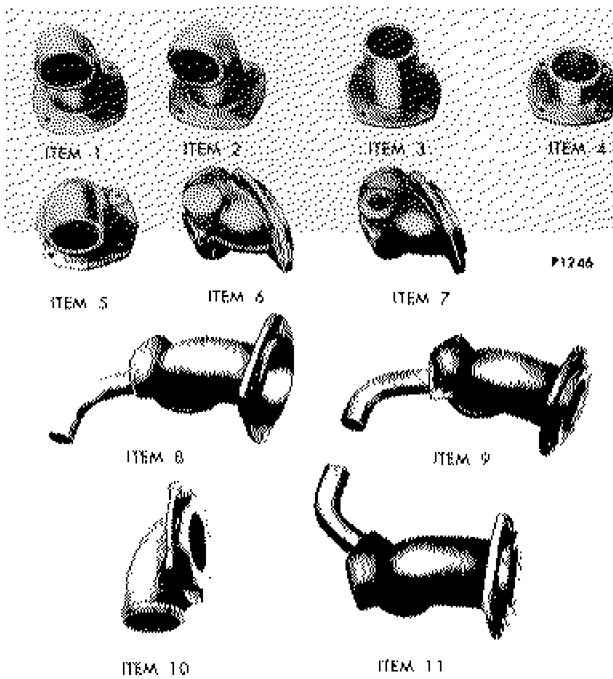


FIG 2A

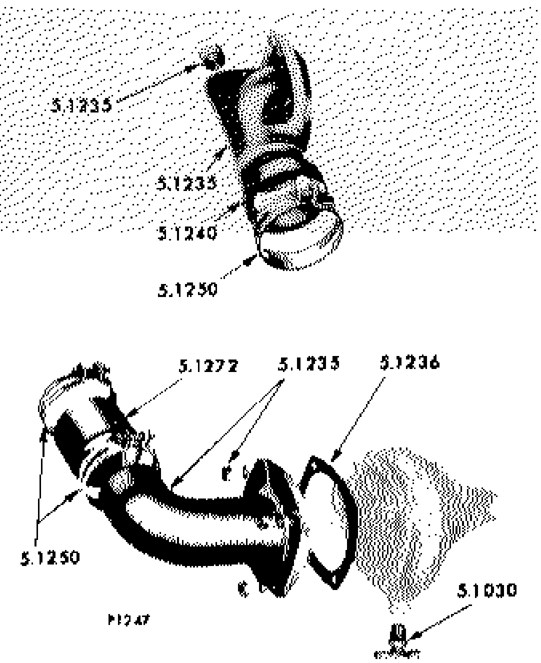


FIG 2B

FRESH WATER PUMP COVERS

Figs. 1C, 2A & 2B of 5.0000

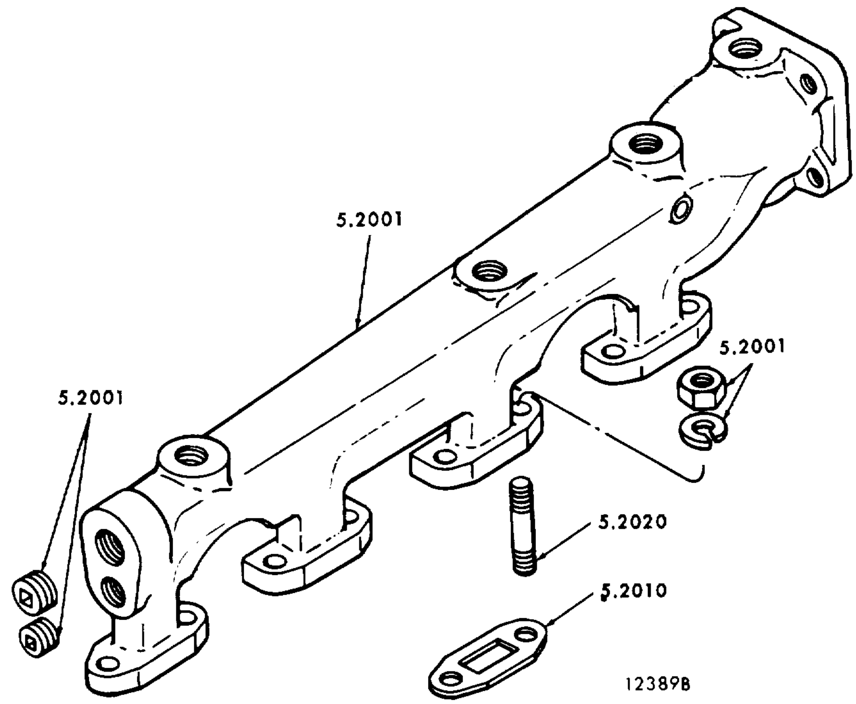
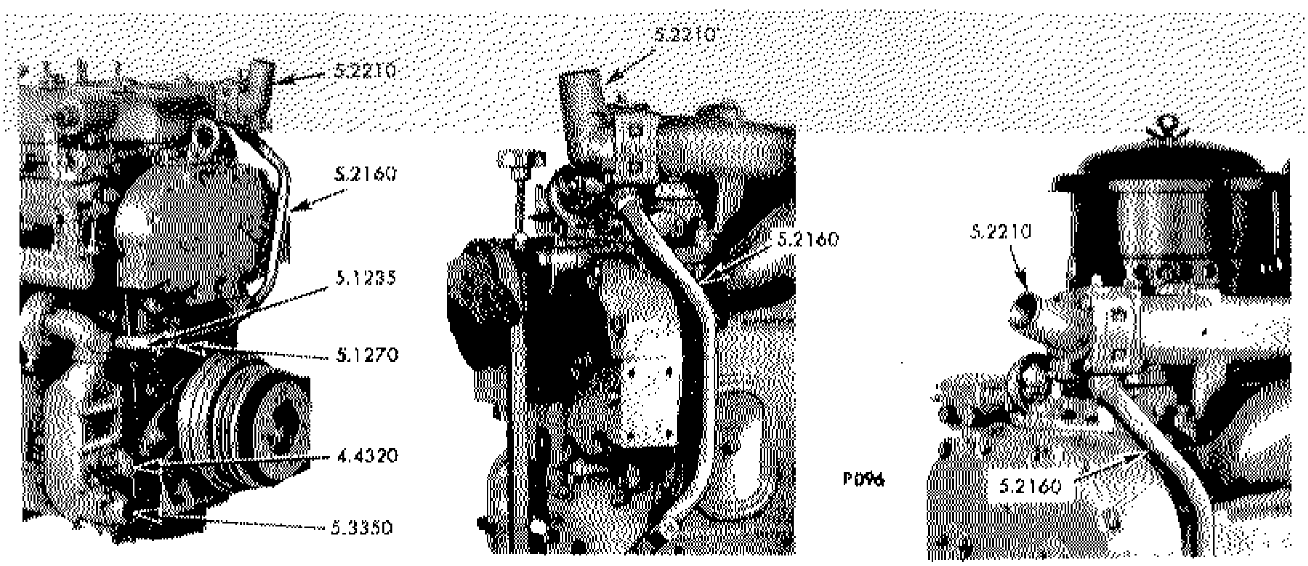


FIG. 2D WATER OUTLET MANIFOLD



WATER BY-PASS TUBE

Figs. 2D, 3E, 3F & 3G of 5.0000

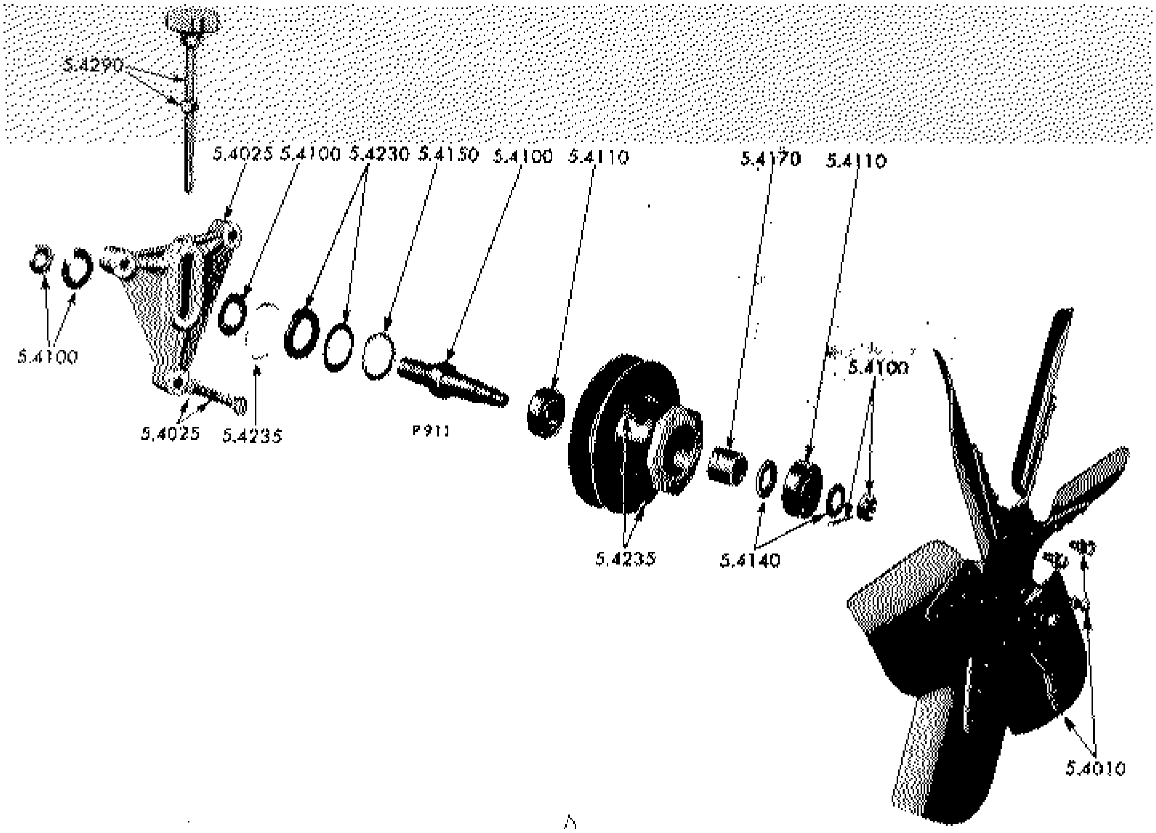


FIG. 6C

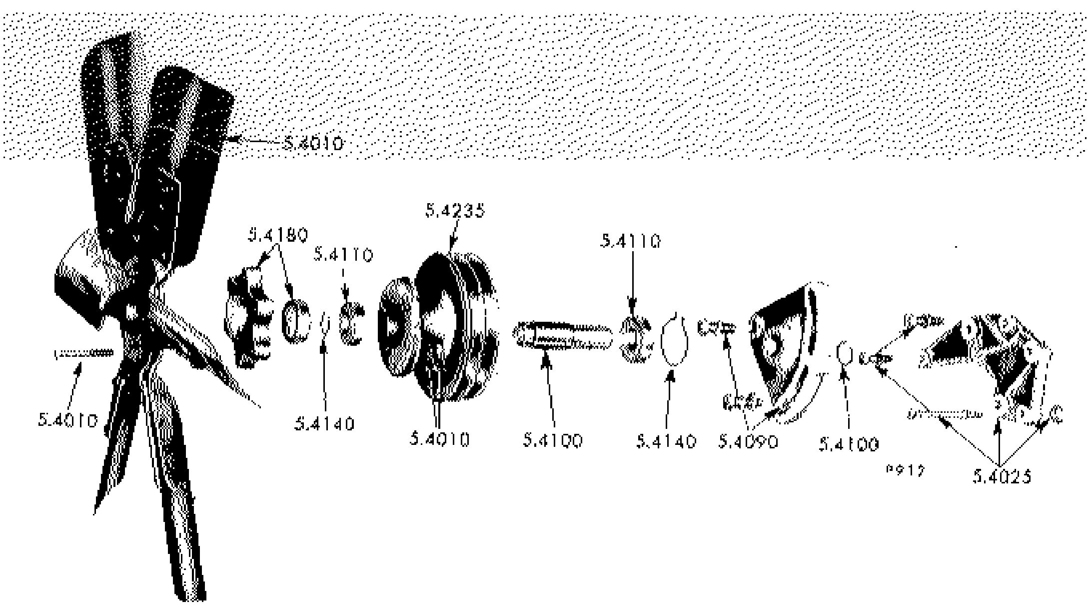


FIG. 6D

FAN

Figs. 6C & 6D of 5.0000

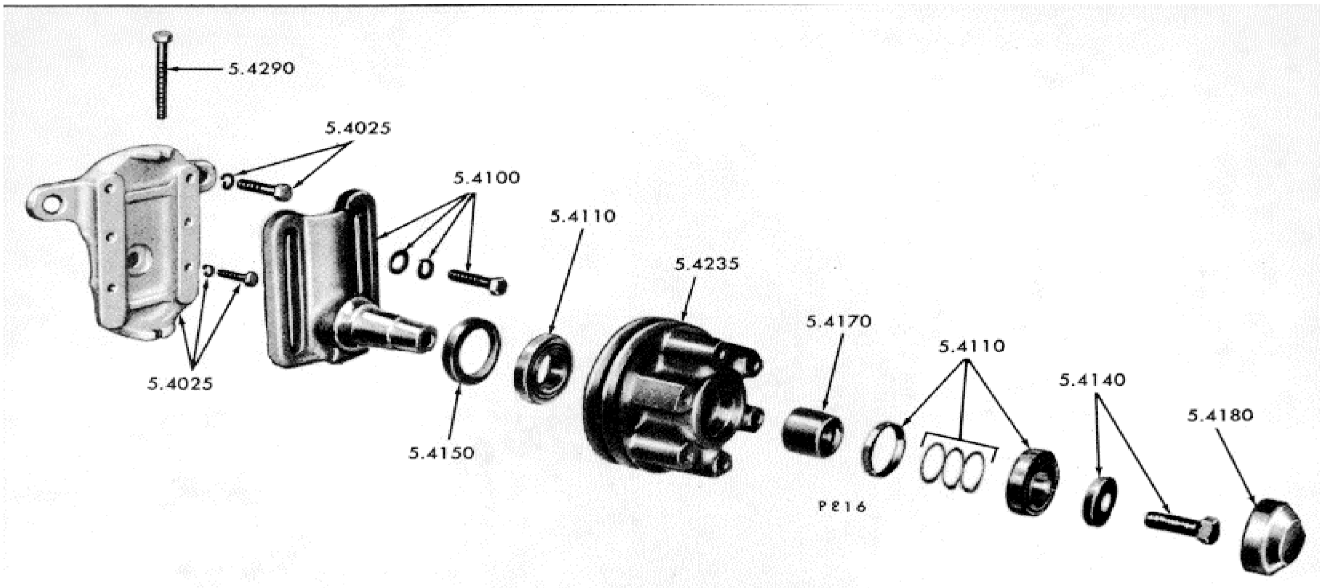


FIG. 6E FAN HUB

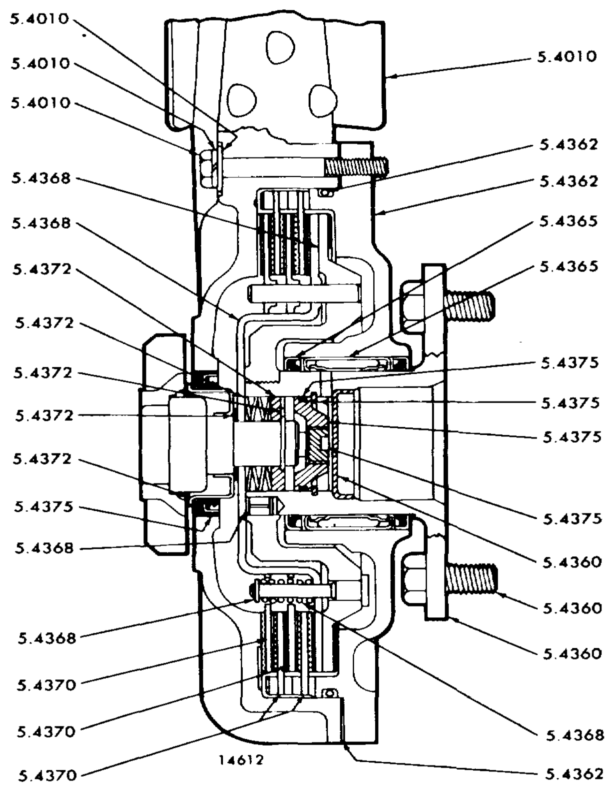


FIG. 6F THERMO MODULATING

Figs. 6E & 6F of 5.0000

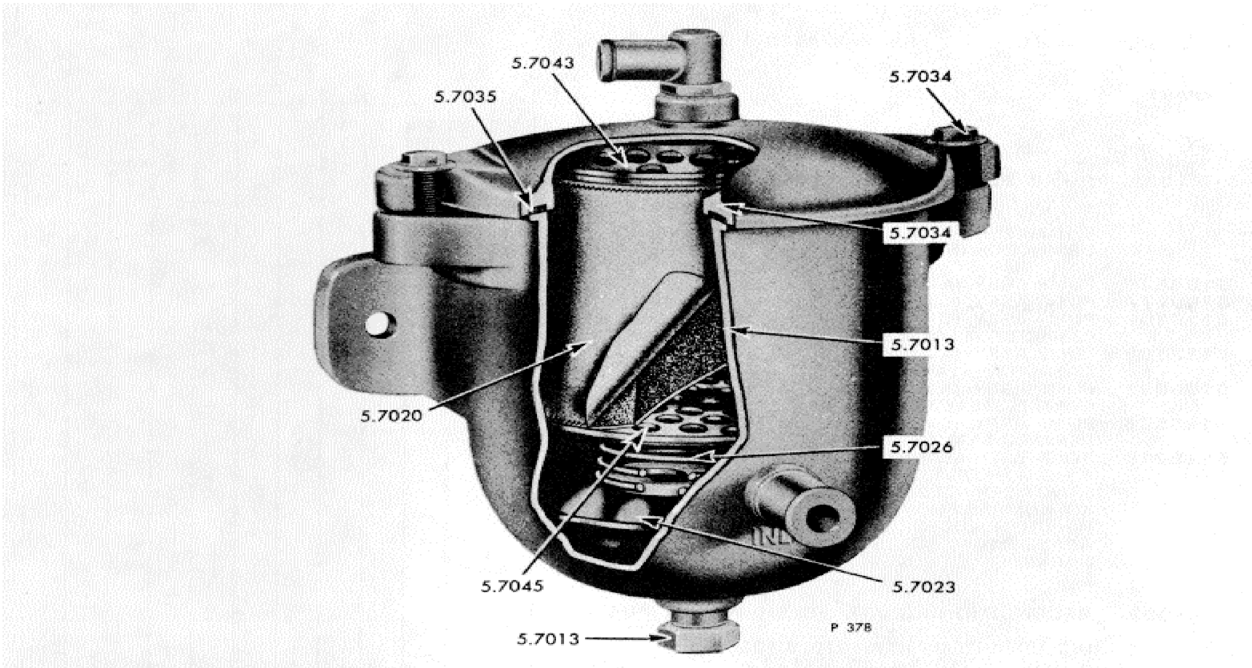


FIG. 11A WATER FILTER ASSY.

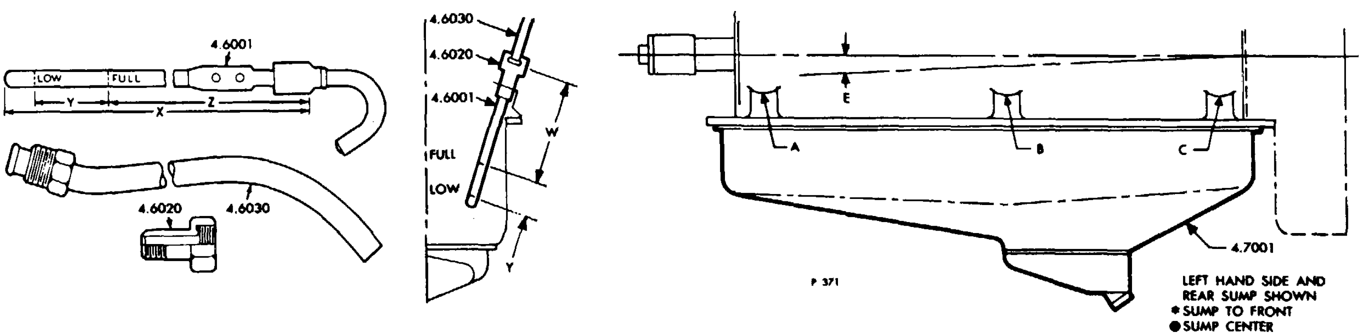


FIG. 11B WATER FILTER INSTALLATION

Figs. 11A & 11B of 5.0000

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 1	2	7	26	110	111
	5.1001 - PUMP ASSY., FRESH WATER							
		A PUMP ASSY INCLUDES ITEMS IN 5.1030 THRU 5.1210, EXCEPT DRAINCOCK IN 5.1030.						
*	5186575	# PUMP ASSY (A AND B ENG.) (5149373)						
*	5186576	# PUMP ASSY (C AND D ENG.) (5149374)						
*	5113109	# PUMP ASSY (C AND D ENG.) (HIGH CAPACITY) (5149368)			1			
*	5113108	# PUMP ASSY (A AND B ENG.) (HIGH CAPACITY) (5149367)						
*	5135596	# PUMP ASSY (A AND B ENG.) (WITH CERAMIC SEAL SEAT) (5149371)						
*	5135596	# PUMP ASSY (C AND D ENG.) (WITH CERAMIC SEAL SEAT) (5149372)						
1C	5118219	BOLT (WITH SEAL-WASHER) (2.2001)			3			
		*FIG 11H OF 1.0000.						
		# NOT SERVICED, REPLACED BY PUMP KIT NUMBER SHOWN IN PARENTHESES WHICH INCLUDES ITEMS IN 5.1001 PUMP ASSY., 5.1040 BOLTS AND 5.1236 GASKET.						
	5.1002 - RECONDITIONING KIT, FRESH WATER PUMP							
		INCLUDES ITEMS IN 5.1010, 5.1035, 5.1050, 5.1110, 5.1130, 5.1140. 5.1210, 5.1220 AND 5.1236.						
	5198307	RECONDITIONING KIT						
	6198308	RECONDITIONING KIT (HIGH CAPACITY WITH CARBON SEAL)			AR			
	6198281	RECONDITIONING KIT (STD WITH CERAMIC SEAL SEAT)						
	5.1010 - GASKET, FRESH WATER PUMP							
1C	6160193	GASKET			1			
	5.1030 - BODY FRESH WATER PUMP							
		A BODY ASSY INCLUDES ITEMS IN 5.1035 AND 5.1040.						
1C	6186573	BODY ASSY (A AND B ENGINE)						
1C	6186574	BODY ASSY (C AND D ENGINE)						
1C	6182070	BODY ASSY (C AND D ENGINE)			1			

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	1	2	7	26	110	111
	5.1030	**BODY, FRESH WATER PUMP (CONT'D)**						
1C	5182069	BODY ASSY (A AND B ENGINE)						
1C	5136601	BODY (A AND B ENGINE)						
1C	135602	BODY (C AND D ENGINE)						
IC	118536	DRAINCOCK, 3/8' (12.9510)			1			
5.1035 - INSERT, FRESH WATER PUMP BODY								
1C	5186572	INSERT			1			
	5.1040 - STUD, FRESH WATER PUMP BODY							
1C	5102258	BOLT, 1/4'-20X3/4'			4			
	5.1050- SHAFT ASSY., FRESH WATER PUMP							
		A SHAFT ASSY INCLUDES SLINGER IN 5.1090.						
1C	5136671	SHAFT ASSY			1			
1C	907919	SHAFT (INCLUDES BEARING)						
	5.1090 - SLINGER, FRESH WATER PUMP SHAFT							
1C	5189041	SLINGER			1			
	5.1110 - IMPELLER, FRESH WATER PUMP							
1C	5126911	IMPELLER-						
1C	5134335	IMPELLER			1			
1C	5135597	IMPELLER (WITH CERAMIC SEAL SEAT) -						
1C	5118468*	PIN, 3/16'X7/8' GROOVE			1			
		* THRU 3A-53735, 4A-106822, 6A-114837.						
	5.1116 - REPLACEMENT KIT, FRESH WATER PUMP SEAL							
		REPLACEMENT KITS EXCEPT 5197279 INCLUDE ITEMS IN 5.1010, 5.1035, 5.1050, 5.1130, 5.1220, GASKET IN 5.1236 AND PIN IN 5.1110.						
	519305	REPLACEMENT KIT			AR			

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 1	2	7	26	110	111
	5.1115	**- REPLACEMENT KIT, FRESH WATER PUMP SEAL (CONT'D)**						
	5198514	REPLACEMENT KIT						
	5197279	@ REPLACEMENT KIT						
		@ INCLUDES CERAMIC SEAL AND SEAT AND ADHESIVE WHICH ARE NOT SERVICED SEPARATELY.						
	5.1130	**SEAL, FRESH WATER PUMP**						
1C	5186671	SEAL ASSY (INCLUDES SPRING)			1			
1C	6130959	SEAL ASSY						
	5.1140	**SPRING, FRESH WATER PUMP SEAL**						
1C	5186570	SPRING			1			
	5.1210	THROWER, FRESH WATER PUMP						
1C	5114011	THROWER			1			
	5.1220	**PACKING, FRESH WATER PUMP OUTLET**						
1C	6150191	PACKING 1						
1C	56160191	PACKING		1				
	5.1230	**FLANGE, FRESH WATER PUMP OUTLET PACKING**						
1C	5173730	FLANGE						
1C	5178274	FLANGE 1						
1C	179819	BOLT, 5/16'-18X1 1/8' (12.9001)			2			
	103320	LOCKWASHER, 5/16' (12.9200)			2			

4.2000A FRESH WATER PUMP COVER

TYPES: 12 | 13 | 14 | 15 | 22 | 23 | 24 | 25 | 40 | 53 | 59 | 61 — NOT APPLICABLE

FIG	PART NUMBER	NAME AND DESCRIPTION
	5.1235 - COVER, WATER PUMP	
2A	5179101	* COVER (ITEM 7)(5146469)
2A	5177244	* COVER (AENG.) (ITEM 11) (5146450)
2A	5177220	COVER (C ENG.) (ITEM 9)
2A	5116770	COVER(ITEM7)
2A	5173727	= COVER
2A	5173720	@ COVER (5146784)
2A	5173719	@ COVER (5146783)
2A	5113203	@ COVER (5146781)
	5145014	PLUG, 3/8' PIPE (12.9550)
	5145012	PLUG, 1/2' PIPE (12.9550)
	5115214	PLUG, 1/2' PIPE (12.9550)
	9409961	PLUG, 3/4' PIPE (12.9550)
	118536	DRAINCOCK, 3/8' (12.9510)
3E	5175683	CONNECTOR
	103319	LOCKWASHER, 1/4' (12.9200)
	5177218	CONNECTOR (HOSE)
	121902	NUT 1/4-28 HEX (12.9120)
		* NOT SERVICED, USE 5146469, 5150364, 5153902, 2-179816. 2-103320.
		NOT SERVICED, USE 5146469 PLUS 3-5142549.
		NOT SERVICED, USE P/N IN PARENTHESES AND 5139988.
	5.1236-	**GASKET, WATER PUMP COVER**
1C	5150188	GASKET
1C	5178273	GASKET
	5.1240 - SEAL, WATER PUMP INLET	
2B	5159457	SEAL (2 1/2' O ....D.)
2B	5156770	SEAL (2 3/4' O.D.) (5.2043)
	5.1250 - CLAMP, WATER PUMP-INLET SEAL	
2B	111626	CLAMP, 2 1/2' DIA ....HOSE (12.9660)
2B	5135647	CLAMP 2 3/4' DIA........HOSE (12.9660)
	5.1270 - HOSE, WATER BY-PASS TUBE -	CONNECTING
3E	5118149	* HOSE (1 I.D.X3 1/2-) (4.1642)
	111612	CLAMP, 1 3/8 DIA HOSE (1 2.9660)
		* STANDARD LENGTH HOSE; CUT TO

71 VEH ENGINES

5.1O0OA FRESH WATER PUMP COVER

FIG...............PART NUMBER............NAME AND DESCRIPTION...TYPE

5.1235 - COV'ER, WATER PUMP

2A 5150366 COVER...1

5.1236 - GASKET, WATER PUMP COVER

1C 5150364 GASKET..1

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	117	118	121	126	136	143	147	148	156	158	159	162	170
	5.2001 - MANIFOLD, WATER OUTLET														
2D	5113380	* MANIFOLD, 671 (ITEM 2)													
	2191562	MANIFOLD, 671 ALUM													
2D	5101772	MANIFOLD, 471-671												1	
2D	5122286	MANIFOLD, 671 (ITEM 3)													
	5117344	* PLATE, CYL HD (1.2001)												2	
2D	5101773	MANIFOLD, 671													
2D	5115214	PLUG, 1/2' PIPE (12.9550)												AR	
2D	5142549	PLUG, 3/4' PIPE (12.9550)												AR	
2D	5145014	PLUG, 3/8' PIPE (1 2.9550)													
2D	5145013	PLUG, 3/4' PIPE (12.9550)													
	142269	BUSHING, 1/2'X3/8' RED PIPE												1	
	103870	PLUG, 1' PIPE (12.9550)													
	144034	BUSHING, 3/4'X1/2' RED PIPE (12.9570)													
2D	103321	LOCKWASHER, 3/8' (12.9200)												8	
2D	117049	NUT, 3/8'-24 HEX (12.9120) (12.9570)												8	
	5150757	NUT, 3/8'-24 HEX (SPECIAL)													
		* NOT SERVICEDUSE 5101772 PLUS 2-5117344, 2-5150361, 4-5101377.													
		= NOT SERVICED USE 5101773 PLUS 2-5117344, 2-5150361, 4-5101377.													
	5.2010 - GASKET, WATER OUTLET MANIFOLD														
2D	5150361	GASKET												4	
	5.2020 - STUD, WATER OUTLET MANIFOLD														
	60141	STUD, 5/16 -18-24X1 5/16 (FLG.)													
	5101377	BOLT, 3/8'-16X1' W/SEAL												4	
2D	5150362	STUD(1 11/16'L.)													
		* OPT TO 5150362, ALL TYPES.													

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 173	174	187	198	206	217	223	229	234	269	270
	5.2050 - THERMOSTAT ASSY.												
NPN		THERMOSTAT ASSY (CUSTOMER......................											
	5172141	THERMOSTAT ASSY (173 DEG OPENING.......... TEMP.) (FORD TRUCK)											
	5188383	THERMOSTAT ASSY (VENT HOLE). (173 DEG OPENING TEMP.)											
	6133367	THERMOSTAT ASSY (180 DEG OPENING..........		1									
	6104096	THERMOSTAT ASSY (180 DEG OPENING TEMP.)											
	5.2090 - HOUSING, THERMOSTAT												
		THERMOSTAT HOUSING FOR SOME TYPES ARE PART OF UPPER WATER BY-PASS TUBE ASSYS IN 5 2160.											
	5140520	HOUSING											
	5138566	HOUSING											
	5147299	HOUSING											
	5187069	* HOUSING ASSY...											
	5147298	ELBOW, 90 DEG HOSE (TOP OF HSG.) .... (1/4' REST.)											
	5147271	ELBOW, 90 DEG HOSE (TOP OF HSG.)											
	5145014	PLUG, 3/8' PIPE (12.9550) .... (5/32' REST.)		1									
	5115214	PLUG 1/2' PIPE (12.9550)											
	5111798	PLUG 1' PIPE (12.9550)											
	103320	LOCKWASHER, 5/16- (12.9200).											
	121917	NUT, 5/16'-24 HEX (12.9120)											
		* NOT SERVICED, USE 5187009, 1 -5151931, 3-62632, 4-60320.											
	5.2110 - GASKET, THERMOSTAT HOUSING												
3L	5169478	GASKET											
	5173772	GASKET											

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	15	16	18	21	22	33	40	44	56	69	80	102
		5.2160 - TUBE, WATER BY-PASS												
3E	5186203	#TUBE ASSY (UPPER)	1											
3E	5186204#	TUBE ASSY (UPPER)												
3G	5188130#	TUBE ASSY (UPPER) (SD-25)												
5F	5188129	TUBE ASSY (LOWER)												
5F	5113371	#TUBE ASSY (UPPER) (SD-13)												
	5177279#	TUBE ASSY (UPPER)												
	5145010	PLUG, 1/4' PIPE (12.9550)												
	5145014	PLUG, 3/8' PIPE (12.9550)	2											
	5145014	PLUG, 3/8' PIPE (12.9550)												
	103647	DRAINCOCK, 1/4' (12.9510)	1											
	118536	DRAINCOCK, 3/8' (12 9510)												
3J	186625	BOLT, 5/16'-18X7/8' (12 9001)												
	186625	BOLT, 5/16'-18X7/8' (12.9001)												
	103320	LOCKWASHER, 5/16- (12.9200)												
		# INCLUDES THERMOSTAT HOUSING.												
		5.2165 - HOSE, WATER BY-PASS TUBE												
5F	5156170	HOSE (1'I.D.X2 1/2') (5.5470)												
	5186840	CLAMP, 13/16'-1 1/2' DIA HOSE (12.9660)												
		5.2170 - GASKET, WATER BY-PASS TUBE (UPPER)												
	5169478	GASKET (5.2110)	2											
	5.2180	- GASKET, WATER BY-PASS TUBE (LOWER)												
	5153902	GASKET (4.1520)												
		5.2190 - CLIP, WATER BY-PASS TUBE												
	5155664	CLIP, .1' SPECIAL (4.1570)												
10B	5157702	CLIP (4.8040)	1											
	5160425	SPACER (13/32'1.D.X23/32')	1											
	179846	BOLT, 3/8'-16X1 7/8' (12 9001) (2.2367)	1											
	189330	BOLT, 3/8'-24X3 3/4- (12.9001)												
		5.2210 - ELBOW, WATER MANIFOLD OUTLET												
	5186206	ELBOW (WITH VENT) (2 1/4' O.D.) (VERTICAL)												
3G	5186281	ELBOW (WITH VENT)												

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 15	16	18	21	22	33	40	44	56	69	80	102		
	5.2210	**-ELBOW, WATER MANIFOLD OUTLET_ (CON'T)**														
5F,10B	5186205	ELBOW (WITH VENT) (2.06'O.D.) (10 DEG VERTICAL OFFSET)	1													
	5186260	ELBOW (WITH VENT)														
3F	5177193	ELBOW (WITHOUT VENT) (2.06'0.D.) (10 DEG VERTICAL OFFSET)														
	5145010	PLUG, 1/4' PIPE (12.9550)	1													
	5145014	PLUG, 3/8' PIPE (12.9550)														
	103647	DRAINCOCK, 1/4' (12.9510)														
	179828	BOLT, 5/16'-18X2 1/2' (12.9001)	4													
	103320	LOCKWASHER 5/16' (12.9200)	4													
	5.2215 - GASKET, WATER BY-PASS TUBE ELBOW															
	516947B	GASKET (5.2110)														
	5.2250	TUBE, WATER BY-PASS VENT														
	5182882	TUBE ASSY (3/16'X20 1/2') (FLEX.) (7.4074)														
	120401	ELBOW, 1/8' STREET 90 DEG (12.9590)														
	187321	CONNECTOR, 1/4' INV FL TUBE (12.9460)														
	5145009	PLUG, 1/8' PIPE (12.9550)														

4.2000A FRESH WATER PUMP

FIG	PART NUMBER	NAME AND DESCRIPTION	15	16	18	21	22	33	40	44	56	69	80	102
5.3290 - HOSE, RADIATOR INLET														
	5187231	HOSE(1 3/4'I.D.X9 1/2')												
5.3300 - CLAMP, RADIATOR INLET HOSE														
	111622	CLAMP, 2 1/8' DIA ....HOSE (12.9660)												
5.3310		**CONNECTOR, RADIATOR OUTLET**												
	5170684	TUBE (INTERMEDIATE)												
5.3330 - HOSE, RADIATOR OUTLET														
	5199778*	HOSE (2'I.D.X4 1/2') (3.1270)												
		* STANDARD LENGTH HOSE; CUT TO LENGTH SHOWN.												
5.3350 - CONNECTION, OIL COOLER WATER INLET														
NPN		ELBOW (CUSTOMER FURNISHED)												
	5139490	ELBOW (45 DEG.) (4.4211)												
	5115247	ELBOW, 90 DEG (4.4211)												
	5134778	ELBOW, 90 DEG												
	5188382	CONNECTION (2.875'B.C.X1.75'L.)												
	6188383	CONNECTION (3.375'B.C.X1.76'L.)		1										
	5172608	CONNECTION (3.380'B.C.X1.76'L.)												
	5136827	CONNECTION (3.00'L.)												
	6146014	PLUG, 3/8' PIPE (12.9550)												
	6146013	PLUG, 3/4' PIPE (12.9550)												
	179826	BOLT, 5/16'-18X2' (12.9001)												
	186679	BOLT, 3/8'-16X1 ¼ (12.9001)												
	193221	BOLT, 7/16'-14X1 1/4' (12.9001)												
	179862	BOLT, 7/16'-14X1 1/2' (12.9001)2												
	179867	BOLT, 7/16'-14X2 1/4' (12.9001)												
	464938	BOLT, 7/16'-14X3 3/4' (12.9001)												
	103320	LOCKWASHER, 5/16' (12.9200)												

5.3000B WATER CONNECTIONS

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPES 15	16	18	21	22	33	40	44	56	69	80	102		
6.3450		**TUBE, HEATER WATER INLET**														
	5114137	TUBE (RETURN) (DEV L 20 9/116')														
	5114253	SUPPORT (12.6407)					NOT APPLICABLE									
	5153902	GASKET (4.1520)														
	2036456	CLIP TUBE (5.3450) -														
	5160629	SPACER (5/8'O.D.X1 3/32'I.D.X7/32')														
	186629	BOLT, 5/16'-1 SX1' (12.9001) (4 2270)														
	179848	BOLT, 3/8'-16X2 1/4' (12.9001)														
	103320	LOCKWASHER, 5/16' (12.9200)														

5.4000A FAN

FIG	PART NUMBER	NAME AND DESCRIPTION	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090
		5.4010 - BLADE, FAN												
	NPN	BLADE (CUSTOMER, FURNISHED)												
	5173872	BLADE, 22'-6 BLADE-SUCTION		1										
	5171228	BLADE, 26'-6 BLADE-SUCTION		1										
	5128508	BLADE, 24' 6 BLADE-SUCTION												
	6177766	BLADE, 26'-6 BLADE-SUCTION												
	5177871	BLADE, 28'-6 BLADE-SUCTION												
	179827	BOLT, 5/16'-1'X2 1/4' (12. 9001)												
	179828	BOLT, 5/16'-18X2 1/2' (12.9001)												
	179830	BOLT, 5/16'-18X3' (12.9001)		6										
	179829	BOLT, 5/16'-18X2 3/4' (12.9001)												
	186643	BOLT, 5/16'-18X2 1/16' (12.9001)												
	103320	LOCKWASHER, 5/16' (12.9200)		6										
		5.4015 - PULLEY & HUB ASSY., FAN												
		ASSEMBLIES INCLUDE ITEMS IN 5.4090 THRU 5.4170 PLUS CAP AND FITTINGS IN 5.4180 PLUS PULLEY IN 5.4235.												
	5103346	PULLEY & HUB ASM												
	5103345	PULLEY & HUB ASM		1										
	6103694	PULLEY & HUB ASM												
	6103344	PULLEY & HUB ASM												
	5103593	PULLEY & HUB ASM												
	5103349	PULLEY & HUB ASM												
		5.4025 - SUPPORT, FAN MOUNTING												
	5100202	SUPPORT		1										
	6140229	SUPPORT												
	5139521	SUPPORT												
	9409914	BOLT, 3/8'-16X4 ¼ (12.900 1)												
	186288	BOLT, 3/8'-16X4 1/2' (12.9001)		2										
	186725	BOLT, 1/2'-13X1 1/2' (12.9001)		1										
	179887	BOLT, 1/2'-13X1 3/4' (12.9001)		2										
	186689	BOLT, 1/2'-13X2' (12.9001)												
	186631	BOLT, 1/2'-13X2 1/4' (12.9001)												
	5150230	WASHER, 3/8' FLAT (3.4120)		2										
	5109949	WASHER, 17/32' FLAT		2										
	103323	LOCKWASHER, 1/2' (12.9200)		3										
		5.4100 - SHAFT, FAN												
	5102381	SHAFT, 4.20' O.A.L		1										
	5103368	SHAFT, 4.08' O.A.L												
	427564	BOLT, 7/16'-14X1 3/8^ (12.9001)		4										

5.4000A FAN

FIG	PART NUMBER	NAME AND DESCRIPTION	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090
	5.4100 - SHAFT, FAN													
	5108436	WASHER, 7/16' SPEC. FLAT		4										
	103322	LOCKWASHER, 7/16' (12.9200)		4										
	5.4110 - BEARING, FAN SHAFT													
	903206	BEARING, BALL-FRONT		1										
	74555969	BEARING, ROLLER-REAR (W) REMOVABLE INNER RACE)		1										
	5.4140 - RETAINER, FAN SHAFT BEARING													
	94227655	RING, BEVELED SNAP		1										
	9409060	BOLT, 1/2'-20X1 1/2' (12.9001)		1										
	5104317	WASHER, 1/2' FLAT-SPEC		1										
	5.4150 - SEAL FAN SHAFT													
	5103951	SEAL		1										
	5.4180 - CAP & SPACER, FAN HUB													
	5103676	SPACER, .56' THICK		1										
	6103718	SPACER, .80' THICK		2										
	5.4235 - HUB, FAN													
	5103372	PULLEY (HUB), 2 GRV.-7 1/2' DIA												
	5104329	PULLEY (HUB), 3 GRV.-7 1/2' DIA		1										
	6104328	PULLEY (HUB), 3 GRV.-6 1/4' DIA												
	5103374	PULLEY (HUB), 2 GRV.-9 3/4' DIA												
	191768	FITTING, 1/8' LUBE (12.9540)		1										
	5.4290 - SCREW, FAN BRACKET + ADJUSTING													
	5108434	* BOLT, 5/16'-18X5'		1										
	5109642	@ BOLT,5/1'-I18X7'		1										
	120393	* FOR 11.5'' TO 12.9" FAN HEIGHT @ FOR OTHER THAN 11.5' TO 12.9' FAN HEIGHT.		1										

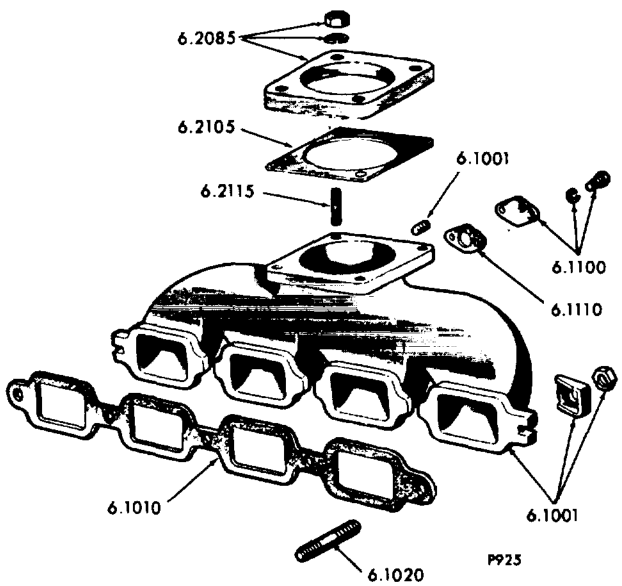
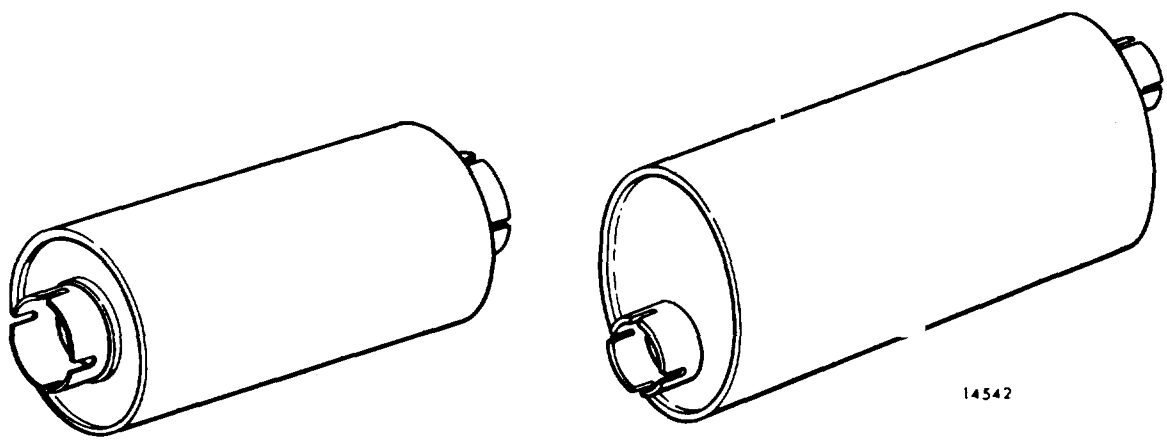


FIG. 1E EXHAUST MANIFOLD



INDUSTRIAL **AUTOMOTIVE**

FIG. 2B EXHAUST MUFFLER

Figs. 1E & 2B of 6.0000

FIG. 3A EXHAUST MUFFLER CONNECTIONS

Fig. 3A of 6.0000

6.1000A EXHAUST MANIFOLD

FIG	PART NUMBER	NAME AND DESCRIPTION	303	304	305	306	308	309	316	347	369	383	388	442		
		8.1001 - MANIFOLD, EXHAUST														
	5176729	MANIFOLD, 6-71 (END HORIZ OUTLET)														
1E	**6176730**	MANIFOLD, 4-71 (SIDE OUTLET)														
1E	**5108427**	MANIFOLD, 4-71 (CENTER VERT OUTLET)														
1E	**5108950**	MANIFOLD, 6-71 (CENTER VERT OUTLET)				1										
1E	**5140200**	MANIFOLD, 6-71 (END OUTLET)														
1E	**5136897**	MANIFOLD,4-71 (CENTER MARMAN OUTLET)														
	5111368	MANIFOLD, 6-71 (END OUTLET)														
	5140200	MANIFOLD, 6-71 (END OUTLET)														
	5148325	MANIFOLD, 6-71 (TURBO VERT OUTLET)														
1E	**5104439**	WASHER (BELLEVILLE)				5										
1E	**5102735**	CRAB (USE WITH 5104439 WASHER)				2										
	113175	PLUG, 1/8' BRASS PIPE (12.9550)														
1E	**127855**	NUT, 7/16'-20 HEX. (12 9120)				7										
1E	**271506**	NUT, 7/16'-20 HEX. (12.9120)														
		6.1010 - GASKET. EXHAUST MANIFOLD														
1E	**5120224**	GASKET, END-METAL CLAD														
1E	**5120223**	GASKET, 6-71 INTERMEDIATE-METAL CLAD				3										
1E	**5120222**	GASKET, 6-71 INTERMEDIATE-METAL CLAD														
		6.1020 - STUD, EXHAUST MANIFOLD TO HEAD														
1E	**5112899**	STUD (2 3/32' L.)				5										
		6.1050 - STUD, EXHAUST MANIFOLD OUTLET														
	5146538	STUD (2.32' L.)														
	5112899	STUD (2 3/32-L.)														
	5162793	STUD (1.76' L.) (6.2115)														

6.2000A EXHAUST MANIFOLD AND/OR CONNECTIONS

FIG	PART NUMBER	NAME AND DESCRIPTION	160	167	168	204	213	214	217	231	232	233	234	235		
		6.2001 - MUFFLER, EXHAUST														
2B	**5129180**	MUFFLER(MEDIUM DEGREE)(AUTOMOTIVE)..														
2B	**2406178**	MUFFLER (MEDIUM DEGREE) (AUTOMOTIVE)														
2B	**2383253**	MUFFLER (MEDIUM DEGREE) (AUTOMOTIVE)														
		8.2085 - FLANGE, EXHAUST														
1E.3	**5175942**	FLANGE (3 1/2'I.D.) (ITEM 10)														
1E,3	**5108921**	FLANGE (4' P.T.) (ITEM 10)										1				
1E,3	**5108351**	FLANGE (3 1/2')(ITEM 10)..................................														
1E,3	**5108632**	FLANGE (3' P.T.) (ITEM 10)														
1E,3	**5109033**	FLANGE (3 1/2'I.D.) (ITEM 10)														
	5127996	ADAPTOR, OFFSET (4' PIPE)														
1E	**103323**	LOCKWASHER, 1/2' ('.2.9200)...........................										4				
1E	**103321**	LOCKWASHER, 3/8' (12.9200)...........................														
1E	**114547**	NUT, 3/8'-24 HEX. BR. (12.9120)														
1E	**114544**	NUT,7/16'-20 HEX. BR. (12.9120)														
1E	**451457**	NUT, 1/2'-13 (HEAWVY BRASS) (12.9120).........														
1E	**114548**	NUT, 1/2'-20 HEX. BR. (12.9120)										4				
		6.2105 * GASKET, EXHAUST														
1E.3	**5108989**	GASKET (ITEM 27)										1				
1E,3	**3221863**	GASKET (ITEM 27)														
	2255237	GASKET (AT MANIFOLD)..................................														
	2258176	GASKET														
1E,3	**5108920**	GASKET(ITEM 27)														
1E,3	**5108377**	GASKET(ITEM 27)														
		6.2115 - STUD, EXHAUST OUTLET														
1E	**3222533**	STUD (7/16'-14-20X2 1/2')..................................														
1E	**5109160**	STUD (1/2'X2.50')...										4				
1E	**5109158**	STUD (3/8'X2.50')...														

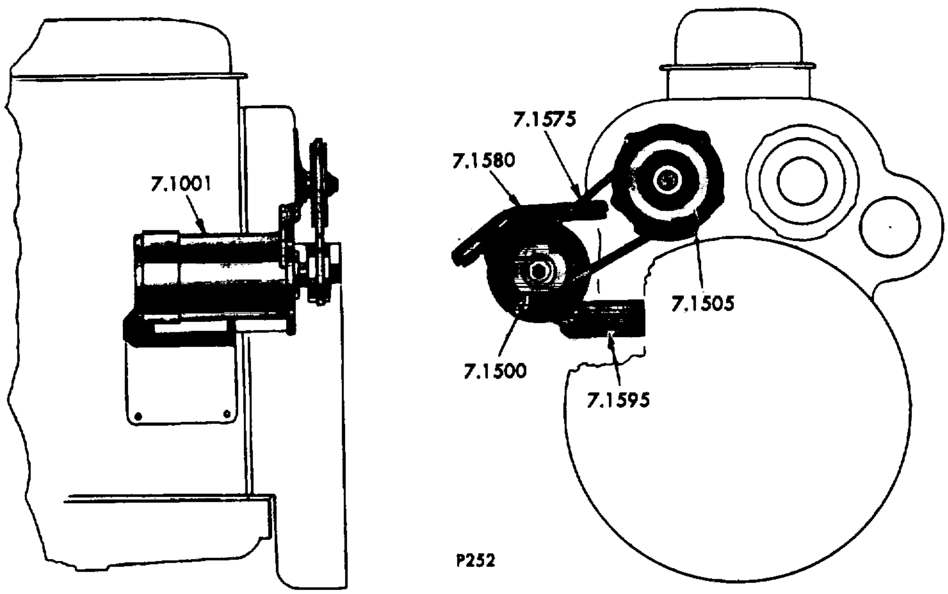


FIG. 1B

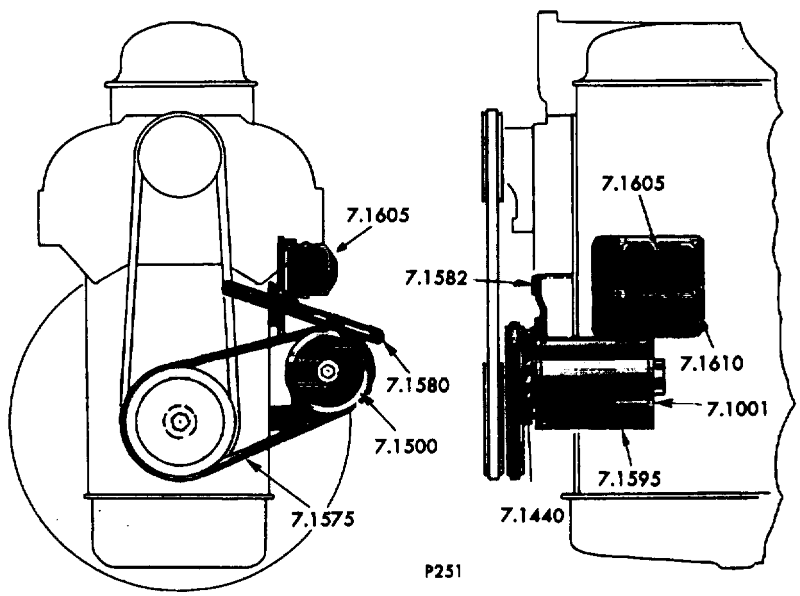


FIG. 1C

BATTERY CHARGING GENERATOR

Figs. 1B, 1C & ID of 7.0000

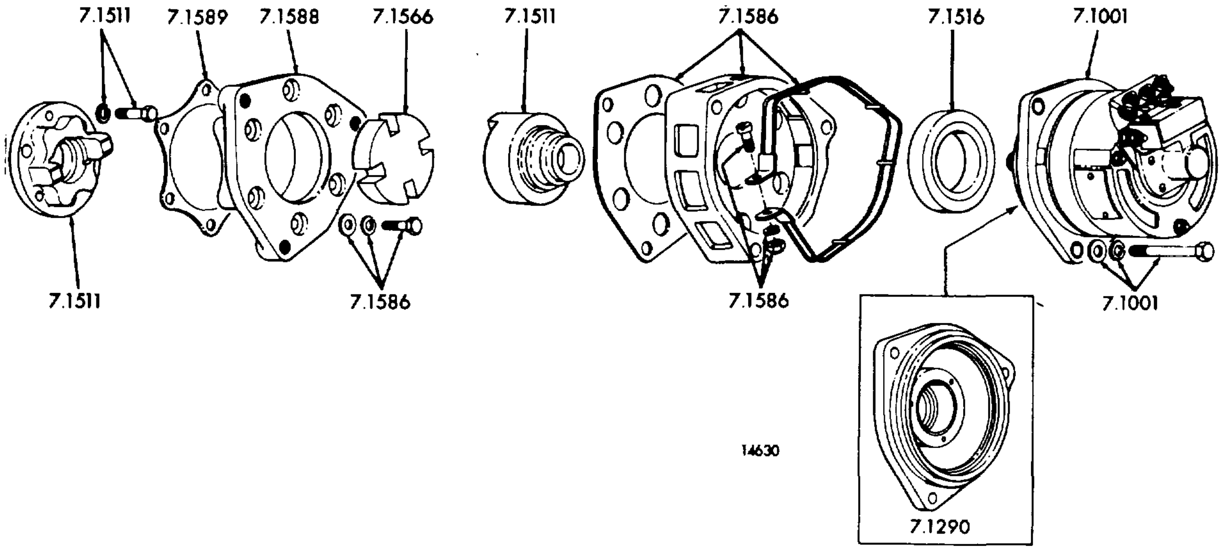


FIG. 1E FLANGED MOUNTED ALTERNATOR

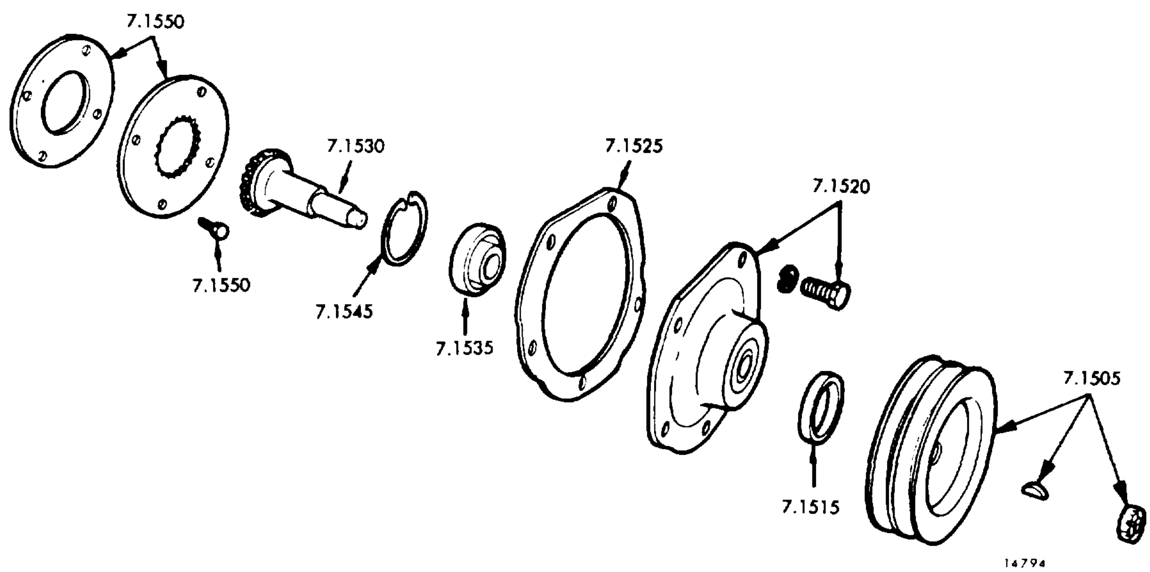


FIG. 1H GENERATOR DRIVE

Figs. 1E & 1H of 7.0000

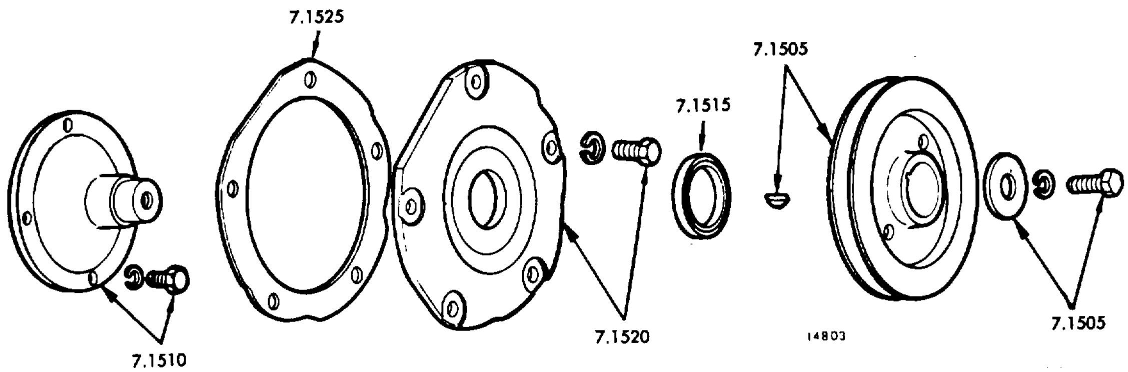


FIG. 1J GENERATOR DRIVE

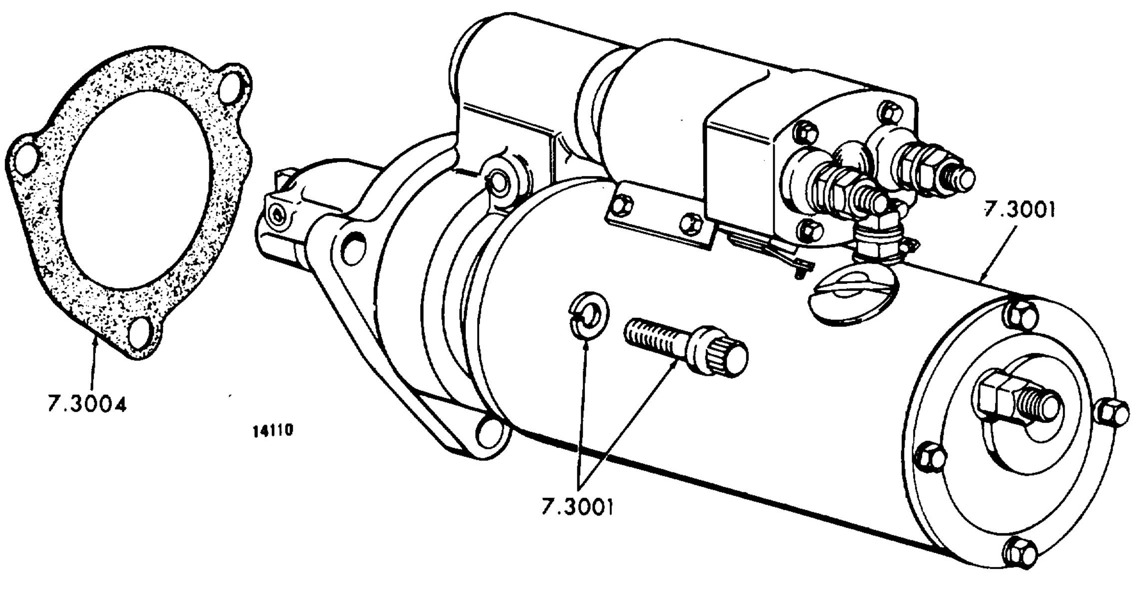


FIG. 3A STARTING MOTOR

Figs. 1J & 3A of 7.0000

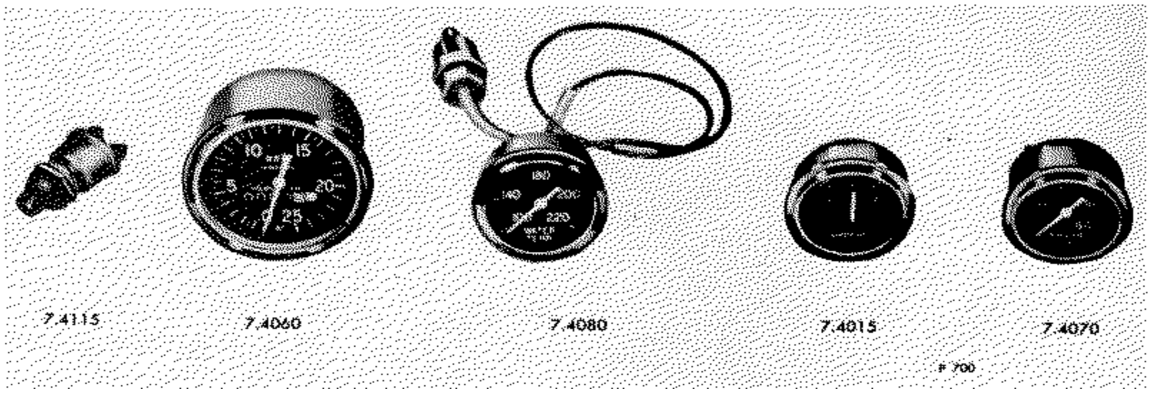


FIG. 4G INSTRUMENTS

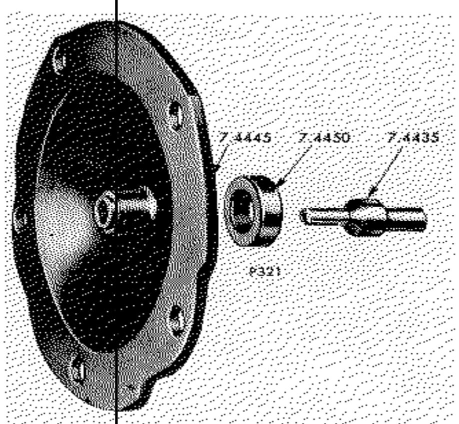


FIG. 5

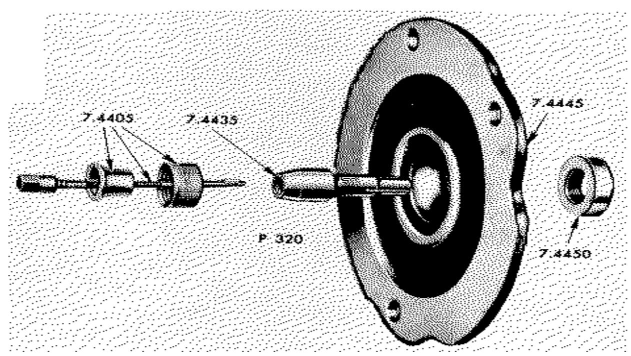


FIG. 5B

TACHOMETER DRIVE

Figs. 4G, 5A & 5B of 7.0000

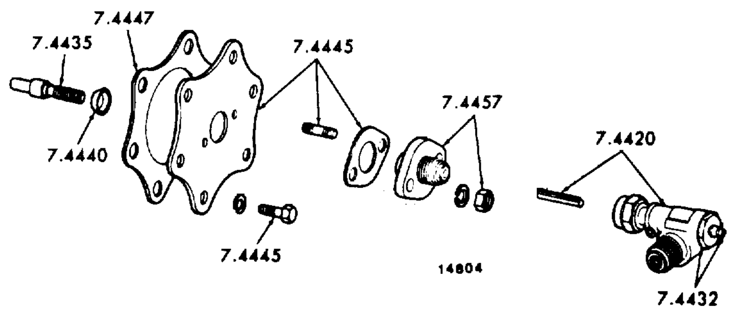


FIG. 5E

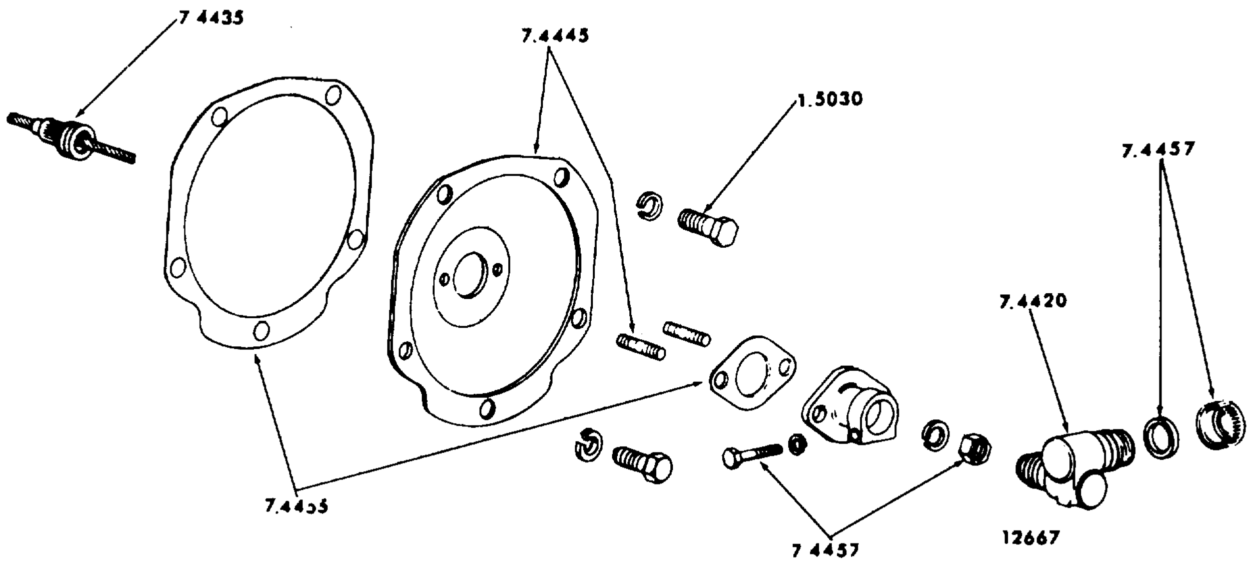


FIG. 5 F
TACHOMETER DRIVE

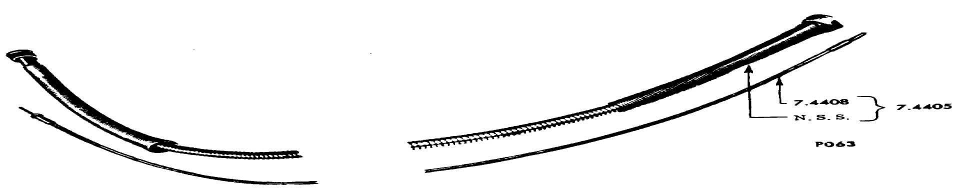


FIG. 5G TACHOMETER DRIVE CABLE

Figs. 5E, 5F & 5G of 7.0000

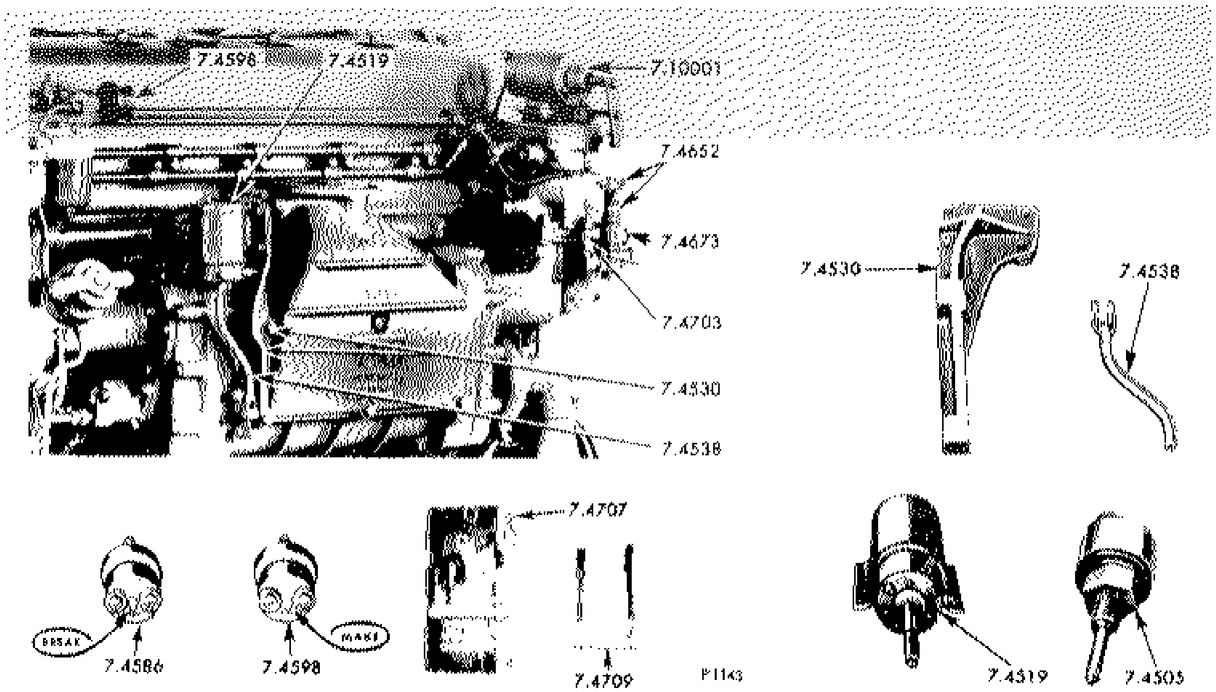


FIG. 6B SHUT-OFF OR ALARM SYSTEM

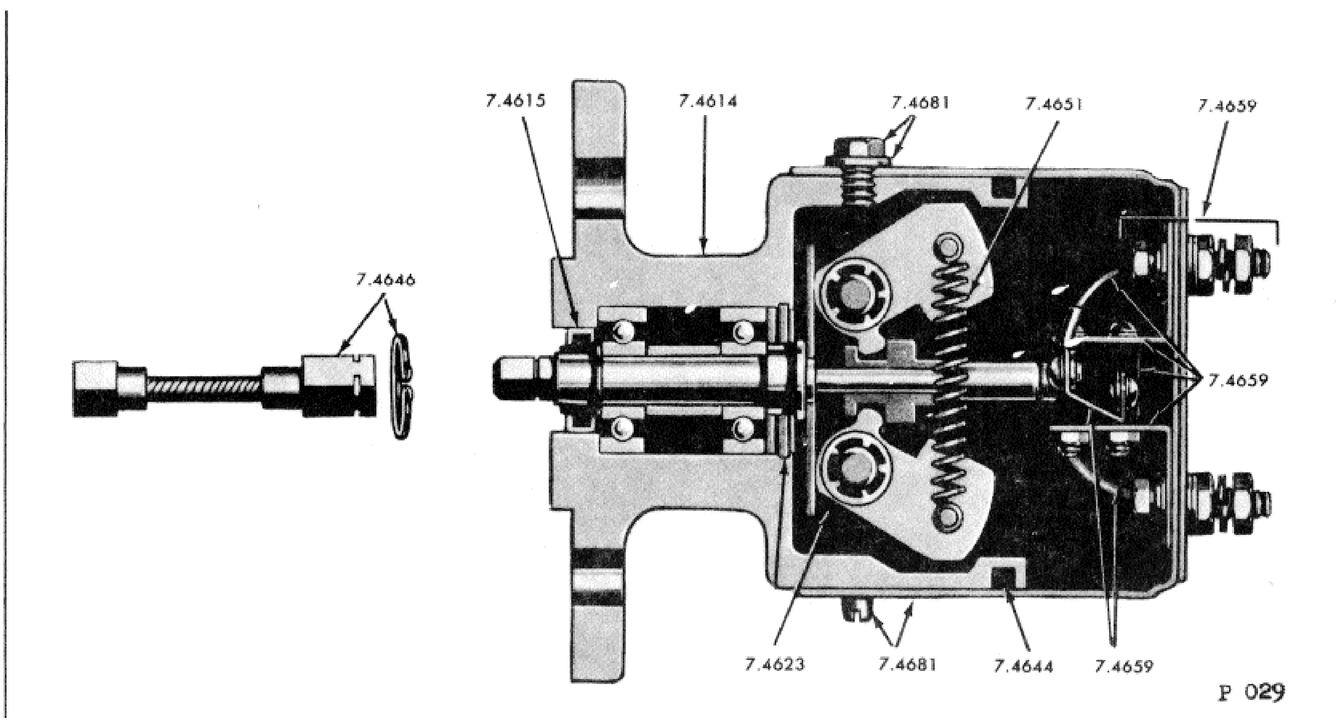


FIG. 6G OVERSPEED GOVERNOR (Single Switch, Licon)

Figs. 6B & 6G of 7.0000

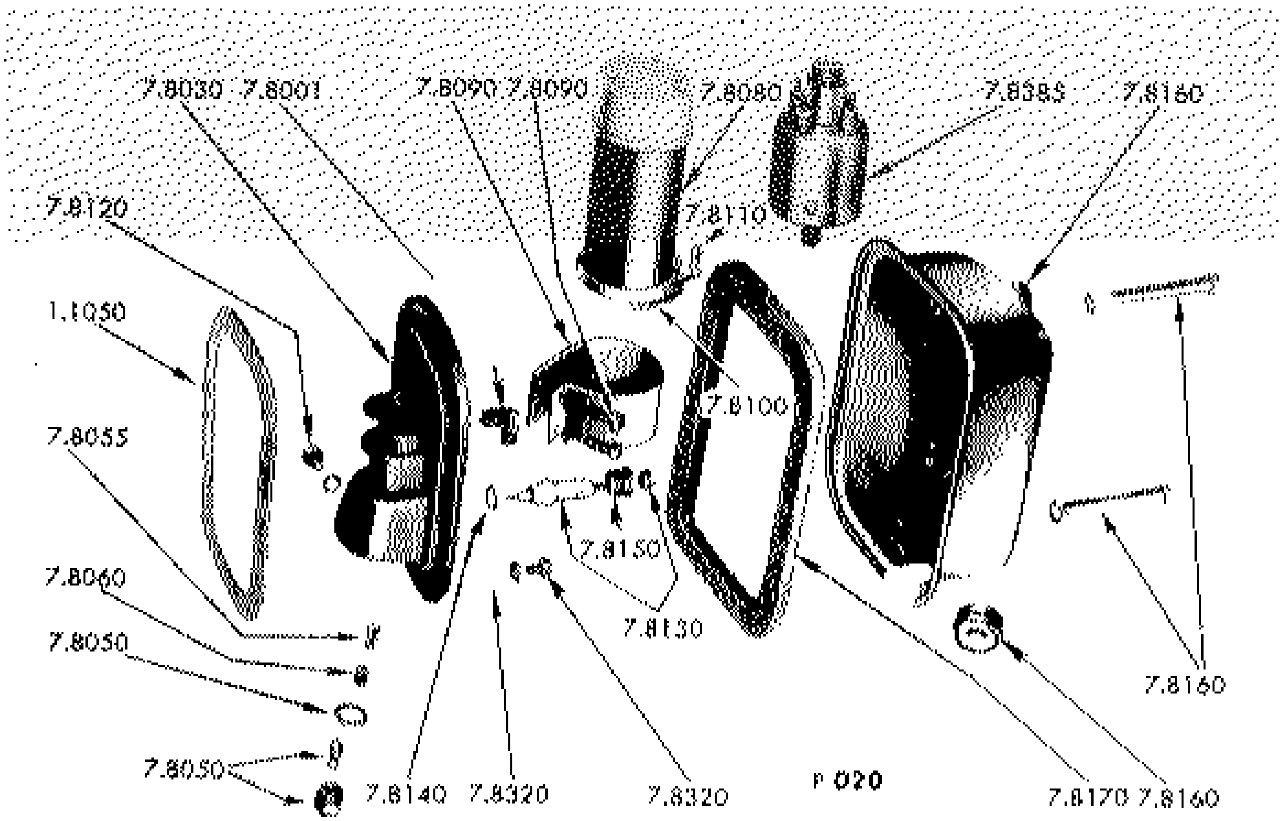


FIG. 9A AIR BOX HEATER

Fig. 9A of 7.0000

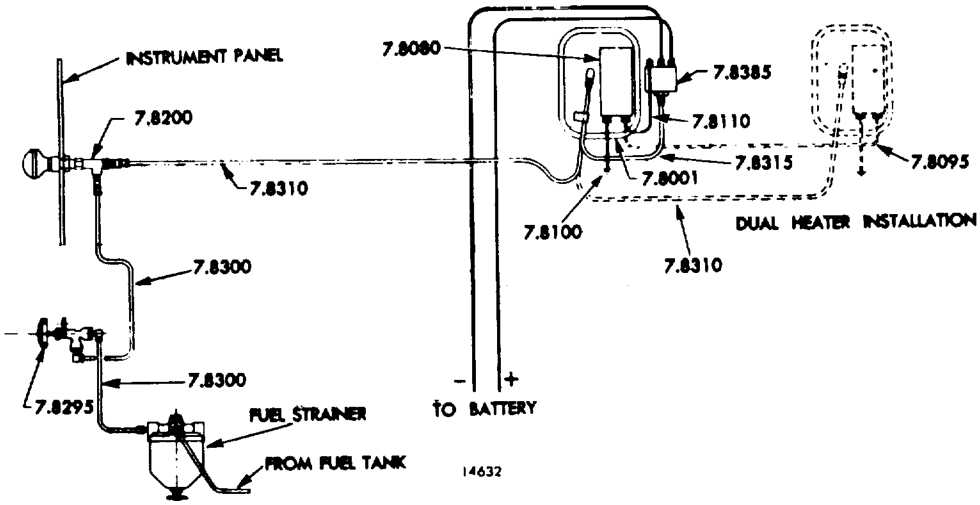


FIG. 9C AIR BOX HEATER INSTALLATION

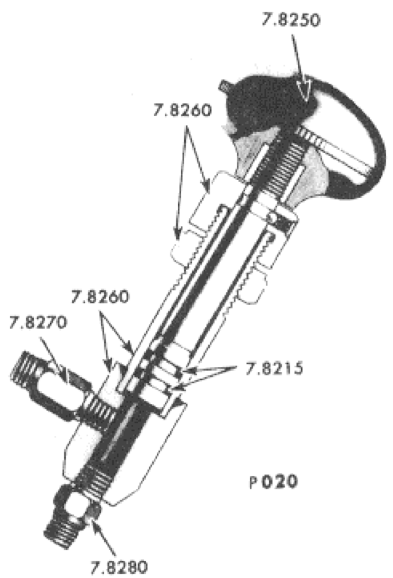


FIG. 9D FUEL PRIMER

Figs. 9C & 9D of 7.0000

7.1000A BATTERY CHARGING GENERATOR

FIG	PART NUMBER	NAME AND DESCRIPTION	1920	1922	1926	1955	1963	1964	1968	1972	1973	1983	1987
	7.1001 - GENERATOR ASSY												
	1100081	* GENERATOR (12V., 65 AMP., CW.)											
	1117242	* GENERATOR(12V, 75 AMP., CW)											
	1102920	* GENERATOR (12V., 42AMP C W.)											
	1102918	* GENERATOR (24V, 40AMP. C.W.)											
	NPN	GENERATOR (CUSTUMOR FURNISHED) -..										1	
	186624	BOLT, 5/16'-8X1 1/47 (12 9001)											
	186282	BOLT, 3/8'-16X3 1/4'(12.9001)											
	9427945	BOLT, 1/2'-13X6 1/4' (12.9001)											
	5159714	WASHER, 1/1 6X1/8											
	5132715	WASHER, .531DX940DX.12 (1 3140)1											
	103320	LOCKWASHER, 5/16' (12 9200)											
	103321	LOCKWASHER, 3/8' (12 9200)											
	103323	LOCKWASHER, 1/2 (129200) .											
	102635	NUT, 3/8'-16 (12 9120).											
	102637	NUT, 1/2--13 (12 9120)											
		* PROCURE FROM UNITED DELCO											
	7.1440* FAN, GENERATOR												
1	**800612**	*FAN .											
		* PROCURE FROM UNITED DELCO											
	7.1500 - PULLEY, GENERATOR												
	5136448	PULLEY, 3 24' DIA											
	5102911	PULLEY. 3 24' DIA., 1 GROOVE											
	7.1505 - PULLEY, GENERATOR DRIVE												
	5145390	PULLEY(9-DIA, 2 GROOVE)										1	
	5139735	PLATE (DRIVE PULLEY BACKING)										1	
	5133854	SPACER, PULLEY										1	
	179838	BOLT, 3/8'-16X7/8' (129001)										3	
	103321	LOCKWASHER. 3/8^ (12 9200)										3	
	7.1575 - BELT, GENERATOR DRIVE												
	9433893	BELT (44.00'L, .500W-VEE)											
	5133519	BELT (42 00'L, .500'W)											
	5140928	BELT (40 OO'L, 500'W)											
	1335158	BELT (4 7.00'L, 500'W)											
	5133518	BELT (41 ' L., 500'W.)											

7.1000A BATTERY CHARGING GENERATOR

7.1580 - STRAP. GENERATOR ADJUSTING

PART NUMBER	NAME AND DESCRIPTION	1920	1922	1926	1955	1963	1964	1968	1972	1973	1983	1987
5100629	STRAP											
5102964	STRAP											
5143161	STRAP											
5148407	STRAP										1	
5164294	SPACER, 1/8” THICK (7.1581)											
5156404	SPACER. 1 7/16- THICK (4 8040) .										1	
191249	BOLT, 3/8”-16X3 3/4'(129001)										1	
422733	BOLT, 1/2”-13X1 1/4'(12.9001)											
179847	BOLT, 3/8”-16X2" (129001)											
186278	BOLT, 3/8”-16X1 7/8^(12.9001)											
186311	BOLT, 3/8”-24X 33/4'(12.9001)											
5117082	WASHER. 53X1 16											
103321	LOCKWASHER, 3/82(129200)										1	
103323	LOCKWASHER, 3/28(12 9200)											

7.1581 - SPACER, GENERATOR ADJUSTING STRAP

PART NUMBER	NAME AND DESCRIPTION	1920	1922	1926	1955	1963	1964	1968	1972	1973	1983	1987
5141765	SPACER (15/32X1 X 76)											
5103096	SPACER (13/32)(3/4X 1/4)											
5164294	SPACER (7/8-13/32X1/8)											

7.1595 - BRACKET, GENERATOR MOUNTING

PART NUMBER	NAME AND DESCRIPTION	1920	1922	1926	1955	1963	1964	1968	1972	1973	1983	1987
5100635	BRACKET LH											
5100672	BRACKET										1	
5143160	BRACKET. FRONT .											
5102913	BRACKET, REAR											
6100910	BRACKET(FROENT)											
5100957	BRACKET.REAR)											
5141765	SPACER. 15/32'X1X 76											
6109349	SPACER. 15/32'X1X 82^											
5141768	SHIM,. 010.											
5138877	SHIM, 010"											
5126323	SHIM. 012.											
5138878	SHIM, 030"											
5158631	SHIM. 031'											
5141767	SHIM, 031'											
193221	BOLT, 7/16'-14X 1 1/4'(129001)										2	
186282	BOLT, 3/8'-16X3 1/4'(12 9001)											
106337	BOLT, 7/16'-14X1 3/8' (129001)											
427564	BOLT, 7/16'-14X1 3/8 (12 9001)											
179867	BOLT, 7/16'-14X2 1/4' (129001)										1	
179862	BOLT, 7/16'-14X1 1/2 (129001)											
454934	BOLT, 7/16'-14X2 1/2- (129001)											
186725	BOLT, 1/2'-13X1 1/4^(129001)											
5108436	WASHER											
5132715	WASHER, 53 X.94X 12 (1 3140)											

7.3000A

FIG	PART NUMBER	NAME AND DESCRIPTION	TYPE 2
	7.3001 - MOTOR ASSY., STARTING		
3A	1113846	MOTOR START 24V INSUL. C.W. O.C.	1
3A	9418228	BOLT 5/8" - 1X1 3/8" (12.9001)	3
3A	103325	LOCK WASHER 5/8" (12.9001)	3
	7.30046 - GASKET, STARTING MOTOR		
3A	5130995	GASKET (W/WET FLYWHEEL HSG)	1

7.4000B TACHOMETER DRIVE

FIG	PART NUMBER	NAME AND DESCRIPTION	248	250	251	269	293	297	353	366	368	388	389	400
		7.4405 - SHAFT ASSY., TACHOMETER DRIVE FLEXIBLE												
		SEE GROUP 12.8000B FOR MATERIAL AVAILABLE FOR FABRICATION OF FLEXIBLE SHAFT ASSEMBLIES AND CABLES. SHAFT ASSY. INCLUDES ITEM IN 7.4408.												
	1568956	SHAFT ASSY. (3'4')												
	1569668	SHAFT ASSY. (101												
		7.4408 - CABLE, TACHOMETER DRIVE FLEXIBLE												
	1635614	CABLE ASSY. (40 29/32')												
	1535530	CABLE ASSY. (60 29/32')												
		7.4420 - ADAPTOR. TACHOMETER DRIVE CABLE												
5E	1565185	# ADAPTOR (90 DEG. R.H., 1:.250 RATIO)												
5E	15668827	# ADAPTOR (90 DEG. L.H., 1:.500 RATIO)												
5E	6131177	& ADAPTOR (90 DEG. R.H., 2:1 RATIO)												
5E	6409857	ADAPTOR (90 DEG. L.H., 1:.500 RATIO)												
	1561509	% KEY (1 9/16' L.) (6478641)												
5E	1562290	% KEY (1 7/16' L.) (6478641)												
	5199122	KEY(I 19/64L.)												
	15855664	SEALAND KEYASSY				1								
		# INCLUDES ITEM IN 7.4432. & INCLUDE KEY IN 7.4420 AND LUBE FITTING IN 7.4432. % NOT SERVICED, USE P/N IN PARENTHESES AND CUT TO REQUIRED LENGTH.												
		7.4432 - PLUG, TACHOMETER DRIVE ADAPTOR BEARING												
5D,E	1582724	PLUG												
5D,E	191758	FITTING, 1/8' LUBE (12.9540)												
5D,E	178779	FITTING, RELIEF VALVE (12.9540)												
		7.4435 - SHAFT, TACHOMETER DRIVE												
		A SHAFT ASSY. INCLUDES SLINGER IN 7.4440.												
5A	3224992	SHAFT (.061' KEY HOLE)												

7.4000B TACHOMETER DRIVE

FIG	PART NUMBER	NAME AND DESCRIPTION	248	250	251	269	293	297	353	366	368	388	389	400		
		7.4435 - SHAFT, TACHOMETER DRIVE (CONRD)														
5A	5179903	SHAFT (.091' KEY HOLE)														
5D	5188558	SHAFT ASSY				1										
5E	5155881	SHAFT ASSY														
		7.4440 - SLINGER, TACHOMETER DRIVE SHAFT OIL														
SD,E	5155818	SLINGER				1										
		7.4445 - COVER, TACHOMETER DRIVE														
5E	5188555@	COVER ASSY-				1										
5E	5123118	@COVER ASSY														
5A	5125153	# COVER ASSY														
5E	5155854	STUD				2										
	179857	BOLT, 7/16'-14X7/8' (12.9001)														
	179848	BOLT, 7/16'-14X1 '(12.9001)														
	122408	BOLT, 1/2'-13X1' (12.9001)														
	179882	BOLT, 1/2'-13X1 1/8' (12.9001)														
	5150568	WASHER, COPPER (7/16'X3/4')														
	103323	LOCKWASHER, 1/2' (12.9200)														
		@ INCLUDES STUDS IN 7.4445.														
		# INCLUDES SEAL IN 7.4450.														
		7.4450 - SEAL, TACHOMETER DRIVE COVER														
5A,B	3202615	SEAL														
		7.4455 - GASKET, TACHOMETER DRIVE ADAPTOR														
5D,E	5135935	GASKET (ADAPTOR)				1										
5E	5117061	GASKET (COVER)														
		7.4457 - ADAPTOR, TACHOMETER DRIVE COVER														
5E	5155819	ADAPTOR				1										
	849330	CAP				1										
5E	2071181	WASHER, 7/16'X2M/32'				1										
	103320	LOCKWASHER, 5/16' (12.9200)				2										
5E	121917	NUT, 5/16'-24 HEX. (12.9120)				2										

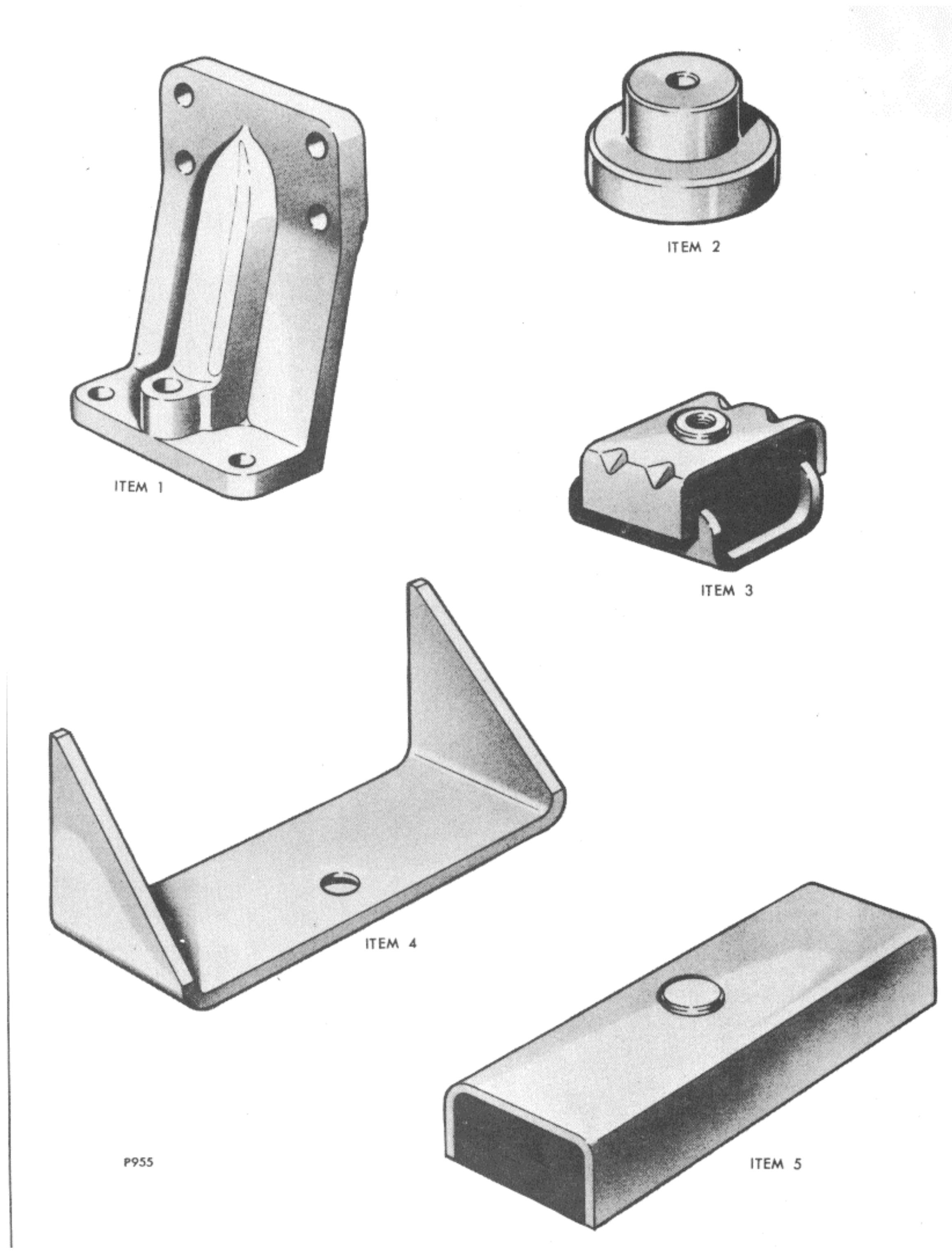


FIG. 1B ENGINE MOUNTS

Fig. 1B of 11.0000

11.1000A ENGINE MOUNTING BASE

FIG	PART NUMBER	NAME AND DESCRIPTION	1	3	254	258	264	292	411	529	530	544	579
		11.1070 - SUPPORT, ENGINE FRONT											
	5112488*	SUPPORT											
		11.1072 - MOUNTING, ENGINE FRONT SUPPORT ELASTIC											
1B	660551 *	SUPPORT ASSY. (ITEM 2)											
1B	2356569	SUPPORT ASSY. (RUBBER) (ITEM 3)											
	2061960	STUD, 9/16'-12-1BX1 11/16 (11.1100)											
	2061960	STUD, 9/16'-12-18X1 11/16 (11.110)											
	2223685	BOLT, 9/16'-1BX2 3/8'											
		* OBSOLETE.											
		11.1090 - SUPPORT, ENGINE FRONT TRUNNION MOUNTING											
		A SUPPORT ASSEMBLY INCLUDES BOLTS AND LOCKWASHERS IN 11.1090.											
	5186647	SUPPORT ASSY		1									
	5139311	SUPPORT ASSY											
	179867	BOLT, 7/16'-14X2 1/4' (12.9001)		2									
	103322	LOCKWASHER, 7/16' (12.9200)-		2									
		11.1094 - RING, ENGINE FRONT TRUNNION MOUNTING SUPPORT CUSHION											
	5166864	RING....1											
		11.1100 - SUPPORT, ENGINE REAR											
1B	3222025	SUPPORT (ITEM 1)											
1B	5113584	SUPPORT (FLYWHEEL HOUSING) (ITEM 4)											
1B	5113611	SUPPORT ASSY. (ITEM 5)											
1B	5112487	BRACKET (REAR FRAME) (ITEM 1)											
	5112434	PLATE (FLYWHEEL HOUSING)											
	180175	BOLT, 1/2'-13X1 1/4' (12.9001)											
	186725	BOLT, 1/2'-13X1 1/2' (12.9001)											
	181429	BOLT, 1/2'-20X1 1/4' (12.9001)											
	181720	BOLT, 9/16'-18 X1 '(12.9001)											
	181725	BOLT, 9/16'-18X1 1/4' (12.9001)											
	181737	BOLT, 9/16'-18X3 1/4' (12.9001)											
	121458	WASHER, 9/16' FLAT (12.9190)											
	103329	LOCKWASHER, 1/2' (HEAVY)(12.9200) .											
	103323	LOCKWASHER, 1/2' (12.9200)											
	103330	LOCKWASHER, 9/16' (HEAVY) (12.9200)											

FIG. 1B VACUUM PUMP

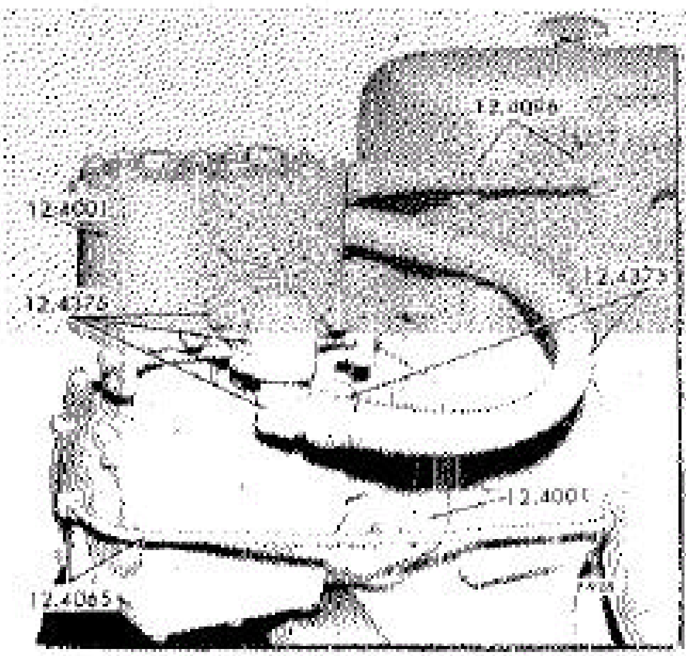


FIG. 2A

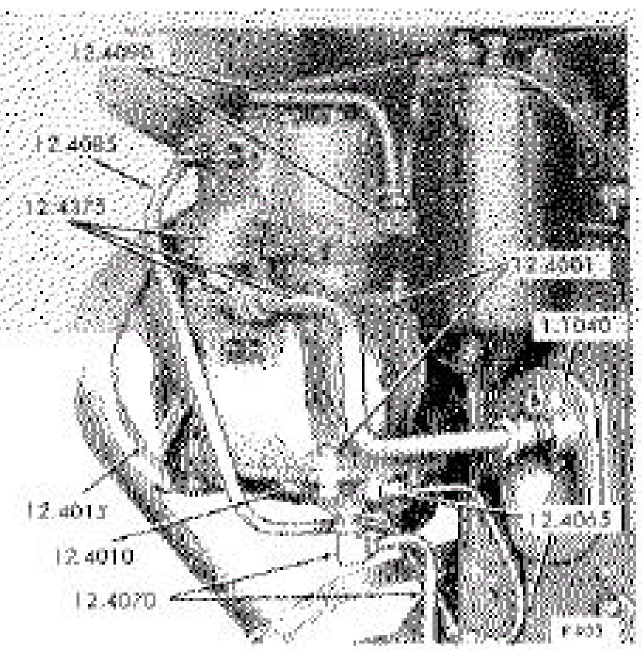


FIG. 2B

AIR COMPRESSOR

Figs. 1 B, 2A & 2B of 12.0000

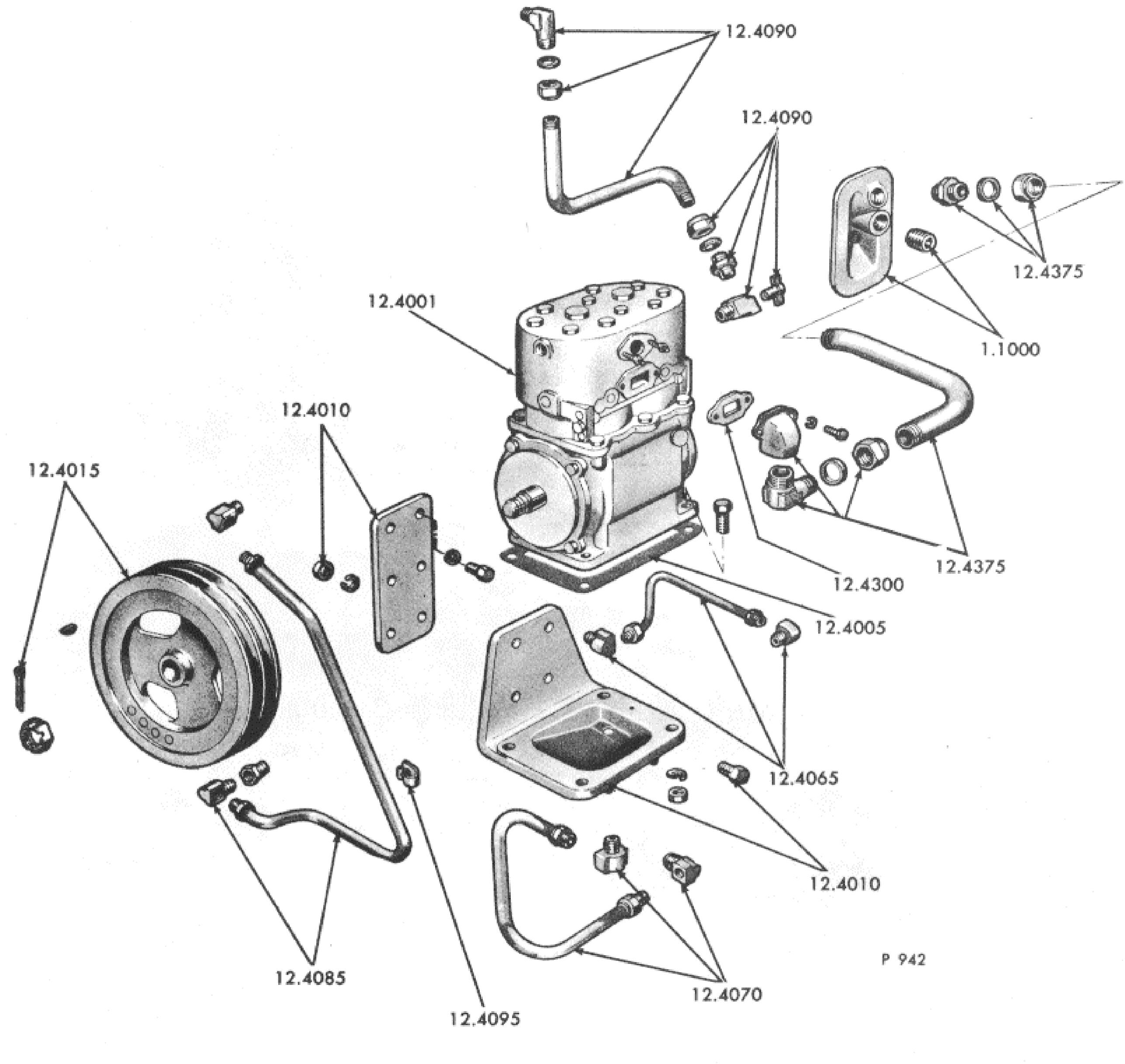


FIG. 2C AIR COMPRESSOR (Bracket Mounted)

Fig. 2C of 12.0000

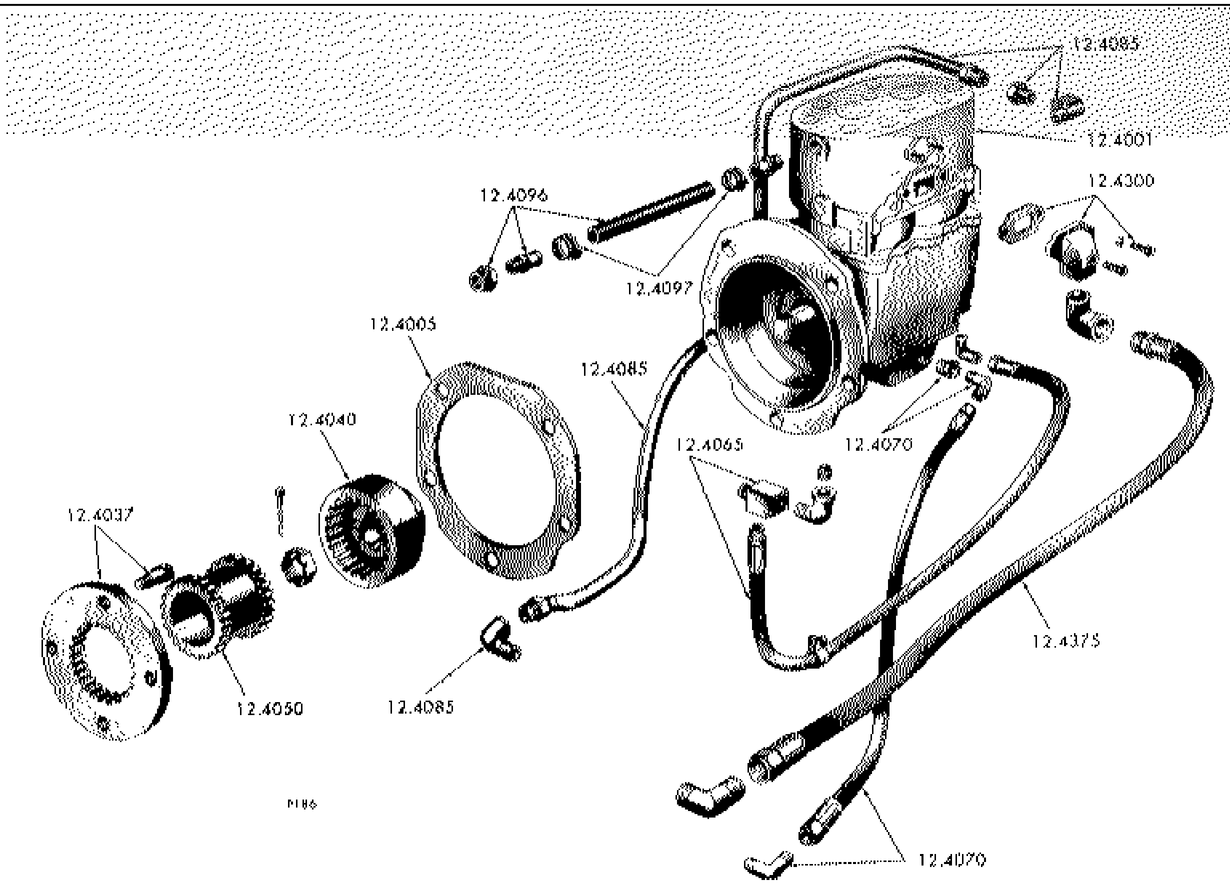


FIG. 2D AIR COMPRESSOR (Flange Mounted)

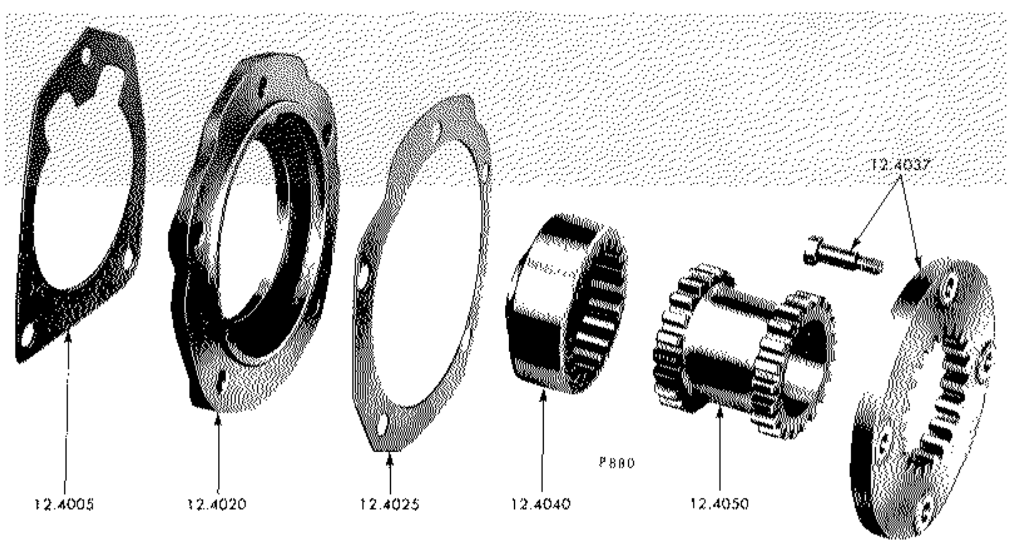


FIG. 3A AIR COMPRESSOR DRIVE

Figs. 2D & 3A of 12.0000

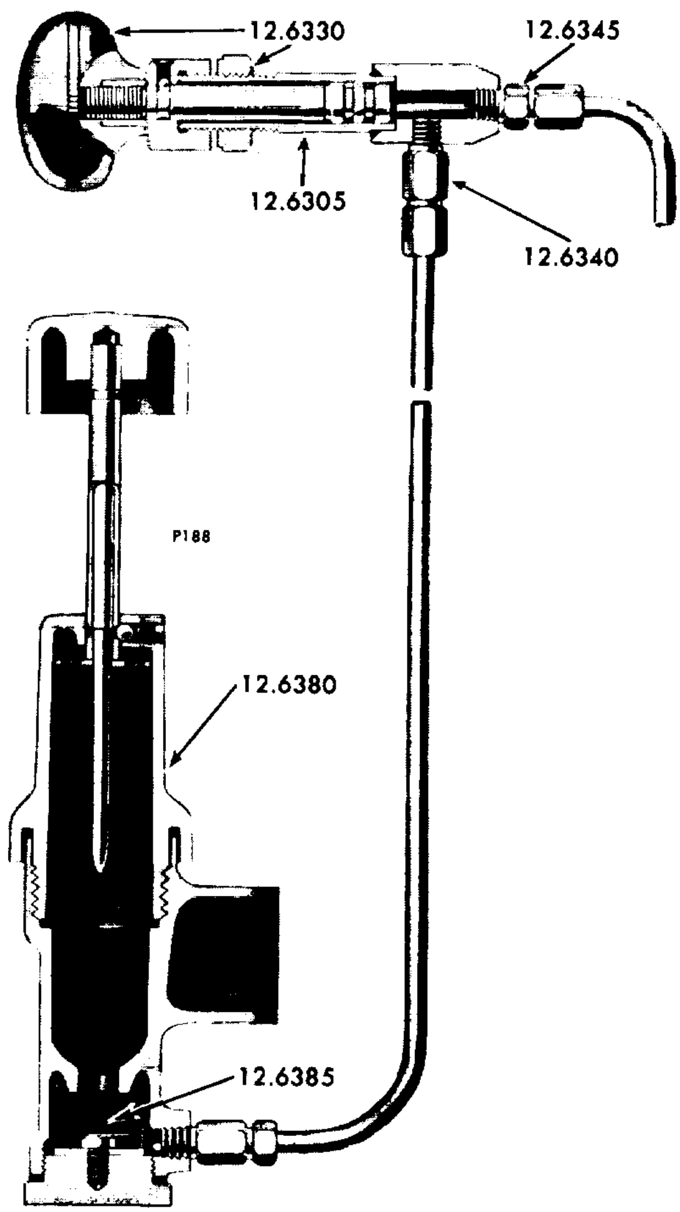


FIG. 4A STARTING AID

Fig. 4A of 12.0000

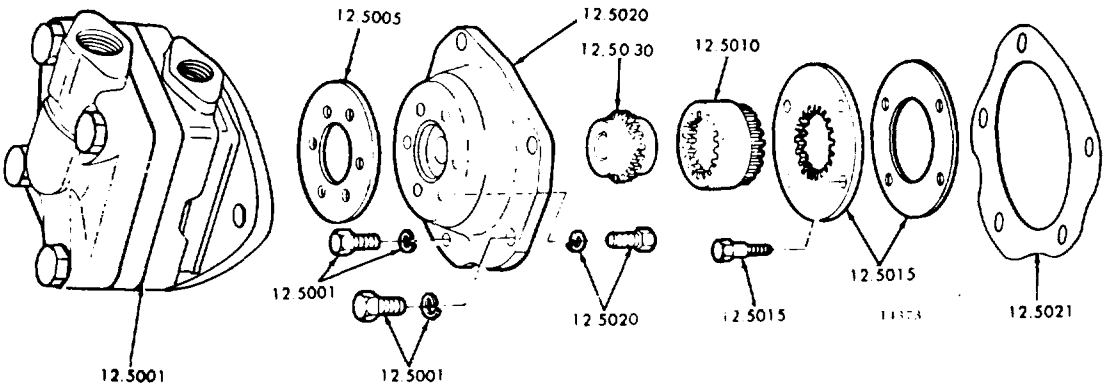


FIG. 5A HYDRAULIC PUMP

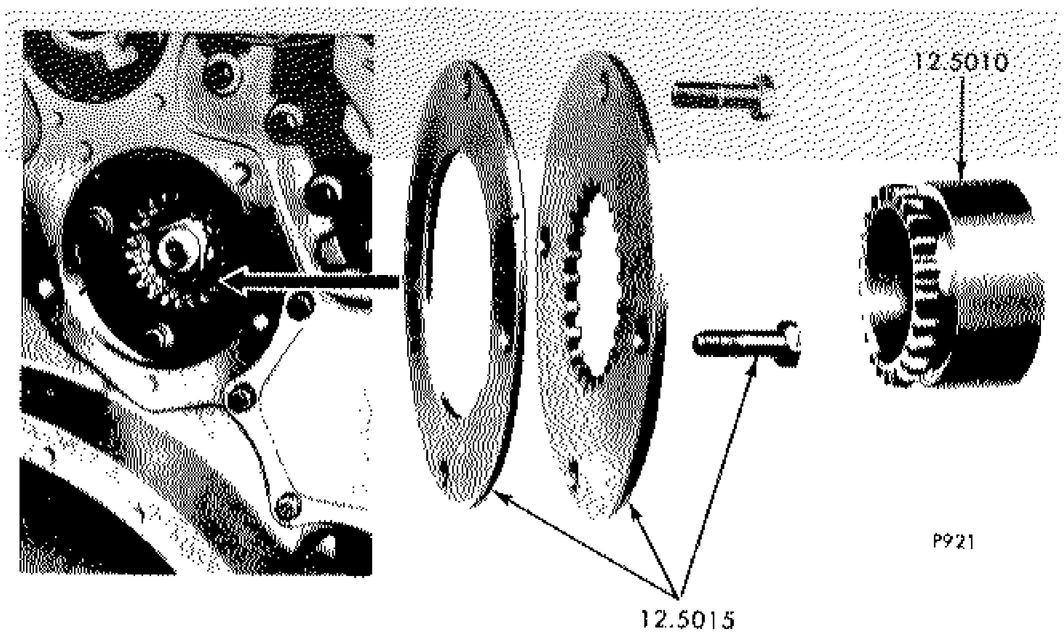


FIG. 5B HYDRAULIC PUMP DRIVE

Figs. 5A & 5B of 12.0000

7.3000A

FIG.	PART NUMBER	NAME AND DESCRIPTION	TYPE 2
	12.4001 -	COMPRESSOR ASSY AIR	
2A	5101017	COMPRESSOR ASM 12 CAM BW285970	1
	12.4037 -	PLATE, AIR COMPRESSOR DRIVE	
2D, 3A	5170450	PLATE (1.7630)	1
	5145092	BOLT, 3/8"-24X1.20" SELF-LOCKING (12.5015)	4
	12.4040 -	HUB, AIR COMPRESSOR DRIVE	
2D, 3A	5144866 -	HUB	1
	103375	PIN, 3/32""X14" COTTER (12.9250)	1
	12.4050 -	COUPLING AIR COMPRESSOR DRIVE	
2D,3A	5141773	COUPLING	1
	12.4065 -	TUBE, AIR COMPRESSOR LUBE OIL SUPPLY	
2A	5135077	HOSE ASSY 3/16X23, OIL SUPPLY	1
	444052	ELBOW, 45DEG ST 1/8	1
	118753	ELBOW, 1/4" TUBE - 1/8" P.T. (90 DEG) (12.9480)	1
	5167220	TEE, 1/4" TUBE (7.8300)	1
	118748	CONNECTOR, 1/4" FL TUBE (12.9380)	1
	186625	BOLT, 5/16"-18X7/8" (12.9001)	2
	103320	LOCKWASHER, 5/16" (12.9200)	2
	12.4080 -	CLIP, AIR COMPRESSOR LUBE OIL TUBE	
2A	5153473	CLIP (1/2" TUBE, 3/8" BOLT) (4.6040)	1
	12.4085 -	TUBE, AIR COMPRESSOR WATER INLET	
2A	5133016	HOSE (1/2"X30/2") WATER INLET	1
	5120020	FITTING, FEMALE (1/2" HOSE X 3/4"-16)	3

FIG.	PART NUMBER	NAME AND DESCRIPTION	TYPE
		12.4090 - TUBE, AIR COMPRESSOR WATER OUTLET	
2A	5133015	HOSE Y2"X242" WATER OUTLET	1
	5120020	FITTING, FEMALE (1/2" HOSE X 3/4"-16	2
	5121825	FITTING, MALE (1/2" HOSE X 3/8"-16	1
	118757	ELBOW, 3/8" FL TUBE 90 DEG (12.9390)	3
	142269	BUSHING, 1/2"X3/8" RED PIPE (12.9570)	1
		12.4095 - CLIP, AIR COMPRESSOR WATER TUBE	
2A	5151189	CLIP, 3/4" SPECIAL (4.8040)	2
	5127861	BRACKET (7.1587)	1
	5155464	BRACKET, TUBE CLIP (7.1582)	1
	179837	BOLT, 3/8"-16X3/4" (12.9001)	2
	103321	LOCKNASHER, 3/8" (12.9200)	2
	102635	NUT 3/8-16	2
		12.4300 - STRAINER, AIR COMPRESSOR	
2D	5110411	STRAINER	1
2C	5110410#	GASKET	1
	118536	DRAINCOCK, 3/8" (12.9510)	1
2D	179827	BOLT, 5/16"-18X2Y4" (12.9001)	2
	103320	LOCKWASHER 5/16" (12.9200)	2

11.1000A ENGINE MOUNTING BASE

FIG	PART NUMBER	NAME AND DESCRIPTION	87	94	98	124	170	173	228
		12.5001 - PUMP ASSY., HYDRAULIC							
	NPN	PUMP ASSY. (CUSTOMER FURNISHED)							
5A	5184293	PUMP ASSY. (LESS ADAPTOR) (VICKERS NO. V-230-8-1C-L.H.) (13 GPM AT 2000 RPM)							
5A	6184292	PUMP ASSY. (LESS ADAPTOR) NO. V-230-8-1C-R.H.) (13 GPM AT 2000 RPM)							
5A	6127127	PUMP ASSY. (LESS ADAPTOR) (VICKERS. NO. V-230-8W-1C-07-12-L.H.) (7 GPM AT 2100 RPM)							
5A	5135317	PUMP ASSY. (LESS ADAPTOR) (VICKERS NO. V-230-11W-1C-12-R.H.) (11 GPM AT AT 2100 RPM)							1
	179858	BOLT, 7/16--14X11- (12.9001)							1
	178583	BOLT, 1/2'-13X 1/8' (12.9001)							
	180083	BOLT, 1/2'-13X1 1/8' (12.9001)							4
	103322	LOCKWASHER, 7/16' (12.9200)							
	103323	LOCKWASHER, 1/2' (12.9200)							
		12.5005 - GASKET, HYDRAULIC PUMP							
5A	5168852	GASKET							1
		12.5010 - COUPLING, HYDRAULIC PUMP DRIVE							
5B	3292492	+ = COUPLING (23 EXTERNAL TEETH).							
5B	5143616	? COUPLING (21 EXTERNAL TEETH) + THRU 3A-54417, 4A-111456, 6A-116508. NOT SERVICED, USE 5143616 COUPLING AND 5131627 PLATE. ? EFFECTIVE WITH 3A-54418, 4A-111457. 6A-116509.							1
		12.5015 - PLATE, HYDRAULIC PUMP DRIVE							
5B	5153449	+ = PLATE (23 TEETH) (1.7630)							
5B	5131627	? PLATE (21 TEETH)							
5A	5170450	PLATE (21 TEETH) (1.7630)							1
5B	5177026	SPACER (1.7630)							
5B	5176474	BOLT (1.7630)							
	5145091	BOLT, 3/8'-24X1.31' (1.7630)							
5A	5145092	BOLT (1.20- L.) SELF LOCKING (12.4037) THRU 3A-54417, 4A-111456, 6A-116508.							4

11.1000A ENGINE MOUNTING BASE

FIG	PART NUMBER	NAME AND DESCRIPTION	87	94	98	124	170	173	228							
	12.5015 -	**PLATE, HYDRAULIC PUMP DRIVE (CONT'D)**														
		=NOT SERVICED, USE 5143616 COUPLING AND 5131627 PLATE. ? EFFECTIVE WITH 3A-54418, 4A-111457, 6A-116509.														
	12.5020 -	**ADAPTOR, HYDRAULIC PUMP**														
5A	5135907	ADAPTOR							1							
	179839	BOLT, 3/8'-16X3' (12.9001)	.						6							
	103321	LOCKWASHER, 3/8' (12.9200)							AR							
	12.6021 -	**GASKET, HYDRAULIC PUMP ADAPTOR**														
5A	6117061	GASKET (1. 5040)														
	12.5030 -	**GEAR, HYDRAULIC PUMP DRIVE**														
5A	5168688	GEAR														

CHAPTER IV

NUMERICAL PARTS LIST
AND QUANTITY FOR
GROVE MODEL TMS 300-5
IN-LINE 71 ENGINE

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
	GENERATOR	1
100001	BOLT	4
100014	BOLT	2
102635	NUT	2
103319	LOCKWASHER	6
103319	LOCKWASHER	1
103319	LOCKWASHER	1
103319	LOCKWASHER	2
103319	LOCKWASHER	1
103319	LOCKWASHER	6
103319	LOCKWASHER	4
103319	LOCKWASHER	3
103319	LOCKWASHER	1
103319	LOCKWASHER	2
103319	LOCKWASHER	6
103319	LOCKWASHER	12
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	6
103320	LOCKWASHER	2
103320	LOCKWASHER	6
103320	LOCKWASHER	2
103320	LOCKWASHER	4
103320	LOCKWASHER	6
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	8
103320	LOCKWASHER	2
103320	LOCKWASHER	2
103320	LOCKWASHER	4
103320	LOCKWASHER	8
103320	LOCKWASHER	6
103320	LOCKWASHER	2
103320	LOCKWASHER	20
103320	LOCKWASHER	1
103320	LOCKWASHER	4
103321	LOCKWASHER	3
103321	LOCKWASHER	6
103321	LOCKWASHER	12
103321	LOCKWASHER	2
103321	LOCKWASHER	6
103321	LOCKWASHER	2
103321	LOCKWASHER	4
103321	LOCKWASHER	1
103321	LOCKWASHER	2
103321	LOCKWASHER	6
103321	LOCKWASHER	6

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
103321	LOCKWASHER	6
103321	LOCKWASHER	12
103321	LOCKWASHER	2
103321	LOCKWASHER	15
103321	LOCKWASHER	12
103321	LOCKWASHER	6
103321	LOCKWASHER	10
103321	LOCKWASHER	3
103321	LOCKWASHER	6
103322	LOCKWASHER	6
103322	LOCKWASHER	4
103322	LOCKWASHER	4
103322	LOCKWASHER	2
103322	LOCKWASHER	4
103322	LOCKWASHER	4
103322	LOCKWASHER	3
103322	LOCKWASHER	2
103323	LOCKWASHER	3
103323	LOCKWASHER	4
103323	LOCKWASHER	2
103323	LOCKWASHER	4
103323	LOCKWASHER	6
103323	LOCKWASHER	8
103325	LOCKWASHER	3
103324	LOCKWASHER	14
103324	LOCKWASHER	14
103340	WASHER	6
103340	WASHER	2
103340	WASHER	1
103341	WASHER	6
103341	WASHER	8
103341	WASHER	1
103341	WASHER	1
103342	WASHER	4
103361	PIN	1
103375	PIN COTTER	1
103647	DRAINCOCK	1
103647	DRAINCOCK	1
103647	DRAINCOCK	1
103647	DRAINCOCK	1
103709	PIN	1
103905	KEY	3
103905	KEY	1
105451	GASKET	8
105456	GASKET	2
106261	WASHER	1
108608	BOLT	8
109371	SCREW	2
110633	NUT	2
1113846	MOTOR ASSY	1
111612	CLAMP	2
1118128	SOLENOID	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
113175	PLUG	1
113500	PIN	1
114492	NUT	1
114492	NUT	1
114493	NUT	2
114493	NUT	2
114493	NUT	4
117049	NUT	12
117049	NUT	12
117049	NUT	2
117049	NUT	2
117049	NUT	4
117049	NUT	4
117296	SCREW	1
118536	DRAINCOCK	1
118536	DRAINCOCK	1
118536	DRAINCOCK	1
118748	CONNECTOR HOSE	1
118753	ELBOW	1
118755	ELBOW	1
118757	ELBOW	1
118757	ELBOW	2
120217	LOCKWASHER	2
120217	LOCKWASHER	2
120380	LOCKWASHER	4
120380	LOCKWASHER	1
120391	WASHER	1
120391	WASHER	2
120392	WASHER	4
120392	WASHER	1
120392	WASHER	4
120393		1
120393	WASHER	4
120613	NUT	3
120687	SCREW	2
121902	NUT	4
122013	NUT	4
122366	NUT	1
123435	BOLT	1
124549	KEY	1
124925	NUT	1
124925	NUT	1
127855	NUT	7
132268	SCREW	3
138234	BOLT	1
141195	PIN	2
141346	DOWEL PIN	4
141346	PIN	4
142269	BUSHING	1
142486	PIN	1
142487	PIN	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
142522	PIN	4
142583	RETAINER	1
142583	RETAINER	1
142583	RETAINER	1
142656	PLUG	1
145382	SCREW	2
147481	BALL	1
148402	BEARING	2
1503536	GASKET	1
1568220	WASHER	1
1585564	SEAL AND KEY	1
169067	BALL	1
179796	BOLT	1
179796	BOLT	2
179803	BOLT	1
179816	BOLT	4
179816	BOLT	2
179816	BOLT	2
179816	BOLT	2
179819	BOLT	2
179819	BOLT	2
179824	BOLT	4
179824	BOLT	4
179827	BOLT	2
179828	BOLT	20
179828	BOLT	4
179829	BOLT	1
179830	BOLT	4
179830	BOLT	6
179837	BOLT	2
179838	BOLT	3
179838	BOLT	2
179838	BOLT	2
179839	BOLT	2
179839	BOLT	6
179839	BOLT	6
179839	BOLT	6
179844	BOLT	4
179846	BOLT	1
179846	BOLT	1
179847	BOLT	1
179847	BOLT	1
179848	BOLT	1
179858	BOLT	1
179862	BOLT	4
179862	BOLT	4
179867	BOLT	2
179867	BOLT	2
179867	BOLT	1
179882	BOLT	4
179882	BOLT	2
179884	BOLT	4

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
18SP-85	CYLINDER HEAD ASSY	1
181360	BOLT	2
181361	BOLT	2
181370	BOLT	4
181370	BOLT	3
181370	BOLT	2
181370	BOLT	2
181374	BOLT	1
181385	BOLT	8
181394	BOLT	6
181595	BOLT	2
182776	BOLT	2
186270	BOLT	1
186274	BOLT	8
186282	BOLT	6
186288	BOLT	2
186309	BOLT	2
186312	BOLT	2
186314	BOLT	1
186317	BOLT	1
186612	BOLT	2
186619	BOLT	1
186622	BOLT	1
186624	BOLT	2
186624	BOLT	1
186624	BOLT	2
186625	BOLT	4
186625	BOLT	4
186625	BOLT	4
186625	BOLT	3
186627	BOLT	3
186631	BOLT	12
186646	BOLT	2
186647	BOLT	2
186647	BOLT	2
186650	BOLT	4
186725	BOLT	2
187953	BOLT	1
189330	BOLT	2
190770	BOLT	4
190910	BOLT	2
191249	BOLT	2
191758	FITTING	2
193004	ELBOW	2
193221	BOLT	2
193221	BOLT	2
225810	ELBOW	1
225815	ELBOW	2
225828	ELBOW	2
2419766	CLIP	1
3290399	PLATE	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
3290572	GASKET	1
3290823	SHAFT	1
3290823	SHAFT	1
3719219	BOLT	8
427564	BOLT	4
427570	BOLT	6
436574	SCREW	2
442322	CONNECTOR	1
443230	PIN	1
443603	BOLT	6
443603	BOLT	6
443603	BOLT	12
444052	ELBOW	1
444687	PLUG	6
447196	BEARING	4
451905	BEARING	1
453593	BALL	3
454992	BOLT	1
454992	BOLT	1
455322	FITTING	1
455862	PIN	4
455862	PIN	1
5100202	SUPPORT	1
5100672	BRACKET	1
5100797	RING	1
5100845	LEVER	1
5100890	CAP	1
5100929	SLEEVE	2
5100974	GOVERNOR	1
5101002	HOUSING ASSY	1
5101002	HOUSING	1
5101017	COMPRESSOR ASSY	1
5101101	INSERT EXHAUST	24
5101101	INSERT	24
5101197	SCREW	1
5101432	PIN	1
5101540	HOUSING	1
5101691	SEAL RING	1
5101772	MANIFOLD	1
5102257	FORK	1
5102270	SCREW	1
5102381	SHAFT	1
5102506	GASKET	1
5102735	CRAB	2
5102772	HEAD ASSY	1
5312772	HEAD ASSY	1
5103044	SCREW	1
5103046	SEAL RING	1
5103007	PISTON	1
5103208	COVER	1
5103345	PULLEY & HUB ASM	1
5103365	CAM	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
5103371	PULLEY	1
5103377	COUPLING ASSY	1
5103534	BOLT	6
5103550	SEAL RING	1
5103601	GASKET	1
5103676	SPACER	1
5103718	SPACER	2
5103738	COVER	1
5103903	BRACKET	12
5103943	HOUSING ASSY	1
5103943	STRAINER	1
5103951	SEAL	1
5103975	CAP	1
5104015	BOLT	4
5104019	GASKET	1
5104089	BOLT	6
5104109	RETAINER	2
5104152	BOLT	2
5104317	WASHER	1
5104380	BODY	1
5104381	GASKET	1
5104390	REGULATOR ASSY	1
5104439	WASHER	5
5104506	GASKET	2
5104514	WASHER	4
5104515	ISOLATOR	4
5104604	BOLT	2
5104609	BOLT	4
5108436	WASHER	4
5108921	FLANGE	1
5108950	MANIFOLD	1
5108989	GASKET	1
5109180	STUD	4
5109642	BOLT	1
5109949	WASHER	2
5110410	GASKET	1
5110411	STRAINER ASSY	1
5110648	PIN	1
5110652	COVER	1
5110654	COVER ASSY	1
5110654	COVER ASSY	1
5110659	CAM	1
5110661	SHAFT	1
5110665	BUSHING	1
5110666	LEVER ASSY	1
5110894	GEAR	1
5111332	NOZZLE	10
5111337	LOCK	48
5111422	BEARING	4
5111423	BUSHING	8
5111424	WASHER	4

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
5111526	PIPE ASSY	6
5111527	PIPE ASSY	6
5111798	PLUG	1
5111798	PLUG	10
5111798	PLUG	2
5111581	SCREEN	1
5111904	SPRING	1
5112719	SPRING	1
5112785	LATCH	1
5112899	STUD	7
5112899	STUD	7
5113056	NAME PLATE	1
5113061	GASKET	1
5113814	GEAR	1
5113817	GEAR	1
5113825	CHAIN	1
5113953	LINER	1
5114011	THROWER	1
5114031	WEIGHT	2
5114124	SPRING	1
5114335	SEAL	1
5114442	COVER	1
5114528	PIN	4
5114726	GASKET	2
5114974	HANDLE ASSY	1
5115087	FOLLOWER	18
5115090	BUSHING	1
5115097	COVER	1
5115097	COVER	1
5115214	PLUG	5
5115214	PLUG	1
5115214	PLUG	4
5115322	LEVER	6
5115454	SEAL	1
5115572	RING	10
5115856	GASKET	1
5115898	GEAR	1
5115922	SPRING	1
5116357	GASKET	1
5117003	BOLT	14
5117186	PLUG	2
5117344	PLATE	6
5117344	COVER	2
5117362	CAP	1
5117369	CONNECTOR	12
5117369	CONNECTOR	12
5117562	SEAT	24
5117562	SEAT	24
5117563	CAP	24
5117564	GUIDE	12
5117564	GUIDE EXHAUST	12
5117565	BRIDGE	12

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

PART NUMBER	DESCRIPTION	QUANTITY
5117629	NUT	2
5118149	HOSE	1
5118219	BOLT	3
5118219	BOLT	6
5118302	COVER	2
5118353	COVER	1
5118362	HOUSING	1
5118951	JOINT	2
5119974	RING SEAL	1
5120020	CONNECTION HOSE	2
5120020	CONNECTION	1
5120082	VALVE	1
5120223	GASKET	3
5120726	COVER	1
5120740	STUD	1
5120753	PLATE	1
5121182	PLUG	2
5121182	PLUG	2
5121182	PLUG	13
5121182	PLUG	13
5121182	PLUG	1
5121182	PLUG	1
5121182	PLUG	1
5121259	CLAMP	1
5121753	GASKET	1
5121815	GEAR	1
5121816	GEAR	1
5121825	FITTING HOSE	1
5121970	WEIGHT	2
5122069	COUPLING	1
5122246	HOSE ASSY	1
5122321	RING	1
5122445	BUSHING	12
5122529	WASHER	1
5122530	BEARING	2
5122623	CAM	1
5123250	SEAT	13
5123383	BOLT	5
5123415	BRACKET	1
5123429	SPACER	1
5123700	BUSHING	18
5123812	GASKET	2
5123812	GASKET	3
5123814	ADAPTER	1
5125108	WASHER	12
5125108	WASHER	1
5125108	WASHER	12
5125144	TUBE ASSY	1
5125237	PLUG	5
5125237	PLUG	5
5125900	HOSE	1
5127861	BRACKET CLIP	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

P/N	ITEM	QTY
5123593	SHAFT	1
5128640	ROD	18
5129101	SCREW	12
5129157	HOSE	1
5129157	HOSE	1
5129844	ADAPTER	1
5129845	CONNECTOR	1
5129884	SUPPORT ASSY	1
5129919	GUIDE	24
5129919	GUIDE	24
5130135	HUB ASSY	1
5130509	BRACKET	2
5131685	BOLT	3
5131719	SPACER ASSY	1
5131724	KEY	2
5131896	DIPSTICK	1
5132383	BOLT	2
5133357	THERMOSTAT ASSY	1
5133854	SPACER	1
5133854	SPACER	1
5134628	COVER	1
5134917	CONE	1
5134961	TUBE	1
5135077	HOSE	1
5135317	PUMP ASSY	1
5135882	BELT SET	1
5135935	GASKET	1
5136240	PLUG	1
5136240	PLUG	1
5136241	PLUG	1
5136241	PLUG	1
5136671	SHAFT ASSY	1
5136809	BRACKET	1
5138090	CLAMP	2
5138091	CLAMP	2
5138332	ADAPTER	1
5138336	CLAMP	2
5138525	LEVER	1
5138553	BLOWER ASSY	1
5138553	ROTOR ASSY	1
5138553	ROTOR ASSY	1
5138619	WASHER FLAT	4
5138619	WASHER FLAT	6
5138687	LINK	1
5138710	SEAL	4
5138725	HOUSING	1
5139735	PLATE	1
5139988	PLUG	2
5140653	DAMPER	1
5140740	FLYWHEEL ASSY	1
5141773	COUPLING	1
5142549	PLUG	1
5142549	PLUG	1
5142549	PLUG	2
5142549	PLUG	4
5142549	PLUG	4
5143023	HOUSING	1
5143616	COUPLING	1
5143836	BUSHING	1
5144177	RETAINER	2
5144173	RETAINER	1
5144744	PIN	1
5144836	SKIRT	1
5144837	RING	1
5144843	BEARING	1
5144846	SPACER	2
5144847	ROD ASSY	1
5144866	HUB	1
5145009	PLUG	1
5145009	PLUG	2
5145009	PLUG	2
5145009	PLUG	1
5145009	PLUG	2
5145009	PLUG	1
5145009	PLUG	7
5145009	PLUG	4
5145012	PLUG	2
5145012	PLUG	1
5145014	PLUG	2
5145014	PLUG	1
5145014	PLUG	2
5145014	PLUG	2
5145014	PLUG	1
5145014	PLUG	1
5145014	PLUG	2
5145014	PLUG	3
5145047	INSULATOR ASSY	1
5145092	BOLT	4
5145092	BOLT	4
5145390	PULLEY	1
5146248	HOOK	2
5146369	SPACER	1
5147019	PIPE ASSY	1
5147078	HOUSING	1
5147345	PIN	1
5147347	SPRING	24
5147359	COLLAR	1
5147683	FILTER ASSY	1
5147684	ADAPTER	1
5148035	RING	1
5148373	BOLT	2
5148407	STRAP	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

P/N	ITEM	QTY	P/N	ITEM	QTY
5148436	BOLT	8	5150361	GASKET	6
5148437	BOLT	34	5150362	STUD	12
5148437	BOLT	22	5150362	STUD	12
5148472	ARM ASSY	6	5156364	COVER	1
5148475	ARM ASSY	6	5150372	SHIM	1
5148810	GASKET	1	5150433	PIPE	1
5149363	PUMP ASSY	1	5150512	SPACER	1
5149393	CAM SHAFT	1	5150829	PLUG	1
5150014	PLUG	1	5150855	SHIM	1
5150020	GASKET	8	5150856	SHIM	1
5150050	BRACKET	1	5150869	SHAFT ASSY	1
5150051	BRACKET	1	5150884	SCREW	1
5151052	GASKET	2	5150889	GASKET	1
5150054	GASKET	1	5150890	GASKET	1
5150060	PLATE	1	5150892	SEAT	1
5150087	NUT	2	5150897	LOCKWASHER	1
5150087	NUT	2	5150893	SCREW	1
5150132	PLUG	2	5150900	GASKET	1
5150154	GASKET	2	5150925	SHAFT	1
5150155	GASKET	1	5150941	WASHER	1
5150174	SLING	1	5150941	WASHER	1
5150181	GASKET	1	5150941	WASHER	1
5150191	PACKING	1	5150941	WASHER	1
5150193	GASKET	1	5150942	PIN	2
5150193	GASKET	1	5150942	PIN	2
5150216	SHAFT	2	5150990	LINK	1
5150230	WASHER	2	5151122	PLUG	2
5150238	WASHER	8	5151189	CLIP	2
5150246	GASKET	1	5151272	PLUG	4
5150250	WASHER	1	5151272	PLUG	6
5150258	SHAFT	1	5151277	PLUG	2
5150259	SHAFT	1	5151370	GASKET	1
5150263	LEVER	1	5151370	GASKET	1
5150268	COVER	3	5151430	GUIDE	1
5150271	BOLT	6	5151444	DOWEL	1
5150279	HUB	1	5151444	DOWEL	1
5150281	LOCKWASHER	1	5151487	WASHER	8
5150298	GUIDE	6	5151487	WASHER	1
5150302	SEAT	18	5151576	DOWEL PIN	4
5150303	RETAINER	13	5151601	NUT	12
5150311	BUSHING	18	5151601	LOCKNUT	18
5150312	CLEVIS	18	5152148	WASHER	1
5150314	PIN	18	5152149	BOLT MAIN BEARING	14
5150313	BUSHING	6	5152149	BOLT	14
5150322	SHAFT ASSY	6	5152613	PLUG	2
5150325	BOLT	12	5152804	NUT	1
5150345	SUPPORT	1	5152878	PLATE	1
5150346	SEAT	4	5152904	GASKET	1
5150349	RETAINER	1	5152944	GASKET	1
5150350	BOLT	6	5153117	COVER	7
5150361	GASKET	6	5153122	BODY ASSY	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

P/N	ITEM	QTY	P/N	ITEM	QTY
5153146	SHAFT	1	5156815	SPRING	1
5153174	BUSHING	2	5156816	PLUG	1
5153154	BUSHING	1	5156955	COVER	1
5153154	BUSHING	4	5156994	PIPE	1
5153247	VALVE	1	5157702	CLIP	1
5153256	GASKET	1	5157930	RETAINER	1
5153257	SPACER	1	5158640	CONE	1
5153258	SHAFT	1	5158673	SHAFT	1
5153260	GEAR	2	5158820	SHAFT	1
5153284	RETAINER	2	5158825	TUBE	2
5153286	SCREEN	2	5158825	TUBE ASSY	1
5153313	GASKET	2	5158901	WASHER	1
5153313	GASKET	2	5159080	WASHER	1
5153473	CLIP	1	5159358	WASHER	4
5153473	CLIP	2	5159388	PIPE	1
5153473	CLIP	1	5160266	BOLT	1
5153617	GEAR ASSY	2	5160425	SPACER	1
5153788	GASKET	1	5161003	GASKET	1
5153815	PIPE	1	5161697	CAP	7
5153823	PIPE	1	5161697	CAP MAIN BEARING	7
5153829	BRACKET	1	5162790	COVER	1
5153902	GASKET	1	5163616	PAN	1
5153902	GASKET	2	5163760	GASKET	1
5153902	GASKET	1	5163906	SPACER	2
5153914	KEY	2	5164294	SPACER	2
5153914	KEY	2	5164318	LEVER	2
5153938	SHIM	1	5164320	COLLAR	1
5153942	PAN	1	5165221	GASKET	1
5153943	PIPE	1	5166265	ELBOW	1
5154319	PLUG	3	5166864	RING	1
5154398	LOCKWASHER	2	5167220	TEE	1
5154400	WASHER	1	5167380	GASKET	2
5154401	DISC	1	5167714	WASHER	1
5154422	LEVER	1	5167714	WASHER	1
5154435	SHAFT	1	5167727	RING	1
5154433	SHAFT	1	5168555	COVER ASSY	1
5154453	PLUG	4	5168688	GEAR	1
5154453	PLUG	4	5168852	GASKET	1
5154503	RISER	1	5169195	SUPPORT	1
5154538	WASHER	1	5169197	WASHER	1
5154640	SHAFT	1	5169473	GASKET	2
5155464	BRACKET CLIP	1	5169648	HOUSING	1
5155765	SPRING	1	5170450	PLATE	1
5155819	ADAPTER	1	5170450	PLATE	1
5155854	STUD	2	5171165	COVER	1
5156295	DOWEL	2	5172031	VALVE	2
5156404	SPACER	1	5172734	RETAINER	2
5156521	GEAR	1	5172365	SEAL	2
5156523	GEAR	1	5172874	NOZZLE	4
5156332	GEAR	1	5173362	BOLT	3
5156683	GEAR ASSY	1	5173363	BOLT	3
5156770	SEAL	1	5173364	SPACER	3

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

P/N	ITEM	QTY
5173365	PLATE	2
5173366	HUB	1
5173482	GASKET	1
5173872	BLADE	1
5173935	PLUG	4
5174428	PIN	1
5174429	RING	1
5174445	HOUSING	1
5174445	HOUSING	1
5174449	CARRIER	1
5174453	SHAFT	1
5174455	WEIGHT ASSY	2
5174456	WEIGHT	2
5174971	PLUG	1
5174973	VALVE	1
5174975	GEAR	1
5175882	GASKET	1
5175941	COVER	1
5175944	WASHER	1
5175988	PUMP ASSY	1
5176035	DOWEL	1
5176066	BAFFLE	1
5176119	SHIM	1
5176121	BODY ASSY	1
5176228	SCREW	12
5176557	SEAL RING	1
5176694	BREATHER ASSY	1
5176834	TUBE ASSY	1
5176998	RETAINER	1
5177083	SCREW	1
5177241	FLANGE	1
5177528	DOWEL	2
5177650	PLUG	1
5177769	LOCKWASHER	2
5177772	PLUG	2
5177773	GASKET	2
5177777	VALVE	2
5177778	SPRING	2
5177798	GASKET	2
5177923	COVER	1
5177924	GASKET	1
5177926	ADAPTER	1
5178273	GASKET	1
5178581	RING	4
5178581	RING	1
5178581	RING SNAP	1
5178700	SHAFT	1
5178976	PLUG	4
5178976	PLUG	4
5178997	GASKET	4
5178997	PLUG	4

P/N	ITEM	QTY
5179017	RETAINER	2
5179017	RETAINER	2
5179045	PLUG	1
5179046	SHAFT ASSY	1
5179068	CRANKSHAFT ASSY	1
5179386	COVER	1
5179954	ARM ASSY	6
5180189	COVER	1
5180250	RETAINER	2
5181746	SHAFT	1
5181747	SHAFT ASSY	1
5182070	BODY ASSY	1
5182310	HUB ASSY	1
5182555	PLUNGER	1
5182557	RETAINER	1
5182558	LOCKNUT	1
5132559	HOUSING	1
5182647	ADAPTER	2
5182977	SEAL	2
5183212	ADAPTER ASSY	1
5183268	CAP	1
5183304	PLUG	4
5183305	GASKET	2
5183704	SPRING	1
5184484	INSERT	1
5184484	INSERT	6
5184530	SPRING	1
5185154	PIN	2
5185605	FORK	1
5185606	CARRIER	1
5186203	TUBE ASSY	1
5186205	ELBOW	1
5186570	SPRING	1
5186571	SEAL ASSY	1
5186572	INSERT	1
5186577	RING SEAL	3
5186579	RING SEAL	10
5186647	SUPPORT ASSY	1
5186858	SPRING	18
5187308	SPRING	1
5187309	RETAINER	1
5187310	GASKET	1
5187806	HOUSING	1
5188383	CONNECTION	1
5188558	SHAFT ASSY	1
5188611	BUSHING	1
5189041	SLINGER	1
5192234	GEAR SET	1
5192751	HUB KIT	1
5192874	SHELL	14
5192895	SHELL	1

PARTS LIST IN-LINE 71 ENGINE
CONTRACT DSA700-77-C-8511
GROOVE MODEL TMS300-5
HYDRAULIC TRUCK CRANE

P/N	ITEM	QTY
5193541	PLUG	1
5193719	PLATE ASSY	2
5194495	NUT	1
5195167	VALVE	24
5195625	GASKET SET	1
5195810	TUBE ASSY	1
5196022	BEARING SET	5
5196146	BLOCK ASM	1
5196146	BLOCK ASSY	1
5196314	SPRING PACK	1
5198558	BUSHING	1
5199350	PISTON	1
5199384	GEAR ASSY	1
5199527	TUBE KIT	6
5199561	PUMP KIT	1
5199561	PUMP KIT	1
5199825	RING SET	1
5199827	RING SET	1
5226186	GASKET	2
5226393	PIN	1
5226400	GEAR	1
5226416	DOWEL	1
5226719	RACK ASSY	1
5226912	PLUG	2
5228104	FOLLOWER	1
5228109	DEFLECTOR	1
5228583	BODY ASSY	1
5228586	RETAINER	1
5228587	ELEMENT	1
5228588	CAP	2
5228594	CAGE	1
5228596	SPRING	1
5228601	NUT	1
5228608	PIN	2
5228694	VALVE	1
5228696	CAGE	1
5228739	SPRING	1
5228766	SEAT	1
5229167	RING	1
5229192	TIP ASSY	1
5229365	INJECTOR	1
5229366	PLUNGER	1
5229369	TAG	1
5230007	SEAL	2
5571024	GASKET	1
5573014	ELEMENT	1
5573162	DECAL	1
5574008	SHELL	1
5574120	RING	1
5574122	SEAT	1
5574124	SPRING	1
5574126	SEAL	1

P/N	ITEM	QTY
5574161	GASKET	1
5574161	GASKET	1
5574516	DECAL	1
5574533	FILTER ASSY	1
5575032	ELEMENT	1
5575032	ELEMENT	1
5575056	SHELL ASSY	1
5575060	RETAINER	1
5575789	COVER ASSY	1
5575790	BOLT	1
5575824	FILTER ASSY	1
5575893	SHELL ASSY	1
6435793	BOLT	1
6435794	GASKET	1
6436060	DECAL	1
6436075	STRAINER ASSY	1
6436075	STRAINER	1
6436746	COVER	1
6437293	GASKET	1
67451054	BEARING	2
7451948	BEARING ASSY	1
7455596	BEARING	2
849330	CAP	1
8514600	CORE ASSY	1
903206	BEARING	1
907594	BEARING	1
607674	BEARING	1
907778	BEARING	1
9409028	BOLT	6
9409060	BOLT	1
9409079	BOLT	1
9412015	BOLT	5
9416857	SCREW	2
9417926	BOLT	1
9418228	BOLT	1
9421917	SCREW	1
9422203	BOLT	4
9422755	RING	1
9425165	PIN	1
9428477	PLUG	6
9431894	BEARING	1
9432337	ELBOW	1
9432337	ELBOW	1
954418	BEARING	2

By Order of the Secretary of the Army:

JOHN A. WICKHAM, JR.
General, United States Army
Chief of Staff

Official:

ROBERT M. JOYCE
Major General, United States Army
The Adjutant General

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THE METRIC SYSTEM AND EQUIVALENTS

LINEAR MEASURE

1 Centimeter = 10 Millimeters = 0.01 Meters = 0.3937 Inches

1 Meter = 100 Centimeters = 1,000 Millimeters = 39.37 Inches

1 Kilometer = 1,000 Meters = 0.621 Miles

SQUARE MEASURE

1 Sq Centimeter = 100 Sq Millimeters = 0.155 Sq Inches

1 Sq Meter = 10,000 Sq Centimeters = 10.76 Sq Feet

1 Sq Kilometer = 1,000,000 Sq Meters = 0.386 Sq Miles

CUBIC MEASURE

1 Cu Centimeter = 1,000 Cu Millimeters = 0.06 Cu Inches

1 Cu Meter = 1,000,000 Cu Centimeters = 35.31 Cu Feet

LIQUID MEASURE

1 Milliliter = 0.001 Liters = 0.0338 Fluid Ounces

1 Liter = 1,000 Milliliters = 33.82 Fluid Ounces

TEMPERATURE

5/9 (°F -32) = °C

212° Fahrenheit is equivalent to 100° Celsius

90° Fahrenheit is equivalent to 32.2° Celsius

32° Fahrenheit is equivalent to 0° Celsius

9/5 C° +32 = F°

WEIGHTS

1 Gram = 0.001 Kilograms = 1,000 Milligrams = 0.035 Ounces

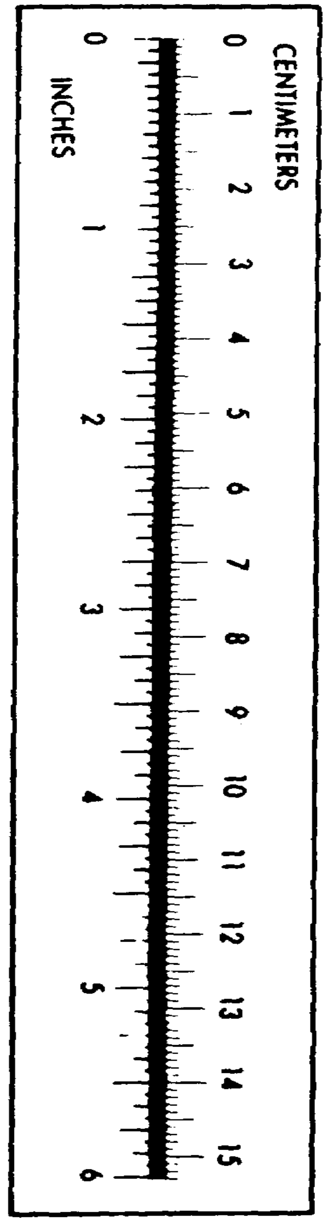
1 Kilogram = 1,000 Grams = 2.2 Lb.

1 Metric Ton = 1,000 Kilograms = 1 Megagram = 1.1 Short Tons

APPROXIMATE CONVERSION FACTORS

TO CHANGE	TO	MULTIPLY BY
Inches	Centimeters	2.540
Feet	Meters	0.305
Yards	Meters	0.914
Miles	Kilometers	1.609
Square Inches	Square Centimeters	6.451
Square Feet	Square Meters	0.093
Square Yards	Square Meters	0.836
Square Miles	Square Kilometers	2.590
Acres	Square Hectometers	0.405
Cubic Feet	Cubic Meters	0.028
Cubic Yards	Cubic Meters	0.765
Fluid Ounces	Milliliters	29.573
Pints	Liters	0.473
Quarts	Liters	0.946
Gallons	Liters	3.785
Ounces	Grams	28.349
Pounds	Kilograms	0.454
Short Tons	Metric Tons	0.907
Pound-Feet	Newton-Meters	1.356
Pounds Per Square Inch	Kilopascals	6.895
Miles Per Gallon	Kilometers Per Liter	0.425
Miles Per Hour	Kilometers Per Hour	1.609

TO CHANGE	TO	MULTIPLY BY
Centimeters	Inches	0.394
Meters	Feet	3.280
Meters	Yards	1.094
Kilometers	Miles	0.621
Square Centimeters	Square Inches	0.155
Square Meters	Square Feet	10.764
Square Meters	Square Yards	1.196
Square Kilometers	Square Miles	0.386
Square Hectometers	Acres	2.471
Cubic Meters	Cubic Feet	35.315
Cubic Meters	Cubic Yards	1.308
Milliliters	Fluid Ounces	0.034
Liters	Pints	2.113
Liters	Quarts	1.057
Liters	Gallons	0.264
Grams	Ounces	0.035
Kilograms	Pounds	2.205
Metric Tons	Short Tons	1.102
Newton-Meters	Pound-Feet	0.738
Kilopascals	Pounds Per Square Inch	0.145
Kilometers Per Liter	Miles Per Gallon	2.354
Kilometers Per Hour	Miles Per Hour	0.621



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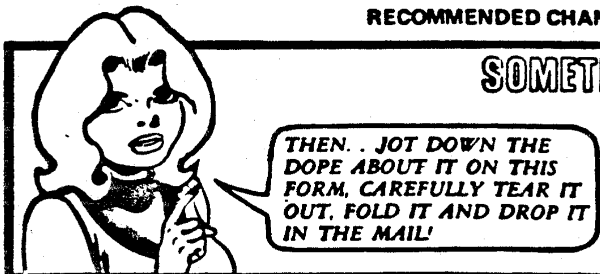

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